ON THE COVER
A commercial fishing boat heads out into the ocean near Seward, Alaska. Researchers with NOAA Fisheries have identified a new way to help resource managers and fishermen reduce salmon bycatch by delivering more timely genetic information to people in the commercial fishing industry. Photo: Michael Olson (iStock)
FROM THE DIRECTOR

In climate science parlance, resilience is comprised of two parts: adaptation and mitigation. That seems like a reasonable summary of the last year and a strategy for at least the near future. As we continue to mitigate and adapt to post-pandemic challenges, life and work uncertainty requires acceptance, purpose, and flexibility, all traits of resilient people and institutions. Articles that you will read in this year’s magazine will demonstrate that CICOES has had another successful, resilient year in the office, in the lab, and in the field (above, below, and at sea level). Thanks to all who contributed to the 2023 CICOES Magazine.

Lots of transitions this year. At UW the administration team has seen significant turnover with Deborah Malarek (grant manager), Collen Marquist (executive assistant and safety officer), and Merly Jones (payroll coordinator) all retiring. New arrivals include Nenad Grubisa (grants specialist), Marlene Poches (executive assistant), Deb’s replacement (coming soon), and the search is beginning for a new payroll coordinator. At UAF, Peter Bienik is now supporting CICOES leadership and Arina Didriksen is the new fiscal programs coordinator. Another exciting transition this year is the first appointment of eight CICOES-UAF employees that are co-located at NOAA partner laboratories in Juneau and Seattle.

We were also successful in obtaining an NSF Research Experiences for Undergraduates (REU) grant to expand and enrich the CICOES summer intern program. Thanks to the funded REU proposal led by Muyin Wang, interns are now able to extend their program participation by attending a scientific conference or continuing their research into the academic year. Applications for the 2024 program will be available the first week of January.

Another highlight of the year was the inaugural CICOES Symposium. Over 90 people registered, with representation from NOAA headquarters and all three of our NOAA partners. The resilient symposium adapted to the concurrent UW Research Scientist and Postdoctoral Scholar strike, and provided a representative showcase of current research, ample opportunities to share research interests for future collaborations, and an ‘indoor Olympics’ event where enthusiastic participants had a lot of fun competing for bragging rights and annual passes to the National Parks. Thanks to all who put in a lot of work to plan and launch this event.

As the year nears its end, we will soon be participating in federal government funding initiatives. Between the Disaster Relief Supplemental Appropriations Act and the Inflation Reduction Act, project and new program funding will be routed through CICOES to initiate and expand collaborative research projects. These three-year programs will provide additional research opportunities for the CICOES community and potentially set the foundation for innovative, long-term collaborations.

But to initiate and execute projects you need a functional financial transaction system. The Workday Financial Transformation software that went ‘live’ on July 1, in combination with college-wide shared services, has exponentially increased our administration (a noun) at UW and interactions with our OSU and UAF financial counterparts. It was expected that replacing 30-year-old legacy systems would have glitches, but no one predicted the magnitude of the impact that this would have on how we conduct business. Have faith we are told; things will get better (they just haven’t told us how or when).

The biggest event on CICOES’s 2024 calendar will be the NOAA 5-year review. A Cooperative Institute is established through a Cooperative Agreement for five years with a potential renewal for an additional five years. The review occurs during the fourth year, which for us is prior to July 1, 2024. An external review panel, led by an appointee from the NOAA Scientific Advisory Board, will evaluate how we conduct collaborative research, education, and outreach with our NOAA partners. Constructive suggestions will be made to improve our science and administrative operations. We have begun laying the groundwork needed to support the process on our end, and preparations are underway to secure an ‘outstanding’ ranking from the review. Everyone is encouraged to contribute and participate in the scientific review. A preemptive thank you to all who have or will contribute to showcasing the great work that is accomplished across the CICOES community.

I hope that you have had a productive and fulfilling year and that next year is even better!

John K. Horne
Executive Director
CICOES MAGAZINE | 2023

PROFILES

4
Celebrating Women's History Month w/
Samantha Wills

6
Scientist Spotlight
Brynn Kimber

8
Question & Answer w/
Lucia Upchurch

9
Celebrating the Career of
Sylvia Musielewicz

10
Get to Know Our
New Employees

RESEARCH

13
Research Highlights
Accomplishments Representing
CICOES's Nine Core Research Themes

15
Our Favorite New Tools
A Showcase of the Tools CICOES Uses to
Better Understand the Planet

18
Assessing Tsunami Hazards
for Diplomatic Posts
CICOES Creates Tsunami Design Zone
Maps for U.S. Department of State

20
Mechanisms of Pacific Cod
Population Decline
Explaining the Mortality Rate Following
Marine Heat Waves

22
Warming Oceans Have
Decimated Marine Parasites
If Parasites Have Declined in Puget
Sound, Where Else is it Happening?

24
What is a Strong El Niño?
Meteorologists Anticipate a Big Impact,
But Forecasts Don't All Agree

26
Shedding Light on Salmon
Bycatch Dynamics in Alaska
A Major Effort to Modernize Genetic
Analysis Workflow

28
Postcard from the Field
A Buoy Ride in the Gulf of Alaska

54
Publications
A Year of Publications Authored by
CICOES Researchers and Affiliates
COOPERATIVE INSTITUTE FOR CLIMATE, OCEAN, AND ECOSYSTEM STUDIES
University of Washington | University of Alaska Fairbanks | Oregon State University

WHO WE ARE

Organization
A Summary of CICOES Research and Financial Structure

Initiatives
The Seven Internal Programs Funded by CICOES

Professional Development Program
Supporting Participation in Workshops, Certificate Programs, and Other Professional Opportunities

Research Development Grants
Funding to Stimulate New, Innovative Research

Impressions from the CICOES Symposium
Reflecting on the Inaugural CICOES Symposium

Research Experience for Undergraduates
The Importance of Female Mentorship

FEATURES

The Search for Deep Ocean Hydrothermal Fields
Rapid Discovery and Characterization of Three New Hydrothermal Fields Onboard the Falkor (too)

Creating the Alaska Oyster
Innovations for Growing the Pacific Oyster at High Latitudes

Satellites and Snowfall
Developing Innovative New Products Across Land, Sea, and Sky

Combining Science and Art
Arctic Portrait Exhibit at the National Academy of Sciences

In Memoriam
Remembering CICOES researcher Dr. Donald Denbo

CICOES Magazine covers news, events, and research that occurred between December 1, 2022 and November 30, 2023.
WHAT DOES CLIMATE RESILIENCE OR CLIMATE-READY NATION MEAN TO YOU? WHAT WOULD YOU WANT PEOPLE TO KNOW ABOUT NOAA’S WORK ON CLIMATE RESILIENCE?

To me, the idea of a climate-ready nation is analogous to a user of a daily weather forecast. The purpose of that weather forecast is to provide a user with information that may alter their day-to-day decision making, such as adjusting a picnic due to impending rain, or packing an umbrella for the commute home. However, it is up to the user to decide whether or not to heed the forecast (which doesn’t always pan out) and prepare themselves to handle an obstacle to their daily routine. In other words, the weather forecast gives the user a chance to get ahead of a potential problem, and not behind one.

And that is the crux of a climate-ready nation – utilizing the best available information to make informed decisions and prepare for future obstacles to the nation’s well-being. Climate change is one such obstacle. NOAA’s contribution to climate resilience is to provide the best possible information to address impacts due to climate change by supporting scientific research aimed at understanding Earth’s complex climate system, which includes the atmosphere, land, ocean, ice, and living organisms.

WHAT PROJECTS OR RESEARCH ARE YOU WORKING ON NOW, AND HOW DOES YOUR WORK CONTRIBUTE TO CLIMATE RESILIENCE?

TO CELEBRATE WOMEN’S HISTORY MONTH, we asked women throughout NOAA Research who make lasting impacts in scientific research, leadership, and support from the field to the office to share how their work contributes to NOAA’s mission of Climate Resilience and preparing for a Climate-Ready Nation. This article highlights an interview with Dr. Samantha Wills, a research scientist at UW’s Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES) and the NOAA Pacific Marine Environmental Laboratory (PMEL). She works in the Ocean Climate Stations group led by Dr. Meghan Cronin, and uses novel Saildrone uncrewed surface vehicles to collect observations over remote regions of the tropical Pacific Ocean. These observations allow her to study mesoscale air-sea variability associated with atmospheric cold pool phenomena over the tropical ocean.

By Jessica Mkitarian & Emily Ashe, NOAA
The ocean and atmosphere form a closely coupled system, and our ability to derive information from the ocean can help us to predict changes to climate and weather patterns across the globe, such as done for the El Niño Southern Oscillation. Unfortunately, compared to land, which only covers ~30% of the Earth’s surface, observations over the ocean are few and far between. I have the rare advantage of working with an emerging technology, uncrewed surface vehicles, that has the potential to push ocean exploration to the next level. Our team is currently exploring the utility of this new technology and its potential for improving the Tropical Pacific Observing System. My research utilizes air-sea observations collected during field campaigns to remote (i.e., far from any landmass), under-sampled, regions of the eastern tropical Pacific Ocean to better understand local scales of air-sea interaction and variability.

**WHAT DO YOU ENJOY MOST ABOUT YOUR WORK?**

I most enjoy working in public service. I believe that science is the pursuit of knowledge and truth, not profit, and I am glad that we push to make our research freely accessible and transparent. I hope that my contributions to the field will have a positive impact on society, and that is what drives me to keep pushing forward, even when the work gets frustrating.

**WHAT CHALLENGES HAVE YOU FACED AS A WOMAN IN YOUR CAREER/FIELD AND HOW HAVE YOU OVERCOME THEM?**

I recall a casual conversation I had with a professor during my time as an undergraduate. We were discussing opportunities post-graduation, such as my interest in attending graduate school in pursuit of a PhD. The professor made an off-handed comment (not maliciously) about how women tend not to get as far in graduate school because their family responsibilities will distract them or get in their way, and it felt as if he was preparing me for that inevitability; like I shouldn’t waste my time. Needless to say, I did not appreciate his insight. Instead, the experience only served to solidify my decision to pursue a doctorate while simultaneously fueling my fire to prove him (and anyone else who dared to doubt me) wrong. So I leaned on those, both professional and personal, who most supported me to achieve my dreams, and here I am now, Dr. Samantha Wills!

**WHAT DRAW YOU TO YOUR CURRENT CAREER OR FIELD?**

Well, the story goes that during my time in the womb, my mother endlessly consumed *The Weather Channel*, so she likes to take credit for my interest in weather and climate! But all jokes aside, I was exposed to severe weather from a young age growing up in Texas, with thunderstorms and tornadoes both terrifying and fascinating me. At school, math was my favorite subject, and as I contemplated college majors, I discovered that mathematics and meteorology go hand-in-hand. As for my journey to graduate school, I have to credit my faculty advisor Dr. Andrew Dessler at Texas A&M University. Given my aptitude for atmospheric science, he encouraged me to pursue a doctorate degree, which I had never considered. He guided me through the necessary steps (summer internships, coursework, GRE test, prospective advisors, etc.) to become a successful candidate, and he pointed out that regardless of the subject matter, I would gain valuable skills and toolsets to become a scientific researcher. Without the guidance and support I received from male and female mentors alike throughout my academic journey, I am not sure where I would be today.

**WHO DO YOU LOOK TO AS A ROLE MODEL AND WHY?**

I look to my advisor Dr. Meghan Cronin as a role model. She is a female scientist with an impressive career who has worked at NOAA for decades, and she is just a force to be reckoned with. The quality I most admire is her self-confidence. I’m not sure if it is a woman-thing or a me-thing, but I tend to downplay my successes and am quick to question my own abilities, especially as an early career scientist. But not Meghan. Meghan is a visionary who pushes our field forward, and she is not afraid to ruffle a feather or two to do so. Time after time, she has demonstrated how much she cares for me and our entire team at NOAA. I hope that one day I can pay forward all that Meghan has done to support me and my career.

**OVER THE COURSE OF YOUR CAREER, WHAT CHANGES OR PROGRESS HAVE YOU SEEN FOR WOMEN IN SCIENCE AND THE WORKPLACE?**

During my first year as a graduate student, I recall there were only two female professors working in my atmospheric science department, out of a group of 15-20 professors. But as time progressed, the department hired more female professors for tenure-track positions, and now the number of female professors has grown from two to eight! While progress takes time, the increased representation of female professors at my old department, all of whom are exceptional scientists, makes me believe that the institutions are listening and working to address inequality in the academic workforce.
By Marlene Poches, CICOES

**HISTORICALLY,** whales, dolphins, and porpoises (i.e., cetaceans), have been somewhat mysterious in terms of their distribution, population structure, and hunting habits. But recent advancements in acoustic technology are being paired with traditional aerial surveys to shed more light on the movements and behavior of cetaceans. Brynn Kimber, a bioacoustics specialist and senior analyst with the Marine Mammal Laboratory’s acoustics team at NOAA’s Alaska Fisheries Science Center, is passionate about underwater sound. That passion fuels Brynn’s daily work, as they study thousands of hours of audio recordings with sounds from cetaceans, pinnipeds (seals), and human-generated noises recorded in the Bering, Chukchi, and Beaufort seas.

Toothed whales (the Odontocete group, consisting of approximately 75 species including bowhead and orca whales) echolocate and make various sounds while hunting and navigating. They do this by sending out a series of clicks and then interpret the echoes these sounds make when they bounce back from objects. Baleen whales (the Mysticete group, containing approximately 14 species including gray whales and humpback whales) do not need to echolocate because they eat tiny crustaceans and fish using a filter-feeder system inside their mouths. They do, however, produce sounds that are used for communicating with one another. Imagine listening to this diverse set of sounds through an underwater recorder as these animals go about their daily routines! For Brynn, that’s another day at the office.

Brynn grew up in Bellingham, WA, and fell in love with the ocean while exploring the tidepools of Puget Sound and the San Juan Islands. Cephalopods, such as squid and octopus, were center stage as a child and drove Brynn to study marine biology at the University of Washington. It wasn’t until later, while attending a lecture on passive acoustic monitoring given by Kate Stafford, an associate professor at Oregon State University, that Brynn became interested in studying marine mammals and the way they interact with their environment. Brynn approached Kate after the lecture and volunteered to assist with her work. Little did Brynn know that this would be the doorway to a career as a research scientist with CICOES.

Now fully immersed in the field of acoustics, Brynn finds the most rewarding experiences come from going out into remote landscapes to witness firsthand how migration patterns and habits of marine mammals are impacted by climate change. At first, it was overwhelming to hear the diversity of their sounds and dialects, but over the years Brynn has become a high frequency specialist and expert at identifying pitches and noises.

BRYNN HAS BECOME A HIGH FREQUENCY SPECIALIST AND EXPERT AT IDENTIFYING PITCHES AND NOISES.
Brynn finds the most rewarding experiences come from going out into remote landscapes to witness firsthand how migration patterns and habits of marine mammals are impacted by climate change.

The biggest surprise of Brynn’s career didn’t take place during a recent two-month research cruise in the Bering Sea — a remote location where researchers were dazzled by the aurora borealis and wowed by polar bears roaming the ice — but instead, it came while doing analysis back home in their Seattle office. Brynn was looking at data from multiple cruises when they discovered a trend in orca distribution indicating that the whales were beginning to migrate further north than usual. These movements and changes in behavior are exactly what Brynn and colleagues are looking for through their analyses of acoustic data.

Brynn’s work involves some fundamental challenges: overcoming seasickness, for starters, and then figuring out the intricacies of bioacoustic communications, and slowly surmounting the language barrier between humans and marine mammals. However, one of the greatest challenges Brynn encounters is manmade. The complexity of the data from the acoustic recorders is beyond the current analytical capabilities of computer technology, even using current Artificial Intelligence (AI) tools. The Marine Mammal Lab has been able to build an autodetector for multiple species that use simple calls, but species with complicated calls cannot be completely and accurately identified by the AI. A bioacoustics specialist must still decipher these high-level sounds in a one-by-one, hands-on approach, until a more advanced technology has been developed. The desire to answer the bigger questions buried in acoustic data still remains very human and drives Brynn’s passion for the work.

Photo: Shaun Bell
Interview by Carol Pérez, CICOES

LUCIA UPCHURCH is a research scientist who has been with CICOES since 2015. She works in the Atmospheric Chemistry group at NOAA’s Pacific Marine Environmental Laboratory (PMEL), and recently she has been organizing a popular baking competition at the lab’s weekly coffee hour.

TELL US A BIT ABOUT YOUR ROLE WITH CICOES.

I’ve been with CICOES for almost eight years now as a research scientist/engineer. Most of the time, I work in the Atmospheric Chemistry group at PMEL. Our group uses shipboard and uncrewed aerial vehicles to collect environmental aerosol samples at field sites and at sea. I measure and analyze aerosol particle composition using techniques such as ion chromatography, X-ray fluorescence, and organic carbon/elemental carbon analysis. These measurements are useful for understanding the sources of the particles, as well as their effect on absorbing or scattering incoming solar radiation. I enjoy both the field and lab work components of my job.

In addition to the Atmospheric Chemistry group, I work as a deputy project manager with the Tropical Pacific Observing System program. In this capacity, I have coordinated and participated in annual international meetings (both remotely and in person) and shepherded the publication of three reports outlining a redesign of the observing system. This role is quite different from my role with the chemistry group. I enjoy the variety of projects I get to work on and I’m grateful for the opportunities that each has provided.

WHAT IS SOMETHING PEOPLE MAY NOT KNOW ABOUT YOU?

Professionally, I spent time as a fisheries observer working out of Dutch Harbor, Alaska, and in my personal time I enjoy foraging for mushrooms and berries, and clamming on the coast.

WHAT IS AN ASPECT OF YOUR JOB THAT MIGHT SURPRISE OTHERS?

I experienced the inside of an airport traffic control tower for part of a project with an uncrewed aerial vehicle (UAV). It was fun to see the small aircraft taking off and landing on a nice day.

WHAT IS THE MOST REWARDING PART OF YOUR WORK?

It’s the field work and travel that keeps me going. Going to sea for research cruises is like summer camp for adults (to me anyway!). It can be incredibly challenging because you have to plan around it and basically put your life on hold for extended periods of time – sometimes for months between preparation, travel, and time in the field – so it certainly isn’t for everyone. But I love the experience of being at sea. Making discoveries, and the challenges that you have to overcome when things break, or supplies run out, or the weather gets dicey, or a myriad of other unexpected things that are part of most cruises.

HOW DO YOU THINK YOU HAVE CHANGED IN YOUR ROLE SINCE FIRST STARTING YOUR POSITION?

I’ve definitely learned a lot about instrument repair and the value of just trying an idea out to see if it will work. I’ve also learned to ask for help when I run into problems, rather than struggling through by myself.

TELL US ABOUT YOUR INSPIRATION FOR THE WEEKLY BAKE-OFFS YOU’VE BEEN HOSTING AT PMEL.

I wouldn’t say I’m a regular viewer of the Great British Baking Show, but I do enjoy it from time to time. Every Thursday, we have what we call a ‘coffee hour’ at the lab (PMEL). During the summer, the people that had been providing the donuts and other treats were all gone due to work travel and vacation so I thought a bake-off might be a way to increase the number of people involved by adding the element of competition. I also thought it would be fun to use seasonal produce as a theme. For our first theme I chose blackberries because there are so many blackberry bushes around Seattle and especially on the NOAA campus. It’s been fun to try the different recipes people come up with and share them with others!

WHAT WAS THE HIGHLIGHT OF 2023 FOR YOU?

This summer we went to Vandenberg Space Force Base in Lompoc, California, for field operations with the UAVs. It was a unique field site and the first time I’ve been on a military base. While it wasn’t technically at sea, it was a memorable experience!
SYLVIA MUSIELEWICZ retired from CICOES in September 2023, after 17 years as a research scientist supporting the NOAA Pacific Marine Environmental Laboratory’s Carbon Program.

Following service with the Peace Corps in Kenya working in agroforestry and employment as a research scientist at Harvard studying aquatic records of paleoecological conditions, Sylvia was hired by JISAO in 2006 to help develop NOAA’s then brand-new marine carbon dioxide observatory network on moorings. Sylvia played an essential role in expanding the moored program into a globally distributed observatory network spanning more than 40 time series sites.

Specifically, Sylvia has made the following key contributions:

1. She supported deployments and operations for dozens of coastal and coral reef moorings and associated chemical sensors spanning the US (Samoa to New Hampshire and Alaska to Puerto Rico) and world (Australia to Iceland), both in person on “buoy rides” and by remotely supporting more than 100 partnering scientists, including training many in field operations.

2. Sylvia authored more than 15 peer-reviewed publications, and contributed to hundreds of publicly archived datasets and synthesis products that are widely used by the global marine science community for original research, ocean and climate modeling, and global climate assessments such as the Global Carbon Budget and Intergovernmental Panel on Climate Change reports.

3. She developed quality control procedures for oxygen, chlorophyll, pH, and other auxiliary data — greatly expanding publicly available time-series of these parameters — and worked closely with the Carbon Program’s software developers to define and enhance data processing and quality control pipelines, user interfaces, and software tools.

4. Additionally, she contributed to the technology transfer and commercialization of the Moored Autonomous pCO₂ instrument.

As a testament to the impact of her work, at a recent meeting of the National Ocean Acidification Network, participants shared their appreciation for Sylvia’s consistent and kind support, a work ethic that always went above and beyond to support their operations, and recognition that the many successes of the moored carbon program would have been impossible without her contributions. Indeed, the observational network she helped grow is beginning to transition from a research project to an official operational program within NOAA, which promises to support ocean acidification and global carbon research for decades to come.

Beyond these contributions, her wonderful sense of humor is deeply appreciated by her colleagues and will be missed. Similarly Sylvia is admired for her ability to craft solutions for both conceptual and practical needs — like her home-made mud pizza oven! •
GET TO KNOW OUR NEW EMPLOYEES

Please welcome these 20 individuals who joined the CICOES-UW staff between December 2022 and November 2023.

COURTNEY AVIOLI
Courtney Avioli (she/her) is a research scientist/mechanical engineer in the Engineering Development Division (EDD). She works on designing, testing, and implementing components and parts for various buoys and moorings across PMEL and has been involved in the Innovative Technology for Arctic Exploration (ITAE) program designing for the Arctic. Along with EDD, Courtney supports many of the labs at PMEL by designing buoys that get reliable data at sea. Before joining CICOES, Courtney graduated from the University of Washington with a bachelor’s degree in mechanical engineering. During Courtney’s time at UW, she has done some work in the renewable energy field and the shellfish farm industry through internships and projects. She has also done previous work at the UW School of Oceanography studying methane plumes in Puget Sound which sparked her interest in ocean sciences.

PAMELA BARRETT
Pamela Barrett (she/her) is a research scientist with PMEL’s Earth-Ocean Interactions (EOI) group. She is a marine chemist whose research focuses on the role of particles in controlling the distribution of bioactive trace metals in the ocean. Prior to joining CICOES in February 2023, she received her PhD in chemical oceanography from UW and held postdoctoral appointments in the UW College of Engineering and the Australian National University Research School of Earth Sciences.

SUSAN CURLESS
Susan Curless (she/her) is a research scientist working with PMEL’s Ocean Carbon Group to analyze water samples sent for dissolved inorganic carbon and total alkalinity. Many of these samples are part of investigations into the impacts of ocean acidification in Puget Sound and surrounding waters. Before joining the Carbon Group, Susan’s work primarily focused on nutrient chemistry and cycling in both fresh and saltwater environments.

LARISSA DIAS
Larissa Dias (she/her) is a postdoctoral researcher who earned a PhD in coastal and marine system sciences from the Harte Research Institute and Texas A&M University – Corpus Christi in 2022. Larissa is working with CICOES researcher Brendan Carter at PMEL to improve the usability of biogeochemical Argo autonomous float data. Ocean acidification and climate changes are increasingly impacting marine systems and the organisms and people who rely on them. Larissa’s research helps to address these pressing issues by helping researchers more efficiently use the growing quantity of available oceanic chemistry data.

NENAD GRUBISA
Nenad Grubisa (he/him) is the new grants specialist for CICOES. He focuses on budget projections, subawards, and grant proposals, and keeps everyone on top of deadlines. Nenad joined CICOES in April 2023 after time with UW’s Cardiology Department, Electrical Engineering/Computer Science Department, and the School of Dentistry. Nenad attended Shoreline College and graduated with honors in 2012 while earning an associate degree in accounting. He likes watching stand-up comedy specials and enjoys walking on the beach at sunset.

ERNESTO GUERRERO-FERNANDEZ
Ernesto Guerrero-Fernandez (he/him) is a postdoctoral researcher who earned a PhD in mathematics from the University of Málaga (Spain) in 2022. Ernesto is working with CICOES researcher Yong Wei and other scientists at the NOAA Center for Tsunami Research to investigate and assess the generation, propagation, and impact of tsunami waves. Ernesto focuses on the development and efficient implementation of new mathematical models and numerical schemes to capture complex hydrodynamic and morphodynamic behavior associated with extreme flooding phenomena, such as tsunami waves. This research allows not only broadening our understanding of these events, but assessing potential risks and providing robust and reliable tools.
EVAN HOWARD
Evan Howard (he/him) is excited to join the talented team at PMEL and CICOES. “I’m grateful for your kindness and warm welcome,” he says. Evan supports the moored carbon group in monitoring ocean carbon chemistry. His prior research explored how marine life responds to changing climate through the lenses of chemistry, models, and big data. Evan’s non-research interest is rabbits.

JANNES KOELLING
Jannes Koelling (he/him) is a postdoctoral researcher who earned his PhD in oceanography from the Scripps Institute of Oceanography in 2020. Jannes is working with Alison Gray from UW, along with PMEL’s Andrea Fassbender and Gregory Johnson, to study ocean ventilation in deep water formation regions using biogeochemical (BGC) Argo floats. At high latitudes, oxygen is taken up from the atmosphere and subsequently transported into the ocean interior, which is the main process by which it can enter the deep ocean and sustain life there. The goal of their project is to improve understanding of these processes using BGC-Argo float data, leading to a more complete picture of this “breathing” of the ocean.

QIUXIAN LI
Qiuxian Li (she/her) is a postdoctoral researcher who earned a PhD in physical oceanography from the Ocean University of China in 2023. Qiuxian is working with CICOES researcher Wei Cheng along with UW’s LuAnne Thompson and Kyle Armour to investigate the relationships between equilibrium climate sensitivity (ECS) and various factors including cloud feedback, characteristics of ocean heat uptake (OHU), and the strength of the Atlantic Meridional Overturning Circulation. Her research aims to determine the individual contributions of cloud feedback and OHU anomalies to ECS and examine their temporal dependencies using the newly developed E3SM-SOM configuration. She will be quantifying the extent to which the spread of ECS values across CMIP6 models can be attributed to distinct OHU patterns in these models.

XINYU LI
Xinyu Li (she/her) is a postdoctoral researcher who earned her PhD in oceanography from the University of Delaware in 2023. Xinyu is working with CICOES researcher Brendan Carter and PMEL’s Richard Feely at the Pacific Marine Environmental Lab to quantify anthropogenic carbon in the coastal and global ocean. The ocean has absorbed anthropogenic carbon (AC) from the atmosphere, playing an important role in mitigating climate change. In the coastal ocean, AC has an outsized impact on the ecosystem and ecosystem services. However, data are limited for how much can be used to gauge impacts and how AC is accumulated and redistributed in the coastal ocean, so there is still need for coastal observational data. Xinyu will focus on using regional multiple linear regression models to quantify the rates and variability of anthropogenic carbon accumulation and explore its storage mechanism along North American coasts using long-term and high-quality cruise data.

CAITLYN MCFARLAND
Caitlyn McFarland (she/her) is a research scientist working with EcoFOCI at PMEL to analyze nutrient and dissolved oxygen samples from arctic research and GO-SHIP cruises. These samples are used to aid in global ocean observations and improve the understanding of ecosystem dynamics in the North Pacific Ocean, Bering Sea, and U.S. Arctic. Prior to working with CICOES, Caitlyn was a supervisor at Sea-Bird Scientific where she led the Final Test team in preparing instruments and carousels for deployment. She also worked with the University of Washington to monitor harmful algal blooms in the Salish Sea, Gulf of Alaska, and Gulf of Maine with partners from UW Tacoma, University of Alaska Fairbanks, and NOAA Beaufort Laboratory. Her other areas of study included microplastic quantification, CTD monitoring in Clayoquot Sound, and ecosystem monitoring in Puget Sound. She serves as a member of the education committee and a science mentor for the local nonprofit, Sound Experience.

LINQUAN MU
Linquan Mu (he/him) is a postdoctoral researcher who earned a PhD in ocean sciences from the University of Georgia in 2021. Linquan is working with CICOES researcher Darren Pitcher and PMEL’s Jessica Cross to investigate Arctic ocean acidification (OA) through biogeochemical modeling. Utilizing output from both a hindcast simulation (1970-present) and seasonal forecasts (3-9 months) for the Bering Sea can provide historical contexts and projected assessments for OA in support of NOAA Fisheries management. Model skills will be evaluated using observations from various platforms, such as research vessels, moorings, and unmanned vehicles, like Saildrones. A comprehensive assessment of Bering Sea OA regional models can be helpful in guiding fisheries management and realizing monitoring goals for carbon dioxide removal research.

MARLENE POCHES
Marlene Poches (she/her) is the new executive assistant to CICOES Director John Horne. She came to CICOES from UW Facilities where she was the executive assistant to the assistant vice president for asset management. Marlene has a long history as an administrator and fundraiser for universities across the country including the University of Oregon, The Ohio State University, Ohio University, and The University of Tennessee at Chattanooga. Born in Florida, she spent her childhood abroad in the Middle East and then in Tennessee upon her return to the U.S. She is a published author of poetry and short stories, a student of entomology, and the former owner of an organic permaculture farm and bakery in Ohio that specialized in edible flowers and heirloom produce. Marlene also served on the executive committee for the Athens Farmers Market and worked in partnership with The Livestock Conservancy and breeders across the country to restore the presence of the endangered Cotton Patch goose and Magpie duck. Marlene spends her free time hiking and exploring the alpine areas and coastlines of Washington and Oregon with her family and two dogs, Angus and Keegan.
VIVEK SEELANKI
Vivek Seelanki (he/him) is a postdoctoral researcher who received a PhD in physical oceanography from the Indian Institute of Technology Delhi in 2022. Vivek is working with CICOES researchers Wei Cheng and Albert Hermann, along with PMEL’s Phyllis Stabeno, on implementation and refinement of a regional Modular Ocean Model version 6 (MOM6) for the Northeast Pacific domain (MOM6-NEP), spanning Baja California to the Chukchi Sea. MOM6-NEP incorporates ocean biogeochemical, sea ice, and tidal dynamics. The goal of the research is to perform multi-decadal simulations using MOM6-NEP under historical atmospheric and oceanic forcing conditions, evaluate the results against in situ and satellite observations, identify model biases, and develop methods to reduce those biases.

HAN WEINRICH
Han Weinrich (they/them) is a research scientist with CICOES. They work onsite at PMEL with the Ocean Molecular Ecology (OME) group to process eDNA and tissue samples for DNA sequencing and contribute to ongoing projects within OME. The OME group uses omics to monitor long term changes in marine ecosystems, assess impacts of climate change, and improve the tools utilized to understand marine ecosystems through biomolecular analyses. Han’s background includes work with microbial eukaryotes at hydrothermal vents, research cruises onboard the R/V Thomas G. Thompson and working with the Regional Cabled Array (NSF Ocean Observatories Initiative) at UW.

MARK YAMANE
Mark Yamane (he/him) is a research consultant working with CICOES Director John Horne to develop open-source fisheries acoustics software. Current projects include building products for a data portal from near-real-time data collected by echosounders mounted on Slocum Gliders, developing a desktop application that processes active acoustic data in batches to produce a standard suite of figures and metrics, and developing a Python package for reading, processing, and plotting acoustic data from multiple types of echosounders. Prior to joining the Fisheries Acoustics Research Lab, Mark graduated from Eckerd College in St. Petersburg, Florida with a double major in marine science and computer science. In his free time, Mark enjoys bouldering, low-tide beach walks, and scuba diving.

Additional new employees include: Jason Broad, Luis Candela, Matias Gradilla, and Joseph Kurina.

YOU CAN ACCELERATE SCIENTIFIC COLLABORATION
Established in 1977, CICOES — known as JISAO until 2020 — fosters innovative research collaborations between the UW and NOAA, and now includes academic partners at the University of Alaska Fairbanks and Oregon State University. Among the oldest and largest of NOAA’s Cooperative Institutes, CICOES research is at the forefront of climate change, ocean processes, and ecosystem science.

CICOES partners with academic and research institutions, government agencies, NGOs, and community organizations to increase scientific understanding, application of results for practical solutions, and education of students and the public on current and emerging environmental issues. By working with NOAA, CICOES can extend its research impact to serve the widest possible regional, national, and global community interests.

You can invest in our research, education, and outreach programs by supporting the Friends of CICOES Fund at the University of Washington.

GIVING.UW.EDU
RESEARCH HIGHLIGHTS

By John Horne, CICOES

Results from CICOES research have local, regional, national, and international impacts that increase scientific and public knowledge, develop data acquisition and analytic techniques, support NOAA’s mission, and enlarge the potential NOAA federal employee pool through education and professional training of staff and students. Impacts can be identified in each of the nine CICOES research themes. Representative projects are described to serve as examples of disciplinary impacts:

**CLIMATE AND OCEAN VARIABILITY, CHANGE AND IMPACTS**

The Observing Systems Research project used a Saildrone to navigate into and collect measurements near the eye wall of hurricane Sam. Results of these measurements are influencing studies on how to deploy autonomous vehicles, to observe air-sea interactions in tropical cyclones, and to improve the ability to forecast high-impact events, including hurricane intensification. A second example links drought, climate variability, and climate change in the Pacific Northwest with real time impacts, operational changes, and response actions. This information adapts climate research and responses to resource management actions.

**EARTH SYSTEMS AND PROCESSES**

The vents fluids project discovered and characterized three new high-temperature hydrothermal fields on the Mid-Atlantic Ridge. These discoveries provide new opportunities for research and improved understanding of hydrothermal systems and mineral formation, which can be used to inform deep-sea mining policy (see story page 39). The tsunami group conducted research and developed warning services that contributed to NOAA’s weather-ready nation and resilient coastal community goals. Continued development of Short-term Inundation Forecasting for Tsunamis (SIFT) and other community tools improves tsunami warning systems, provides accessible graphic interfaces for users, and produces tsunami zone maps that are used to modify international standards in building codes. Characterizing properties of the marine boundary layer aerosols are used to improve climate models and to better understand aerosol-cloud interactions.

**ENVIRONMENTAL CHEMISTRY AND OCEAN CARBON**

The Plumes group examines impacts of the solid Earth on ocean chemistry where iron and trace nutrients are added to surface waters to regulate primary productivity. Recent research survey results have shown that delays in the formation of sea ice in the Southern Ocean may impact the annual resupply of iron to highly productive coastal polynyas along the Antarctic coastline, and indicates that Southern Ocean primary production models may need to be reparameterized. Arctic regions are a bellwether for ocean acidification impacts, experiencing rapid and extensive onset of anthropogenically acidified conditions. Ocean acidification is already occurring in important commercial and subsistence fishery habitats and could have cascading economic consequences. Results from this effort are used to assess vulnerability of Alaskan coastal communities, economic impacts on Alaska fisheries, and tracking biogeochemical conditions in Alaskan waters.

**MARINE ECOSYSTEMS: OBSERVATION, ANALYSIS, AND FORECASTS**

The mission of the Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program is to understand relationships among climate, fisheries, and the marine environment to ensure sustainability of Alaskan living marine resources and healthy ecosystems. Measurement data from biophysical moorings, satellite-tracked drifters, remote sensing, hydrographic and atmospheric measurements, and numerical models over 35+ years has increased understanding of mechanisms linking environmental changes to high-latitude marine ecosystems. The Alaska Climate Integrated Modeling
(ACLIM) project investigates drivers of productivity under climate change, fisheries management approaches to resilient fisheries, and development of climate to community models to evaluate economic and social impacts of climate change on resource-dependent communities. The ‘Omics program modernizes ecosystem assessments and biological measurements with physical and chemical processes across oceanographic cruises and moored buoys. Whole genome sequencing efforts of blue whale samples provide critical information for conservation and management. Linking genomics and acoustics data enhances the ability to track blue whale populations over time and to understand how climate change and anthropogenic sound from vessels and ocean infrastructure impact spatial and temporal habitat use. Development of infrared thermal imagery for surveying warm bodied marine mammals enables larger areas to be covered with higher detection rates, causes less disturbance to the animals, and has been used to develop and improve algorithms for computer vision.

**OCEAN AND COASTAL OBSERVATIONS**

The marine carbon program collects, quality controls, and analyzes seawater carbonate measurements to quantify impacts of variability in natural processes and anthropogenic carbon uptake. Data collection efforts have documented aspects of a changing global climate and enabled improved climate current and future state modeling. The value of improved climate forecasts is estimated to be worth upwards of hundreds of billions of dollars. Data product examples include SO-CAT (350+ citations of the various versions) and GLODAPv2 (140 citations since 2016). Biogeochemical algorithms from this effort have enabled new ocean monitoring strategies with the potential to revolutionize data collection for lower trophic levels and the physical and chemical environment. An observed discrepancy between measured and calculated seawater carbonate parameters has resulted in the formation of a working group to identify the source and resolve the discrepancy. The Global Tropical Moored Buoy Array (GTMBA) program conducts ocean observing in three tropical oceans and researches variability in atmosphere-ocean interactions. In FY 2022 PMEL's GTMBA web pages received 12,936,729 hits and PMEL's data delivery pages served 6,453,672 data files via user requests on the GTMBA website and via File Transfer Protocol (FTP). These data were cited in over 100 publications during this period.

**ENVIRONMENTAL DATA SCIENCE**

The Geographic Information Network of Alaska (UAF GINA) project in partnership with NOAA NESDIS Joint Polar Satellite System Program (JPSS) provides low-latency, polar-orbiting satellite products to Alaskan and Arctic stakeholders. The effort impacts NOAA’s weather-ready nation by providing forecasters, hazard managers, and researchers with information to prepare for weather, water, volcano, and wildland fire events (see story on page 46). Deep Learning Applications for Fish Ageing is developing an artificial intelligence system to age fish otoliths from walleye pollock and red snapper. The system has been shown to be up to 10 times faster than traditional techniques with equivalent accuracy on fish less than 10 years old.

**AQUACULTURE SCIENCE**

A research oyster hatchery is being developed to identify cost efficiency rearing strategies to produce seed for the industry, and to breed oyster strains optimized for growth in Alaska. This facility should contribute to the commercialization of locally sourced oyster mariculture in Alaska (see story on page 44). Genomic and bioinformatic approaches contribute to applications that support sustainable aquaculture, increase understanding of ocean acidification on marine fish and shellfish, and contribute bioinformatic capacity, tools and workflows for research related to aquaculture, genomics and climate change. Development of morpholino bath immersions for mass sterilization with sablefish can be translated to other marine finfish aquaculture species.

**HUMAN DIMENSIONS IN MARINE SYSTEMS**

No projects were explicitly funded under the Human Dimensions theme in 2022/2023.

**POLAR STUDIES**

The U.S. Interagency Program for Antarctic Buoys (US-IPAB) and U.S. Interagency Arctic Buoy Program (US-IABP) maintain observing networks of a network of *in situ* observations of ice/ocean motion, surface meteorology, and oceanography. Over 88 peer reviewed papers have been published using data produced by the USIABP/IABP since 2022. Collection of Arctic empirical data improved evaluation of CMIP6 atmospheric, sea-ice, and Arctic Ocean condition predictions and was used to formulate the 2022 Arctic Report Card, which highlights increasing risk to marine and terrestrial ecosystems.
OUR FAVORITE NEW TOOLS

By Ivonne Ortiz, with contributions from Tim Bates, Calvin Mordy, Heather Tabisola, Burlyn Birkemeier, Molly McCormley, Carey Kuhn, & Thomas Van Pelt

YOUNG AND OLD, we all have our favorite tools. CICOES scientists are no different; in fact, specialized research tools are fundamentally important to our work. So, from high up in the air to hundreds of meters below the ocean surface, here we showcase a few of the tools that CICOES researchers use to better understand the planet.

These fascinating tools are the result of extensive collaborations between CICOES, NOAA’s Pacific Marine Environmental Laboratory (PMEL), the NOAA Marine Mammal Laboratory, and numerous other partners. Together these teams work to develop and transition platforms, sensors, and protocols into operation (a finished new product) for routine data collection. It takes several years to modify a sensor while assuring it continues to work accurately and can operate for longer time periods. Likewise, it takes years to develop protocols to design the best combination of technologies and information obtainable during surveys or the operational lifetime of deployed systems. CICOES actively participates in the development and deployment of new platforms, sensors, and routines for processing the resulting data.

Flying among the clouds as high as 11,000 feet is the FVR-90, a fixed-wing uncrewed aircraft that employs vertical take-off and landing. The FVR-90 can sample the atmosphere at cruise speeds of 50 knots and can remain aloft for up to eight hours. It has been used nationwide for reconnaissance, firefighting, and emergency operations, but at CICOES the FVR-90 is used to study environmental chemistry, specifically aerosols, in an effort led by Tim Bates (CICOES) and Patricia Quinn (PMEL).

Aerosols are more familiar and important than you might think; they include fine particles such as sea spray (produced by waves...
breaking at the ocean surface), dust from sandstorms, combustion from wildfires, volcanic ash, or even sulfate aerosol from phytoplankton. The data collected by the FVR-90 are used to characterize the chemical, physical, optical, and cloud properties of marine boundary layer aerosols, and to identify the processes controlling these properties. These measurements are needed to improve climate models and better understand aerosol-cloud interactions, a critical component of the Earth’s energy budget. This development was a collaboration between CICOES, PMEL, NOAA’s Uncrewed Systems (UxS) Office, and Overwatch Aero, a private-sector provider of aerial data acquisition.

Innovative Technology for Arctic Exploration (ITAE) is a joint program at CICOES (Calvin Mordy, Heather Tabisola) and PMEL (Scott Stalin) that focuses on development of high-risk, high-reward platforms and sensors that can be transitioned into operations. An early transition from ITAE contributions was the saildrone, which is now in wide operation from pole-to-pole. During development, ITAE deployed fleets of saildrones across the eastern Bering and Chukchi seas, where these platforms carried meteorological, oceanographic, and biological sensors over several years. It is truly an interdisciplinary platform with meteorological, ocean, and biological sensors. Applications include ecosystem monitoring, measuring ocean currents, conducting fish surveys, tracking tagged animals (e.g., marine mammals, king crab), and measuring air-sea fluxes of heat, ocean current momentum, and marine CO₂.

ITAE tools deployed last year include the underwater Oculus glider which rolled, pitched, and yawed its way across 250 miles of the Bering and Chukchi seas. They also deployed 20 next generation “pop-up floats” that descended to the seafloor for months of continuous data recording until they float to the surface at a preprogrammed time, sending data back to shore via satellite. These projects were completed through a partnership with Phyllis Stabeno (PMEL). ITAE is also working with partners to develop imaging systems with Artificial Intelligence (AI) classification of phytoplankton, zooplankton, and fish. A microscopic imaging system was deployed in the Chukchi Sea for detection of phytoplankton associated with harmful algal blooms. This was completed through a partnership between ITAE, Don Anderson at Woods Hole Oceanographic Institution, and Jeanette Gann at NOAA’s Auke Bay Laboratory. An underwater microscope tuned for zooplankton was deployed on multiple cruises in the Bering and Chukchi seas. This device (the Continuous Particle Imaging and Classification System or CPICS) collected images of zooplankton, which are being used to fine-tune the sensor and develop strategies for reducing interference from the high particulate load in the samples so that AI deep learning algorithms can successfully classify the zooplankton images. This work is being led by David Kimmel (PMEL) and Deana Crouser (Lynker).

Developing and making these tools operational is full of challenges. For example, while working in the shallow waters of the northern Bering Sea, the Oculus glider was overcome by strong northward currents that were driv-
en by 30-knot winds. Instead of fighting the currents, the large team of scientists that were conducting the mission decided to ride the currents and send the glider through Bering Strait. This would be the first attempt to send an underwater glider through this narrow strait that separates the Bering and Chukchi seas. Upon this successful transit, the glider was recovered by the US Coast Guard Cutter Healy. The glider mission relied on numerous pilots, technicians, and scientists including CICOES personnel Stephanie Grassia, Noel Pelland, Heather Tabisola, Calvin Mordy, and NOAA personnel Phyllis Stabeno, Shaun Bell, Sarah Duncan, Iris Ekmanis, and Cabot Zucker, as well as PMEL engineers Nick Delich, Dirk Tagawa, and Scott Stalin. Alaska waters are never boring!

Other teams at CICOES are certified and trained to operate aerial platforms to survey marine mammals. Quadcopters and hexacopters (that look sort of like flying tarantulas) with high resolution imagery payloads are routinely used to complement boat and air-surveys to monitor the endangered Steller sea lions in the remote Aleutian Islands. In any given year, over 200,000 images are collected. But the Aleutian Islands, with high cliffs, rough terrain, and high winds, can be a challenging place to fly drones, especially when the weather can turn in an instant. Pilots must be skilled at assessing weather and risks and be willing to abort the mission when necessary, even in mid-flight. Trying to catch a returning hexacopter in 25 mph winds is no easy feat! And not to be overlooked, pilots must endure challenges to even make it to their flight areas to begin with, having to navigate choppy waves in small boats and then climbing up slippery wet rocks with heavy gear. Sampling will always be a challenging and exciting adventure. In the words of Dr. Seuss: Oh, the places you’ll go!

Below: Saildrone Arctic fleet ready to deploy in Dutch Harbor, Alaska. Photo: Saildrone
At OBO’s request, CICOES senior scientist Dr. Yong Wei has been leading major modeling efforts to assess potential tsunami hazards at selected DoS diplomatic posts and their vicinity coastlines. This multi-year (2020-2030) project aims at developing Tsunami Design Zone maps for DoS posts in compliance with the American Society of Civil Engineers (ASCE) 7 provisions, a national building design standard addressing tsunami loads and effects on structures. For each post, Dr. Wei and his colleagues at the NOAA Center for Tsunami Research employ state-of-the-art tsunami models and best available Digital Elevation Models to simulate inundation impacts resulting from earthquakes and tsunamis consistent with hazards that have a recurrence time of 2,500 years.

The Department of State has more than 25,000 properties spread across nearly 300 posts. Many of these properties are in areas of potential tsunami exposure.

To tackle inundation hazards caused by climate change, the model simulations include the influence of 50-year projections of local sea level change, a quantity that takes into account the combined effect of sea level rise, vertical land movement, gravity, and local sea...
level variation due to ocean density and circulation change. With horizontal grid spacing of ~10 m, the model simulations produce key inundation parameters that represent tsunami height, flooding extent, current speed, and wave loading on structures over the modeled coasts.

OBO staff and engineers primarily use these parameters to assess tsunami loads and effects for building design at selected DoS posts. Some of these maps are also beneficial to local coastal communities for tsunami hazard preparedness. As a follow-up to the inundation mapping, DoS has allocated additional funding for Dr. Wei and his collaborators at Oregon State University to establish tsunami evacuation maps that can be used for emergency response by DoS staff.

So far, CICOES has completed Tsunami Design Zone maps for nine overseas DoS posts exposed to potential tsunami hazards, in the Pacific, Indian, and Atlantic oceans, and in the Caribbean and Salish seas. Figure 1 shows an example of an aggregated Tsunami Design Zone map along the coastline of Dili, Timor-Leste, resulting from 2,500-year earthquake scenarios from the Flores-Wetar Fault and the Java Trench, simulated with a 50-year projection of local sea level change.

In the past decade, the CICOES tsunami group, led by Dr. Wei, has been actively engaging in the development of ASCE tsunami provisions and several associated Tsunami Design Zone mapping projects for U.S. Navy overseas facilities, Oregon State University, and the State of Hawaii. The DoS modeling study is an excellent example of CICOES scientists collaborating with federal agencies to address coastal hazard mitigation and resilience in the context of climate change.
BEYOND THE BLOB:
PINPOINTING THE MECHANISMS OF PACIFIC COD POPULATION DECLINE

By CICOES staff

THE NORTHEASTERN PACIFIC EXPERIENCED multiple years of unprecedented marine heatwaves in recent years. “The Blob,” a mass of warm water that persisted from 2014-2016, increased sea surface temperatures by up to 7°C, and another heat wave occurred in 2019. Among the many ecological changes that coincided with The Blob was a catastrophic decline in Pacific cod populations in the Gulf of Alaska, reducing abundances by over 71% between the 2015 and 2017 surveys.

Pacific cod have historically supported the second largest groundfish fishery in Alaska, bringing in over $100 million annually in recent years. But marine heat waves, in addition to the more gradual ocean warming, have the potential to dramatically alter both the ecological and the economic landscape.

Researchers with CICOES, UW School of Aquatic and Fishery Sciences (SAFS), Oregon State University (OSU), and NOAA are partnering to understand how warming temperatures affect Pacific cod and whether they have the capacity to withstand increased temperature stressors. Early life stages of Pacific cod — developing eggs, larvae, and juveniles — are thought to be vulnerable to temperature changes and to have contributed to the population crash due to lower recruitment rates.

NOAA biologists Ben Laurel, Louise Cope-man, and Tom Hurst, together with OSU postdoc Emily Slesinger, are leading a series of experiments at the Hatfield Marine Science Center in Newport, OR, to test these early life stages in varying temperatures and monitor their performance. The researchers are finding that the highest temperatures result in the lowest survival rates in larval Pacific cod.

Precisely how the elevated temperature causes these damaging changes is a major research question as is the longer-term potential for early life stages of Pacific cod to adapt to changing climate conditions.

The experimental work at the Hatfield station suggests that while warming causes early-stage Pacific cod to develop and grow faster, it also reduces their liver size and al-

Right: Ben Laurel (NOAA AFSC, lifting the lid) and Steven Roberts (UW SAFS) inspect experimental Pacific cod that were exposed to varying temperatures. Photo: Laura Spencer

Above: Pacific cod juveniles being collected off Kodiak, AK, for experimental work and monitoring purposes. Photo: Ben Laurel
“Ultimately, these studies aim to pinpoint the mechanisms of mortality to explain the Pacific cod population crashes following marine heat waves.”

Laura Spencer is working with NOAA biologist Ingrid Spies and SAFS Professor Steven Roberts to measure gene expression in larval fish from those laboratory experiments.

“We have found that many lipid metabolism processes are altered by high temperature during larval rearing,” says Laura Spencer, “which could indicate that warming reduces energy availability, already a limited resource during the larval stage. On top of that, we see more active immune-related genes, possibly reflecting harmful inflammation or higher levels of pathogens. Warming seems to be a ‘one-two punch’ to larval Pacific cod.”

Research is ongoing and includes more gene expression studies in juvenile fish. This is being paired with other ‘omics approaches (e.g. whole-genome sequencing) to look for potential genetic variation associated with warming tolerance.

“If mechanisms are more clearly understood, it may be possible to identify populations or individuals that are genetically and physiologically predisposed to fare better under warmer conditions. Understanding the physiological responses to climate change will help inform fishery management on the level of risk associated with climate-driven warming.”

This research was made possible by CICOES, the NOAA Ocean Acidification program, and the Pacific States Marine Fisheries Commission.

Below: Age-1 Pacific cod juveniles in experimental systems at the Hatfield Marine Science Center in Newport, OR. Photo: Ben Laurel

Above: Age-0 Pacific cod juveniles being enumerated and measured from annual beach seine surveys conducted by NOAA Alaska Fisheries Science Center in Kodiak, AK. Photo: Ben Laurel
WARMING OCEANS HAVE DECIMATED MARINE PARASITES — BUT THAT’S NOT A GOOD THING

By Hannah Hickey, UW News

MORE THAN A CENTURY of preserved fish specimens offer a rare glimpse into long-term trends in parasite populations. New research from the University of Washington shows that fish parasites plummeted from 1880 to 2019, a 140-year stretch when Puget Sound — their habitat and the second largest estuary in the mainland U.S. — warmed significantly.

The study, published the week of January 9, 2023, in the Proceedings of the National Academy of Sciences, is the world’s largest and longest dataset of wildlife parasite abundance. It suggests that parasites may be especially vulnerable to a changing climate.

“People generally think that climate change will cause parasites to thrive, that we will see an increase in parasite outbreaks as the world warms,” said lead author Chelsea Wood, a UW associate professor of aquatic and fishery sciences. “For some parasite species that may be true, but parasites depend on hosts, and that makes them particularly vulnerable in a changing world where the fate of hosts is being reshuffled.”

While some parasites have a single host species, many parasites travel between host species. Eggs are carried in one host species, the larvae emerge and infect another host and the adult may reach maturity in a third host before laying eggs.

For parasites that rely on three or more host species during their lifecycle — including more than half the parasite species identified in the study’s Puget Sound fish — analysis of historic fish specimens showed an 11% average decline per decade in abundance. Of 10 parasite species that had disappeared completely by 1980, nine relied on three or more hosts.

“Our results show that parasites with one or two host species stayed pretty steady, but parasites with three or more hosts crashed,” Wood said. “The degree of decline was severe. It would trigger conservation action if it occurred in the types of species that people care about, like mammals or birds.”

And while parasites inspire fear or disgust — especially for people who associate them with illness in themselves, their kids or their pets — the result is worrying news for ecosystems, Wood said.

“Parasite ecology is really in its infancy, but what we do know is that these complex-lifecycle parasites probably play an important role in pushing energy through food webs and in supporting top apex predators,” Wood said. She is one of the authors of a 2020 report laying out a conservation plan for parasites.

Wood’s study is among the first to use a new method for resurrecting information on parasite populations of the past. Mammals and birds are preserved with taxidermy, which retains parasites only on skin, feathers or fur. But fish, reptile and amphibian specimens are preserved in fluid, which also preserves any parasites living inside the animal at the time of its death.

“The degree of decline was severe. It would trigger conservation action if it occurred in the types of species that people care about, like mammals or birds.”

Left: These monogenean worms (Microcotyle sebastis) were dissected from the gills of a preserved copper rockfish specimen from the UW Fish Collection at the Burke Museum. Photo: Katherine Maslenikov, UW Burke Museum
The study focused on eight species of fish that are common in the behind-the-scenes collections of natural history museums. Most came from the UW Fish Collection at the Burke Museum of Natural History and Culture. The authors carefully sliced into the preserved fish specimens and then identified and counted the parasites they discovered inside before returning the specimens to the museums.

"It took a long time. It’s certainly not for the faint of heart," Wood said. "I’d love to stick these fish in a blender and use a genomic technique to detect their parasites’ DNA, but the fish were first preserved with a fluid that shreds DNA. So what we did was just regular old shoe-leather parasitology."

Among the multi-celled parasites they found were arthropods, or animals with an exoskeleton, including crustaceans, as well as what Wood describes as "unbelievably gorgeous tapeworms:" the Trypanorhyncha, whose heads are armed with hook-covered tentacles. In total, the team counted 17,259 parasites, of 85 types, from 699 fish specimens.

To explain the parasite declines, the authors considered three possible causes: how abundant the host species was in Puget Sound; pollution levels; and temperature at the ocean’s surface. The variable that best explained the decline in parasites was sea surface temperature, which rose by 1 degree Celsius (1.8 degrees Fahrenheit) in Puget Sound from 1950 to 2019.

"This study demonstrates that major parasite declines have happened in Puget Sound. If this can happen unnoticed in an ecosystem as well studied as this one, where else might it be happening?"

A parasite that requires multiple hosts is like a delicate Rube Goldberg machine, Wood said. The complex series of steps they face to complete their lifecycle makes them vulnerable to disruption at any point along the way.

"This study demonstrates that major parasite declines have happened in Puget Sound. If this can happen unnoticed in an ecosystem as well studied as this one, where else might it be happening?" Wood said. "I hope our work inspires other ecologists to think about their own focal ecosystems, identify the right museum specimens, and see whether these trends are unique to Puget Sound, or something that is occurring in other places as well.

“Our result draws attention to the fact that parasitic species might be in real danger,” Wood added. “And that could mean bad stuff for us — not just fewer worms, but less of the parasite-driven ecosystem services that we’ve come to depend on.”

The research was funded by CICOES, the National Science Foundation, the Alfred P. Sloan Foundation, the University of Washington, and the Washington Research Foundation.
WHAT IS A STRONG EL NIÑO?

METEOROLOGISTS ANTICIPATE A BIG IMPACT IN WINTER 2023, BUT FORECASTS DON’T ALL AGREE

In October 2023, winter is still weeks away but meteorologists are already talking about a snowy winter ahead in the southern Rockies and the Sierra Nevada. They anticipate more storms in the U.S. South and Northeast, and warmer, drier conditions across the already dry Pacific Northwest and the upper Midwest. One phrase comes up repeatedly with these projections: a strong El Niño is coming. It sounds ominous, but what does that actually mean?

By Aaron Levine (CICOES) for The Conversation

WHAT IS A STRONG EL NIÑO? During a normal year, the warmest sea surface temperatures are in the western Pacific and the Indian Ocean, in what’s known as the Indo-Western Pacific warm pool. But every few years, the trade winds that blow from east to west weaken, allowing that warm water to slosh eastward and pile up along the equator. The warm water causes the air above it to warm and rise, fueling precipitation in the central Pacific and shifting atmospheric circulation patterns across the basin. This pattern is known as El Niño, and it can affect weather around the world.

A strong El Niño, in the most basic definition, occurs once the average sea surface temperature in the equatorial Pacific is at least 1.5 degrees Celsius (2.7°F) warmer than normal. It’s measured in an imaginary box along the equator, roughly south of Hawaii, known as the Niño 3.4 Index.

But El Niño is a coupled ocean-atmosphere phenomenon, and the atmosphere also plays a crucial role.

What has been surprising about this year’s El Niño — and still is — is that the atmosphere hasn’t responded as much as we would have expected based on the rising sea surface temperatures.

IS THAT WHY EL NIÑO DIDN’T AFFECT THE 2023 HURRICANE SEASON THE WAY FORECASTS EXPECTED?

The 2023 Atlantic hurricane season is a good example. Forecasters often use El Niño as a predictor of wind shear, which can tear apart Atlantic hurricanes. But with the atmosphere not responding to the warmer water right away, the impact on Atlantic hurricanes was lessened and it turned out to be a busy season.

The atmosphere is what transmits El Niño’s impact. Heat from the warm ocean water causes the air above it to warm and rise, which fuels precipitation. That air sinks again over cooler water.

The rising and sinking creates giant loops in the atmosphere called the Walker Circulation. When the warm pool’s water shifts eastward, that also shifts where the rising and sinking motions happen. The atmosphere reacts to this change like ripples in a pond when you throw a stone in. These ripples affect the jet stream, which steers weather patterns in the U.S.

This year, in comparison with other large El Niño events — such as 1982-83, 1997-98 and 2015-16 — we’re not seeing the same change.

Above: The box shows the Niño 3.4 region as an El Niño pattern develops in the tropical Pacific in 2023. Image: NOAA Climate.gov

NOAA’s Climate Prediction Center, in its October 12, 2023, update, described a high chance of a strong El Niño developing during the winter. While that doesn’t always translate to local conditions, California’s mountains could be in for another wet winter. Photo: Mario Tama/Getty Images
Above: The jet stream takes a very different path in a typical El Niño vs. La Niña winter weather pattern. But these patterns have a great deal of variability. Not every El Niño or La Niña year is the same. Image: NOAA Climate.gov

in where the precipitation is happening. It’s taking much longer to develop, and it’s not as strong.

Part of that, presumably, is related to the whole tropics being very, very warm. But this is still an emerging field of research.

How El Niño will change with global warming is a big and open question. El Niño only happens every few years, and there’s a fair amount of variability between events, so just getting a baseline is tough.

WHAT DOES A STRONG EL NIÑO TYPICALLY MEAN FOR US WEATHER?

During a typical El Niño winter, the U.S. South and Southwest are cooler and wetter, and the Northwest is warmer and drier. The upper Midwest tends to be drier, while the Northeast tends to be a little wetter.

The likelihood and the intensity generally scale with the strength of the El Niño event.

El Niño has traditionally been good for the mountain snowpack in California, on which the state relies for a large percentage of its water. But it is often not so good for the Pacific Northwest snowpack.

The jet stream plays a role in that shift. When the polar jet stream is either displaced very far northward or southward, storms that would normally move through Washington or British Columbia are steered to California and Oregon instead.

WHAT DO THE FORECASTS SHOW FOR 2023?

Whether forecasters think a strong El Niño will develop depends on whose forecast model they trust.

This past spring, the dynamical forecast models were already very confident about the potential for a strong El Niño developing. These are big models that solve basic physics equations, starting with current oceanic and atmospheric conditions.

However, statistical models, which use statistical predictors of El Niño calculated from historical observations, were less certain.

Even in the most recent forecast model outlook, the dynamical forecast models were predicting a stronger El Niño than the statistical models were.

If you go by just a sea surface temperature-based El Niño index, the forecast is for a fairly strong El Niño.

But the indices that incorporate the atmosphere are not responding in the same way. We’ve seen atmospheric anomalies — as measured by cloud height monitored by satellites or sea-level pressure at monitoring stations — on and off in the Pacific since May and June, but not in a very robust fashion. Even in September, they were nowhere near as large as they were in 1982, in terms of overall magnitude.

We’ll see if the atmosphere catches up by wintertime, when El Niño peaks.

HOW LONG DO EL NIÑOS LAST?

Often during El Niño events — particularly strong El Niño events — the sea surface temperature anomalies collapse really quickly during the Northern Hemisphere spring. Almost all end in April or May.

One reason is that El Niño sows the seeds of its own demise. When El Niño happens, it uses up that warm water and the warm water volume shrinks. Eventually, it has eroded its fuel.

The surface can stay warm for a while, but once the heat from the subsurface is gone and the trade winds return, the El Niño event collapses. At the end of past El Niño events, the sea surface anomaly dropped very fast and we saw conditions typically switch to La Niña, El Niño’s cooler opposite.

What has been surprising about this year’s El Niño is that the atmosphere hasn’t responded as much as we would have expected based on the rising sea surface temperatures.
FASTER TURNAROUND TIMES SHED LIGHT ON SALMON BYCATCH DYNAMICS IN ALASKA

A major effort to modernize genetic analysis workflow shows a clearer picture of salmon bycatch that can help managers ensure sustainable fish populations, fisheries, and fishing communities.

By Stori Oates (IBSS Contractor in support of NOAA AFSC), Thomas Van Pelt (CICOES), Patrick Berry (AFSC), & Wes Larson (AFSC)

THERE’S CONCERN that salmon being caught unintentionally may be contributing to a decline in Chinook and chum salmon runs, especially in western Alaska. As one component of a broad set of responses to this issue, NOAA Fisheries has identified a new way to deliver more timely genetic information that can help resource managers and fishermen reduce salmon bycatch in commercial fisheries.

UNDERSTANDING THE ISSUE

Fishermen off the coast of Alaska sometimes catch fish they don’t want, can’t sell, or are not allowed to keep. These unwanted fish are collectively known as bycatch.

In Alaska, the North Pacific Fishery Management Council and NOAA Fisheries have adopted measures to limit the bycatch of species taken incidentally in groundfish fisheries. Certain species, such as chum and Chinook salmon, are designated as “prohibited species” in management plans because they are important species to other fishing sectors, including traditional and customary fisheries.

The incidental catch of salmon is closely monitored to ensure that all salmon are counted, and representative samples are analyzed using genetic tools to estimate the geographic origins (or ‘stock’) of fish caught as bycatch. Until recently, the genetic analyses have been slow and therefore limited in their utility, so scientists at the Alaska Fisheries Science Center (AFSC) Genetics program have been working hard to deliver more comprehensive information faster, so that it can be more efficiently integrated into the management process. Now, within just one year, scientists can share results and integrate the information into bycatch avoidance strategies.

Because salmon ecology, and therefore management, is very watershed-specific, managers need to understand the watershed or stock-specific origins of the bycatch in order to understand the relative impact on salmon runs within the North Pacific. For example, if a fishery takes a certain number of Chinook salmon as bycatch, the impact of that bycatch might be moderate if the fish were spread evenly among all of the source watersheds in Alaska, whereas the impact might be increasingly serious if the fish came from a...
In studying salmon bycatch, scientists hope to:

- Determine the geographic origin of salmon caught in federally managed groundfish fisheries and collected by NOAA Fisheries observers to estimate stock-specific impacts of bycatch.
- Determine the number of adult Chinook salmon that would have returned to their natal (birth) rivers if not caught as bycatch.
- Merge stock identification with other data to predict stock-specific distributions and potentially help fishing fleets avoid certain stocks.

**ADVANCEMENTS IN GENETIC STOCK IDENTIFICATION**

Each year, genetic stock identification of the salmon bycatch from commercial trawl fisheries in the Bering Sea and Gulf of Alaska is done to determine which salmon stocks are most affected by the fisheries. Stock composition reports are completed annually for both regions.

Scientists use genetic information from chum and Chinook salmon bycatch in the pollock trawl fisheries to estimate the number and proportion of these salmon being caught.

Since 2002, NOAA Fisheries geneticists have worked with the Alaska Fisheries Information Network (AKFIN) to develop comprehensive databases for chum and Chinook salmon. These databases link information collected by on-board fisheries observers with genetic and age data.

Scientists have integrated new Genotyping-in-Thousands (GTseq) chemistry into the laboratory workflow. This method simultaneously generates genotypes — the genetic makeup of an organism — for thousands of individuals, subsequently increasing the statistical power available to distinguish salmon sub-populations or stocks. As a result, scientists have been able to decrease turnaround time. They have also piloted the collection of dried DNA by fisheries observers for more efficient sampling and higher sample quality.

Additionally, Patrick Barry, a NOAA post-doc who receives funding through CICOS, developed tools and software to process data, conduct additional analysis, and streamline reports more quickly.

These advancements have allowed the genetics laboratory to deliver data much faster. For example, the lag time between bycatch occurrence and reporting of data was decreased by nearly a year for chum salmon in 2022, and these advancements are now available for Chinook salmon starting in 2023.

With these advancements, resource managers and industry personnel have information from the most recent year when starting to fish. This should facilitate more effective stock-specific avoidance strategies. The stock-specific impacts of bycatch also can be estimated more quickly which is important for informing management of different stock groupings.

**WHAT’S NEXT?**

Preventing and reducing bycatch is a shared goal of fisheries managers, fishermen, the environmental community, and subsistence users. AFSC is involved in several research efforts to learn more both about bycatch impacts and about ways to reduce bycatch.

NOAA has reduced turnaround time for chum and Chinook estimates by nearly a year. NOAA is also collaborating with the commercial fishing industry to identify new ways of fishing and to explore fishing gear modifications and new technologies to minimize bycatch in commercial trawl fisheries.

Additionally, the Genetics Program is working with state agencies, industry, and university partners such as CICOES to develop stock-specific distribution models. The goal of these models is to help predict where important stocks, such as Western Alaska, are found. This will help fishermen to avoid these stocks. This group effort integrates data from a large number of sources including genetics, fleet fishing patterns, environmental variables, and surveys. These models will continue to be developed and integrated into bycatch management over the next few years.
The Gulf of Alaska Ocean Acidification surface buoy, known as GAKOA, has been monitoring surface seawater carbon dioxide (CO₂) since 2013, aiming to detect change in seawater CO₂. But behind that simple sentence, there’s a long and ongoing story of challenging fieldwork.

In the beginning — 2011 — we did a trial run to test the equipment. At that time, the moored autonomous system, measuring the partial pressure of carbon dioxide (or pCO₂), hadn’t previously been deployed at a high-latitude site with freezing conditions, and we ran into a lot of technical problems. The first two years were tough! Luckily, we had a group of people at University of Alaska Fairbanks (UAF), University of Washington, and the NOAA Pacific Marine Environmental Laboratory (PMEL) that were committed to working through the engineering and design issues.

“Working through the issues” sounds nice and tidy, but in the fieldwork reality, fixing technical problems on moored systems can get pretty wild. For example, in those first two years, there were lots of what we call ‘buoy rides’. This is when we have to physically get on the floating buoy to fix or replace parts that aren’t working properly. We do this because it is too expensive to charter a ship and recover the whole mooring each time something goes wrong. “Recover” is a term we use to summarize the complicated and laborious process of bringing an entire mooring onto the deck of a ship, including the big surface float, a string of vulnerable and expensive instruments, communication cables, chain, and a very heavy anchor.

A buoy ride is much less expensive than a full-blown mooring recovery, in terms of ship and personnel time, but riding a buoy requires some fortitude, a strong grip, and reasonably calm weather conditions. This isn’t always easy in the stormy northern Gulf
of Alaska, where some say the “Pacific breaks its back.”

In 2013 we moved GAKOA from an exposed location at the mouth of Resurrection Bay near Quetckak (Seward), AK, to a more sheltered location in Sunny Cove. We had great success with the modifications we made to the equipment, and we could get reliable data year-round. This started a new trend: no more buoy rides! Or so I thought...

GAKOA and our science team had relatively smooth progress for most of a decade, but in May 2023, we hit a major snag. One critical piece of instrumentation on GAKOA failed.

We always deploy the MAPCO₂™ sensor with a “reference gas” to ensure that we have the most accurate data. Our goal is to detect the anthropogenic trend of carbon dioxide in seawater; for that, our uncertainty needs to be less than 1 μatm, or less than one one-millionth of an atmosphere (‘atmosphere’ here being a standard unit approximately equal to average atmospheric pressure at sea level). We achieve this by calibrating each measurement with the reference gas.

But in the spring of 2023, there must have been a small leak in our fittings. I had turned the buoy around (mooring-speak for a seasonal maintenance and data-download visit to the buoy) at the end of February. It was May when Sylvia Musielewicz texted me, “GAKOA’s out of gas”. The real time data transmissions are received at PMEL and Sylvia is usually the first to see any issues. Being out of reference gas means that the data GAKOA was collecting would be unusable.

At the time Sylvia told me we were no longer collecting quality data at GAKOA, I was aboard the NOAA Ship Oscar Dyson, deploying the same pCO₂ sensor on the long-term EcoFOCI mooring site in the southeastern Bering Sea (M2). So, I immediately started making plans to return to Seward after I got back from Unalaska. A buoy ride in the Bering Sea or Gulf of Alaska, no thanks... but a buoy ride in Sunny Cove, that’s doable on a nice day!

UAF’s Seward Marine Center runs the small but very capable RV Nanuq (‘polar bear’ in Iñupiaq language, and the UAF mascot!). Once I got to Seward, it was just a matter of waiting for the right weather conditions, and then we headed for GAKOA. I replaced the reference gas and quadruple-checked the fittings, like usual, for leaks. No leaks... we headed back to harbor. Another successful buoy ride in the books! They sure make for fun stories after the fact, but a buoy ride always means something went wrong, and hopefully I won’t have to do one for another ten years! ♦

A ‘buoy ride’ is when we have to physically get on the floating buoy to fix or replace parts that aren’t working properly.
CICOES ORGANIZATION AND INITIATIVES

The Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES) was originally established as the Joint Institute for the Study of the Atmosphere and Ocean in 1977 to foster collaborative research between the National Oceanic and Atmospheric Administration (NOAA) and the University of Washington (UW). In 2020, this unique collaboration expanded to include academic partners at the University of Alaska Fairbanks (UAF) and the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University (OSU), and the Institute name changed to reflect the broadening mission and partnership. Among the oldest and largest of NOAA’s nationwide system of Cooperative Institutes, CICOES research is at the forefront of important and impactful investigations on climate, ocean, and ecosystem science.

CICOES scientists work internationally with academic scientists, research institutions, government agencies, NGOs, and local community organizations to advance scientific knowledge about the planet’s climate, oceans, and ecosystems. Through collaborative efforts, the integrated team of CICOES researchers and affiliates strengthen and extend their areas of research and expertise in the service of regional, national and global community interests.

RESEARCH

CICOES and NOAA researchers represent a broad range of expertise within nine core themes (see pages 13-14 for highlights within each theme). Investigators focus research on critical issues, including:

• Collecting and analyzing data to better understand physical, biological, and chemical processes of ocean and coastal areas.
• Increasing our knowledge of climate variability, change, and impacts on ecosystems.
• Studying hydrothermal vents and volcanoes on the seafloor.

CICOES ORGANIZATION AND INITIATIVES

$25,089,039

TOTAL FUNDING

Ci-funded projects (Task I, II, & III) from July 2022 - June 2023

• Studying effects of interactions between human communities and natural ecosystems.
• Developing tools and technologies to restore and protect marine habitats.
• Improving tsunami forecasting and prediction of impacts.
• And much more: cicoes.uw.edu/research/

FUNDING

CICOES research and administration is funded through five tasks:

**TASK I** is the Institute’s “core” program. It funds the administration of CICOES and our internal Initiatives including the:

• Summer internship program (funded in part by NSF)
• Postdoctoral scholar program
• Graduate student fellowships
• Research development grants
• Professional development program
• Diversity, equity, and inclusion program
• Visiting scientist program

**TASK II** provides funding for research scientists, postdoctoral scholars, and technical staff who work at the local NOAA laboratories in directed, collaborative research efforts between NOAA and university scientists.

**TASK III** supports research related to CICOES’ themes on the UW, OSU or UAF campuses and includes a broad range of departments. Principal Investigators include university academic and research faculty, as well as research scientists.
TASK IV represents externally-funded projects including all sponsored research funding that is not part of the NOAA Cooperative Agreement (e.g., grants from the National Science Foundation or the North Pacific Research Board).

TASK V is our newest task; it includes NOAA funding under the three federal initiatives listed below. $1,825,475 was received in 2023.
- Inflation Reduction Act
- Bipartisan Infrastructure Law
- Disaster Relief Supplemental Act

INITIATIVES

CICOES uses Task I funding to support seven internal Initiative programs:

SUMMER INTERNSHIP PROGRAM

Now expanded with funding from a new NSF REU grant, the CICOES internship program offers nine-week research opportunities for 14 undergraduate students. Interns are matched with a research project and work with a CICOES, NOAA, or University of Washington mentor at either the UW campus or the NOAA Western Regional Center in Seattle. See page 36 to read about Leila Fischer’s experience. The 2023 cohort includes:
- Phillip Telgen – Whitman College
- Leila Fischer – Willamette University
- Karla Jimenez – Florida International University
- Marc Sailer – University of Washington
- Benny Adler – Bowdoin College
- Adelina Rodriguez – Wesleyan University
- Nick Burgos – University of California Los Angeles
- Krista Matuska – University of Washington
- Lashaun Jackson – University of Michigan
- Katie Jackson – University of South Carolina
- Lily Wu – Texas A&M University
- Sophia Wagner – Haverford College
- Stephanie Procopio – Louisiana State University
- Anna Gruchala – University of Alabama

POSTDOCTORAL SCHOLARS PROGRAM

Since 1977, CICOES has committed a significant share of its initiative budget to support three 2-year postdoctoral research scholars. The program has been highly successful; postdocs are provided the opportunity to conduct their own research project, think broadly, and to work with the distinguished scientists at UW, UAF, OSU, and the NOAA laboratories. Current participants in the postdoctoral scholars program include:
- Veronica Farrugia Drakard (UAF)
- Hannah Joy-Warren (UW)
- Jannes Koelling (UW)
- Xinyu Li (UW)
- Sam May (UAF)
- Alexandra McInturf (OSU)
- Hauke Schulz (UW)
- Yang Xiang (UW)

CICOES spent more than $600K of its Task I funding on internal Initiatives in 2023.

- Postdoctoral Scholars: $375,124
- Graduate Student Fellowships: $43,000
- Research Development Grants: $96,454
- Professional Development Program: $8,300
- Diversity, Equity, and Inclusion: $2,300
- Summer Intern Program: $129,897

Above: The 2023 CICOES REU students visit Mount Rainier National Park. Photo: Jed Thompson
DIVERSITY, EQUITY, AND INCLUSION

While Diversity, Equity, and Inclusion (DEI) have always been important components of research and outreach efforts at CICOES, a group of employees came together in July 2019 to form the first official DEI working group at CICOES. Since then, CICOES has allocated $20K per year to support DEI working group activities. The group has planned and executed numerous DEI programs that help educate employees, decrease bias in HR processes, and build community within CICOES.

VISITING SCIENTIST PROGRAM

The Visiting Scientist Program, funded at approximately $25K per year, promotes scientific exchanges that strengthen existing collaborations, promote new collaborations, and/or offer opportunities for educating staff on new ideas. Visitors interact with CICOES scientists as well as with scientists in other units of the UW College of the Environment and/or NOAA research facilities, and they present at least one public seminar on their research interests.

GRADUATE STUDENT FELLOWSHIPS

The graduate student award program was initiated in 2019. The program awards up to 8 student quarters per year to support graduate work conducted in association with CICOES and NOAA research scientists as well as UW faculty in CICOES-affiliated departments.

RESEARCH DEVELOPMENT GRANTS

Since 2015, CICOES has allocated an average of $120K per year to stimulate new, innovative research. See page 34 for more details and projects funded in 2023.

PROFESSIONAL DEVELOPMENT PROGRAM

Piloted in 2019, the CICOES professional development program allocates $25K per year for employees to use toward professional development opportunities. For more information, see story on the next page.

FIELD WORK & CRUISES

Employees went into the field a total of 49 times totaling 1,558 days of travel.

Employees participated in 5 cruises totaling 830 days at sea on 13 different vessels.

Countries were visited including Chile, Mauritius, Australia, Panama, New Zealand, Maldives, Brazil, Spain, Iceland, South Africa, & the U.S.

Employees participated in crewed aerial surveys on the NOAA Twin Otter totaling 172 hours of flight time.

Employees participated in 16 cruises totaling 830 days at sea on 13 different vessels.

COUNTRIES WERE VISITED INCLUDING CHILE, MAURITIUS, AUSTRALIA, PANAMA, NEW ZEALAND, MALDIVES, BRAZIL, SPAIN, ICELAND, SOUTH AFRICA, & THE U.S.
INVESTING IN THE FUTURE

PROFESSIONAL DEVELOPMENT PROGRAM

By Carol Pérez, CICOES

The CICOES Professional Development Program (PDP) allocates $25K per year for CICOES employees to engage in professional development opportunities. These funds are commonly used to support participation in conferences, workshops, certificate programs, and UW Professional and Organizational Development classes. The PDP is especially focused on opportunities that grow an employee’s development in a new or expanded direction, beyond an employee’s more mainstream day-to-day activity.

Applications for the PDP are accepted year-round, and are reviewed by a committee of representatives from the Pacific Marine Environmental Lab (PMEL), Alaska Fisheries Science Center (AFSC), and the CICOES administrative staff. All CICOES employees are eligible for support up to $1,000 annually, and can request up to $800 more if the additional funds are matched by their grant or program budgets.

Cynthia Christman, a research scientist at the AFSC Marine Mammal Laboratory, used funds from the program to attend the Posit Conference in Chicago, Illinois. Cynthia has been a member of the PDP review committee for two years but this is the first time she’s taken advantage of the program herself. Posit, formerly known as RStudio, was founded in 2009 to create open-source software for data science, scientific research, and technical communication. The structure of the conference included two days of hands-on workshops and two days of concurrent talks.

“I was absolutely awe-struck by the supportive learning environment and sense of community,” Cynthia wrote. “My workshop on Advanced Quarto Applications (the next generation of RMarkdown) gave me the knowledge and confidence to broaden my own use of the software and it inspired new ideas for data products, communicating our research to the public, and creating more organized and efficient workflows with colleagues. I highly recommend this conference to anyone who works with data, and I encourage others who have thought about applying for funds from the Professional Development Program to finally take the leap!”

Postdoctoral Scholar Vivek Seelanki heard about the PDP through conversations with his advisors at PMEL. In September he applied for and received funding to attend the 69th annual Eastern Pacific Ocean Conference (EPOC) in Fallen Leaf Lake, California. Vivek’s research focuses on ecosystems in the Pacific, so EPOC was an enticing opportunity for him. In addition to the thematic relevance, he was eager to engage with the array of world-renowned experts coming together for the conference.

“Learning from their experiences and research findings was, for me, a significant motivator to attend,” Vivek said.

“This exciting event was an invaluable opportunity for me to stay at the forefront of the latest trends and innovations in my research field. I am grateful for the support and resources that CICOES provides for professional development. This program has been instrumental in helping me enhance my skills and contribute to the success of CICOES.”
Since 2015, JISAO and now CICOES have used internal funds to stimulate new, innovative research. Over time, the name and the objectives of the program have evolved. The original “mini-grant” program provided salary to existing PIs to initiate or expand research efforts. This program has been expanded to enable grantees to collect proof-of-concept data in support of external research proposals; to widen the eligibility pool to include non-PI Research Scientists and Postdoctoral Scholars; and now, since the evolution of JISAO to CICOES, to include applicants from our partner universities, UAF and OSU. This larger, more inclusive eligibility pool enables early career scientists to gain experience in the conception, management, and execution of research projects and, at the same time, facilitates collaboration among the CICOES community of scientists throughout UW, UAF, OSU and NOAA. We now sponsor projects that are collaborative efforts among at least two of the three CICOES universities, and maintain opportunities for UW-based scientists to broaden their research portfolios. While serving multiple purposes, you will see in the highlighted projects below — both funded in 2023 — that this long-standing program continues to bolster the expertise of our research community.

UNCOVERING POPULATION BOUNDARIES OF THE ENDANGERED BLUE WHALE: IMPROVED MANAGEMENT AND CONSERVATION THROUGH EXPANDED SAMPLING AND WHOLE-GENOME RESEQUENCING

Sean McAllister, CICOES (UW); Angie Sremba, CIMERS (OSU); Matt Galaska, PMEL (NOAA)

With passive acoustic data being the primary means of identifying endangered blue whale populations that overlap geographically, it is critically important to maximize the number of genetically sequenced individuals from populations with acoustic differences and from regions where populations overlap. Correlating call type with genetic identity and establishing a database of single nucleotide polymorphisms (SNPs) that can be used to identify blue whale populations in the future, are the logical next research steps. Combining acoustic call type with whole-genome sequencing would provide greater resolution than standard genetic tools and provides insights into the population structure of Pacific blue whales. Our project objectives include:

1. Sequence 10 individual blue whales from the Eastern South Pacific and 30 additional individuals from regions of acoustic overlap (the Central Washington North Pacific and northern and southern East Tropical Pacific), merging this data with PMEL-leveraged data from 90 individuals.
2. Define population structure, population introgression (including directionality), demographic history, ROH (Runs of homozygosity a.k.a. inbreeding depression), and develop a SNP database for management efforts.
3. Use this worldwide blue whale population structure to correlate acoustic calls with their genetic identity.

ADVANCEMENT OF ARTIFICIAL-INTELLIGENCE-BASED METHODS TO DEVELOP GRIDDED FIELDS OF OCEAN INTERIOR BIOGEOCHEMISTRY FROM NOVEL OBSERVATIONS

Jonathan Sharp, CICOES (UW)

This project builds on research that produced the first version of Gridded Ocean Biogeochemistry from Artificial Intelligence (GOBAI-O2) by addressing some of the available opportunities for progress. This is critical method development work that will ensure our global observational system is being leveraged to its fullest extent, providing valuable near-real-time information about natural ocean variability and anthropogenic change. Specifically, we will:

1. Assemble an updated merged dataset of measurements from ship-based surveys and profiling floats — along with ancillary data (e.g., satellite observations, model reanalysis products) — then use this dataset to form spatiotemporal clusters within which to train machine learning algorithms.
2. Train cluster-specific algorithms that will be applied to gridded observational fields of temperature and salinity. Algorithms will chiefly focus on neural networks, but we will also test regression-tree-based methods, support vector regression, and other algorithms. These AI-based methods will refine and improve the publicly-available GOBAI-O2 product.
3. Package the algorithms used to construct GOBAI-O2 to make them easily available for end-users to generate dissolved oxygen estimates from new input data.
IMPRESSSIONS FROM THE CICOES SYMPOSIUM

The inaugural CICOES Symposium was a major event and an important milestone for our Institute. Hosted on the University of Washington campus from June 13-14, 2023, the Symposium provided opportunities for CICOES employees and affiliates to showcase current research, meet potential NOAA and academic collaborators, and initiate new cooperative project ideas. We also made time for some fun competition during an “indoor Olympics” with timed events including ping pong, air hockey, pool, and the most thrilling of all – bean bag toss! To help broaden participation across our entire Institute, travel support was provided for participants from the University of Alaska Fairbanks (UAF) and Oregon State University (OSU). The two-day event brought together more than 90 people, including leadership representation from all three CICOES-affiliated universities and local NOAA laboratories, and was highlighted by a talk from Dr. Michael Morgan, the assistant secretary of commerce for environmental observation and prediction at NOAA headquarters in Washington, DC. Presentations were organized into three overlapping themes spanning the CICOES research portfolio — climate, oceans, and ecosystems — and included talks from research scientists, faculty, postdocs, and graduate students from all three universities. To incentivize new collaborative research, 2024’s Research Development Grants are earmarked to support project ideas generated at the symposium.

I was excited to hear about the prospect of a CICOES symposium, particularly given that, as an OSU postdoctoral scholar, most of my interactions with the CICOES community were remote. However, I didn’t anticipate just how many amazing researchers would attend, and how many connections I would form throughout the course of just two days. The two-minute flash talks were actually a great way to incorporate a lot of information in a brief time span (although my brain definitely hurt by the end!), and we had ample time during the breaks and Olympics to chat more with other attendees about our work. I had many memorable interactions with researchers, especially other CICOES postdocs, with whom I was grateful for the opportunity to chat informally outside of our monthly lunches. I will also say the symposium was productive in generating conversations that led to collaborations, as I am now working on an aspect of my CICOES project with a researcher who I met at the symposium! Overall, I really enjoyed the symposium and I definitely think it could be an annual event.

SARAH DOHERTY, UW

There are fewer of us within CICOES working in the area of atmospheric science than there used to be, so I don’t often discuss what I’m doing with many people at the Institute. I was lucky enough to get to present at the Symposium the work I’m doing with colleagues here at the University of Washington and elsewhere, studying how aerosol perturbations affect low marine clouds and the concept of marine cloud brightening. I was surprised at how much interest there was in our project, and the number of great conversations I had during coffee breaks with other CICOES scientists about their thoughts on how these cloud changes could interact with the marine environment. I also got some great input on observations that would be useful for our studies. These are connections I never would have made without the Symposium. In general, the Symposium was a great chance to expand my thinking beyond my own work and to learn about all of the really interesting science going on at CICOES across UW, OSU, UAF, and NOAA — and to strengthen my feeling that I’m part of a unified institute. I hope the Symposium becomes a regular event!

ALEXANDRA MCINTURF, OSU

Some of the participants at the 2023 CICOES Symposium. Photo: Jed Thompson
THE IMPORTANCE OF FEMALE MENTORSHIP

HOW THE CICOES REU CHANGED MY PERSPECTIVE ON THE TERM ‘WOMAN IN STEM’

By Leila Fischer, Willamette University

“GOOD LUCK! I LOVE MY WOMAN IN STEM! ~ EVA” reads the sticky note that’s been taped to my laptop for over a year now. My roommate wrote it when I left my Organic Chemistry notes all over our kitchen table after a particularly late night of studying for a midterm and it’s been stuck there ever since. Until recently, I always felt that the term “woman in STEM” implied a loneliness or solitude within a woman’s career of choice, or an indication of the sacrifices women make to receive the same recognition as their male peers. However, my summer research internship at CICOES caused me to reflect on what it means to be a “woman in STEM” and how the presence of female-identifying mentors on my journey as an aspiring scientist influences my long-term career goals.

Last summer, the CICOES Research Experience for Undergrads provided the opportunity for me to work with PhD candidate Emma Heitmann and her advisor Professor Kate Huntington doing isotope geochemistry research. Since learning about the use of isotopes as a form of proxy data during my very first semester of college, I’ve been interested in research opportunities that include isotope chemistry. This was the perfect opportunity for me to unite my fascination with chemistry on the microscopic scale and my passion for studying the Earth’s processes on a macroscopic scale.

From my very first moments as an intern, Emma and Kate made every effort to welcome my presence in the lab group, and strove to find ways to enrich my research experience with unique learning opportunities. I was given my own desk in an office with graduate students, introduced to researchers in the lab from other subdisciplines, and allowed to pursue projects that interested me. For example, as a chemistry major, I understood the chemical processes behind my research much better than the geological aspects. Emma managed to secure a spot for me on a field trip to the Chuckanut Mountains with UW’s senior geology field camp class, which gave me experience working on a geological field project and also provided connections with other undergraduates with similar interests in the earth sciences.

In order to better contextualize what kind of work I would have the resources to do during my research experience and the types of questions Emma and Kate were asking, I had to read up on a lot of past research efforts on the Colorado Plateau, including materials from Emma’s PhD General Exam. I learned that despite the Colorado Plateau being one of the most well-known landforms in the United States, there is little understanding of its topographic history. Marine sediment deposits have been documented all over the region, yet there is no confirmed hypothesis of what earth processes caused the plateau to uplift from sea level to the 2,000 m elevation it exists at today.
The unsolved mystery of the Colorado Plateau’s topographic history really intrigued me, so I designed a study of how climate and topography changed on the Colorado Plateau during the Miocene (around 10-20 million years ago), using clumped isotopic compositions of carbonates that precipitated out of ancient lakes. My analysis showed temperature changes in line with the global climate record, but also showed potential signs of topography change because we observed a steeper temperature decrease during the time period than the climate record suggests. The results of this research have the potential to guide future research on the Colorado Plateau and contribute to our evolving understanding of the formation of both the Grand Canyon and the Colorado Plateau.

Despite the Colorado Plateau being one of the most well-known landforms in the United States, there is little understanding of its topographic history.

Doing research in an Earth Science department made me realize how many exciting research paths there are in this field. I was also impressed with how researchers in this field collaborate across institutions, and how scientific endeavors are shared to help accelerate others’ work. Going into my CICOES internship, I was already fascinated with how large-scale earth processes from millions of years ago can be traced on the atomic scale. Coming out of this research experience, I am now confident that this is a career path I want to pursue, and I feel equipped with the skills needed to conduct graduate level research.

Emma and Kate proved to be great mentors, due to their scientific expertise, passion for their field of study, and coordinated efforts to make my research experience unique and applicable to my future. In addition to these assets, I also witnessed their successes as women in research and could envision my future self in their endeavors.

Although my experience working with Kate and Emma was a final push in the direction of a research career, prior to working with them there have been several women in my life who were just as impactful to my future in the sciences: My mom, who adamantly encourages me to dream big for myself and has

Above: Leila, center, with her mentors Kate Huntington (left) and Emma Heitmann (right) during a lab group celebration at the end of the 2023 REU program. Photo courtesy of Emma Heitmann
ADVENTURE CAMP VISITS CICOES

By Denise Kester, CICOES

As a kid, my favorite days were the ones we spent on fieldtrips or had a guest speaker in the classroom! Decades later I still remember each one of those experiences and visitors, so as an adult I can’t pass up the opportunity to pass along that great feeling to some young students visiting CICOES.

This summer I had the pleasure to work with the CICOES REU interns to plan an outreach event for Adventure Camp, a summer camp for kids with social needs that encourages the development of social skills through science.

I helped the CICOES interns brainstorm ideas and pare down their interests into one science related theme to teach the kids. They settled on a marine science concept and were challenged to design three different hands-on experiments that could be done in a ninety-minute window.

Adventure Camp brought two groups of students – the morning group was kindergarten through 4th grade and the afternoon group was 5th through 8th grade – so our challenge was to use the same activities but incorporate more in-depth science for the older kids.

The week after our brainstorming session, the interns met on their own to design the presentation. It started with a catchy introductory video to grab the kids’ attention and the rest of the event was hands-on and fantastically messy; using food coloring, shaving cream, paint brushes, modeling clay, and various crafting accoutrements! In addition, the older group of kids each got to decorate small wooden boats as part of a program called Float Your Boat through the UW Applied Physics Lab. The cedar boats, which are each branded with a unique ID number, are deployed on an Arctic ice floe by a field scientist and, with any luck, they will someday wash ashore, be found, and get reported to APL after years of drifting at sea.

It takes so little time to give a kid a lasting memory. I can’t wait for the next opportunity to volunteer!

It is the resilience, intellect, and passion from these women in their respective roles that has changed my perspective and redefined the term “woman in STEM” to reflect the community and inspiration I have found in other woman scientists and their work. In a recent review publication of mentorship programs for women in sciences, it was found that “women’s experiences in STEM fields are enhanced when they have strong mentors and facilitators to support their work.” My positive personal experiences are corroborated by peer-reviewed journals, which further illustrates the importance of female mentorship.

The CICOES summer internship program was an invaluable experience for both academic and personal reasons, and one of the most impactful aspects of it was Emma and Kate’s advising.
THE SEARCH for DEEP OCEAN HYDROTHERMAL FIELDS

By David Butterfield, CICOES Principal Research Scientist
RAPID DISCOVERY AND CHARACTERIZATION OF THREE NEW HYDROTHERMAL FIELDS DURING THE FIRST SCIENCE EXPEDITION OF FALKOR (TOO)

A multidisciplinary science team representing 11 institutions from the United States, Canada, and France departed Puerto Rico aboard the R/V Falkor (too) on March 3, 2023, heading for the deep ocean’s Mid-Atlantic Ridge. The team’s primary goal was to use a combination of technologies to rapidly survey large areas of the seafloor to find new hydrothermal features, and to characterize their geochemistry, biological communities, and mineral deposits. Locating hydrothermal features and understanding their chemistry and ecology is becoming an increasingly vital field of study as interest in deep-sea mining intensifies, in part because active hydrothermal vents produce large quantities of metal sulfide deposits, enriched in commercially valuable mineral ores.

For the CICOES/PMEL Earth-Ocean Interactions research group, the mission aboard the R/V Falkor (too) was the latest expedition in a decades-long series of missions to characterize how the chemical and biological properties of hydrothermal systems are linked to their geologic setting. In this case, the setting was the slow-spreading Mid-Atlantic Ridge between 20° and 25°N, where oceanic core complexes expose mantle rocks, normally deeply buried under several kilometers of volcanic material produced by mantle melting under the ridge axis.

Prior to this expedition, only two hydrothermal fields (“TAG” and “Snakepit”) were known in this section of the Mid-Atlantic Ridge, and both were discovered in 1985. To find new hydrothermal systems on oceanic core complexes away from the ridge axis, the science team aimed to survey bathymetry and water properties over very large areas of seafloor at high resolution, using a nested approach. The newly refitted Schmidt Ocean Institute (SOI) research vessel Falkor (too) — a name inspired by a German fantasy novel, The Neverending Story — had the capacity for a large science party and the multiple technologies required for this mission. Equally important, the ship’s crew and marine technical team are extremely talented and dedicated to success.

The operational plan was built around an approach of nested scales. The team planned to first use the ship’s multi-beam sonar to generate a medium-resolution but spatially broad basemap, then use the basemap to design fine-scale Autonomous Underwater Vehicle (AUV) surveys in selected areas to generate 1-meter scale resolution bathymetric maps. The team would then use the high-resolution maps combined with water col-
umn data from onboard sensors to home in on areas of active hydrothermal output. The Monterey Bay Aquarium Research Institute (MBARI) AUVs used by the team map at 75 meters above the seafloor, and clearly reveal hydrothermal chimney features. The ship’s CTD rosette is towed to collect water for methane and hydrogen analysis on board, providing more clues on where to look for hydrothermal vents. With high-resolution maps and water column signals in hand, the team’s final step is to launch the remotely operated vehicle (ROV) “SuBastian” (a name also inspired by *The Neverending Story*) attached to the ship with a fiber-optic cable, and use visual clues to find the active vents on the seafloor.

The expedition continued with this same approach at two oceanic core complex sites that were much larger than Puy des Folles volcano, successfully finding and characterizing two more high-temperature vent fields with the characteristics of serpentinitization reactions. Overall, the AUVs collected high-quality, one-meter scale resolution bathymetric data from 170 square kilometers of seafloor across three sites, an area approximately the size of Manhattan Island.

The team’s primary goal was to use a combination of technologies to rapidly survey large areas of the seafloor to find new hydrothermal features.
“This cruise exceeded expectations with the discovery of so many amazing hydrothermal vents vibrant with life,” said Dr. Jyotika Virmani, executive director of the SOI. “We are delighted with the new capability that Falkor (too) brings to the ocean science community, including the ability to put multiple different types of technology in the water simultaneously. The dedication of the scientists and crew, along with the capabilities of the ship, was evident in the success of this expedition and we look forward to more.”

Large sections of the Mid-Atlantic ridge are in international waters beyond national jurisdiction and are designated areas for deep-sea mining exploration. Active hydrothermal vents produce metal sulfide deposits – mineral ore enriched in copper, zinc, and other valuable metals. All mineral-resource-related activities in international waters are regulated by the International Seabed Authority (ISA), established by the United Nations. The ISA is currently considering whether to allow commercial-scale deep-sea mining, and is working to develop Regional Environmental Management Plans to predict and manage environmental impacts of mining. Presently, the main focus for deep-sea mining is not hydrothermal metal sulfide deposits, but rather the potato-sized polymetallic nodules that cover millions of square miles of the deep, sediment-covered seafloor. Mining of mid-ocean ridge metal sulfide deposits is more difficult and therefore less likely, but is still under consideration.

The first R/V Falkor (too) science cruise explored new areas and surveyed new hydrothermal vents, finding rich biological communities, and collecting small mineral samples for chemical analysis. The vents were teeming with marine life including massive swarms of vent shrimp and a rare sighting of a big fin squid. Many species found exclusively on hydrothermal vents live off chemical energy (chemosynthesis) instead of energy from sunlight, which doesn’t reach below a few hundred meters. There is still much to learn about how hydrothermal processes affect ocean chemistry and ecology, what ecosystem services they provide to the deep ocean, and how those relate to overall ocean health and ecosystem function.

It’s impossible to understand or protect what is unknown or unseen, and that is why scientific exploration is needed. The Regional Environmental Management Plans being developed for ISA regulation of ocean mining require accurate scientific data on the presence of animal communities on and around mineral depos-

The first expedition for Falkor (too) revealed three new vent systems in an area under evaluation for deep-sea mineral mining.
its and an understanding of how sites are colonized. The first expedition for Falkor (too) revealed three new vent systems in an area under evaluation for deep-sea mineral mining. It is clear that removing metal sulfide mineral chimneys from actively venting areas would destroy habitats for chemosynthetic vent fauna communities. Fortunately, there is some agreement that sites with active venting and chemosynthetic communities should be excluded from mining because of the very limited extent of hydrothermal vent habitat, which is restricted to a narrow band of activity on the global mid-ocean ridge system.

In the big picture, there is ongoing discussion about the overall necessity of extracting seafloor minerals and the degree of environmental harm that might be caused by removing inactive metal sulfide deposits. Balancing the global economy’s need for critical minerals with the need to protect ocean health is a complex issue, requiring the collection of scientific data and communication among an informed public capable of understanding the deep-sea mining debate and decision-making process. Live-streaming our ROV dive videos from hydrothermal vents, and archiving that video on freely accessible sites (e.g. YouTube), allows the public to see what exists on the seafloor and to hear comments from scientists regarding what they are seeing, hopefully bolstering the public’s understanding of the potential consequences of deep-sea mining.

The R/V Falkor (too) continues her support of cutting-edge research, with an eighth expedition underway at the time of writing, October 25 to November 23, 2023, conducting an ultra fine-scale seafloor mapping project at the Galapagos Spreading Center. The new, highly capable vessel will be used for global ocean exploration and scientific investigation, focused on a different region of the world each year. “Falkor (too)’s inaugural expedition has demonstrated all that’s possible when you bring together scientists from around the world and give them access to the latest tools and technology, all aboard a collaborative floating laboratory,” said Wendy Schmidt, co-founder and president of SOI. “The discoveries on this expedition underscore how much we have yet to learn about deep-sea ecosystems — and why, before marching ahead with mining or other potentially damaging activities, we need to learn more about our unknown ocean.”

David Butterfield is a Principal Research Scientist at CICOES and leader of PMEL’s Earth-Oceans Interactions group.

“Falkor (too)’s inaugural expedition has demonstrated all that’s possible when you bring together scientists from around the world and give them access to the latest tools and technology, all aboard a collaborative floating laboratory.”

Below: Black smokers on the large Hydra/Swarm chimney structure near 25°N on an oceanic core complex associated with a non-transform ridge offset. Shrimp cover most of the surface where there is warm fluid flow, and snails congregate around the cooler periphery. Photo: Schmidt Ocean Institute
Pacifc oysters comprise the majority of Alaska’s aquaculture production and the industry is projected to grow rapidly in the next decade due to the region’s existing maritime labor force, abundant coastline for growing shellfish and seaweed, and strong focus on Indigenous and rural representation. However, challenges remain that are unique to Alaska’s climate and ecology.

Oysters in Alaska must be able to survive and grow in extremely low water temperatures with highly seasonal food availability. The gear required to grow oysters must be able to withstand harsh environmental conditions and high rates of biofouling, while protecting oysters from sea otter and sea star predation. Farms also must be able to reliably secure juvenile oysters or “seed.”

To date, oysters have not been spawned in Alaska successfully, consistently, and cost-effectively, creating a reliance on seed supplied from outside the state. In recent years this has led to extreme business insecurity and a shortage of seed supply available to Alaskan oyster farmers.

Oyster strains cultivated in the Pacific Northwest and Hawaii hatcheries have been bred for optimized growth in the mid-latitude Pacific Northwest, where nearshore marine conditions differ markedly from those found in Alaska. Ongoing breeding efforts currently focus on enhancing the industry in California, Oregon, and Washington. Alaska has historically been omitted from national efforts aimed to enhance industry performance through breeding and hatchery innovations due to the logistical challenges of working with farms in such remote settings.

“For decades, farming of Pacific oysters has been a small but viable industry in Alaska,” said Henry Fleener, the Hatchery Manager at the NOAA Alaska Fisheries Science Center (AFSC). “We want to help this sustainable industry grow with improved genetics, technology, and resources.”

Over the last year, the aquaculture research group at AFSC and the Mariculture Lab at the University of Alaska Fairbanks College of Fisheries and Ocean Sciences have worked towards addressing these critical challenges through collaborations with the U.S. Department of Agriculture’s Agricultural Research Service (USDA-ARS) and Pacific Hybreed, a private lab based in the Pacific Northwest, specializing in shellfish breeding. Our group members have also experimented with nursery and farm innovations in an Alaska setting, including testing the efficacy of novel gear configurations at farm sites, evaluating the growth and survival of se-
lectively bred oysters for Alaska farms, and establishing the first research oyster nursery in the state.

“Our goal as a federal research group is to enhance the sustainability and resiliency of the Alaska shellfish and seaweed aquaculture industry,” said Jordan Hollar-smith, the AFSC aquaculture research lead. “Improving Alaska’s access to high-quality oyster seed and growing methods is a critical step to help the industry grow.”

Our group constructed the first research oyster nursery in Alaska at the Auke Bay Laboratories (a division of AFSC) in Juneau, Alaska. This research nursery supports the production of local oyster seed and promotes oyster breeding and shellfish research efforts in Alaska. The lack of oyster nursery capacity presents significant hurdles to develop oyster strains optimized for growth in the region and for current and future farm operations. Nursery and selective breeding efforts align specifically with state, federal, and industry goals to enhance sustainable industry growth, confront climate change proactively, support education and information exchange, and to increase the portfolio of other high-value shellfish species. The nursery also bolsters partnerships and research collaborations with neighboring students and researchers at UAF.

“The benefits of this UAF-NOAA Fisheries partnership extend beyond oyster research,” said Schery Umanzor, who leads the Mariculture Lab at the UAF. “Together, we’re significantly enhancing public outreach, driving technology development, and creating valuable educational opportunities.”

Initial capital investment in the Alaska aquaculture industry has also limited industry growth, including oyster aquaculture. Recently though, the Alaska Mariculture Cluster was chosen as one of the Build Back Better Regional Challenge recipients, winning nearly $49 million in grants to enhance the development of the industry through support for innovation and sharing of best practices. Alaska aquaculture scientists also received funding from the Exxon Valdez Oil Spill Trustee Council, totaling $32 million over the next 5 years. These funds will be distributed across the entire mariculture industry in Alaska, with a unique focus on Indigenous and rural representation, securing Alaska’s future in aquaculture development, furthering ingenuity and best practices in the industry.
SATELLITES & SNOWFALL
DEVELOPING INNOVATIVE NEW PRODUCTS ACROSS LAND, SEA, AND SKY

By Grace Veenstra, UAF Geographic Information Network of Alaska
In the basement of the Butrovich Data Center on the University of Alaska Fairbanks’ Troth Yedda campus, the constant deafening whir of computer servers fills the room. The rows of server cabinets are nothing remarkable to look at, filled with small black boxes covered by blinking lights. But in the virtual space made by their circuits, these computers are generating critical data and imagery, while just a few floors above, the very phenomenon they are helping to measure is occurring — slowly accumulating snowfall.

For over half the year, snow falls on Alaska, making snowfall one of the key elements for discussion and analysis of Alaska’s regional weather and climate. In order to understand snowfall — among other dynamic weather-driven processes in Alaska, from flooding to wildfire — these servers are running around the clock.

“The servers are where everything happens,” said Mike Peterson, a system administrator at the Geographic Information Network of Alaska, or GINA, part of the Geophysical Institute at the University of Alaska Fairbanks. With funding through CICOES and in partnership with NOAA’s Joint Polar Satellite System, GINA works in satellite science and innovation, providing the remote sensing data used for geospatial information and weather monitoring of Alaska and its surrounding oceans.

“The satellite data comes in from the antennas, gets stored in the servers, and then virtual machines can come in and run computations on it,” said Peterson. “The servers do the computation for all the satellite imagery that we collect and put out, turning it into usable data that people can see.”

**SATELLITE OBSERVATIONS**

For those who live and work in Alaska, its size is one of the biggest hurdles. Alaska’s land area is one fifth that of the entire “Lower 48,” and a majority of the state is inaccessible by road. In a landscape this vast and remote, ground-based observations are sparse. For forecasters and scientists, one method of bridging this spatial divide is with the use of satellites.
Using a pair of high-latitude antennas located near Fairbanks, GINA collects and processes the raw data received from a constellation of ten polar orbiting satellites, five of which are operated by the NOAA Joint Polar Satellite System. The end results of this processed raw data, loosely called “products,” take many forms, which are made available to the public on public servers, web-portals, and social media. The data and imagery are used by scientists such as meteorologists and oceanographers, as well as by agencies such as the Alaska Fire Service and Alaska Volcano Observatory.

To receive the information generated by the satellites, GINA uses “direct broadcast,” where a satellite scans Earth as it passes overhead and simultaneously transmits that data to ground-based antennas. The data are rapidly processed on the GINA servers in the Butrovich Data Center, and then published in near-real-time, about 10 to 30 minutes after the servers finish receiving the satellite data. This rapid processing of data is particularly important for forecasters at the National Weather Service whose mission it is to quickly provide warnings, forecasts, and data to those who need it.

But more than simply receiving and processing satellite data, GINA also plays a key role in testing developmental products.

“The servers do the computation for all the satellite imagery that we collect and put out, turning it into usable data that people can see.”
“GINA serves as a conduit between research and operations,” said Jen Delamere, the director of GINA. “We rapidly provide the base data from the satellites to researchers across the country. When their products are ready to be field tested, GINA provides the infrastructure to take these innovative new products from research into operations, connecting researchers to weather forecasters and wildland fire managers to help generate the best products possible.”

THE SNOWFALL PRODUCT

Among the products currently being tested through GINA is the Alaska Snowfall Rate Product. The snowfall rate product was developed by a NOAA STAR (Center for Satellite Applications and Research) and CISESS (Cooperative Institute for Satellite Earth System Studies) team led by Dr. Huan Meng to identify areas where significant snowfall was occurring.

The snowfall product isn’t new — it’s already used by forecasters and scientists — but Dr. Meng and her team are continuing to improve the product by adapting it for new satellites and new computing technologies so the product can better detect snowfall. In Alaska and other high-latitude regions, the snowfall product is a valuable addition to the toolbox of forecasters and scientists.

“The snowfall rate product uses passive microwave measurements to give an instantaneous estimate of the liquid equivalent of snowfall in inches per hour,” said Carl Dierking, the satellite liaison at GINA and one of the people helping to develop the product.

In order to create a visible and readable product for
The snowfall rate product uses passive microwave measurements to give an instantaneous estimate of the liquid equivalent of snowfall in inches per hour.

Forecasters, the direct broadcast data GINA collects from polar satellites is sent to a virtual processing system housed in the Butrovich Data Center. Using the machine learning algorithms created by Dr. Meng and others on the development team, the raw data are processed into a map depicting snowfall rates.

Unlike visible or infrared satellite imagery, the passive microwaves used by the snowfall product can penetrate clouds and detect precipitation underneath and within the cloud itself. This makes the product well suited for understanding the extent and intensity of precipitation.

“The snowfall product can provide situational awareness during snowstorms,” said the lead developer, Dr. Huan Meng, in a talk she gave for the Virtual Alaska Weather Symposia on the snowfall rate product, where she discussed its development and application. “It’s also useful for areas with poor ground-based observation.”

In mountainous and remote regions where weather stations are few and radar coverage is minimal, which describes much of Alaska, the snowfall product is at its most valuable.

“At this time, it’s primarily being used by National Weather Service forecasters,” said Dierking. “However, it may have value for other groups where precipitation is important.”

Over the last few years, the product development team has made a number of updates to the snowfall product. It has been extended to measure snowfall over water, including open ocean and sea ice, whereas previous snowfall algorithms were restricted to land. Its accuracy in detection and rate estimation has also improved. As versions of the snowfall product begin to include additional satellites, the reach and frequency of observations will improve.

This winter, the Alaska Snowfall Rate Product will continue to be assessed by the National Weather Service, which will provide feedback to Dr. Meng’s team. It will be used to monitor the precipitation across the state and to caution Alaska residents of heavy snowfall, adding that much more information to build the picture of Alaska’s winter weather. All the while, the basement servers at the Butrovich Data Center will continue their computations, powering the non-stop stream of weather and climate data that supports safety and productivity for people in Alaska and beyond.

Left: This image taken March 23, 2023, shows the Gulf of Alaska and the southern coastline using the ATMS Snowfall Rate product. Snowfall over the coast is highlighted light blue to green, indicating snowfall rate from 0.02 in/ hr (light blue) to 0.1 in/hr (green). Credit: Geographic Information Network of Alaska

To explore GINA’s product inventory and learn more about product research to operations, contact: satellite@gina.alaska.edu
How can artistic and creative practices contribute to scientific endeavors while making research visible to the public? That’s the question asked by UW climatologist Ignatius Rigor, artist Cy Keener, landscape researcher Justine Holzman, and scientist John Woods, who collaborated on a four-year project resulting in the *Iceberg Portraiture* series; four aluminum panels with images depicting icebergs undergoing constant change as they journey from glacier to fjord to coastal islands and the ocean beyond.

By integrating field data, remote satellite imagery, and multimedia visual representations, Keener and Holzman’s goal for this artwork is to make scientific data a visceral and tangible documentation of Arctic ice that is disappearing due to climate change. The *Iceberg Portraiture* images—which were featured in the National Academy of Science’s 2023 exhibition *Arctic Ice: A Visual Archive*—show icebergs with vastly different scales and shapes, some the size of a car and others a third of a mile wide. The series combines a range of digital capture and scale drawing techniques to provide a glimpse into the life of four icebergs observed and recorded in August of 2021 in western Greenland.

What is unique about this project is that the artists were involved in the design and construction of the tools that collected the data as well as their placement in the environment. According to Rigor, a polar scientist with UW’s Applied Physics Laboratory who receives funding through CICOES, “the data-collecting instruments are themselves hybrids of art and exquisite engineering.”

Rigor has long worked with John Woods, the country director at the Office of Naval Research, and together they manage the International Arctic Buoy Program, which is responsible for coordinating the deployment of weather and climate instruments on the Arctic Ocean to maintain a 45-year-record of Arctic climate data.

In 2018, Keener reached out to Woods, who brought Rigor into the conversation, to discuss their mutual need for drifting buoys. The two scientists required the buoys for scientific research, but Keener wanted to gather source material for an artistic investigation. Over a six-month period in 2019, the artists worked with the scientists to develop a Light and Ice Mass Balance (LIMB) buoy that could take measurements in floating sea ice along a string of sensors. Lightweight and easy to deploy, the buoy gathers data on sunlight, air pressure, temperature, and depth, which are used to estimate the growth and melt of sea ice, called ice mass balance. Rigor admired the buoy saying, “The hull that protected the electronics of the LIMB buoy was so exquisite, I thought it was a crime to leave this instrument on the remote confines of sea ice to never be seen again.”

Being deeply embedded in each other’s processes fostered new ideas and unexpected outcomes. Rigor put it this way: “Keener and Holzman’s work uses science to inform their art, which in turn informs science, creating more questions and a cycle where engineering, art, and science interact to expand our knowledge.” This blending creates alternative perspectives on the collection and representation of environmental data that help viewers to better understand the physical, experiential, and technical landscapes of climate science.
Iceberg Portraiture
Cy Keener & Justine Holzman
2022
aluminum, ink, and wax pastel
84 x 42 inches each
Photos: Kevin Allen
CICOES researchers authored or co-authored the following publications between November 2022 and October 2023. Names in bold indicate CICOES-affiliated authors.

**JOURNALS**


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BOOKS


MAGAZINE ARTICLES


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IN MEMORIAM

DR. DONALD W. DENBO
1952 - 2023

By Nancy Soreide, NOAA PMEL

Don grew up in Pleasant Home, Oregon. As a youth, he worked in farming and construction. His professional life started with a PhD in Physical Oceanography from Oregon State University and included work at Harvard, Battelle, and the University of Washington on ocean models of the Gulf Stream, carbon dioxide, and tsunamis as well as oceanographic data analysis. He was a superb software engineer, and his software is widely used in the oceanographic community.

Don had a lifelong love of music and was an accomplished musician, playing flute, alto flute, and soprano and tenor saxophone with multiple groups, including some that he founded. He enjoyed caving, belonged to the National Speleological Society, and was part of a research team placing instrumentation to monitor the environment in bat caves for the Park Service in the Lava Beds National Monument in northern California. Don loved the outdoors, hiking in the mountains, and trail running in the woods. He participated in meets and set courses for the Cascade Orienteering Club. He was an excellent photographer.

Don was a kind and generous person and a wonderful friend, who always worked from a depth of knowledge and understanding of his subject, and everything he did, he did well. He died comfortably at home on February 9, 2023 following a diagnosis of pancreatic cancer. He is survived by his wife Lynnette, his brothers Garry and Den, and extended family and friends. ♦
A rare sighting of a bigfin squid (Magnapinna sp.) at a depth of approximately 2,000 meters (6,562 feet) during the Falkor (too)'s inaugural expedition led by CICOES Principal Scientist David Butterfield (see story page 39). Photo courtesy of Schmidt Ocean Institute.