EXECUTIVE SUMMARY

The long-term data set collected on the Lake Tahoe ecosystem by the University of California, Davis, and its research collaborators is an invaluable tool for understanding ecosystem function and change. It has become essential to public agencies tasked with restoring and managing the Tahoe ecosystem, in part because it allows for the monitoring of progress toward reaching Tahoe's restoration goals and desired conditions.

This annual *Tahoe: State of the Lake Report* presents 2009 data in the context of the long-term record. While the focus is on data collected as part of ongoing, long-term measurement programs, this year we have also included updates on current research related to the impacts of the Angora Fire and the Asian clams on Lake Tahoe.

The report also includes data about changes in the algae composition and concentration, lake clarity and the effects of climate change on snowmelt timing, lake water temperature and density stratification. The UC Davis Tahoe Environmental Research Center has developed sophisticated computer models that help scientists more accurately predict how Lake Tahoe's ecosystem behaves. Long-term data sets are essential to refine the accuracy of those models and to develop new models as knowledge increases and new challenges arise. In times of rapid change, reliable predictive models are indispensable tools for Lake Tahoe Basin resource managers.

This report is available on the UC Davis Tahoe Environmental Research Center website (terc.ucdavis.edu).

Here are some of the highlights presented in the following pages.

RECENT RESEARCH UPDATES

Angora Fire

- Most nutrient and sediment concentrations in Angora Creek increased for the two years since the fire.
- Despite an increase in phosphorus and other constituent loads immediately downstream of the burn area, the overall impact on the Upper Truckee River and Lake Tahoe was insignificant.

Asian clams

- A control methodology to use rubber mats to deprive invasive clams of oxygen was tested and found to produce 100 percent mortality in Asian clams
- A large scale experiment is currently underway to test the long term effectiveness and deployment costs of an expanded control program.
- A multi-agency boat launch inspection and education program for all invasive species is an important component of the invasive species strategy. Over 20,000 boats were inspected in 2009, Mussels were found on ten of them.

METEOROLOGY

The Lake Tahoe ecosystem is highly influenced by meteorology. In the short term, meteorological conditions are expressed as daily variations in weather. In the long term, they are expressed as normal cyclical variations such as wet and dry cycles, and long-term trends related to global climate change.

Historical record:

- The nightly minimum temperatures recorded at Tahoe City have increased by more than 4 degrees F since 1910. (Fig. 7.1)
- Days when air temperatures averaged below freezing have generally decreased by 30 days per year since 1910, although 2009 was a colder than average year. (Figs. 7.2 and 7.3)
- Since 1910, the percent of precipitation that fell in the form of snow decreased from 52 percent to 34 percent. (Fig. 7.7)
- Peak snow melt averages 2 1/2

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[1]*"Previous year" for some parameters means data collated in terms of the water year, which runs from October 1 through September 30; for other parameters, it means data for the calendar year, January 1 through December 31. Therefore, for this 2010 report, water year data are from Oct. 1, 2008 through Sept. 30, 2009. Calendar year data are from Jan. 1, 2009 through Dec. 31, 2009.*

EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.1)

weeks earlier than in the early 1960s. (Fig. 7.8)

Previous year:

- Precipitation in 2009 was slightly below the long-term average, but significantly wetter than the previous two years. This was largely due to exceptionally high spring precipitation (March and May). (Figs. 7.5 and 7.6).
- The decline in the percent of snow in 2009 was consistent with the long-term trend.

PHYSICAL PROPERTIES

Lake Tahoe's physical properties are largely a response to external factors, especially meteorology. Physical properties, in turn, determine the environment for all the lake's chemical and biological processes (see next sections).

Historical record:

- Lake level fluctuates throughout the year, and from year to year (Figs. 8.1 and 8.2)
- Water temperature (volume averaged) rose by more than 1 degree F in the past 38 years. (Fig 8.3)
- Surface water temperatures have risen since data collection commenced. (Figs. 8.4, 8.5 and 8.6)
- Density stratification of Lake Tahoe has increased over the last 39 years as surface water warmed due to climate change. (Fig. 8.8)

Previous year:

- In 2009, lake level fell to a low of 6222.76 feet on December 31, almost 3 inches below the natural rim. (Figs. 8.1 and 8.2). For over two months there was not outflow from Lake Tahoe to the Truckee River.
- Winter surface water temperatures were higher in 2009, due to the absence of deep mixing. (Fig. 8.5).
- The maximum depth of mixing in 2009 was approximately 700 feet. (Figs. 8.7 and 8.9).

NUTRIENTS AND PARTICLES

Lake Tahoe's clarity is determined especially by fine sediment particles, and also by nutrients. Tahoe's urban areas contribute 72% of fine particles, despite representing only 10% of the land base. Nutrients affect lake clarity by promoting algae growth. Offshore, algae make the water greenish and less clear. Along the shoreline, algae are a problem because it coats rocks with green slime.

The two nutrients that most affect algal growth are nitrogen and phosphorus. These nutrients are measured at various depths at TERC's mid-lake and western lake stations. One form of nitrogen that is readily available to algae—nitrate—enters the lake through stream and urban runoff, groundwater and atmospheric deposition. Phosphorus occurs naturally in Tahoe Basin soils and enters the lake from soil disturbance and erosion, as well as atmospheric deposition.

Historical record:

- Stream inputs of particles, nitrogen and phosphorus are directly linked to the annual amount of precipitation to the annual amount of precipitation via runoff and stream flow. (Figs. 9.3 to 9.5)
- Atmospheric deposition of nutrients, both in concentration and total loads, are also linked to precipitation. (Figs 9.6 and 9.7)
- Nitrogen concentrations in the lake have remained generally constant for many years. (Fig. 9.8)
- Phosphorus concentrations in the lake have been generally declining. (Fig. 9.9)

Previous year:

- The west-side watersheds contributed far more particles and nutrients to Lake Tahoe in 2009 (a three-fold increase over 2008). The east-side streams were similar to 2008. This is a reflection of the dry conditions of the previous two

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EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.2)

years. (Fig. 9.2)

- In 2009, the volume-weighted, annual average concentration of available phosphorus was just under 1.4 micrograms per liter (parts per billion); the lowest value since continuous monitoring began in 1980. (Fig. 9.9)
- The lowest concentration of particles in the lake occurred immediately after mixing in late February. The highest concentration is during the spring snowmelt in April. (Fig. 9.10)
- The highest concentrations of fine particles were in the Upper Truckee River, followed by Ward, Trout and Incline Creeks. (Fig 9.11).

BIOLOGY

The longest data sets for lake biology come from the base of the food web—the free-floating algae (or phytoplankton). This algae influences the lake's food web, clarity and aesthetics.

Historical record:

- Primary productivity, the rate at which algae produce biomass through photosynthesis, has been generally increasing since 1959. (Fig. 10.1)
- The average annual abundance of algae (by concentration of chlorophyll-a) has remained relatively uniform since 1996. (Fig 10.2)
- Since 1984, the annual average depth of the deep chlorophyll maximum has declined. (Fig. 10.4)
- Diatoms remain the dominant algal species and provide high quality food for aquatic species. (Fig 10.6)
- While phosphorus limited in the early part of the year, the lake is generally co-limited (needing both nitrogen and phosphorus) for optimum algal growth. (Fig. 10.8)

Previous year:

- Periphyton (attached algae) concentrations were similar to values recorded in 2008, with the exception of Tahoe City, which experienced a 60 percent decrease to the highest values ever recorded at that site. (Fig. 10.9)
- Periphyton distributions were significantly elevated along the north-east shoreline of the lake. (Fig. 10.10)

CLARITY

Clarity remains the indicator of greatest interest for Lake Tahoe because it tracks both degradation and the community's efforts to restore clarity to historic levels. Secchi depth (the point below the lake surface at which a 10-inch white disk disappears from view) has been measured continuously since 1968, and is the longest continuous measure of Lake Tahoe's water clarity.

In 2009, the annual average Secchi depth was 68.1 feet, a decline of approximately 1.5 feet from the previous year. This can in part be explained by the higher precipitation, particularly the high spring precipitation. Summer Secchi depths were significantly improved on the previous year, with an increase in summer clarity of over 10 feet.

In the last nine years, Secchi depth measurements have been better than predicted by the long-term linear trend. There is statistical support that Lake Tahoe's clarity decline has slowed significantly, and is now best represented by a curve. (Fig. 11.1)

EDUCATION AND OUTREACH

The public can learn about the science behind Lake Tahoe restoration at TERC's Incline Village education center (the Thomas J. Long Foundation Education Center). In 2009, over 9,400 people participated in our education and outreach activities. (Fig. 12.1)

There is now a second science education center located at the Tahoe City Field Station (Eriksson Education Center).

For more information about our education centers or education programs, contact tercinfo@ucdavis.edu or visit http://terc.ucdavis.edu.