

The Tahoe Environmental Research Center (TERC) is dedicated to interdisciplinary research and education to advance the knowledge of aquatic and terrestrial ecosystems and their interactions within natural and developed Earth systems, and to communicate science-informed solutions worldwide.

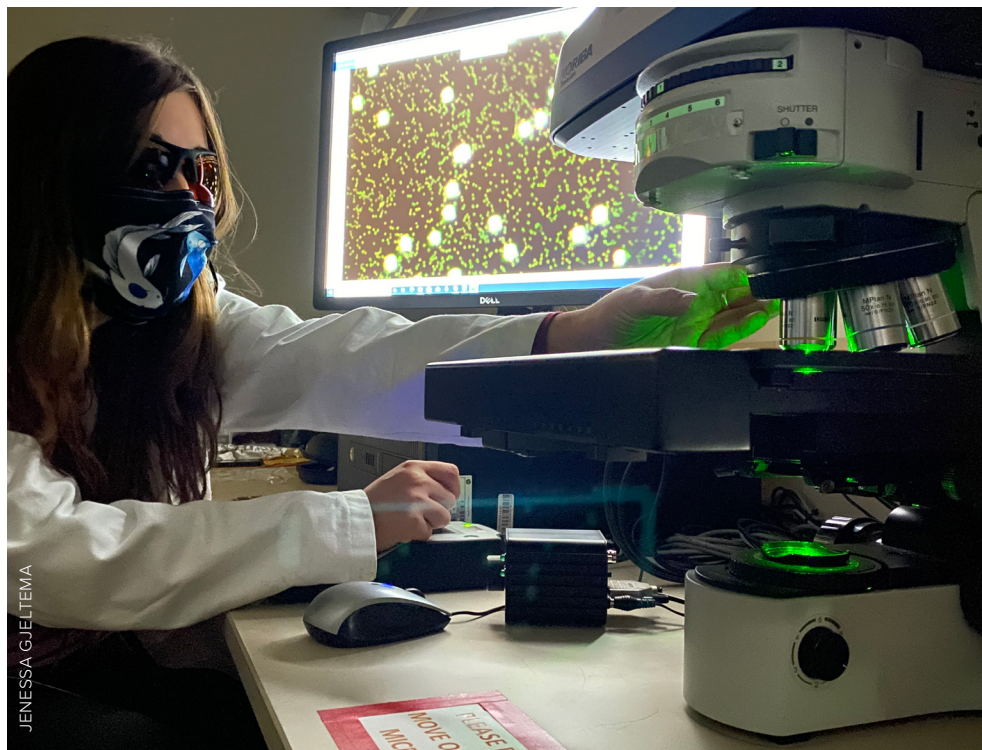
TERC educates the next generation of leaders and inspires environmental stewardship in thousands of students, community members, and visitors annually through its outreach centers.

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Research Associate Jackelyn Lang analyzes microplastic samples with Raman microspectroscopy in the Gjeltema lab.

RESEARCH UPDATES

MICROPLASTIC RESEARCH

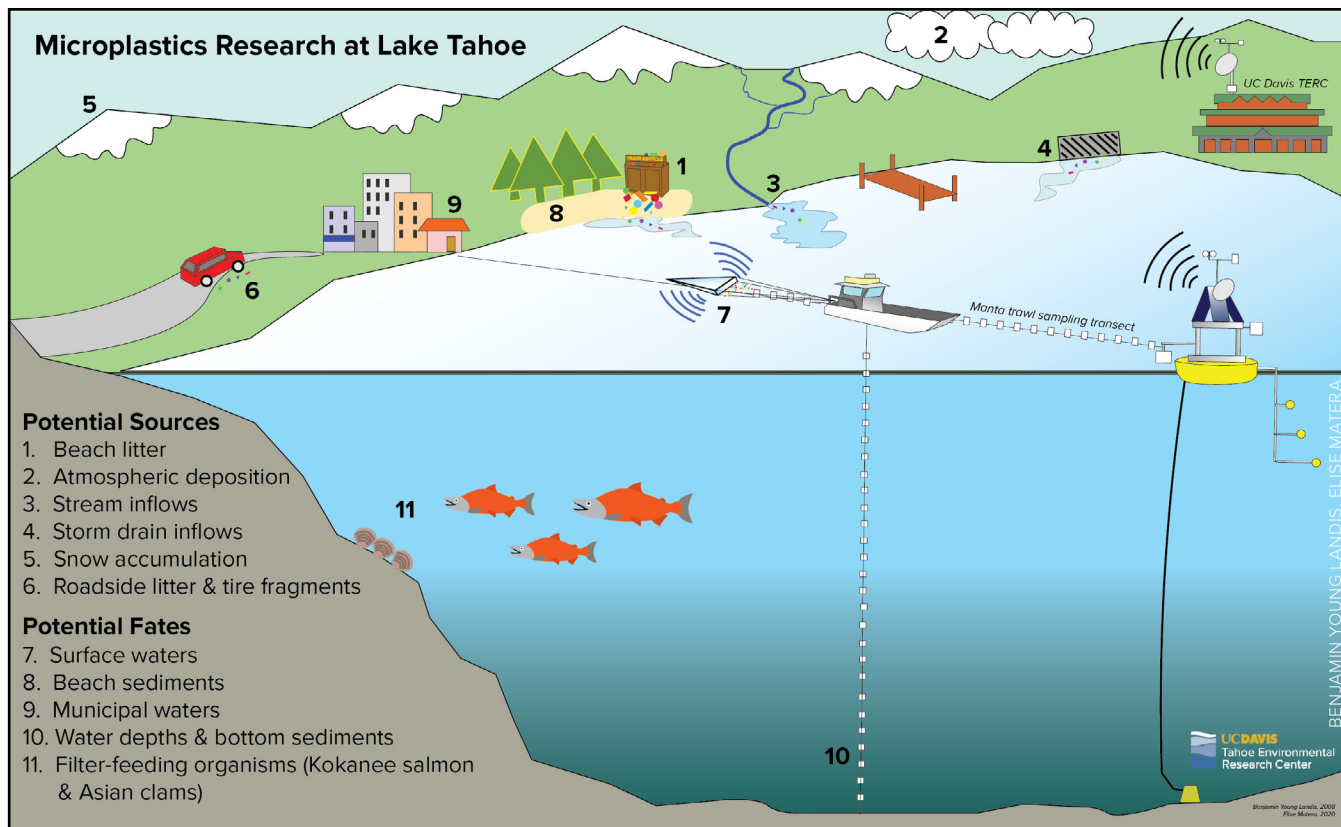
TERC scientists are sampling throughout the water column and the sediments of Lake Tahoe to investigate the fate of microplastics in the iconic lake. Microplastics are smaller than five millimeters, and pose a threat to aquatic ecosystems and potentially to human health.

The researchers will also sample municipal water treatment facilities to assess the

potential for human health impacts. The team is also looking into Kokanee salmon stomach contents and Asian clams tissue to determine the impacts of microplastics on the lake's biota.

The samples taken in the field are processed in the laboratory, first by TERC chemist Steven Sesma, to separate the plastics by size class then by UC Davis scientist Dr. Jenessa Gjeltema, who uses Raman microspectroscopy to determine the composition of the very smallest

RESEARCH UPDATES *(Continued from Page 1)*



DRI and TERC sampling sites around the lake. DRI is sampling items 3, 4, 5, and 8. TERC is responsible for sampling items 7, 9, 10, and 11.

microplastic particles.

Scientists from Desert Research Institute (DRI) are collaborating with TERC to study the threat microplastics pose to the entire Lake Tahoe Basin. DRI is studying the inputs—inflowing streams, accumulation on snow, storm drains, and even dryer vents, while TERC is researching the distribution and fate of microplastics once they have entered the lake. See the infographic above to see the different sampling methods used for these projects.

The collaboration of efforts will ultimately provide a more complete picture of the sources of microplastics and their impacts. This

is one of the first investigations of microplastics in lakes and it will also inform future pollution mitigation strategies.

See page 8 to learn how TERC is leading the way to create behavior change in the community to reduce plastic pollution.

Learn more at <https://tahoe.ucdavis.edu/microplastics>.



Katie Senft holds plastics found in the lake during sampling.

RESEARCH UPDATES



A harmful algal bloom in Clear Lake, CA, the site of TERC research.

PREDICTION OF HYPOXIA AND HABs AT CLEAR LAKE

TERC researcher Dr. Alicia Cortes and her team have developed a simple, new method to predict low dissolved oxygen (DO) levels in lakes. When lakes become stratified in warm weather, it limits the amount of DO available in cold, deep waters, causing an event called “hypoxia.”

Hypoxic conditions can trigger the release of nutrients accumulated in the bottom sediments, decrease the available fish habitat, and lead to more harmful algal blooms (HABs). HABs are an emerging water quality concern as they impact ecosystem health, have taste and odor implications for drinking water, and are a public health concern due to the toxins they may produce.

Clear Lake, a shallow, nutrient-rich lake in northern California suffers from severe hypoxia HABs and serves as a research model for how these factors can impact an

ecosystem.

While complex tools, such as numerical models, have been developed for predicting hypoxia, they are notoriously difficult to use. The TERC team developed a simple method for predicting hypoxia using meteorological data.

TERC’s in-lake monitoring stations were used to validate the model’s results. The results endorse the newly developed method as a cost-effective tool for predicting hypoxic events. This method can be a compelling decision-making tool for management actions to address aquatic ecological challenges, particularly for highly polluted lakes.

This tool was presented at the 35th Annual Symposium of the California Lake Management Society on October 19, 2020. The video of the full presentation is available online: <https://www.calms2020.org>. Learn more at <https://terc-clearlake.wixsite.com/cldashboard>.

Graduate Student Updates

TERC graduate student **Samantha Sharp** was awarded a NASA Fellowship to support her Ph.D. work. Her research aims to better understand cyanobacteria blooms—a type of HAB—in freshwater lakes. The research proposes to quantify the spatial and temporal variability in freshwater lakes using a combination of autonomous underwater and aerial robotics. This applied research study will also contribute to the validation of satellite-based remote sensing tools for application to lakes and reservoirs in California. The results of this work will support decision-makers with the management of our water resources, allowing for improvements in ecological health and water quality. A pilot study of this work was completed at Clear Lake and a paper presenting the results of this early work is currently in review for publication.

TERC graduate student **Micah Swann** has been an integral part of field data collection efforts for a multi-year monitoring and modeling program at Clear Lake. Swann manages TERC’s real-time stream monitoring and meteorological monitoring network at Clear Lake. He and fellow student **Ruth Thirkill** have been responsible for organizing field sampling teams to travel to Clear Lake every two months to download data from seven in-lake monitoring stations, and to collect water samples for TERC’s lab to analyze for nutrients and fine particle concentrations.

RESEARCH UPDATES

TERC IN TWO HEMISPHERES

Canadian Arctic

Canada's last intact ice shelf collapsed at the end of July 2020 causing a loss of equipment for both TERC and Canadian collaborators. The ice shelf collapsed as a result of warming sea temperatures and open water conditions at the ice front driven by global climate change.

TERC researcher Alex Forrest and his team have been studying this system and the associated epishef lake since 2016 using a combination of velocity, temperature, and salinity

sensors. These sensors, destroyed during the collapse, were being used to study melt rates of this system. Thankfully, as a result of COVID travel restrictions, no people were at the research site when this happened. The team plans to revisit the site next season to understand the ecosystem response to this major event.

Northern Patagonia, Chile

Across the globe, in Patagonia, TERC has been working with a consortium of Chilean organizations, private companies and universities. Graduate student Micah Swann is currently setting up TERC's three-dimensional hydrodynamic lake model for Lago

Ranco, a large, deep, low-nutrient lake. One application of the model is to predict the dispersion of a pollutant into the lake. In Lago Ranco, he has been working on a particle tracking simulation that visualizes the movement of particles discharged from two wastewater treatment plants along the lake's shoreline. This month he will be analyzing real-time data from Lago Llanquihue, the largest lake in Northern Patagonia. The data will be used to build a lake model similar to Lago Ranco which will enable them to compare the similarities and differences of the two lakes.

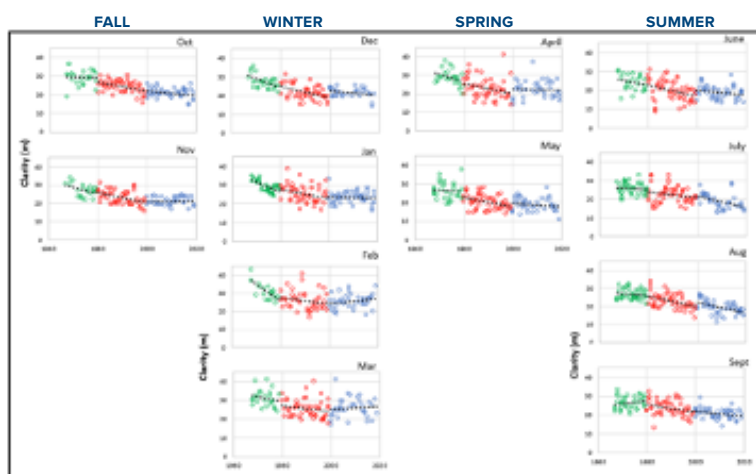
SUMMER AND WINTER CLARITY

TERC scientists Drs. Shohei Watanabe, Lidia Tanaka, Alicia Cortes, and Geoff Schladow, as well as sabbatical visitor Dr. Sebnem Elci from Izmir Institute of Technology, Turkey, were part of the Tahoe Science Advisory Council (TSAC) team that completed a study on the causes of the seemingly diverging trends of winter and summer clarity at Lake Tahoe. The report showed that two summer months, July and August, have displayed a significant decline in clarity over the last 20 years. Winter, on the other hand, has seen clarity plateau (see the figure to the right).

Understanding the drivers of Lake Tahoe's clarity is important and the causes of these trends are complex, with no factor being solely

responsible. Inflows of fine particles from urbanized areas and streams, the presence of tiny algal cells, increased thermal stratification, and the impacts of *Mysis* shrimp were all concluded to play significant roles in decreasing clarity and all are being exacerbated by climate change.

The TSAC report will help management agencies better understand climate change impacts to lake clarity and potentially alter related restoration efforts accordingly. TSAC will continue to use the findings to guide future research and monitoring.



Observed Lake Tahoe clarity in fall, winter, spring, and summer periods during 1967–79 (green), 1980–1999 (red) and 2000–2019 (blue) periods. Linear fitted line through each group of observations is represented by black dotted line.

RESEARCH UPDATES

WILDFIRE RISK

The 2020 wildfire season was the worst in recent record for California. More than four million acres of land burned, compared to about 260,000 acres in 2019. This resulted in poor and hazardous air quality in August and September throughout California, with smoky skies and ash deposition affecting the entire western United States and even parts of the Midwest.

As part of the TERC Science Speaks Series, UC Davis' Dr. Kent Pinkerton gave a webinar on the health effects of wildfire smoke. Check out his recorded webinar as well as TERC's previous webinars at <http://tahoe.ucdavis.edu/recorded-lectures>.

In addition to human health concerns, wildfire smoke impacts lakes. Smoke and ash are high in nutrients, and act like fertilizers, stimulating algae growth which will ultimately result in fish die-offs from a lack of oxygen in a process known as eutrophication. TERC scientist Dr. Steve Sadro is leading an NSF-funded RAPID grant to examine the effects of smoke and ash nutrient loading on algal growth, oxygen, and temperature dynamics. The team will be examining lakes throughout the Sierra Nevada and Crater Lake in Oregon.

TC FIELD STATION

The Tahoe City Field Station, also known as the historic fish hatchery, was recently selected to receive more equipment and technology as a part of an initiative from the University of California (UC) Center for Information Technology Research in the Interest of Society (CITRIS) and the Banatao Institute. CITRIS is a UC research center that works to "create information technology solutions for society's most pressing challenges."

There are several CITRIS research laboratories around the state with different specialties. The new Tahoe City Field Station CITRIS lab will be the Environmental Robotics Lab, specializing in autonomous vehicles from both underwater systems to autonomous surface vessels and aerial vehicles. This new technology will allow the TERC team to respond quickly to new problems and to continue to work even under difficult sampling conditions such as hazardous weather conditions.



Graduate student Nick Framsted holding newly constructed incubation chambers for growing periphyton.

SAGEHEN SET-UP

UC Davis professor Dr. Holly Oldroyd and her team are preparing for the third season of winter field studies at the UC Berkeley Sagehen field station near Truckee. The studies are aimed at better understanding snow hydrology, water balances, and snow variability in microclimates. This work is in collaboration with Drs. Anne Nolin and Steve Drake at the University of Nevada, Reno.

The research includes snow characterization, ground-truthing of remote sensing, and interactions between the atmosphere and snow. The research aims to quantify the impacts on these physical processes due to edge effects at forest and meadow interfaces.

PERIPHYTON LAB INCUBATION

Blooms of benthic algae, or periphyton, are thought to be increasing in frequency and severity in Lake Tahoe and other lakes across the Sierra Nevada. While other studies are investigating the role of nutrients such as nitrogen and phosphorus in periphyton metabolism and growth, scientists do not fully understand the extent to which temperature controls periphyton metabolism in Tahoe. With climate change expected to increase temperatures in Lake Tahoe, TERC graduate student Nick Framsted is conducting laboratory incubations to investigate how periphyton growth and future water quality will be affected.

EDUCATION AND OUTREACH

CLIMATE CHANGE AR

TERC was recently awarded a grant from the Institute for Museum and Library Services (IMLS) to develop two unique, interactive augmented reality (AR) experiences for understanding climate change at Tahoe. These AR experiences will enhance awareness and understanding of impacts driven by climate change in alpine ecosystems.

By using AR technology to help people visualize how global warming is predicted to affect the Tahoe region, TERC hopes to empower everyone who loves Tahoe to become part of the solution.

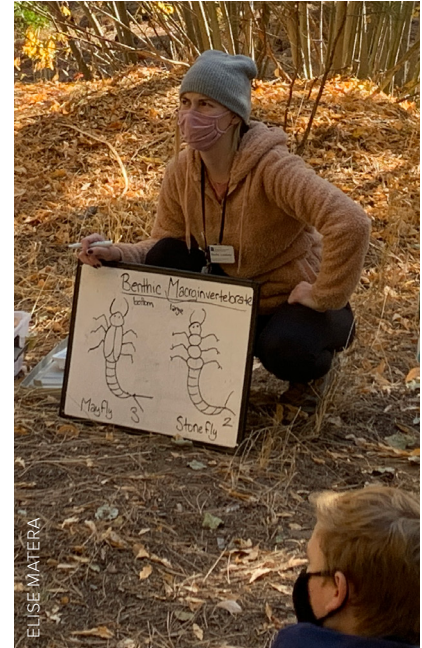
The first AR experience will focus on climate and weather patterns—rising air temperatures, decreasing snowpack, and increasing extreme events like droughts and atmospheric rivers. The second will focus on lakes and aquatic environments—changes in lake circulation and

thermal stratification, warmer water temperatures, increased potential for harmful algal blooms, and threats to native species. The team is in the early stages of this two-year project and will narrow the scope of the experiences to be the most effective and visually compelling.

While focused on Lake Tahoe, these topics are also applicable to other lakes and mountain ecosystems around the world.

The end goal of this project is to increase understanding that climate change will negatively impact people personally: as skiers, snowboarders, visitors to Lake Tahoe, swimmers, and beach-goers.

By increasing understanding and tying complex interactions to concrete, visual examples, TERC will be a part of the climate change solution, guiding the education of participants and providing mechanisms for change.



Outdoor education continues—with masks and social distance—as long as the weather will allow it. Education Programs Associate Baylee Goodwin leads a lesson.

VIRTUAL EDUCATION

The TERC education team continues to provide educational opportunities for students in the Tahoe basin and beyond. Due to local districts' hybrid and virtual models that continue to change, it is more important than ever to expand online learning opportunities to provide every student with equitable access to high quality science education.

The TERC education team has created new, COVID-safe ways for students to participate in environmental education from home and in person. In the fall, when weather permitted, outdoor in-person field trips started again for small groups with mandatory face coverings and social distancing.



Education Programs Associate Elise Matera presenting TERC's newest virtual field trip on climate change in the Tahoe basin.

EDUCATION AND OUTREACH

The outdoor field trips focused on teaching students about water quality and stream monitoring.

Virtual Field Trips

The education team has also created six new virtual field trips. These programs are available in a variety of formats to best suit students' needs. Teachers or parents can sign up for live virtual field trips that are led by TERC educators over Zoom in real-time, or they can opt for pre-recorded field trips that can be explored at home at the students' own pace. Field trip topics include Tahoe's formation, geology, aquatic food web, trees, forest health, and climate change.

TERC's education team is excited to work with students again and to continue promoting environmental stewardship to younger generations. If you are interested in scheduling a virtual field trip for your class or child(ren), fill out this form: <https://tinyurl.com/TERCVirtualFieldTripRequest>.

Virtual Science Center Tour

While the UC Davis Tahoe Science Center remains closed, TERC's staff and volunteer docents continue to engage the public virtually through free virtual tour videos. Videos feature a different staff member or docent discussing a variety of TERC research projects and environmental issues relevant to Lake Tahoe. Check out all of these videos and more on the UC Davis Tahoe YouTube channel: <https://www.youtube.com/ucdavis Tahoe>.



TERC docent Christie James reads *The Giving Tree* to a group of students during the summer literacy and science program.

IN-PERSON SUMMER PROGRAMS

In July and August, the TERC education team partnered with the Tahoe-Truckee Unified School District (TTUSD) and the Incline Village General Improvement District (IVGID) to offer a summer literacy program and a science camp, respectively. To allow in-person education to take place, the team worked hard to create as safe an environment as possible for the students and staff.

The TTUSD summer literacy program took place in Tahoe Vista. Twice a week, the team gathered with the same group of students to cover different scientific topics that also

focused on improving literacy skills. Topics included microplastics, space, geology, trees, animals, water, and more. Due to the success of this program, TTUSD extended programming an additional week.

The summer science camp took place for three weeks from late July to early August. Each Monday a small group of students came to the North Tahoe Demonstration Garden for an afternoon of learning and hands-on fun. Over each four-day camp, students completed activities on lake-friendly gardening practices, microplastic pollution, stream monitoring, and engineering solar-powered devices.

EDUCATION AND OUTREACH

PLASTIC REDUCTION PROJECT

Reducing plastic pollution and educating residents and visitors about its impacts has never been more important. Numerous efforts are underway to help with this initiative.

In September 2020, Clean Up the Lake, UC Davis TERC, and DRI sorted and categorized 2,248 pounds of trash collected from the lake. The data will be used to develop educational programs, to better inform policymakers, and to generate public awareness about microplastics.

The plastic reduction team also continues its partnership with Raley's grocery stores to encourage the use of Drink Tahoe Tap® reusable water bottles instead of single-use plastic bottles. Originally launched in July 2020 in Incline Village, the

project has since expanded the sale of these reusable water bottles to six additional stores in Truckee, South Lake Tahoe, and Reno, with plans to expand to an additional 80 stores by spring 2021.

TERC also partnered with the Sierra Watershed Education Partnerships (SWEPP) to get local high school students involved with the plastic pollution solution. TERC met with high school environmental clubs to encourage students to get involved with the project. Students will perform a plastic assessment of Raley's stores to determine where sustainability improvements can be made. They will present these findings to the Raley's management team along with their suggestions.

The TERC team is also preparing a GIS Storymap to explain the impacts of microplastics at Lake Tahoe to a wider audience.



These plastic items were pulled from Lake Tahoe by the nonprofit Clean Up the Lake, and the TERC team helped sort and quantify them.

TAHOE FILM FEST

The 6th annual Tahoe Film Fest was held December 3–6, 2020 in Incline Village and Crystal Bay with strict restrictions and safety adaptations. The films ranged from environmental documentaries to feature-length dramas to musical histories. All profits from ticket sales directly benefitted the Tahoe Environmental Research Center.

Please note that the contract for each film does not allow for virtual screening of these films. At a later date, we hope to provide a virtual “Best of the Fest.” Visit www.tahoeilmfest.com for more information.

SCIENCE OF COCKTAILS

The fifth annual Science of Cocktails event will be postponed until spring or summer 2021 so that it can be held safely outside. The annual fundraiser combines science education with celebration and fun, and it is always a hit in the community.

Rest assured, the extra planning time will only make this event all the more memorable! Science of Cocktails is one of TERC's biggest fundraising events, so if you find yourself in a position to give this winter, please don't hesitate! <https://give.ucdavis.edu/TERC/TENVGED>.

TERC TEAM UPDATES



GOLOKA SAHOO RETIRES FROM DAVIS

October 30, 2020 was the final day of TERC scientist Dr. Goloka Sahoo's working career, before he began a

well-earned retirement. Dr. Sahoo joined UC Davis in 2003 after moving from the University of Hawaii. Dr. Sahoo led the development of the Lake Tahoe clarity model and was instrumental in providing the science that led to the adoption of the Tahoe Total Maximum Daily Load program, or TMDL. He has helped mentor many graduate students working at Lake Tahoe and has been a caring and productive member of the Tahoe team. We all wish him the very best for the future and want him to know that he will always be a part of our family at TERC.

AMERICORPS MEMBERS RETURN

TERC could not be more excited that the 2019–20 AmeriCorps cohort of Baylee Goodwin, Anne Graham, and Elise Matera have decided to stay for year two! For the first time, all three of TERC's AmeriCorps members are returning for a second term of service through the Sierra Nevada AmeriCorps Partnership (SNAP).

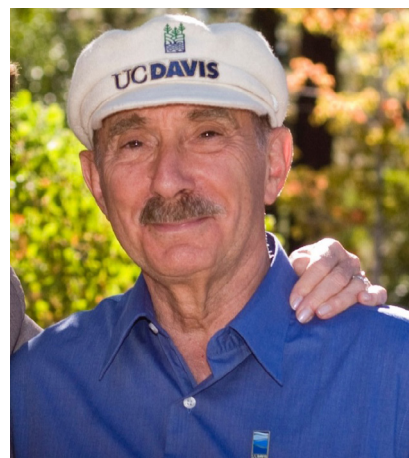
Facing the challenges of the COVID-19 pandemic forced the team to make many adjustments, but they have taken it in stride, with flexibility and a positive attitude.

The education team has had to reimagine many of the programs including adapting TERC's most popular field trips and making them accessible online. TERC Education and Outreach Director Heather Segale said, "None of this would

have been possible without the three energetic, well-educated, and highly motivated AmeriCorps members on the team. These three individuals have proven especially willing to work hard and have come up with great ideas to continue the education and outreach mission of the Tahoe Science Center in a socially distanced way."



From left to right: Elise Matera, Baylee Goodwin, and Anne Graham at the summit of Rubicon peak.



DR. CHARLES GOLDMAN TURNS 90

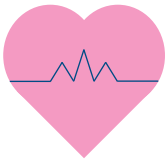
UC Davis pioneering limnologist Dr. Charles Goldman celebrated his 90th birthday on November 9. Dr. Goldman formed the Tahoe Research Group in 1959 and worked to build awareness and action of the declining clarity of Lake Tahoe throughout his career. His initiative led to the creation of the Tahoe Environmental Research Center as we know it today.

His work is globally acknowledged today as the model for how to unite the public and private sectors in addressing urgent environmental threats, guided by science.

Dr. Goldman's greatest passion has been preparing tomorrow's leaders to take up these critical efforts. To celebrate his living legacy, TERC and the League to Save Lake Tahoe launched the "Thanks a Million" campaign. To date, almost \$200,000 has been raised by the campaign, which will provide student fellowships in perpetuity. To honor Dr. Goldman's legacy, please follow the link: <https://give.ucdavis.edu/TERC/123313>.

UC DAVIS TERC BY THE NUMBERS

6 **DECADES OF
MONITORING
LAKE HEALTH**



OVER ONE-HUNDRED FIFTY



**GRADUATE
STUDENTS**

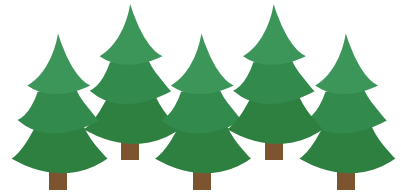
OVER

600

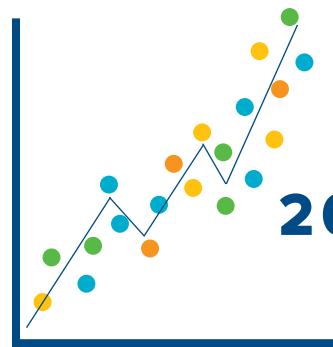


SCIENTIFIC PUBLICATIONS

84



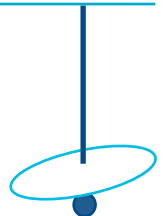
**MONITORED FOREST PLOTS
ARE HELPING US UNDERSTAND
FOREST RESILIENCE**



**ADVANCED
TECHNOLOGIES
COLLECTING
20 MILLION
DATA POINTS
ANNUALLY**

THOUSANDS

OF CLARITY AND WATER QUALITY SAMPLES MEASURED

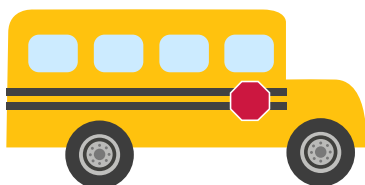


EIGHTY

**SCHOOL FIELD
TRIPS AND OVER**

FIVE THOUSAND

**STUDENTS REACHED
ANNUALLY**



159,000



**PEOPLE REACHED BY
EDUCATIONAL PROGRAMS**

2 SCIENCE CENTERS AROUND



Tahoe City, CA



Incline Village, NV

LAKE TAHOE

GIVING TO THE TAHOE ENVIRONMENTAL RESEARCH CENTER

Private Support is critical to continuing the Tahoe Environmental Research Center's legacy of groundbreaking work in restoring and sustaining Lake Tahoe. Gifts at every level support research, education and outreach, and give the flexibility to address emerging needs and opportunities. Every gift makes a difference and there are many ways to give. Thank you!

- ☐ **YES**, I wish to support the Tahoe Environmental Research Center with the gift amount shown below.
- ☐ Please contact me about how I can make a deferred or estate gift to UC Davis.
- ☐ I wish this gift to remain anonymous.

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- 2) Fill out the information below and mail with a check payable to UC Regents

Enclosed is my tax-deductible contribution.

Please make checks payable to UC Regents.

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Spouse/Partner: _____

Address: _____

City, State, Zip: _____

Phone: _____

Gift Amount: _____

MAKE A GIFT TAX-FREE WITH AN IRA

- ☒ Do you want to support TERC's Science at Lake Tahoe?
- ☒ Are you over 70 ½?
- ☒ Do you need all of your required minimum distribution from retirement assets?

» **Consider a gift via an IRA.** Visit <http://plannedgiving.ucdavis.edu/ira-charitable-rollover> for more details.

UPCOMING EVENTS

December 10, 2020: Local Renewable Energy Transition Planning & Climate Resilience with Gerry Braun, Integrated Renewable Energy Systems Network

January 7, 2021: Cannabis and Hemp Research with Li Tian and C. Bryan Cameron, UC Davis Cannabis and Hemp Research Center

March 25, 2021: Calculating the Costs of Climate Change

with Fran Moore, UC Davis Department of Environmental Science and Policy

April 22, 2021: Conspiracy Theories and American Democracy with Kathryn Olmsted, UC Davis Department of History

For more information visit: <https://tahoe.ucdavis.edu/events/>