

The Tahoe Environmental Research Center (TERC)

is a global research leader providing the science for restoring and sustaining Lake Tahoe and other treasured lakes worldwide for over 50 years.

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



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Project UPWELL equipment is prepared in the Tahoe City Field Station

RESEARCH UPDATES

UPWELLED PELAGIC WATER EXCHANGE DRIVING LITTORAL LIMNOLOGY (UPWELL) EXPERIMENT

Spring upwelling events are common between May and June. Variable spring weather combines with a weakly stratified lake to generate upwelling. Prior to this period, the lake is typically vertically mixed. After June, stratification strengthens and upwelling is uncommon.

UC Davis Ph.D. student Derek Roberts has been overseeing a large experiment

along the west shore this spring. The overarching goal of the Upwelled Pelagic Water Exchange driving Littoral Limnology experiment, or “Project UPWELL,” is to measure the impact of upwelling nutrients on the growth of algae on shoreline rocks (periphyton).

Derek, with other TERC staff and AmeriCorps member Christine Limon, have deployed a whole array of instruments extending a half-mile offshore. Over \$0.5 million of instruments

LETTER FROM THE DIRECTOR

You have no doubt heard that “what happens in Vegas stays in Vegas.” By contrast, what happens at Tahoe is seen and heard everywhere, and having a positive impact in some of the most remote and threatened places on earth.

I recently traveled to Lake Panguipulli, the gateway to the Chilean Patagonia. If you like deep, pristine lakes surrounded by forests with snowcapped Andean peaks as a backdrop, you should consider visiting it. As was the case at Tahoe many decades ago, Lake Panguipulli is poised at the precipice of unregulated second-home construction on its fringing wetlands, contending with a sewer system that frequently overflows into the lake on account of high precipitation, and no long-term science and monitoring to know how the lake may be changing or what needs to be done to preserve it.

What the community at Panguipulli wants to know is how Lake Tahoe survived the same kinds of pressures. With Jesse Patterson from the League to Save Lake Tahoe and Devin Middlebrook from the TRPA, we kicked off a day-long workshop in an overflowing

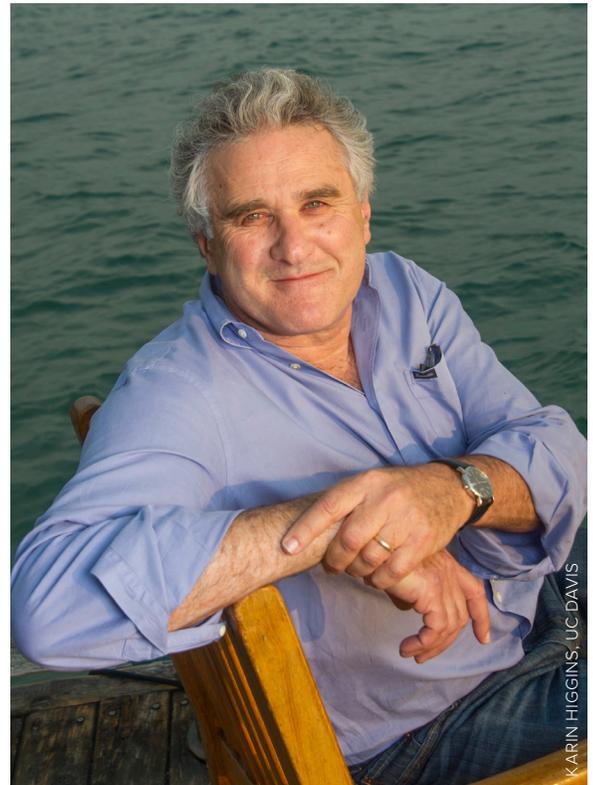


Lake Panguipulli in the early morning with Mocho-Choshuenco volcano in the background

auditorium attended by Senators, Governors, local officials, tribal representatives, scientists, activists and developers.

This is merely the latest example of the enormous reach that Tahoe has. The collective efforts have not solely had an impact here at home. What Lake Panguipulli reminds us is that the successes and ongoing challenges of Lake Tahoe have a global dimension. What we have shown at Tahoe is that long-term science needs to be the foundation of lake restoration strategies, implementation programs, and public education. As conditions change, those strategies and programs need to be adapted.

In some ways the Panguipulli community is far ahead of us. It took many decades for all the stakeholders at Tahoe to realize that we needed a common vision to restore the lake, and that coming together in the same room and working constructively together was the only rational course of action. Prior to that realization the lake's condition declined. In Chile, however, they want to apply Tahoe's lessons from the outset and prevent significant decline from even starting. And using Lake Panguipulli as the starting point, they wish to extend these efforts to their lake region and



Geoffrey Schladow, Ph.D., Director,
UC Davis Tahoe Environmental Research Center

into Patagonia.

In the coming months we will be working with our Chilean counterparts to help them establish the science, management and education programs that have been developed at Tahoe. Reciprocal visits are being planned, and opportunities for greater collaboration between our two countries are being formulated. Please let me know how you may want to be involved in this exciting new endeavor. “Chile Lagos Limpios!”

RESEARCH UPDATES *(Continued from Page 1)*

are involved, made possible by researchers from TERC, UC Davis Civil Engineering, Bodega Marine Lab, and Stanford University pooling their resources.

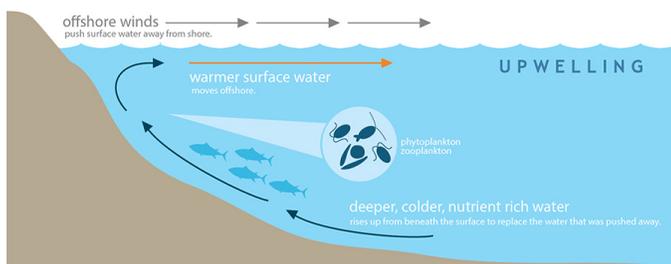
Derek and team sampled water one to two times each week for nutrient/particle analysis, filtered samples in the lab, and took samples to TERC labs for processing.

Sustained wind events during weak spring stratification have been observed to induce upwelling of deep, cold water along the upwind shore of Lake Tahoe. These spring storms typically follow the prevailing southwesterly wind pattern, causing upwelling along the west side of the lake.

CONTROLLING INVASIVE SHRIMP TO IMPROVE WATER CLARITY IN LAKE TAHOE

A team led by TERC director Geoff Schladow, Alex Forrest from civil and environmental engineering, and Steve Sadro from environmental science and policy, launched a pilot project to test and optimize a strategy to improve water clarity in Emerald Bay and Lake Tahoe.

The team aims to reduce the



Upwelling is a process in which deep, cold water rises toward the surface. Winds blowing across the lake surface push water away. Colder water then rises up from beneath the surface to replace the water that was pushed away. (Image source: NOAA)

abundance of Mysis shrimp, one of Lake Tahoe's most ubiquitous invasive species, to population levels where they no longer impact the ecosystem of the bay. If the number of Mysis are reduced, native zooplankton species will return to levels not seen since Mysis introduction in the 1950s. This could lead to a significant improvement in water clarity—one of the long-term goals for the lake.

State-of-the-art echosounding equipment is used to determine the distribution of Mysis shrimp. By using real-time, remote sensing to locate the position of high-density Mysis patches, the team is mapping the variability in distribution and daily migration of these organisms through Emerald Bay.

Mysis rise to the top of the water at night and sink to deeper water during the day. Consequently, the project team has to work at night, leaving the dock at 8 p.m. and returning around 5 a.m. The migration of shrimp during these dark, nighttime hours, is detectable across the entire depth of Emerald Bay.

The TERC team is testing out various



KATIE SENFT, UC DAVIS TERC

Night research is necessary to capture Mysis shrimp as they make their daily migration toward the surface

Mysis shrimp collection trawls to determine the most efficient techniques. The TERC team is working in collaboration with the University of Nevada, Reno, with assistance from Cal State Parks for the work in Emerald Bay, and is supported by the California Tahoe Conservancy and the Nevada Division of Environmental Protection.



BRANT ALLEN, UC DAVIS

Mysis shrimp are non-native and are eating our native zooplankton

Continued on Page 4

RESEARCH UPDATES *(Continued from Page 3)*

“The Lake Tahoe ecosystem has changed dramatically in the last 50 years, and restoring ecological function of the lake’s native species in place of the invasive Mysis shrimp cannot be overstated,” says Schladow. “Our findings in Emerald Bay will be critical in developing a plan and strategy for Lake Tahoe.”

Brant Allen, TERC boat captain and fisheries biologist, is excited about the prospect of using ecological strategies to restore long-term clarity loss. “A great deal of money and effort has been spent restoring the basin’s landscape. I believe additional opportunity exists by focusing on restoration of the lake’s native ecosystem.”

ENVIRONMENTAL ROBOTICS LABORATORY

Alex Forrest, TERC researcher and assistant professor with civil and environmental engineering is heading up the new UC Davis Environmental Robotics Laboratory. The goal of this new group is to use emerging technologies, either autonomous or semi-autonomous, to study environmental water problems in lakes and oceans. From the Arctic to the Antarctic, robots are tackling issues in a range of environments.

Storm Glider, an autonomous underwater glider, can take observations for weeks at a time. After its 2017 maiden launch in Antarctica to examine melting of ice shelves, it is currently deployed in Lake Tahoe. Storm Glider measured temperature, chlorophyll, and dissolved oxygen in Lake Tahoe as part of Project UPWELL (see article on Page 1 and 3).



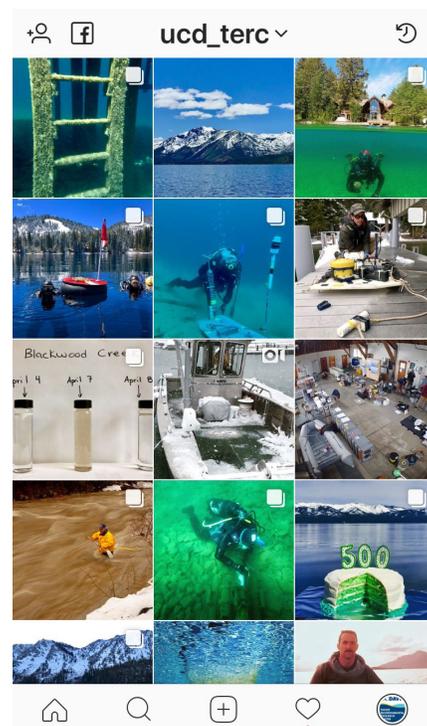
Alex Forrest trains members of the Royal Australian Navy to use underwater robots

In July 2018, it is off to Lake Geneva to measure turbulence effects on lake ecosystem health.

UBC-Gavia, a self-propelled autonomous underwater vehicle, is currently returning from Australia where it was used to train the Royal Australian Navy.

In addition to these autonomous platforms, a suite of ship-mounted sensors are being used to find fine-scale organisms in the water column (such as Mysis shrimp) as well as imaging the lake bed with acoustic imagery. The team aims to use these, and similar platforms, in the future at Lake Tahoe for areas of the lake that can’t be surveyed using traditional techniques.

“Applying emerging technologies and untethered, autonomous robotics enables an understanding of aquatic habitat and ecosystem assessment not available today,” adds Forrest.



UCD_TERC on Instagram

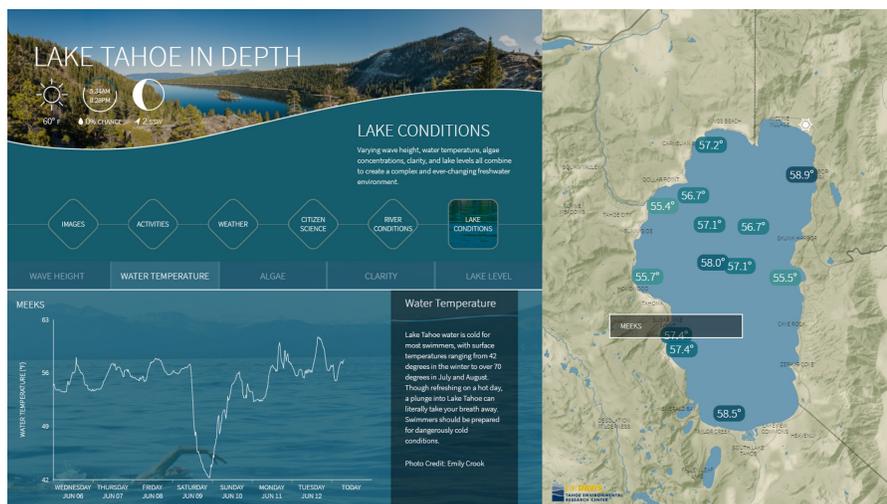
EDUCATION AND OUTREACH

WHAT CAN YOU LEARN FROM TERC'S NEARSHORE NETWORK?

The “Lake Tahoe in Depth” touchscreen exhibits are available at the UC Davis Tahoe Science Center, Tahoe City Visitor Center, and Tahoe Maritime Museum. Additional exhibits are available for other sites around the lake. Please contact Heather Segale, UC Davis TERC, at hmsegale@ucdavis.edu if you are interested in hosting a touchscreen exhibit at your site.

Within the “Lake Tahoe in Depth” exhibit you will see the patterns of water quality data, including:

Wind/wave patterns – The prevailing winds at Lake Tahoe come from the southwest and blow northeast. This pattern results in 2 to 8-inch (5 to 20 cm) waves along the north and east shores of the lake. Winter and spring conditions may be very calm for days on end, but when storms hit the lake, winds tend to be much more powerful. We have recorded waves as high as



Upwelling visible in this screenshot of the Lake Tahoe in Depth exhibit showing the temperature plunging as cold bottom water comes up to the surface after wind event

6 feet (1.8 m) at Tahoe Vista and Dollar Point during winter.

Sediment resuspension – When waves are large enough, the sensors record increases in turbidity, algae, and dissolved organics, as waves re-suspend sediments and churn particles and attached algae up into the water column. Wind waves are the dominant driver of turbidity in the nearshore of Lake Tahoe.

Upwelling – Upwelling occurs when strong, sustained winds drive surface waters to the downwind end of the lake, slightly increasing the lake depth (about 1 inch maximum). There is a compensating back-flow as deep water flows toward the upwind end of the lake and rises to the surface. Since Tahoe’s deep water is (comparatively) rich in nitrate, upwelling plays a role in internal nutrient cycling in the lake (see also article on Project UPWELL).



Science Expo 2018 included 30 activities related to human health, nutrition, and other life science topics

TERC SCIENCE EXPO DONORS SUPPORT SCIENCE EDUCATION

The 13th annual North Lake Tahoe Science Expo at the Tahoe Science Center in Incline Village was a huge success. This year’s theme was Life Science and Health, with thirty activity stations covering organisms and ecosystems, inheritance and adaptations, and health and nutrition. Over four days, TERC hosted over 1,100 students from 11 schools and 40 different classes.

EDUCATION AND OUTREACH *(Continued from Page 5)*

Teachers, parents, and volunteers gave incredibly positive reviews, and many teachers plan to implement life science extensions in their classroom.

The third annual South Lake Tahoe Science Expo at the Lake Tahoe Community College in South Lake Tahoe had similar success, reaching over 1,000 students from six schools and 40 different classes.

Grants from Tahoe-Douglas Rotary and Soroptomists International of South Lake Tahoe helped to make the 2018 Science Expo possible.

TROUT IN THE CLASSROOM

In collaboration with SWEP, USFS, and USFWS, the TERC Education Team helps support teachers in our region who participate in the Trout in the Classroom (TIC) program.

The Trout in the Classroom program is designed to give students a unique opportunity to witness Lahontan Cutthroat Trout (LCT) hatching and care for them during their early life stages. In the process, students learn about trout habitat requirements and how to become good stewards of our aquatic resources. TERC hosted a TIC Teacher training event in March, which walks new participants through background information, aquarium set-up, successfully raising the fish, and curriculum connections. On April 17th, the eggs were picked up from the Lahontan National Fish Hatchery and distributed to the classrooms. Once the LCT are in the fry stage, they are released into Lake Tahoe, Incline Creek, Third Creek, or the Truckee River. NDOW is currently

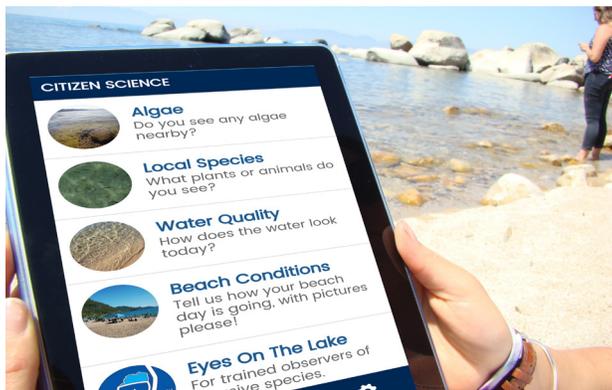
conducting a long-term study on Third Creek, which includes monthly population monitoring in both Third and Incline creeks, so the introduction of the LCT could provide some interesting findings.

TAHOE SCIENCE CENTER BRANDING

In preparation for a visit from the UC Davis Chancellor Gary May, the UC Davis Office of Strategic Communications developed some beautiful new signage for the UC Davis Tahoe Science Center. New signs were installed behind the front desk and on the post near the research boat. A colorful wave element was added above the hands-on exhibits and logos for both UC Davis and Sierra Nevada College were placed on the exterior windows. New exterior signage on the east side of the building will be coming soon.



Students carry fingerling Lahontan cutthroat trout for release into Lake Tahoe



Join the 3,000 users of the Citizen Science Tahoe app to collect observational data that is shared with scientists to better understand conditions around the lake (Download at www.CitizenScienceTahoe.com)

FACULTY AND STAFF HIGHLIGHTS

BRANDON BERRY

Brandon Berry is a research associate and dive officer primarily assisting Brant Allen and Katie Senft with lake monitoring. He received his bachelor of science in environmental engineering from the University of Nevada, Reno. After school, Brandon worked in environmental consulting while finding time to pursue SCUBA diving whenever possible. He lived in Thailand while getting his dive-master certification.

Brandon started working with



Brandon Berry is TERC's newest addition to the research team

TERC in May of 2017 and has been involved with lake monitoring and special projects such as the Mysis Project and Project UPWELL. He enjoys the opportunity to be on or under the water every week, and claims the cold water is a small price to pay for the clarity he gets to experience while at work.

His goals with TERC are to experience as many projects as possible and to continue learning on a daily basis. Brandon has already gained valuable field experience -- from sewing trawling nets together to deploying instruments 400 meters deep in the lake. The work is never dull, and he is excited to continue exploring new technologies and learning more about environmental science.

Recently, Brandon traveled to Australia to assist in Autonomous



Underwater researcher and dive officer Brandon Berry

Underwater Vehicle (AUV) training for the Royal Australian Navy. The two-week course consisted of basic AUV operations training for the mine countermeasures team. Classroom theory and field exercises prepared the team for integrating AUVs into their mine countermeasure operations. Brandon enjoyed working with the Royal Australian Navy as well as getting to experience Australia at the same time.

UPCOMING EVENTS

June 14: Time Travel: Revisiting Lake Tahoe with Dr. Peter Goin, Director of Photography/Time-based Media at the University of Nevada, Reno

July 13: Science Speaks Luncheon: A fundraising event supporting science to save Lake Tahoe

July 26: State of the Lake Report

with Geoffrey Schladow, UC Davis TERC Director

Aug. 25: Children's Environmental Science Day at Tahoe City Commons Beach

Aug. 30: Special summer lecture with Jared Blumenfeld, former EPA Region 9 Administrator

Oct. 11: Mike Miller and

Conservation Genetics

Nov. 1: Lynda Walsh and the Rhetoric of Climate Change

Nov. 8: Chris Cappa and Aerosol Pollutants

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

GIVING TO THE TAHOE ENVIRONMENTAL RESEARCH CENTER

Private Support is critical to continuing the Tahoe Environmental Research Center's legacy of ground-breaking 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.

Mail to: *UC Davis Tahoe Environmental Research Center*
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Science Sustainer

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- 1) Make a secure online gift at <http://give.ucdavis.edu/TERC>
- 2) Fill out the information below and mail with a check payable to UC Regents

Enclosed is my tax-deductible contribution.

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