ON THE COVER
A rare sunny day on Saint Paul Island, Alaska, where CICOES researchers are using drone technology as a new, less invasive, method of monitoring fur seal pup production.

STORY ON PAGE 34
Photo: NOAA Fisheries, Permit 23283
FROM THE DIRECTOR

Can we call this a transition year? My sense is that everyone would like to be done with COVID and shift to their new work routines, which may or may not be the same as BC (Before Covid). Signs of a transition include an increasing number of people on campus and in our offices at Wallace Hall, the long-delayed DEI workshop that was finally held last spring, and resumption of administrative office hours at PMEL (including our new HR manager, Carol Pérez).

Despite uncertainties that accompany any transition, there have been lots of accomplishments over the last year. The number of CICOES-UW fieldwork trips—using small aircraft, boats, and/or remote field camps at locations all over the world—continues to increase, with more than 115 trips since we started tracking using Environmental Health and Safety Plans. We had a record number of 305 applications for the 14 available positions in our Summer Undergraduate Internship program, which meant a tremendous amount of review and then matching of students to mentors by the internship admissions committee. I am also happy to highlight increased research activity by the CICOES-UAF community, where their funding continues to double each year since we formed the consortium. This year also marks the first time that UAF employees will be co-located in NOAA Alaska Fisheries Science Center laboratories in Juneau and in Seattle. And finally, among our 2022 cohort of CICOES Postdoctoral Scholars there will be two new postdocs at UW and a second postdoc working at UAF, joining the group of ten current postdocs across UW, UAF, and OSU.

There are also transitions in administrative leadership at the UW College of the Environment, at OSU’s College of Earth, Ocean, and Atmospheric Sciences (CEOAS), and at NOAA headquarters. These transitions have all contributed to an increased enthusiasm for science and the potential for additional research funding. The new Dean at UW’s College of the Environment, Dr. Maya Tolstoy, is excited to increase the role of CICOES within the college and establish stronger bonds with other departments. At OSU CEOAS the interim Dean, Dr. Tuba Özkan-Haller, has appointed Dr. James Lerczak as the Deputy Director for CICOES-OSU to increase CEOAS’ participation in the consortium. On the NOAA federal side, new appointments at headquarters include Chief Scientist (Dr. Sarah Kirkpatrick), Assistant Administrator for Oceanic and Atmospheric Research (aka NOAA Research; Dr. Steve Thur), and the Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator (Dr. Rick Spinrad). Transitions in these positions will influence NOAA’s perspective on its mission and strategic planning, and will establish new opportunities for collaborative research between our NOAA partners and the CICOES community. We were fortunate to be included in a dedicated meeting when the NOAA leadership team was in Seattle to visit NOAA laboratories and partners. An action-packed set of presentations sparked many questions from the delegation and identified discussion points for future interactions.

Looking forward, a number of current and upcoming transitions are in progress. Negotiations for the unionization of research scientists and engineers at UW have begun. CICOES has over 70 employees within the affected job categories (the largest number among units within our College) and many job-related processes are on hold until an agreement is reached. An exciting upcoming event is the first CICOES Summer Symposium that is planned for June 2023 on the UW campus. Participants from all three partner universities, our NOAA laboratory partners, and hopefully NOAA headquarters will assemble to share our latest science results, get introduced to colleagues from our institutional partners, and to discuss and strategize future research. Planning for this event is underway. We will share details as soon as they are available, and if you would like to help with the planning, please let me know.

John K. Horne
CICOES Executive Director
CYNTHIA CHRISTMAN
Whales, seals, and polar bears! Cynthia’s life as a research biologist

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The people who have joined CICOES in the past 12 months

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Q&A with our new HR manager

HANNAH JOY-WARREN
New CICOES postdoc leads a life full of adventure

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How Dungeness crabs are being affected by climate change

2021 ARCTIC REPORT CARD
111 scientists from 12 countries release 16th annual report

KILLER WHALES LINGER IN ICE-FREE ARCTIC
Recordings show whales are spending more time in the Arctic

eDNA DETECTS GREEN CRAB
Techniques to control outbreaks of invasive species

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CICOES Magazine covers news, events, and research that occurred between December 1, 2021 and November 30, 2022.
SCIENTIST SPOTLIGHT: CYNTHIA CHRISTMAN

Whales, seals, and polar bears, oh my! Cynthia Christman’s life as a research biologist has taken her to the Atlantic, Pacific, and Arctic oceans to study all sorts of marine mammals.

By Haley Staudmyer, CICOES

CYNTHIA STARTED AT THE MARINE MAMMAL LAB (MML) as a NOAA affiliate through CICOES in 2016. There, she works with the Polar Ecosystems Program, which focuses on researching and monitoring seals in Alaska. “I’m primarily involved with aerial surveys; all aspects of them, from planning and logistics to conducting the surveys and then processing the imagery and data that we come back with,” said Cynthia. She typically spends two to three months of the year in Alaska doing flights to collect imagery and data on five species of seals.

What is it like to be part of an aerial survey? While in the air, Cynthia’s job as a marine biologist is to spot seals, take photographs of them, and make notes on their behaviors. “It’s a small team of people. We usually have two pilots and three or four biologists in the back, so it’s a very tight-knit group of people. It’s almost like a surrogate family,” said Cynthia. “We’re working very closely in a potentially risky environment. We take a number of steps to mitigate those risks, and frequently do safety training together. It’s very much a collective team effort.”

The work is challenging but rewarding, and not just for the science that comes out of it. “It’s exciting being able to cover such a huge geographic area in the plane. It’s maybe a little bit more removed than if you were working hands-on with animals or on a ship, but you also cover so much more ground and you see just amazing landscape, especially up in Alaska,” said Cynthia. “This past year, some parts of our harbor seal surveys were over glacial fjords in Alaska, and the view was stunning. It’s beautiful, and it reminds you how small you are in comparison to many other things in life.”

Not everything seen from a bird’s eye view of the Arctic is so pleasant, though. The impacts of climate change become starkly visible in the air. “When I worked with the Cetacean Assessment and Ecology Program at MML, we did large-scale aerial surveys in the Arctic over the Chukchi and Beaufort seas. We started to see massive walrus haulouts form along the Alaskan coastline,” said Cynthia. The walruses are hauling themselves out of the water onto land rather than onto ice because sea ice cover has dwindled too much — the sea ice that remains is too far north for them. “Large walrus haulouts are normal for the Russian coast, but for the U.S., they were a relatively new phenomenon. Now they are a regular occurrence. It’s one thing to hear about drastic ecosystem changes from people that live along the coastline, that are seeing things shift over a period of decades or a lifetime. It’s another to actually see these changes in real time during a relatively short window of work.”

“IT’S EXCITING BEING ABLE TO COVER SUCH A HUGE GEOGRAPHIC AREA IN THE PLANE... YOU COVER SO MUCH MORE GROUND AND YOU SEE AMAZING LANDSCAPES, ESPECIALLY UP IN ALASKA.”

The Marine Mammal Lab’s aerial surveyors come home with important and fascinating results. It’s more important than ever that the public be invested in the well-being of our natural world, and Cynthia has been trying to make that happen: “I’ve been starting to do more outreach activities, which used to be way out of my comfort zone. It’s still out of my comfort zone, but I’m trying to push myself to do more of it because I think it’s important to connect with people and make research more accessible. It’s rewarding.”

Her advice for anyone pursuing their passions, scientific or otherwise? “Don’t let people put up roadblocks or try to talk you out of things that are important to you,” said Cynthia. “I think you just have to rise above other people's agendas and keep going.”

Whales, seals, and polar bears, oh my! Cynthia Christman’s life as a research biologist has taken her to the Atlantic, Pacific, and Arctic oceans to study all sorts of marine mammals.
GET TO KNOW OUR NEW EMPLOYEES!

The following people joined the CICOES-UW staff between December 2021 and November 2022.

AARON LEVINE

Aaron is working on a new project exploring the role of precipitation and air-sea feedbacks around the warm pool edge in false alarm El Niño forecasts in seasonal forecast models. Prior to this project, he was working on evaluating sailldrone observations and weather forecast models in the Arctic, diurnal precipitation in the maritime continent, and future projections of extreme temperatures in the Arctic with Drs. Chidong Zhang and Muyin Wang. Prior to working at CICOES, Aaron was a NRC postdoctoral fellow at PMEL with GTMBA working on El Niño-seasonal cycle interactions and multidecadal El Niño variability and a research scientist with the Department of Atmospheric Sciences at University of Washington with projects on MJO-mean-state interaction, El Niño representation in climate models, and ITCZ/precipitation processes in CMIP6 models.

CHRIS IKEDA

Chris is a research scientist working with the Ocean Carbon group at PMEL to analyze samples we receive from our collaborators for dissolved inorganic carbon and total alkalinity. Many of these samples are used to monitor the impact of ocean acidification within Puget Sound, Strait of Juan de Fuca, and coastal Washington. Before joining the Ocean Carbon group, his work involved studying the impact ocean acidification has on the growth and toxicity of various harmful algal blooming species in both the Salish Sea and coastal California.

CAROL PÉREZ

Carol is the new HR Manager for CICOES. She graduated from UC Berkeley in 2013 with a degree in Anthropology and is currently earning her online MBA with Washington State University. Before joining CICOES, Carol completed 10 years of work at Leader Creek Fisheries. From May to August she would spend her summers in Bristol Bay, Alaska at a wild sockeye salmon processing facility and then work remotely for the rest of the year. She began that job as a member of the Quality Assurance team in 2013 and eventually became the company’s Human Resources Manager. Some of her duties as an HR Manager included overseeing the payroll, handling employee relations, and running the social media across various platforms. Carol’s hobbies include cross stitching and visiting U.S. National Parks. She has visited 18 National Parks and hopes to visit many more.

HANNAH JOY-WARREN

Hannah is a postdoctoral researcher working with Dr. Alison Gray (UW Oceanography) and Dr. Andrea Fassbender (NOAA PMEL) to decipher the role of phytoplankton community composition in air-sea CO₂ flux variability and carbon export in the Southern Ocean. Specifically, they will correlate phytoplankton taxa distribution (modeled from in situ observations) to CO₂ fluxes, net primary production (NPP), net community production (NCP), and carbon export to determine differences in CO₂ flux related to phytoplankton species composition. The assessment of phytoplankton species composition in relation to CO₂ flux variability will represent a significant contribution towards quantifying the role of Southern Ocean phytoplankton in shaping carbon cycling. By combining satellite-based and biogeochemical Argo float-based NPP, as well as NCP and float-based respiration, they will provide a more detailed picture of air-sea CO₂ flux in the Southern Ocean, enabling a more accurate attribution of biological processes to carbon cycling.
HAUKE SCHULZ

Hauke is a postdoctoral researcher working with Professor Robert Wood (UW Atmospheric Sciences) and Dr. Dongxiao Zhang (CICOES/NOAA PMEL) to better understand the atmospheric and oceanic processes leading to the organization of shallow convection in the trades. Hauke and his colleagues have recently discovered the importance of the meso-scale organization of shallow clouds for the net cloud-radiative effect and their ability to cool the atmosphere. The formation mechanism of these cloud formations remains, however, an open question. Hauke will use autonomous saildrones to particularly capture the processes at the air-sea interface to study the importance of small-scale processes like cold pools for the formation of meso-scale cloud structures. Paired with satellite observations and large-eddy simulations these measurements will shed light on how shallow clouds organize in the current climate, but also addresses the question on how the clustering of clouds will react and feedback in a future climate.

JOHN DIENER

John worked as a UW Research Scientist for NOAA’s Marine Mammal Lab, Alaskan Ecosystems Program. He assisted with Northern Fur Seal pup shearing, pup/adult tagging, and resighting flipper tags on the South Rookery, St. George, AK. This important work sheds light on the annual productivity and overall demography of this historically, culturally, and ecologically important species. “It was an honor to work with such amazing and dedicated staff,” John said. He has been a seasonal wildlife biologist for 16 years together with his wife Lizzie.

ROB HAGG

Rob recently joined the Global Tropical Moored Buoy Array (GTMBA) group at PMEL. Previously he had been living and shipping out of Seattle for 24+ years working at sea for 6-8 months per year. The majority of Rob’s career has been in support of oceanographic research as a shipboard oceanographic technician, science party liaison, and in U.S. Navy funded anti-submarine warfare research at sea. His duties ranged from shipboard computer networks, and data acquisition to deployments of OOI, Tsunami buoys, and environmental MetOcean moorings sampling the water column. His career has taken him from the Arctic MIZ, with PMEL groups, throughout the South Pacific, Samoa, Tahiti, Line Islands, North Sea, Norwegian Sea, Tasman Sea, South Atlantic, Antarctica and ports in-between.

Q&A with CAROL PÉREZ

Carol joined UW and CICOES on July 1 to serve as the institute’s Human Resources Manager.

WHAT WERE YOU DOING BEFORE YOU JOINED CICOES IN JULY 2022?

Before coming here, I was beginning my 10th summer in Bristol Bay, Alaska where I was the Human Resources (HR) Manager at a salmon processing facility in the rural town of Naknek. I started there in 2013 as a Quality Assurance (QA) member, and after three summer seasons as a QA, I joined the HR team and worked my way to HR Manager for the company. What started off as a summer job soon became a career.

WHAT CIRCUMSTANCES LED YOU TO CICOES?

I had a somewhat intense schedule at my last job. From November through April I was recruiting individuals to work in Alaska. It was a lot of interviewing and attending school fairs, since we hired a lot of college-age people. From May to August I was in Naknek working 12-16 hour shifts, seven days a week. That’s 100 hours per week without any days off! Then I would have a few months available to travel, and the process would repeat itself all over again.

One year, I spent two months traveling through Central and South America followed soon after with a month in Europe. That lifestyle was great for a few years, but it came to an abrupt stop with the COVID-19 pandemic. During that time, I felt
that I needed a change, and I spent my down time thinking about my future. Working in Alaska was fun, but I needed a new challenge. The following year I became a grad student and decided to explore other career options. During my job search, I came across the HR Manager position at CICOES and felt like it was right up my alley. I applied and here I am, excited and happy to be part of the team!

WHAT DO YOU ENJOY MOST ABOUT YOUR WORK?
I like that I am supporting people who are engaging in research that is making a positive contribution to the environment.

WHAT HAVE THE FIRST FEW MONTHS AT CICOES BEEN LIKE?
My first few months have involved a lot of learning (and asking Fred, our assistant director, a lot of questions!). I was at my last job for 10 years and could recite policies forwards and backwards. It has been refreshing, and a bit challenging, to learn a whole new set of policies and procedures. I’ve enjoyed learning more about the history of UW, CICOES, and NOAA. I still have a lot to learn, and I appreciate everyone’s patience and willingness to help!

HAS ANYTHING SURPRISED YOU DURING YOUR FIRST FIVE MONTHS?
Before joining CICOES, I thought the University primarily focused on working with students, I had no idea that an organization like CICOES existed! I was also surprised at how many people were part of CICOES.

WHAT DREW YOU TO THE HR FIELD?
Ever since I was little I liked creating order, having a routine, and making sense of the environment around me. I also like meeting new people and constantly learning. This led me to study anthropology as an undergraduate student. From there, human resources seemed like an area where I could use the anthropology skills I had gained. I did a few temp positions in HR roles and enjoyed it!

WHAT WAYS ARE YOU A DIFFERENT PERSON NOW THAN YOU WERE WHEN YOU FIRST BEGAN YOUR HR CAREER?
When I first started I was too focused on making sure that everyone was following the rules. I was also nervous to ask for feedback! I soon realized that I wasn’t focusing enough on the human aspect of human resources. I learned a lot from having a mentor and learned even more from being one. Now, I like to get opinions from the team and welcome all feedback. I can 100% say that I am a different person now than who I was when I began my career.

IS THERE AN ACHIEVEMENT OR CONTRIBUTION THAT YOU’RE MOST PROUD OF?
I am a proud product of public education and that is a big reason why I’m excited to work with a public institution now! I’m most proud of having attended a community college then transferring and graduating from UC Berkeley. I was the first person in my family to attend and graduate from college.

WHAT ARE YOUR INTERESTS OUTSIDE OF WORK?
I’m currently a graduate student getting my MBA through an online program, so unfortunately, I do not have too much free time. But I’m in a book club with friends where we read books written by authors of color, and we have interesting discussions. That has been a big highlight of growing my community in Seattle.

Prior to the pandemic I did a lot of solo travel. I’ve been to 26 countries, 25 U.S. states, and 13 National Parks. I love to talk about my time traveling and I enjoy playing geography games such as Worldle (not to be confused with “Wordle,” the word guessing game) and Tradle.

WHAT ARE YOU LOOKING FORWARD TO IN 2023?
Exploring more of Seattle and the surrounding area! This winter I would like to try to learn how to ski or snowboard, and in the warmer months I would like to spend more time paddle boarding. I’m looking forward to getting to know everyone a little bit more, and becoming more integrated into the CICOES community! ⇤
SCIENTIST SPOTLIGHT: HANNAH JOY-WARREN

By Haley Staudmyer, CICOES

IN JANUARY OF 2022, CICOES welcomed a new postdoctoral researcher, Hannah Joy-Warren. Hannah is a biogeochemical oceanographer working with Dr. Alison Gray (UW Oceanography) and Dr. Andrea Fassbender (NOAA PMEL). In her current work, she hopes to understand the details of the biological component of the transfer of carbon from the atmosphere to the ocean in the Southern Ocean.

Hannah came away from her undergraduate studies knowing that she was on the right path. “I realized that I could do a job where I get to be outside and answer the questions that I have anyway. I was surrounded by incredible people who love being outside playing in the natural world, answering questions […] so I realized that graduate school would be a really fun thing to do with great, cool people that I like to spend time with.” In pursuit of this goal, she packed up her life again and moved to California to study polar biological oceanography and biogeochemistry at Stanford University. Though her traveling slowed down a bit during her graduate studies, she did join four separate research cruises to both the Arctic and the Southern Ocean before moving back home to Vancouver, B.C. in 2020 for the last few months of her Ph.D. – just enough time for the cabin fever to set back in.

“I spent seven years in California, and that was too long to be in one place,” said Hannah. She hopped on a plane once more and landed in Sweden, where she spent one year as a Fulbright Scholar studying physical oceanography at the University of Gothenburg. This time, though, she wasn’t moving across the world by herself. She was joined by her dog, Luna, and the two of them quickly felt at home in Sweden. Said Hannah, “I did a bunch of bike trips. I did ‘bikepacking,’ where I brought Luna, and she would run and run and run for miles and then ride in the backpack when she got tired. There’s lakes all over Sweden, so we’d bike from lake to lake and go swimming and camp along the way.”

Hannah has landed at CICOES for now, where she is thrilled to be surrounded by the water and mountains she loves. Her advice for moving around and leading the life of an adventuring scientist? “I think trusting yourself is one of the biggest things. Every time I’ve made the decision to move, I have been very confident in that decision and excited about it. And every time I’ve shown up to the place, I have thought, ‘What have I done and why have I done this to myself?’ So, I’ve had to learn how to trust my past self and remember that the first few weeks or months are really hard […] I just tell myself, let’s jump in with both feet and find the fun things and go explore.”
RESEARCH ACCOMPLISHMENTS

OUR 2022 RESEARCH ACCOMPLISHMENTS are grouped in the nine CICOES themes. Major goals of research conducted under these themes include: collecting and analyzing data to better understand physical, biological, and chemical processes of ocean and coastal areas; understanding climate variability and change; improving our understanding of ocean and atmospheric processes associated with climate change and determining adaptation strategies; studying how the ocean absorbs carbon dioxide and the resulting increase in acidity of ocean water; studying the impact of the solid Earth on ocean chemistry and biology; studying effects of interactions between human communities and natural ecosystems; developing tools and technology to restore and protect marine habitats; and improving prediction and forecasting of weather, ecosystems, and tsunami impacts.

CICOES accomplishments in support of NOAA’s mission are numerous and wide-ranging. One example is given for each of the themes below, with additional accomplishments and project summaries listed on our website at cicoes.uw.edu/research.

AQUACULTURE SCIENCE
Genomic data were collected on Littleneck, Manila, and Geoduck clams to evaluate changes associated with ocean acidification in the marine environment and marine aquaculture.

CLIMATE AND OCEAN VARIABILITY, CHANGE, AND IMPACTS
Transient tracer and carbon-system measurements made as a part of the Global Ocean Ship-Hydrographic Investigations Program (GO-SHIP) suggest that fossil-fuel CO₂ uptake appears to be slowing in each of the Southern Hemisphere subtropical gyres.

EARTH SYSTEMS AND PROCESSES
The Short-term Inundation Forecasting for Tsunamis, or SIFT, was updated for operational use at NOAA’s Tsunami Warning Centers. In January, a tsunami produced by the eruption of a submarine volcano in Tonga was successfully modeled in real time.

ENVIRONMENTAL CHEMISTRY AND OCEAN CARBON
Measurements of aerosols in the marine boundary were made from the NOAA RV Ronald H. Brown as part of the Atmosphere Mesoscale Interaction Campaign (ATOMIC). The effort to improve understanding of the effects of aerosol particles on clouds and radiation transfer over the northwest tropical Atlantic is essential to effectively model climate, requiring a better understanding of the chemical, physical, optical, and cloud-nuclei properties of these aerosols.

ENVIRONMENTAL DATA SCIENCE
The deployment of five saildrones — robotic sailboats equipped with state-of-the-art ocean and meteorological sensors — enabled collection of direct observations of a major (Category 4) hurricane and five other tropical storms. These results will improve our ability to predict the rapid intensification of hurricanes.

HUMAN DIMENSIONS IN MARINE SYSTEMS
Physical and financial risk are inherently part of the commercial fishing industry and working in rough seas for long hours with heavy equipment is hazardous. Harvesters face some of the highest fatal and non-fatal occupational injury rates. Despite this, research reveals vessel owners are less likely to have health insurance compared to the general population.

MARINE ECOSYSTEMS: OBSERVATIONS, ANALYSIS, AND FORECASTS
Regional model output simulations and measurements of ocean acidification in the Bering and Chukchi seas provide the first high-resolution projections for changing water chemistry over the 21st century. Some regions of the Bering Sea shelf are expected to acidify faster than the rest of the shelf. This trend was identified in 2018, when certain regions of the shelf were more acidic than normal, and continued into 2021 and 2022 with the model suggesting that pH in spring 2022 is the lowest in the last 50 years.

OCEAN AND COASTAL OBSERVATIONS
The dominant modes of ocean-atmosphere variability have major impacts on weather and climate; they continue to be monitored in each of the three tropical oceans by the Global Tropical Moored Buoy Array. Four cruises were successfully completed to maintain the ocean moorings in tropical oceans. A cruise on the Korean ship R/V ISABU re-established mooring sites in the Indian Ocean after a period of data and asset loss during the COVID pandemic.

POLAR STUDIES
Large changes in the Arctic are potential drivers for weather at midlatitudes in coming decades. In addition to loss of sea ice in the Arctic and the movement of the Polar Vortex over continental regions, jet stream variability adds to scientific uncertainty as reflected in poor correlations in model studies. Further understanding requires examining this as a potentially two-step process dependent on Arctic temperatures and regional sea ice extent and then jet stream phase and movement which in turn is impacted by the stratospheric polar vortex.
HOW DUNGENESS CRABS’ COMPLEX LIFECYCLE WILL BE AFFECTED BY CLIMATE CHANGE

By Hannah Hickey, UW News

RECENT RESEARCH ON THE PACIFIC NORTHWEST PORTION of the Dungeness crab fishery, which spans the West Coast of the U.S. and Canada, projects how this crustacean will fare under climate change.

Results show that by the end of this century, lower-oxygen water will pose the biggest threat. And while these crabs start as tiny, free-floating larvae, it’s the sharp-clawed adults that will be most vulnerable, specifically to lower-oxygen coastal waters in summer.

The open-access study from researchers at the University of Washington, the University of Connecticut and the National Oceanic and Atmospheric Administration was in the December 2021 issue of AGU Advances, a journal of the American Geophysical Union.

"Including all life stages allowed us to identify a critical life stage, and thus make a management recommendation," said co-author Samantha Siedlecki at the University of Connecticut, who began the study while at the UW. "Looking seasonally, instead of annually, gives different — and more severe — vulnerability estimates."

Dungeness crab is the largest single-species fishery in the northwestern U.S. Washington’s Dungeness Crab Festival takes place in October near the Dungeness Cove that gives the species its name, and the crustacean is a favorite of Pacific Northwest holiday meals and in traditional diets. The study was designed in consultation with the Hoh, Makah, Quileute, and Quinault Indian Nation tribes, whose members harvest, study, and eat Dungeness crab on Washington’s Olympic Peninsula.

The researchers used a detailed computer model of ocean conditions to simulate the shifting properties of the water the crabs inhabit. Using a scenario of high carbon emissions through 2100, the model looks at how heat-trapping gases in the atmosphere...
will make the ocean warmer, carbon dioxide transferred from the air will make the surface waters more acidic, and warmer water will hold less dissolved oxygen.

Previous research has shown that the Dungeness crab is vulnerable to climate change. Those studies focused on changes in ocean pH, while the new paper includes multiple ocean properties and uses a model that is more detailed in space and time.

Time and place are both important. Crabs mate in spring and females produce eggs in late fall. Eggs begin to hatch in January and release larvae, which float in the offshore currents while growing, shedding and regrowing their shells five times. In summer the fully developed larvae come back closer to shore and molt, becoming juvenile crabs that scamper on the ocean floor.

The authors used an ocean model to study the consequences of climate stressors at different times throughout the Dungeness crab’s life stages — from eggs, to larvae, to juveniles, to adults.

“We found that for all three stressors there will be increased population-level vulnerability, and the most severe is to low oxygen levels,” said first author Halle Berger, a doctoral student at the University of Connecticut. “Low-oxygen events happen during the coastal upwelling season in spring and summer, which impacts the adults, whereas ocean acidification manifests more year-round in the future, impacting all life stages but less severely.”

Lab studies of Dungeness crab combined with model results suggest that the most severe effects will be lower dissolved oxygen along the coastal seafloor in summer, harming the adults. This is unlike other species of shellfish which are thought to be most vulnerable in the larval stage.

Like other animals, crabs require oxygen. Warmer water holds less dissolved oxygen, so even if marine life can handle the higher temperature and acidity, the drop in oxygen may lower the chance for survival.

“The value of this down-scaled model is that it can help tribes and state agencies to focus their efforts in both space and time,” said co-author Jan Newton, an oceanographer at the UW Applied Physics Laboratory and co-director of the Washington Ocean Acidification Center. “This information is very pertinent to resource managers.”

The researchers say these results could be incorporated into decision-making as ocean conditions change.

“An example would be monitoring low-oxygen events in the summer, and maybe pulling the crab traps earlier,” Berger said. “This would help mitigate from the crabs dying in the trap.”

Further research on the Dungeness crab should include more lab studies on how the species responds to multiple stressors. More generally, authors say, the study shows a way to understand how marine species with complex life stages will respond to climate change.

Other co-authors are Darren Pilcher and Emily Norton at the UW Cooperative Institute for Climate, Ocean and Ecosystem Studies; Simone Alin and Isaac Kaplan at the National Oceanic and Atmospheric Administration; and Catherine Matassa at the University of Connecticut.

The research was funded by NOAA and was part of a regional vulnerability assessment for the Olympic Coast to ocean acidification.
HUMAN-CAUSED CLIMATE CHANGE FUELS WARMER, WETTER, STORMIER ARCTIC

2022 Arctic Report Card features Indigenous observations and knowledge

Press Release From NOAA Communications

A TYPHOON, SMOKE FROM WILDFIRES, AND INCREASING RAIN are not what most imagine when thinking of the Arctic. Yet these are some of the climate-driven events included in NOAA’s 2022 Arctic Report Card, which provides a detailed picture of how warming is reshaping the once reliably frozen, snow-covered region that is heating up faster than any other part of the world.

This year’s Arctic Report Card also features the most comprehensive chapter in the annual report’s 17-year history about how these dramatic environmental changes are felt by Arctic Indigenous people, and how their communities are addressing the changes.

The 15th chapter of the report card, authored by a team that includes Native Alaskan scientists, describes how warming air temperatures, shrinking sea ice, shorter periods of snow cover, increased wildfire, rising levels of precipitation and changes in animal migration patterns and their abundance profoundly affect the safety, food security, health, economic wellbeing and cultural traditions of Indigenous people.

“Living and innovating in Arctic environments over millennia, Indigenous peoples have evolved holistic knowledge that provides resilience and sustainability,” said Jackie Qatalina Schaeffer, a co-author of the chapter, Director of Climate Initiatives for the Alaska Native Tribal Health Consortium and an Inupiaq from Kotzebue, Alaska. “Addressing the unprecedented environmental change requires listening to one another, aligning values and collaborating together as communities, businesses, governments, Indigenous and non-Indigenous scientists and decision-makers.”

“With this important new chapter and other timely additions, the 2022 Arctic Report Card underscores the urgency to confront the climate crisis by reducing greenhouse gasses and taking steps to be more resilient,” said NOAA Administrator Rick Spinrad, Ph.D.

“The report provides observations and analysis to help build a Climate-Ready Nation in a region on the front lines of climate change.”

Compiled by 147 experts from 11 nations, the report card includes three sections: Vital Signs, Indicators, and Frostbites. Vital Signs provide annual updates on key topics. This year, a chapter on precipitation has been add-
ed, reflecting an improvement in available data and showing the dramatic increase in precipitation across the Arctic in recent decades. Indicators explore topics that are periodically updated, and Frostbites report on new and emerging issues.

**MAJOR FINDINGS IN THIS YEAR’S REPORT INCLUDE:**

Arctic annual air temperatures from October 2021 to September 2022 were the sixth warmest dating back to 1900, continuing a decades-long trend in which Arctic air temperatures have warmed faster than the global average. The Arctic’s seven warmest years since 1900 have been the last seven years.

Arctic sea ice extent (coverage) was higher than many recent years, but much lower than the long-term average. Multidecade ice extent, sea-ice thickness and volume rebounded after a near-record low in 2021, but was below conditions in the 1980s and 1990s, with older ice extremely rare. Open water developed near the North Pole for much of the summer, allowing polar-class tourist and research vessels easy access. The Northern Sea Route and Northwest Passage were also largely open.

Satellite records from 2009 to 2018 show increasing maritime ship traffic in the Arctic as sea ice declines. The most significant increases in traffic are occurring among ships traveling from the Pacific Ocean through the Bering Strait and Beaufort Sea. This opens economic opportunities for new trade routes and also poses potential human-caused stresses on Arctic people and ecosystems.

The 2021-2022 Arctic snow season saw a combination of above-average snow accumulation but early snowmelt, consistent with long-term trends of shortening snow seasons in several areas.

Wetter-than-normal conditions predominated over much of the Arctic from October 2021 to September 2022. Precipitation has increased significantly since the 1950s across all seasons and datasets. Heavy precipitation events are more common in the North Atlantic subarctic, while much of the central Arctic shows increases in consecutive wet days and decreases in consecutive dry days.

Typhoon Merbok, which was fueled by unusually warm water in the north Pacific, dramatically shaped 2022 in the Bering Sea region. Merbok struck the west coast of Alaska in mid-September, bringing a destructive storm surge that caused homes to break loose from foundations and damaged infrastructure in several coastal and river communities.

The Greenland ice sheet lost ice in 2022, the 25th consecutive year of ice loss. In September, 2022 was the Arctic’s 6th-warmest year on record.
ber 2022, the Greenland ice sheet had unprecedented late-season warming, creating surface melt conditions over 36% of the ice sheet on September 3, including the Greenland ice sheet’s summit at 10,500 feet. This followed a July 18 large surface melt event observed across 42% of the Greenland ice sheet surface.

The August 2022 sea surface temperatures continued to show a warming trend that has been observed since 1982 for much of the ice-free Arctic Ocean. In the Barents and Laptev seas, August 2022 mean sea surface temperatures were 3.5 to 5.5 degrees Fahrenheit (2 to 3°C) warmer than 1991–2020 August mean values while unusually cool August sea surface temperatures of 5.4 degrees Fahrenheit (3°C) below the August mean occurred in the Chukchi Sea, likely driven by late-summer sea ice in the region that was kept in place by the winds.

Much of the Arctic continued to show increased ocean plankton blooms in 2022, as has occurred over the 2003–2022 satellite observation period. Summer storms in 2022 in the Bering Sea may have been responsible for higher-than-average plankton blooms, due to increased vertical mixing of nutrients from deep ocean waters to the surface.

Two separate reports on Arctic birds reveal opposite health trends. While the populations of Arctic geese across the Arctic are stable or rising, many seabird species, such as ducks, auklets, shearwaters, murre and puffins in the northern Bering and Chukchi seas experienced their sixth consecutive year of a substantial die-off.

“The Arctic remains a varied and expansive region to monitor, especially as widespread disturbances unfold and seasons shift,” said Matthew Druckenmiller, a research scientist with the National Snow and Ice Data Center and the lead editor of the 2022 Arctic Report Card. “To understand its transition, we need local to international partnerships, especially with Arctic peoples and Indigenous communities, who are vital to the use of diverse observations and knowledge, as well as to identifying solutions to long-term climate impacts and abrupt disturbances.”

MATTHEW DRUCKENMILLER
Research Scientist, National Snow and Ice Data Center (NSIDC), Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder. Matthew receives funding from the National Oceanic and Atmospheric Administration (NOAA) to serve as a scientific editor of the Arctic Report Card.

RICK THOMAN
Alaska Climate Specialist, University of Alaska Fairbanks. Rick receives funding from the National Oceanic and Atmospheric Administration (NOAA) via Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES) to serve as a scientific editor of the Arctic Report Card.

TWILA MOON
Deputy Lead Scientist, National Snow and Ice Data Center (NSIDC), Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder. Twila receives funding from the National Oceanic and Atmospheric Administration (NOAA) to serve as a scientific editor for the Arctic Report Card.
Killer whales, also known as orcas, are not the largest whales, but they travel in groups known as pods and can cooperatively hunt larger prey. New research shows that they spent more time in the Arctic Ocean in recent years.

Underwater microphones placed off the western and northern coasts of Alaska show that killer whales — also known as "orcas" after their scientific Latin name *Orcinus orca* — have spent more time than previously recorded in the Arctic, following the decrease in summer sea ice. Brynn Kimber, a researcher from the Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES), presented the study, "Tracking killer whale movements in the Alaskan Arctic relative to a loss of sea ice," in Seattle at a meeting of the Acoustical Society of America.

Killer whales will often travel to different areas to target varieties of prey. In the analysis of acoustic data recorded by four underwater microphones from 2012 to 2019, the Seattle-based team found that killer whales are spending longer in the Arctic Ocean in more recent years, despite risks of ice entrapment there. Their readings indicate this change is directly following the decrease in sea ice in the area.

"It’s not necessarily that killer whales haven’t been reported in these areas before, but that they appear to be remaining in the area for longer periods of time," said Kimber. "This is likely in response to a longer open-water season."

The study didn’t set out to focus on the killer whales said Kimber, who was surprised by the results.

“Our work mostly centers on examining the migration patterns of marine mammal species through the Bering, Chukchi, and Beaufort seas, based on acoustic presence or absence. But when looking for other species, like beluga whales, I noticed more and more killer whales in areas where I didn’t expect them. That was what motivated me to take a closer look at our killer whale detections."

The reduction in sea ice may be opening new hunting opportunities for killer whales, if certain species of prey can no longer use the ice to avoid the highly adaptive predator. For example, the endangered bowhead whale is vulnerable to predation by killer whales, but can hide under sea ice to avoid being circled by orcas. Another recent study led by CICOES researcher Amy Willoughby showed the first direct evidence of killer whales attacking bowhead whales in the Arctic.

This vulnerability, Kimber said, is likely to increase due to longer open-water seasons.

"Although there is high spatial and interannual variability, the September Arctic sea-ice minimum is declining at an average rate of 13% per decade when compared to values from 1981 to 2010," Kimber said. "Killer whales are being observed in the Chukchi Sea in months that were historically ice covered, and more consistently throughout the summer."

This study was funded by NOAA, the U.S. Navy and the Interior Department’s Bureau of Ocean Energy Management. Collaborators are Jenna Harlacher, a former UW master’s student who is now at CICOES; Eric Braen at CICOES; and Catherine Berchok at NOAA.

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**KILLER WHALES LINGERING IN INCREASINGLY ICE-FREE ARCTIC OCEAN**

By UW News Staff

**KILLER WHALES ARE INTELLIGENT, ADAPTIVE PREDATORS,** often teaming up to take down larger whales as prey. Continuous reduction in sea ice in the Arctic Ocean is opening areas to increased killer whale presence and predation, potentially creating an ecological imbalance.

Underwater microphones placed off the western and northern coasts of Alaska show that killer whales — also known as “orcas” after their scientific Latin name *Orcinus orca* — have spent more time than previously recorded in the Arctic, following the decrease in summer sea ice. Brynn Kimber, a researcher from the Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES), presented the study, “Tracking killer whale movements in the Alaskan Arctic relative to a loss of sea ice,” in Seattle at a meeting of the Acoustical Society of America.

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In January 2022, Gov. Jay Inslee issued an emergency order in response to more than 70,000 green crabs caught on Lummi Nation land as well as dramatic increases in crab populations on Washington’s outer coast and other locations in Puget Sound in recent years.

As the green crab invasion in the state worsens, a new analysis method developed by University of Washington and Washington Sea Grant scientists could help contain future invasions and prevent new outbreaks using water testing and genetic analysis. The results, published in the journal Ecological Applications, show that the DNA-based technique works as well in detecting the presence of green crabs as setting traps to catch the live animals, which is a more laborious process. Results suggest these two methods could complement each other as approaches to learn where the species’ range is expanding.

“We have limited resources to be able to combat this problem, and it’s important to think about how to allocate those resources efficiently and effectively,” said lead author Abigail Keller, who completed the work as a master’s student in the UW School of Marine and Environmental Affairs. “Knowing the best situations for using eDNA to detect invasive green crabs is important, and that’s what our study tried to tackle.”

The research team relied on data collected over three months in 2020 from green crab traps in 20 locations throughout Puget Sound and the outer coast. Trapping at these locations was done by a large number of partners participating in statewide efforts to monitor and control European green crab, including multiple tribes, Washington Department of Fish and Wildlife — the state lead for green crab management — Washington Sea Grant’s

**eDNA: A USEFUL TOOL FOR EARLY DETECTION OF INVASIVE GREEN CRAB**

By Michelle Ma, UW News

**EUROPEAN GREEN CRABS FEAST ON SHELLFISH**, destroy marsh habitats by burrowing in the mud and obliterate valuable seagrass beds. The invasive species also reproduces quickly, making it a nightmare for wildlife managers seeking to control its spread in Washington’s marine waters.

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The new method relies on genetic material in the environment, known as ‘environmental DNA’ or eDNA, that is found in the water after organisms move through. Scientists can collect a bottle of water from a location, extract DNA from the water and discern which species were present recently in that area.

By Michelle Ma, UW News

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Crab Team, and other state and federal agencies.

For this study, the researchers visited each trapping location and collected water samples, then ran genetic analyses to estimate both the presence and quantity of European green crab in each location. In this way they could validate the eDNA data with the actual presence and numbers of crabs. They found that using eDNA to detect the presence and abundance of the species was as sensitive as trapping and counting live crabs.

This is significant, the researchers said, because eDNA as a detection method is new, and it hasn’t always been clear how to interpret eDNA detections in past scenarios. This study shows how conventional monitoring methods — in this case, trapping and counting crabs — can be combined with eDNA techniques to more effectively find and control invasive species outbreaks.

“Here’s a really well-validated example of how to use eDNA in the real world. To me that’s really exciting,” said co-author Ryan Kelly, a UW associate professor in the School of Marine and Environmental Affairs. “There are lots of invasive species, and many imperiled and endangered species that are hard to monitor, so this is one significant way forward on all of those fronts.”

The study also evaluates when eDNA would add value in monitoring for invasive crabs, and when conventional trapping and counting still make the most sense. For example, taking water samples and testing for green crab DNA in remote locations — or in areas where outbreaks haven’t yet been identified — could save time and resources instead of deploying traps. Alternatively, eDNA probably wouldn’t be helpful in locations where large numbers of green crabs are already living and where community scientists and managers are already trapping and controlling those populations, the researchers explained.

“From a management perspective, the value of this tool just really comes to life in places that are more remote or have a lot of shoreline to cover, like Alaska, where green crabs haven’t yet been detected,” said co-author Emily Grason, a marine ecologist who leads the Washington Sea Grant Crab Team. “I see eDNA as another tool in the toolkit, and we can imagine scenarios where it can be used alongside trapping, especially as an early detection method.”

Finding these crabs soon after they have occupied a new location is important for controlling the population and protecting native habitats. Managers could get ahead of new invasions by testing water from multiple locations, and then follow up with more water testing, on-the-ground monitoring and trapping if green crab DNA is detected.

The paper identified green crab DNA in one location where the species hasn’t yet been captured, near Vashon Island. The research team followed up a year later with intensive trapping and retested the water; no green crabs or additional green crab DNA were found. The researchers think the earlier positive sample likely was picking up green crab larvae, which weren’t present in that location a year later. Notably, the effort represented an important test case for how eDNA and traditional trapping can be implemented together for green crab management.

“The reason we pursued this project in the beginning is that early detection of green crabs is difficult — it’s like finding a needle in a haystack,” said co-author P. Sean McDonald, a UW associate teaching professor in environmental studies and aquatic and fishery sciences and the UW principal investigator for Crab Team research. “So if adding eDNA to our toolkit helps us detect those needles, then that’s great to have at our disposal.”

Ana Ramón-Laca of the Cooperative Institute for Climate, Ocean and Ecosystem Studies is an additional co-author. This research was funded by Washington Sea Grant.
Hi all,

Brief update to let you know we successfully deployed six passive acoustic monitoring (PAM) moorings in Kotzebue Sound last week, in collaboration with Wildlife Conservation Society and the Native Village of Kotzebue.

From there we traveled to Cook Inlet where we recovered our instruments deployed in silos along the Eklutna Tribe shore in Knik Arm and serviced the dual rock silo (F-POD echolocation logger and ST-600HF sound recorder) to continue sampling throughout the overwinter period. These instruments are monitoring the endangered Cook Inlet beluga whale population and a quick look at the data shows plenty of beluga detections starting in mid August. Special thanks to Chris Garner from Joint Base Elmendorf Richardson and his fantastic team of field technicians for hauling the gear across the Eklutna land.

Our attempt to fly via helicopter today to recover our silos deployed in Chinitna and Tuxedni bays failed due to borderline weather (silos are instruments we bolt to rocks or install in drilled holes in the sediment during a strong low tide where they remaining at about 4 feet below the average low tide). A decision was made to postpone the flight.

Editor's note: This is an edited version of an email sent by CICOES researcher Manuel Castellote on September 12, 2022.
prior to take off. We only have one opportunity to get to these instruments – due to the high cost of the helicopter flight time – so we decided to wait until the next negative low tide window in October to maximize chances of a successful flight.

We are driving to Homer tomorrow with one PAM mooring ready to be deployed at Johnson Creek on the southwest side of Cook Inlet, to obtain baseline data from that area prior to potential mining operations. The weather forecast is looking good for Tuesday and Wednesday so we’ll also use the boat day to recover two PAM moorings we deployed in May at the mouths of Chinitna Bay and Tuxedni Bay. This area is of interest because oil and gas leases will be available soon in that region and we need to understand how important this habitat is for beluga and other marine mammal species.

Ahead of us awaits a long winter digging into the data to understand beluga seasonal presence and foraging occurrence, as well as learn what other marine mammal species frequent this section of Cook Inlet.

Cheers,

Manolo Castellote
Research Scientist, CICOES
STUDYING THE ECOLOGICAL IMPACT OF SALMON SHARKS IN THE NORTHEAST PACIFIC

By Alexandra G. McInturf, Oregon State University

NO MATTER WHERE YOU LIVE in the United States, it’s likely that you have heard of, seen, or even tasted salmon. They are important fish in many ways—economically, culturally, and ecologically. As a result, much research focuses on making sure we can harvest wild salmon populations sustainably; that is, without causing a decline in the harvested population. However, natural ecosystems are complicated and can be hard to predict. For some salmon populations, conservation and sustainability strategies work quite well, while other populations don’t respond as we might expect. This may be because while we can control our own actions (by limiting our fishing, for example), there are other factors affecting salmon populations that we need to consider. Key among these is predation.

In January 2022, I began my project as a CICOES postdoctoral fellow at Oregon State University. I have been collaborating with many branches of NOAA and several universities nationwide to study a potentially impactful salmon predator: the Salmon shark (*Lamna ditropis*). Salmon sharks are a species in the ‘mackerel shark’ group, which also includes the white shark. In fact, they closely resemble a scaled-down version of a white shark, at 6-8 feet in length. They can be found from California to Alaska, and their presence seems correlated with that of salmon. However, very little is known about the Salmon shark, including what it eats, how often, and where. Our study, which will take place through 2023, aims to fill these gaps. I am examining stomach contents of deceased individuals, taking tissue samples to see what the sharks are eating over long periods of time, and using biologging tags (like a wild animal version of FitBits) to determine how much prey Salmon sharks need to consume to compensate for their energy use. This information will be used to assess the impact of this large predator on salmon populations in Alaska, Oregon, and Washington. Ideally, it will also allow managers to consider the impact of predators like the Salmon shark when making decisions about sustainable fishing.


FINANCE AND INITIATIVES

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 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 fiscal year 2022 totals $25,485,300. CICOES’ funding for non-Cooperative Agreement grants for the same period (Task IV) is an additional $2,243,700.

**THE PATH OF A NON-COOPERATIVE AGREEMENT PROPOSAL (TASK IV):** CICOES PIs often submit competitive grant proposals to both Federal and non-Federal agencies to support their research. Usually, these projects are complementary to the research work they’re supported on via the NOAA cooperative agreement. The funding agencies that support the work of CICOES PIs run the gamut from major Federal agencies like NSF, ONR and the US Forest Service to non-profits like the North Pacific Research Board and the Packard Foundation.

For details about cooperative agreement proposals see pages 28-29 in the 2021 CICOES Magazine.
TOTAL FUNDING: $27,729,000

FUNDING BY RESEARCH THEME:

- Polar Studies | $267,300
- Ocean & Coastal Observations | $6,028,300
- Multiple | $906,100
- Marine Ecosystems: Observations, Analysis, & Forecasts | $7,023,900
- Environmental Data Science | $498,900
- Environmental Chemistry & Ocean Carbon | $4,256,500
- Earth Systems & Processes | $1,986,600
- Climate & Ocean Variability, Change, & Impacts | $1,521,100
- Aquaculture Science | $532,200

CICOES INITIATIVES:

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

- Postdoctoral Fellowship Program | $350,500
- Summer Intern Program | $127,000
- Graduate Student Awards | $117,200
- Research Development Grants | $78,000
- Diversity, Equity, and Inclusion | $11,500
- Professional Development | $9,800

UW Office of Sponsored Programs (OSP) reviews and submits proposal to funding agency

If awarded, UW's OSP reviews and accepts award, forwards to UW Grants & Contracts Accounting who will set up account
RESEARCH DEVELOPMENT GRANTS

Since 2015, JISAO and now CICOES have used internal funds to stimulate new, innovative research. Over time the name and the objectives of the program have evolved. The original “mini-grant” program provided salary to existing PIs to initiate or expand research efforts. This program has been expanded to enable grantees to collect proof-of-concept data in support of external research proposals, to widen the eligibility pool to include non-PI Research Scientists and Postdoctoral Scholars, and now, since the evolution of JISAO to CICOES, to include applicants from our partner universities. This larger, more inclusive eligibility pool enables early career scientists to gain experience in the conception, management, and execution of research projects and, at the same time, facilitates collaboration among the CICOES community of scientists throughout UW, UAF, OSU and NOAA. We now sponsor projects that are collaborative efforts among at least two of 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 project described below that this long-standing program continues to bolster the expertise of our research community.

The following project was funded in 2022:

SEA-ICE MICROBES IN WARMING ARCTIC COASTAL LAGOONS: CONTRIBUTIONS TO BIODIVERSITY AND ESTUARINE FOOD WEBS

Byron C. Crump, College of Earth, Ocean, and Atmospheric Sciences (OSU); Karen Junge, Applied Physics Laboratory (UW)

We seek to understand the role of sea-ice microbial communities on lagoon ecology in a warming Arctic by measuring microbial community parameters in sea ice and water throughout the annual ice-water cycle, combining microbiological and biogeochemical techniques with metagenomics and metatranscriptomics, and by leveraging support of the BLE-LTER. Our specific science objectives for this pilot study are to:

• Develop and validate ice-melt metatranscriptomic techniques for quantifying metabolic responses of microbes to in-ice emplacement and from-ice release (performed by a Research Development Grant in the UW-APL ice laboratory).
• Characterize changes in microbial signatures (whole-cell numbers [total and active cells], metagenomic and metatranscriptomic diversity) in ice and water samples in winter and spring to establish baseline microbial life-metrics throughout the water-ice-water system evolution (UW-APL, OSU, UAF).
• Correlate baseline life-metrics and environmental variables measured through the BLE-LTER to functional gene abundance and expression (metagenomes and metatranscriptomes) of microbial populations in ice and water and quantify the impact or exchange between the two systems (OSU).

Beaufort Sea lagoons bounded by ice.
Photo: Kenneth Dunton, Marine Science Institute
In early June, the CICOES DEI community-facing sub-committee formed a partnership with Seattle MESA to put on an event for middle school students. MESA, Math Engineering Science Achievement, is an organization that provides teachers and students in the Seattle area with opportunities for hands-on learning, specifically for STEM subjects. Partnering with Seattle MESA was therefore an opportunity for CICOES scientists to give students a peek at what it’s like to be a marine researcher. As our partnership is in the early stages, we focused our efforts on inviting 30 middle school students to UW, picked from different classes by a teacher who regularly participates in the Seattle MESA program. Our goal was to do an initial pilot program in order to work through the logistics of hosting students at UW.

The students met at the Fisheries Building where they participated in activity stations run by our very own CICOES scientists, which included topics such as ocean acidification, marine mammal behavior, and ocean current circulation. We focused on hands-on activities in order to provide insight into ongoing research and greater context for the importance of studying the biological and physicochemical processes of our oceans. We then transitioned into a squid dissection, where students got to get their hands dirty (literally), investigating one of the oceans most intriguing camouflageers. While there was some aversion at the prospect of handling a squid, students quickly got over their squeamishness and dove right into the dissection, even writing out their names with squid ink! For the final leg of this event, students were taken into the Fisheries Teaching and Research Building for a tour of the amazing fish bone collection on display.

The students were very engaged throughout the entire program and asked great questions! Overall, we think this was a huge success and we look forward to partnering with Seattle MESA in the future.
WADING INTO RIP CURRENTS: MY SUMMER AS A CICOES INTERN

By Audrey Casper, George Washington University

LIKE MANY MARYLANDERS, my love for environmental science has deep roots in the Chesapeake Bay. I remember the elementary school field trips where I stood gazing at the largest estuary in the United States, trying to picture a past when its water was clear. This was the place where I first learned about over-harvesting, habitat loss, and the impact of pollution throughout a watershed — all environmental issues that guide my studies to this day.

But despite visiting these Maryland coastal zones my entire life and a growing general awareness of marine environmental issues, I went into my UW Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES) summer internship knowing next to nothing about the details and mechanisms of coastal processes.

When CICOES coastal physical oceanographer Dr. Melissa Moulton reached out to me about joining her project, I knew this would be a great opportunity to expand my knowledge. She outlined a research experience where we would investigate NOAA’s rip current hazard forecast. I couldn’t have been more excited! My first week in Seattle, I met my two graduate student mentors, Emma Nuss and Christine Baker, both in the final stages of a PhD in Civil and Environmental Engineering. Talking with Melissa, Emma, and Christine about the information I learned as I read through articles and watched Python tutorials, I began to grasp an image of what work in this field could look like.

I began to think of coastal issues like I never had before. I found out that rip currents, fast offshore-directed flows, are the leading cause of death and rescues on surf beaches worldwide. To minimize this threat, NOAA provides rip current hazard likelihood forecasts, based on a range of environmental conditions. I came to understand that rip currents come in several types, including bathymetric rip currents (those that form when waves break on sandbars interspersed with channels) and transient rip currents (those that form when there are breaking waves coming from multiple directions).

I have always loved math and problem solving, and discussing equations created to parameterize rip current speed with Emma and Christine made me realize that I could bring these passions into environmental research. In UW’s Harris Hydraulics Laboratory, other graduate students showed me their experiments modeling turbulence, microplastics, and estuarine systems. Their enthusiasm was infectious, and they opened my eyes to modeling as a tool for environmental analysis. Now thrust into the world and work of these mentor figures, I felt my excitement expanding each day.

I worked with my mentors to start shaping the research experience to my emerging interests. We discussed how the NOAA hazard likelihood model was developed and tested in an area where bathymetric rip currents may be the most prevalent type of rip current. Because of the way the model was created, we wondered how well the model would perform in areas where other rip current types,

Areas images of (a) transient rip current ejections highlighted with dye release and (b) bathymetric rip current ejections. Image: Morgan et al. (2018)
including transient rip currents, are more common. Holding onto these questions and observations, we set up a meeting with our collaborator, Dr. Gregory Dusek, Senior Scientist at NOAA’s National Ocean Service.

As we explained the ways we wanted to approach our research question, Dr. Dusek provided us with invaluable resources including NOAA’s wave and rip model outputs and lifeguard data from 2021. This latter data was obtained when NOAA asked lifeguards working at Salt Creek Beach, California, to record the rip currents they detected, their strength, and their type (noting ‘semi-permanent and stationary’ for bathymetric rip currents and ‘transient’ for transient rip currents). The NOAA models are powerful tools for processing large amounts of environmental data to present a probabilistic hazardous rip current output. When coupled with the lifeguard data that provided discrete timestamps to compare the model’s hazard likelihood with rip current type and our speed parameterizations, we now had an innovative tool to start running forecast validation statistics.

I started by creating several time series to document the NOAA model’s inputs, including environmental conditions like wave height, tidal level, wave direction, and directional spread. I then plotted the rip current hazard likelihood output with our rip current speed parameterizations for both transient and bathymetric rip currents. By comparing the times when the input conditions predicted hazardous rip current speeds with NOAA’s hazard forecast, I developed a better understanding of the potential biases of the model. With the lifeguard data, I focused on a 19-day stretch in September 2021 when there were 13 rip current reports, 9 of which were classified as transient rip currents and the other 4 as bathymetric rip currents. By comparing the model data we obtained from Dr. Dusek against each lifeguard timestamp, I found that the model’s hazard likelihood output averaged 49.7% for transient rip current records and 36.9% for bathymetric rip current records.

I could not be happier with my CICOES research experience. I would like to thank my mentors Dr. Melissa Moulton, Emma Nuss, and Christine Baker, collaborator Dr. Gregory Dusek, and all affiliates of CICOES for granting me this opportunity.
A LOT HAS CHANGED for Karen Valladares since she was a CICOES intern in 2017. “I ended up in graduate school, that’s something I never thought I’d do,” she exclaimed over Zoom in early February, 2022.

Five years earlier, Karen was majoring in chemistry at Mount San Antonio College. She had been there for quite a long time – nearly seven years – and was preparing to transfer to the University of California Irvine when a professor told her about a research internship offered by CICOES, then known as JISAO, at the University of Washington (UW). She applied, was accepted, and soon flew to Seattle to work with her new mentor, Dr. Casey Saenger, studying tap water samples in a UW isotope lab.

“I constantly look back on my conversations with Casey and the director at the time, Dr. Tom Ackerman,” Karen recalls. “I was sitting in Tom’s office wondering why in the world did I get picked to be an intern? I felt so out of place and so incapable, but Tom and Casey never questioned my ability and never wondered if I was good enough.”

After nine weeks in Seattle, Karen left feeling ready for a new challenge at UC Irvine. “That’s when I started to lean more toward the public policy and how climate change impacts people rather than the planet,” she said.

“I started to learn about climate refugees and I’m realizing this is a really big deal.” So, after one quarter at UC Irvine, Karen switched majors from chemistry to public health policy. “I completely stopped taking science classes,” she confessed, “I was so much more concerned about local environmental health issues.”

When Karen learned that Santa Ana, California, a low-income community neighboring Irvine, was dealing with high levels of lead poisoning – an issue that the more affluent Irvine wasn’t facing – she was struck by the staggering difference and inspired to focus her senior year efforts on environmental justice issues. “I worked on a project utilizing PhotoVoice, a research tool used to convey something with pictures rather than words,” Karen explained. The project encouraged a group of young adults and children to go out in their community and take pictures of things in their environment that concerned them. “That’s when I realized that I really liked advocating for communities and allowing people to have a voice,” she said. The project ended up winning UC Irvine’s award for Outstanding Contribution to Public Health, Community, and UCI Service.

Around this time, she started attending city council meetings in Santa Ana and found many of them to be quite depressing. “There was a lot going on in Santa Ana,” Karen explained. “The University of Southern California did a study and found that a lot of low-income housing in Los Angeles had been built on old industry areas where the soil was extremely contaminated. How’s that allowed?” she wondered. Karen wanted to understand these issues, so she accepted a fellowship opportunity through CivicSpark AmeriCorps to implement the ‘Disadvantaged Communities Involvement Program.’ “I was trying to amplify voices of indigenous people across the watershed – everything you see is on stolen land, so I’m trying to acknowledge that while allowing people to express what they feel is wrong with their water.”

A comment at one of the steering committee meetings concerning the Santa Ana Watershed was Karen’s first push to consider graduate school. The council was discussing an emerging class of contaminates known as...
By Sara Dixon, Colorado College

The week after I graduated from Colorado College in May 2022, I got the chance to present my senior thesis research in Maui, Hawaii! In 2021 I worked with CICOES Research Scientist Dr. Yong Wei to create high-resolution probabilistic tsunami design zone maps for Maui, Hawaii. The American Society for Civil Engineers uses the maps to determine what areas need to have buildings that can withstand tsunami flooding.

For my thesis, I wanted to continue this project but also look at the impact tsunamis have on water quality in Hawaii. I found that other countries have experienced severe saltwater intrusion into coastal aquifers following the 2004 and 2011 tsunamis. One thing that places have done to mitigate this risk is to create risk assessment maps with geographic information systems software like ArcGIS. In my thesis, I used the probabilistic tsunami design zone maps in conjunction with my own risk assessment maps to determine tsunami-induced saltwater intrusion risk in Maui, Hawaii.

Thanks to CICOES and my research mentor, Dr. Wei, I had the ability to travel to Hawaii and meet up with members who work for the Governor's Office in Maui. The meeting took place at the Hawaiian Islands Humpback Whale Sanctuary, which is managed by NOAA. Being able to present my research to people who are working on similar city planning and hazard mitigation problems was extremely rewarding. Many of them had not had the chance to look into using GIS software to mitigate tsunami hazards, so being able to share my work was impactful. It was also interesting to travel around the island and see all of the places that I mapped in person. Additionally, being able to talk to locals about the issues of tsunamis and learn more about their perspectives on the problem of water quality was insightful. Before this trip, traveling on Google Earth was the closest I got to these areas, so I am extremely grateful that CICOES made this experience possible for me.

SARA DIXON (2021) PRESENTS TSUNAMI THESIS FOR MAUI COMMUNITY LEADERS

PFAS (per- and polyfluoroalkyl substances), which are very persistent bioaccumulative chemicals. "They were talking like PFAS wasn't a big deal, and the guy is specifically talking about a low-income area with large minority population," Karen explained with frustration. “I was really offended by that.” Karen asked the representatives if they would drink the water and they wouldn't answer. “They just kept saying it's not a big deal. This is the reason we have health disparities, because people don't care and they talk about others in this way.”

For the first time in her life Karen was considering graduate school, but suddenly and tragically her older brother passed away during her senior year, a shocking loss that put an end to thoughts of academics. After a long pause on future planning, in January 2020, her professor reached out and said that she knew Karen was very passionate about water issues and wanted to introduce her to another professor at UC Irvine. “I think they were just trying to make sure I didn't quit because my whole world was destroyed at that time,” Karen said. It turns out this professor, Dr. Scott Bartell, had a grant from the CDC to do work on PFAS; it sounded like a perfect connection, so Karen agreed to the introduction. “I’ll just go talk to them and geek out on stuff,” she thought to herself. “We ended up talking for two hours and at the end of the conversation he said ‘I really want to work with you, would you be willing to start your PhD in the fall?’” Karen was taken aback but enthusiastically agreed.

A short time later, Karen was accepted into UC Irvine’s graduate program, received a prestigious fellowship to help fund her education, and is now studying the health impacts of PFAS and the health disparities that may be exacerbated by the contaminants.

“So here I am in my second year of graduate school working on a PhD in Environmental Health,” Karen says. “I’ve been super lucky. I received a lot of encouragement, first from CICOES and now from my graduate advisor. There have been so many people who have believed in me and that’s really comforting!”

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SARA DIXON (2021) PRESENTS TSUNAMI THESIS FOR MAUI COMMUNITY LEADERS

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ALASKA SEISMIC STATIONS

KEEP WATCH FOR TSUNAMIS
On July 21, 2020, people in coastal communities in southern Alaska were winding down the day when just after 10 p.m. wailing sirens halted everything: tsunami warning. A magnitude 7.8 earthquake had struck off the coast of the Alaska Peninsula, and the National Tsunami Warning Center (NTWC) issued the warning for south Alaska and the Alaska Peninsula. Text messages, emergency broadcasts, and sirens urged residents to evacuate to tsunami shelters on high ground. People posted videos on social media of lines of cars headed up the roads. The NTWC sent out estimates of when waves would reach nearby communities.

Ultimately, this earthquake — dubbed the “Simeonof Earthquake”, after the nearby Simeonof Island — was deep enough that the tsunami was minimal and only light damage was observed in local communities. The highest wave was about 10 inches (~25 cm) in Sand Point, the community closest to the epicenter. The warning was ultimately canceled at 12:25 a.m. on July 22.

The NTWC must issue tsunami warnings within 5 minutes or less after an earthquake occurs. Seismic stations across Alaska, maintained by the Alaska Earthquake Center (AEC), support NTWC’s mission of being on watch for large earthquakes that could cause dangerous tsunamis.

THE SEISMIC MONITORING NETWORK

Alaska is the most seismically active region in the U.S. Offshore of Alaska’s southern coast lies the subduction zone, where the Pacific Ocean tectonic plate scrapes under the continental plate of mainland Alaska, causing much of this earthquake activity. The AEC records an average of 50,000 earthquakes per year. The vast majority of those are relatively small with little or no discernable impact on coastlines, but since 2018 alone, the AEC has observed five major earthquakes greater than magnitude 7.

The AEC maintains a seismic station network across the state. The stations detect earthquakes and send real-time data to the Earthquake Center in Fairbanks. CICOES funds eight seismic stations that are particularly important for detecting “tsunamigenic” earthquakes — those with the potential to cause tsunamis. The project places special emphasis on coverage in the Aleutian Islands and Bering Sea, locations critical for tsunami monitoring. Six of the eight stations are locat-
The Earthquake Center field crew explores the shoreline along St. Paul Island. Photo: Alaska Earthquake Center


All of these sites include both broadband and strong motion seismic sensors. Broadband instruments are very sensitive, able to detect seismic waves smaller than people can feel. But if a large earthquake happens nearby, broadband instruments can be overwhelmed, like getting your ears blasted by turning on a stereo with the volume at maximum. Strong motion sensors are built to capture data from even the largest earthquakes, such as major offshore events that generate tsunamis.

THE FIELD WORK CHALLENGE

Maintaining seismic stations in remote Alaska communities presents challenges. “Some trips you spend two days of travel for a half hour of work,” says Nate Murphy, Interim Field Manager for the Earthquake Center. In the 2022 field season, the Earthquake Center field team visited Bering Sea sites at St. Paul Island and the community of Gambell on St. Lawrence Island, and a site near Juneau.

Unlike many remote Alaska network sites that rely on solar and battery power, these Aleutian and Bering Sea sites tap into local community infrastructure for power and cell or Wi-Fi connectivity. “One thing that is neat about these sites is that there is a lot of community support, from schools, government groups, etc., that we don’t have with our very remote sites,” says Murphy. “In these communities every elder has a story about a tsunami event in the area. There’s a lot of cultural and historical knowledge about tsunamis, which makes them supportive of our work.”

LARGE EARTHQUAKES TEST THE NETWORK

SIMEONOF EARTHQUAKE: The magnitude 7.8 (M7.8) Simeonof Earthquake occurred on the active subduction zone off the Alaska Peninsula, and regional communities from Perryville and Sand Point to King Cove and Cold Bay reported strong shaking. The

USArray Alaska Station Design
Remote stations are often powered by solar panels and batteries, unless they can connect to a local power source. Station batteries, computers, and other equipment are sheltered inside the hut. The seismometer is buried in a borehole in the ground to reduce the amount of non-seismic surface noise (such as vehicles) that it picks up. Some sites have strong motion sensors, which are buried in a shallower vault with a concrete bottom. Image: Alaska Earthquake Center
The M7.8 Simeonof Earthquake, its M7.6 aftershock, and the M8.2 Chignik Earthquake occurred offshore of the Alaska Peninsula. All three generated tsunamis that triggered community evacuations. Stars mark the epicenters of the three large earthquakes, circles mark smaller aftershocks. The Chignik Earthquake was triggered by, and occurred immediately to the east of, the M7.8 Simeonof Earthquake one year earlier. Map: Alaska Earthquake Center

Anchorage and Mat-Su Valley areas more than 500 miles away felt weak shaking. Three months later on October 19, Earthquake Center stations recorded a M7.6 aftershock that shook the region again. The National Tsunami Warning Center issued tsunami warnings for much of the Alaska Peninsula for both events, prompting evacuations. Several Alaska Peninsula communities also reported damage.

CHIGNIK EARTHQUAKE: On July 28, 2021, a magnitude 8.2 earthquake struck offshore of the Alaska Peninsula, near the community of Chignik. This was the largest recorded U.S. earthquake in 50 years. The Chignik Earthquake occurred about 45 miles (72 km) east of the M7.8 Simeonof Earthquake. The Simeonof Earthquake helped trigger the Chignik Earthquake; both occurred along the interface between the subducting Pacific and overriding North America plates, although the Chignik Earthquake was the deeper of the two.

Because of the offshore location, the National Tsunami Warning Center issued a tsunami warning for much of coastal Alaska. At least 11 communities issued evacuations. Recorded wave heights were less than a foot, however, and the warning was downgraded a couple hours after the event.

PARTNERING TO PREVENT DISASTER

Fortunately, the recent Simeonof and Chignik earthquakes and tsunamis did not cause any casualties or much damage, but the possibility is always present in coastal Alaska. Tsunamis are trains of waves that may arrive over the course of a full day, and initial waves are rarely the largest. To be effective, tsunami warnings must go out before any wave heights are known, so three successful tsunami evacuations in just over a year are a testament to the strong relationships the National Tsunami Warning Center has established with Alaska communities. Partnering with CICOES and other organizations to support seismic stations that detect earthquakes as soon as possible, and sharing that data with the National Tsunami Warning Center, helps give Alaska communities the edge they need to stay safe.
A rare sunny day on St. Paul Island.

Photo: NOAA Fisheries, Permit 23283
NEW METHOD MONITORS FUR SEAL PUP PRODUCTION USING UNCREWED AIRCRAFT

By Burlyn Birkemeier and Molly McCormley, CICOES

Traditionally, scientists from the Marine Mammal Laboratory have traveled to the Pribilof Islands every other year to complete pup production surveys of the largest population of northern fur seals in the world, the eastern Pacific stock. This population declined from 2.1 million in the 1950s to just over 600,000 in 2019, despite the 1984 commercial harvest ban. In order to monitor the population of this depleted stock, pup production surveys are completed to estimate pup counts using mark-recapture methods. While marking a specified portion of pups is necessary to monitor this population, these methods require handling of pups and displacement of adults, which consequently disturbs the breeding areas called rookeries. With the rise in uncrewed aircraft systems (UAS) or ‘drone’ technology, less invasive survey methods have become a more practical alternative. In 2021, the first UAS survey to assess pup production of all northern fur seal rookeries on St. Paul Island was completed.

This year, we traveled with Nancy Young (NOAA) to St. Paul Island, the largest of the four Pribilof Islands located in the Bering Sea, to complete a second year of UAS surveys. Just getting there is one of the many challenges associated with conducting research in this area of the world; weather and mechanical issues constantly plague the flights from Anchorage to St. Paul Island. We were delayed two days in Anchorage for weather, which some may consider lucky since there have been instances of delays over a week long. We successfully made it to St. Paul Island on Thursday, July 28, and quickly settled into “Staff Quarters,” an 18-bedroom house maintained by NOAA for researchers.

St. Paul Island is home to 14 northern fur seal rookeries (see map on next page). Our goal was to capture images of each rookery, plus Sea Lion Rock, at least twice in about a week using the DJI Mavic 2 Pro UAS system. While this may sound like a simple task, the challenges facing UAS pilots on St. Paul Island are seemingly endless. First, FAA protocols state the UAS must remain 500 feet below the clouds and within visual line of sight. Additionally, the integrated UAS camera cannot capture decent images if there is low fog, if it is raining, or if it is too dark (which we discovered cannot always be determined with the naked eye). St.

Why is pup production a key metric?
The northern fur seal population on the Pribilof Islands has been monitored using pup production estimates since the early 1900s. Since at any given time only a portion of the non-pup fur seal population is on land, abundance at each rookery is monitored using estimates of pup production. However, the abundance, location, and distribution of pups makes a complete count, or census, very difficult at best. Therefore, since the early 1960s, pup production on the Pribilof Islands has been estimated using mark-recapture methodology. Northern fur seal population estimates are then obtained using an expansion factor based on published survival rates.

Image: Northern fur seal pup on St. Paul Island. Burlyn Birkemeier, NOAA Fisheries. Permit 23283
Paul is known for summertime fog and low cloud cover, which makes finding appropriate weather windows for flying very difficult. Another challenge is battery power. We had seven DJI batteries with us, which provided just over two hours of flight time. The flight time required to complete a full survey of the island is about eight hours, which meant we had to be very strategic in our battery use and charging plan. Lastly, even when we were able to fly, there was no guarantee the images would be clear or well lit, resulting in some useless images.

We had arrived at St. Paul early with the hopes of completing the UAS surveys before the rest of the team joined us, at which point we would begin the traditional mark and recapture method of surveying. Unfortunately for them, the team joining us was also delayed in arriving due to weather, so we had five extra days to complete our

Top: A DJI Mavic survey image of northern fur seals at Morjovi rookery. *Photo: NOAA Fisheries. Permit 23283*

Right: Map of the northern fur seal rookeries on St. Paul Island, Alaska. *Image: NOAA Fisheries*
THE POPULATION DECLINED FROM 2.1 MILLION IN THE 1950s TO JUST OVER 600,000 IN 2019

UAS survey. That time was very helpful and allowed us to finish surveying despite the weather, battery, and image quality challenges. We were able to fly 11 days and complete over 26 hours of flight time. We collected 25,950 images, and we flew every rookery at least twice. It was a very successful trip.

A successful UAS survey means there is now a lot of image processing, pup counting, and method verification to be completed. Specifically, both the traditional and UAS pup population counts have to be compared to determine if the UAS method is a feasible alternative in determining accurate pup production estimates. Counting the pups in the images collected from UAS, however, is a very challenging and time consuming endeavor. In order to combat these issues, NOAA scientists have been starting to employ machine learning techniques to help in producing accurate and timely pup counts. These techniques, however, are in the early stages of development. While these methods are undergoing many changes, there remains hope that UAS surveys can one day be the new standard for monitoring this depleted northern fur seal population.◆

Top: The UAS survey pilots in command (Burlyn Birkemeier, Molly McCormley, and Nancy Young). Photo: NOAA Fisheries

Bottom: The DJI Mavic 2 Pro UAS in flight. Photo: Paul Hillman
In fall, the Council discusses and sets the quotas for fishing in the following year. This is no mean feat! The Council sets catch limits for about 190 fish species in the Bering Sea, Aleutian Islands, and the Gulf of Alaska. And the physical and economic scale of those fisheries is huge.

Alaskan fisheries comprise more than half of the U.S. domestic landings by volume — Dutch Harbor, in the Aleutian Islands, has been the leading port in terms of volume for over 20 years in a row. Chances are that if you, your family or friends throughout the country have had some fresh fillets, fish sticks, surimi, or fish and chips, you’ve enjoyed some fish from Alaska. In economic terms, Alaskan fisheries generate an annual wholesale value of more than $4 billion. A lot of those earnings go to Washington State and elsewhere in the U.S.; the true value and importance of Alaskan fisheries extends nationwide.

So given the giant scale of Alaskan fisheries, you can imagine that there is a lot of careful discussion and work required to set fair rules for sustainable harvests and to implement ecosystem-based fishery management, a holistic approach that recognizes all the interactions within an ecosystem rather than considering a single species or issue in isolation.
Before catch limits are set, an important first step is for the Council to be informed about current ecosystem status and trends. The core mechanism for this step are “Ecosystem Status Reports” (ESRs), which are included within the SAFE Report. ESRs provide context for catch determination of groundfish and crab, and are the result of a large collaboration across 28 institutions and over 130 individual contributors who prepare sections according to their expertise. Most information comes from indicators, which are quantitative measurements that serve as proxies for the conditions of the ecosystems. The information is curated by a lead editor for each of the ecosystems: Eastern Bering Sea, Aleutian Islands, and Gulf of Alaska.

Here we highlight some of the contributions to the ESRs by CICOES researchers, and give a behind-the-scenes look at the process of putting together the Ecosystem Status Reports. Ivonne Ortiz edits the report for the Aleutian Islands along with Stephani Zador (AFSC, NOAA). Elizabeth Siddon and Bridget Ferris (also from AFSC, NOAA) edit the reports for the eastern Bering Sea and Gulf of Alaska, respectively.

The main activity starts in early summer amid the numerous summer surveys for fish, seabirds, and marine mammals. Requests for contributions go out to experts across Alaska and beyond: “Will you be able to provide …?” Information must be for the current year, so the most readily available information is based on spring surveys and satellite data. Those trickle in from mid-August all the way through mid-September, just in time to give a cli-
mate and oceanography preview to the Council in early October.

The preview starts with an overview of the North Pacific climate, provided by Washington State Climatologist Nick Bond. This year Nick highlighted what entering a third La Niña year may mean for each region, explained some aspects of cooling in the Eastern Bering Sea and Gulf of Alaska and a continued warm phase for the Aleutian Islands. This intro is followed with other information on the environment, like winds, temperature, sea ice, transport, and ocean acidification.

Kelly Kearney, who ordinarily spends her days modeling the biogeochemistry of the eastern Bering Sea, provides information on the extent of the annual “cold pool”, based on a regional ocean modeling system for the Bering Sea. The cold pool is the region of the Bering Sea shelf where bottom water is < 2°C throughout the summer. It is a very meaningful oceanographic feature, forming a boundary between Arctic and subarctic aquatic animal communities and influencing the distribution of many commercially important fish, and thus the distribution of the fishing fleet. In 2020, Kelly’s model-based contribution was the only information available on bottom temperature, as there was no traditional bottom trawl survey that year due to COVID-19.

Air temperature is also included for the eastern Bering Sea, thanks to Muyin Wang, who provides information on air temperature at St. Paul Island. Wei Cheng continues the section on eddy kinetic energy (a section started by recently retired PMEL oceanographer Carol Ladd) which provides key information about nutrient and heat transport in the Aleutians and Gulf of Alaska. Darren Pilcher’s contribution on ocean acidification has gained relevance in recent years, particularly with regard to crab stocks in the eastern Bering Sea.

Biological information, whether from satellite data or summer surveys, is left for the full report in November. Indicators from satellite data arrive first. Jens Nielsen and Noel Pelland each lead analyses of remotely sensed (satellite) chlorophyll, used as a proxy for phytoplankton biomass. At the base of the food web, phytoplankton support a large portion of marine food webs. And in case you are wondering, the un-eaten portion of phytoplankton sinks and supports the benthos — those organisms living on or near the bottom of the sea, or within the sediments. Noel is a physical oceanographer, but developed the phytoplankton indicator for the Aleutian Islands upon request, in collaboration with other researchers.

Jens leads an assessment of coccolithophores, which are single-cell marine algae with an outside boundary of overlapping limestone plates/shields, called coccoliths. Smaller than diatoms, coccolithophores may be a less desirable food source for microzooplankton in the eastern Bering Sea. Depending on its magnitude, a coccolithophore bloom can reduce the light transmitted through water and make it difficult for visual predators to find prey. These blooms turn the ocean milky white, which can be seen from space depending on their scale, and have been implicated in seabird die-offs.

By now summer survey data start coming in! Freshly collected and analyzed, these data are often prioritized for the SAFE report but provided after the information for the individual stock assessments. Survey based information can arrive as late as October, just before edits and drafts are finished to be sent for review in early November. Andy Whitehouse specializes in food-webs and contributes several
community indicators based on groundfish. These include a stability index, and biomass of pelagic foragers and apex predators. The report also includes one-time projects that are noteworthy, or surveys that are regular but not done at fixed intervals. Examples from last year’s report include marine mammal distribution in the Gulf of Alaska, featuring work by Alex Zerbini, and Cynthia Christman’s collaboration on aerial surveys to determine the abundance of harbor seals in the Aleutian Islands. There can be over 60 indicators included in the report.

During October and November, each lead editor discusses the information with the contributors, evaluates the information, and after some sleep-and-food-deprived days, wraps up an assessment and draft of the ecosystem status report. The draft goes through internal review, and then is made available and presented to the Groundfish Plan Team, a group of scientists who review all stock assessments and prepare harvest recommendations. The Plan Team has a broad membership, including Council staff working with scientists from the regional office of the National Marine Fisheries Service (NMFS), NMFS’ Alaska Fishery Science Center, the Alaska Department of Fish and Game, the Washington Department of Fisheries, the International Pacific Halibut Commission, the University of Alaska, the University of Washington, and other institutions and universities.

A special kind of camaraderie develops from the brief but intense period of late nights and working weekends prior to the Plan Team meeting... a Sunday morning call to discuss some ideas, late afternoon chats about coding (the report is written in LaTeX), coordinating answers to comments and recommendations from last year. There is a collective sigh of relief by everyone involved between the end of the Groundfish Plan Team meeting in mid-November and the Council meeting in early December.

But we are not done yet! The time between the Groundfish Plan Team and the Council meetings — when final decisions are made — is when the “inBriefs” are put together. These 4-page graphical summaries provide a public-friendly version of the assessment with highlights specific to each ecosystem.

Final drafts of the Ecosystem Status Reports along with the rest of the SAFE Report and the inBriefs are uploaded to the Council website and made publicly available. Then our group of lead editors head up to Anchorage to present to the Council meeting, three times: first to the Statistical and Scientific Committee, then to the Advisory Panel (fishing industry, fishermen, consumers, observers, and NGOs) and — finally! — to the Council: 15 members who are a mix of fishery representatives, ADF&G, NOAA, Coast Guard, NGOs, WA and AK state representatives. And yes, as editors we get different questions each time depending on that year’s conditions, status of the fisheries, and each panels’ interests. The fall frenzy comes to its end during this final stage, when quotas are discussed and finalized. This last public and well attended meeting wraps up the ESR process, and is a buzzing get-together from morning to night.

Alaskan fisheries generate an annual wholesale value of more than $4 billion
FOURTH TIME’S A CHARM
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OAA’s biophysical mooring site 2 (M2), led by the Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) co-lead Phyllis Stabeno, has been collecting seawater measurements in the southeastern Bering Sea since 1995. Measurements of temperature, salinity, nitrate, oxygen, chlorophyll and currents have been the cornerstone of many interdisciplinary objectives over the years that M2 has consistently been in operation.

Subsurface instruments monitor the water column at M2 year-round, supplemented by additional measurements from a surface buoy that must be recovered prior to the advance of seasonal sea ice. EcoFOCI partnered with the University of Alaska Fairbanks (UAF) in 2011 to add sensors to the M2 mooring site that would monitor surface carbon dioxide (CO2) dynamics and ocean acidification.

The global oceans absorb ~26% of human emitted carbon dioxide, causing seawater pH to decline. This global decline in pH, or Ocean Acidification (OA), is happening faster in the Arctic and subarctic, and can negatively affect important subsistence and commercial fisheries. The Bering Sea supports some of the most productive fisheries in the world, and the M2 site serves as the longest-running ecosystem monitoring station within this vital region.

The UAF CO2 sensors are housed in the seasonal surface buoy, nicknamed Peggy (photo on opposite page), which is typically deployed from May to September. In recent years, a second seasonal surface buoy, nicknamed Oscar, has been established at M2 to support the newly-developed ‘Prawler’, a seawater profiler that uses wave energy from the surface mooring to crawl up and down the anchor line, taking temperature, salinity, oxygen, and chlorophyll measurements along the way.

In September 2021, the annual fall mooring cruise — slated to handle the recovery of both Peggy and Oscar, among other tasks — was canceled due to COVID-19 and we began what turned out to be a 5-month long odyssey to get the surface equipment recovered before it would be destroyed by the advance of sea ice.

With the Bering Sea’s notorious autumn storm season fast approaching, our first obstacle was to secure a new charter while most vessels and their crews are heading for home or laid up in harbor. The first of many storms that fall took place in mid-October, bringing hurricane force winds to the Aleutians. The meteorological package at M2, ~325 kilometers north of Unalaska, experienced howling winds of 25 m/s, or about 56 mph, at one meter above the sea surface. Thankfully there were no weath-
er-related injuries reported in the region, and the passing storm wound up driving an interesting oceanographic event that was recorded at M2.

Our 10-year record of observing surface carbon dynamics at M2 shows a seasonal, biological drawdown of seawater CO$_2$, driven by the spring phytoplankton bloom, with a gradual return to near-equilibrium with air by the fall. As summer progresses, the biological pump on the continental shelf exports organic carbon from surface to bottom waters, where bacterial degradation remineralizes this organic matter, causing increases in CO$_2$ at depth. During the October 2021 storm, deep, CO$_2$-rich water was mixed to the surface, and Peggy recorded a significant event with CO$_2$ in the seawater greater than that in air by ~100 µatm. This causes the ocean to release CO$_2$ back into the atmosphere.

We have rarely had the opportunity to observe late-season outgassing events like this in the Bering Sea, since the surface mooring with its CO$_2$ sensor package is usually recovered and removed much earlier in the season. Observing these late-season dynamics helps create a better understanding of the annual carbon cycle, which is critical for measuring future change.

That “bonus” data was exciting, but we were feeling increasing pressure to secure a charter for the M2 surface moorings recovery before seasonal sea ice advance could threaten the equipment. Two additional attempts to recover the mooring late in 2021 fell through, because of COVID-19, weather, or both.

Peggy’s mooring line is engineered to withstand strong storms, but the float is not designed to handle sea ice. In some winters, sea ice may not reach M2, but as the season progressed the forecast of relatively extensive ice in 2021/2022 was beginning to ring true, and our stress levels were rising. Finally, we were able to establish a charter with the M/V Resolve, and our team traveled to Unalaska in mid-January. As the crew waited...
THESE FIRST-EVER SURFACE OCEAN MEASUREMENTS DURING FREEZE-UP IN THE BERING SEA ARE PROVIDING A GLIMPSE INTO A SEASONAL SHIFT THAT IS RARELY CAPTURED.

Though a capable vessel and skilled crew allow for recovery in less favorable conditions.

Arriving at the M2 site as daylight was fading, after the long crossing from Unalaska, the crew immediately spotted the buoy Oscar, slightly damaged but still afloat. Peggy was nowhere in sight. The M/V Resolve set up to maintain station overnight, and begin operations at first light. As dawn broke the next day, the crew spotted Peggy. Sea ice had ridden over the top of her, tearing off the tower, meteorological package, and communication antennas and badly damaging the torrid, turning Peggy into a low-riding lump that was being claimed by fur seals as their couch.

After a difficult and challenging day of recovery operations by the Resolve and crew, both Oscar and Peggy — together with the 70 m of instruments below the surface — were recovered and brought back to Unalaska.

Now that the instruments and recorded data are safely back in Seattle at PMEL, these first-ever surface ocean measurements during freeze-up in the Bering Sea are providing a glimpse into a seasonal shift that is rarely captured. Climate change is faster paced in the sub-Arctic and Arctic, and the lack of baseline conditions make it hard to predict changes in primary production and the CO₂ cycle. The autonomous observations collected at M2 can help address these gaps in our understanding. The M2 data, along with supplemental discrete samples collected during ship-based fishery assessments in the Bering Sea, will be used by CICOES researcher Darren Pilcher and colleagues to validate a carbonate chemistry package for the “Bering 10K” regional ocean model. These observations and model outputs ultimately benefit fishery biologists and managers, through the addition of an ocean acidification index in NOAA’s Ecosystem Status Report.

Even before the recovered gear had been shipped out of Unalaska, planning for the 2022 spring mooring cruise was in full swing. Unfortunately, we no longer could rely on our flagship buoy: Peggy sustained irreparable damage to her fiberglass hull from the sea ice.

Thankfully, the PMEL Carbon Group loaned us a surface buoy and we deployed the replacement Peggy on schedule in April 2022. We then successfully recovered the buoy on September 8th, 2022, just in time — only one week before ex-typhoon Merbok entered the Bering Sea.
FAREWELL KEVIN — WE WISH YOU FAIR WINDS AND FOLLOWING SEAS!

By Kelly McBroom

DR. KEVIN R. WOOD, husband, father, scholar, scientist, adventurer, and maker died at home in Seattle, WA on February 14, 2022 at the age of 59 from metastatic lung cancer. Kevin was a seeker of the sublime in nature, a sailor, gifted writer, artist, storyteller, cyclist, book and curiosity collector, and a kind and gentle spirit. He was deeply committed to understanding and communicating the nuances of science and history in a way that inspired and motivated people to work for an end to climate change.

Kevin was born in Jacksonville, Florida in 1962. His passion for maritime history and love of tall ships took him to the Eastern seaboard where he began his sailing career. After a stint as a lobsterman on Matinicus Island, and a transatlantic voyage on a Polish vessel, he began work with Sea Education Association, where he was second mate on the RV Westward and the SSV Corwith Cramer out of Woods Hole. Kevin spent 8 years teaching students about the ocean, navigation, and maritime history from Maine to the Caribbean. It was on these vessels that some of his most important friendships were made.

His interest in science led him to join the U.S. Antarctic Program, where Kevin provided scientific and logistic support for the missions at Palmer and McMurdo stations from onboard the Polar Duke icebreaker, and he was later chosen as scientist to sail on the NSF icebreaker Nathaniel B. Palmer on a joint U.S.-Russian ice camp in Antarctica. He worked on the design and build of the SSV Robert Seamans, a 134-foot steel brigantine and the most sophisticated oceanographic research/sailing school vessel ever built in the United States. He received an MS in Marine Affairs at the University of Washington in 2004, and his PhD in Geophysics in 2010.

Kevin joined CICOES (then known as JISAO) and the Arctic Group at the National Oceanic and Atmospheric Administration (NOAA) in 2004. He was a leader in the Old Weather project—a citizen science program which transcribes historical ships logs from the 19th and early 20th century to reconstruct the climate record from this time period. He published original weather logs from the 19th century Arctic explorations for the first time, noting their year-to-year variability. He was the principal investigator of a

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grant funded by the Council on Library and Information Resources that digitized old U.S. Navy logbooks and muster rolls in a way that researchers across the world could access.

In addition to his maritime history project, Kevin was an expedition scientist on RUSALCA (Russian American Long-Term Census of the Arctic), a collaborative U.S.-Russian Federation oceanographic expedition to the Arctic marine regions shared by both countries: the Bering and Chukchi seas. He was chief scientist for the Arctic Heat open science experiment, flying aerial missions in NOAA research aircraft from 2016-2021 to deploy marine robotic vehicles (MRVs) and ocean temperature floats in the Bering Sea. Finally, Kevin was the main video producer for the Arctic Report Card, which documented multiple changes in the Arctic each year, and was responsible for the script. Due to his expertise he was selected to participate in an international expedition to locate the wreck of the USS Jeannette, which sank in Russian Arctic waters in 1881, an effort supported by the Prince Albert II of Monaco Foundation.

Kevin's colleagues shared stories and reflections on a kudoboard after his death. The most common words used to describe him were generous, enthusiastic, passionate, and a "scientist who loved the humanities." As both a historian and scientist, he thrived in the spaces between disciplines, and had a unique knack for understanding the scientific implications of obscure nautical source material. He valued collaboration, and never failed to welcome colleagues to participate in his projects. He was humble, approachable, and always ready to engage in spirited discussions. He delighted in mentoring young scientists, graduate students, and seekers of all ages and volunteered to help develop science curriculums based on compelling maritime stories for both middle and high school students.

On the home front, he married Kelly McBroom in 2005, and together they had many adventures, among them raising their two boys Ryan (age 15) and Galen (age 12). Kevin channeled his creativity into parenting and spent many hours putting together train tracks, making swords, makeshift sailboats, mentoring the boys as artists, biking, reading aloud, travelling, and snuggling. As a family, they sailed in Norway, lived in England while he was a fellow at the Scott Polar Research Institute at Cambridge, and camped widely in the Pacific Northwest. He and Kelly enjoyed travel to Europe and Central America.

When he wasn't on expedition, Kevin loved to haunt salvage yards, finding treasures like the old mining cart that he transformed into a kitchen island, or the antique toilet tank cover he crafted into an altar. He used his merchant mariner skills to renovate their two hundred-year-old houses, doing much of the carpentry, plumbing, and electrical work himself. He constructed a cabin out of wood harvested on the family land in Spirit Lake, Idaho, as well as a number of chicken coops, pergolas, and innumerable house and art projects. He leaves behind a trove of nature photography, as well as many pen and ink drawings, and watercolors of fish and insects. His final claim to fame is that he brought coffee in bed to his wife every day of their marriage that they were both in the same country, conservatively, more than 6,200 cups of joe.

Kevin is survived by his wife Kelly, two sons Galen and Ryan, sister Barbara Pearson, brother Bill Wood, and father Willard Wood.


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