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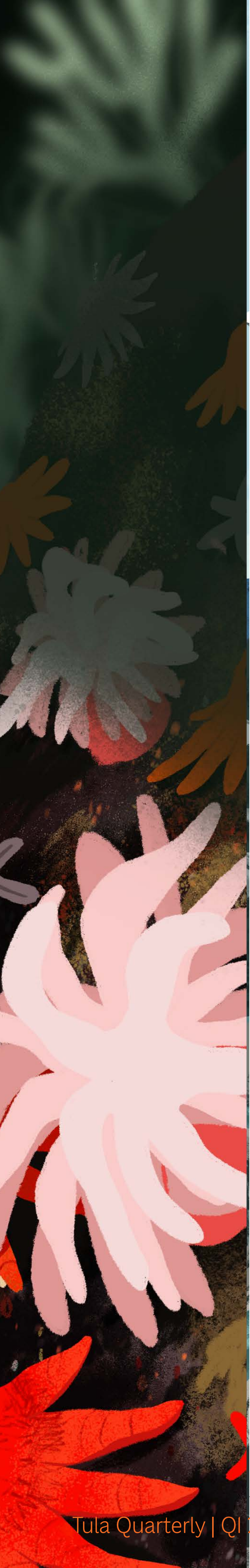


What's Inside

Welcome to the *Tula Quarterly*

Welcome to our first 2025 issue of the *Tula Quarterly*! Now that the sun and blossoms have returned, spring into a fresh collection of stories about Tula Foundation science, discoveries, and cutting-edge technology.

In this issue:

- Hakai Institute videographer Grant Callegari shares his full-circle journey to a new film project about a traditional cedar canoe recently built on northern Vancouver Island by three generations of Indigenous carvers.
- Artificial intelligence and deep learning are transforming the way the Hakai geospatial team monitors mussel beds on British Columbia's Central Coast.
- Members of the 50 Watersheds Project—a research collaboration between the Hakai Institute and Nanwakolas Council—take us behind the scenes of their fieldwork to study salmon habitat.
- Biological oceanographer Justin Del Bel Belluz looks to the understudied Central Coast to find out how shrinking glaciers could be creating conditions ripe for harmful algal blooms.

This issue's cover art by illustrator Mercedes Minck is inspired by Hakai Institute researchers diving into the rich biodiversity of the cold-water fjords of British Columbia's Central Coast—featured in "When the Tide Is Just Right" and "Short Take: Threatened Sea Stars Are Finding Refuge in BC Fjords."

When the Tide Is Just Right

There's a narrow window when Hakai researchers are able to dive British Columbia's Hoeya Sill, a site of rich biodiversity hidden within dynamic currents and challenging depths.

Research diver Ondine Pontier illuminates a rare red tree coral near the Hoeya Sill in the Gwaxdlala/Nalaxdlala Marine Refuge in Knight Inlet, British Columbia.

Scientific diver Zach Monteith floats in the frigid black waters 40 meters below the surface of Knight Inlet, British Columbia, taking measurements of rare red tree corals. At this depth, he has only a few minutes before his time is up and he must surface and return to the boat waiting in the middle of the inlet.

To signal his surfacing location to the boat, he fills a marker buoy with air from his tank and releases it, expecting it to blast upward. But instead, as he lets go, the balloon-like marker moves sideways, pulled by the currents. This is one of the difficulties of doing scientific dives at Hoeya Sill, a raised ridge on the seafloor formed by glacial deposits halfway up Knight Inlet.

"Because you have no reference point, it feels pretty calm and normal as you ascend," says Monteith. "And then when you shoot the surface marker and it goes sideways, you realize, Oh, I'm whipping along in the current."

With limited windows for slack tide and reduced dive time due to the depth, the experienced divers have learned that it's next to impossible to dive at this location when the tide is rushing in or out. Monteith and his fellow divers plan carefully in advance to hit the 10- to 15-minute window at slack tide for each survey. Even then, currents can be strong and the divers must adapt their dive plans to fit the local conditions. Monteith says it's easily the most technical diving done by Hakai Institute dive teams. Local experience and knowledge of the conditions are critical.

Monteith and his highly skilled colleagues are part of a team of Hakai Institute scientists working alongside the Mamalilikulla First Nation Guardians, who are traditional stewards of the area and have extensive knowledge about these waters. The dives are part of a survey program now entering its fourth year in the Gwa̲xdlala/Nala̲xdlala Marine Refuge in Knight Inlet: more than 20 square kilometers designated in 2021 as an Indigenous Protected and Conserved Area (IPCA).

"The Mamalilikulla are extremely grateful to have formed a partnership with the Hakai divers," says Barb Drennan, resource stewardship coordinator for Mamalilikulla First Nation. "Without them, we would not have valuable information about the sill."

The underwater surveys are part of a multifaceted approach to studying and monitoring the inlet. They include bathymetric surveys and the collection of environmental DNA (eDNA) samples in the water. Dive surveys are well suited to recording conspicuous invertebrates like sea stars and corals; eDNA is effective at capturing a snapshot of the local biodiversity, from fish to algae and marine fungi.

By identifying the rare shallow occurrence of gorgonian corals like the red tree coral, and shedding light on the biodiversity that thrives in these deep inlets—home to basket stars, glass sponges, and endangered sunflower sea stars—the project partners hope to detect changes in these underwater ecosystems and prevent the unintentional destruction that can occur without the protections of IPCA status.

Underwater videographer Grant Callegari prepares to reboard a dive boat in Knight Inlet, burdened by his heavy dive camera as he swims against a strong current.

On the request of the Mamalilikulla First Nation's stewardship team, the divers have been keeping their eyes open for signs of human impacts on the corals. The dive team has observed fishing lines tangled in the intricate coral branches on several occasions. "There was a fan that I found that was knocked over on the sill, lying down and in the process of dying," says Monteith.

Upon further inspection, they discovered there was monofilament line tangled around in it. The team suspects that came from a trolling fisherman and got wrapped in the coral, pulling it over and breaking the line.

Red tree corals grow less than two centimeters each year, so finding a coral fan the size of a hula hoop means the organism could be well over 100 years old. To explore ways of quantifying the growth rate of red tree coral, the research team is experimenting with techniques like photogrammetry, a method of creating a three-dimensional model from a series of photos.

Red tree coral can be found at the upper extent of their preferred depth, where currents whirl over the Hoeya Sill. The sill restricts water entering the inlet and results in strong currents that surge over it—creating a high-nutrient shallow environment that teems with life.

But finding the pinnacles—the coral hotspots—and staying on them is a challenge unto itself.

The old Mamalilikulla village site and float house can be seen on Village Island with Knight Inlet extending beyond.

The inlet ranges from 300 to 700 meters deep, and landing on a pinnacle without the help of instrumentation and data would be like playing a blind game of Battleship.

Fortunately, thanks to multibeam surveys, researchers can map out the seafloor ahead of time and target the pinnacles and boulders that might be good habitat for red tree coral.

Ondine Pontier, a fellow Hakai Institute research diver on the project, describes the satisfaction of nailing the slack tide and seeing the habitat in all its glory.

"You'll be down there and all of a sudden all the fish just come out when it's slack," she says. "So you're lighting up this scene of pink, orange, and gold like you're in a dragon's lair."

The team also benefits from deploying an ROV, or remotely operated vehicle, which Hakai Institute hydrographer Nick Viner uses to film the seafloor and scout proposed dive sites. The divers refine their strategy for surveying with each passing season, learning from the conditions as they go. Luckily it's a team effort.

"You have your dive tender who's helping you do all those checks beforehand and getting you into that mental space … and helping with the dive tables," says Pontier. "It's great to have a team that you really trust in the end."

Underwater videographer Grant Callegari has been diving with the team for two years and has the additional task of making sure all his camera gear is arranged perfectly for each dive. With all the work that goes into these dive trips, it can sometimes be hard to tear himself away from that perfect shot while they're underwater, he says.

"I remember the last dive of my first trip, going down and just at the very end of that intense dive on the sill, I swam a little bit farther on from where we usually go and I found this motherload of giant corals," says Callegari. "But I'd run out of time, so we had to go back up and wait a whole other year before we were able to dive at that exact same spot." ■

Ancient Canoes, New Connections

From bush tools to wooden boats, Hakai Institute videographer Grant Callegari appreciates the old and handmade. He's part of a new film project about Indigenous canoe building that's forging fresh connections to culture, craft, and community.

A new dugout cedar canoe named Namaxsala was carved by three generations of Indigenous carvers—Długweyaxalis (Karver Everson), ƛaqwasgəm (Junior Henderson), and See-wees (Max Chickite)—shown here steaming the canoe at Kelsey Bay in Sayward, British Columbia. All photos by Grant Callegari

During a trip to Tofino, British Columbia, in summer 2024, Grant Callegari had a literal déjà vu.

He was in the forest in front of a cedar canoe with Tuu-tah-qwees-nup-sheetl (Joe Martin), a master canoe carver from Tla-o-qui-aht First Nation, while Martin was offering tips to fellow Indigenous carvers ƛaqwasgəm (Junior Henderson) and Długweyaxalis (Karver Everson). Henderson and Everson were in the midst of crafting a different cedar canoe in the tradition of their ancestors, a project Callegari was filming for the Hakai Institute.

But 20 years earlier, Callegari was the one acting as Martin's apprentice. That experience kicked off a full-circle journey of connection and cultural understanding, forged through the ancient art of canoe building.

Back then, Callegari was in his early 20s, working at the Scottish Crannog Centre near Loch Tay in central Scotland. This open-air museum explores how people lived in stilted lake dwellings known as crannogs during the Iron Age, more than 2,500 years ago, and showcases traditional activities and technologies. One aspect of Callegari's job was to make replicas—physical blueprints—of structures and tools from that era, such as handwoven hurdle fences and foot-powered lathes capable of turning wood into bowls.

For a former Boy Scout who loved working with his hands and spending time outdoors, it was a dream job.

"Breathing in the scent of wood smoke and farm animals, hearing the loch lapping at the stilts—it was like time travel grounded in archaeology and human connection," Callegari recalls.

One day, a few years into the job, the center's archaeologists relayed a remarkable discovery from the 1990s: a 3,000-year-old dugout canoe so beautifully preserved by the lake's peat sediments that the tool marks were still visible.

"It was made of a solid piece of oak, over nine meters long, straight-grained, not many knots," Callegari remembers. "Oak trees like that just don't exist anymore. It offered a rare glimpse into how massive the trees must have been in ancient Britain."

A former Boy Scout with a deep interest in traditional and Indigenous crafts, Grant Callegari has spent much of his life in the forest making implements by hand. "It's like page one of being human," he says of traditional tool-making.

For Callegari, learning about the canoe deepened his appreciation for the ingenuity of early peoples and sparked a desire to understand how they built such vessels by hand from the behemoths of the forest. Fortunately, Callegari was placed on a team tasked with building a working replica.

Once he got into the research, all paths led to British Columbia—starting with his source tree. Unable to find local oak of the length and girth that was used 3,000 years ago, Callegari's colleagues searched for alternative wood. In the United Kingdom, locating a tree of any species large enough to carve a nine-meter canoe was not easy. Luckily, some giant Sitka spruce were growing at Scone Palace about an hour from the Crannog Centre. The trees were slated for removal and donation to the museum.

Unlike oak, Sitka spruce is not native to Scotland; these trees came from seedlings collected in British Columbia by the Scottish botanist David Douglas (namesake of the Douglas fir), who planted them back home in Scotland. The massive Sitka spruce the Scottish Crannog Centre settled on would turn out to be a particularly fitting bridge between the Pacific Northwest and Callegari's homeland—foreshadowing the cultural journey he was about to embark on.

Spruce, Cedar, and a Master Carver

Learning about the spruce and its birthplace led Callegari to Indigenous woodworking from the trees of the Pacific Northwest. That's when he remembered master canoe carver Joe Martin, whom he had heard about during

From the forest to the beach, master canoe carver Tuu-tah-qwees-nup-sheetl (Joe Martin) can be found working on traditional cedar canoes, imparting techniques and wisdom to anyone curious enough to stop by.

From left: Everson, Henderson, and Chickite celebrate the completion and naming of Namaxsala at a canoe blessing ceremony held in June 2024.

a vacation to Tofino years earlier. It just so happened that Callegari was planning a trip to Canada when his canoe project surfaced. He mailed Martin a letter, asking if he could visit him in Tofino to get a few pointers. To his surprise, Martin responded, and within a few months, Callegari was working on a red cedar canoe alongside him.

Western red cedar, known as the "tree of life" to coastal First Nations, is the preferred tree for canoe carving—and just about everything else—in the Pacific Northwest. "The cedar tree is important to all Indigenous peoples along the coast here," Martin says. "We get our canoes from it, we get our homes built out of it, and the totem poles. And then the bark is weaved into regalia and really strong rope."

While soaking up the sea breeze and Martin's wit, Callegari learned about his teacher's culture and techniques, like how to use a hand adze and create scarf joints. Mostly, he sat in Martin's oceanfront workshop feeling awed by the functional beauty of Pacific Northwest Indigenous constructions.

"Everything they make is totally useful and beautiful at the same time, and the canoe is the epitome of that," Callegari says. "It has to be balanced, the right angle, the right weight—all of that to function well in a powerful, unpredictable ocean."

He was especially moved by Martin's deep knowledge, not just of canoe carving but of the cultural teachings woven into every step, from not cutting down cedar trees in the spring or summer when eagles and other birds are nesting to taking only what one needs to preserve materials for future generations: "Mother Nature provides for our need, but not our greed," Martin likes to say.

"Joe carries that knowledge with such clarity and generosity. It was humbling just to listen and learn," says Callegari.

Equipped with fresh tips and insights from Martin, Callegari returned home to collaborate on the replica project—a much more rudimentary dugout canoe in the style of his own ancestors.

All in the Same Boat

Callegari never guessed that 20 years later, he'd be living in British Columbia, making a film about another special canoe project.

In 2024, Nanwakolas Council, a collective of six Kwakwaka'wakw First Nations on northern Vancouver Island, invited Callegari to document a new cedar canoe being built as a collaboration between three generations of carvers—Henderson, Everson, and See-wees (Max Chickite)—from three different First Nations

From left: Chickite and his daughter Heh-mah-khoo-doh-gah (Jessica Chickite) paint the whale-and-moon design that Jessica created on to Na̱max̱sa̱la. Jessica and Everson then add a fresh coat of paint.

(Wei Wai Kum, K'ómoks, and We Wai Kai, respectively). It was the first canoe in a century to be constructed in the traditional way in these nations' territories, carved in the H'kusam forest where the red cedar blew down—right near Callegari's doorstep in Sayward, British Columbia.

Although he had some experience with traditional carving, Callegari walked into the project feeling like an outsider, aware of his British heritage and colonialism's devastating legacy on Indigenous communities. Despite generations of efforts to suppress Indigenous cultures across Canada, the artwork and carving traditions of the northwest coast have endured. For many nations, these traditions are the pillars of an ongoing cultural revival.

During one of the first interviews Callegari conducted for the film, Henderson assured Callegari that he wanted him there to document, since they were building a "blueprint for the future." With Henderson's blessing, Callegari was able to relax into gratitude.

"I'm from distant lands," he says, "and so being able to immerse in a culture like this and to see the culture gaining strength is really inspiring."

To craft the new canoe, the three carvers built a small cabin in the H'kusam forest, where Henderson and Everson lived for a full month of carving—except for the final night when they slept in the canoe itself.

The most inspirational part, says Callegari, was attending the xwax'wana (canoe) blessing ceremony when around 100 people descended on the site where the artists had been living and carving. Donning woven cedar headpieces and button blankets of different colors and crests, attendees joined together from many neighboring First Nations to witness the canoe being sprinkled with eagle down and receiving its name: Na̱max̱sa̱la, meaning "everyone on the boat together."

"Three generations, three carvers from different nations, coming together for the better purpose of our people—showing that by working together, we can create magic," Henderson said through tears on that poignant summer day.

Then 18 people, chosen by the carvers, helped carry the nine-meter canoe to a trailer using ropes slung around their shoulders.

Na̱max̱sa̱la was then driven the rest of the way to Kelsey Bay in Sayward where the canoe was steamed. Heh-mah-khoo-doh-gah (Jessica Chickite)—daughter of Max Chickite—came up with a whale-and-moon design, which she and the carvers painted on the canoe the following week to honor the place where the cedar grew.

Returning Home

Through talking with Henderson and Everson about their experience on the land, Callegari was reminded of the different sense of time one possesses in the forest—shaped by daylight, weather, and the rhythm of mind, body, and hands. Crafting a canoe also takes extra time and care; working too fast could cause irreversible mistakes.

Henderson spoke about his ability to slow down in the forest, “to relax a little bit while I’m up here, not worrying about being here or there,” he said, while woodpeckers hammered their natural percussion in the background.

“It sure feels nice to feel what [our ancestors] must have felt back then,” he added. “I hope that the next generation gets to feel this a little sooner than over 100 years.”

Members of the Na̲nwak̲olas Council First Nations have paddled the canoe through Johnstone Strait to Tsa-Kwa-Luten Lodge, a We Wai Kai First Nation healing center on Quadra Island, where the boat will be based.

For Callegari, the project has rekindled his own deep love of traditional crafts. “It’s like page one of being human,” he says.

“The more you learn about the natural world, the plants and other resources and how to use them to live and thrive in a place, the less you see that place as ‘wild.’ It simply becomes home.”

Back at home near Sayward, Callegari is working to finish the film project, which Na̲nwak̲olas Council will launch later this year.

Katherine Palmer Gordon, Na̲nwak̲olas’s communications lead, says the council and the carvers have appreciated Callegari’s passion and dedication to the project. “It’s really gratifying to work with someone so committed to Indigenous rights and reciprocity, and sensitive to the history and culture,” Gordon says. “We all offer a huge gilakas’la [thank you] to Grant.”

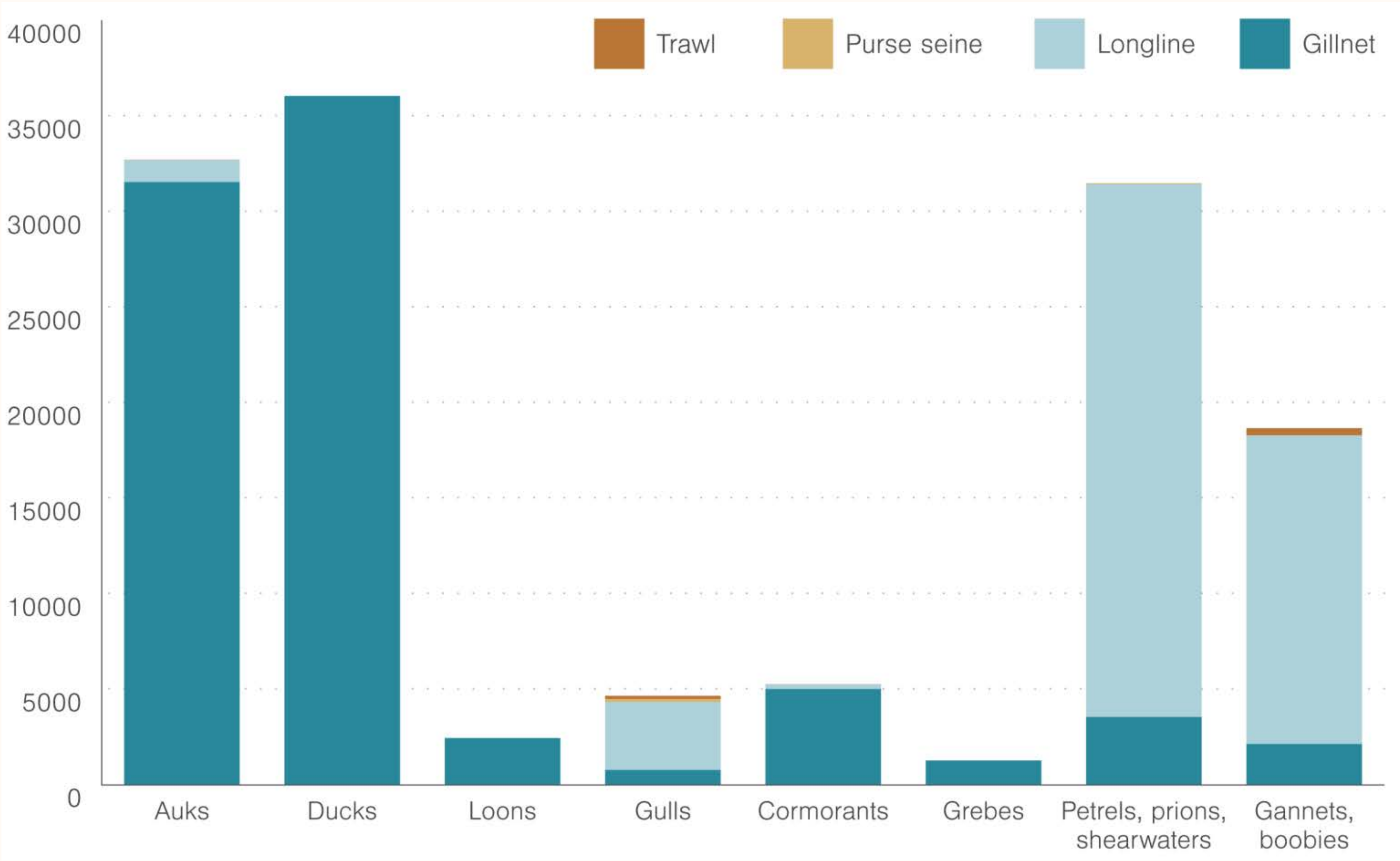
Once the project is complete, Callegari says he’d like to build something with his young son and daughter: a small dugout canoe made of cedar—perhaps a replica of Na̲max̲sa̲la, using “the same techniques, the same cuts, the same steaming process,” Callegari says, “just scaled down.”

It would be a chance to slow down and plant seeds for his kids, to honor the past while creating a blueprint for the future.

Henderson, Everson, and Chickite worked on Na̲max̲sa̲la in the H’kusam forest near Sayward, British Columbia, for a month. Callegari visited for the film and for fun, one time with his two children in tow.

By-caught Birds

Research estimates that some 200,000 birds are accidentally caught in fishing gear in Europe each year.

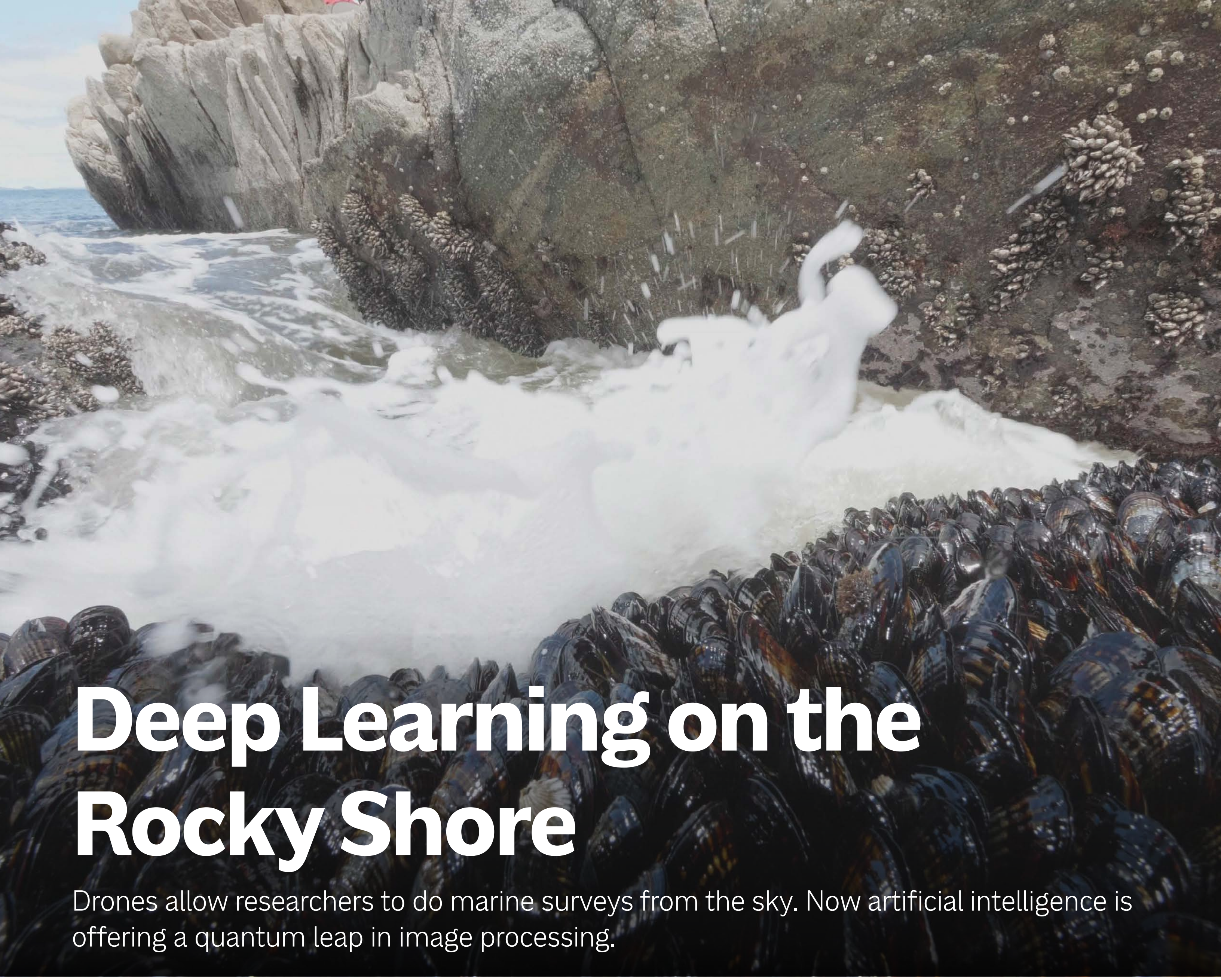


In Europe, gillnets and longlines entangle the highest number of avian by-catch. Graphic by Mark Garrison and Marina Wang, with data from Ramirez et al.

When commercial fishers haul up their nets, they often find a plethora of nontarget species—known as by-catch—entangled amid their catches. From dolphins to sea turtles, millions of animals worldwide die this way each year, and a significant portion of these trapped animals is made up of seabirds such as gulls and albatrosses.

Nearly one-third of seabirds are at risk of extinction, and a new study estimates that almost 200,000 individual birds are caught and killed in European waters as by-catch annually. Gillnetting and longlining are the most deadly for seabirds, with the top three species of by-catch being common guillemots, northern fulmars, and northern gannets.

Although researchers think they've probably underestimated seabird by-catch, there's already enough data to show that coastal EU countries are failing to adequately protect threatened seabird populations. See the original story in *Hakai Magazine* or check out the study in the journal Animal Conservation. ■



Deep Learning on the Rocky Shore

Drones allow researchers to do marine surveys from the sky. Now artificial intelligence is offering a quantum leap in image processing.

A wave crashes into a bed of California mussels (*Mytilus californianus*) on Calvert Island, British Columbia.

The rocky intertidal zone is an area of high biodiversity, and mussel beds are a critical part of this ecosystem—creating habitat and providing an important food source for a variety of animals, from humans to birds to sea stars.

Climate change and sea level rise are subjecting these habitats to increasing stress, however, and there is a growing need to assess the health and resilience of the blue mussels (*Mytilus edulis*) and California mussels (*Mytilus californianus*) that make them up.

Hakai has been monitoring mussel beds on the Central Coast for nearly a decade via nearshore field studies performed in situ by researchers and through annual drone surveys. The Institute has been a leader in deploying drones to extend observational reach, allowing researchers to assess sites that are too dangerous or difficult to access.

Traditional methods for processing drone imagery data, however, are time-consuming and expensive. The use of deep neural networks—designed for processing imagery—has been a major leap forward, enabling Hakai researchers to quickly process and analyze vast amounts of imagery.

But how does it all work? And what is a neural network, anyway? *Tula Quarterly* sat down with Taylor Denouden and Will McInnes, both members of the Hakai Institute geospatial team, to learn how the job gets done.

What are your respective backgrounds in working with these kinds of AI processes?

Taylor: I did my master's degree at Ontario's University of Waterloo on computer vision systems for autonomous vehicles, which meant a lot of machine learning training as well as research in that area. After grad school, I came to Hakai and took on a project to detect kelp beds in drone imagery, and then later on, using aerial imagery. And so this mussel-mapping work is an extension of that, where we're looking at mussel beds on rocks rather than kelp in water.

Will: I've been working in the remote sensing and GIS fields for over a decade. I did my training at the University of Calgary with satellite remote sensing and airborne systems, like aircraft, with traditional remote sensing techniques, and doing classification and time series analysis. The last few years we've been using drones at Hakai, and the AI thing is new to me, so it's been quite interesting to learn that process. So I know a lot about the other techniques, mainly the drone side of things, and I've been learning a lot about how to implement the AI part of it.

From a standpoint of efficiency, it seems like artificial intelligence is offering us a quantum leap in terms of processing these visuals.

Will: Yeah, absolutely. We're now talking about being able to do quantification of species over large areas in a matter of minutes, rather than the hours or days it would take to process individual scenes by hand.

How does the drone process work in terms of the initial gathering of imagery?

Will: It's always done by an operator or team who is keeping the drone in their line of sight. For some of the more remote locations, we're on a boat and we launch the drone from out on deck. On a good weather day, the drone can be up to a kilometer away. It's been set on autopilot, and it's following an automated pattern: taking pictures that get overlapped and put together in software back at home, creating stitched-together images that can be fed into the machine learning model. We'll get between half a square kilometer to one square kilometer of terrain covered in a day.

Tell us a bit about how these AI processes work once you have the visual data.

Taylor: The images we have from a survey have red, green, and blue color channels. The AI model "learns" what transformations and combinations of those red, green, and blue pixels add up to being mussels. There are multiple, complicated steps to go from pixel color to something that says "This is a mussel" or "This is not a mussel."

Hakai Institute research scientist Alyssa Gehman surveys the motile invertebrates that live within the intertidal mussel beds on Calvert Island.

Will McInnes looks back at himself using a drone that's monitoring mussel beds near Calvert Island.

From the start, this technology is based on simple-input information. It learns how to adjust and combine information so that it can discern between mussels and non-mussels, whether that's a rock, the water, the sky, or whatever.

Can you explain what is meant by deep learning and neural networks?

Taylor: The terms neural networks and deep learning are pretty well synonymous. A neural network describes the model itself, something that would be similar to linear regression, which is an algorithm that provides a linear relationship between variables. In neural networks, we use non-linear relationships instead of linear ones and stack a bunch of them together to find much more complex relationships.

Deep learning is the process for finding the best parameters for our model so it can figure out how to identify things. We do this by showing examples of what we want. So we'll have a bunch of example images showing mussels, and then have images that have been labeled by a human that show the locations of the mussel beds in that image.

Those outputs, those definitions, are hand-labeled in the old, slow way. But when we have a whole bunch of them, we can show them to our model over and over again and adjust the parameters. The model then learns to repeat that process without necessarily having to explicitly define how to do that transformation. That's the "deep learning" part—how it learns to reproduce some process that is hard to describe in words, but that a human can do automatically.

So deep learning is that kind of iterative learning where, by being shown something over and over, it starts to "understand" and be able to identify something?

Taylor: Right. It comes up with some internal representation, or a set of transformations to go from that input to your output. The "deep" part refers to the neural network itself. Neural networks have a number of layers of transformations, and the deep part just means there's many of them. And the "learning" part refers to that iterative process.

If one of us is looking at an image, we might think that anything that's sort of dark and shiny and round is probably a mussel, but the model figures out how to come up with those descriptors itself, without you having to explicitly state them, because there are other things that are black and shiny and round as well that aren't mussels. The model tries to find a more precise set of descriptors to figure out how to tell those things apart.

And you don't have to tell it that, right? In other words, that is where the artificial intelligence aspect of this comes in?

Taylor: That's the really powerful part of all of this, that it finds the most useful features itself—it finds millions and millions of them and different combinations of them, something that would be pretty impractical to do manually.

To humans on the outside of these operations, is it sort of a black box how it all works? It seems that after you set these AI processes in motion, you are getting all these results and looking at the output and basically saying, "This is great. We don't know how it's doing it, but it's doing a hell of a job."

Taylor: It's largely a black box of mathematical operations. We can't do much more than have the model tell us what part of the image it was looking at when it came up with decisions. There's a lot of research looking into that, because we would love to know how it's making decisions so that we can validate them, but that kind of machine learning research is still in its adolescence.

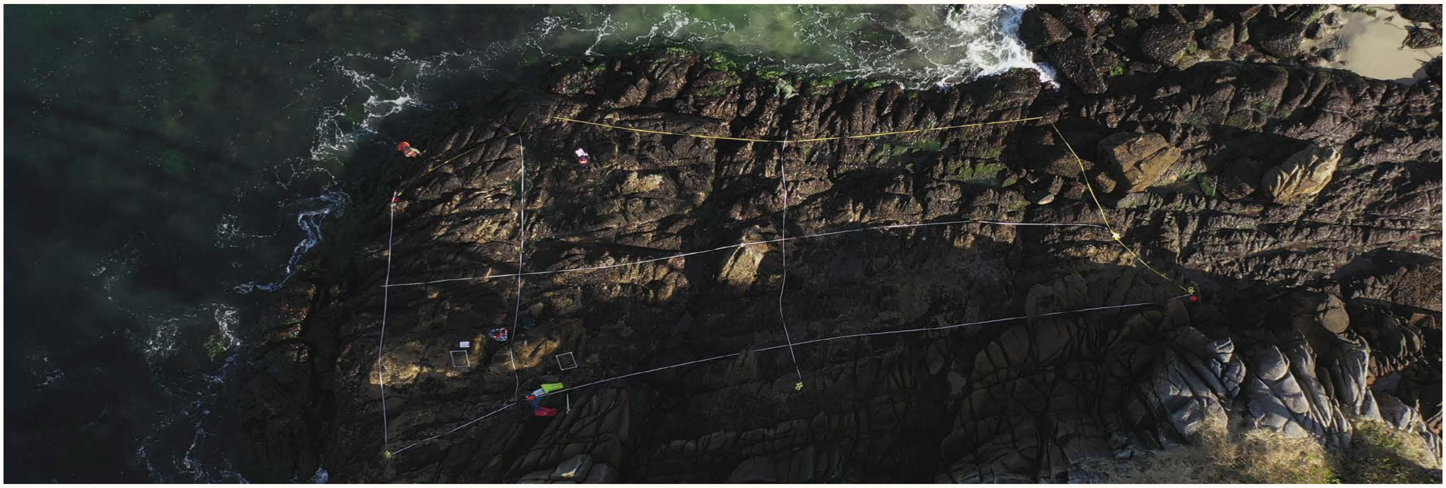
What is most exciting to you about this project, with this application of AI into mussel mapping?

Will: It's exciting because it expands our possibilities for collecting scientific data quickly. It's not the same type of data that we get when we send our crews out into the field and they're on their knees looking at individual plants and animals and measuring and weighing them, but it gives us an amazing way to survey quickly.

Right now, we're working on gooseneck barnacles to add that in as part of the modeling. That's an interesting one because those have been too difficult or dangerous for our teams to study well, since they're located on exposed outer rocks. But we can get imagery with the drones, and look at dynamics of how they're interacting with mussels and sea stars and all sorts of stuff. Seagrass will be another one.

Taylor: I don't know how much I would add to that. I'd only agree that it's impressive just how much faster these processes are getting, and that it's saving people a lot of time that would have been spent on boring manual tracing work. This allows them to focus their efforts on more interesting research questions.

Regarding seagrass, that is something that we've looked at, but there's a big challenge in terms of seagrass being covered in water a lot of the time. Our images can't differentiate very well between submerged seagrass or dark-colored mud. And so it might be interesting to start exploring other kinds of sensors. Things like four-band multispectral imagery, which includes near-infrared, or some other specialized camera could help figure out what things are underwater—which right now we can't do with a regular image. ■



A drone photo captures researchers and their transect lines on a rocky outcrop on Calvert Island. At this location, the surveys track seaweed and invertebrate populations, including sea stars, mussels, barnacles, and marine algae.

Boosting the Barcode

Two decades of DNA research has led to a widely adopted method for cataloging life on Earth.

Hakai Institute research technician Emma Myers (left) and research scientist Matt Lemay sort through zooplankton specimens for DNA barcoding at the Quadra Island Ecological Observatory. Photo by Kelly Fretwell

DNA barcoding has become a standard method for studying biodiversity and has led to the discovery of many new species.

For the last seven years, the Hakai Institute has been a leader in DNA barcoding of marine life. DNA barcoding is the use of a short, standardized region of DNA to identify different species. By sequencing the DNA barcode region from as many species as they can get their hands on, scientists have created a massive reference database—the Barcode of Life Database (BOLD)—for identifying species by their genetic information.

Through large-scale bioblitzes and collaborations with marine scientists and taxonomists, Hakai Institute researchers have contributed thousands of new DNA barcode sequences from historically understudied groups.

"It's no exaggeration to say that every survey we do uncovers something new," says Hakai Institute scientist Matt Lemay. "The ocean contains an astonishing diversity of creatures that have received much less attention than terrestrial creatures. Many ocean species are small, cryptic, or live deep down, making them challenging to collect and identify."

BOLD has become an indispensable tool for scientists using environmental DNA (eDNA) to study biodiversity. This method works by sequencing all the DNA present in an environmental sample—for example, from a liter of seawater.

However, scientists can't use eDNA to fully identify what is present in an ecosystem if there isn't a barcode sequence for each species in the reference database. Gaps in BOLD and other databases mean that species will go undetected in eDNA studies.

This is where Hakai Institute researchers and partners are making a difference. So much of the ocean is understudied, Lemay notes, that on average "we find that 20 percent of the DNA barcodes we sequence for marine invertebrates are completely new and haven't been sequenced before."

Biodiversity surveys combined with DNA sequencing mean that Hakai Institute researchers are filling many of the holes in BOLD that might otherwise go unnoticed, a significant contribution in the effort to catalog life on Earth.

"Our ability to use eDNA to study biodiversity is only as good as the underlying reference database," says Lemay. ■

Will Shrinking Glaciers Mean More Harmful Algal Blooms?

Marine algae known as phytoplankton form the essential foundation of marine food webs. Some are dangerous to marine mammals and humans, and researchers are exploring how the diversity and abundance of certain phytoplankton are linked to fresh water—which may be bad news in a changing climate.

In 2019, with dry conditions on land and a marine heatwave in the northeast Pacific Ocean, warmer, saltier waters brought harmful phytoplankton species to the Central Coast of British Columbia. As part of their studies, Hakai Institute researchers collected the toxic diatom *Pseudo-nitzschia seriata* at the head of Hakai Pass, near the west coast of Calvert Island, shown here.

Toxic algal blooms—formerly known as red tides—can cause devastation throughout the marine food web. When a species of phytoplankton known as *Pseudo-nitzschia seriata* is abundant, for instance, herring, clams, mussels, and crabs can accumulate domoic acid from the plankton in their tissues.

In marine mammals and people, domoic acid acts as a neurotoxin that can cause disorientation, memory loss, seizures, and even death, making it very dangerous to harvest traditional foods in First Nations communities. Government agencies in Washington State have closed shellfish beaches and crab fisheries during harmful blooms, while in British Columbia, a lack of monitoring for toxins means that most beaches are closed to shellfish harvesting year-round.

Justin Del Bel Belluz, a biological oceanographer at the Hakai Institute, studies how conditions in the ocean—temperature, salinity, and other factors—affect the diversity and abundance of marine phytoplankton.

"Phytoplankton form the base of the marine food web, so if you have big changes in species or biomass, it definitely perpetuates upward," Belluz says. "In BC, there are strong ties between spring phytoplankton blooms and fisheries returns and seabird breeding success."

Though scientists have studied phytoplankton farther up the coast in Alaska, and in the Salish Sea to the south, says Belluz, little is known about these tiny algae on the Central Coast. "A lot of knowledge gaps still exist in this region, and building a baseline understanding of these ecosystems is important considering the level of expected change."

One important linkage appears to be the relationship between freshwater inputs and the abundance of different types of phytoplankton. Winters on British Columbia's Central Coast are notoriously rain-drenched, with places like Rivers Inlet—a mainland fjord located roughly

Domoic acid from *Pseudo-nitzschia* species has been linked to poisonings and death in marine mammals, including sea lions in California.

65 kilometers north of Vancouver Island that's home to the Wuikinuxv Nation—receiving three meters of precipitation in a year. Including meltwater from snow and glaciers flowing off the land, fresh water has a big impact on the region's marine environment.

In a recent study, Belluz and his coauthors collected phytoplankton and measured ocean conditions at three locations of different distances from the mainland: a fjord site in Rivers Inlet, a site in Fitz Hugh Channel, and a site on the continental shelf, just west of Hakai Pass.

The study linked this biological and oceanographic information with the Hakai Institute's watershed and weather data, and found that the unique features of the Central Coast shape ocean conditions and the phytoplankton community.

At the Rivers Inlet site, for example, algae bloomed earlier in the spring than Belluz and his coauthors expected; wind data from a nearby weather station suggests that the fjord's steep walls shelter the area from cold winter winds that delay plankton growth in more exposed locations. Without this sheltering effect, spring blooms in Fitz Hugh Channel and on the shelf require periods of reduced wind and increased sunlight, which is consistent with what researchers have observed elsewhere.

Belluz and his coauthors from Fisheries and Oceans Canada also observed periods when high temperatures and salinity were associated with blooms of the diatoms *Pseudo-nitzschia seriata* and *Rhizosolenia setigera*. While not toxic to marine mammals or humans, spiky *Rhizosolenia setigera* can damage the gills of fish, including Pacific salmon.

As the climate changes, shrinking glaciers will supply less meltwater to the Central Coast during summer months, leaving nearshore areas warmer and saltier. Under these conditions, harmful algae like these could bloom more often.

Climate change models predict that the Central Coast will receive more rain in the fall and winter, with less snowfall at high elevations. Glaciers in the Coast Mountains will continue to shrink. According to a new study coauthored by Hakai Institute affiliate Brian Menounos, glacial ice in Western Canada is melting faster than almost everywhere else in the world.

Over time, as high-elevation snow and ice fields disappear, rivers will lose that essential source of cool fresh water during spring and summer, leaving nearshore areas warmer and more saline. This change could shift the balance from a phytoplankton community dominated by nutritious species like *Skeletonema marinoi* to harmful ones, such as *Pseudo-nitzschia seriata*.

"Phytoplankton communities on the Central Coast appear highly sensitive to fresh water," Belluz says. "So those changing freshwater dynamics could completely alter the base of the marine food web, which currently supports a very productive ecosystem." ■

The toxic diatom *Pseudo-nitzschia*. Photo courtesy of Oregon State University

Watching the Waters in Their Territories

Bushwhacking, tailgate labs, and “secondhand fun”: partners from Na̱nwaḵolas Council, five First Nations, and the Hakai Institute take us behind the scenes of the 50 Watersheds Project.

K’ómoks First Nation Guardian Rylan Wright takes water quality readings, such as temperature and dissolved oxygen, in the Adam River watershed as part of the 50 Watersheds Project.

For what seemed like hours, Wei Wai Kum First Nation Guardians Montell Henderson Brown and Anthony Roberts, along with Na̱nwaḵolas Council forest research coordinator Emily Doyle-Yamaguchi and Na̱nwaḵolas wildlife biologist Melanie Clapham, bushwhacked through soggy salmonberry and devil’s club in search of the Apple River.

The group was on a reconnaissance mission for the 50 Watersheds Project—a collaboration between the Hakai Institute and Na̱nwaḵolas Council, a collective of six First Nations on northern Vancouver Island, British Columbia. They were trudging through a Sitka spruce forest at the head of Loughborough Inlet on the province’s mainland, in grizzly country, when the Apple River finally came into view.

You can’t just find river access on a map. “You have to go there and wander around to figure it out,” Doyle-Yamaguchi says. “It took us two hours to get down to the river from the road, and as the crow flies, it’s not very far.”

The goal that day was to find a suitable location for installing a water temperature sensor near the mouth of the Apple River. It’s one of 62 primary watersheds on the BC coast that Na̱nwaḵolas Council, and the Mamalilikulla, Tlowitsis, Wei Wai Kum, We Wai Kai, and K’ómoks First Nations, alongside the Hakai Institute, are studying as part of the 50 Watersheds Project, supported by the British Columbia Salmon Restoration and Innovation Fund. Now in its third year, the project aims to assess the impacts of forest management and climate change on salmon habitat, and to give Na̱nwaḵolas member First Nations new tools for decision-making in their territories.

“We want to find out more about salmon,” says Shane Pollard, project lead for We Wai Kai First Nation where he's also the manager of the nation's Guardian program. "Salmon was a resource we once relied on that's kind of gone away. So we want more answers about that."

By gathering temperature readings from those 62 primary watersheds—along with data on the presence of invertebrates and salmon in 51 smaller catchments—the project combines Indigenous and Western science to fill knowledge gaps. Specifically, the study is exploring the links between forest cover, water temperature, and the health of salmon habitat in a range of watershed types, from rain-fed lowlands to glacierized mountains, many of which hold great significance to the First Nations involved.

"If you go back to data from the 1970s or 1980s, you see a pretty consistent decline in salmon," Pollard says. "It gives us a lot more ammunition if we have Western science behind us that we can corroborate. Like if we do find out that forest practices are impacting salmon, we'll have the science to show that we have to adjust things to change population trends in the other direction."

To date, the team has collected countless temperature readings—taken every 10 minutes from 144 sensors—as well as 400 environmental DNA (eDNA) samples that the Hakai Institute's genomics team is currently analyzing. During thousands of hours of fieldwork, collaborators have coordinated dozens of teams traveling by truck, boat, and even helicopter, while managing complicated equipment and erratic weather, from heatwaves to downpours.

When Doyle-Yamaguchi and the Wei Wai Kum Guardians finally reached the Apple River, they could tell from the plants and riverscape that the area was under tidal influence, which meant it was not an ideal place to install a freshwater temperature logger.

The crew—including (from left) Nanwakolas wildlife biologist Melanie Clapham and Wei Wai Kum First Nation Guardians Anthony Roberts and Montell Henderson Brown—finally reaches the Apple River, one of the primary watersheds in the 50 Watersheds Project. Photo by Emily Doyle-Yamaguchi

But bushwhacking for hours from a logging road wasn't all in vain, says Doyle-Yamaguchi. The team learned how not to travel in the area the next time around.

"I think we concluded that walking from the road is not the best way to come back," she laughs. The next time, they would take a boat.

Hakai Institute research technician Mariella Becu calls Doyle-Yamaguchi's experience "secondhand fun."

"It's secondhand fun because it's a great story later," Becu explains. "While you're out there, it's so rainy that you're soaked before you actually get to the stream, or you fall into the river on the first installation, or you try to take a shortcut that turns out to be the long way. But you bond over how hard it was during lunch, and how good your food tastes afterward."

Becu oversees the collection of water samples to study the presence of salmon and insects such as mayflies, stoneflies, and caddisflies that are sensitive to habitat disturbance and therefore serve as indicators of ecosystem health.

There are two types of water samples—filtered water that captures only eDNA and others that capture physical samples of invertebrates and stream debris. A batch of the latter is blended, literally, into a "bug smoothie," Becu says, which is then sent to the lab for DNA analysis.

Fellow research technician Isabelle Desmarais is responsible for filtering water into eDNA samples, which usually occurs on the truck tailgate right after the water is collected. Within minutes, off-road pickups become mobile ecology labs, topped with bottles and hoses sterilized with ethanol.

“You’re in field clothes and waders but then you have your gloves on and you’re constantly cleaning,” Desmarais says. “The setup is very lab-y, but it’s really just the back of a pickup truck. It’s a funny contrast.”

Desmarais remembers some secondhand fun in August 2024, when a freak summer storm dropped at least 20 millimeters of rain in the Adam River watershed near Sayward on northern Vancouver Island within a few hours. Desmarais’s team had five site visits that day, and by early afternoon, they had already soaked through their extra set of clothes.

“Let’s just say the morale was pretty low,” Desmarais laughs.

But spirits lifted every two hours when the team had to check in with their safety contact, Emily Haughton, through their inReach satellite communicator. Safety check-ins often include riddles on tough field days like this one, but the rain inspired a music game instead, starting with lyrics from a popular Natasha Bedingfield song.

“Instead of being like, ‘I’m checking in, I’m all good,’ we just wrote ‘I feel the rain on your skin,’ and then Emily replied with an explosion of lyrics,” Desmarais recalls. “It’s these stupid things that make you so happy.”

Desmarais and her fellow technicians couldn’t filter water on the truck bed that August night; it was still pouring. So, they set up their mobile lab in the Hakai Institute’s Campbell River office after hours instead.

Results from the 50 Watersheds Project are expected in early 2026 and should give partners a better idea of which watersheds are the most and least vulnerable to the effects of logging and climate change. They will also provide partner First Nations with information to support their stewardship rights and responsibilities in the watersheds within the territories.
In the meantime, it’s the many experiences of laughing, struggling, and learning together that make the collaboration so rewarding, Doyle-Yamaguchi says.

Making space for relationship building—“not just working but hanging out”—was part of the project design, she adds. Partners held a kickoff event in Port Neville so the field teams could learn about the Indigenous history and Guardians’ work in the area. Another group event was hosted last year at the Hakai Institute’s Meeting House on Quadra Island.

“It’s not just about data, it’s also about the people and why they’re there,” Doyle-Yamaguchi says. “A huge number of us live in Campbell River and work in these watersheds. So we are all neighbors and residents of this place, making the place-based work that much more important.”

Becu echoes that sentiment. “We all care about these watersheds, and we depend on them,” she says. “I think we all want to make sure they’re thriving in the future.” ■



Emily Doyle-Yamaguchi (left) and the 50 Watersheds team hiked through two-meter-tall devil’s club and along fresh grizzly tracks to reach the Apple River. Luckily, Wei Wai Kum First Nation Guardian Sam Henderson rescued them for the trip back to the car. Photos by Montell Henderson Brown and Emily Doyle-Yamaguchi

Don’t Drain the Swamps: Tidal Wetlands Store Huge Amounts of Carbon

Research published by the American Geophysical Union digs deeper into the carbon-storing power of wetlands along North America’s Pacific coast.

Forested tidal swamps like the upper reaches of the Sayward Estuary on northern Vancouver Island, British Columbia, store vast amounts of carbon in their soils.

A new paper featuring Hakai Institute researchers and led by Oregon State University reveals that the forested tidal swamps of the Pacific Northwest, alongside mangroves in Mexico, stash away the largest amounts of carbon on the Pacific coast of North America.

Analyzing transboundary datasets from Canada, the United States, and Mexico, the study contributes vital regional estimates for the carbon-storing potential of different coastal ecosystems, including seagrass meadows, unvegetated mudflats, marshes, mangroves, and tidal swamps—which are all threatened by development.

While mangroves have become known for their carbon-rich soils—due to the trees and plants that deposit carbon locally in their soils, and the low-oxygen conditions that lock it away—the new research shines a light on forested tidal swamps. These wetlands are defined by large tide swings and woody shrubs and trees, including northern species such as willows and Sitka spruce. The study finds that forested tidal swamps in the Pacific Northwest can bury around three million tonnes of organic carbon (or around 10 million tonnes of carbon dioxide) in the top meter of sediment alone. That’s equivalent to around what two million gas cars burn every year, and is more carbon storage per area than all the terrestrial ecosystems the authors analyzed save for Canadian peatlands.

“Our northwest tidal swamps are some of the best tidal swamps in the world in terms of carbon storage,” says Margot Hessing-Lewis, one of the Hakai Institute researchers involved in the study. “It’s a unique but very understudied ecosystem that’s quite threatened. They’re like the temperate version of mangroves.”

The high carbon storage of these swamps backs up recent evidence from the Pacific Northwest Blue Carbon Working Group—a US and Canadian network of scientists, practitioners, conservationists, carbon market experts, and government representatives working to understand and restore these ecosystems. The group found relatively low methane emissions from swampy soils, despite their low salinity. “This suggests that swamps may be one of the best natural climate solutions,” says Chris Janousek, the lead author of the new paper.

Coastal habitats—including seagrass meadows, mudflats, marshes, mangroves, and forested tidal swamps—collectively store more carbon on an annual basis than the aviation industry emits.

While previous research has quantified the carbon stocks of coastal habitats, often referred to as "blue carbon" ecosystems, their dynamic ocean influence makes calculations challenging, and few studies have looked at the variability of soil carbon across broad climatic and geographic ranges.

In response, the new study analyzes 1,284 sediment cores collected along more than 6,500 kilometers of the Pacific coast of North America to fill in knowledge gaps around certain habitat types as well as understudied regions, including northern British Columbia and Alaska.

"The cool thing about the dataset is that it brings together a huge number of cores taken by many different research groups," says Carolyn Prentice, a Hakai Institute researcher responsible for some of the seagrass samples in the paper. "The power of the study is the sheer amount of data compiled to compare different habitat types. This paper solidifies what everyone was thinking we knew was happening in a robust way."

One surprising finding was that even mudflats without trees and shrubs store significant amounts of carbon, on par with seagrass meadows—a major focus of blue carbon studies worldwide. While these two ecosystems have the lowest carbon stocks of the five habitats in the new research, they have larger footprints than mangroves and tidal swamps, and seagrass meadows in particular offer many additional benefits, from sheltering juvenile salmon to stabilizing sediment to improving water quality.

Overall, the new study helps cement the carbon-storage powers of these ecosystems, Hessing-Lewis says, and could help guide local and regional decision-making about what areas to prioritize for conservation. "For example, restoring one tidal swamp would be good bang for your carbon buck," she says.

Global studies have shown that, collectively, blue-carbon ecosystems on a yearly basis could store roughly the equivalent of three percent of global greenhouse gas emissions—more than the annual emissions of the aviation industry.

While carbon storage suggests the ability to help offset greenhouse gas emissions, this study focuses on static carbon stocks and doesn't directly measure new carbon removal from the atmosphere, Janousek says. The power of these ecosystems to sequester carbon is an area of active research.

"That is indeed something the Pacific Northwest Blue Carbon Working Group is addressing, but it is not the focus of this particular paper," Janousek says.

But the new estimates for carbon storage are valuable in their own right. They'll soon be deployed in climate mitigation modeling in Oregon, Washington, and British Columbia, and will inform British Columbia's new Coastal Marine Strategy. They'll also help guide Indigenous organizations and governments working to protect and restore coastal ecosystems—for their carbon stocks and other important ecosystem services. ■

Woody plants and trees in tidal wetlands deposit large quantities of carbon into low-oxygen soils.

Sunflower sea stars (*Pycnopodia helianthoides*) are clinging to life in the cold-water fjords of British Columbia's Central Coast.

A new study suggests that cold-water fjords on British Columbia's Central Coast could be marine refuges for sunflower sea stars (*Pycnopodia helianthoides*). The sea stars were once a common fixture of the Pacific Northwest intertidal zone. However, since 2013, sea star wasting disease (SSWD) has wiped out over 90 percent of the global sunflower sea star population between Alaska and Mexico. SSWD outbreaks have been linked to marine heatwaves, which are becoming more frequent due to climate change. This study indicates that consistently cold water could offer a potential refuge for the threatened sunflower sea stars.

Research collaborators at the Central Coast Indigenous Resource Alliance and member First Nations reported sightings of large sunflower sea stars in Central Coast fjords—a sign that remnant populations might have avoided SSWD. So Hakai Institute researcher Alyssa Gehman traveled to Burke Channel for a dive and saw a window into the past before SSWD took hold.

Compared with the sunflower sea stars found around offshore islands, the ones in the cold-water fjords were larger and more abundant, suggesting these areas act as refuges. Fjords have complex dynamics, and researchers observed that the sea stars were found below a surface layer of freshwater from snowmelt. This suggests that low-salinity surface water is a factor in the sea star's habitat selection, emphasizing the way environmental systems interact to support species survival. ■

Short Takes

Sounding the Alarm for Global Glaciers

The Klinaklini Glacier—the largest glacier in North America, located in the Heiltsuk Ice Field of British Columbia—loses about one gigaton of water every year. Photo courtesy of Brian Menounos

As the world's glaciers retreat, the magnitude of their loss becomes clearer—and more alarming. Brian Menounos, a researcher at the University of Northern British Columbia and chief scientist at the Hakai Institute's Airborne Coastal Observatory (ACO), is part of an international research team that recently published findings on global glacial loss in *Nature*. Studying 19 different regions across the globe, the team found that between 2000 and 2023 these areas lost significant amounts of glacial ice. The greatest percentage of loss was in central Europe, which lost 39 percent of its glacial mass. Alaska lost nearly nine percent, and the southern Canadian Arctic lost over seven percent.

Canada is home to an astonishing 25 percent of Earth's glaciers, and the Hakai Institute's ACO collects important airborne data on western Canadian glaciers that's helping link space campaigns—such as NASA's Ice, Cloud, and Elevation Satellite—with high-caliber aircraft observations. This data will be crucial for improving regional and global forecasts of glacier loss, and for validating how we can measure glacier health from space.

In March 2025, Menounos was invited to attend the World Day for Glaciers in Paris—part of the 2025 International Year of Glaciers' Preservation initiative—where he shared some results from his work with the ACO. ■

Short Takes

Bobbing for Data

Hakai Institute researchers deployed a newly refurbished buoy, equipped with a range of oceanographic tools, into the waters of Bute Inlet, British Columbia, in February 2025.

Inlets play an important role as potential refugia for marine life amid a growing number of marine stressors, such as ocean acidification, but their constantly changing conditions can be difficult to monitor. Real-time observation platforms are a critical monitoring tool, yet there are few such platforms in British Columbia to track pattens of ocean acidification and carbon dioxide exchange.

The launch of a newly refurbished oceanographic buoy in Bute Inlet on the Central Coast will help contribute to our understanding of changing conditions within one of British Columbia's refuge inlets. Deployed in early February 2025 by Hakai Institute researchers, the buoy is equipped to take high-resolution measurements of the surface ocean and lower atmosphere, including wind, temperature, salinity, oxygen, and carbon dioxide levels.

Bute Inlet is an area of particular importance to Homalco First Nation, which can now make timely decisions about the release of juvenile salmon from their hatchery, based on indicators such as phytoplankton abundance and algal blooms. Continuous data from the buoy will also support marine safety efforts and be available online for broader access.

In addition, data from the buoy will be integrated with Bute Inlet survey data dating back to late 2017, along with datasets from partners at Fisheries and Oceans Canada and the University of British Columbia. Maintaining these time series is crucial, since ocean science is facing increasing threats that put vital data records at risk. ■

Short Takes

Species of the Day

Hakai scientists and technicians use a careful photo-taking process—good lighting, flashes, and a black background—to document bioblitz organisms in the lab, like this *Amphicteis mucronata* tube worm.

Beauty, as the saying goes, is in the eye of the beholder. This *Amphicteis mucronata* tube worm might not be everyone's choice for a charismatic organism, but this photo shows off its vibrant coloring and unusual form, which some will surely find beautiful

Submitted by polychaete expert Leslie Harris, the tube worm was a "Species of the Day" winner at the 2024 Quadra Island Bioblitz, where the Hakai Institute team gathered dozens of researchers for a three-week-long survey of the biodiversity of Quadra Island, British Columbia. You can learn more about the bioblitz and view the full list of winners here. ■

Tula in the News

Critically Endangered Sunflower Sea Stars are Seeking Refuge in BC Fjords

Alyssa Gehman and other Hakai Institute researchers recently published a new study about *Pycnopodia helianthoides* (sunflower sea stars) finding refuge from sea star wasting disease in the fjords of British Columbia's Central Coast. The results have been widely published in various media outlets around the world, including *The Canadian Press*, the CBC, and *Nature*.

New Research Links Storm Season Intensity in British Columbia with Ocean Acidification in the Strait of Georgia

An eight-year study, led by Hakai Institute researcher Wiley Evans and published in *Nature*, was featured in the *Vancouver Sun*. The study finds that ocean acidification levels in the northern Strait of Georgia are linked to storm season intensity in British Columbia.

The West Coast's Tidal Swamps are Supercharged Carbon Sinks

A collaborative cross-border study that includes Hakai Institute scientists Margot Hessing-Lewis and Carolyn Prentice digging into forested tidal swamps was picked up by *Canada's National Observer*.

Tackling Eutrophication: From Small Island to Big Nations with GEM-in-a-Box

Throughout our freshwater, brackish, and marine ecosystems, we face problems with eutrophication. The recent Commonwealth Blue Charter Incubator supported training at the Hakai Institute's Quadra Island facility, alongside the GEM-in-a-Box team, to address this issue. They shared this story about it.

Western Canada's Glacier Melt is Accelerating at "Tremendous" Pace, says BC Coauthor of Global Study

Brian Menounos, chief scientist at the Hakai Institute Airborne Coastal Observatory, was recently featured in various media outlets, including the *Vancouver Sun*, for his contribution to a collaborative research paper recently published in *Nature* on the impacts of global glacial loss.

Canadian Embassy in Guatemala Highlights the Work of TulaSalud

The Canadian Embassy in Guatemala recently featured the work of TulaSalud in a short video posted to their Facebook page, highlighting 20 years of crucial work to improve access to healthcare services for women and girls in remote Guatemala.

Hakai Magazine Highlights

Check out a selection of some of the most popular and fascinating magazine stories from recent months.

The Canoe in the Forest

by Joshua Hunt

An unfinished boat hidden on a remote island in Alaska illuminates a missing chapter in the history of traditional Haida and Tlingit canoe building. Full story here.

To Speak the Language of the Land

Story by Nic Low
Photos by Te Rawhitiroa Bosch

Maori people are reclaiming their native language, even in the face of growing threats to the natural world on which it depends. Full story here.

The Other Side of the World's Largest Dam Removal

by J.B. MacKinnon

Removing dams from the Klamath River in Northern California seems like a clear win for fish and rivers. Why do some locals hate it? Full story here.

Is Deforestation Supercharging Cyclones?

by Erica Gies

The airborne water cycle, destabilized by industrial logging and other land use, may be a hidden force behind growing superstorms. Full story here.

The Coming Collision Between Whales and Tankers on British Columbia's Coast

Story by Laura Trethewey
Photos and video by Chelsey Ellis

Decades after they were hunted to local extinction, fin whales are recovering in the Kitimat fjord system—only to be threatened by a booming LNG industry. Full story here.

Where the Rivers Run Pink

Story by Jude Isabella
Photos and videos by Katrina Pyne

Non-native pink salmon have swarmed Norway's rivers, prompting a relentless—and potentially fruitless—fight to beat back the invaders. Full story here.

Recent Publications

Genetic differentiation and precolonial Indigenous cultivation of hazelnut (*Corylus cornuta*) in western North America

Abstract excerpt:

Cultivation studies evaluating land-use histories and coevolutionary dynamics between humans and plants focus predominantly on domesticated species. Traditional anthropological divisions of "foragers" and "farmers" have shaped our understanding of ancient cultivation practices but have several limitations, including how people stewarded and managed nondomesticated species. To investigate the long-term effects of plant management in the Pacific Northwest, this study focuses on beaked hazelnut (*Corylus cornuta*) which has a long, precolonial history of management, transportation, and cultivation in British Columbia.

Armstrong, C. G., Clemente-Carvalho, R. B. G., Turner, N. J., Wickham, S., Trant, A., & Lemay, M. A. Genetic differentiation and precolonial Indigenous cultivation of hazelnut (*Corylus cornuta, Betulaceae*) in western North America. (2024). *Proceedings of the National Academy of Sciences*, 121(48).

https://pnas.org/doi/10.1073/pnas.2402304121

Airborne lidar intensity correction for mapping snow cover extent and effective grain size in mountainous terrain

Abstract excerpt:

Differentially mapping snow depth in mountain watersheds from airborne laser altimetry is a valuable hydrologic technique that has seen an expanded use in recent years. Additionally, lidar systems also record the strength of the returned light pulse (i.e. intensity), which can be used to characterize snow surface properties. For near-infrared lidar systems, return intensity is relatively high over snow and inversely related to the effective grain size, a primary control on snow albedo.

Ackroyd, C., Donahue, C. P., Menounos, B., & Skiles, S. M. (2024). Airborne lidar intensity correction for mapping snow cover extent and effective grain size in mountainous terrain. *GIScience & Remote Sensing*, 61(1).

https://doi.org/10.1080/15481603.2024.2427326

Phytoplankton community composition links to environmental drivers across a fjord to shelf gradient on the central coast of British Columbia

Abstract excerpt:

Rapid environmental change is altering coastal phytoplankton dynamics and thereby the productivity of coastal marine food webs. Unfortunately, a paucity of phytoplankton community data hinders the prediction of future conditions in ecologically productive regions such as the coastal northeast Pacific. To help fill this gap, this study characterized phytoplankton communities from 2018 to 2020 across a fjord, channel, and shelf station transect on the Central Coast of British Columbia, Canada.

Del Bel Belluz, J., Jackson, J. M., Kellogg, C. T. E., Péna, M. A., Giesbrecht, I. J. W., & Hobson, L. A. (2024). Phytoplankton community composition links to environmental drivers across a fjord to shelf gradient on the central coast of British Columbia. *Frontiers in Marine Science*, 11.

https://doi.org/10.3389/fmars.2024.1458677

Bull kelp (*Nereocystis luetkeana*) growth rates as climate stress indicators for Canada's Pacific coast

Abstract excerpt:

Primary producers' growth rates are ideal bioindicators of changing climate due to their sensitivity to environmental conditions. On the Central Coast of British Columbia, we assessed growth rates of *Nereocystis luetkeana*, a canopy-forming annual kelp, by assessing baseline variability in growth rates and their response to environmental conditions of over 600 individuals and across three sites (2016–2019).

Pontier, O., Rhoades, O., Twist, B., Okamoto, D., & Hessing-Lewis, M. (2024). Bull kelp (*Nereocystis luetkeana*) growth rates as climate stress indicators for Canada's Pacific coast. *FACETS*, 9:1-19.

https://doi.org/10.1139/facets-2023-0237

Advancing an integrated understanding of land-ocean connections in shaping the marine ecosystems of coastal temperate rainforest ecoregions

Abstract excerpt:

Land and ocean ecosystems are strongly connected and mutually interactive. As climate changes and other anthropogenic stressors intensify, the complex pathways that link these systems will strengthen or weaken in ways that are currently beyond reliable prediction. In this review we offer a framework of land-ocean couplings and their role in shaping marine ecosystems in coastal temperate rainforest (CTR) ecoregions, where high freshwater and materials flux result in particularly strong land-ocean connections.

Hunt, B. P. V., Alin, S., Bidlack, A., Diefenderfer, H. L., Jackson, J. M., Kellogg, C. T. E., Kiffney, P., St. Pierre, K. A., Carmack, E., Floyd, W. C., Hood, E., Horner-Devine, A. R., Levings, C. & Vargas, C. A. (2024). Advancing an integrated understanding of land-ocean connections in shaping the marine ecosystems of coastal temperate rainforest ecoregions. *Limnology and Oceanography*, 69(12): 3061–3096.

https://doi.org/10.1002/lno.12724

Marine and freshwater sounds impact invertebrate behavior and physiology: a meta-analysis

Abstract excerpt:

The diversity of biotic and abiotic sounds that fill underwater ecosystems has become polluted by anthropogenic noise in recent decades. Yet, there is still great uncertainty surrounding how different acoustic stimuli influence marine and freshwater (i.e., aquatic) communities. Despite capabilities to detect and produce sounds, aquatic invertebrates are among the most understudied taxa within the field of soundscape ecology. We conducted a meta-analysis to understand how sounds from various sources influence the behavior and physiology of aquatic invertebrates.

Davies, H. L., Cox, K. D., Murchy, K. A., Shafer, H. M., Looby, A. & Juanes, F. (2024). Marine and freshwater sounds impact invertebrate behavior and physiology: A meta-analysis. *Global Change Biology*, 30(11).

https://doi.org/10.1111/gcb.17593

Seagrass wasting disease prevalence and lesion area increase with invertebrate grazing across the northeastern Pacific

Abstract excerpt:

Disease is a key driver of community and ecosystem structure, especially when it strikes foundation species. In the widespread marine foundation species eelgrass (*Zostera marina*), outbreaks of wasting disease have caused large-scale meadow collapse in the past, and the causative pathogen, *Labyrinthula zosterae*, is commonly found in meadows globally. Here, we investigated links between epifaunal grazers and seagrass wasting disease using a latitudinal field study across 32 eelgrass meadows distributed from southeastern Alaska to southern California.

Aoki, L. R., Ritter, C. J., Beatty, D. S., Domke, L. K., Eckert, G. L., Graham, O. J., Gomes, C. P., Gross, C., Hawthorne, T. L., Heery, E., Hessing-Lewis, M., Hovel, K., Koehler, K., Monteith, Z. L., Mueller R. S., Olson, A. M., Prentice, C., Rappazzo, B., Stachowicz, J. J., Tomas, F., Yang, B., Harvell, C.D., & Duffy, J. E. (2025). Seagrass wasting disease prevalence and lesion area increase with invertebrate grazing across the northeastern Pacific. *Ecology*, 106(1).

https://doi.org/10.1002/ecy.4532

Developing a collaborative Dungeness crab larval monitoring network in the Salish Sea to provide long-term, fishery-relevant data

Abstract excerpt:

Many natural resources are managed without essential, biologically relevant data. Fisheries are particularly susceptible to this reality and, thus, are vulnerable to environmental changes and disturbances, with both human livelihoods and the health of ecological systems at stake. Here, we explore how the Pacific Northwest Crab Research Group (PCRG) employs a collaborative, stakeholder-driven approach to generate the information needed to inform a data-poor, co-managed fishery, using the example of Dungeness crab (*Metacarcinus magister*) in the northeastern Pacific's Salish Sea.

Buckner, E. V., Grossman, S. K., Cook, C., Brownlee, A., Barber, J. S., Earle, H., Becker, B. J., Bosley, K., Harrington, N., McDonald, P. S., Paul, B., Homerding, M., Houle, K., Galiotto, A., Pantaleo, G., & Paul, A. (2025). Developing a collaborative Dungeness crab larval monitoring network in the Salish Sea to provide long-term, fishery-relevant data. *Fisheries*, 50(1), 5–18.

https://doi.org/10.1093/fshmag/vuae002

Variability in storm season intensity modulates ocean acidification conditions in the northern Strait of Georgia

Abstract excerpt:

Large changes in marine CO_2 chemistry manifest in areas with weakly-buffered seawater where ocean acidification (OA) acts in concert with natural CO_2 additions. These settings can exhibit periods of extreme OA in the form of multiple co-occurring stressors, including calcite undersaturation and low pH. Such conditions were observed in the northern Strait of Georgia, on the northeast Pacific coast, where extreme OA spanned a 3-year period.

Evans, W., Campbell, K., Weekes, C., Del Bel Belluz, J., Barrette, J., Jordison, D., Mackenzie, C., Bergshoeff, J., Prentice, C., Savage, R., Desmarais, I., Feje, B., Myers, E., Bedard, K., Hare, A., Giesbrecht, I. J. W., Kellogg, C. T. E., Sandwith, Z., & Jackson, J. M. (2025). Variability in storm season intensity modulates ocean acidification conditions in the northern Strait of Georgia. *Nature Scientific Reports*, 15(1).

https://doi.org/10.1038/s41598-025-88241-8

Fjord oceanographic dynamics provide refuge for critically endangered *Pycnopodia helianthoides*

Abstract excerpt:

Disease outbreaks as a driver of wildlife mass mortality events have increased in magnitude and frequency since the 1940s. Remnant populations, composed of individuals that survived mass mortality events, could provide insight into disease dynamics and species recovery. The sea star wasting disease (SSWD) epidemic led to the rapid >90% decline of the sunflower star *Pycnopodia helianthoides*. We surveyed the biomass density of *P. helianthoides* on the central British Columbia coast before, during, and after the arrival of SSWD by conducting expert diver surveys in shallow subtidal habitats from 2013 to 2023.

Gehman, A. M., Pontier, O., Froese, T., VanMaanen, D., Blaine, T., Sadlier-Brown, G., Olson, A. M., Montheith, Z. L., Bachen, K., Prentice, C., Hessing-Lewis, M., Jackson, J. M. (2025). Fjord oceanographic dynamics provide refuge for critically endangered *Pycnopodia helianthoides*. *Proceedings of the Royal Society B*, 292.

http://doi.org/10.1098/rspb.2024.2770

Mapping the spatial heterogeneity of watershed ecosystems and water ecosystems and water quality in rainforest fjordlands

Abstract excerpt:

Small coastal watersheds (<10,000 km²) can play a large role in forming biogeochemical linkages between land and sea, yet the spatial heterogeneity of small watershed ecosystems is poorly understood due to sparse observations in many regions. In this study, we examined the spatial heterogeneity of water quality exported from diverse watersheds in two rainforest fjordland complexes.

Giesbrecht, I. J. W., Lertzman, K. P., Tank, S. E., Frazer, G. W., St. Pierre, K. A., Gonzalez Arriola, S., Desmarais, I., & Haughton, E. (2025). Mapping the spatial heterogeneity of watershed ecosystems and water quality in rainforest fjordlands. *Ecosystems*, 28.

https://doi.org/10.1007/s10021-025-00964-x

Regression-based characterization of the marine carbonate system across shelf and nearshore waters of Queen Charlotte Sound

Abstract excerpt:

Marine carbonate system measurements are essential for understanding ocean acidification and $CaCO_3$ saturation states, and their response to oceanographic and anthropogenic processes. Acquiring such measurements in remote coastal areas is limited by challenges in the development and deployment of autonomous sensors for these parameters, and by the complexity and costs of directly measuring them. We address this challenge by extending an established method of estimating carbonate system parameters through proxy variables to the remote waters of Queen Charlotte Sound, British Columbia.

Hare, A. A., Evans, W., Dosser, H. V., Jackson, J. M., Alin, S. R., Hannah, C., Ross T., & Klymak, J.M. (2025) Regression-based characterization of the marine carbonate system across shelf and nearshore waters of Queen Charlotte Sound. *Marine Chemistry*, 270.

https://doi.org/10.1016/j.marchem.2025.104511

Blue carbon stocks along the Pacific coast of North America are mainly driven by local rather than regional factors

Abstract excerpt:

Coastal blue carbon ecosystems such as seagrass meadows, marshes, mangroves, and other tidal wetlands, efficiently accumulate and store organic carbon in their sediments. For the west coast of North America, we investigated whether the amount of carbon stored in the sediment ("carbon stock") differed by ecosystem type and whether differences were linked to local-scale factors such as elevation and plant type or to regional-scale factors such as latitude and climate conditions. We found the highest sediment carbon stocks in mangroves in Mexico and tidal swamps in the Pacific Northwest, ecosystems both dominated by woody plants.

Janousek, C. N., Krause, J. R., Drexler, J. Z., Buffington, K. J., Poppe, K. L., Peck, E., Fernanda Adame, M., Watson, E. B., Holmquist, J., Bridgham, S. D., Jones, S. F., Ward, M., Brown, C. A., Beers, L., Costa, M. T., Diefenderfer, H. L., Borde, A. B., Sheehan, L., Rybczyk, J., Prentice, C., Gray, A. B., Hinojosa-Corona, A., Ruiz-Fernánez, A. C., Sanchez-Cabeza, J., Kohfeld, K. E., Ezcurra, P., Ochoa-Gómez, J., Thorne, K. M., Pellatt, M. G., Ricart, A. M., Nahlik, A. M., Brophy, L. S., Ambrose, R. F., Lutz, M., Cornu, C., Crooks, S., Windham-Myers, L., Hessing-Lewis, M., Short., F. T., Chastain, S., Williams, T., Douglas, T., Fard, E., Brown, L., & Goman, M. (2025). Blue carbon stocks along the Pacific coast of North America are mainly driven by local rather than regional factors. *Global Biogeochemical Cycles*, 39(3).

https://doi.org/10.1029/2024GB008239

DNA metabarcoding captures temporal and vertical dynamics of mesozooplankton communities

Abstract excerpt:

In this study, we evaluated how well DNA metabarcoding of environmental samples captures changes in marine mesozooplankton community composition to optimize the use of sequencing data for studying seasonal dynamics. Although DNA metabarcoding is increasingly used to monitor the distribution of marine communities, there is a lack of standardized methods, and it remains uncertain to what extent the DNA data reflects patterns of community dynamics observed by other methods.

Novotny, A., Rodrigues, C., Jacquemot, L., Clemente-Carvalho, R. B. G., Piercey, R. S., Morien, E., Galbraith, M., Kellogg, C. T. E., Lemay, M. A., & Hunt, B. P. V. (2025). DNA metabarcoding captures temporal and vertical dynamics of mesozooplankton communities. *ICES Journal of Marine Science*, 82(2).

https://doi.org/10.1093/icesjms/fsaf007