From the Director

In 2019 the first sentence I wrote in the welcome message was: “Welcome to the inaugural edition of JISAO Magazine!” Without trying to be redundant, or overly dramatic, that inaugural phrase can be recycled to read: Welcome to the inaugural edition of CICOES Magazine! The change to the magazine title is just one indicator of how the Cooperative Institute continues to evolve and how as individuals we continue to adapt our lives and work in an ongoing pandemic. Like last year, “What a difference a year can make!” remains an appropriate statement. This magazine represents the shift from a co-located to a consortium Cooperative Institute with our new partners the University of Alaska Fairbanks (UAF) and the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University (OSU). We are working to realize our ambitious vision of an integrated Cooperative Institute that deepens and broadens our collaborative research, education, and outreach goals across the three partner institutions.

We now have completed a year, albeit a unique one, under the CICOES banner. Our core research themes were expanded to nine by NOAA to include an amalgamation of existing themes and the explicit addition of aquaculture, environmental data science, human dimensions, and polar science. The response to our last NOAA request for proposals included six from UAF that were accepted in the overall projects package. Other notable changes that have enhanced our program initiatives included: revising membership of our CICOES advisory groups; extending our internally funded Postdoctoral Scholarship program to include UAF and OSU CICOES-affiliated faculty; added a CICOES-wide collaborative grant category to our Research Development Grant program; expanded our virtual summer internship program to include a partner university student and a mentor from NOAA’s Alaska Fisheries Science Center in Juneau; and started partner management meetings with all Deputy Directors to ensure coordinated policies and procedures across the three CICOES campuses. Adopting a wider perspective, a new initiative has been launched to align common Pacific Basin research interests among Cooperative Institutes in the west to form a left coast Cooperative Institute group: CICOES, CIMEAS (formerly known as CIMEC) at the Scripps Institute of Oceanography, and CIMAR (formerly known as JIMAR) at the University of Hawaii.

As predicted there have been several unanticipated challenges in our efforts to integrate policy and initiate programs across three universities. Many challenges have been amplified by shifts in policy from a new US Administration and by constraints imposed by a global pandemic. Despite these challenges I see the vision of CICOES being realized with continued potential for future growth. The ongoing pandemic has slowed progress in many of these initiatives, but all are moving forward and will become fully operational once conditions permit.

As we all strive to establish routines in our new normal(s), I continue to appreciate the resiliency and innovation of the CICOES community. Thank you for your continued support.

John Horne
CICOES Executive Director
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BONNIE CHANG
Bonnie’s career in oceanography takes her around the world

UMA BHATT
Associate Director of CICOES-UAF

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ONE OFFICE, TWO SCIENTISTS, 100 DEGREES
When temperatures rise people turn to the OWSC for answers

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Drier, warmer air is making some fires more active at night

IN MEMORIAM
Remembering CICOES employees Achim Nicklis and Mary Smith
A DECADE AFTER EARNING HER PH.D. IN OCEANOGRAPHY from the University of Washington, Bonnie Chang continues to serve as a Research Scientist at UW’s Cooperative Institute for Climate, Ocean, and Ecosystem Studies. Her favorite element on the periodic table? Nitrogen.

Chang came to the ocean’s nitrogen by way of examining chemicals in the lab. “I studied inorganic chemistry in college and during the summers we were encouraged to find internships and work in labs to gain real-world experience,” Chang said. “But I was also interested in sailing and having fun adventures during the summer and so during my junior year in college, I applied for an internship in marine chemistry.”

The real-world application of her classroom learning made this internship memorable for Chang. “That summer I got to dig wells in the wide, sandy beaches of Delaware to investigate groundwater seepage and learn about its role in the ecosystem of Delaware Bay,” she said. “I became fascinated by the intersection of all the different disciplines in that one project – chemistry, biology, hydrology, geology – and then thinking about the impacts to the entire Bay and all its inhabitants.”

Chang received both personal and institutional support for this change of direction. “I’m a first-generation Chinese-American, so obviously my mom hoped I would become a doctor or a lawyer,” Chang said, “but she never batted an eye when I said I was going to go to graduate school to study oceanography.”

Undergirding it all was funding at the national level. “I was surprised to find out late in my senior year of college that the U.S. federal government supports the majority of graduate science education, across many scientific disciplines, not just oceanography, in the form of graduate student research assistantships which pay for students’ graduate school tuition and stipends for living expenses,” Chang said. “In exchange, graduate students carry out much of the lab and field work, data analysis, and writing up of research studies that are funded by the federal government at colleges and universities.”

So what is Chang’s fascination with nitrogen? “Nitrogen is necessary for life,” she said. “It is an important component in the proteins and DNA of all living organisms.”

It is also inescapable. “Nitrogen is all around us,” Chang said. “It makes up approximately 80% of the atmosphere, but nitrogen gas is not a form that is usable to most life.”

THE UNIQUELY STUNNING BEAUTY AND ADVENTURE OF ANTARCTICA ARE ALL GREAT DRAWS FOR ME.

The uniquely stunning beauty and adventure of Antarctica are all great draws for me. By Roxanne Ray, International Examiner

From The Hood Canal To The Arabian Sea, BONNIE CHANG’s Career In Oceanography Takes Her Around The World

By Roxanne Ray, International Examiner
Chang explains the chemical nature of nitrogen: "Nitrogen gas is composed of two atoms of nitrogen triple-bonded to each other – a very strong bond – making it difficult to get a single atom of nitrogen to form a bond with a different atom to make a molecule of, say, protein," she said. "High energy processes can break this triple bond in nitrogen gas. In the ocean, special algae use sunlight to break that triple bond and they, in turn, supply the rest of marine organisms – from microbes to corals to whales – with nitrogen in a form that they can use to build proteins and DNA and a whole host of organic compounds needed to sustain life."

In other words, life depends on nitrogen. "In much of the ocean, the amount of life that can grow, the fertility, in other words, is limited by the amount of nitrogen supplied by these special nitrogen-triple-bond-breaking algae," Chang said.

Nitrogen also has a significant impact on the carbon cycle and, therefore, on climate change. "You have probably heard about the impacts of one of the widely discussed components of the carbon cycle, carbon dioxide, on climate, and so the amount of nitrogen that is available for marine life to use for growth impacts the carbon cycle," Chang said. "Understanding all these linkages is important to predicting what can happen with our climate in the future."

But studying the elements at sea doesn’t come without surprises, as Chang learned during a research cruise in the Arabian Sea in 2007. "The Arabian Sea is host to large regions of water that naturally do not contain any oxygen," she described. "No fish or larger life can survive in those waters, but the absence of oxygen provides a niche for anaerobic microbes to carry out unique and biogeochemically important reactions – with nitrogen, of course."

The surprise, however, didn’t arise from the water. "We were just about to put a scientific instrument in the water when we noticed another ship coming towards us," Chang reported. "As soon as I saw that ship turn to come alongside us, I realized that something was wrong and I, and the couple of other scientists on deck, ran inside, locking the doors behind us as we went."

The scientists went straight to their assigned emergency station and awaited instructions. "Luckily, a U.S. research ship is much more maneuverable than a comparably-sized commercial ship and we were able to get away," Chang said. "The truth is, we never did know what the intentions of the other ship were but, since we were in a region frequented by pirates, I’m fine that we didn’t find out."

Chang’s work has also been affected by the COVID-19 pandemic, which has resulted in the cancellation of many research cruises, including one near South Africa for which Chang was scheduled in March, 2020. "We usually work in close quarters in ships and labs, so a lot of that type of work has been delayed or reorganized," she said. "Since then I’ve been teleworking like so many others, a good time to catch up on data analysis and writing."

But Chang hasn’t given up on her intended project, that of measuring dissolved nitrous oxide and chlorofluorocarbons (CFCs). "Both of these compounds are powerful greenhouse gases and play a significant role in the destruction of our ozone layer," she said. "Nitrous oxide is produced by both natural and human processes; CFCs are completely human-made although their production and use are currently banned."

"SCIENTIFIC CURIOUSITY IS ENTRCING"
Chang toward cold climates at both poles on earth’s axis. "We have relatively little data from the Arctic due to it being a very inhospitable place to work, difficult to access in the summer due its remoteness, and virtually impossible in the winter when the ice can make it impassable for even the strongest ice breaker, so what little information we have from the Arctic is all biased to the relatively warm, ice free summer months," she said of the Arctic region near the North Pole. "In order to find out the whole story all year long, I have been working on an instrument that can be anchored under the ice where it can take measurements and samples throughout the winter, providing the first data of its kind during the Arctic winter."

She also dreams of Antarctica at the Earth’s southern pole. "The uniquely stunning beauty and adventure of Antarctica are all great draws for me," Chang said. "I’ve been across the Antarctic Circle on ships and have seen sea ice and ‘bergy bits, but I would like to stand in the shadow of those huge towering ice shelves that flow off of Antarctica, maybe walk on some of those ‘rivers’ of ancient glacial ice."

But in Antarctica, Chang plans to look upward, as well. "In the summer months, the sun never sets or sets at such an oblique angle to the horizon that you see sunset and sunrise colors in the sky for hours," she mused. "And if or when it does get dark, you have the chance to see the aurora australis."

For now, Chang is practicing her skills here at home. "I’m also working on a project here in Hood Canal," she said, "looking at how ocean acidification, which is a side effect of increasing carbon dioxide concentrations, might affect nitrogen cycling in the surface ocean which has impacts on the whole marine food web."

The fast pace of science and the funding that drives it keep Chang focused on the near term. "Grants from the federal government, which funds the vast majority of oceanographic research, are mostly three to five years long, so that’s about as far as we can plan," she said. "Despite her passion for snowy icecaps, COVID-19 may ultimately next take Chang to warmer climates that don’t cross forbidden international borders, most likely to Puerto Rico or the U.S. Virgin Islands."

Regardless of location, though, Chang will continue to practice science that leads to discovery. "I’m interested by the creativity, or maybe ingenuity or insightfulness are better words," she said, "that it takes to bring all the bits and pieces of evidence together to explain complex phenomena."
Dr. Bhatt earned a B.S.E. in Mechanical Engineering as well as a B.A. in Russian from the University of Pittsburgh. Her interest in solar technology and sustainable energy research drew her to the field of engineering, but her path changed when she and her husband decided to join the Peace Corps for two years after her undergraduate studies.

“I served in East Africa for two years in the Peace Corps during ’83 to ’85, when it basically didn’t rain for two years in Kenya. And the impact on humans was very clear, because in Kenya, you have to pay to go to high school. Most of our students were from farming families and they just didn’t have the money to pay their school... the human toll was very, very evident,” said Bhatt. Though sustainability had always been of interest to her, seeing the impact that climate could have on communities firsthand helped her realize what she truly wanted out of her research. “What drove me into this field was doing something that was actionable science.”

Dr. Bhatt’s time in the Peace Corps also inspired her to switch gears when it came time to return to graduate school. “Kenya has the most amazing atmospheric phenomena — like huge cumulus convection, and rainbows, and we were at 9000 feet where there was hail. So I just became so enamored with the idea of meteorology,” said Bhatt. She would go on to chase that interest and earn both her M.S. and Ph.D. in Atmospheric Sciences at the University of Wisconsin-Madison.

During her subsequent multi-decadal career at UAF, Dr. Bhatt has worked on a variety of research projects concerning climate variability in the Arctic. These days, among other projects, she is the lead for the Sea Ice Prediction Network, which consolidates user-contributed sea ice minimum forecasts and investigates the sensitivity of sea ice predictability to a warming ocean, among other things. She is also very excited to be working on seasonal fire weather forecasting in Alaska. “It gives fire managers one other piece of information when they’re making decisions in March... They decide what’s going to happen in logistics – like, ‘do we need to order some more people from the lower 48?’ They want to know if it’s going to be a really bad year or not such a bad year,” said Bhatt.

Dr. Bhatt emphasized the value of working on interdisciplinary teams to solve the complicated problems she tackles in her research. “I think one of my goals in the last few years of my career as I get closer to retirement is really to think about how to help the next generation navigate what is changing, because you have to have this balance between looking out for yourself and working in a team, you know, how do you balance that? I think [CICOES] is actually a really good active exercise in how we do that,” said Bhatt. “It’s very important to think about what your strengths and weaknesses are, think about where you see yourself fitting in. In this multidisciplinary activity, for it to work, everybody needs to see where they fit in and where they contribute, so it is really important to have some deep expertise.” Her additional advice to current students: “Learn as many computer skills as possible. Reflect on things. Don’t beat yourself up but reflect. We beat ourselves up way too much and it’s just not positive or you know that’s not getting you farther. Find older mentors — it’s good to have a trusted person or multiple people that you can go to for advice, and asking for help is OK.”

ONE OF MY GOALS IN THE LAST FEW YEARS OF MY CAREER IS REALLY TO THINK ABOUT HOW TO HELP THE NEXT GENERATION NAVIGATE WHAT IS CHANGING, BECAUSE YOU HAVE TO HAVE THIS BALANCE BETWEEN LOOKING OUT FOR YOURSELF AND WORKING IN A TEAM.

UMA BHATT, Associate Director of CICOES-UAF

By Haley Staudmyer

DR. UMA BHATT IS AN ASSOCIATE DIRECTOR for CICOES at the University of Alaska Fairbanks. She directed the NOAA Cooperative Institute for Alaska Research (CIFAR) between 2015 and 2020 and has been a professor at UAF since 1998. Her research primarily focuses on climate variability and change.
NICK BOND
Retired But Still In Demand

By Fred Averick

“LET’S ASK NICK.” Whether it was a question about atmospheric forcing in the Bering Sea, the infamous Blob, regional heat waves or what the weather would be like this weekend, too many times to count, people at PMEL, the UW Atmospheric Sciences department, or the Seattle Times would inevitably say, “let’s ask Nick!”

And even though he retired from CICOES as a full-time research scientist in the fall of 2020, Nick seems nearly as involved as ever… and so people still turn to him for answers. He’s our living Google, our Superman. But, like any superhero, he has an origin story:

As a kid, Nick saw himself playing professional sports, but by high school he realized some kind of scientific career would suit him better (though he certainly never gave up sports: biking, softball, triathlons!) and got his bachelor’s in physics from UC Riverside. He claims to have been on the nerdy, insecure side then (“I had bruises all over me from 11-foot poles because the girls wouldn’t touch me with the ten-footers”), but wouldn’t Clark Kent or Peter Parker say the same?

After college, he started working as a landscape contractor but soon the call of weather beckoned and he began grad school at the University of Washington (and has really never left the UW!). He got his Ph.D. in Atmospheric Sciences and in 1986 began his long association with JISAO, first as a post-doc. Then in 1990, Nick began his longtime work with PMEL as a JISAO Research Scientist, eventually becoming JISAO Deputy Director, Washington State Climatologist, and Affiliate Professor in the UW Department of Atmospheric Sciences.

But now, looking back, how does Nick see his career at JISAO? Let’s ask Nick! “I really liked the diversity of topics that I was able to study. I am kind of a jack-of-all-trades and so that variety suited me. I was quite happy with my situation so no complaints there.”

Any advice to newer scientists? “Spread your wings. Much of our strength is in the wide range of subjects being studied and the tools being used. There are almost certainly other groups that could benefit from what you could bring to the table. The trick here is to nurture those connections, and there is no substitute for time.”
Heather Tabisola is a research coordinator at the Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES) supporting NOAA’s Pacific Marine Environmental Lab. She describes her job as working at the interface across and between research and engineering to connect people and develop new tools to explore and monitor the ocean (including in the Arctic).

What drew you to your current career or field?

Very early on, I had a curious and joyous love of the shore and ocean and marine animals that communicate by making songs. In 1995, Sylvia Earle released the book “Sea Change.” I was 13 and it solidified that I wanted to be an ambassador for the ocean.

What is your typical day at NOAA like?

On a typical day, I’m up early to get ready and beat traffic. I drive to the NOAA Seattle campus each morning with my two children (ages four and two) who attend the daycare on campus. I drop them off at 7 a.m. and then head to my office.

My day always starts with reviewing my calendar and outlining goals and needs for the day with pen and paper. I then check emails for anything that needs to be addressed or added to my list. Hopefully I remember to make my coffee, and from there, it’s a blur until I pick-up the kids.

I coordinate and support research efforts for the Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI) and the Innovative Technology for Arctic Exploration programs. While my roles vary slightly, my focus is organization across research and written and oral content for internal and external communications. I also organize and lead the EcoFOCI seminar series, a bi-annual series focused on fisheries and oceanography in Alaska’s marine ecosystems.

My time in the office is spent primarily in meetings or at my desk. On occasion, I go to sea and those days look very different! Or I travel to communities in Alaska and attend conferences in places near home, like Seattle, or farther away in Washington, D.C. or San Diego.

How has the pandemic changed your typical work day?

During the pandemic I have been thankful to lose the commute, but have gained two small coworkers, one of whom refused to let go of me the first few months. The other got an excessive amount of ‘working’ time on her iPad until a routine was established in the house. These routines tend to be short-lived and constantly evolving, and some haven’t been able to be sustained (for instance, at one point I was working from 5-7 a.m., caretaking sometimes until dinnertime, and then working in the evenings until I would fall asleep).

Working from home allows me to block time off and focus on the tasks at hand versus in a setting where I can’t close my door or don’t have the opportunity to lock-in. Oddly, I found myself more productive when the kids were home because I had to be so focused and intentional with my time. Now that they are back in daycare, I am a bit more open to conversations, meetings, etc. that I was not before. So, now it’s more of a blend, which I think has been a healthy change!

I’ve also been able to contribute to programs such as NOAA Live! to share some of the research and development work with Saildrones to kids and adults across the globe.
What were some of the challenges you faced this year? Have you been able to adapt and if so, how?

It's hard to recognize challenges when I know and see so many folks across the globe that have faced losing loved ones, jobs, homes, the ability to provide for their families, and more to Covid-19. I am thankful for a working team that is compassionate; the ability to make boundaries when needed; and a healthy family with a roof over our head and a lawn to play in. I am also very thankful to our daycare staff and the fact that our daycare is open. Without it, I would be completely out of hours to take-off and properly give both my work and family the love and attention they deserve — and maybe, even, no longer in the workforce.

What experience or advice helps you when you’re faced with setbacks?

Always stay true to yourself and never let what someone else says distract you from your goals. Michelle Obama said it this way, and I like that she's added “distract you” from your goals. I’ve been told I can't have this career by teachers, by folks who I thought were mentors, and I’ve been on boats as the only female floating some 200+ miles offshore for months at a time. Put in the hard work, the really hard, roll-up-your sleeve type work, and it will not only shape your character — it will guide you in your life.

I would also add that it is important to seek out and establish your community. Life is hard and we humans are resilient, but the resources we have can uplift us and get us to where we want to be. I do not lean on my friends enough; it is my personality to fight alone. But in the darkest moments, it is my community who reminds me of what is next and helps me get there.

Have any opportunities opened up by the change to virtual-only work, or any unexpected benefits from working from home?

Yes! While I absolutely love to travel, I have appreciated attending conferences virtually and the creative ways that folks are working to create connections across technology.

Given the drastic changes in work environments, how do you see your workplace changing in the future, or what do you hope will change?

I hope for normalizing flexibility, a non-traditional office (the desire and ability to keep your team connected no matter where they are) and kids popping onto phone and video calls when you least expect them. I know there will be lots of innovation born from the pandemic, but I do hope to see some that address the inclusivity of caregivers while working from home.

Has your idea or definition of success changed in the past year?

I am not sure I know what success looks like for myself right now, because I am exhausted — but I will say that supporting others, uplifting others’ hard work, a “how can I help you”, “thank you” or even a “well done” — go a very long way.

What gives you hope, either with regard to science, your field in NOAA, or in general?

A generation of scientists willing to put in the work to diversify the field(s) and amplify voices that are required to save this planet and the people who rely on it.

What do you enjoy most about your work?

What I love about my work is connecting people, constantly learning, and sharing the extremely important work that my team carries out and making it digestible to someone not in the field.

What advice would you give to women who are starting out in their careers?

First, that it is important to have support — especially the support of other women. Build your tribe, choose people who will lift you up, and find people who make you better.

Second, that failure is an important part of growth, in life and work. Do not be afraid to fail, and do not be afraid to express what you need or want at that given time.
TYLER BLACK
I am working remotely with Dr. Kevin Wood on the Seas of Knowledge Project with UW CICOES. Usually the project has me imaging naval logbooks at the National Archives, but since the pandemic began, we have been harvesting and enhancing metadata of those logbooks, which will be turned into an index of all known naval ship logs with flushed-out data. We also use the data and images on Zooniverse to create citizen-science transcription projects, where the data can be transcribed by the public. My background is in information science, and I graduated from UMD with an MLIS, concentrating in Archives and Digital Curation.

SHANNON BROWN
I recently joined NOAA-PMEL as the new lab manager for Omics Lab. I have a BSc in Marine Biology from the University of Oregon and an MSc in Marine Science from King Abdullah University of Science and Technology. Before joining CICOES, I focused on using molecular and morphological analyses to examine marine invertebrate diversity in the Middle East. In the Omics Lab at PMEL, we currently use eDNA metabarcoding to monitor community biodiversity in marine ecosystems. We also use other genetic techniques, such as RADseq, to understand the population connectivity of ecologically significant species. By researching how a population is structured, we can better understand how to manage it.

HARTMUT FRENZEL
I work as a Research Scientist/Engineer with Dr. Andrea Fassbender in the GO-BOP (Global Observations of Biogeochemistry and Ocean Physics) group at PMEL, providing software development and data management for the Biogeochemical (BGC) Argo program. The addition of BGC floats to the Argo program will provide researchers with a vast new trove of data (oxygen, nitrate, chlorophyll, pH, particles, and light). I have an MSc in Physics from Heidelberg University in Germany. Prior to joining CICOES/PMEL, I worked on biogeochemical ocean modeling, first at UCLA, then in the School of Oceanography at UW. Outside of work I enjoy being outside, cycling, running, hiking, kayaking, as well as traveling near and far, and photography.

NILS HUTTER
I am working with Dr. Cecilia Bitz (Atmospheric Sciences) and Dr. Wei Cheng (CICOES/PMEL) to investigate how sea ice deforms under the forcing of wind and ocean currents. Specifically, we examine how sea ice breaks apart into smaller floes during a fracture event. Here, the number, size, and thickness of the newly formed floes are of special interest, as these quantities determine the mechanical strength of sea ice as well as how fast ice melts in response to a warming ocean and atmosphere. Our main challenge is the chaotic nature of ice fracture, which we will address by applying machine learning techniques to the wealth of satellite

And Now, Please Welcome Our New Additions

The following people joined the CICOES staff between October 2020 and September 2021.
observations of Arctic sea ice. In doing so, we constrain the two-way relationship between floe sizes and deformation. Finally, we will include these effects in a continuum sea-ice model to improve sea-ice predictions and climate simulations.

GUANG-SIN LU
I joined the Earth-Ocean Interaction Group at NOAA-PMEL and started work with Dr. Dave Butterfield in August. Prior to arriving at PMEL, my research career focused on describing interactions between microorganisms and their geochemical environments in the terrestrial and shallow-sea hydrothermal system. The discovery of deep-sea hydrothermal vent ecosystems expanded our understanding of the requirements for life. The high flux of reduced chemicals discharged from hydrothermal vents is able to shape fauna communities and chemosymbiotic microbial populations. The EOI group had discovered many deep-sea hydrothermal vents in the Pacific Ocean and collected thousands of geochemical sets. In my new role, I hope to draw upon my previous experiences to (1) systematically compile statistics of hydrothermal geochemistry from different vent types, vent substrate, and its geological tectonics, (2) quantify the in-situ bioavailable energy obtained from the chemolithoautotrophic metabolic reaction, (3) understand the interaction between seawater, hydrothermal fluids/gases, mineral precipitates, and microbes.

ANNIKA MARGEVICH
I am collaborating with PMEL’s Ocean Climate Stations team to study the 70-year meteorological and oceanographic time series from Ocean Weather Station Papa (OWS P) located in the Gulf of Alaska. Our goal is to better understand how trends in precipitation and evaporation have been changing and how these changes may be related to the previously observed freshening of the sea surface in the region.

JENS NIELSON
I am a research scientist working with Calvin Mordy at NOAA. I am a biological oceanographer, working primarily with plankton dynamics, long-term data sets and marine ecosystem ecology. Much of my current research focuses on assessing climate-mediated influences on plankton and primary production in the Bering Sea, Northern Bering Sea, and US Arctic. I work with a range of data such as satellite, survey, and in situ ocean monitoring arrays to examine phytoplankton ecology.

JON SHARP
I am a postdoctoral researcher working with the Biogeochemical Argo and Ocean Carbon groups from NOAA PMEL to study marine biogeochemical processes and tracer distributions, both globally and within the California Current Ecosystem. To do this work, I’m using measurements from an array of autonomous profiling floats, as well as research vessels and fixed ocean moorings. Some of my research focuses include characterizing air-sea carbon dioxide flux, quantifying marine primary production and respiration, and monitoring the progression of ocean acidification. All of these are important in the context of marine ecosystem functioning and biogeochemical cycling, including the cycling of carbon, which has both long-term and short-term impacts on the Earth’s climate.

HALEY STAUSDYER
I am working with the Office of the Washington State Climatologist (OWSC) with Dr. Nick Bond and Karin Bumbaco. I am helping to update a paper the OWSC published in 2013 alongside the former deputy director of the Oregon Climate Service Dr. Kathie Dello on heat waves in the Pacific Northwest. I also help write the monthly OWSC newsletter. When I’m not working with the OWSC, I help with whatever other odd jobs Jed Thompson needs dealt with on the administrative side of CICOES, including contributing to this magazine! I graduated from the UW in June of 2021 and plan to begin graduate school in fall of 2022. In my spare time, I enjoy playing board games, spending time with pets, cooking, and exploring new places.
The following summaries, organized by research theme, were selected to represent the broad range of research projects and collaborations happening at CICOES in 2021.

**CLIMATE AND OCEAN VARIABILITY**

**CRYSTAL RAYMOND**  
*Northwest Water Year Impacts and Resilience Planning*

The objective of this project is to provide the water sector of Washington and Oregon with resources to improve understanding and planning for drought and other climate related impacts. This objective will be accomplished through annual water year recap and outlook meetings, annual sectoral specific assessments of water year impacts, and an evaluation of the potential to include long-term climate planning in existing requirements for water system plans.

**YOLANDE SERRA**  
*High-Resolution Large-Ensemble Probabilistic Forecasts of Precipitation for the Northwestern US*

This project relies on the University of Washington Weather Research and Forecasting Mesoscale Ensemble (UWME) forecasting system to provide an end-to-end convection-permitting ensemble system with sophisticated calibration. This system serves as a prototype for a national system to be developed by NOAA under the auspices of the Unified Forecasting System (UFS).

**EARTH SYSTEMS AND PROCESSES**

**JOSEPH RESING**  
*Earth Ocean Interactions Plumes (EOI-Plumes)*

The EOI Plumes group examines the impact of the solid Earth on the chemistry of the oceans. Of primary interest is the role that these interactions play in adding iron to the surface ocean where it behaves as a trace-nutrient that regulates primary productivity in important highly productive parts of the global Ocean. In addition to examining inputs from coastal margins, sea ice, and aerosol dust, a significant effort by EOI Plumes focuses on understanding how and if iron released from submarine volcanoes and methane seeps reaches the shallow ocean where it impacts ocean productivity.

**DAVID BUTTERFIELD**  
*Earth-Ocean Interactions Program Vent and Seep Chemistry*

The Earth-Ocean Interactions Vent and Seep Chemistry project discovers hydrothermal and cold seep vents in the ocean and investigates their importance for chemosynthetic communities on the seafloor and their impact on ocean chemistry. The project also conducts measurements of dissolved methane in the coastal zone to evaluate the air-sea flux of this greenhouse gas and understand methane cycling. Using specialized sampling and sensing instruments and a broad range of chemical analysis, we investigate sub-seafloor chemical, biological and geological processes. This research supports the NOAA strategic goals for ocean exploration, ocean stewardship, healthy oceans, and developing observing technology.
ENVIROMENTAL CHEMISTRY AND OCEAN CARBON

CALVIN MORDY
Repeat Hydrography – Deep Sea Nutrient Content (Task II Nutrients)

This research program contributes to the Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP), a systematic and global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, carbon dioxide (CO2), nutrients, and related parameters. GO-SHIP reveals much about internal ocean pathways and their variability, which impacts carbon and heat sinks on decadal time scales. It is designed to document and assess changes in the ocean’s biogeochemical cycles and transport of heat and freshwater in response to natural and/or man-induced activities. GO-SHIP provides the bulk of global-scale deep ocean nutrient measurements.

WEI CHENG & DARREN PILCHER
Projected Changes in Carbon Cycling and Aragonite Saturation in the Bering Sea

This project uses a combination of regional model output and in-situ data from ships and autonomous vehicles to improve our scientific understanding of ocean carbon cycling and acidification in the Bering and Chukchi Seas. Model output has generated both long-term projections for changing ocean chemistry in the Bering Sea used in strategic fisheries management planning, and short-term forecasts used for tactical planning and producing products for the fisheries management pipeline. Autonomous vehicle output elucidates historical trends in ocean carbon uptake and supports model validation.

OCEAN AND COASTAL OBSERVATIONS

DONGXIAO ZHANG
TASK II-GTMBA

The Global Tropical Moored Buoy Array (GT-MBA) is the foundation of observing systems in each of the three tropical oceans. CICOES GTMBA research on tropical atmosphere-ocean interaction seeks to improve understanding and prediction of phenomena such as the El Niño-Southern Oscillation (ENSO), the seasonal monsoons, the Indian Ocean Dipole (IOD) and tropical Atlantic climate variability. These are the dominant modes of ocean-atmosphere variability that have profound global impacts on weather and climate, as well as marine ecosystem through ocean and atmospheric teleconnections.

YONG WEI
Task II Tsunami

During the reporting period, the CICOES/National Center for Tsunami Research (NCTR) team has continued to thrive and has accomplished most of the goals set for 2021. The main efforts include: 1) continuing to enhance SIFT capability for the Tsunami Warning Centers through new DART 4g arrays and GNSS implementation in SIFT; 2) continuing working on tsunami hazard assessment projects with federal, state, and international agencies for a variety of international and national coastal communities; 3) continuing to collaborate with UNESCO IOC to provide training, guidance, and tool development towards building community-level models for the Pacific and Caribbean regions; 4) continuing to explore capability building and advanced technology through collaboration with other agencies and university partners. The group is slightly behind in SIFT 5.0 delivery due to administrative restrictions and shortage of testing force due to the pandemic. This situation will be largely improved by a new hire in the near future.
MARINE ECOSYSTEMS

ALBERT HERMANN
Projecting climate impacts on the Gulf of Alaska using a 3km Regional Ocean Model with biogeochemistry

The Gulf of Alaska (GOA) is a region impacted by multiple atmospheric drivers (the Aleutian low, the Pacific Decadal Oscillation, and ENSO), with strong tidal mixing and complex topography, and is located at the interface of rapidly changing freshwater cycles (glacial retreat). In such regions, there is a critical need for a high spatial resolution model that can resolve local processes while spanning known ecosystem boundaries within, and between, the eastern and western GOA. This project aims to modify an existing 3 km resolution Regional Ocean Model System (ROMS) with 42 vertical layers configured for the GOA (GOA-ROMS-3K) that is coupled to an 11-component ecosystem model, to project future ocean conditions through 2100 under low and high emission scenarios.

IVONNE ORTIZ
The Role of Cetaceans in Alaska Marine Ecosystems

In partnership with the Cetacean Assessment and Ecology Program at MML, this project conducts multidisciplinary research aimed to inform and improve management, including: 1) aerial-based (manned and unmanned), vessel-based, and shore-based surveys to collect visual sightings, photo-identification and photogrammetry, biological and environmental sampling, instrument deployment; 2) passive acoustic monitoring; 3) telemetry; 4) genetics and ‘omics; 5) chemical tracers including POPs, stable isotopes and hormones; 6) quantitative modeling using abundance, demographic, spatial, habitat, genetic, trophic, and energetic data, and 7) investigation of new technologies to improve the collection of data on the density/abundance, distribution, population genetics and stock structure, life-history parameters, timing, and behavior of marine mammals.

ANDRE PUNT
Sorting through stomachs: Using two decades of Hake diets to update ecosystem models and test hypotheses on predator consumption in the California Current

Pacific hake are an important component of the commercial fisheries on the West Coast. They are also abundant predators in the California Current Ecosystem (CCE). Hake predator-prey dynamics will be analyzed using the CEATTLE model, which has previously been applied to groundfish in Alaska. This will enable an evaluation of the influence of hake in the CCE food web using an updated ecosystem model with time-series of newly available hake diet data and a newly parameterized multispecies bioenergetics model.

SARAH WEBSTER
Testing and Improvements for In-Situ eDNA Water Filtration Sampler

The goal of this project is to upgrade SADIE (Sampling At Depth In situ E-DNA) water filtration sampler from a 100m capability to a 1500m capability, perform the first full field trial, and iterate on the design for the second article. SADIE is designed to be attached to a CTD carousel and filter water samples in situ, alleviating the risk of contamination from filtering samples on the ship. The at-sea testing will enable us to compare in situ filtration results with results from traditional techniques where water samples are collected and filtered in the lab on board the ship.
**POLAR STUDIES**

**MUYIN WANG**  
*Task II Arctic*

The goals of the Project are to 1) Maintain an up-to-date Arctic change detection activity for NOAA that includes improved understanding and communication of Arctic change, and local to global impacts, to scientists, policy makers, the Arctic Council, fisheries managers, and the public, 2) Improve NOAA’s operational sea ice and weather forecasts and knowledge of physical impacts on ecosystems in the Alaskan Arctic, and 3) Assess climate models uncertainties, and provide projections of Arctic climate at pan-Arctic and regional scales.

**WEI CHENG & MICHAEL STEELE**  
*Arctic freshwater pathways and their impact on North Atlantic deep water formation in a hierarchy of models*

Freshwater transport from the Arctic to the Atlantic Ocean is expected to increase or experience changes in its pathway owing to changing winds, declining sea ice and increasing liquid freshwater, but the details of these changes and what ocean-cryosphere feedbacks are invoked as a result are not well understood. The goal of this project is to investigate freshwater pathways (both oceanic and ice) between the Arctic and subpolar North Atlantic, their controlling mechanisms, and interactions with North Atlantic deep water formation and the Atlantic Meridional Overturning Circulation (AMOC).

**HUMAN DIMENSIONS**

**MARK SCHEUERELL**  
*A simulation and case-study comparison of existing and spatio-temporal methods to apportion coastwide catch limits for subregional management*

The North Pacific Fisheries Management Council (NPFMC) sets Total Allowable Catch (TAC) for all stocks and complexes listed in several Fisheries Management Plans. Currently, harvest regulations occurring for strata within each stock are informed by applying a smoother of available (and often highly uncertain) area-specific survey indices. However, this approach can result in large interannual variability in strata-specific harvest regulations, especially for stocks that are more challenging to survey or surveyed less frequently. In this project, we will investigate multiple alternative approaches to determine apportionment of subregional groundfish harvest in the Gulf of Alaska.

**SUNNY JARDINE**  
*Columbia Basin Salmon Conservation Planning*

We develop and apply methods for analyzing sparse cost data for salmon riparian habitat restoration projects. In our application, we link data from over 1,200 completed fish passage barrier correction projects with geospatial datalayers to generate relative cost estimates for over 27,000 documented barriers across Washington and Oregon. These cost estimates will be used by resource managers to prioritize barrier correction funding, which is projected to dramatically increase in the coming years as state and local agencies work to restore access to spawning habitat.
By Natalie Monacci

AS LEAD OF THE Ocean Acidification Research Center in the College of Fisheries and Ocean Sciences at the University of Alaska Fairbanks, I collaborate with Dr. Jessica Cross, a research oceanographer at NOAA’s Pacific Marine Environmental Laboratory, to monitor ocean acidification in Alaska’s waters.

Coastal regions around Alaska are experiencing some of the most rapid onset of ocean acidification events in the United States. Our objectives will lead to a comprehensive carbonate chemistry assessment of Alaska’s four Large Marine Ecosystems in the Gulf of Alaska: Bering Sea, Chukchi Sea, and Beaufort Sea. Integrating the observational data with species response studies, ocean acidification forecast models, and human impact assessments is a critical step forward to identify important ecosystem vulnerabilities, uncover areas of unexpected resilience, and identify opportunities for adaptation and mitigation.

Dr. Cross and I are working towards three main objectives: (1) We will continue work in the Distributed Biological Observatory to understand how environmental transitions will impact keystone ecosystem species from the northern Bering Sea to the Arctic Basin; (2) We will also work with other CICOES partners, the NOAA Alaska Fisheries Science Center, and the National Marine Fisheries Service to link chemical oceanography data with biogeochemical models, laboratory species response studies, and fisheries management initiatives such as the NOAA Ecosystem Status Reports for the Bering Sea and Gulf of Alaska; (3) We will continue operational and data management for the long-term mooring sites in the Bering Sea and Gulf of Alaska as part of the National Ocean Acidification Observing Network.

This work is funded by NOAA’s Arctic Research Program and the Ocean Acidification Program under the CICOES theme Environmental Chemistry and Ocean Carbon.
By Hannah Hickey

**FRESHWATER IS ACCUMULATING IN THE ARCTIC OCEAN.** The Beaufort Sea, which is the largest Arctic Ocean freshwater reservoir, has increased its freshwater content by 40% over the past two decades. How and where this water will flow into the Atlantic Ocean is important for local and global ocean conditions.

A study from the University of Washington, Los Alamos National Laboratory and the National Oceanic and Atmospheric Administration shows that this freshwater travels through the Canadian Archipelago to reach the Labrador Sea, rather than through the wider marine passageways that connect to seas in Northern Europe. The open-access study was published Feb. 23 in Nature Communications.

“The Canadian Archipelago is a major conduit between the Arctic and the North Atlantic,” said lead author Jiaxu Zhang, a UW postdoctoral researcher at the Cooperative Institute for Climate, Ocean and Ecosystem Studies. “In the future, if the winds get weaker and the freshwater gets released, there is a potential for this high amount of water to have a big influence in the Labrador Sea region.”

The finding has implications for the Labrador Sea marine environment, since Arctic water tends to be fresher but also rich in nutrients. This pathway also affects larger oceanic currents, namely a conveyor-belt circulation in the Atlantic Ocean in which colder, heavier water sinks in the North Atlantic and comes back along the surface as the Gulf Stream. Fresher, lighter water floats at the top, and clockwise winds in the Beaufort Sea push that lighter water together to create a dome.

“We know that the Arctic Ocean has one of the biggest climate change signals,” said co-author Wei Cheng at the UW-based Cooperative Institute for Climate, Ocean and Ecosystem Sciences. “Right now this freshwater is still trapped in the Arctic. But once it gets out, it can have a very large impact.”

Fresher water reaches the Arctic Ocean through rain, snow, rivers, inflows from the relatively fresher Pacific Ocean, as well as the recent melting of Arctic Ocean sea ice. Fresher, lighter water floats at the top, and clockwise winds in the Beaufort Sea push that lighter water together to create a dome.

“**RIGHT NOW THIS FRESHWATER IS STILL TRAPPED IN THE ARCTIC. BUT ONCE IT GETS OUT, IT CAN HAVE A VERY LARGE IMPACT.”**
When those winds relax, the dome will flatten and the freshwater gets released into the North Atlantic.

"People have already spent a lot of time studying why the Beaufort Sea freshwater has gotten so high in the past few decades," said Zhang, who began the work at Los Alamos National Laboratory. "But they rarely care where the freshwater goes, and we think that’s a much more important problem.”

Using a technique Zhang developed to track ocean salinity, the researchers simulated the ocean circulation and followed the Beaufort Sea freshwater’s spread in a past event that occurred from 1983 to 1995.

Their experiment showed that most of the freshwater reached the Labrador Sea through the Canadian Archipelago, a complex set of narrow passages between Canada and Greenland. This region is poorly studied and was thought to be less important for freshwater flow than the much wider Fram Strait, which connects to the Northern European seas.

In the model, the 1983-1995 freshwater release traveled mostly along the North American route and significantly reduced the salinities in the Labrador Sea — a freshening of 0.2 parts per thousand on its shallower western edge, off the coast of Newfoundland and Labrador, and of 0.4 parts per thousand inside the Labrador Current.

The volume of freshwater now in the Beaufort Sea is about twice the size of the case studied, at more than 23,300 cubic kilometers, or more than 5,500 cubic miles. This volume of freshwater released into the North Atlantic could have significant effects. The exact impact is unknown. The study focused on past events, and current research is looking at where today’s freshwater buildup might end up and what changes it could trigger.

"A freshwater release of this size into the subpolar North Atlantic could impact a critical circulation pattern, called the Atlantic Meridional Overturning Circulation, which has a significant influence on Northern Hemisphere climate," said co-author Wilbert Weijer at Los Alamos National Lab.
Sleeper sharks (genus *Somniosus*) are slow-growing and long-lived. Sharks in this genus are estimated to reach ages of 250-300 years and take decades to reach sexual maturity. Two species within this genus, the Pacific sleeper shark (*S. pacificus*) and the Greenland shark (*S. microcephalus*), are primarily differentiated by their geographic distributions, with the Pacific sleeper shark commonly found in deep waters in the Pacific, from northern Baja California to the Chukchi Sea, while the Greenland shark occupies waters in the Atlantic, from the Arctic Circle to the Gulf of Mexico. While both species are caught as bycatch in other fisheries, the Greenland sharks have also been targeted by fisheries in Greenland, Iceland, and Norway. While data deficiencies remain, slow growth rates could make them vulnerable to overfishing and population declines.

Previous molecular work has sought to confirm the species status of both species and characterize the genetic structure within each species. Few population genetics studies have focused on these species, but multilocus studies have confidently separated *S. pacificus* and *S. microcephalus*. Additionally, some evidence has suggested these two species may hybridize. Previous research has consistently found a lack of population genetic structure within each species.

I work with CICOES researcher Andrés López at the University of Alaska Fairbanks, alongside collaborators from NOAA’s Alaska Fisheries Science Center and California State University, Fullerton, to address questions of species status and genetic structure with a much larger molecular dataset: leveraging a reduced representation library method, we identified over 30,000 single nucleotide polymorphisms (SNPs) from across the genomes of each species. The results support a clear genetic differentiation between *S. pacificus* and *S. microcephalus*, with no evidence of introgression, and provide population size estimates in the high hundreds. Moreover, our findings support genetic homogeneity within each species.
IN 2020, NORTH SLOPE BOROUGH, NOAA, UW, AND CICOES SCIENTISTS COLLABORATED TO MONITOR WHALES IN NORTHERN ALASKA

By NOAA Fisheries Staff

IN THE ARCTIC, each year before daylight disappears and winter arrives, thousands of bowhead whales make their fall migration across the Beaufort Sea off northern Alaska. The timing of the migration is something Alaska Indigenous communities and scientists can count on. However, 2019 was not a normal year.

WHAT HAPPENED IN 2019?
The year 2019 was unusual in several ways. It was Alaska’s hottest year on record. Sea surface temperatures were significantly warmer than average. There also were salmon die-offs across the state as river temperatures, in some areas, hit 70 degrees Fahrenheit.

The timing of the bowhead whale migration was also different. By late October, the largely subsistence-based community of Utqiaġvik, Alaska, had seen few whales. Never in recent memory had whales come so late. NOAA researchers observed that both the edge of the sea ice and the bowhead whales were farther north than in previous years of surveying the area in Bureau of Ocean Energy Management-funded aerial studies.

"Whales are a vital part of our communities. Bowheads help us to feed our communities and are central to many of our cultural traditions. Hunting whales has been our way of life for thousands of years," said North Slope Borough Mayor Harry K. Brower, Jr.

"In 2019, the whales arrived two to three months later than normal and few came close to shore, making it difficult for hunters to reach them. We were really worried that this might become the new normal," said Robert Suydam, senior wildlife biologist, North Slope Borough.

The Bureau of Ocean Energy Management had been funding surveys since 1979 but 2019 was the last year of their funding. So, the North Slope Borough, through the efforts of Mayor Brower, supported an aerial survey in 2020 to collect data on the bowhead whale migration timing, density, distribution, and activities in the western Beaufort Sea.

Collecting data on the bowhead whale migration in the fall of 2020 was particularly important to the community. The changes in the bowhead whale migration in 2019 meant that Utqiaġvik hunters were only able to harvest one bowhead whale very late in the season in mid-November. More typically, whales in Utqiaġvik are harvested from about mid-September through mid-October.

HIGHLIGHTS OF 2020 NORTH SLOPE BOROUGH SURVEY

For scientists, conducting an aerial survey during autumn 2020 would enable them to compare results with data collected over
WHEN IT COMES TO OBSERVING BOWHEAD WHALES IN ARCTIC WATERS, SCIENTISTS AND INDIGENOUS COMMUNITIES ARE LEARNING TO “EXPECT THE UNEXPECTED.”

Scientists attribute the dense whale concentrations to optimal feeding conditions set up by perfect environmental conditions. Winds near Utqiaġvik during late summer and early autumn this year were favorable for creation of a “krill trap.” There were repeated occurrences of pronounced upwelling, which brings krill onto the shallow waters of the continental shelf. This was followed by relaxed winds that could have promoted the aggregation of krill. Discharge from the Meade River into Dease Inlet in the early part of October was more than twice the average amount. That freshwater discharge potentially creates stronger nearshore weather patterns outside the barrier islands, which can further concentrate krill and promote bowhead feeding.

Throughout the survey, scientists also observed small numbers of gray, humpback, and fin whales and clusters of beluga whales. They also encountered a few harbor porpoises, walruses, seals and a polar bear mom and her cub. The polar bears were feeding on a large whale carcass located on a barrier island west of Camden Bay.

Ferguson was joined by long-term research partners from Cooperative Institute for Climate, Ocean, and Ecosystem Studies at the University of Washington, Amelia Brower and Amy Willoughby, and Clearwater Air. Due to COVID-19, NOAA Fisheries, North Slope Borough and research partners adopted strict protocols. This ensured the safety of the community of Utqiaġvik (where the team was housed) and the observers and pilots. Overall, it was a really successful survey on all counts.

Bowhead whale feeding aggregation, sighted approximately 60 km east of Point Barrow, Alaska (event 145), North Slope Borough Autumn Aerial Surveys Flight 14, on 15 October 2020. Photo: NOAA Fisheries.
ADDING ACOUSTIC INTELLIGENCE TO AN AUTONOMOUS UNDERWATER GLIDER

By John Horne and Chad Lembke

THE INCREASED USE OF OCEAN ROBOTS, such as autonomous underwater vehicles (AUVs), is expanding the resolution, range, and duration of physical and biological measurements collected throughout the water column in the world’s oceans. Remote sensing instrument packages installed within AUVs measure physical, chemical, and biological water properties as they sample from the surface to near the ocean floor or to their depth limitation.

Biological measurements typically consist of plant pigment concentrations that are used as an index of microscopic phytoplankton abundance. But what about distribution and density measurements of larger animals such as shrimp, squid, and fish that are found deep in the water column, form distinct layers, and migrate hundreds of meters to shallow water every night?

In a collaborative effort among NOAA (NOAA Ocean Exploration and National Centers for Coastal Ocean Science), universities (University of Washington, University of South Florida, Florida International University, and Nova Southeastern University), and industry (Teledyne Webb Research and Kongsberg Underwater Technology Inc.), a Slocum glider was equipped with a Simrad WBT mini echosounder to measure macroscopic animals during the glider’s descents from the surface to bottom waters.

Collecting active acoustic data from an underwater glider is not unique, but what is special about this technological development is the availability of data in “glider time.” Until now, echosonders on gliders stored data on internal memory cards that could only be retrieved and read once the vehicle had been recovered. No data was available while the glider was deployed because there was no way to send large data volumes to shore. Therefore collected measurements could not be used to alter the glider’s path to investigate something interesting. The addition of an “acoustic brain” solves the challenge of sending large data volumes through a limited satellite data channel. An additional small computer was integrated into the glider sensor package to read acoustic data during each dive, compute a suite of statistical metrics called “Echometrics,” which characterize the distribution of biomass through the water column (below), and then transmit those metrics and a low-resolution echogram through the glider’s satellite connection to the pilots and scientists who deployed the glider. The use of Echometrics and low-resolution echograms to synthesize the acoustic data record solves the problem of limited bandwidth in satellite data transmissions as raw acoustic data are about 40 times larger than the Echometric values that are transmitted.

The availability of Echometric values and data snapshots provides pilots and scientists with additional information to be used to direct the glider during its deployment. A glider’s sampling plan or mission can be altered during a deployment to investigate features that are revealed by the data. Higher resolution measurements of animals, monitoring change in biological aggregations, predator-prey interactions, and investigating deep scattering layers as they migrate to the surface at night or back down to deep water before dawn are now possible with the addition of an echosounder, acoustic brain, and a lot of computer programming. The acoustic glider can now provide near real-time insight into distributions and dynamics of animals that inhabit mesopelagic waters of the ocean.

Screenshot of the glider mission control software showing individually colored plots of “Echometric” values through two dives. The x-axis represents time and the y-axes represent scales for each metric plotted. The echosounder collects data during dive descents, so values are shown until the end of one dive and then the plots jump to the start of the next dive. In the figure the first descent occurs during the first quarter of the graph. The second dive starts after the ascent and is located in the final quarter of the graph. Image courtesy of Chad Lembke, University of South Florida.
REMOTELY PILOTED SAILBOATS MONITOR ‘COLD POOLS’ IN TROPICAL ENVIRONMENTS

By UW News Staff

CONDITIONS IN THE TROPICAL OCEAN affect weather patterns worldwide. The most well-known examples are El Niño or La Niña events, but scientists believe other key elements of the tropical climate remain undiscovered.

In a study recently published in Geophysical Research Letters, scientists from the University of Washington and NOAA’s Pacific Marine Environmental Laboratory use remotely piloted sailboats to gather data on cold air pools, or pockets of cooler air that form below tropical storm clouds.

“ Atmospheric cold pools are cold air masses that flow outward beneath intense thunderstorms and alter the surrounding environment,” said lead author Samantha Wills, a postdoctoral researcher at the Cooperative Institute for Climate, Ocean and Ecosystem Studies. “They are a key source of variability in surface temperature, wind and moisture over the ocean.”

The paper is one of the first tropical Pacific studies to rely on data from a type of uncrewed surface vehicle (USV) called Saildrones, wind-propelled sailing drones with a tall, hard wing and solar-powered scientific instruments. Co-authors on the NOAA-funded study are Dongxiao Zhang at CICOES and Meghan Cronin at NOAA.

Atmospheric cold pools produce dramatic changes in air temperature and wind speed near the surface of the tropical ocean. The pockets of cooler air form when rain evaporates below thunderstorm clouds. These relatively dense air masses, ranging between 6 to 125 miles (10 to 200 kilometers) across, lead to downdrafts that, upon hitting the ocean surface, produce temperature fronts and strong winds that affect their surroundings. How this affects the larger atmospheric circulation is unclear.

“Results from previous studies suggest that cold pools are important for triggering and organizing storm activity over tropical ocean regions,” Wills said.

To understand the possible role of cold pools in larger tropical climate cycles, scientists need detailed measurements of these events, but it is hard to witness an event as it happens. The new study used Saildrone USVs, to observe the phenomena.

Over three multi-month missions between 2017 and 2019, 10 Saildrones covered over 85,000 miles (137,000 kilometers) and made measurements of more than 300 cold pool events, defined as temperature drops of at least 1.5 degrees Celsius in 10 minutes. In one case, a fleet of four vehicles separated by several miles captured the minute-by-minute evolution of an event and revealed how the cold pool propagated across the region.

THE PAPER IS ONE OF THE FIRST TROPICAL PACIFIC STUDIES TO RELY ON DATA FROM SAILDRONES

“This technology is exciting as it allows us to collect observations over hard-to-reach, under-sampled ocean regions for extended periods of time,” Wills said.

The paper includes observations of air temperature, wind speed, humidity, air pressure, sea surface temperature and ocean salinity during cold pool events. The authors use the data to better describe these phenomena, including how much and how quickly air temperatures drops, how long it takes the wind to reach peak speeds, and how sea surface temperature changes nearby. Results can be used to evaluate mathematical models of tropical convection and explore more questions, like how the gusts created by the temperature difference affect the transfer of heat between the air and ocean.
HOW’S THE SNOW on Northwest mountains during the 2020-2021 winter? Overall a little deeper than normal, but it depends where you look.

A new collaboration between the University of Washington and the Northwest Avalanche Center (NWAC) lets you see how the current snow depth compares to past years for nine sites in Washington and two in Oregon.

The new mountain snow depth tool is freely available on the Office of the Washington State Climatologist’s website. It replaces a tool made more than a decade ago that collected snow depth data from the NWAC website to create a simple graphic on the state climatologist’s website.

“When that display wasn’t working, that’s the one where we would get emails from ski enthusiasts or other meteorologists or climatologists. To us that was a good sign that we should rebuild it,” said Karin Bumbaco, a UW research scientist who is the assistant state climatologist.

The new version, built with support from Tableau, is interactive, displays more data and is more reliable. It lets users explore differences in mountain snow depth from one season to the next and create a graphic of the results.

“This is a tool that people in the weather community, like meteorologists and climatologists, as well as snow recreationalists, can use to communicate the current snow conditions and how they relate to average conditions and previous years,” Bumbaco said.

A default view shows the current year compared to the past 30 years of data at a single location. Changing the settings can display measurements back as far as 1927 for the longest-running stations, on Mount Baker and Paradise on Mount Rainier. Measurements go back to 1974 for the two most recent sta-
tions, at Mount Hood Meadows and Timberline in Oregon.

The Northwest Avalanche Center monitors mountain snow depth for their forecasting operations as avalanches pose risk to roadways and people venturing onto the winter slopes. Data are entered 12 times a year, on the 1st and the 15th of each month, during the monitoring season from Nov. 15 to May 1.

The monitoring sites are part of the center’s mountain weather station network. Some sites are owned by the Washington state Department of Transportation, while others are partnerships between NWAC and the transportation department, ski areas or national parks. While other measures exist, they don’t have the same history of similar measurements.

“We use this tool to track how our snow depth is building across NWAC’s forecast region in a historical context,” said Dennis D’Amico, meteorologist and forecast director at the Northwest Avalanche Center, who worked on the project. “Local professionals and recreationists track this report all season long. This new tool will allow them to explore historical snow depth data in a modern visualization tool at winter recreation access points.”

The new tool complements a previous UW data visualization looking at long-term weather trends. Official trends in mountain snowpack are measured in snow-water equivalent, or the amount of water when the snow is melted. Those trends vary throughout the state and generally show long-term declines of about 3%-10% per decade, Bumbaco said.

“Tableau Public is an ideal medium for this sort of civic, historical data,” said Blair Hutchinson, product manager at Tableau. “The visual dashboards we created provide people with a great way to interact and make informed decisions regarding the snowpack on a seasonal scale.”

The many people seeking outdoor recreation during the pandemic are lucky that as of early February 2021, most of the 11 stations measured slightly above-normal snow depth. The winter had been forecast to be an La Niña year, which is often slightly cooler and wetter in the Northwest, Bumbaco said. It delivered on half that promise, with December-January conditions generally warmer and wetter than average.

The spring 2021 outlook continues to predict conditions slightly cooler and wetter than normal, Bumbaco said, which means we’re likely to see a healthy snowpack.
CICOES RESEARCHERS AUTHORED THE FOLLOWING PUBLICATIONS BETWEEN OCTOBER 2020 AND OCTOBER 2021


Doherty, S. J., et al. (2021), Modeled and observed properties related to the direct aerosol radiative effect of biomass burning aerosol over the
Southeast Atlantic, Atmos. Chem. Phys. Discuss., 2021, 1-88, doi:10.5194/acp-2021-333.


Essington, T. E., M. E. Matta, B. A. Black, T. E. Helser, and P. D. Spencer (2021), Fitting growth models to otolith increments to reveal time-varying growth, Canadian Journal of Fisheries and Aquatic Sciences, 0(ja), null, doi:10.1139/cjfas-2021-0046.


CICOES BRIDGES FOUR MAJOR INSTITUTIONS and can be a management challenge because of its complexity. The UW infrastructure ensures CICOES’ ability to manage large financial and human resources portfolios, to meet reporting requirements, to maintain and improve the required compliance systems and procedures, and to provide the best possible overall business management of the Institute’s resources. CICOES administrators at UW, OSU and UAF as well as local NOAA administrators have formed a strong partnership that works efficiently and contributes to the success of the Institute.

CICOES is funded through four tasks:

**TASK I**
- Three to four postdoctoral scholars (at UW, OSU and UAF) on annual appointments, renewable for a second year.
- Internal research development grants to CICOES PIs (at UW, OSU and UAF), mainly to provide seed funding for new areas of research
- Funding for three to five UW graduate student quarters
- Visiting scientists on leave from their home institutions
- Honoraria and travel expenses for short-term visitors
- Education and outreach activities
- A portion of administrative support

**TASK II**
- Task II serves as a vehicle for funding 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**
- 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 III also supports postdoctoral research scholars housed at NOAA and graduate students working in a variety of campus departments.

**TASK IV**
- Task IV includes all sponsored research funding received that’s not part of the NOAA cooperative agreement (e.g., grants from NSF or NPRB)

The CICOES/NOAA Cooperative Agreement funding for the period April 1, 2020 - March 31, 2021 totals $23,175,568. CICOES’ funding for non-Cooperative Agreement grants for the same period (Task IV) is an additional $2,926,181.

The following charts break down Cooperative Agreement funding by tasks and themes.

**FINANCE AND INITIATIVES**

**GOOD IDEA**

- PI and NOAA sponsor agree to fund project
- PI submits abstract and budget to CICOES staff at their local university
- UAF/OSU sponsored research office submits letter of commitment to CICOES staff

**THE WINDING PATH OF A COOPERATIVE AGREEMENT PROPOSAL** Although NOAA has already agreed to fund projects through the CICOES Cooperative Agreement with UW, UAF, and OSU, a proposal still follows a long path to go from an idea to a research project.
### TOTAL FUNDING:

**$23,175,568**

<table>
<thead>
<tr>
<th>Program</th>
<th>Funding ($)</th>
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<tbody>
<tr>
<td>Postdoctoral Program</td>
<td><strong>UW:</strong> $165,800</td>
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<td><strong>UAF:</strong> $94,488</td>
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<td><strong>OSU:</strong> $83,198</td>
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<td>Other Funding</td>
<td><strong>$7,478</strong></td>
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<td>(see page 31)</td>
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<td><strong>$56,360</strong></td>
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<td>(4 UW quarters)</td>
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### FUNDING BY RESEARCH THEME:

- **Polar Studies** - $446,402
- **Ocean and Coastal Observations** - $5,492,530
- **Multiple** - $1,758,996
- **Marine Ecosystems: Observation, Analysis, and Forecasting** - $7,344,334
- **Human Dimensions in Marine Systems** - $191,431
- **Environmental Chemistry** - $4,302,250
- **Earth Systems and Processes** - $1,768,952
- **Climate and Ocean Variability, Change and Impacts** - $1,337,884
- **Aquaculture Science** - $532,789

### INSTITUTIONAL PROGRAMS:

Besides providing the ongoing infrastructure and support to successfully manage CICOES, the administration funds the following initiatives to improve and strengthen CICOES as an organization.

**POSTDOCTORAL PROGRAM**
- **UW:** $165,800
- **UAF:** $94,488 (sub-awarded from UW)
- **OSU:** $83,198 (sub-awarded from UW)

**DIVERSITY, EQUITY, AND INCLUSION**
- $7,478 (see page 31)

**PROFESSIONAL DEVELOPMENT**
- $8,100 (13 UW staff received funding)

**RESEARCH DEVELOPMENT GRANTS**
- $149,581
  - (see page 30)

**GRADUATE STUDENTS**
- $56,360 (4 UW quarters)

**UNDERGRAD INTERN PROGRAM**
- $103,583
  - (13 students)
RESEARCH DEVELOPMENT GRANTS

Since 2015, JISAO and now CICOES has 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, widened the eligibility pool to include non-PI Research Scientists and Postdoctoral Scholars, and now to include applicants from our partner universities. 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 scientists throughout the CICOES community. We now sponsor projects that are collaborative efforts among at least two of our three partner universities and maintain opportunities for UW-based scientists to broaden and deepen their research portfolios. While serving multiple purposes, you will see in the projects described below that this long-standing program continues to broaden and deepen the expertise of our research community. The following projects were funded in 2021.

ROLE OF THE DIURNAL CYCLE OF PRECIPITATION IN GLOBAL CLIMATE MODEL SIMULATIONS
Muyin Wang (CICOES), Aaron Levine (CICOES)

The diurnal cycle of precipitation in the Maritime Continent using observations from 33 weather stations over three years in Indonesia are investigated. This is a region where the global climate models have large precipitation biases. By comparing the diurnal cycle of precipitation in the observations to the diurnal cycle of precipitation in blended global precipitation products, we found that the global products capture the diurnal cycle of precipitation well. The diurnal cycle of precipitation is strongly tied to the land-sea breeze cycle in the region. We have found that in some locations, the land-sea breeze cycle in these observations have a large asymmetry between the strength of sea breeze and the strength of the land breeze, suggesting the role of non-linear forcing for the land-sea breeze cycle. We hypothesize that the non-linearity in the land-sea breeze cycle contributes to the poor simulation of the diurnal cycle in climate models and through upscale energy cascades influences the biases in annual mean precipitation over the Maritime Continent.

NORTH PACIFIC MOMENTUM AND HEAT FLUX VARIABILITY: A BRIDGE BETWEEN OCEAN AND ATMOSPHERE
Justin Wettstein (OSU), Nicholas Bond (UW), Melanie Fewings (OSU), Larry O’Neill (OSU), Michael Litzow (AFSC)

This project will advance our understanding of the strength and importance of multiple mechanisms of coupled northeast North Pacific ocean-atmosphere (O-A) variability (e.g., O’Neill et al. 2020) by focusing on momentum and heat flux variability across the O-A interface using novel techniques and targeting novel aspects of the coupled evolution. Understanding momentum and heat flux variability is itself scientifically meaningful and also avoids the temporally and mechanistically complex physical influences on surface variables such as sea surface temperature, sea surface height, and sea level pressure that are typically used to characterize large-scale variability. In addition, an assessment of momentum and heat flux variability provides for a direct analysis of the mechanistic bridge causing synchronous and lagged relationships inherent in coupled O-A variability. More simply, we anticipate that a targeted analysis of the variability in momentum and heat fluxes will provide insight into the robustness and evolution of leading patterns of ocean and atmosphere variability over the North Pacific, including the Pacific Decadal Oscillation, North Pacific Gyre Oscillation and Pacific North America patterns.

IS CLIMATE WARMING ASSOCIATED WITH ELEVATED PARASITE BURDEN FOR MARINE FISHES IN THE GULF OF ALASKA?
Chelsea Wood (SAFS), Andrés Lopez (UAF), Steven Bograd (SWFSC)

Funding from CICOES will allow us to collect pilot data to assess long-term (early 1900s–present day) trends in the abundance of parasites among 10 Gulf of Alaska fish species by performing parasitological dissection of liquid-preserved museum specimens held in the UW Burke Museum, UAF Museum of the North, and other natural history collections. We will use the resulting database of historical parasite abundance to identify the Gulf of Alaska regions experiencing the greatest and the least change over time in parasite abundance. We will also assess the degree to which parasite abundance may be driven by climate warming for each parasite taxon detected, by regressing annual sea surface temperature against parasite abundance using existing climate reconstructions.

CIRCULATION OVER THE EASTERN CHUKCHI SHELF: A MODEL-OBSERVATION SYNTHESIS
Wei Cheng (CICOES), Jiaxu Zhang (CICOES), Phyllis Stabenno (PMEL), Milena Veneziani (DOE), Wilbert Weijer (DOE)

The objective of the project is to provide a description of intra-seasonal to interannual variations in the eastern Chukchi shelf (ECS) circulation through a model-observation synthesis using a coupled ice-ocean model and a range of satellite and in situ observations. Specifically, we aim to 1) provide a synthesized description of the circulation pattern and its associated heat and freshwater transport in the ECS for the observational period 2010–2020, and 2) to evaluate intra-seasonal to decadal variability of ECS circulation for an extended period 1985–2020.
WORKING TOWARD TANGIBLE CHANGE

By Abby Zorn

While Diversity, Equity, and Inclusion have always been an important part 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 (then JISAO). Since then, the working group has planned and executed numerous DEI initiatives that have helped to educate employees, decrease bias in HR processes, and build community within CICOES. These working group members come from all of CICOES-UW’s locations and represent the institute’s wide range of research programs. For Executive Director John Horne, “it is important to not only support but to facilitate efforts to develop DEI awareness within our community.”

As with many groups in the DEI space, George Floyd’s murder in May 2020 and the subsequent Black Lives Matter protests inspired a broader reckoning about what institutions were doing to increase the participation of BIPOC (Black, Indigenous, People of Color) and other underrepresented groups in science. Dozens of CICOES employees attended a series of open community conversations with topics ranging from outreach and recruitment to how to improve inclusion for current CICOES employees. At these community discussions, employees shared their desires to invest more time into DEI efforts at CICOES. As a result, the DEI working group grew to include three new sub-committees to better execute on the ideas that came through during the open conversations.

The Employee Experience sub-committee has focused its efforts on how employees connect with each other and on improving the recruitment process. One initiative this sub-committee started was “Conversations,” where CICOES employees are paired up with each other or with an employee at PMEL each month. So far, this program has resulted in nearly 100 casual conversations between employees, most of whom either did not know each other at all or who knew each other by name only. One participant noted after one of these conversations that they “would not have otherwise reached out, and appreciate this simulated ‘hallway discussion.’” Lucia Upchurch, a CICOES Research Scientist at PMEL who leads this initiative, says that “Conversations” has been “an easy way to get to know new people that have joined since the pandemic forced everyone to work remotely.” She hopes it will lead to coworkers conversing more with people outside of their immediate bubbles and that it is also “increases collaboration among projects, and injects a smidge of fun and variety into our current working situation.”

The Outreach sub-committee formed to answer scientists’ calls that there be better ways to engage with underrepresented groups in the local community. The subcommittee has been in contact with Seattle MESA, an organization that helps underrepresented groups at the high school level with science, and hopes to plan outreach events through MESA’s network. Zack Gold, a CICOES postdoctoral scholar who works at the Northwest Fisheries Science Center, joined this group “to leverage the incredible science done at CICOES to support the career development and training of a more inclusive and representative generation of scientists.” One of the initiatives in this sub-committee that most excited Molly McCormley, another member and Research Scientist at the Marine Mammal Lab, was a panel that fellow scientist Burlyn Birkemeier organized so that CICOES interns could engage with individuals in the field with diverse backgrounds. Molly thought it was a great success, and that it was “quite impressive how prepared the students came and the depth of the questions that were asked, as well as the thoughtful answers the panelists were able to give.”

The programming subcommittee spearheaded a book club where over 30 CICOES employees were mailed a copy of Uncomfortable Conversations with a Black Man by Emmanuel Acho and then attended discussions to share what they learned. This group also plans joint workshops with the PMEL Diversity committee. John commented that these workshops “have all been well attended and provided great content to participants,” and that he is “grateful for the work done by both DEI committees to organize and conduct these events and to the participants to be actively engaged in the workshops.”

Looking to the future, John is excited to see the working group and subcommittees expand their efforts in the outreach and education arenas. He hopes to see the members explore how CICOES can increase exposure to STEM education and careers to those that may not have access, and how the institute can recruit future members of our workforce that will increase diversity in our community. Many CICOES scientists and PMEL colleagues participated in URGE (Unlearning Racism in Geosciences), a series of educational modules that seek to spark policy change in research institutions. Zack is looking forward to “facilitating CICOES engagement with young local scientists from underrepresented backgrounds and opening doors into the sciences while sharing the exciting work being done at the institute.” “I hope to see us make a tangible change,” adds Molly, “in whatever form that might be.”
OUTREACH & EDUCATION

NOAA LIVE!
CICOES RESEARCHERS PARTICIPATE IN INTERACTIVE WEBINARS

The NOAA Live! Alaska webinar series is a partnership between NOAA Fisheries’ Alaska Fisheries Science Center, the NOAA Alaska Regional Collaboration Network, and the National Weather Service. The webinar series, targeting Alaska students in grades 2-8, is a weekly series of interactive webinars featuring NOAA scientists, educators, and partners to explore NOAA’s work in Alaska. Each week features a different NOAA-affiliated expert and a moderated live Q&A with participants.

NOAA Live! webinars provide safe online interaction for students with the goal of sharing scientific content, demonstrating possible career paths, and providing a fun opportunity to interact with NOAA staff and connect with other kids in Alaska and across the country.

During the pandemic, NOAA has been relying on its employees and partners from throughout the Agency to volunteer their time and expertise. In the past year the following CICOES employees have stepped up and helped NOAA connect science to Alaska students and communities.

HEATHER TABISOLA - Saildrones: Sailing the Seas for Science

COLLEEN HOFFMAN - Exploring the Seafloor: Underwater Volcanoes and Their Habitats

CYNTHIA CHRISTMAN - That’s the Seal-iest Thing I’ve Heard: Studying Ice Seals in Alaska

DANA WRIGHT - Needle in a Haystack: Studying the World’s Rarest Large Whale

SOPHIE CHU - What’s up with Carbon? The 5 W’s of Ocean Acidification

CICOES INTERNS
RESEARCH INTERNSHIPS FOR UNDERGRADUATE STUDENTS

CICOES selected 13 students to participate in its 2021 summer internship program. The first nine weeks were done remotely, but in August the students were given the option to visit Seattle for a week-long research conference.

The students concluded the program by presenting research posters at UW’s Waterfront Activities Center. Each student gave a brief introduction/project preview and following the talks guests moved outdoors for a traditional poster session on the deck overlooking Lake Washington.

For many attendees it was their first in-person gathering since March 2020. The event followed UW’s Covid-19 Prevention Plan and everyone was required to wear a mask indoors regardless of vaccination status.

Each student’s poster and a recording of their presentation can be viewed on the CICOES website at:

CICOES.UW.EDU/EDUCATION/INTERNSHIPS

“...The experience I had with UW and CICOES was honestly life changing and I could not have dreamed of an internship more geared towards my research interests.” Lucy Roussa
I HAVE ALWAYS HAD AN AFFINITY FOR JELLYFISH. They were my favorite organism to watch in the aquarium, not to mention the various jellyfish-related wall hangings and trinkets I have around my house, so it was an uncanny coincidence that I was chosen to work on a CICOES intern project with Dr. Julie Keister involving Moon jellyfish (Aurelia labiata). As you can imagine, I was very excited!
A thick-horned Nudibranch I carefully caught at the Bremerton dock. This little creature was the size of my pinky and very slow moving. Using the flash from my phone camera, its vibrant colors came to life.

The focus of the project is to investigate the effects that large Aurelia aggregations have on forage fish populations in Puget Sound. My role was to improve an existing image processing protocol that uses aerial photos of jellyfish aggregations to estimate their size in square meters. This process was primarily done using ImageJ, a tool that is used to equate pixels to actual measurements. The data could then be used to make comparisons over years to gain an understanding of how the aggregations are changing. After my internship was finished, I was given the amazing opportunity to join Dr. Keister and other scientists on the R/V Rachel Carson, University of Washington’s research vessel where I would aid in field work for this project for six days.

I HAD NEVER SAILED ON A BOAT for more than a few hours, let alone a few days! I did not know what to expect, but I was completely ready to be hands-on with jellyfish. When I arrived at the dock the main objective was to set up all of the equipment so we could begin working that same day. Before we started working there were many items that needed to be checked such as all the wet lab equipment (fluorometer, centrifuge, filtration system, acetone dispenser), and all the equipment on the deck (ring nets, jellyfish measurement station, bottles, hoses). After an introduction and a safety briefing it was time to get going. We headed to our first destination of Quartermaster Harbor.

My first job on the ship was to scout for jellyfish; not a bad task if you ask me. I stood on the stern on a beautiful sunny day while I stared into the water. Once we found jellyfish, we dropped anchor, attached the ring net to the winch, and dropped it into the water. I remember making a beeline for the weighing station. The thing I wanted the most was to pick up a jellyfish with my bare hands! Thankfully moon jellyfish are not able to sting humans, so they are safe to handle. When the first net with jellyfish was on the boat I took the end of the net, unclipped the cod end, and dropped the slimy, translucent creatures into a bucket. Releasing them from the net always made a satisfying “plop” which I came to enjoy over the six days. Once the jellyfish were captured, I took them one by one from the bucket and flipped them upside down onto a ruler and measured them end to end. They ranged in size from two inches to a large dinner plate but on average they were about the width of my hand if I stretched out my pinky and thumb as far as I could. I loved every job on the ship, but handling the jellyfish had to be my favorite part.

Each day we would switch jobs with someone else, and by the end of the cruise we were all capable of working every position. One of those positions was learning how to collect zooplankton samples. This was done using an identical method to collect jellyfish, but we used a ring net with mesh that was very fine so microscopic animals could not escape. Once the net was on board it needed to be washed meticulously to ensure each zooplankter went into the catch bottle. I would then detach the bottle and pour the water into a sieve. After lots of rinsing, the zooplankton would be put in a bottle with formalin (a preservative) and stored for later analysis. Out of all of the jobs this was, in my opinion, the hardest especially if a jellyfish was caught in the net. It takes a long time to collect tiny zooplankton when they are all suspended in jellyfish goo!

I also enjoyed learning about the large, highly technical equipment on the boat such as the CTD and Multinet. These devices were deployed into the water by the winch and then controlled by a computer inside the boat.
I didn’t know what to expect, but I was completely ready to be hands-on with jellyfish.

where the bottles/nets could be closed at different depths. It was amazing to see these specialized tools in action.

One of my favorite places that we stayed overnight was the Bremerton dock. After dinner we would look over the concrete dock and gaze at the water teeming with life. Anemones, nudibranchs, crabs, jellyfish, tube worms, barnacles, limpets, seaweed, and schools of little fish all in a concentrated area. I would lay on the dock and hang my head over the side just looking at all the little things going on. I was even able to catch a few nudibranchs which are tiny, cute sea slugs smaller than your pinky. One night when I was laying there, I saw three Lions Mane jellyfish floating around the boat. They were so large and beautiful with their hundreds of thread-like tentacles drifting below them. Unlike the moon jelly, their sting is quite powerful.

IT IS BECAUSE OF THIS opportunity to work on a research vessel that I feel fully confident in my pursuit of biological oceanography. It is no longer just a dream but has become my reality. I am proud to say that I have experienced research at sea, and I will continue my education to do just that. I plan to apply to graduate programs in this field and would like to embark on similar research projects as I have been part of in Dr. Keister’s lab. The experience I’ve had with UW and CICOES was honestly life changing and I could not have dreamed of an internship more geared towards my research interests.

I would like to thank UW and all affiliates of CICOES for allowing me to become a more confident researcher and all around more confident individual. I cannot express how much I have enjoyed my time spent working on this project over the summer both remotely and in person.

SUPPORT THIS PROGRAM

Donating to the CICOES summer undergraduate internship program provides a unique opportunity to make a significant and lasting impact on the life of an aspiring scientist. Your participation will help expand our internship program to offer underrepresented students their first scientific research experience. With your help we can reach our goal of $10,000 to fund one additional summer intern, an experience that could kickstart the career of a young scientist.

Please join us as a partner today by making a gift to the Friends of CICOES Fund at the University of Washington.

giving.uw.edu
SOLUTIONS IN WATER
“You don’t go negative without some sort of intentional carbon dioxide removal,” said Dr. Brendan Carter, a principal investigator at CICOES working with the National Oceanic and Atmospheric Administration (NOAA)’s Pacific Marine Environmental Laboratory (PMEL) and their collaborators at Stony Brook University. That’s why Carter, alongside other members of the Carbon Group at PMEL, are researching a promising way to take carbon dioxide out of the atmosphere called ocean alkalinity enhancement.

The benefits of electrodialysis could be two-fold. First, there is hope that extracting acid reduces the impacts of ocean acidification on local marine life. Second, removing acid from ocean water increases the ocean’s alkalinity, allowing the ocean to take up more CO₂ from the atmosphere.

Additionally, the weak acid extracted from the ocean via this process may have its own benefits. For example, large amounts of dilute acid can potentially be used to reduce the environmental impacts of mining operations. The commercial applications for the acid that this ocean alkalinity enhancement technology produces could thus offset its costs.

However, in a future where this kind of ocean alkalinity enhancement is implemented on
Carbonic acid contributes to ocean acidification, which impacts marine life, especially shell-forming organisms.

Instead of escaping the atmosphere, CO₂ and other gasses bounce back and trap heat in the atmosphere.

The ocean absorbs CO₂ from the atmosphere.

CO₂ + H₂O → H₂CO₃

Acid is removed from the ocean via electrodialysis, allowing the ocean to take up more carbon dioxide and reducing the greenhouse gas effect.

a large scale, the amount of weak acid produced might be more than the existing market has uses for. That brings it to the same conundrum other climate interventions often grapple with: What happens to the byproduct? If the acid is easier to store on land or underground than gaseous carbon dioxide, this ocean alkalinity enhancement process may have a leg up when compared to direct air capture carbon dioxide removal techniques.

Additionally, the weak acid may even be useful for other approaches to enhance oceanic alkalinity, such as dissolving various minerals on land, effectively moving alkalinity from land rocks into the ocean. This is something that happens naturally; researchers are hoping to speed the process up. These efforts are separate from Carter’s research, but the processes could work in tandem with the electrodialysis technique. “Thinking in the long term, acid production from a method like the one we are testing might be one way to speed up these rates of dissolution. In turn, this might mean that the minerals won’t need to be scattered over such a large area, and that might then save on costs from mineral dispersal,” said Carter.

Carter could not give an exact date of when the first small-scale field experiments might take place but remained optimistic. “There are institutions all up and down the coast that are excited about the ocean acidification mitigation research and very keen to be involved in potential climate solutions,” he said. Matt Eisaman, Carter’s Co-PI at Stony Brook University, is leading the charge to start testing in various environments and is hopeful that a trial could begin as early as the first half of 2022.

Even when these initial experiments get started, they won’t be close to the scale necessary to make significant progress towards net negative CO₂ emissions. “These careful tests are going to be mitigating from kilograms to up to a few tons of carbon, so not a lot more carbon than people use commuting to work or on a cross-country flight. It’s still just a proof-of-concept study at this stage,” said Carter. More importantly, the electrodialysis requires electricity, so this approach won’t be net negative for carbon emissions until the
electrical grid is mostly decarbonized, and it may be some time before the world hits that important benchmark. That said, the approach could function as a logical use for excess output from the green energy grids of the future, when energy supplies aren’t expected to always match up in time with energy demands.

If these small-scale experiments go well, though, the technology could be used to solve immediate problems related to ocean acidification. As an example, shellfish farmers are protecting their shellfish by putting alkaline-boosting chemicals in the water with them. This prevents acidic ocean water from destroying their shells. “If shellfish farmers could get a system that pulls acid out of the seawater and does it in an automated fashion without them having to manually add the minerals, then we think that there might be commercial applications there within the next 5 to 10 years,” said Carter.

Until then, there’s still a lot that Carter’s research group has yet to figure out. “Initially it’s ocean acidification mitigation,” Carter said. “Later on, it’s carbon dioxide removal, so when do we switch from one of these to the other? And that’s among the questions that we’re researching with our modeling efforts.” Simultaneously, Carter’s colleagues at Stony Brook are doing the engineering and the budget analysis. There is a lot of first-order research that has yet to be done.

Scientists have been thinking about carbon dioxide removal technologies like this for a long time, but the research has recently been under a spotlight due to the need for negative CO$_2$ emissions highlighted by the Paris Climate Accord. “There’s a moral quandary of, if you give someone an untested way to mitigate their damages, they feel okay to do more damage,” Carter said, “so that’s been one reason why everyone is cautious when advocating, or even researching, carbon dioxide removal technology.”

“That said,” he continued, “we’re now increasingly recognizing that we need to find ways to do carbon dioxide removal and that, without small-scale pilot studies now, we’ll never be at that point where we can do a large-scale intervention in the future without it being half-baked.”

Ideally, the world will continue to focus on decarbonizing the existing energy grid while CO$_2$ removal research is ongoing. Then, once the low-hanging fruit of decarbonization has been picked, CO$_2$ removal technologies will be ready to go that last mile towards net-zero or negative emissions.

Ocean alkalinity enhancement is just one approach to carbon dioxide removal. Other proposed methods include direct air capture of carbon, direct ocean capture of carbon, regrowing coastal wetlands, reforestation, growing macroalgae, and artificial upwelling or downwelling of ocean water. Each of these approaches has pros and cons. “I’m not here to advocate for one technique over another,” Carter said. “My involvement in this project is asking the questions of, what impacts do we expect ocean alkalinity enhancement to have in the ocean, and how can we verify that this intervention is doing what we expect it should do?”

Only after much research will we know whether carbon dioxide removal technologies will be effective in preventing global warming or mitigating ocean acidification. Assuming they are, people will likely use a mix of different approaches to bring greenhouse gas emissions to below zero. Until we understand exactly what the best path forward is, though, Carter’s research group is excited to test the strengths and weaknesses of this and other climate change mitigation strategies. All of this research is done in the hope that ocean alkalinity enhancement and other approaches like it could become important tools in our solutions toolbox in the decades to come.

“If there was some way to increase the alkalinity of the ocean, that would shift the balance a little bit so that the ocean could naturally take up more CO$_2$ from the atmosphere.”
WHEN A HEAT WAVE in late June brought three consecutive days with temperatures exceeding 100°F, Washingtonians were in trouble. The Pacific Northwest is not built to withstand heat. Over half of all housing units in the Seattle metropolitan area are not air-conditioned. Without respite from extreme temperatures, the impacts of heat on human health can be dangerous – even lethal. Citizens and city leaders alike were wondering why this heat wave had happened, what they could do to mitigate the damage, and what to expect of future heat waves.

The state turned to the Office of the Washington State Climatologist (OWSC) for answers. The OWSC, a small office housed within CICOES, is called upon by the State of Washington to provide expert analysis of regional climate and weather patterns to state leaders, agencies, and the public. As such, Washington State Climatologist Dr. Nicholas Bond and Assistant State Climatologist Karin Bumbaco found their inboxes full and phones ringing off the hook as temperatures across the state began to soar.

“OWSC regularly talks with media, but interest in this heat wave exceeded any prior weather event,” said Bumbaco. Bond and Bumbaco received over fifty different requests from various reporters during the week of the heat wave. Their quotes appeared in The Guardian, KUOW, and twice in The New York Times, among other publications. “On the one hand, it was exciting to have that opportunity to talk with that many outlets,” said Bumbaco, “but on the other, all of our other project work came to a screeching halt.”

In every quote given, the OWSC’s message remained consistent. Bumbaco told the New York Times that a peer-reviewed analysis of the heat wave would need to be completed to understand just how much of it was related to climate change. “But it’s a safe assumption, in my view, to blame increasing greenhouse gases for at least some portion of this event,” she said. “When you have that warmer baseline, when you do get these extreme events, it’s just going to get that much warmer.” Indeed, less than two weeks later, a rapid attribution analysis with contributors from 21 different
The OWSC has studied this subject in the past. In 2013, Bumbaco and Bond, alongside the former deputy director of the Oregon Climate Service Dr. Kathie Dello, published a paper on the historical patterns and trends of Pacific Northwest heat waves. Their research found no trend in the frequency or strength of daytime extreme heat events, which they defined as three consecutive days above a threshold. However, the data did show an increase in the frequency of nighttime heat waves. Higher minimum temperatures prevent residents from getting a much-needed respite from extreme daytime temperatures. Without a break from the heat, the risk of heat-related illnesses increases. At the time of the 2013 study, the longest-lasting nighttime event (2009) and warmest nighttime event (2006) accompanied the most heat-related hospitalizations of any heat waves since 1987.

2021’s remarkably hot summer and other recent hot years such as 2015 sparked renewed interest in heat waves at the OWSC. Shortly following the June heat wave, the OWSC enlisted the help of Oregon State Climatologist Dr. Larry O’Neill to begin updating the 2013 paper to include the heat waves of the previous decade. The project is still in its early stages, but the OWSC is excited to provide an up-to-date summary of extreme heat events in the PNW that can inform local governments’ strategies for handling future events.

Both the 2013 paper and its in-progress update are motivated by the OWSC’s commitment to conducting impactful research and outreach efforts for local communities. The OWSC’s other current work includes gathering sector-specific impacts from the current drought in the Pacific Northwest and writing a regional impacts assessment report, setting up a real-time monitoring system for the Puget Sound, and quantifying the weather and climate conditions that are needed for wildfires to burn west of the Cascade Mountain crest. Their monthly newsletter rounds up the latest weather events and seasonal outlooks for the state of Washington. Bond and Bumbaco are regularly invited to speak to state agencies, emergency managers, and K-12 classrooms about Washington climate and climate change. In August and September, they presented to members of the Joint Legislative Committee on Water Supply During Drought, a bipartisan effort of the Washington State Legislature to improve the state’s response to drought conditions.

All these efforts do not go unnoticed. The OWSC is an excellent resource for local communities and a point of pride for CICOES. With their efforts, the state of Washington is better prepared to face the challenges that come with human-caused climate change.

The OWSC’s current project on heat waves in the Pacific Northwest is another example in a long history of the OWSC providing research opportunities to early-career and student scientists. I graduated from the University of Washington with a B.S. in Atmospheric Sciences this past June. I’m working at CICOES during a gap year between my undergraduate and graduate education. The OWSC has enjoyed working with other students and early-career scientists in the past on projects that include developing new web applications to better visual climate data and linking weather and climate data to incidences of vector-borne diseases in Washington State.

Working with the OWSC since June has been a wonderful experience. I interned with CICOES last summer, where I fell in love with the feeling of sinking my teeth into an interesting research project. The work felt meaningful, the team I worked with was brilliant, and my fellow interns became fast friends. It ended all too soon. Needless to say, I was thrilled when I was invited back to CICOES to work with the OWSC after graduation. Now, I am taking the lead on processing the historical temperature record data for the updated heat wave paper. As with my internship, the programming skills I’m learning on the job are much more than I could have learned during my coursework. This in-the-field experience is exactly what students and early-career scientists like me need to prepare for graduate school and beyond. CICOES and the OWSC have given me the confidence that I can succeed in whatever career endeavors I choose to pursue, and for that, I will always be grateful.

To receive the OWSC monthly newsletter sign up at climate.washington.edu/newsletter
DRIER, WARMER NIGHT AIR IS MAKING SOME WESTERN WILDFIRES MORE ACTIVE AT NIGHT

By Hannah Hickey
A study by University of Washington and U.S. Forest Service scientists shows why: the drying power of nighttime air over much of the Western U.S. has increased dramatically in the past 40 years. The paper, titled Multi-Decadal Change in Western US Nighttime Vapor Pressure Deficit, was published online in July 2021 in Geophysical Research Letters, a journal of the American Geophysical Union (Volume 48, Issue 15).

“Nighttime is an important time in fire management. When fires die down at night it gives firefighters a chance to rest, move equipment and strategize. The problem firefighters are reporting is an unexpected increase in nighttime fire activity,” said lead author Andy Chiodi, a UW research scientist at the Cooperative Institute for Climate, Ocean & Ecosystem Studies, a joint center with the National Oceanic and Atmospheric Administration. “Our findings support that this has been going on over the last 40 years over much, but not all, of the Western U.S.”

Earth’s atmosphere is warming due to climate change, and warming in many places has been greater at night. Warmer night air had been suspected as the culprit altering the daily pattern of wildfire activity, with burns continuing later into the night.

The new study, however, shows it’s not just that the night air is warmer, but also a dramatic shift from 1980 to 2019 in its drying power — how much moisture the nighttime air can carry away from the fuels — over much of the Western U.S. This shift is not captured in climate models, and the authors say it could be related to natural long-term cycles rather than to climate change.

“We paid special attention to the change in recent years compared to the conditions seen in the ‘80s and ‘90s, which is when many of the current firefighters started their careers, and presumably formed their ideas about what normal fire behavior should look like,” Chiodi said. “We tried to quantify the changes that we were hearing about from firefighters.”

The study looks at the “vapor pressure deficit,” or the difference between the moisture in the air and the saturation moisture level at that air temperature. This difference is a measure of the air’s drying power.

“In the southern Sierra Nevada, the average summer nighttime vapor pressure deficit for the recent decade was 50% higher than the average in the ‘80s and ‘90s,” Chiodi said. “I was surprised — it’s unusual to see geophysical data change that dramatically.”

Some of this shift in vapor pressure deficit is happening because warmer nighttime air,

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Firefighters have reported that Western wildfires are starting earlier in the morning and dying down later at night, hampering their ability to recover and regroup before the next day’s flareup.

The research study calculated the percent change from the ‘80s and ‘90s to the 2010s in the nighttime vapor pressure deficit, a measure of the drying power of the air, during summer months. Nighttime conditions were much more conducive to drying in recent years, especially in California’s central valley and the Bitterroot-Blue Mountain region of Idaho and surrounding states. Chiodi et al./Geophysical Research Letters.
caused by climate change, produce higher saturation values. But part of the drying power is happening because the nighttime air in some regions has less moisture, and that effect is not predicted by climate change models, at least this much or in this pattern. The authors find a possible connection to the Pacific Decadal Oscillation, a long-term cycle that can influence inland weather.

The increased drying power of nighttime air is especially pronounced in California’s San Joaquin Valley and in the Bitterroot-Blue Mountain Region — including parts of the Idaho Panhandle, southeast Washington, northeast Oregon and western Montana.

“Firefighters had been saying for several years that they feel some fires burn later into the evening than they used to,” said co-author Brian Potter at the U.S. Forest Service’s Pacific Wildland Fire Sciences Laboratory. “We found that in some areas, the amount of water in the air is decreasing, sort of doubling up on the warmer nights. These areas, including where the Snake River Complex and Lick Creek fires are burning [in July 2021], are much more likely to have fires burn late into the night.”

The analysis used hourly weather outputs from the European Centre for Medium-Range Weather Forecasts. The recently released hourly reconstructions of historical weather allowed investigation of daily cycles.

The next step, Chiodi said, is to further explore the causes of these changes in nighttime vapor pressure deficit. After that, he hopes to connect the atmospheric conditions more directly to fuel moisture and fire behavior.

The other co-author is Narasimhan ‘Sim’ Larkin at the U.S. Forest Service’s Pacific Wildland Fire Sciences Laboratory in Seattle. The research was funded by the U.S. Forest Service through its AirFire research team and by NOAA.

Focusing on the two areas with the biggest change in nighttime air — the Northern Rockies (orange line at top) and the southern Sierra Nevada (orange line at bottom) — shows much bigger changes in summer nighttime vapor pressure deficit than the average across the West (green line). The study finds a link between the average value across the West and the Pacific Decadal Oscillation, a long-term climate pattern shown in the inset. Chiodi et al./Geophysical Research Letters

“WE TRIED TO QUANTIFY THE CHANGES THAT WE WERE HEARING ABOUT FROM FIREFIGHTERS.”

Photo: Noah Berger / The Associated Press
IN MEMORIAM

Achim Nicklis
1965-2020

By Peggy Sullivan

Born in 1965 in the German village of Lachen-Speyerdorf, Achim came to the US for graduate school (Atmospheric Sciences) in Madison, Wisconsin, and eventually made his way to the Emerald City. He was a lover of opera (Wagner’s Parsifal, Tristan und Isolde, and The Ring Cycle [Der Ring des Nibelungen] were favorites), book clubs with themed dinners, and the Eurovision song contest.

Achim was also an avid outdoorsman, traversing the Pacific Northwest in frequent hiking and bicycle outings (including hiking an old train trestle in the Pass and along the Yakima River Canyon). A lover of travel and community, Achim made an annual spring trip to Germany to visit family, and always tagged on an extra trip to find new adventures abroad, often with an old friend or two.

Achim began his work at PMEL’s Computing and Networking Services Division (CNSD) in the late 1990s and became a JISAO employee in 2011. Many people have said that Achim was the first person they met, a positive and welcoming face, when they came to PMEL.

He passed away on December 23, 2020. Achim is survived by his partner David McSperitt, his sister and parents in Germany, and a large community of friends who journeyed with him to the end. He enriched our work community with his entertaining, respectful and kind demeanor.

Mary Smith
1948-2021

By Fred Averick

A native Seattleite, Mary grew up in the Wallingford neighborhood and if you ever took a car ride with her you’d likely be treated to a special tour — she’d always drive unusual routes while sharing stories from her life and Seattle’s history along the way.

Mary began working at UW in 1978 (first in Bilingual Education, then the Provost’s office, and Geological Sciences), before becoming Operations Director at the YMCA Earth Services Corp in 1991. Mary made her way back to UW in the late nineties, working in Bioengineering, before becoming the Assistant Director of JISAO in 2003, where she stayed until her retirement in 2018.

Along the way Mary also adopted a son, finished her BA in Spanish, got married, volunteered in the community (tutoring Spanish, working with high school students, being on the EcoSound advisory board), fostered a lot of dogs through Cavalier Rescue USA, became a Seahawks megafan, did a ton of home renovation, was (through her son) a huge and passionate supporter of musical theatre and the arts, and was a friend, ally and mentor to so many in the JISAO/PMEL community.

Mary passed away on September 12, 2021. She is survived by her husband Larry, her son Jesse, a large extended family, and many friends — both human and canine.


Maslenikov, K. P. (2021), Specimens by the Millions: Managing Large, Specialized Collections at the University of Washington Burke Museum Fish Collection, Ichthyology & Herpetology, 109(2), 397-406, 310, doi:10.1643/t2019314.


Meyer, R. S., et al. (2021), The CALeDNA program: Citizen scientists and researchers inventory California’s biodiversity, California Agriculture, 75(01).


Overland, J. E., et al. (2021), How do intermittency and simultaneous processes obfuscate the Arctic influence on midlatitude winter extreme


Trainor, V. L., R. M. Kudela, M. V. Hunter, N. G. Adams, and R. M. McCabe (2020), Climate Extreme Seeds a New Domoic Acid Hotspot on the


Sea ice near 86° N from a porthole in the icebreaker R/V Polarstern during the Arktis IV/3 expedition in 1987.

Photograph by John (Oz) Osborne.
This activity was conducted pursuant to NMFS ESA/MMPA Permit No. 22289. Photos: NOAA Fisheries.

**SEA LION SCIENCE TAKES TO THE SKIES**

Join CICOES and AFSC researchers as they survey and photograph Steller sea lions in Alaska onboard a NOAA Twin Otter aircraft. See their blog at: fisheries.noaa.gov/science-blog/sea-lion-science-takes-skies-post-1

Katie Luxa and Burlyn Birkemeier finishing the Southeast Alaska portion of the survey.
A western wildfire during the summer of 2021. Firefighters have reported that fires are starting earlier in the morning and dying down later at night. CICOES findings support that an increase of nighttime fire activity has been going on for the last 40 years over much of the Western U.S.