2025

University of Washington

APPLIED PHYSICS LABORATORY

ANNUAL REPORT

APL-UW

University Affiliated Research Center

The Applied Physics Laboratory is a research unit of the University of Washington. We serve as a trusted research and development agent by anticipating broad scientific and engineering challenges and responding quickly to rising national research priorities. Core expertise is in ocean physics and engineering, ocean and medical acoustics, polar science, environmental remote sensing, and signal processing.

Designation by the U.S. Navy as a University Affiliated Research Center requires that APL-UW operate in the public interest. From our integral position within the University of Washington scholarship, research, and innovation enterprise, we apply rigorous scientific inquiry and engineering excellence in pursuit of solutions for the good of our region, nation, and world.

APL-UW has a formal, strategic relationship with the U.S. Navy, offering a unique arrangement of basic and applied research within one organization, and ensuring that essential engineering and technology capabilities are maintained.

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LEADERSHIP
The University and the Laboratory

My second full year as Executive Director at the Applied Physics Laboratory of the University of Washington began in May 2025. The best part of this job has been, and continues to be, learning about the amazingly interesting research and development performed by our outstanding staff of scientists and engineers on behalf of the organizations that sponsor the work, with critical support provided by the Laboratory's top-notch professional administrative teams. As a University Affiliated Research Center (UARC), APL-UW is charged with executing basic and applied research in one organization, leveraging talent and innovation through its UW affiliation, and transitioning knowledge and material products to operational use. We continue to succeed in our mission, as you will see in the following pages of this *Annual Report*.

APL-UW continued its financial growth trajectory in the last closed fiscal year, despite challenges in the federal research funding landscape. Our overall continuing success and alignment with U.S. government requirements was rewarded with the execution of the five-year option on our Indefinite Delivery/Indefinite Quantity contract administered by the U.S. Navy. The option was executed after an extensive comprehensive review by the Navy UARC Office at Naval Sea Systems Command (NAVSEA). The continuation of this important contract allows APL-UW to respond rapidly to the needs of the varied sponsor base who use this contracting vehicle. The confidence shown in APL-UW by our government partners is a testament to the hard work and dedication of every single person associated with the Laboratory, and all are to be congratulated on this accomplishment.

As national priorities change, staying aware of those priorities and the evolving needs of our sponsor base is critical, and APL-UW is well-aligned to maintain those connections. At the same time, APL-UW is charged with being an innovation hub, and as we are aligned with the University and its mission of scholarly research and breaking new ground in relevant technology areas, we will continue to provide advice to our sponsors on newly developed capabilities that can make an operational impact.

This report, as is tradition, highlights exciting research taking place at APL-UW over the last year. The stories cover a wide swath of the Laboratory's areas of expertise, and many of the stories center on work done by early career principal investigators. Supporting and mentoring the next generation of staff is an important mission for APL-UW. It is a core value that is not only in keeping with our status as a UARC, but allows us to ensure the maintenance of our core competencies for years to come. I hope you enjoy the individual stories represented in this *Annual Report* and take away the bigger picture of the organization's overall story.



WELCOME

Executive Director Warren L.J. Fox

We conduct experiments in the field around the world and build research collaborations with academic, government, and industry partners nationally and internationally. (Look for this globe graphic throughout the report.)



GLOBAL REACH & INFLUENCE

Congratulations to Michael Bailey and the entire team that developed ultrasonic therapies for kidney stones. (See page 26.) *Bailey was named 2025 UW School of Medicine Inventor of the Year.*



INVENTION & APPLICATION

The confidence shown in APL-UW by our government partners is a testament to the hard work and dedication of every person associated with the Laboratory.

We train aspiring scientists and engineers to ensure our core competencies are maintained for years to come. (See pages 12, 23, 38, and 40.)



NEXT GENERATION

FINANCES

Growth and Fiscal Responsibility

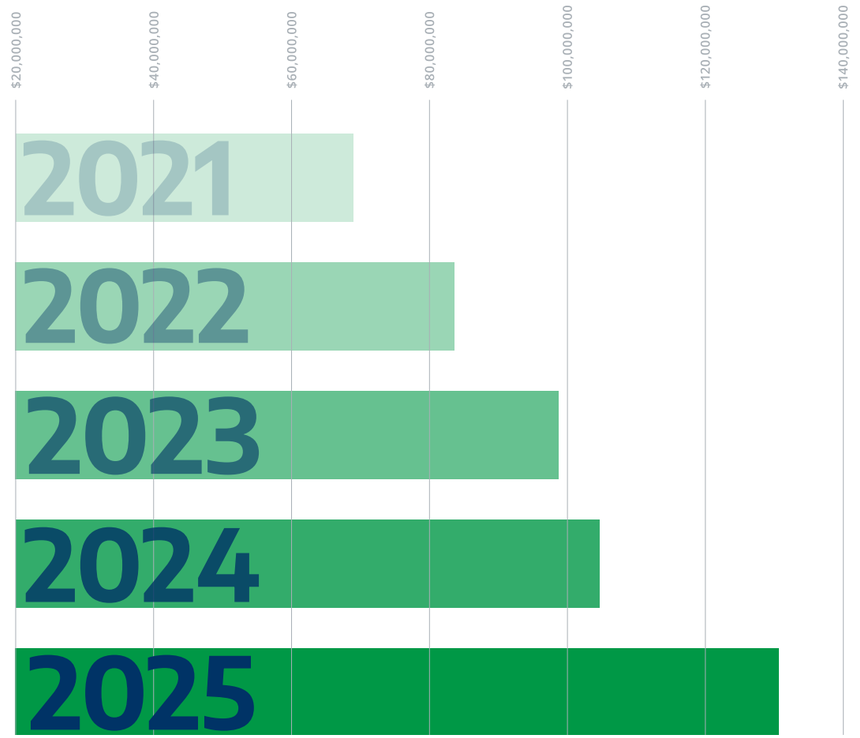
The Applied Physics Laboratory experienced another year of growth in total awards during FY25. The record total of $131.1M is a 26.7% increase from FY24.

Since the 2020 execution of APL-UW's 10-year Indefinite Delivery/Indefinite Quantity contract, the Laboratory has broadened its role in meeting evolving U.S. Navy requirements. This expansion reflects our commitment to delivering responsive support to our sponsors.

The increased work led to a ceiling increase in 2024 — only four years into the contract term. This milestone marked the first time in the organization's history that such an adjustment was required, underscoring the scale and pace of our growth.

To support this growth, the Laboratory implemented a strengthened leadership structure and added personnel to key administrative and support teams. These enhancements ensure the Laboratory is able to maintain the high standards of service expected by our partners.

In addition to investments in personnel, the Laboratory continues to prioritize the modernization and expansion of our infrastructure. Targeted initiatives support emerging technical requirements and maintain readiness for future research needs.













EXPERIMENTAL OCEANOGRAPHY

Regional Energy Exchanges, Turbulent Cascades

Ocean scientists from six U.S. and two Taiwanese institutions aboard R/V *Thomas G. Thompson*, having departed Guam at the end of January 2025, spent a part of their one-month research cruise following a small vortex, crossing back and forth with the ship through the swirling currents. Every hour or so, explains cruise Chief Scientist and APL-UW Senior Principal Oceanographer Luc Rainville, the team evaluated data from shipboard instruments and the dozens of floats, drifters, and undersea drones in the ocean around them to decide whether they had fully crossed the eddy and where they should direct the ship next to optimize sampling. "We were discovering the ocean physics together," says Rainville.

The 25-day cruise was one of the final observational campaigns of the Office of Naval Research Departmental Research Initiative called ARCTERX — Island ARC Turbulent Eddy Regional eXchange. Targeting the region between the colder waters of the Subtropical Countercurrent, a narrow, eastward flowing current, and the warmer North Equatorial Current, a westward, wind-driven current in the Philippine Sea, the research team arrived at the end of winter when the currents and thick surface ocean mixed layers interact, spinning off energetic eddies and meanders. These, in turn, can generate smaller, ephemeral instabilities – fronts and filaments – along their edges, breaking down to smaller and smaller eddies leading to turbulence or, counterintuitively, can merge and lead to a transfer of energy to larger scales. The initiative's broad goal is to characterize the strength and properties of the cascade of kinetic energy at the submesoscale, that is, ocean features that are 100 m to 10 km wide, 10 to 100 m deep, and last hours or days. Though ubiquitous throughout the world's oceans, submesoscale features, unlike major currents, are inherently chaotic and evolve quickly, limiting their predictability.

Designing a program to observe the evolution of submesoscale instabilities on fronts and filaments that drive turbulence is a grand technological and logistical challenge. Though capable, ships such as R/V *Thompson* are not entirely sufficient. The initiative's science goals require hundreds of autonomous platforms deployed at sufficient density and over long durations to fully understand the physics of the targeted processes.

Satellite remote sensing of sea surface temperature (SST) and numerical models were used to identify a region with the most interesting and relevant physics. As the researchers arrived on site, SST gradients were large and high-resolution images revealed instabilities developing on a temperature front. The ship's X-band radar, a scientific instrument installed by the University of Miami measuring surface roughness and the wave field to produce current maps at a range of about 4 km from the ship, proved invaluable on exploratory surveys and throughout cruise operations. "Filaments of cyclonic vorticity nearly always coincided with sharp gradients in temperature measured by the ship, so it was a surefire way to identify and track fronts within 4 km of the ship," explains Rainville.

Researchers, with aid from the ship's crew, deployed autonomous instruments – 62 floats, 10 undersea gliders, a Wave Glider, and 135 surface drifters – and completed five surveys with the Triaxus towbody that profiled the ocean's upper 150 m 4635 times while covering 2000 km. Arrays of floats, programmed to profile the upper 175 m of the ocean to measure quantities such as temperature, salinity, and velocity, were deployed near observed instabilities developing along a temperature front. "We chose to deploy the floats in two arrays, where a smaller array was nested inside a larger array to capture the range of scales important for energy exchange in the surface mixed layer," explains Principal Oceanographer Caitlin Whalen. The smaller array was dropped from the ship in a 2 x 2-km region with about 200-m separation, which was only two ship's lengths, between each. The profiling float arrays were placed on the edge of a cyclonic eddy so that they might remain caught up in the evolving and unstable region for the longest period, instead of being swept away by the larger regional currents.

As the ocean was seeded with floats, two Seagliders were deployed to spend the duration of the cruise sampling across features in coordination with a Wave Glider on the surface. The Seagliders, along with five other underwater gliders from Scripps Institution of Oceanography and Oregon State University, remained and continued to sample the patch of ocean for several months, ultimately recovered by a Taiwanese ship. The evolving arrays of floats provided a coordinate frame for the continuous ship surveys. Triaxus was towed across temperature fronts and along the edges of filaments, capturing the horizontal and vertical structure of submesoscale processes.

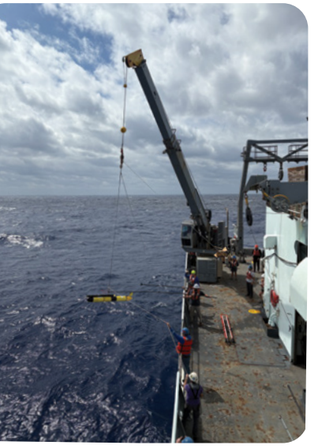
Each of the tools used has one way that it samples the ocean, and none is perfect, but together they make a powerful observing system. A situational awareness website was built to track instrument positions and data processed from them in real time. Displaying all this information in a geographic, ship-centric map was useful for the bridge crew and the science team to plan adaptive surveys hour-by-hour. "We relied heavily on data flow to decide where to sample next," notes Rainville.

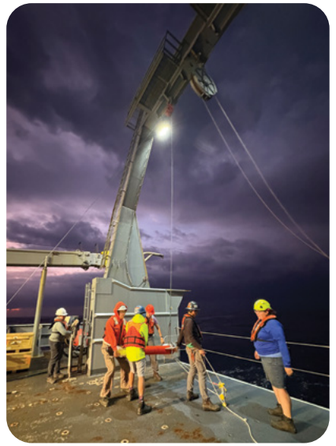
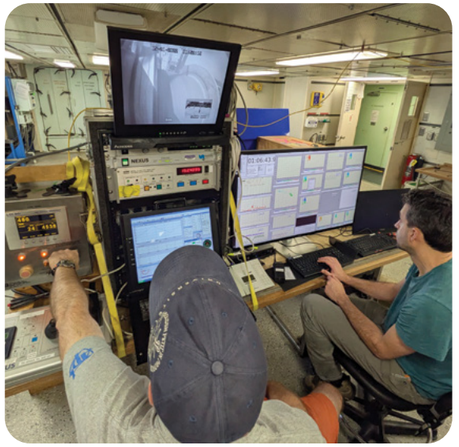
Several of the floats, the two Seagliders, and a Slocum glider were equipped with sensors to sample the smallest scales in the ocean — centimeter-scale fluctuations of velocity and temperature used to estimate turbulence. Combined with vertical microstructure profiler sections conducted from R/V *Thompson*, the team collected thousands of microstructure measurements to study the smallest extent of the submesoscale range, where instabilities on the fronts and filaments drive turbulence, dissipating energy. In one case, the team surveyed a small vortex for several days, capturing intense turbulence and mixing within a stratified layer on the cyclone's flank. Observing decreases in salinity variability and mixing rate, they concluded the relaxation due to irreversible mixing rather than advection of a homogenous water mass into the vortex. "Advances in recent years have allowed our field campaign to collect microstructure profiles from a wide range of different platforms," says Whalen. "This makes our turbulence dataset truly unique in that we can quantify variability on timescales ranging from hours to months and spatial scales ranging from meters to hundreds of kilometers."

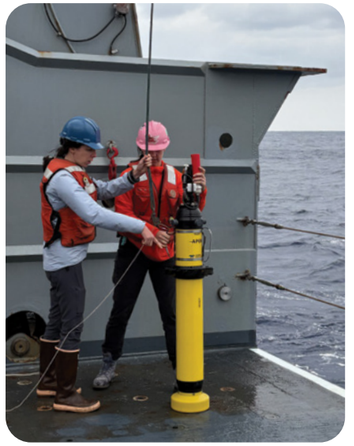
2025 was the last year of field observations for the ARCTERX initiative. The 25-day cruise that ended in Taiwan was a huge success and the value of the data collected cannot be overstated. Ongoing analyses are exciting. Rainville explains: "With so many instruments and ways to measure the ocean, we are now discovering how what is measured at one spot can relate to everything else."

Sponsor: Office of Naval Research

APL-UW Team: Jake Dossett, Kyla Drushka, Jason Gobat, Maya Gong, Caitlin Guerin, Ben Jokinen, Craig Lee, Luc Rainville, Justin Shapiro, Harper Simmons, Louis St. Laurent, Zoltan Szuts, Caitlin Whalen










ESSENTIAL ENGINEERING

Novel Ocean Observations by µFloats at a Towering Glacier

Swarms of small, inexpensive buoyancy-controlled floats, first developed during Senior Engineer Trevor Harrison's graduate student research in the UW Department of Mechanical Engineering, are a critical technology to study the melting retreat of LeConte Glacier, Alaska. The southernmost tidewater glacier in the Northern Hemisphere, it is known for 'shooter' icebergs that calve underwater. Often much larger than bergs falling from the highest elevations of the glacier face, Harrison describes the underwater calving as, "A sudden, huge bulge of water that appears and grows, and as the berg surfaces it generates enormous waves that propagate down the bay."

A trigger for tidewater glaciers' retreat is the melting caused by the inundation of warm ocean water against the glacier's submerged face. During summer, rain and surface meltwater drain to the bottom of the glacier and emerge at the grounding line – 100–250 m deep in LeConte Bay – as a freshwater plume that rises and spreads down the bay. This energetic, buoyant discharge – an upside-down waterfall – entrains comparatively warm ocean water as it rises in a turbulent plume along the underwater face of the glacier, melting ice.

Despite the central importance of this discharge plume to the glacier's total melt rate, observations at the glacier face are scarce because it is simply too dangerous for scientists to work there. APL-UW investigators and colleagues at Oregon State University (OSU) designed observational campaigns using the unique capability of µFloats to target and ride the multilayer circulation in the bay, become entrained in the buoyant discharge plume, all while their movements are tracked acoustically.

"This was a first," says Harrison. "No one has ever taken direct measurements inside the discharge plume of a tidewater glacier." The flow-following µFloat offers novel observations for the science team, allowing them to address the open question of why LeConte and other tidewater glaciers melt back at a rate two to ten times faster than theoretical estimates.

Over the past two summer field seasons, the observations at LeConte Glacier were directed from a research vessel in the bay maintaining a safe distance. Operations began by deploying four subsurface moorings. Robotic rigid hull inflatable boats, outfitted with oceanographic sensors, were sent on missions to sample nearer the terminus. OSU collaborators have used observations from this platform to show that ambient melting across the submarine glacier face away from the discharge plume is ubiquitous and perhaps two orders of magnitude greater than thought previously.

Before µFloats were deployed, five surface buoys were set out to create a network of acoustic beacons. Dropped in small swarms about 300 m from the terminus, µFloats were programmed to descend to depths ranging from 45 to 90 m, targeting the layer of ocean water drawn toward the glacier face. As they were entrained into the discharge plume, they accelerated to speeds up to 2.5 m/s and rose quickly toward the surface with the buoyant plume. "With all the upward momentum, the floats cannot maintain their programmed depth," explains Harrison. "Now on the surface, they work to go to depth again, become entrained, and take the grand ride again, circling back into the buoyant flow." Typical float drifts played out over four hours. As currents inevitably carried the surface buoys away from the terminus, the team retrieved and relocated them to maintain the acoustic localization network for the floats. At day's end, all assets were collected as they drifted down the bay with the freshwater plume.

Harrison's work with the µFloat began as an engineering solution to a marine renewable energy research question, that is, how to best characterize fluid flows and predict efficiency at proposed tidal energy conversion sites. Unlike well-known oceanographic floats built for five-year deployments in the open ocean that communicate their data through a satellite network, µFloat missions are no longer than one day and conducted in shallow, turbulent environments. Its fast, high-volume buoyancy control engine can move the float to depth quickly, overcoming moderate currents and strong density gradients, and their onboard acoustics system, working in tandem with a multi-node tracking network, allows reconstructions of their position and velocity in three dimensions.

NEXT GENERATION

Doctoral Student Research at LeConte Glacier

Integral to the research team's observational campaign last summer were the contributions of **Ashley Howard** and **Murad Mehrab Abrar**, UW Ph.D. students in oceanography and mechanical engineering, respectively. Ashley, advised by **Principal Oceanographer Zoltan Szuts**, assisted with µFloat deployments, but was focused on leading the EM-APEX profiling float operations: programming, as well as launches and recoveries in LeConte Bay. "I got to work with an amazing science team and ship crew to retrieve as much data as possible, even when the ice conditions became challenging," says Howard.

Since the summer cruise she has been calculating the floats' trajectories from GPS fixes surrounding each dive to correct measured subsurface velocities to an absolute velocity and thus understand tidal forcing in the bay. Combining these observations with those taken by other autonomous platforms near the glacier terminus, Howard is contributing to the complete picture of stratification, mixing, and subsurface circulation in LeConte Bay.

Mehrab Abrar became interested in the µFloat platform in the fall of 2024 because its underwater acoustic localization technique aligns with his research experience in robotic navigation. Now, with **Senior Engineer Trevor Harrison** as his Ph.D. advisor, he is developing algorithms to track µFloats acoustically with high precision from maximum position updates. "I use trilateration techniques aided by multiple GPS tracked surface buoys and underwater beacons," explains Murad. "My algorithm integrates acoustic range measurements from multiple devices to reconstruct float trajectories, accounting for relative depth and speed variations among devices."

During operations at LeConte, Mehrab Abrar teamed with Harrison to deploy and recover floats and surface tracking buoys, record experiment times and locations, then perform localization calculations after each experiment. Since, he has been improving these localization estimates by integrating µFloat-to-µFloat acoustic communications. Murad remarks, "What I've enjoyed most about this project is the balance between theory and field testing, where I can validate and refine the algorithms using actual field data."

When Harrison joined APL-UW as a postdoctoral researcher, it was an opportunity to develop µFloats beyond their marine energy origins and into a general oceanographic research platform. After applying them to studies of riverine plume mixing in coastal ocean environments, the idea of using an array to sample near the towering face of a tidewater glacier was discussed among APL-UW and OSU oceanographers. The µFloats were well-positioned to work here, but to execute the science mission at LeConte Glacier and operate at depths up to 300 m, the original clear acrylic housing was replaced with an aluminum hull designed to match the compressibility of seawater. This modification improves the buoyancy control engine's efficiency and enables a constant density control scheme to complement the original constant depth scheme. The original cellular modem-based recovery communications – sufficient in populated coastal areas – were upgraded to use satellites for recovery in remote Alaska.

µFloat measurements of the discharge plume highlight how the theoretical layered, two-dimensional flow – with warm, salty deep inflow toward the glacier and cold, fresh outflow away – is an oversimplification. "The floats caught in the discharge plume tumble up and down multiple times before entering the shallow outflow," remarks **Principal Oceanographer Zoltan Szuts.** Tossing in this turbulent eddy adjacent the glacier face, the µFloats' temperature and salinity sensors detected the signatures of fresh discharge plume water, the salty inflow water, and the melting of submerged ice.

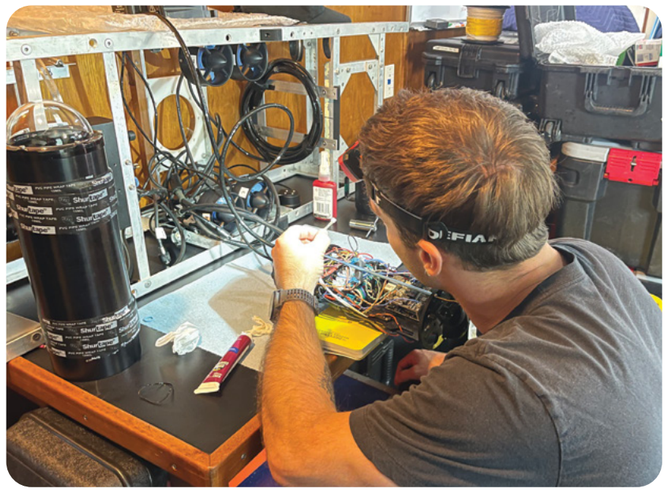
A swarm of small, inexpensive instruments filled a gap in sampling capabilities at LeConte Glacier. With them, researchers gained new insights into the complexity of the ocean circulation and a new basis for estimates of melt rates at this and other tidewater glaciers.

APL-UW Team: Murad Mehrab Abrar, Paul Gibbs, Caitlin Guerin, Trevor Harrison, Ashley Howard, Jessica Noe, Zoltan Szuts

Sponsor: National Science Foundation









SEAGLIDER SERVICE CENTER

Sustaining a Remarkable Technology for Ocean Scientists

Seaglider, developed in the mid-1990s by the Laboratory and UW School of Oceanography, was originally conceived as a 'virtual mooring'. Seaglider pioneered a family of autonomous undersea vehicles that use changes in buoyancy for thrust to dive and ascend at shallow glide angles. A flexible sensor payload measures ocean properties; data are transmitted using global satellite telemetry. It is capable of missions lasting weeks to months covering thousands of miles. Over the decades, use of Seagliders has expanded from a small number of specialized research groups to a broader cross-section of ocean scientists. To better serve this community, an APL-UW team of oceanographers and engineers decided in 2023 to step in with direct support. They established the Seaglider Service Center to provide technical advice, maintenance, software updates, and new vehicle fabrication.

APL-UW oceanographers staffing the center have a storied history with the vehicle. "Last summer we recovered two gliders after a year in the Arctic," recounts **Senior Principal Oceanographer Jason Gobat**. This is the first time two Seagliders surveyed in the Arctic Ocean for an entire year and were recovered amid the ice floes. "We waited for them to surface in just the right open water lead and then picked them up from the USCGC *Healy*." Back in 2008, the first quantitative sampling of biophysical interactions in the ocean by autonomous platforms was performed by Seagliders and Lagrangian floats. During the North Atlantic Bloom Experiment, they observed the totality of the spring bloom — initiation, evolution, death, and export. The team agrees that the greatest achievement by Seagliders was the mission to fly under an Antarctic ice shelf. "It felt like going to the moon," says Gobat. "Nobody has ever been under there before and we did it."

Seaglider had been licensed to several commercial entities in succession over nearly two decades. But each glider is bespoke and built by hand. A small vehicle that sells in the tens of units does not make a lot of sense for companies that operate at much greater scale. When the last company decided to let go of the license, it made sense to the APL-UW team to sustain Seaglider capabilities for research groups outside the Laboratory. "The Lab is the technical home for Seaglider. Many groups have acquired a lot of skill operating them, but we are the platform developers, and the only group that fabricates vehicles and offers a full range of services," says **Senior Principal Oceanographer Craig Lee.**

The center's goal is to support the existing user base that has a strong history with the platform, and to outfit new users with vehicles if it is a good fit for their needs. For example, since 2014 the NOAA Atlantic hurricane program has put out a fleet of gliders for the duration of the hurricane season. Seagliders have sampled the upper ocean preceding, under, and in the wake of about two dozen tropical cyclones. NOAA scientists use the data to understand and predict the ocean's role in hurricane intensity.

The current model – the Seaglider Global Explorer, or SGX – has 60% more battery capacity and more flexible payload options compared to earlier generations of the vehicle. All gliders are now outfitted to perform under-ice missions using acoustic navigation technologies, and the center supports web-based piloting and data visualization applications. They also integrate new sensors when it makes sense for the vehicle's technical capabilities. For example, new pH and nitrate sensors are being added to the vehicle for a research group at Oregon State University.

"It's been really gratifying to have established the center," explains Gobat, "because we've invested a lot of energy into the platform's development and we get to see it out in the community, how people are using it to do science."

APL-UW Team: Kyla Drushka, Jason Gobat, Mike Johnson, Ben Jokinen, Craig Lee, Geoff Shilling









In spring 2025 a research team riding snow machines hauled scientific instruments out on to the sea ice locked to the coastline of Utqiagvik, Alaska, to establish a new observing system. Their goal: work with the local community to better forecast sea ice breakout events.

Seasonal landfast ice is a unique aspect of daily life in the Arctic. It protects the coastline from erosion, provides ecological habitat, and is used as a stable platform for travel and hunting by coastal communities. Utqiagvik residents have deep expertise observing and understanding the ice during freeze-up, how it evolves over the winter season, and when the ice will start to move before breakout. As the melt season commences, everybody is concerned about breakout events because of the significant hazards of injury and strandings.

In a warming Arctic, the landfast ice season in Utqiagvik is trending shorter by over two weeks per decade. Embedded in this long-term trend, however, is a large year-to-year variation in breakup date — from early May to mid-July. Current sea ice forecasts are based on statistical models and satellite observations that predict sea ice extent and thickness across Arctic Ocean basins. “Most of the operational sea ice forecasts do not include landfast ice as a distinct ice type,” explains **Senior Principal Oceanographer Jim Thomson**. “But it requires special treatment because of the way it’s locked to the coast.”

SEA ICE FORECASTS

Predictions Powered by Continuous, Distributed Observations

The observatory established at Utqiagvik, designed and deployed by APL-UW and partners from the University of Alaska Fairbanks and the Pacific Northwest National Laboratory, seeks to measure the combination of environmental variables that destabilize landfast ice and precondition breakup. The effort is driven by several questions: Can we better predict coastal ice conditions by getting data straight from the ocean? How can we get these data immediately and continuously? What observations and forecasts matter most to the community?

Radar is a good tool to track landfast ice motion, and the University of Alaska Fairbanks has operated a station atop a community bank building in Utqiagvik for over 10 years. It can also serve as an early warning system for breakout events. Features on the ice’s roughened surface scatter the radar’s outgoing signal. Rapid and localized changes in backscatter response – a flickering in the radar images – is caused by small movements of the landfast ice.

The research team designed the observatory with scientific instruments on the ice, in the ocean, and on the seafloor to augment the land-based radar, with the goal of turning a breakout alert system into a forecasting one. With continuous data from these instruments reported in real time, “We will see the ice ‘twitching’ along the coast. We will also see the arrival of warm water that can cause melting under the ice, the accumulation of solar radiation causing surface melt, and the winds, waves, and currents that push and deform the ice,” explains Thomson. “We have an underlying understanding of the processes and combination of factors that cause breakout events, and when we account for each quantitatively, we can say there is a high likelihood the ice will move.”

Three moorings, with instruments extending through the water column, are foundational to the observatory. They were deployed in the spring through the ice, recovered during the open-water period during summer, and replaced with a set to overwinter. With temperature and pressure measurements, plus acoustic Doppler current profilers, they track ocean heat content and its propagation onshore from the deep basin. To retrieve mooring data

Arctic PISCES

Pacific Infrastructure Supporting Continuous Engineering and Science

The collaborative effort at Utqiagvik is an Arctic implementation of the APL-UW PISCES initiative. This project and those centered in the Pacific Northwest are organized to achieve several major goals:

- Conceive, construct, and operate continuously distributed, autonomous ocean sampling infrastructure in the coastal oceans
- Improve the availability of real time ocean information and the prediction of future ocean conditions
- Transition new knowledge and innovative engineering from the laboratory to operations

immediately and continuously **Senior Principal Oceanographers Craig Lee** and **Jason Gobat**, with their expertise in under-ice observations by autonomous platforms, outfitted the moorings with acoustic telemetry. Here, a receiver sits on the ice while an acoustic modem transmits from the mooring on the seafloor. Gobat and Lee also prototyped and fielded a lower cost system using a thin wire to get data from the seafloor to the sea ice node.

Miniature, surface floating instruments – microSWIFTs – developed in Thomson's lab, have been used to study coastal wave dynamics under hurricanes and in the Arctic's seasonal ice zone. Here, they are planted out across the ice, up and down the coast in spring. Their drift with the ice is tracked by GPS. Thomson notes that the buoys were conceived as a flexible, modular platform that could be deployed in tropical, temperate, and frozen oceans. **Senior Principal Physicist Bonnie Light**, who studies sea ice optics, worked with Thomson to integrate an inexpensive sensor with the microSWIFT to measure incoming solar radiation. "Bonnie is the expert on interpreting the data," says Thomson, "and knowing what's required to make a scientifically valuable measurement while also lowering the cost of the sensing platform." At the Utqiagvik test site, the small buoys now measure 10 channels of light. Arrayed across the landfast ice they provide a valuable accounting of how sunlight and surface melt precondition breakup.

During the seasonal transition, microSWIFTs melt out of the ice and become free-drifting ocean buoys, providing up-to-date wave information to the science team and local community via integration with another APL-UW innovation: the Backyard Buoys web application. This National Science Foundation Convergence Accelerator project, with APL-UW scientists in lead roles, leverages low-cost, scalable wave buoys and a mobile app to put ocean data immediately into the hands of coastal community members throughout Alaska, the Pacific Northwest, and Pacific islands. At Utqiagvik, the microSWIFTs are a force multiplier for the buoys residents have put out over the past several open-water seasons.

The observatory's assets recorded clear signals during the 2025 transition season. Upwelled water arrived underneath the ice and there were multiple occasions of offshore pack ice colliding with the landfast ice, providing significant mechanical forcing. As analyses continue the team is implementing new, more sensitive accelerometers on the microSWIFTs for the 2026 field campaign to detect very small motions in the landfast ice.

Team members are developing a high-resolution numerical model to represent ocean and sea ice conditions near Utqiagvik. Such a model could be embedded into weather service products, because the community is already accustomed to using them. The national rip current forecast serves as an example. NOAA's forecast model predicts the hourly probability of dangerous rip currents along beaches throughout the U.S. up to six days out. A similar outlook for sea ice could benefit operations of the North Slope Burrough search and rescue squad, a community advisor to the project, who must weigh the safety of putting snow machines or helicopters out on the ice when responding to a call for help.

APL-UW Team: Alex de Klerk, Laura Crews (APL-UW and UAF), Jason Gobat, Amy Larsen, Craig Lee, Bonnie Light, Axel Schweiger, Joe Talbert, Jim Thomson

Sponsor: Office of Naval Research











ACOUSTICS, BIOLOGY, CLOUD COMPUTING

New Technologies for Fisheries Assessments

Working alongside their NOAA collaborators aboard R/V *Shimada*, APL-UW investigators are testing artificial intelligence methods and a ship-to-cloud data processing pipeline against traditional methods to identify Pacific hake aggregations in acoustic data. The technologies they have developed to automate fishery stock assessments during routine surveys seek to increase the speed and consistency of data analysis and interpretation.

Principal Oceanographer Wu-Jung Lee and graduate student Caesar Tuguinay joined a 10-day leg of the Integrated West Coast Pelagics Survey when *Shimada*, a vessel capable of acoustic trawl surveys and oceanographic research, was conducting operations off the coast of Northern California. Beginning at the southern border with Mexico, the three-month survey is conducted along transit lines extending 20–35 miles out from the coast that repeat at 10–30-mile intervals all the way north to Dixon Entrance, British Columbia. Until 2025, there had been two separate West Coast surveys that used different equipment and methods; the integrated survey of 2025 ensures consistency in data collection.

Echosounders mounted on the vessel emit sound pulses into the water column below and measure the intensity and timing of returning echoes that bounce off objects including fish, plankton, and the seafloor. An echogram is a color-coded map of echo intensity. NOAA scientists aboard R/V *Shimada* are experts in the art of echogram analysis — labeling where along the survey line they see the distinctive acoustic signature of Pacific hake schools. Hake is the most abundant commercial fish stock on the Pacific coast, excluding Alaska, but the fish are difficult to distinguish in echograms because they can school at significant depth amid other fish species and they range over a large region with complex bathymetry. Though expert, scientists' manual interpretation of echogram data is time consuming, dependent on subjective labeling, and prone to human bias and unreproducible errors.

Machine learning algorithms (convolutional neural networks) are very good at finding complex features. In this case, Lee trained a neural network on datasets of echograms annotated by NOAA scientists that stretch back to 2005, teaching the model to recognize and classify the acoustic signatures of Pacific hake. "Our current model uses the acoustic frequency and backscatter intensity only," says Lee. "Human experts take bathymetry, ship direction, water temperature, and other environmental variables into account. That said, the model does distinguish patterns of 'fish' and 'not fish' very well." For example, the strong echoes from the seafloor that can contaminate the backscatter

measurement from biology are excluded correctly by the model. The model also predicts hake school regions within continuous, unfragmented boundaries, which is how human analysts work, by circling a region of backscatter consisting of hake.

To maximize the efficiencies that AI can provide and achieve an echogram-to-biomass estimate in near-real time, the APL-UW team developed a modular, ship-to-cloud data processing pipeline. First, the echosounder raw files are consolidated and calibrated. Then the machine learning prediction computations are performed to identify regions of hake in the echograms. From here, data are transformed into a Nautical Area Scattering Coefficient (NASC), which is an acoustic proxy for fish number density. NASC is combined with net trawl catch data – length, sex, and weight of fish – to estimate abundance and biomass in the cloud. Data products are then available on cloud-hosted visualization dashboards that scientists onshore can access for web-based exploration and interpretation. All of this processing is completed on a suite of open-source software packages available to the community.

During the 10-day research leg of the survey, Lee and Tuguinay were embedded in survey operations, attending to the incoming echo data for signs of hake, gaining a better understanding of NOAA's operational priorities, and watching the outputs of their models. With their workflow running as expected, they were careful not to share data visualizations with NOAA colleagues. "We all agreed that it is best to not bias their analysis," says Lee. "It's interesting that the aggregations that create debate among human analysts are the same for which the model will return inconsistent results. Unlike humans, however, the model is inconsistent in the same way every time, so we may be able to correct the bias."

To address the problem of disambiguating mixed species assemblages, the APL-UW team used opportunities between net trawls and ship-based CTD operations to deploy a profiling echosounder. The Kongsberg wideband autonomous transceiver was lowered from the ship deep into the water column. These new acoustic data, which are higher resolution than those from the ship's echosounder because of proximity, will be used to further train the models to recognize the differences among hake and other species in mixed assemblages.

Back at the Laboratory, Lee and Tuguinay are at work on methods to compare expert scientist annotations and model predictions at sea as the survey progresses. "Taking in their real-time annotations will coach the model progressively throughout the survey," says Lee. This could be a significant improvement in model performance because of observed year-to-year differences in the acoustic data.



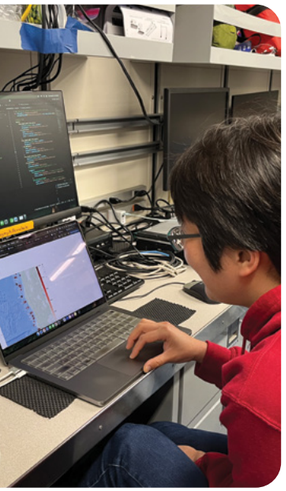
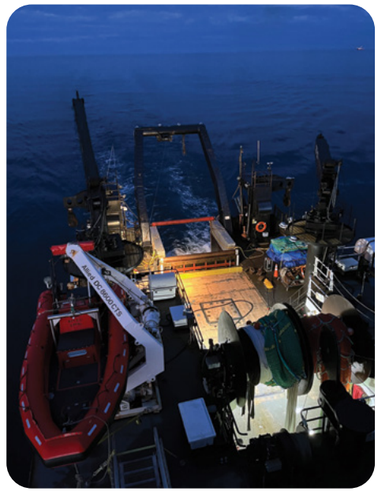
NEXT GENERATION

A Mathematician Immersed in Acoustics Research

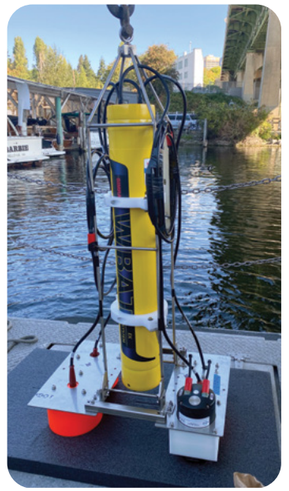
Only two years ago **Caesar Tuguinay** knew very little about the fields of ocean acoustics or fisheries science, but a student opportunity posed by **Principal Oceanographer Wu-Jung Lee** caught his attention. "I had just finished my undergraduate degree and was looking for an experience that mixed coding and research," says Tuguinay. Now a first-year Ph.D. student in electrical engineering at UW, he has gained expertise through his involvement with the Integrated West Coast Pelagics Survey project and is now writing a paper providing guidance on organizing and processing fisheries acoustic data.

Since joining the project Caesar has tackled tasks essential to streamlining acoustic data analysis, from raw data consolidation and cloud-optimized standardization to writing base code for the Pacific hake recognition model. He recounts that to make the code generalizable across many years of survey data, he and Lee read many physical logbooks and conducted interviews with the NOAA experts who had collected the data. "The coolest part of this experience," says Tuguinay, " has been to see others in the fisheries acoustics community use the code that I helped to develop."

Joining the research leg of the survey on *Shimada* last September, Caesar gained a new perspective and appreciation for maritime research by experiencing all the shipboard operations he had read about. While at sea he and Lee also observed intriguing backscattering phenomena in the acoustic data; he is looking forward to developing methods to interrogate the scattering source and its role in the ecosystem.






APL-UW ANNUAL REPORT 2025

SEAFLOOR HAZARD MITIGATION

Detect, Classify, and Geolocate with Acoustic Technologies

The science and engineering team that designed and built the Multi-Sensor Towbody (MuST) platform are now demonstrating its capabilities in performance tests for the Naval Facilities Engineering Systems Command and the Army Corps of Engineers. During 10 days of surveying near the Florida Keys this past spring, MuST, now designated Technology Readiness Level 7, searched for hazardous objects buried in seafloor sediments. Towed by R/V *Pelican* in a lawnmower pattern, MuST flew at controlled altitudes above the bottom to search for mine-like objects that may have been left behind on a mid-20th century training field and subsequently buried over the decades.

To detect, classify, and geolocate buried and proud mine-like objects at performance levels and area coverage rates superior to other modalities, the APL-UW team conceived the MuST system as a combination of underwater acoustic sensing technologies and shipboard handling and data processing systems. A specialized, three-dimensional, sub-bottom profiler manufactured by EdgeTech and two high-frequency sonar systems were integrated by the APL-UW engineering team with the FOCUS-3 towbody produced by MacArtney Underwater Technology. Together, the sonars image the top 1–2 m of the sediment with a resolution of 10 cm^3 and the sediment–water interface at sub-centimeter precision. A fiber optic, two-way communication cable connects the towbody to the data acquisition and vehicle control systems. This division of components minimizes the number and complexity of in-water, at-risk technologies and provides operators aboard with a real-time image map of the sediment volume during survey operations.

MuST was shipped from APL-UW to Cocodrie, LA, and loaded on R/V *Pelican* before its two-day transit to the survey site. “This was the first time MuST was operated with a non-APL-UW vessel and crew,” says Senior Principal Scientist Kevin Williams, “and the first in a ‘live’ operational environment with significant ocean waves and currents.” The survey covered 9 km^2 of nearshore waters about 30 m deep. The site had been a mine sweeping training field and unfortunately there are no records of mine-like objects having been recovered. “This was truly a ‘live’ site in that nobody knows what’s on the bottom or buried in the sediment,” adds Williams. The survey identified six buried, man-made objects including an anchor, shrimp trawling hardware, and cables. No mines were found.

Prior research experiments with MuST had been confined to 100 m^2 test beds in quiescent lakes and bays in Washington that were seeded with inert ordnance targets and other objects to act as clutter. In these, MuST achieved a high rate of correct classifications for object detections, few false alarms, and a geolocation accuracy of 1.5 m.

Next up for MuST is another site survey off the island of Vieques, Puerto Rico in May 2026. This Superfund site was used for naval training for decades. Remediation of the area around Vieques is a precursor to opening the region to recreational activities. And in the longer term, the team's goal is to build more copies of MuST and train commercial surveyors to use them.

Integrating acoustic sensing and signal processing capabilities to perform seafloor hazard mitigation is the culmination of many years of fundamental acoustics research and engineering innovations. Williams recounts experiments in test tanks and open ocean environments, where systems were designed and deployed to study acoustic penetration into and backscattering from sediments, and acoustic scattering from targets. Subsequent modeling studies using these data characterized the acoustic fingerprints of various targets. Through iteration, APL-UW investigators built an understanding of the physics of target acoustics, both proud and buried in seafloor sediments, and ultimately how to make classification decisions in an area with a great deal of acoustic clutter. “We know from our target physics research what we are looking for,” says Williams.

Performance tests are demonstrating that MuST is both proficient and efficient as a hazard remediation platform, producing three-dimensional images of objects in seafloor sediments and determining their shape, size, and properties. “MuST exemplifies what APL-UW does exceedingly well,” concludes Williams. “We seek to understand the fundamentals of a problem, conceive a solution and propose it to our sponsors, then execute the science and engineering needed to solve it.”



Sponsors: Strategic Environmental Research and Development Program
Environmental Security Technology Certification Program

APL-UW Team: Paul Aguilar, Eric Boget, Ben Brand, Mike Kenney, Nick Michel-Hart, Jennie Mowat, Tim Marston, Kevin Williams



ULTRASONIC THERAPIES TREAT KIDNEY STONES

University Research Will Improve Lives

Major milestones were achieved in the past year by an investigative team at the Center for Industrial and Medical Ultrasound and their multi-institutional collaborators who developed ultrasonic therapies to treat kidney stones. Results of several successful clinical trials have been published and the spin-out company commercializing the University inventions has received medical device clearance from the Food and Drug Administration. “These recently published studies are the culmination of our work to invent ultrasonic therapies for kidney stones," says Senior Principal Engineer Mike Bailey. "Stones can be treated when first discovered and patients are not sent home to wait in pain and anxiety over whether they'll have more pain or surgery," adds Bailey.

The team's office-based system to visualize and treat kidney stones in awake patients uses transcutaneous, focused ultrasound waves from a handheld probe to break (burst wave lithotripsy) and push (ultrasonic propulsion) stone fragments within the kidney toward the renal pelvis and ureter to facilitate their natural passage through the urine. “The two technologies we’ve been working on are different than anything that exists currently,” notes University of Washington Professor of Urology Matthew Sorensen. “This changes how patients are treated. We focus on treating any stone rather than trying to avoid surgery at the risk of painful stone passage.”

Recent clinical trial results are conclusive. In one study subjects were recruited to receive treatment with ultrasonic propulsion (UP) to reposition residual stone fragments from a previous surgery. Fragment passage rate was 58% greater in the treatment group, they had a 70% lower incidence of relapse, and their time to relapse was longer by nearly 1.5 years than patients who did not receive UP. These results were duplicated in another trial conducted by an independent group of UW investigators who were novice users of the ultrasonic system. They achieved a 66% greater rate of residual fragment clearance in the UP treatment group vs. controls, and in one year of follow-up, 0 of 12 in the treatment group returned to the emergency department or operating room for their stones versus 6 of 12 in the control group. And in the first human feasibility study of burst wave lithotripsy followed by ultrasonic propulsion in a clinical setting, the investigators achieved a clearance rate of 70% for small, asymptomatic stones. In all trials, the awake participants, now totaling over 200, tolerated the procedure without anesthesia or serious adverse events.

SonoMotion, the medical device company spun off from the University of Washington inventions, has developed a single platform that can fragment stones with Break Wave and reposition stones with Stone Clear. The company received FDA 510 (k) *de novo* clearance for Stone Clear in late 2024 and a multicenter pivotal trial conducted in the U.S. and Canada has been completed to support clearance of Break Wave.

The idea to pursue research into ultrasonic therapies for renal stone disease was conceived by Laboratory and University investigators contributing to a multi-institutional consortium funded by the National Institutes of Health to study shock wave lithotripsy (SWL). The most common treatment for kidney stones worldwide, the broad research program was covering the fundamental physics of SWL stone breaking, efficacy, and safety. Bailey recounts, “There was a moment when the APL-UW team members shared with each other that we could have a greater impact if we were to show the community how to do it better.”

Around that time, NASA, looking to retire the risk of kidney stones on long-duration space missions, began funding the Laboratory and University team to develop a small device that could be used to treat a stone emergency. The noninvasive, handheld ultrasound system was conceived. Sorensen admits, “It wasn’t clear whether there would be a treatment window where you could treat stones effectively and not injure tissue.” Over the past 15 years and with sustained support from several sponsor agencies, the University-based research has progressed through theoretical and laboratory studies, work in animal models, human feasibility studies, and randomized human clinical trials with results submitted to FDA. The team continues to improve the technology.

As the SonoMotion device appears poised to come online in clinics, Bailey describes the impact of their research and development journey. “This technology isn’t just another tool that might work better. We are proving that it can access a different set of patients.” Sorensen adds that the ultrasonic system will dramatically change the way urologists approach stone treatment, resetting the bar of whether to treat or not. “Instead of deciding whether it’s worth taking someone to surgery, we can treat asymptomatic, but potentially troublesome, stones right in the clinic.”

SONICBOND

Future Manufacturing with Focused Ultrasound

Investigators at the Laboratory's Center for Industrial and Medical Ultrasound (CIMU) have disrupted medical treatments by harnessing the power of acoustic energy delivered inside the human body. Now, a multi-disciplinary team centered at CIMU is poised to develop a manufacturing technique based on well-known high-intensity focused ultrasound (HIFU) technology that could change the way entire industries assemble the ubiquitous devices of modern life: tablets and smartphones, wearables and toys.

Many of these devices are complex assemblies of mixed materials, electronics, and batteries bonded with thermal epoxies. These adhesives are cured by heat to create strong, durable bonds between materials. The team's alternative to the traditional oven-curing process that predates our era of smart electronic devices is called SonicBond. They are developing and testing the technologies to deliver acoustic energy to generate heat in a precise target zone, sparing heat-sensitive components such as lithium-ion batteries from exposure. HIFU has a unique combination of speed, precision, and adaptability, offering manufacturers an innovative tool that aligns with modern production demands.

CIMU Director Thomas Matula leads the team that includes Mechanical Engineer Cody Birkland, recent MBA graduate from the UW Foster School of Business Amy Swanson, and Mike Pinch, a Seattle-based mechanical product design engineer. SonicBond research efforts were motivated initially by Pinch's presentation to Matula of a real-world technology manufacturing problem. He was involved in developing a new touchscreen stylus for an e-notebook: it was assembled with epoxy and cured in an oven. To avoid damaging the lithium-ion battery, magnets, and other components, the oven temperature was lowered and exposure time lengthened. "The stylus couldn't be heated at the epoxy's optimum curing profile," explains Pinch. The process was time-consuming, increased the product failure rate, and resulted in low manufacture yields.

CIMU scientists and engineers are pioneers in creating the technologies and methods to direct high-frequency sound waves through the human body, where they converge into a small region of tissue at the focal zone. They have developed therapies to treat cancer tumors, where HIFU is scanned over the three-dimensional tumor volume to kill all the cancer cells, even in the brain, where

ultrasound must travel through bone before focusing to a small treatment volume. "CIMU has shown high-precision targeting of HIFU within the human body, so, by comparison, a smartphone seems easier," notes Swanson.

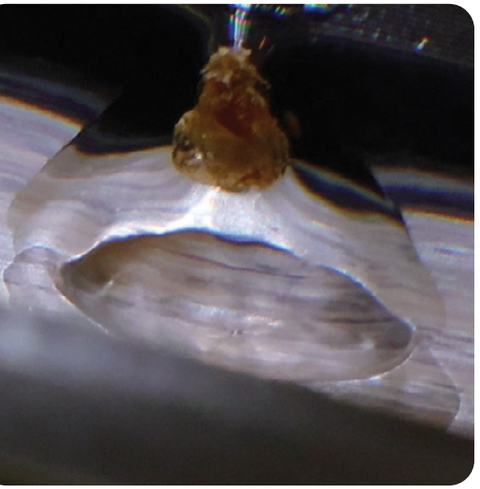
The team received kick-starter funding from CoMotion, the University of Washington's innovation hub that supports the journey from researchers' ideas to commercialization and societal impact. They have also won UW Royalty Research Fund and Washington Research Foundation grants, and with this support, performed simulations and built a HIFU apparatus for lab bench tests.

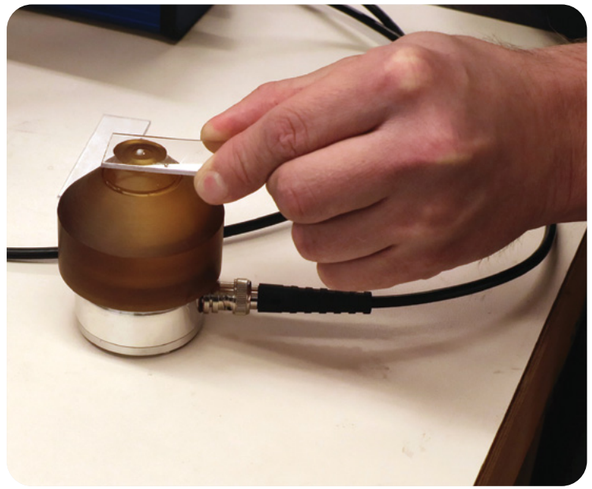
Early experiments with thermal camera imaging show that ultrasound energy deposition is both controlled and precise, that appropriate epoxy curing temperatures of 100°C are generated only 2 to 3 mm distant from safe, lower temperatures. They have also shown that the HIFU heating process is self-limiting and that a steady-state curing temperature can be maintained for over 10 minutes. Further studies demonstrate that a greater mass of epoxy can be cured over the same amount of time by increasing the ultrasound power. Matula points to an early achievement: HIFU bonded polycarbonate and composites have shear strengths similar to those same materials bonded by traditional oven curing.

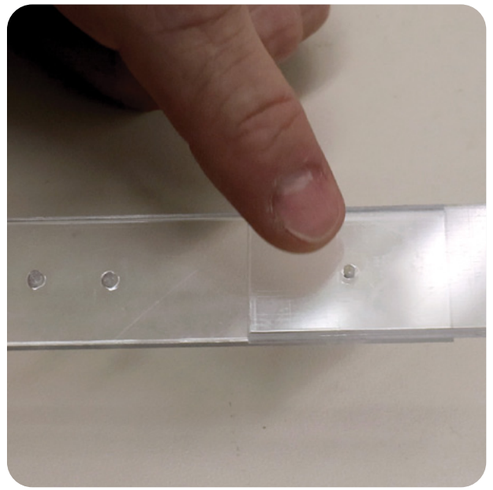
Birkland's engineering is essential to driving the project further. He has designed a pulse-echo apparatus to measure acoustic attenuation of the HIFU beam through various coupling materials, including plastics, glass, and metals, as well as to measure the acoustic scattering across boundaries between materials. The team's HIFU apparatus has been integrated into a computer-controlled motor system designed to (re)position the transducers over complex assemblies. And they have shown that HIFU parameters – frequency, duty cycle, and pulse length – can be tuned to optimize energy delivery to different materials. Matula is enthusiastic about SonicBond's potential impact and the interesting science beyond ultrasound physics to be performed on the journey to reach it. "There are so many basic questions, including materials science and fast reaction rate chemistry. How does ultrasound, for example, interact with materials that change phase with heat?"

CoMotion also assisted the team with the filing of a patent application: *Bonding of Structures Using High-Intensity Focused Ultrasound*. The intellectual property underlying SonicBond provides broad coverage for the processes and methods of bonding structures using HIFU. "The patent attorney performing the work was surprised there were no blocking patents for such a broad use case of the technology," remarks Swanson.

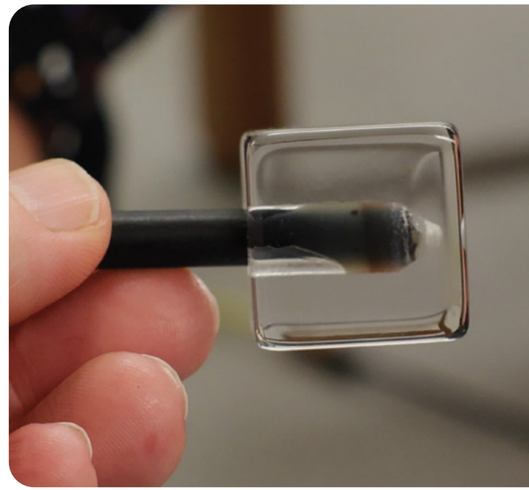
To bridge the gap between university research and industrial application, the team plans to build and test a programmable HIFU lab prototype as a demonstrator to potential sponsors and commercial partners. This follows the successful development strategy Matula and his co-inventors used for PIXUL – pixelated ultrasound – a device that processes cells in microplates for genomic and epigenetic studies. While the SonicBond idea makes sense upon initial presentation, the prototype will be critical to give hands-on demonstrations of HIFU's ability to target bond areas, minimize thermal damage, and be effective across a range of adhesives and materials. Swanson says that those most interested in the technology are engineers like Pinch, who are looking for an alternative to oven curing for complex stack-ups that contain batteries and magnets. "The product design engineers are excited that HIFU can go through curved surfaces and opaque materials with targeted spatial control."













INNOVATION IMPERATIVE

Nontraditional Teams Enhance Laboratory's Agility, Capability

IIR&D

Interdepartmental Independent Research & Development

A competitive APL-UW program seeks and supports new ideas proposed by multidisciplinary workgroups. The criteria: teams much be comprised of nontraditional collaborators within the Laboratory. The proposed effort must also lead to innovations that can win funding from government or industry research sponsors and/or advance capabilities that enable future APL-UW research and development programs.

ONE INTERNAL PROJECT SUPPORTED IN 2025 TACKLES THE FUNDAMENTAL SCIENCE AND ENGINEERING EFFORTS THAT WILL BE NEEDED FOR A MISSION ACROSS THE SOLAR SYSTEM to detect signs of life on an icy moon of Saturn. The team's goal: develop technology to determine changes to biosignatures of life after rapid ejection into a subzero vacuum environment analogous to geyser ejections through the icy crust of Enceladus.

Any microbial life or the biosignatures left behind that could be detected by a vehicle sampling the geyser plumes of Enceladus would have been exposed to the stresses of aerosolization, surface temperatures of –200°C, near-vacuum conditions, and irradiation. Polar biologists **Karen Junge** and **Erin Firth**, who are experts working with psychrophilic microorganisms in cryogenic conditions, are joined by engineers **Anuscheh Nawaz** and **Kaizer Contreras**, who have skills working with vacuum chambers and the ingenuity to create complex test designs on a tight budget using off-the-shelf parts.

Previous ejection simulation experiments at other institutions have been limited to imaging biosignatures under the stressful conditions that are harmful to bacteria.

They have not been conducted, however, at cryogenic temperatures, which Junge and Firth know can help preserve psychrophilic microorganisms.

Early engineering designs for the geyser simulator relied on the forced ejection of prepared microorganism solutions through a nozzle into the cryogenic vacuum, but it was prone to clogging. The team pivoted to pursue a new aerosol generation method: bubble bursting.

With limited funds and time, the team has designed, built, and tested a thermal vacuum chamber that incorporates aerosol injection, cryogenic temperatures, and microorganism sample collection. With the data and geyser simulator proof of concept, they are well-positioned to compose a highly competitive proposal to agency sponsors to continue the line of inquiry and prepare to search for signs of life on distant icy worlds.

Another collaborative project showcases the development of electronic systems and signal processing techniques to increase the precision, efficiency, and safety of therapeutic ultrasound. Therapies utilize focused ultrasound to fragment and (re)position kidney stones and destroy tumor tissue. Multi-element array transducers, consisting of several small transducer elements bundled together, are becoming the standard in therapeutic ultrasound due to their ability to steer the ultrasound beam to target treatment locations.

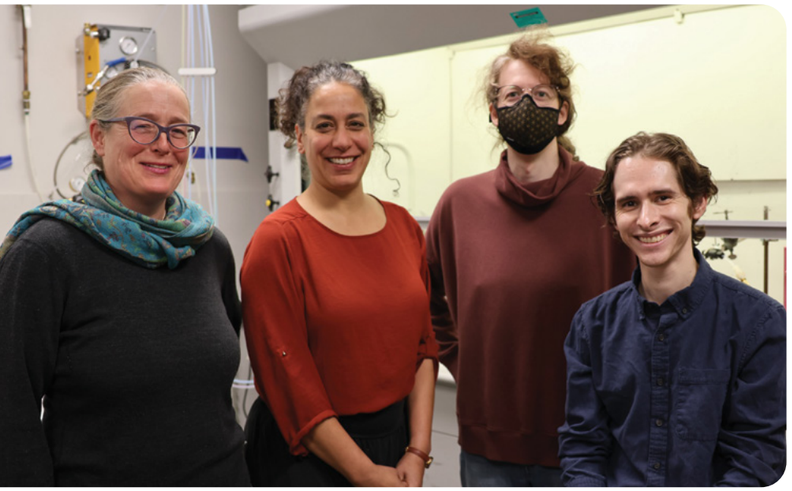
To achieve treatment, the ultrasound ray must pass through heterogenous layers of tissues of differing thickness and sound speed. "Because each element of the therapy transducer experiences a different acoustic path, the focal gain is reduced and the beam shape is distorted at the target location," explains Senior Research Scientist Mohamed Ghanem. This distortion requires an aberration correction scheme.

Ghanem and colleagues at the Center for Industrial and Medical Ultrasound (CIMU) developed an *in vivo* aberration correction method, but needed a way to speed it up dramatically to make it clinically viable. Their correction algorithm, run on a computer set up in parallel with the treatment system, cross-correlates each element's pulse-echo signal with the signals of its closest neighboring elements, then calculates the interelement delays. Once all delays are found, they are implemented for the next pulse-echo signal sequence and the process is repeated until convergence is achieved.

The respiratory motion of people undergoing ultrasound therapy provides a two-second window during which the abdominal organs are stable enough to run the aberration correction algorithm. Data transfer delays between the therapy system and computer, however, stretched correction processing times well beyond this window. Senior Research Engineer John Mower in the Environmental and Information Systems Department brings expertise designing high-power acoustic drivers and extremely low-latency digital signal processing techniques to the problem.

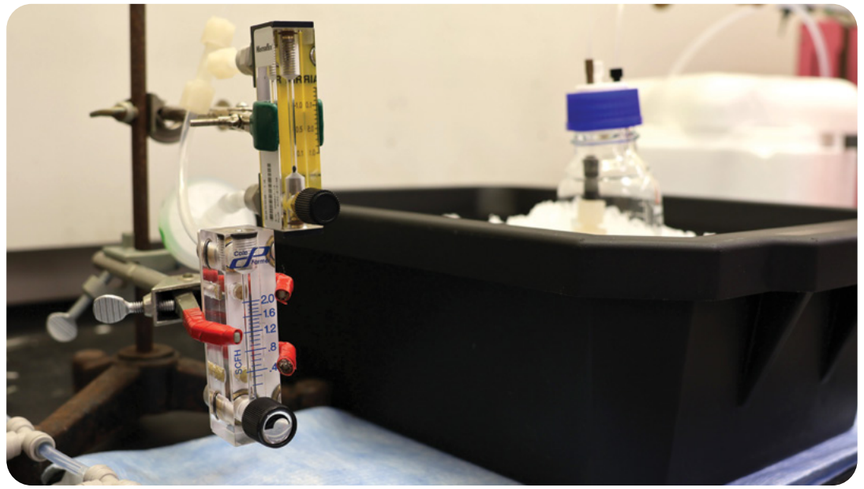
Mower has proposed using a field programmable gate array (FPGA) integrated with the therapy system itself to acquire the acoustic signals and complete correction processing within a few hundredths of a second. "Because the algorithm only requires time domain cross-correlation over a small window of time and then solving a least-mean-square optimization problem," explains Mower, "it can be executed quickly on the therapy system directly, rather than a separate, parallel computer."

Development continues to adapt the algorithm to the FPGA architecture, which is fundamentally different than a microprocessor. System tests will proceed *in silico* and then using tissue phantoms and *ex vivo* tissue samples that are readily available at CIMU. Application of this technology across CIMU's range of ultrasonic therapeutic research will provide further safety assurances for future human clinical trials.



"These internal projects sharpen our ability to work outside our comfort zones and to communicate with others outside our realm of expertise."

— Erin Firth











ONE ISLAND ONE OCEAN

Science, Education, and Community Engagement

The Laboratory celebrated the launch of the One Island One Ocean, 27,000-mile, 14-month expedition to circumnavigate North and South America. Since embarking in May 2025, the sailors and citizen scientists aboard are making scientific observations, educating students and the public, and raising awareness of ocean health and sustainability.

APL-UW scientists and engineers are partners on the journey, supporting the crew's science goals and outfitting the 48-foot sailboat to collect a novel dataset. Atop the mast of *One Ocean*, the APL-UW team mounted a weather station to gather wind speed, air temperature, and relative humidity, as well as an infrared radiometer. They also installed an ocean temperature sensor through the hull and data acquisition equipment in the cabin.

Senior Principal Oceanographer Andy Jessup is using these observations to estimate the ocean's 'cool skin effect' — the temperature of the ocean at the very surface that is usually a few tenths of a degree cooler than the temperature just a millimeter below. Measured by the combination of the radiometer and through-the-hull sensor, this seemingly small temperature difference between the ocean surface and the bulk temperature below is important when making estimates of heat and gas transfer.

The air-sea interface acts like a rigid surface, requiring a gradient to drive an exchange across it. The water temperature at the very surface has to be a little cooler than the water below for the heat to flow from the ocean to the atmosphere. Gases also transfer across the surface and are affected by the temperature difference.

The oceans absorb and store 30% of the global CO_2 from the atmosphere. Because cooler water can absorb more gas than warmer water, the precise measurement of temperature at the surface has a significant effect when integrated over the entire global ocean. "The latest studies of CO_2 flux that include the gradient of the cool skin report the ocean absorbing about 7% more CO_2," explains Jessup. Those estimates are based on data from the open ocean, so the One Island One Ocean expedition provides a great opportunity to study the cool skin effect in the coastal ocean from the Equator to high latitudes in the Western Hemisphere.

Jessup notes that the first seven months of data reveal near-surface ocean temperature gradients, as expected, due to solar heating, but because *One Ocean* is sailing near the coast, gradients are also driven by river outflow and meltwater from sea ice and glaciers, providing new information to compare with observations from the open ocean.

NEXT GENERATION

Young Scientists Gain Research Experience

Conducting oceanographic research aboard the University of Washington's R/V *Rachel Carson* was a highlight for the group of student interns hosted at the Laboratory last summer. During a two-month internship program, Amanda Labrado, STEM Development Program Coordinator, guided the cohort through a professional development seminar series, matched each with an APL-UW scientist mentor to tackle project-based research, and encouraged peer-to-peer learning and networking.

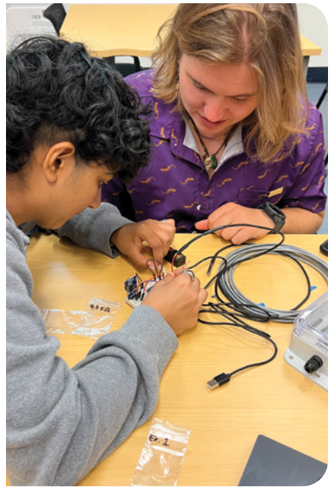
The Summer Undergraduate Research Program, now in its third year under Labrado's leadership, provides undergraduate students the opportunity to conduct research, participate in professional development, build community with young scientists, and learn how to navigate pathways to a career in maritime and oceanographic science, technology, engineering, or mathematics (STEM).

At the heart of each intern's experience is an independent research project under the guidance of an APL-UW research staff mentor recruited and trained into the program by Labrado. Rooted in mentors' areas of expertise, individual research projects in 2025 ranged from wireless power and data transfer by underwater robots to the effect of changing sea ice conditions on phytoplankton blooms in the Southern Ocean circling Antarctica. Each intern's project is designed to generate data and the opportunity for analysis. The program is capped with the interns presenting results in public poster fairs.

Peer learning is a key to program success. "We intentionally recruit students with different majors and experience levels. Most have had no prior opportunities to conduct research," says Labrado. "This naturally leads to layers of peer mentoring." Organized team learning activities include building a sensor in a maker-space lab, understanding and applying computer data processing and visualization tools, and deploying oceanographic technologies from a research vessel. "We're working with the CTD. It's great practice," says oceanography major Lydia Kelly aboard R/V *Carson*. "I love being on the ship and it helps me realize what I want to do in my career."

The program's classroom component is a seminar series designed and led by Labrado on topics that include a crash course in oceanography to increase proficiency for interns without prior classes in the subject, resume writing, well-being for STEM professionals, and poster creation and presentation. Guest lecturers from industry are invited to give in-depth talks about specific technologies and discuss their career journeys into the private sector.

The program is gaining in popularity and receiving national recognition. "Every year we have received double the number of applications from the prior year," says Labrado. "It's great to see the program's success, how our recognition has grown, and how students are really excited to participate."







GRADUATE DEGREES EARNED

Jacob Davis, Ph.D., Civil and Environmental Engineering
Measuring Waves in Difficult Places: New Approaches to Observing Waves in Hurricanes and Sea Ice
JIM THOMSON

Nicholas Guimond, M.S., Mechanical Engineering
Autonomous Capture of Submerged Plastic Bags
AARON MARBURG

Yingzhong Lou, Ph.D., Civil and Environmental Engineering
Dynamics of Small-Scale River Plumes in the Surf Zone: Idealized and Realistic Modeling
MORTEZA DERAKHTI

Miguel Mejia, M.S., Physics
Observed and Predicted Maximum Significant Wave Heights within Tropical Cyclones
JIM THOMSON

Emma Nuss, Ph.D., Civil and Environmental Engineering
An Investigation of Surf Zone Vorticity using Phase-Resolved Numerical Modeling and Eddy Tracking
MELISSA MOULTON

EJ Rainville, Ph.D., Civil and Environmental Engineering
Little Buoys, Big Ocean: Observations of Wave-Driven Transport of Buoyant Objects in the Nearshore and Marginal Ice Zone
MORTEZA DERAKHTI, MELISSA MOULTON, JIM THOMSON

Jennifer Stern, Ph.D., Aquatic and Fishery Sciences
Examining Hair Growth Rates and Dietary Patterns of Wild and Captive Bears
KRISTIN LAIDRE

STUDENT ACHIEVEMENT

Scholarship, Discovery, Innovation, Application

The Applied Physics Laboratory's parent institution, the University of Washington, is one of the world's preeminent universities, linking academic excellence to cutting-edge research. Our success in meeting the needs of our research sponsors with science-based knowledge and applied technologies is enhanced by our deep integration into the UW enterprise: research excellence, student opportunity and achievement, relentless innovation, and our promise of public service.

Contributing to the University's education mission, Laboratory scientists hold joint appointments in UW academic departments, principally the College of Engineering and the College of the Environment, where they teach, mentor, and advise students engaged in research. We recognize with pride every year the graduate students who earned degrees and the APL-UW scientists who served as their advisors.

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LEADERSHIP

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