TAHOE: STATE OF THE LAKE REPORT 2010

RECENT RESEARCH UPDATES

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Overview

Each year a different research areas emerge as the most topical in the State of the Lake Report. In the 2008 report, the focus was on the response of Lake Tahoe to the immediate effects of the Angora Fire, which had burned 3100 acres of the southern basin the previous July. With the discovery of an invasion of Asian clam in Lake Tahoe in 2008, the 2009 State of the Lake Report described the initial observations of this most recent threat.

This year the State of the Lake Report will revisit both of these topics, and provide an overview of recent research advances that have been made in relation to each topic.

The Angora Fire threatened water quality in Angora Creek, Upper Truckee River and Lake Tahoe with the potential for ash and sediment delivery to receiving waters in and downstream of the fire.
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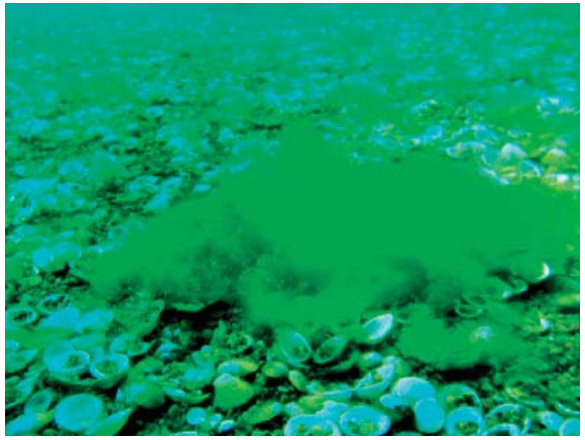

An extended algal bloom, resulting from the clams concentrating nutrients, can have long lasting impacts on the nearshore condition of Lake Tahoe. Residual dead and dying algae are washed up onto beaches where they decompose and influence nearshore water quality.

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Angora Fire

While the impacts of the Angora Fire on Lake Tahoe due to the immediate atmospheric deposition were limited, larger concerns remained about the longer term inputs from stream flow from the burned watershed. With primary funding from the Lahontan Regional Water Quality Control Board, the US Army Corps of Engineers by way of a cooperative agreement with the California Tahoe Conservancy, and the US Forest Service – Lake Tahoe Basin Management Unit, researchers from UC Davis and the Desert Research Institute have been monitoring the stream intensively since the fire. The complete report *Water Quality Conditions Following the 2007 Angora Wildfire in the Lake Tahoe Basin*. 2010. J. Reuter, A. Heyvaert, A. Oliver, A. Parra and R. Susfalk has been submitted to Tahoe management agencies for review and comment. The US Geological Survey - Carson City, NV also contributed to this project by establishing and monitoring a new sampling station on Angora Creek near its confluence with the Upper Truckee River.

Smoke from the Angora Fire rises above Lake Tahoe. Photo courtesy of Timothy D. Rains.

The aftermath of the fire in the Angora Creek watershed.

RECENT RESEARCH UPDATES: ANGORA FIRE

Nutrient concentrations for Angora Creek for several time periods

Water quality data collected at a monitoring site on Angora Creek, just upstream from an urban subdivision, allowed for an evaluation of pre-fire and post-fire sediment and nutrient concentrations in the creek. This site represents the cumulative effects of the burned, undeveloped, upland forest where both the erosion hazard and the severity of the fire were high. An historic dataset from this site from an earlier erosion control project, collected by the USFS – Lake Tahoe Basin Management Unit between 1991-2001, proved invaluable for this comparison. All the measured nutrient and sediment constituents, shown below, indicate a post-fire increase in nutrient concentrations – especially for nitrate (a form of nitrogen available to algae). An eventual decline in nitrate, as seen in 2009, is typically reported from many wildfire sites. All the other constituents, except soluble reactive phosphorus (SRP), showed an increase in concentration in Year 2 (2009), presumably due to increased precipitation and flow. Other studies in the western US suggest a period of 3-10 years is needed for a recovery to near-baseline conditions. There was no evidence of massive sediment or nutrient inputs from the burned area into Angora Creek.

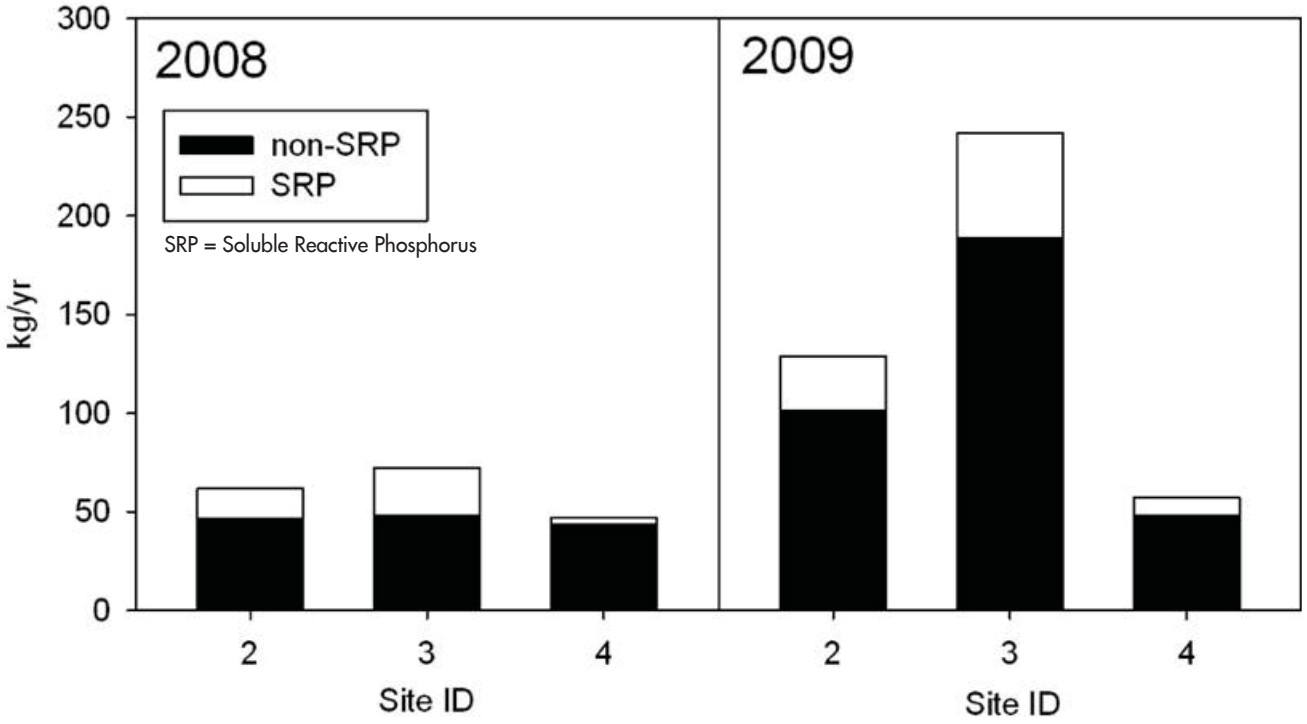
	Pre-Erosion Project 1991 - 1997	Post-Erosion Project 1998 - 2001	Post- Angora Fire 2008	2009
Precipitation Range (inches/year)	36 - 91	34 - 73	40	54
Nitrate (µg/L)	6 ± 3	12 ± 11	72	59
Total Nitrogen (µg/L)	134 ± 45	190 ± 55	280	360
Soluble Reactive Phosphorus (µg/L)	2 ± 1	4 ± 2	7	7
Total Phosphorus (µg/L)	15 ± 5	15 ± 2	22	39
Total Suspended Sediment (mg/L)	2.4 ± 1.3	1.4 ± 0.8	3.4	6.5
Turbidity (NTU)	0.5 ± 0.1	0.9 ± 0.4	1.6	3.1

Data courtesy of DRI and UC Davis

RECENT RESEARCH UPDATES: ANGORA FIRE

Annual load of phosphorus as measured at three sites in WY 2008 and WY 2009

The annual downstream load of phosphorus carried by Angora Creek since the fire was evaluated at three monitoring sites downstream of the burn area. Sites 2 and 3 were located on Angora Creek immediately upstream and immediately downstream of the urban subdivision, while site 4 was positioned near the confluence of Angora Creek and the Upper Truckee River. Total Phosphorus load increased as the creek flowed through the urban landscape. This difference was most significant in Water Year (WY) 2009 when precipitation and flow was higher. In WY 2008, phosphorus load declined by approximately 35 percent before reaching the Upper Truckee River while in WY 2009 this reduction was 75 percent. The load reduction was most likely related to groundwater infiltration, which is characteristic of the wet meadow. In years of higher flow the wet meadow vegetation should act to also reduce downstream transport. Nitrogen showed a similar pattern.

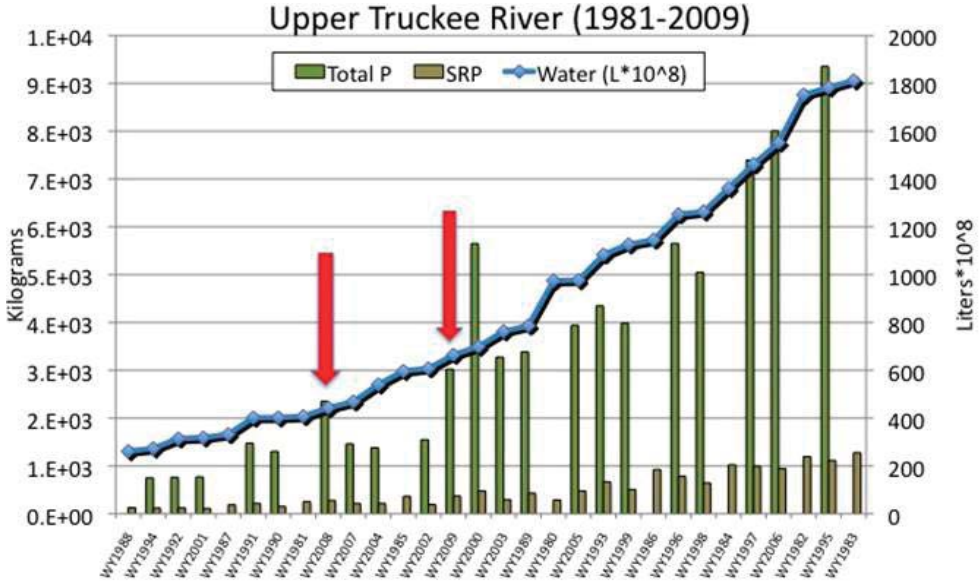


Data courtesy of DRI and UC Davis

RECENT RESEARCH UPDATES: ANGORA FIRE

Annual loads of total phosphorus and soluble reactive phosphorus following the Angora fire

Following the Angora Fire there was concern that ash-laden runoff could travel down Angora Creek, into the Upper Truckee River (UTR) and consequently into Lake Tahoe. To determine if the impact of the Angora Creek fire-derived load could be seen in the annual nutrient load of the much larger UTR, the extensive database provided by the Lake Tahoe Interagency Monitoring Program (27-year pre-fire record) was utilized. Since nutrient concentration and load depend on hydrologic patterns and amount of flow, a total of 16 years from the historical database were selected to represent the flow and nutrient conditions in the Upper Truckee River. The annual UTR flows were plotted in increasing order for every year between 1981 and 2009 (blue line). The total P and SRP loads for the corresponding loads were plotted as bars on the same figure. Flow and load of total phosphorus and soluble phosphorus from Angora Creek in Water Years 2008 and 2009 had no statistically significant impact on the UTR. The red arrows in the charts below denote Water Years 2008 and 2009. Both fit within the accepted flow versus nutrient load relationship seen historically for the Upper Truckee River. Data for suspended sediments, total nitrogen and dissolved nitrogen showed similar relationships.



P = Phosphorus
SRP = Soluble Reactive Phosphorus

Data courtesy of DRI and UC Davis

RECENT RESEARCH UPDATES

Asian clams

Since the discovery of Asian clams (Corbicula fluminea) in large numbers in the south-east of Lake Tahoe in 2008, both the research community and management agencies operating in the Basin have responded swiftly. The multi-agency Lake Tahoe Aquatic Invasive Species Program was established to coordinate basin-wide prevention, control and eradication efforts. As part of the control efforts of this multi-agency partnership, a team of researchers from UC Davis TERC and the University of Nevada, Reno, have been conducting experiments to better understand the distribution and the behavior of Asian clams in Lake Tahoe as well as impacts to native biodiversity and nearshore ecology. Much of this effort has been focused on devising ways to control the spread and reduce the present concentrations of these invasive invertebrates in Lake Tahoe. Funding for these efforts have come from a variety of sources, including the Lahontan Regional Water Quality Control Board, Nevada Division of State Lands, the Tahoe Regional Planning Agency, the US Fish and Wildlife Service and the US Forest Service (through the Southern Nevada Public Lands Management Act). In addition, the Tahoe Resource Conservation District, California State Parks, Nevada Department of Wildlife, Tahoe Water Suppliers Association, Nevada Division of Environmental Protection and California State Lands Commission are members of this multiagency partnership. The localized populations of Asian clams in Lake Tahoe have densities amongst the highest observed worldwide, with over 6000 clams per square yard in the most heavily infected regions. The clams are present in highest concentration at water depths of between 20 to 30 feet, although they have been found at water depths in excess of 200 feet. Typically the clams burrow into sandy sediments to a depth of about 2 -3 inches.

Asian clams recovered from Lake Tahoe by UC Davis TERC researcher Marion Wittmann.

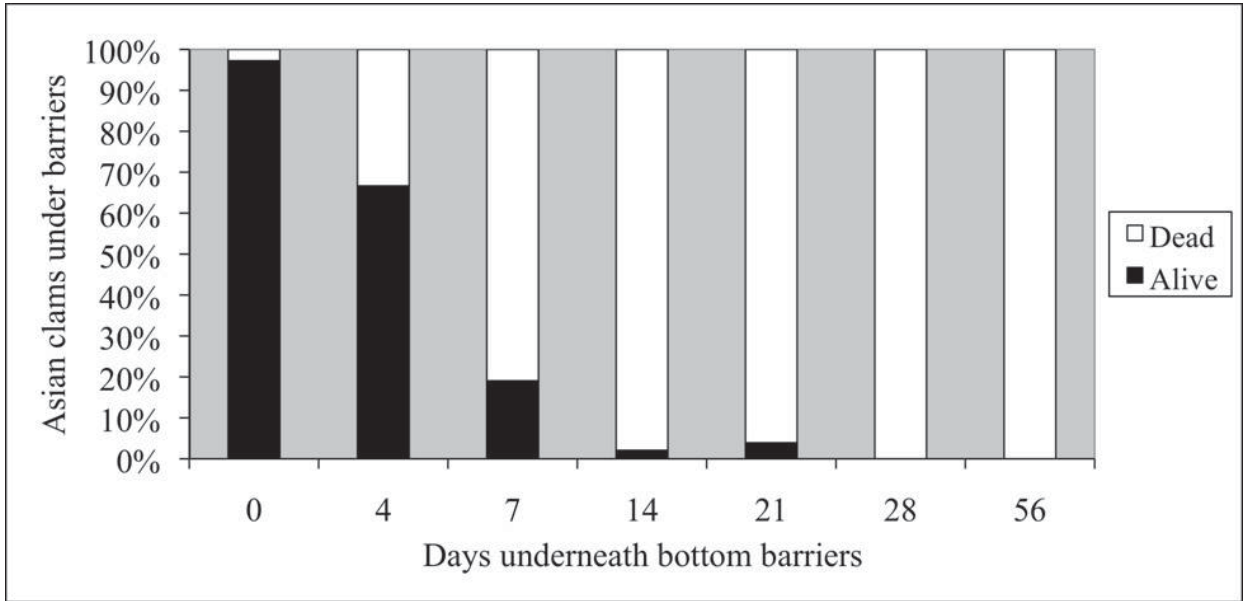
UC Davis TERC divers roll out rubber bottom-barrier mats to reduce oxygen levels below survivable concentration for clams.

The first 100 foot long strip of rubber mat laid out on the lake bottom is visible in Marla Bay on July 9, 2010.

RECENT RESEARCH UPDATES: ASIAN CLAMS

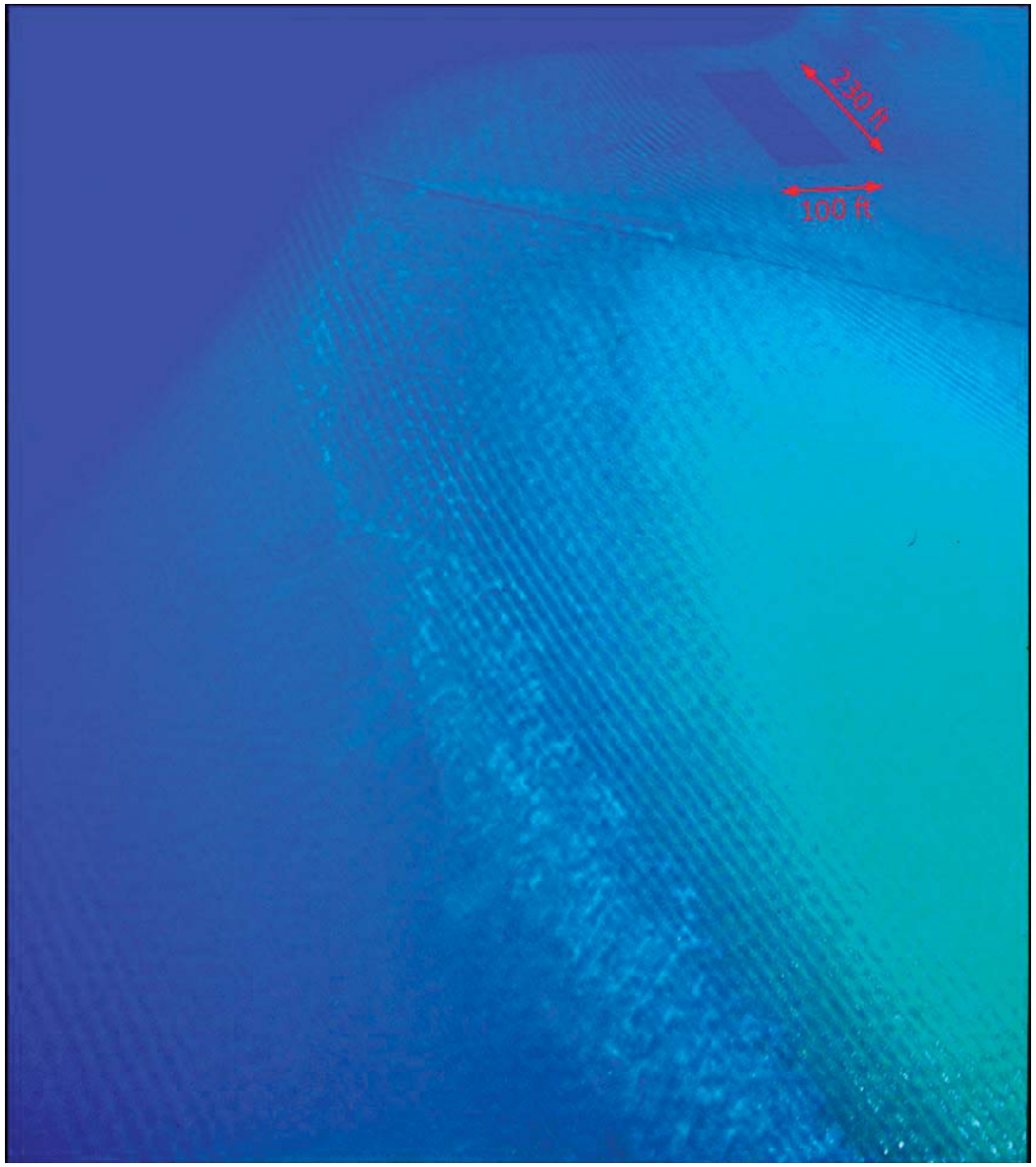
The percentage of Asian clam mortality under the bottom barriers. After 28 days all Asian clams were killed.

The control strategy that is currently being pursued is the application of thin rubber sheets (or barriers) on the lake bottom. These barriers have been shown to cut off the oxygen supply to the clams. The figure below shows the rate at which the Asian clams are killed following the application of the rubber barriers. Although oxygen concentrations immediately below the mats is reduced to zero within 2 days, it took approximately 4 weeks to kill all Asian clams under the barriers at peak summer water temperatures. These results were obtained during summer 2009, using small (10 feet x 10 feet) rubber barriers. Larger scale (100 feet x 230 feet or about ½ acre) barriers are now being tested at two locations in the lake to determine the cost and practicality of these large-scale deployments. Figure 6.8 shows one of the test sites in Marla Bay. The dark blue water indicates a sharp drop in the lake depth. The rectangular barrier test area is clearly visible in the upper right hand corner of the photograph. The thin line across the upper part of the image is a drinking water intake line. The whitish arc extending from the lower right hand corner to the upper central part of the photograph are clam shells (from dead clams) laying on the lake bottom at approximately 30 - 40 feet water depth.



Data courtesy of UC Davis TERC and UNR

RECENT RESEARCH UPDATES: ASIAN CLAMS



Aerial photograph of one of the bottom barrier test sites (courtesy B. Allen, UC Davis TERC)

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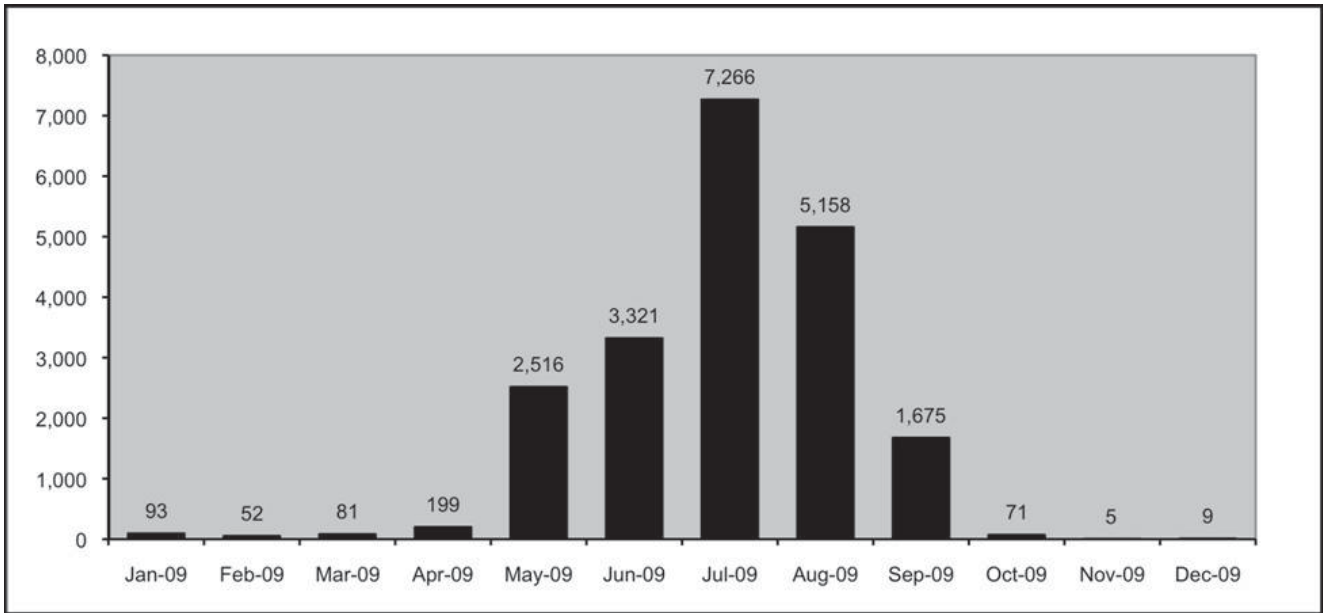
The number of boats inspected at Lake Tahoe during 2009

In parallel with the research effort being conducted by the research community to control species present in Lake Tahoe, management agencies have been actively engaged in preventing new introductions of invasive species. Central to this effort is a comprehensive boat inspection program carried out by the Tahoe Regional Planning Agency and the Tahoe Resource Conservation District, and funded by the U.S. Fish and Wildlife Service. These agencies have developed one of the most comprehensive recreational boat inspection programs in the United States. The program was first implemented in 2008. Through this program, every boat entering Lake Tahoe is inspected for aquatic invasive species at boat inspection stations that are located at entry ways to the Tahoe Basin. The primary target of the boat inspections are quagga mussels. Although quagga mussels are not yet in Lake Tahoe, they do exist in several water bodies in California and Nevada, and can readily be transported by attaching to boats. The figure below provides the Lake Tahoe boat launch data for 2009. There were over 20,446 launch inspections performed during 2009, with the largest number being in July (7266). Approximately 63 percent of the boats were from California and over 33 percent were from Nevada. Quagga and zebra mussels were found on 10 of the 20,446 boats inspected; these vessels were quarantined and not permitted to enter the lake upon discovery of invasive mussels. Quagga mussels can inflict tremendous economic and ecological damage to lakes once they become established.



Data courtesy of K. Kasman and T. Thayer, TRPA