TAHOE: STATE OF THE LAKE REPORT 2012

RECENT RESEARCH UPDATES

UCDAVIS
TAHOE ENVIRONMENTAL RESEARCH CENTER

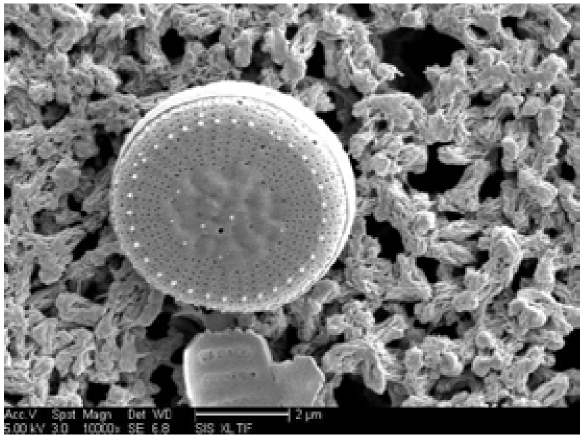
RECENT RESEARCH UPDATES

Overview

Each year different research areas emerge as the most topical in the State of the Lake Report. In past years we have focused on topics such as the remote sensing, climate change, and the emergence of Asian clams as a major threat to Lake Tahoe's ecosystem. This year we are taking a broad look at a range of ongoing research. These include the issues associated with invasive species in Emerald Bay, the currents of the lake, the long-term water quality impacts of the Angora Fire and forest health.

Emerald Bay boat traffic across the sill was recorded in 2011 using a remotely operated camera.

This Aquadopp instrument measured current velocity at one-inch intervals through the water column in Emerald Bay. The instrument was on loan from the University of Iceland.



Cycoletella sp. diatoms are very small algae which are less than 4 microns in size. This size of particle scatters light causing a reduction in lake clarity.

Lake Tahoe color

Lake Tahoe is renown for its dazzling blue color. In the early 1880s, it was said that the Lake water was "Marie-Louise blue", the color of the French army uniforms. The intense blue results from light scattering in deep and very dilute waterbodies. Using state-of-the-art field and lab instruments, we measured individual wavelengths in the full spectral range and converted them to color. Values were less blue than reported in 1970 (the only other time similar measurements have been made). This is supported by visual observations by the two long-term TERC boat captains. Also, note how real water color changes with depth. Employing these sophisticated techniques, color change can serve as an indicator of lake optical properties, along with Secchi depth. Additional measurements are planned for February, 2013.

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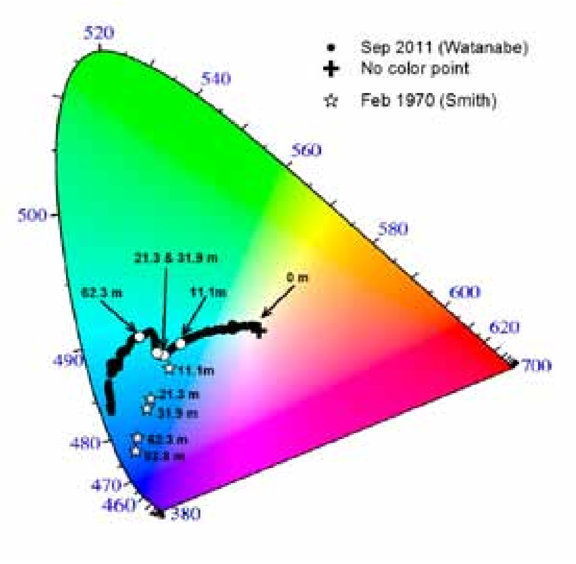


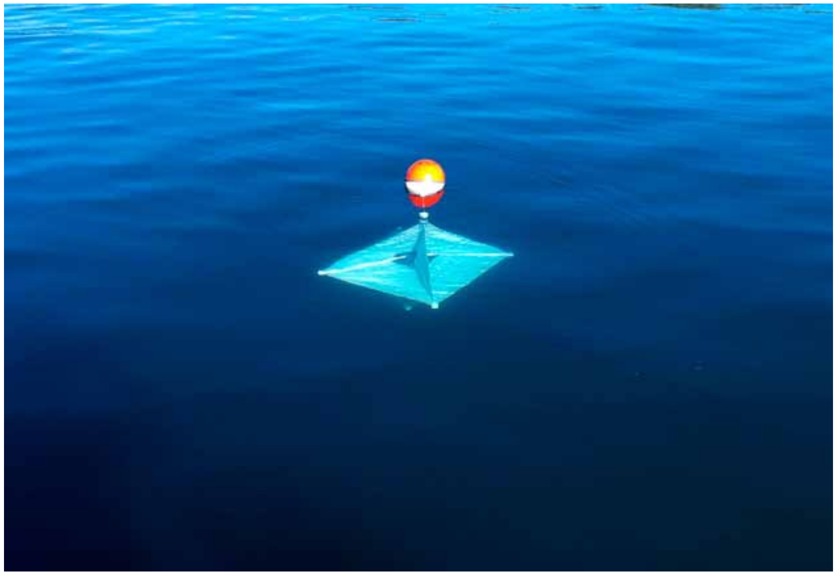
A plot of the true color of Lake Tahoe at different depths in 1970 and 2011

Research buoys on Lake Tahoe a collaborative project with UC Davis TERC and NASA/JPL

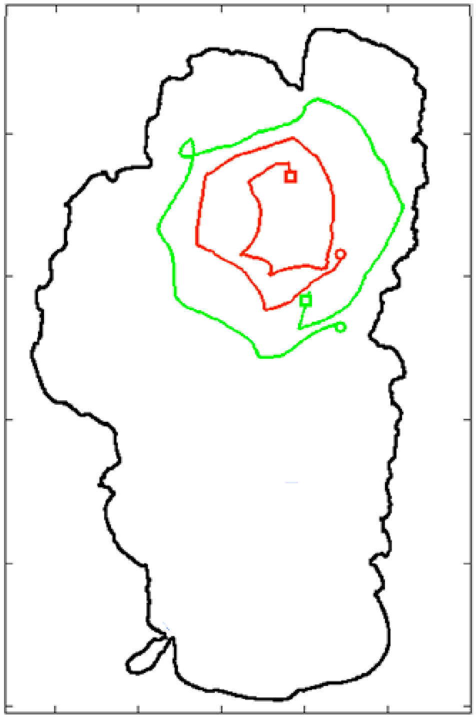
RECENT RESEARCH UPDATES: LAKE PHYSICS

Gyres within Lake Tahoe

Gyres are the names given to large scale circular motions that are traced out by currents in large lakes and the ocean. In lakes such as Tahoe, they arise on account of both the wind patterns and the earth's rotation. One way of measuring gyres is to use drogues, that comprise of underwater sails connected to a surface buoy containing a GPS recorder and satellite transceiver (left panel). Two drogues were released in Lake Tahoe between August 18 and August 22, 2011. The map below shows the path of the drogues and the gyres they traced out. The squares represent where they were released and the circles where they were picked up. Both drogues traced out a counter-clockwise gyre, consistent with previous satellite observations.

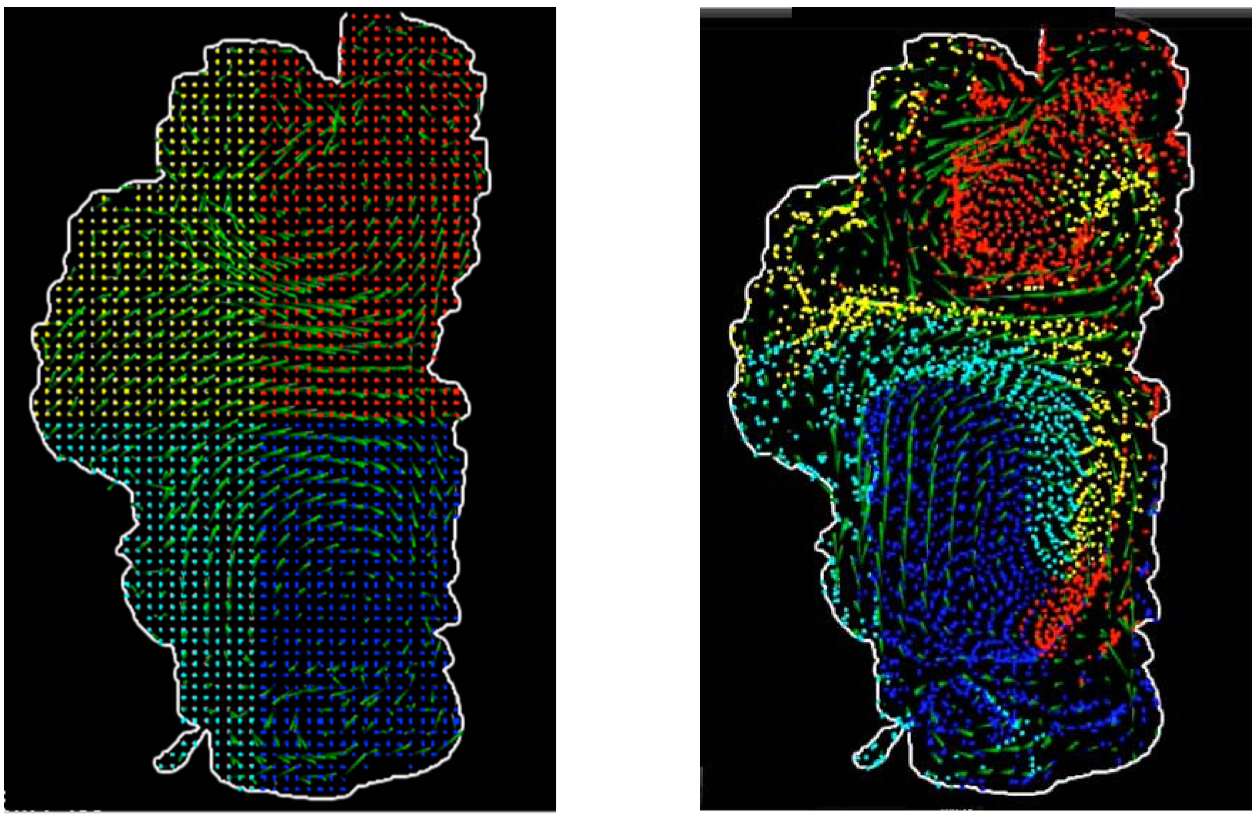


Drogue floating in Lake Tahoe used to measure surface currents



Gyres within Lake Tahoe, continued

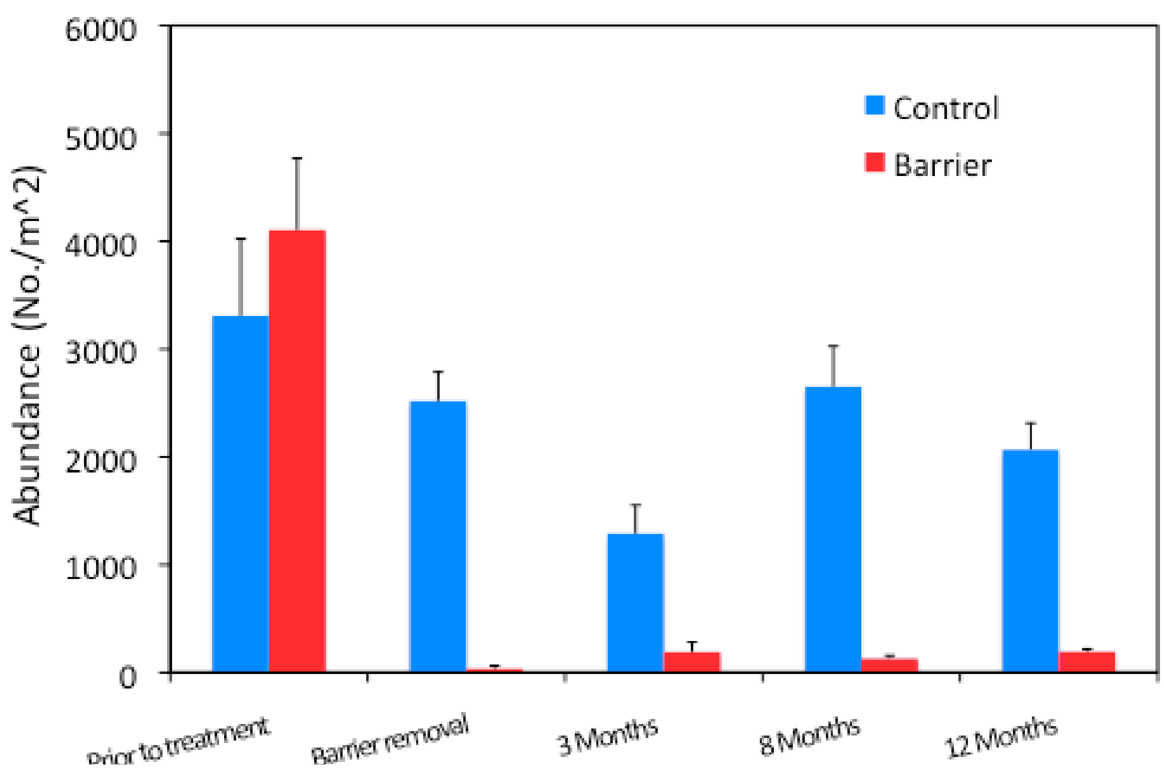
Computer models help us better understand the processes that occur within Lake Tahoe. The green pointers in the figure below show the surface currents in Lake Tahoe on one day in August. The red, yellow, cyan and blue dots represent "floating particles" that have been added to the surface. In the figure on the right we see how these particles have been moved by the gyres in just 18 hours. The counter-clockwise gyre in the north of the lake is evident, as is a clockwise gyre in the south of the lake. Smaller gyres are evident closer to the shoreline. What is most remarkable is the distance around and across the lake that particles (and pollutants) can get carried in a relatively short time.



RECENT RESEARCH UPDATES: AQUATIC INVASIVE SPECIES

Asian clams: Large-scale experiment

In June 2010 two half-acre synthetic rubber barriers were placed over the Asian clam infestations in the southeast portion of the lake to deprive the clams of oxygen. The barriers were removed after 120 days. Clams under the barrier were reduced by more than 98 % due to oxygen removal. Twelve months later, clam density was still reduced by more than 90%. The density of of clams in an untreated "control" plot remained high throughout. Non-targeted benthic organisms were also reduced, but they returned at greater rates than the Asian clams. The data shown is from Marla Bay. This work is a joint effort by UC Davis and University of Nevada, Reno.

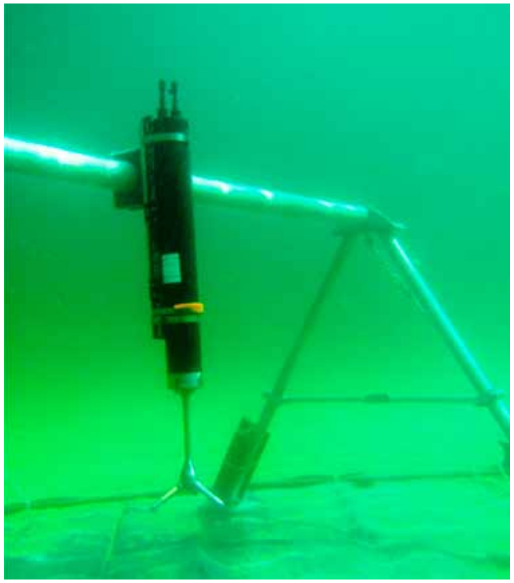


Asian clams in Emerald Bay

Asian clams on the sill between Emerald Bay from Lake Tahoe, necessitated experiments to confirm whether their spread can be controlled. Unlike prior Asian clam infestations, the Emerald Bay population was adjacent to heavy boat traffic and was on a permeable glacial moraine.

A test rubber barrier (100 ftx10 ft) was installed in the Emerald Bay boat channel (left panel – barrier at lower center) and acoustic instruments (right panel) were installed to measure water velocity over the barriers. Instruments for measuring water temperatures and dissolved oxygen were also installed. The results indicated that boat wakes did not disturb the rubber mats, however, despite this, the dissolved oxygen did not fall sufficiently under the barriers to kill the clams in the expected 30 days. This was due to water travelling through the permeable sill from Lake Tahoe to Emerald Bay, carrying highly oxygenated water.

Aerial photo of the rubber bottom barrier installed on the sill of Emerald Bay



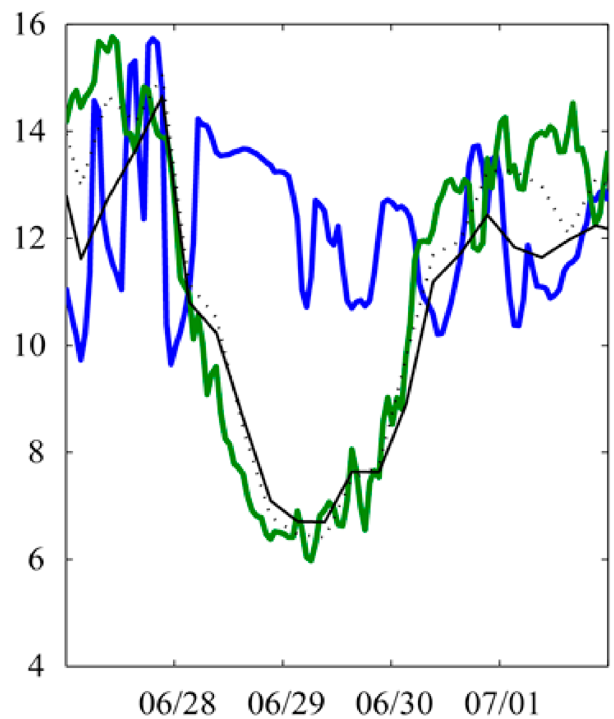
Acoustic instrument used to measure water velocity across the sill of Emerald Bay

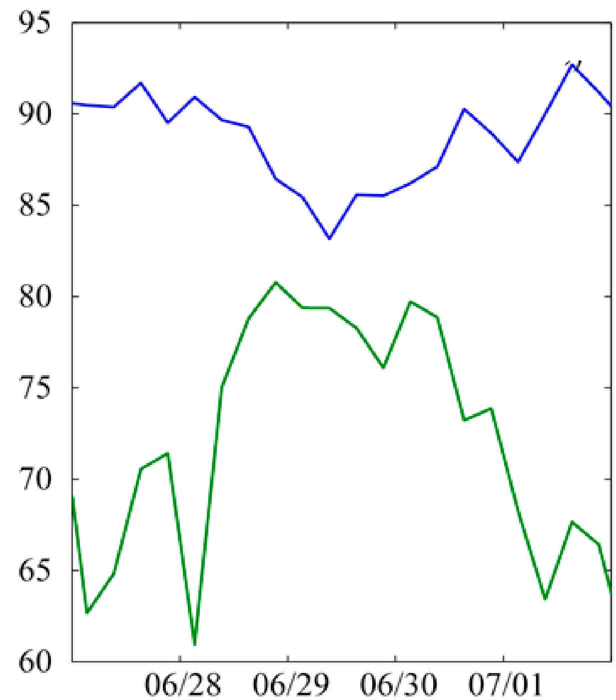
Asian clams in Emerald Bay, continued

The left panel shows water temperature (deg C) in Lake Tahoe (green line), in Emerald Bay (blue line), beneath the barrier (black line) and above the barrier (dotted line). When the lake temperature dips, the colder water is transmitted though the sill to the barrier in a few hours.

The right panel shows the oxygen below the mat (green line) at the same time in terms of percent oxygen saturation. The blue line is dissolved oxygen above the barrier. Such spikes in oxygen are sufficient to sustain the clams.

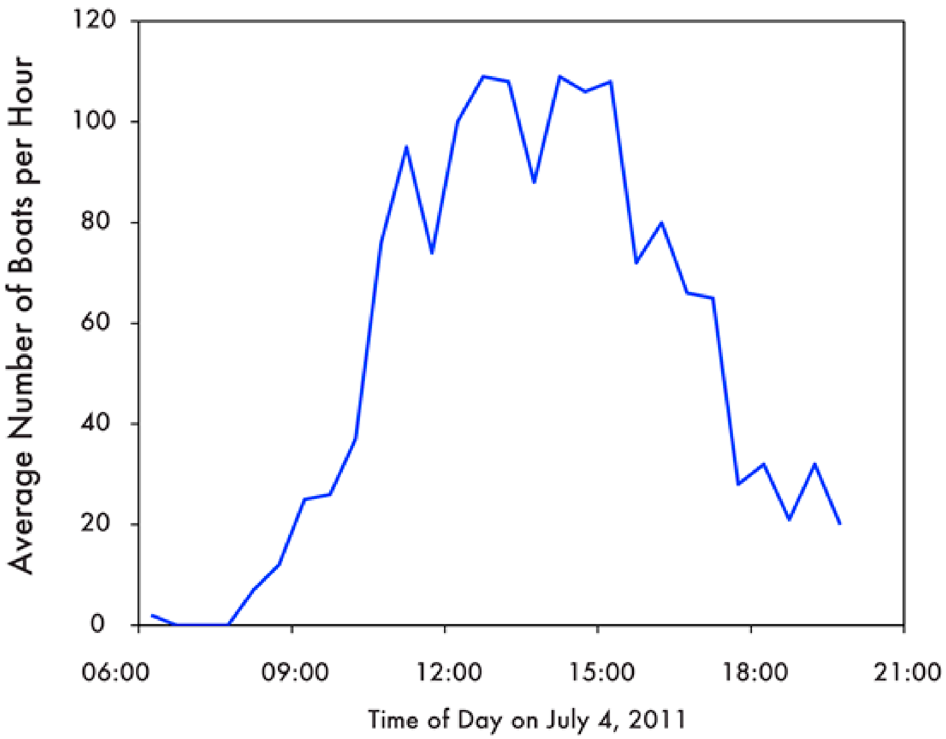
Experiments using organic material under the barriers have produced much lower oxygen under the barriers, sufficient to produce clam mortality under these conditions. This approach will be used in 2012-2013 in Emerald Bay.





Boats in Emerald Bay

Emerald Bay is the most frequented part of Lake Tahoe, but exactly how many boats pass through the channel each day has not been known. As part of an invasive species study at Emerald Bay, TERC researchers mounted a high resolution camera in a tree above Emerald Bay, and images were recorded every 10 seconds. The results indicated that July was the busiest boating month, with almost 1000 boats visiting the bay on a single day (July 3). The figure below indicates the number of boats per hour entering Emerald Bay on July 4, 2011. In the middle of the day this number exceeded 110 boats per hour.

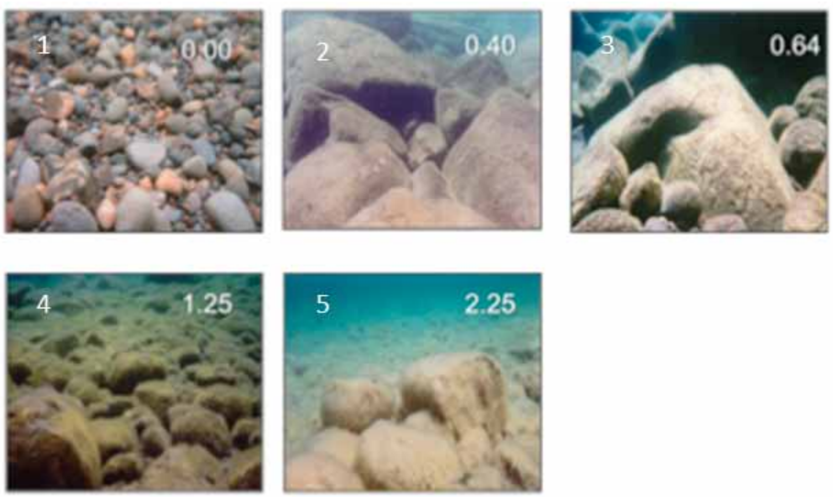


Desired conditions for shoreline algae

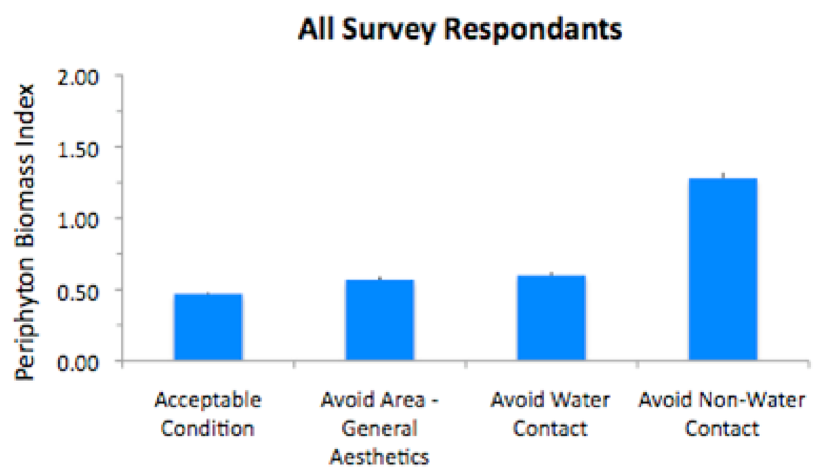
Water quality standards to protect Lake Tahoe from excessive shoreline algae are underway. One approach to setting these target values involves public perception.

Nearly 150 visitors to the UC Davis, Thomas J. Long Education Center were asked to rank five photos. Each condition received a PBI (periphyton biomass index) score, related to the area of bottom covered and length of the algae. The photographs covered a range of PBI values including, 0.00 (no visible biomass), 0.40 (limited biomass), 0.64 (moderate biomass), 1.25 (heavy biomass) and 2.25 (very heavy biomass).

A PBI of 0.50-0.60 was considered acceptable for aesthetics and non-water contact (between photos 2 and 3). A higher values of 1.25 (photo 4) was considered the upper limit for non-water contact activities.



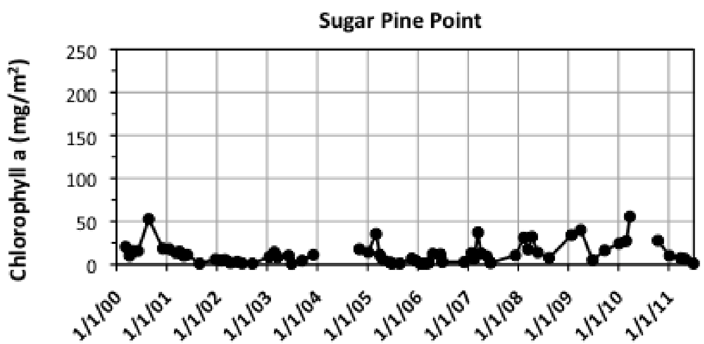
Periphyton Biomass Index (PBI) for different substrate conditions

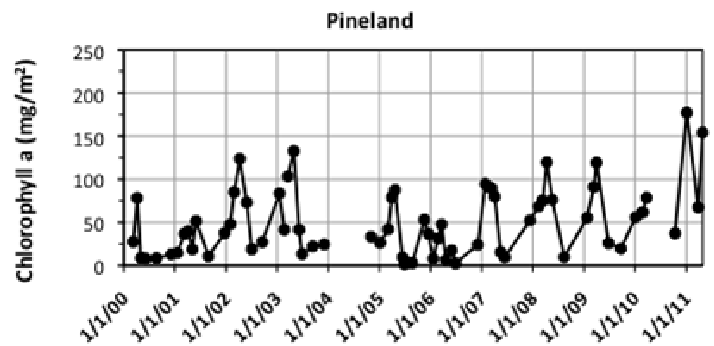


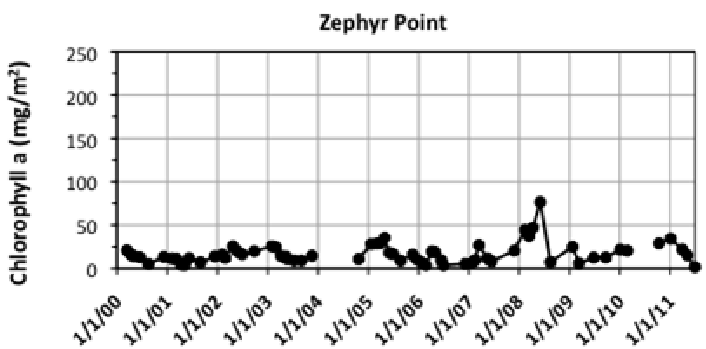
RECENT RESEARCH UPDATES: BIOLOGY

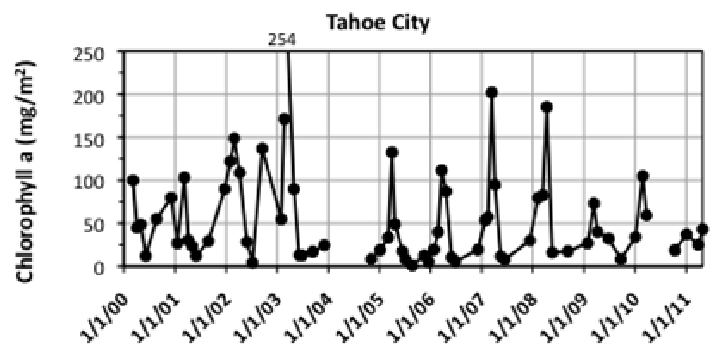
Time series for shoreline algae

Unsightly shoreline algae exhibit a distinct and regular seasonal pattern with a peak in the late-winter to early spring. These points of annual maximum are best seen in areas of high urban development and high algal growth (e.g. Pineland and Tahoe City). Algae declines rapidly following maximum growth and is often washed up on the shore or trapped in marinas and other enclosed areas. Minimum algae are seen in the summer and by December-January the buildup begins anew.









Angora Fire: Stream Water Quality

The 2007 Angora Fire burned 3,100 acres or 9 % of the Upper Truckee River drainage. A large portion of the burn area was on steep slopes. Angora Creek water quality data were collected within the burn area, upstream of the residential parcels, with wide agency support. DRI, USGS and TERC partnered in this study. The 'x' symbol in the Table represents the increase above the baseline level.

Data from a 1991-2000 El Dorado County study served as a baseline for water quality.

Nitrate spiked in 2008 but returned to baseline by 2010. Total N, Total P and sediment increased, although less dramatically and have remained elevated, but constant. In 2010 turbidity was still above baseline. Conductivity, a measure of ionic concentration, returned to baseline in 2010.

While concentrations in Angora Creek are still higher than historic conditions, no effects have been seen further downstream in the Upper Truckee River or in Lake Tahoe. A full report of the study was published in the journal Biogeochemistry in 2011.

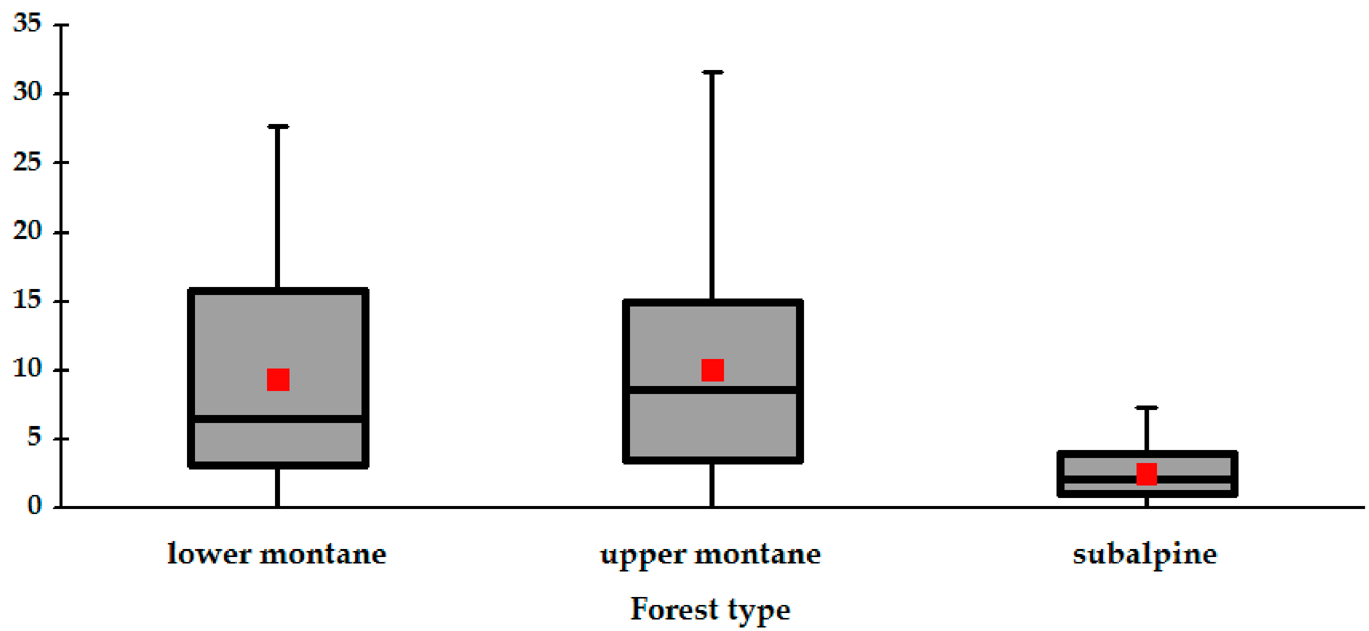
	Baseline Concentration 1991 - 2000	Post - Angora Fire		
		2008	2009	2010
Nitrate	6 μgN/L	12.2 x	8.2 x	1.3 x
Total nitrogen	154 μg/L	1.0 x	1.7 x	1.6 x
Soluble phosphorus	3 μg/L	2.0 x	1.7 x	1.7 x
Total phosphorus	15 μg/L	1.3 x	1.6 x	1.7 x
Suspended sediment	2.0 mg/L	1.9 x	2.3 x	1.8 x
Turbidity	0.55 NTU	2.9 x	4.5 x	3.8 x
Conductivity	23 μS/cm	1.7 x	1.8 x	1.2 x

Tree mortality

From 2007 to 2009 forest health assessments (observations of pathogens, insects, and mortality) were made across elevation zones in the Lake Tahoe Basin by researchers from the UC Davis and USDA Forest Service collaborators.

These are long-term monitoring plots to evaluate changes in forest health conditions in the Lake Tahoe Basin.

The highest levels of mortality were found in upper montane forests (dominated by red fir and western white pine), followed by lower montane mixed-conifer forests (white fir, Jeffrey pine, sugar pine and incense cedar), with the lowest levels of mortality in subalpine forests dominated by whitebark pine.



Tree mortality, continued

As shown, bark beetles and dwarf mistletoes are the most common forest pests found across forest types. Dwarf mistletoe, root diseases, and white pine blister rust, in combination with drought stress, can predispose trees to bark beetle attack and subsequent beetle-mediated mortality.

High disease pressure is found in the Lake Tahoe Basin by the invasive and exotic pathogen, Cronartium ribicola (cause of white pine blister rust), infecting sugar pine (lower montane), western white pine (upper montane), and whitebark pine (subalpine). Adverse effects of white pine blister rust are on cone production (i.e. reproductive output) and survival of small- and intermediate-sized trees.