Lake Almanor Water Quality Report, 2009

Prepared for

Plumas County Flood Control & Water Conservation District
and
Almanor Basin Watershed Advisory Committee

By

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Submitted December 2009

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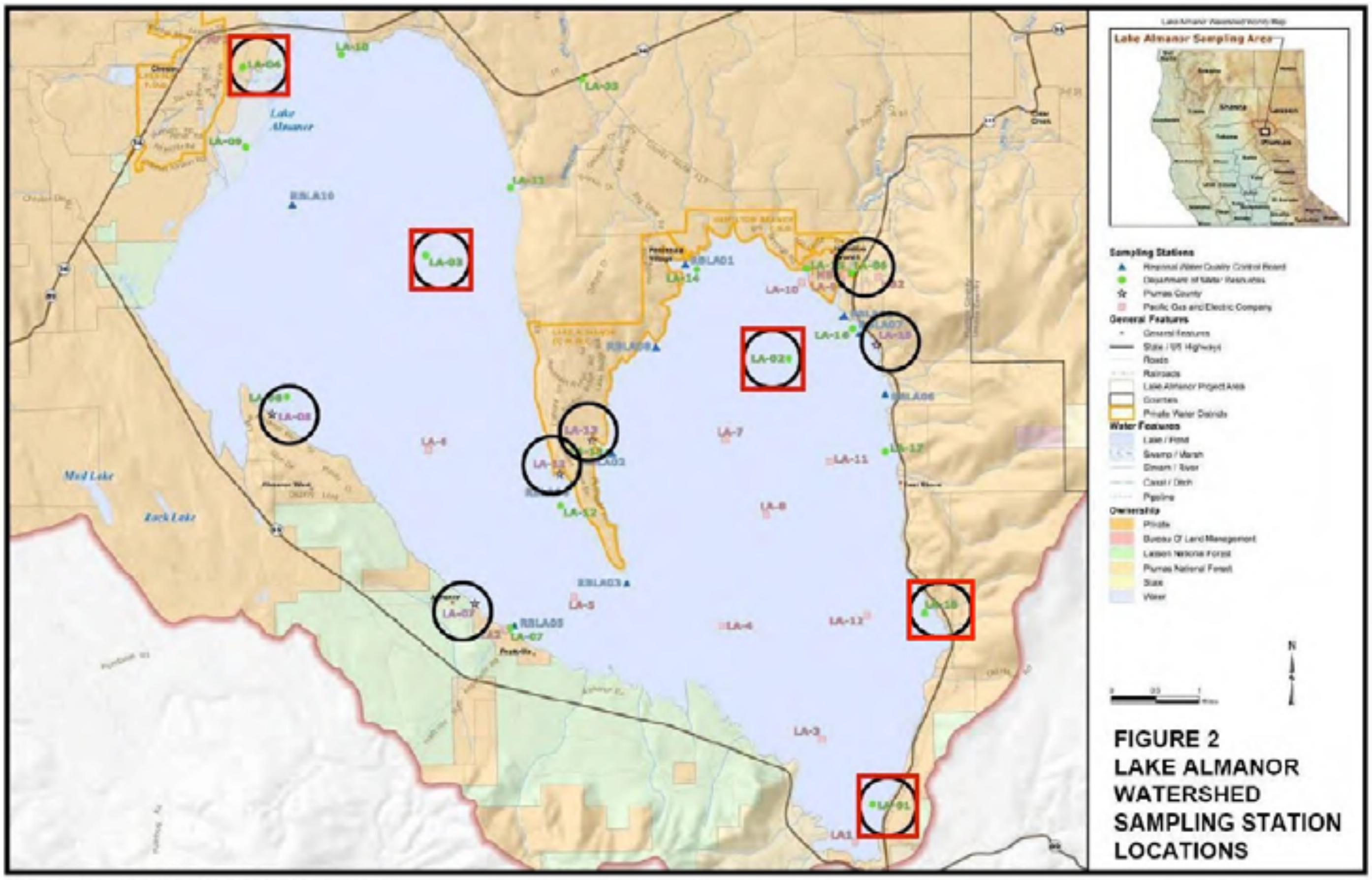
Introduction and Project Overview

A water quality monitoring program for Lake Almanor was conducted during 2009. The Plumas County Flood Control and Water Conservation District, in conjunction with the Almanor Basin Watershed Advisory Committee (ABWAC), provided oversight for the contract. Due to the limited funds available for this project, ABWAC selected some of the important parameters that had been monitored in the past by California Department of Water Resources (DWR), the County of Plumas and Pacific Gas & Electric Company. Four sampling windows were chosen for sampling to provide a look at lake health: during spring turnover (April 6-11), the period of heavy recreational use (July 6-11 and August 31- September 5) and fall turnover (November 16-21). Four stations in the lake were selected: LA-01, near the Canyon Dam Intake Tower; LA-02, in the east lobe; LA-18, near the east shore; and LA-03, in the west lobe. A station in Chester (LA-04) was selected for monitoring the North Fork of the Feather River just prior to discharge into the lake. Their locations are shown in Figure 1. The parameters and sampling times are shown in Table 1, below.

Table 1. Lake Almanor Parameters Monitored in 2009

Parameter	Specific Parameters	Locations	Sampling Window
Physical	Temperature Dissolved oxygen Electrical Conductivity Turbidity Secchi depth	LA-01 LA-02 LA-03 LA-04 (no secchi)	April July August November
Organics (petroleum products)	TPH BTEX	LA-02 LA-18	July August
Plankton	Zooplankton Phytoplankton	LA-02 LA-03	April July August November
Metals	Calcium	LA-03	April
Nutrients	Total phosphorus Total nitrogen	LA-02 LA-03	April

Figure 1. Sampling Station Locations in Lake Almanor (Adapted from Lake Almanor Watershed Water Quality Report, CH2M HILL , April 2006). Note: LA-01, LA-02, LA-03, LA-04 and LA-18 (highlighted in red) were used in this investigation.



Methods Used for Sampling and Analysis

a. Procedures for Field Measurements: Temperature, Dissolved Oxygen, pH, Electrical Conductivity, Turbidity and Secchi Depth

   Temperature, dissolved oxygen, pH and electrical conductivity were measured with a Hydrolab Surveyor 4 water quality meter equipped with these probes. All probes were calibrated in the lab prior to each field measurement day. The probes were lowered into the water column and readings were taken at 0.5 meter below the surface and at every two meters to within one meter of the lake bottom.

   Water samples for turbidity measurement were collected at three depths (0.5 meter below the surface, 3.0 meters below the surface and 1.0 meter above lake bottom). Turbidity was measured using a Hanna Instruments turbidimeter in the lab.
   Secchi disk transparency was measured using a standard Secchi disk which was lowered on the shady side of the boat. The disappearance and reappearance depth was recorded and averaged.

b. Procedures for Chemical Measurements

   Water samples for chemical analysis were collected with a Van Dorn style 2.2 liter sampler at three depths (0.5 meter below lake surface, 3.0 meters below surface and 1.0 meter above lake bottom). They were poured into appropriate bottles provided by Basic Lab. All samples were stored in a styrofoam ice chest and packed in ice to maintain a temperature of 4° C and dark conditions. They were transported to the Basic Lab branch office in Chico, CA within 24 hours of collection.

   Basic Laboratory in Redding, CA, performed the nutrient (TP, TN and ortho-phosphate) analyses and calcium, as well as the TPH and BTEX analyses. Basic Lab is certified by the California Department of Public Health to conduct all of the above analyses.

c. Procedures for Plankton Collection and Analyses

   Phytoplankton were collected with a Wisconsin type conical net (80 micron mesh) that was pulled from the bottom to the surface to produce an integrated sample. They were preserved with Lugol’s solution, as well as 40% formalin.

   Phytoplankton were counted and were identified to division (Chlorophyta, Chrysophyta, etc.) and to genus when this would allow for comparison with previous data and when the genus would be indicative of water quality.

   Zooplankton were collected with a net towed from the bottom to the lake surface to produce an integrated sample and preserved with 40% formalin solution.

Zooplankton were enumerated and identified to order (Cladocera, Copepoda, etc.) and to suborder or genus when this would allow for comparison with previous data or where the identity has water quality significance. (Again, certain genera are indicators of lake health and it will be important to know their abundance.)

Results and Discussion

1. Physical Parameters

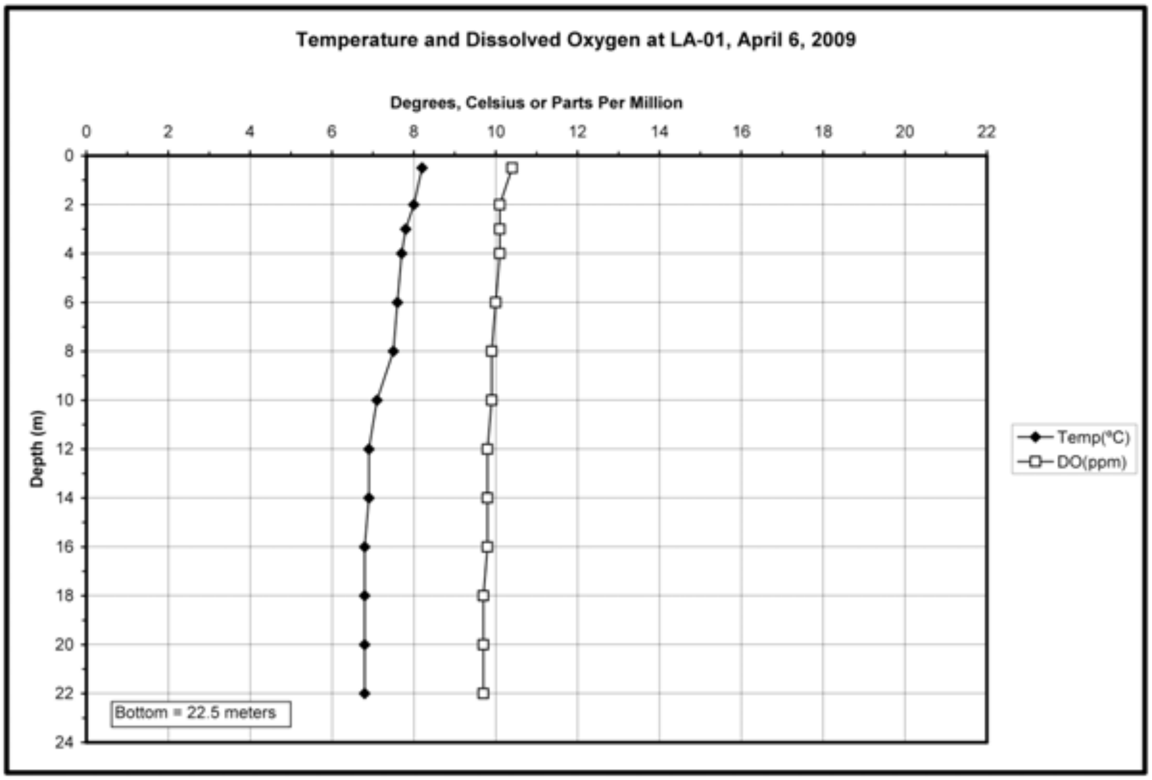
   a. Temperature

      The temperature data are shown in graphic form for each station (See figures 2, 3, 4 and 5, as well as in a table (See Table 1 in Appendix). In April 2009 all three lake stations (LA-01, LA-02 and LA-03) were well-mixed with little temperature difference between surface and bottom. Temperature at the surface was near 8 °C and at the bottom was near 7 °C. By July 2009 the lake was thermally stratified at the two deeper stations. At LA-01 and LA-02 the epilimnion (upper region of well-mixed warm water) was about 21°C. The thermocline (region where temperature change with depth exceeds 1 ºC per meter) at LA-01 was between 8 and 12 meters. At LA-02 it was between 6 and 10 meters.
      The hypolimnion (the region of coldest water below the thermocline) extended from 12 meters to 22 meters at LA-01 and from 10 meters to 16 meters at LA-02. LA-03 did not stratify because it was so shallow that wind could keep it mixed. The temperature in July was about 20 ºC throughout the water column.

      In August 2009 the temperature and extent of the epilimnion had increased at LA-01 and LA-02 and the thermocline had become deeper. At LA-01 the upper 10 meters (the epilimnion) was about 22 ºC, the thermocline extended from 10 meters to 14 meters. The hypolimnion had decreased in volume since July, extending from 14 to 22 meters. At LA-02 the epilimnion extended to 8 meters, and the thermocline extended from 8 meters to the bottom at 14 meters, and there was no hypolimnion. LA-03 remained well-mixed with the temperature at about 21 ºC throughout.

      By November 2009 the lake was no longer thermally stratified. Both LA-01 and LA-02 were about 11 ºC from surface to bottom. LA-03 was about 8 ºC.

Figure 2. Temperature and Dissolved Oxygen at Lake Almanor, Station LA-01, During 2009



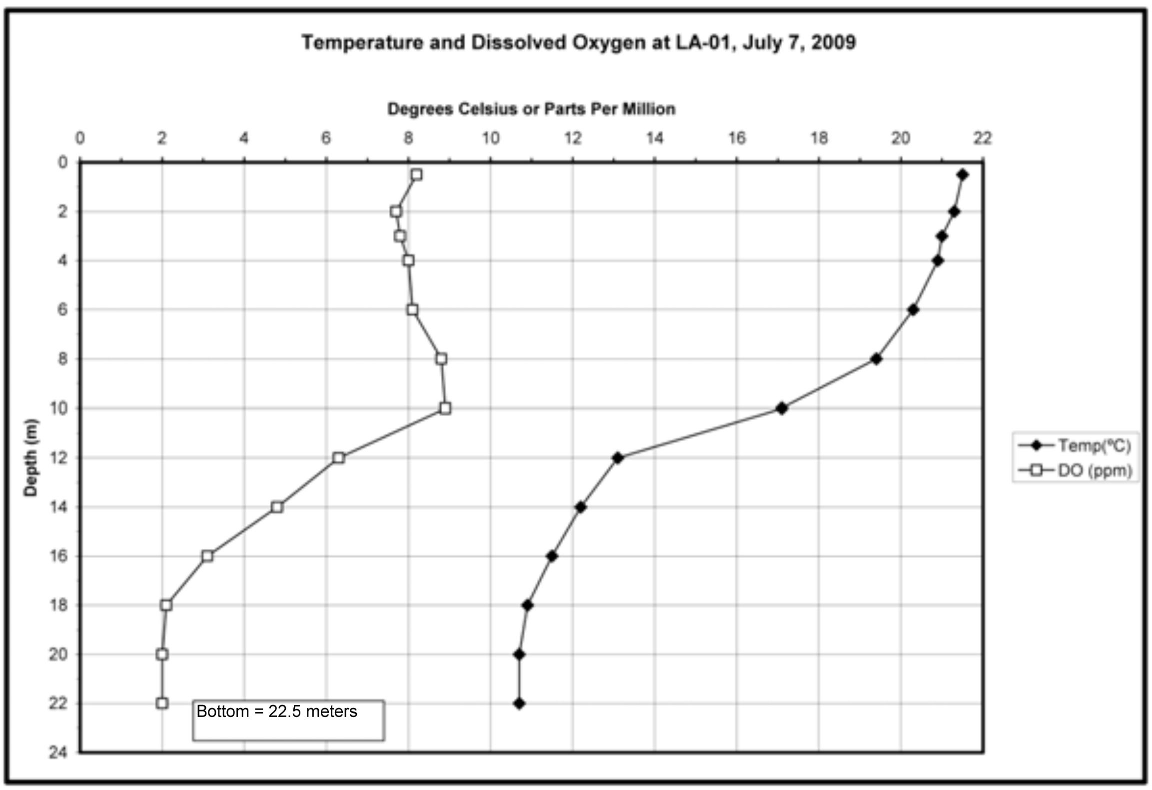
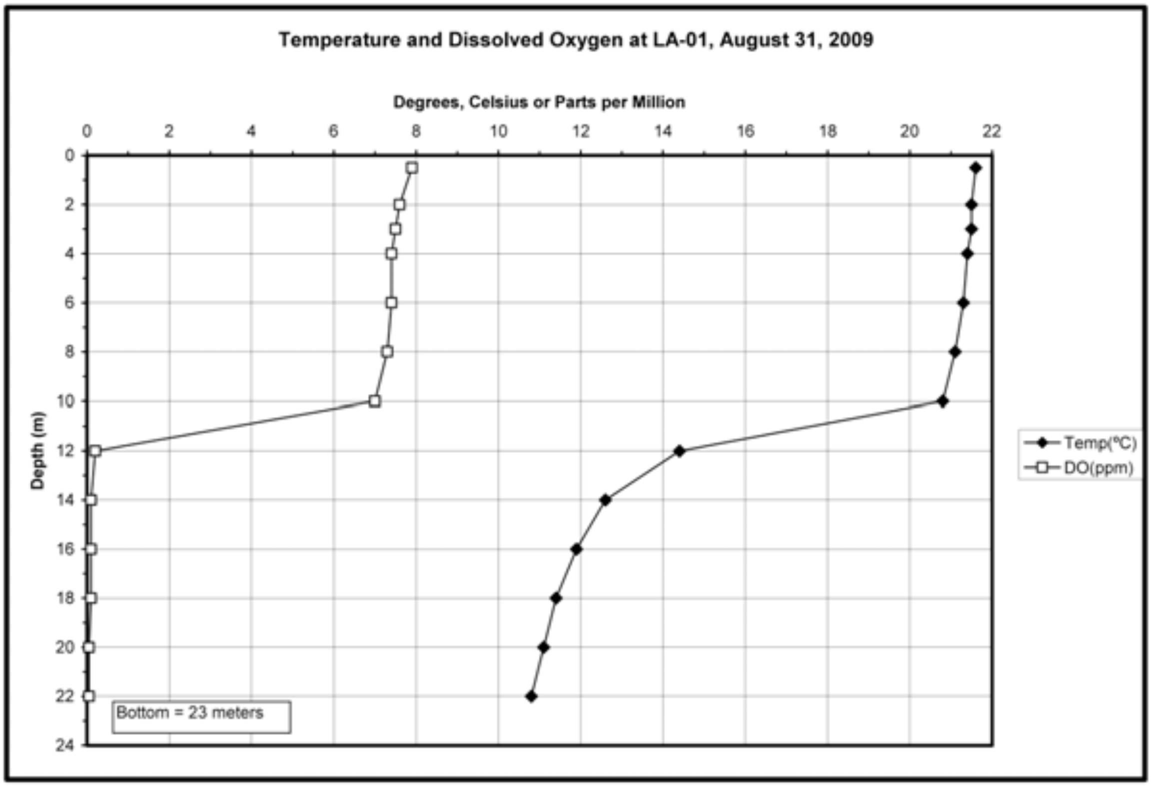


Figure 2 (continued). Temperature and Dissolved Oxygen at Lake Almanor, Station LA-01, During 2009



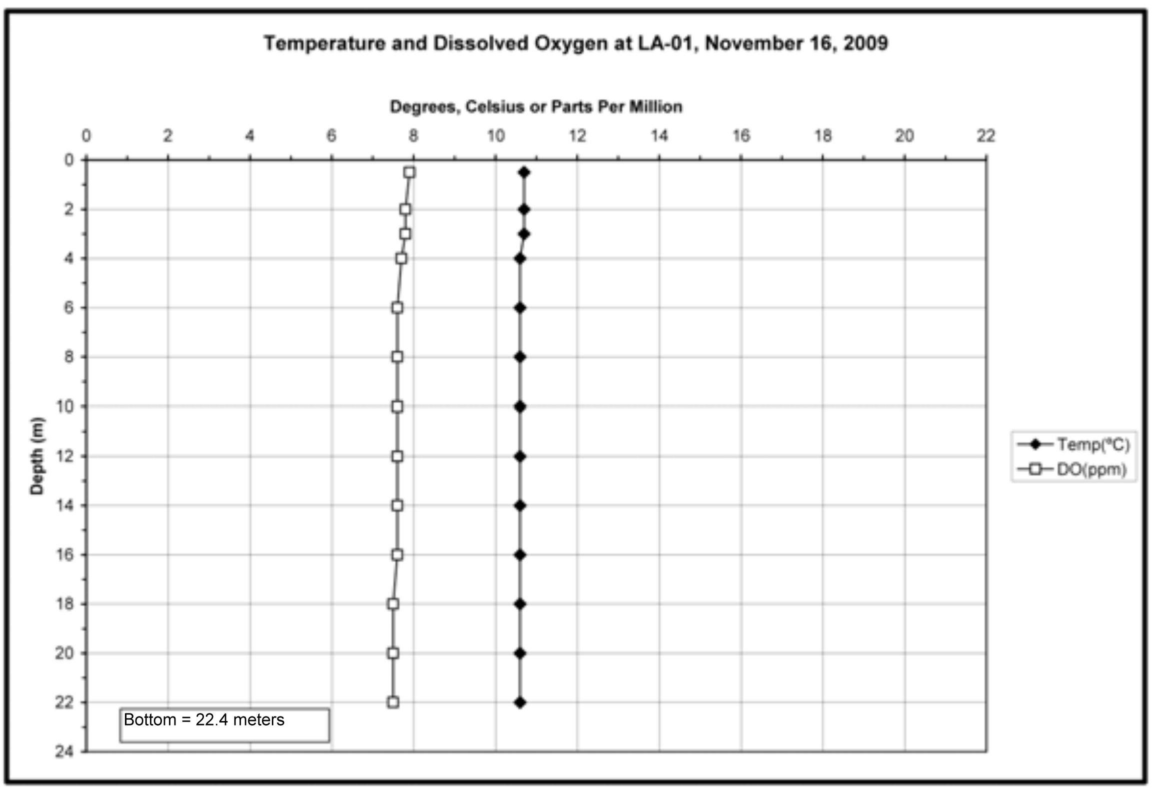
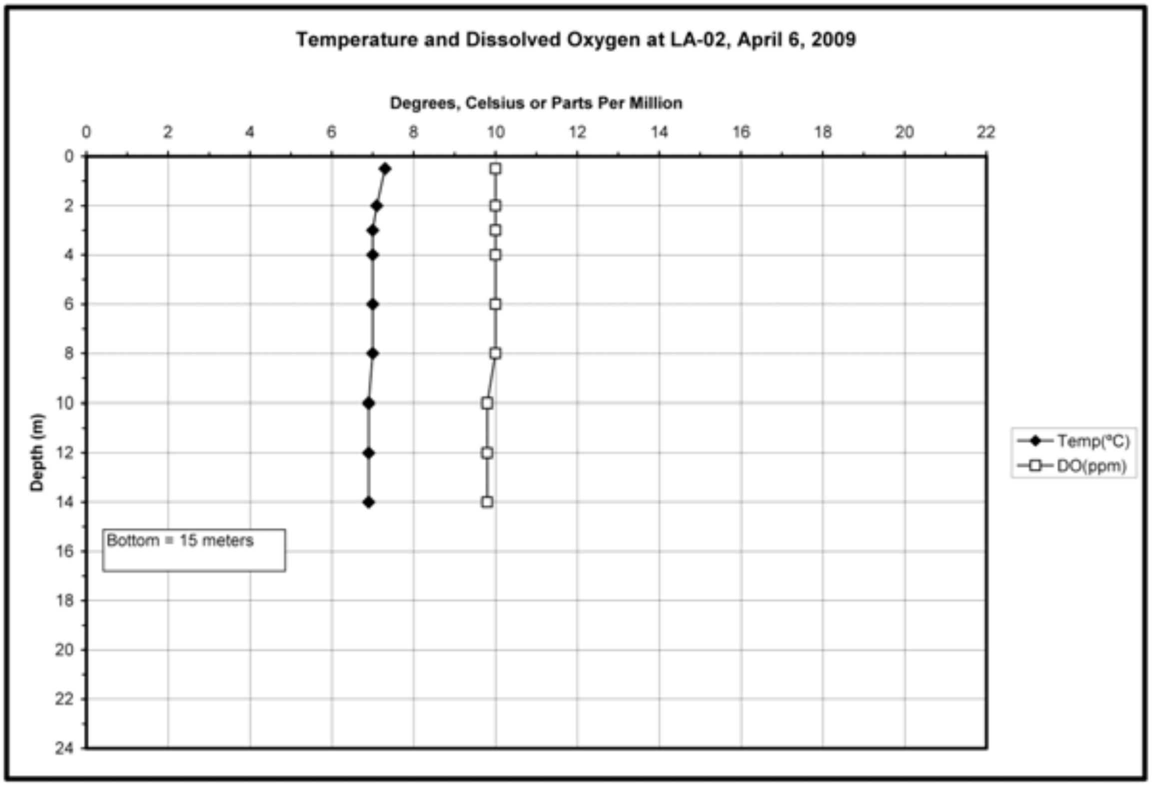


Figure 3. Temperature and Dissolved Oxygen at Lake Almanor, Station LA-02, During 2009



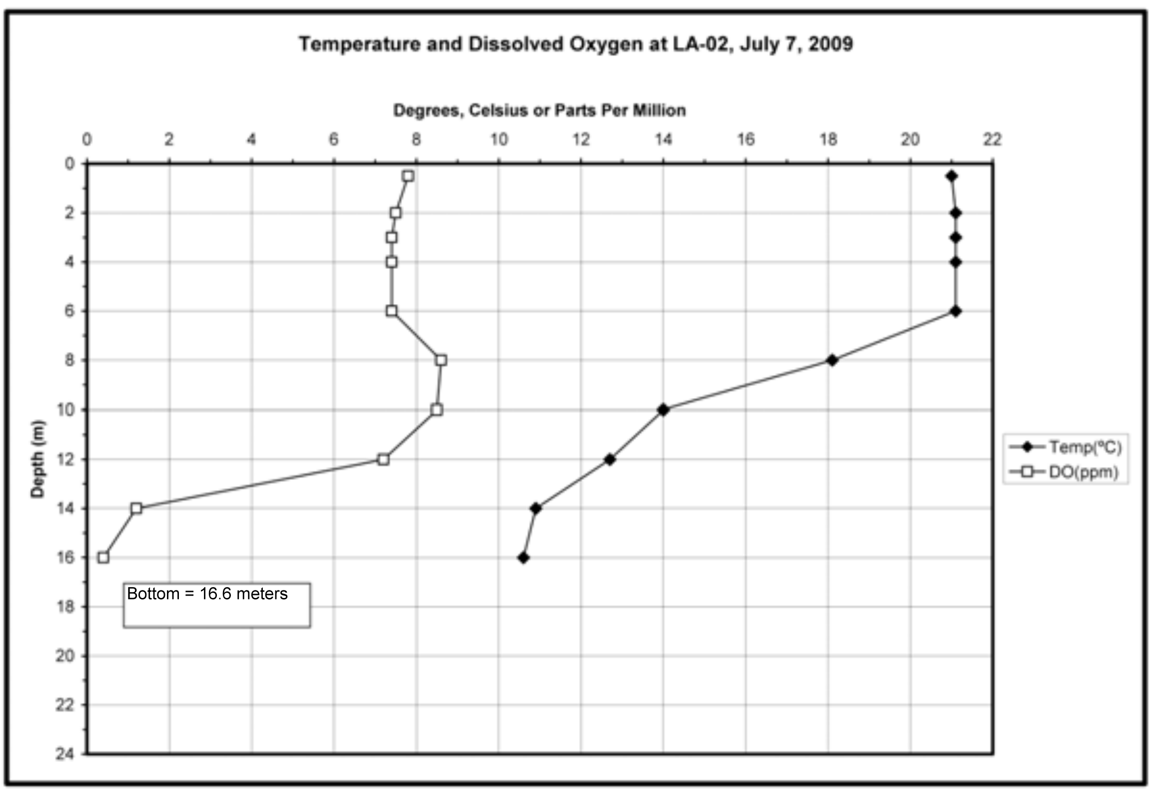
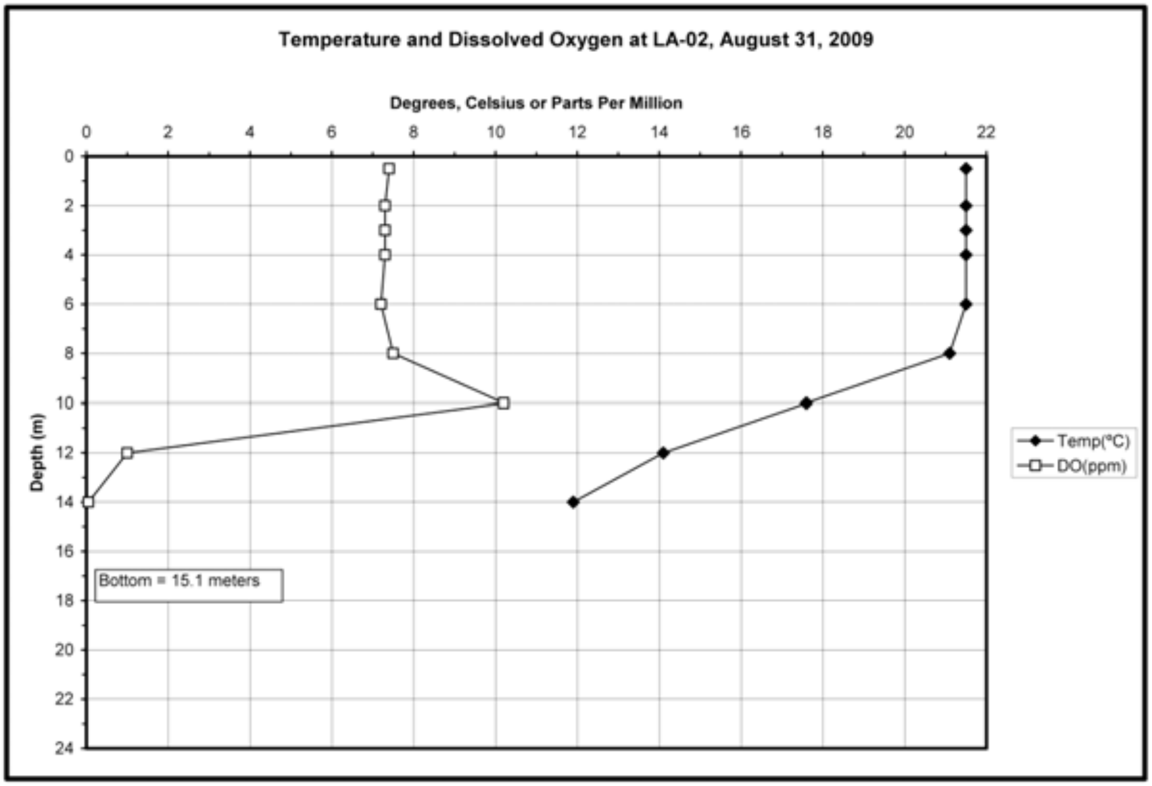


Figure 3 (continued). Temperature and Dissolved Oxygen at Lake Almanor, Station LA-02, During 2009



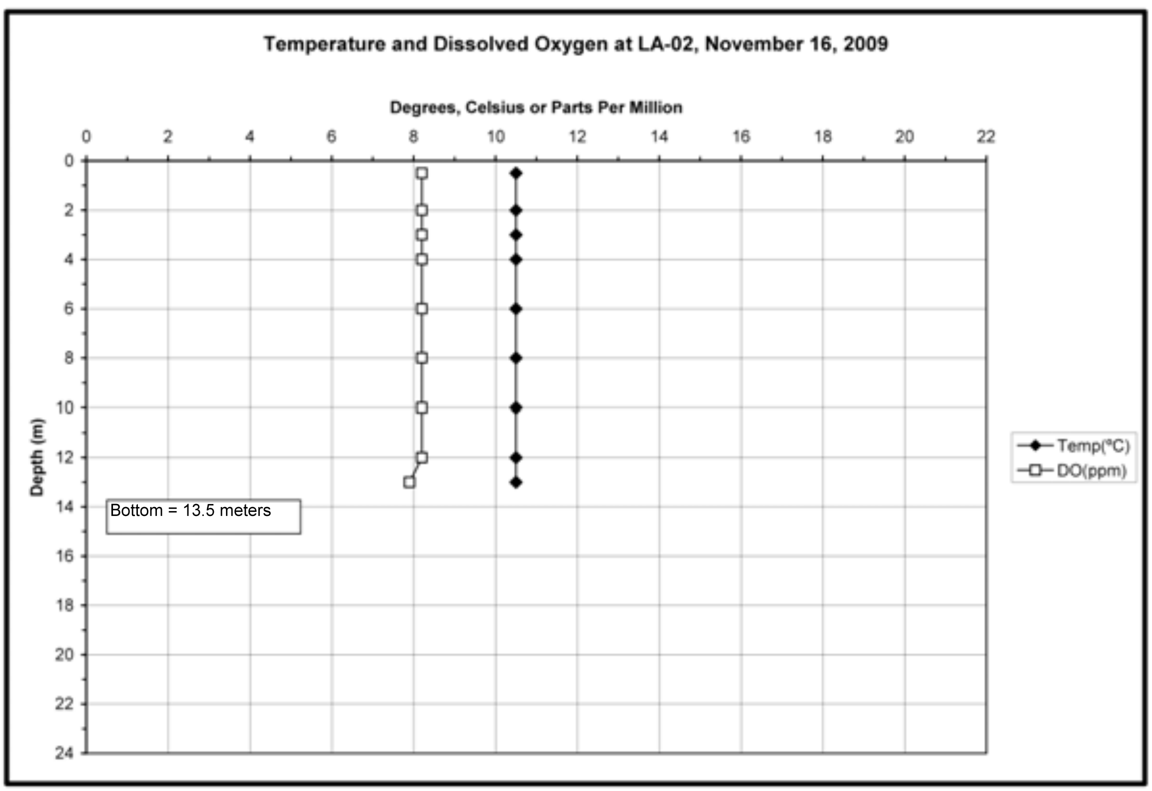
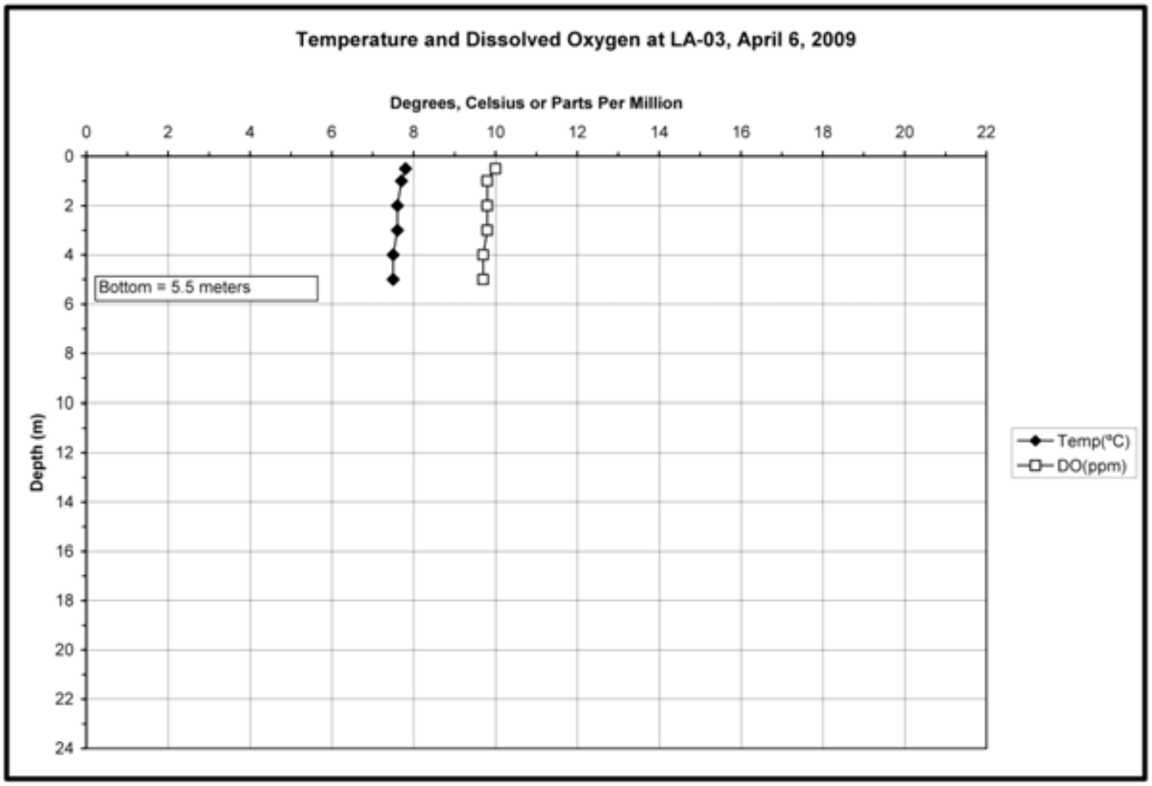


Figure 4. Temperature and Dissolved Oxygen at Lake Almanor, Station LA-03, During 2009



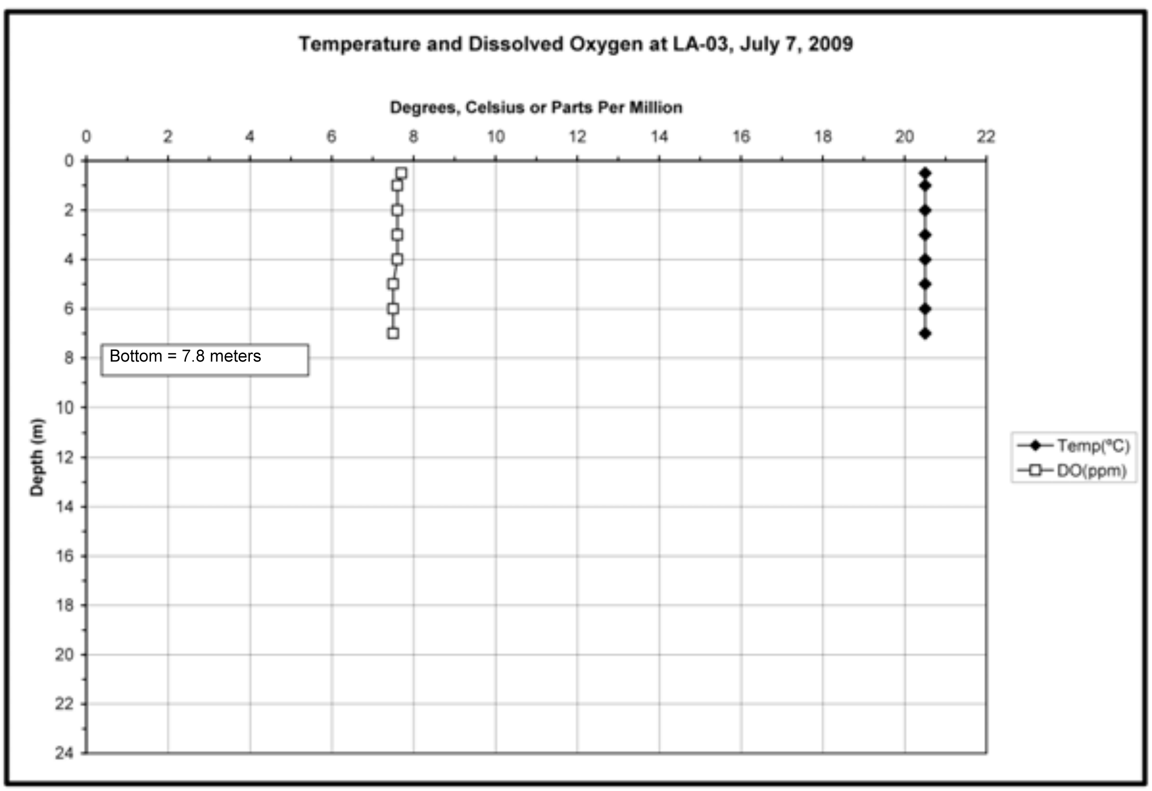
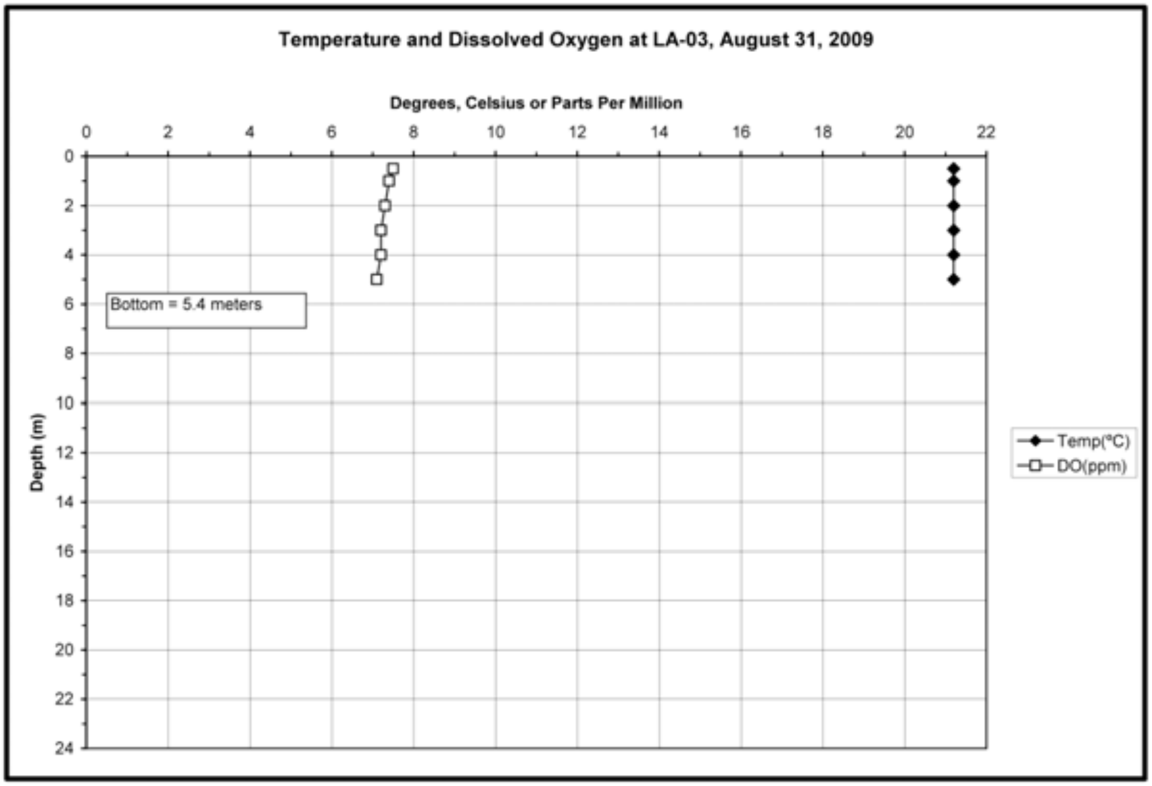
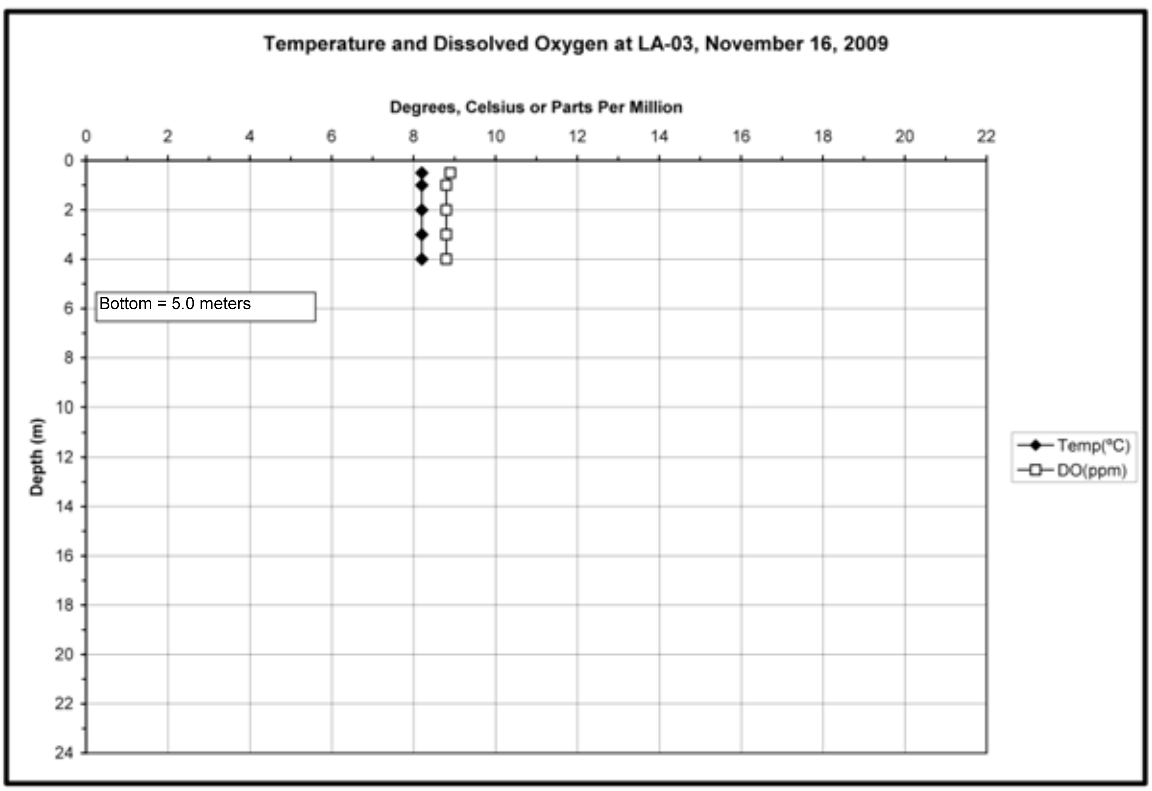


Figure 4 (continued). Temperature and Dissolved Oxygen at Lake Almanor, Station LA-03, During 2009

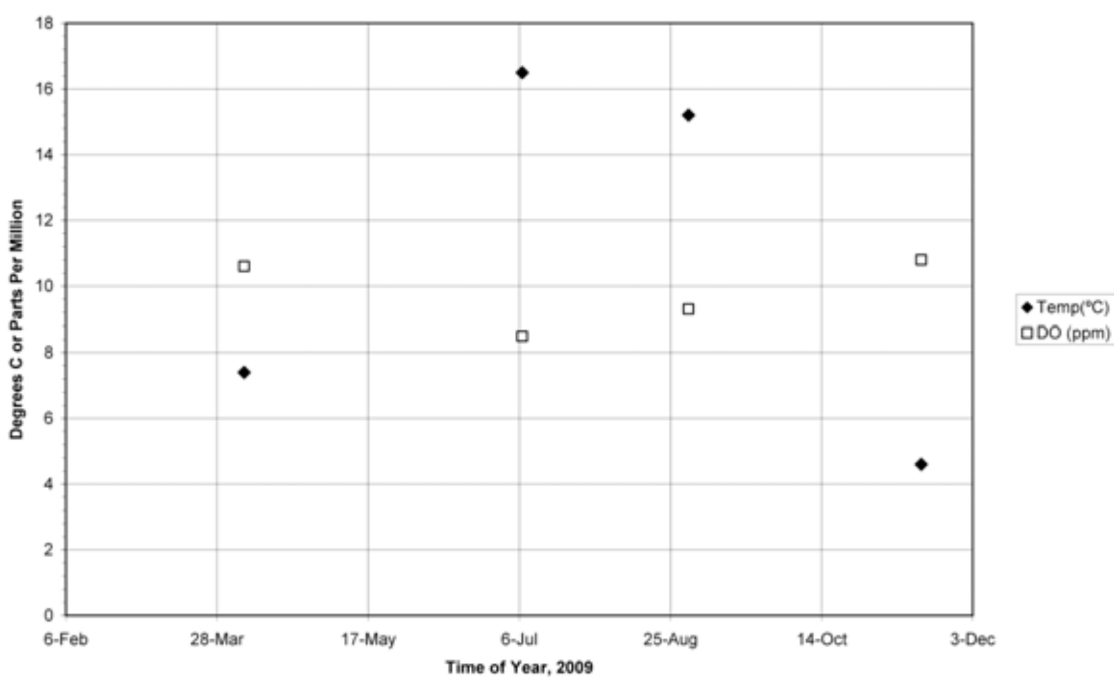




In summary, the lake warms up over the summer as it absorbs solar radiation and that heat energy gets distributed through the water column by wind. By late summer a high percentage of the lake volume is at 20 ºC or more, with a low percentage of the volume cooler than 12 ºC.

Temperature in the North Fork of the Feather River at station LA-04 follows a similar pattern to that found in Lake Almanor. See Figure 5, as well as Table1 in the Appendix.

Figure 5. Temperature and Dissolved Oxygen at LA-04 (NFFR at Chester, CA) 2009



b. Oxygen

The oxygen data are shown in graphic form (Figures 2, 3, 4 and 5) along with the temperature for each station for each date, as well as in Table 1 in the Appendix. The amount of oxygen that can be dissolved in freshwater is primarily a function of temperature and atmospheric pressure. Temperature is very important, since the higher the temperature the less oxygen can be dissolved. The higher the elevation, the lower the atmospheric pressure, and the less oxygen can be dissolved. Biological processes can affect the oxygen concentration. Photosynthesis produces oxygen and respiration, including decomposition, consumes oxygen. The amount of mixing with the atmosphere (usually due to wind action in a

lake) can change oxygen concentration. All of these factors must be considered when trying to interpret the change in oxygen concentration with depth or with time.
In April 2009 the oxygen concentration at all three lake stations was about 10 parts per million (ppm) throughout the water column. This was approximately the maximum that could be dissolved at that temperature (8 ºC) and atmospheric pressure.

In July 2009 oxygen concentration in the epilimnion at LA-01 and LA-02 was about 8 ppm, even though the water temperature was over 20 ºC. Oxygen was being maintained at a high level due to wind mixing and also photosynthesis. Due to the shallow conditions at LA-03, oxygen was about 8 ppm throughout. In the region of the thermocline and into the hypolimnion at LA-01 and LA-02 oxygen levels dropped even though temperature was decreasing. Once the lake was stratified, the deeper portion of the lake was isolated from the atmosphere. Decomposition consumed oxygen at a faster rate than photosynthesis could produce it, so levels dropped. In the deepest part of the hypolimnion at LA-01, oxygen was at 2 ppm and at LA-02 oxygen was at 1 ppm or less.

By August 2009, oxygen was still near 8 ppm in the epilimnion of LA-01 and LA-02, and throughout the water column at LA-03. In the region of the thermocline at LA-01 and LA-02, oxygen levels dropped off very abruptly to near zero. The hypolimnion at LA-01 was essentially devoid of oxygen.

As the lake cooled in the autumn, the thermal stratification broke up. By November, all stations were again well-mixed and oxygen levels were about 8 ppm throughout.

An examination of the DWR data base (1989-2004) for Lake Almanor showed that the annual pattern for temperature and oxygen has been about the same since their records began. Low levels of oxygen in the hypolimnion are the “norm”.

Lake Almanor has populations of fish that prefer cool and well-oxygenated water. Adult rainbow trout select water with temperatures between 7- 18 ºC and avoid water warmer than 18 ºC. The lethal level of dissolved oxygen for adults and juveniles is 3 ppm. Although fish can survive at levels just above this, their growth rate and general health is jeopardized. (Raleigh et al, 1984). Other species of trout may have narrower ranges of tolerance.

This information and the temperature-oxygen data for Lake Almanor lead to the conclusion that rainbow trout are limited to the deeper water of the lake during the summer. As summer progresses, a smaller volume of the lake meets their requirements for both temperature and oxygen. By late summer the coldest water is devoid of oxygen, so certain species of fish are not able to find optimal levels of temperature and oxygen anywhere in the lake.

c. Electrical Conductivity and pH

Electrical conductivity is a measure of the dissolved salts in water. The data for this report is presented in Table 1 in the Appendix. Values ranged from 98 – 108 micro Siemens/cm at all lake stations and from 64-84 micro Siemens/cm in the river. There was little difference between lake stations, although LA-03 tended to be lower, due to the influence of the river. The range of data is similar to that in the DWR data base for 1989-2004.

pH (a measure of acidity or basicity of water) ranged from 6.9 – 8.8 at the three lake stations (See station data in Table 1 in the Appendix.) Values tended to be higher in the epilimnion where photosynthetic activity was high and lower in the hypolimnion where decomposition predominated. Values were similar to those in the DWR data base. pH in the river only varied from 7.8 – 8.2.

d. Secchi Depth and Turbidity

Both Secchi depth and turbidity are an indication of suspended particles in the water column. Data for Secchi depth is presented in Table 1 in the Appendix. For all three lake stations, Secchi depth was 3-5 meters in April. It increased to 7-9 meters in July and August and then decreased in November to about 3 meters. Variation is probably related to sediment carried by inflowing streams. Values were in agreement with those in the DWR data base.

Data for turbidity is presented in Table 1 in the Appendix. Turbidity levels were low at all stations and never exceeded 10 NTU. Generally turbidity was low at the surface and higher near the bottom. The river station, LA-04, was highest in April (5.6 NTU) and near zero at the end of the sampling period. Spring should be the time of greatest sediment transport by the river.

2. Chemical Parameters

a. Nutrients

These tests were performed to get an estimate of the amount of nitrogen and phosphorus available to phytoplankton at the time of lake turnover. Total nitrogen, total phosphorus and ortho-phosphate were analyzed in April at LA-02 and LA-03. Data are presented in Table 2 in the Appendix.

Nitrogen and ortho-phosphate were below detection limits for all samples. Total phosphorus was very close to the detection limit at 0.03 ppm. The concentrations may have been low because there was already a large population of phytoplankton present in the lake in April. If these tests are repeated, samples should be collected earlier in the spring.

b. Calcium

Calcium was measured at 0.5 meters and at 5.0 meters depth at station LA-03. The concentration was 9 ppm at both depths, which corresponds to measurements in PG&E data for Lake Almanor. (See Table 2 in the Appendix.)

c. TPH and BTEX

These tests were selected to determine if significant amounts of compounds from motorized craft were in the lake water. Total petroleum hydrocarbons (TPH) and Benzene/toluene/ethylbenzene/xylene (BTEX) were monitored at LA-02 and LA-18 during July and August, 2009. No TPH was detected at either station and very low levels of toluene and xylene (0.2 ppb) were found at LA-18 in July. (See data in Table 2 in the Appendix.) If these tests are repeated, sites at boat launching ramps may show higher concentrations.

3. Phytoplankton and Zooplankton

Phytoplankton were collected at LA-02 and LA-03 on all four sampling dates. Data for the major groups of phytoplankton are presented in graphic form in Figures 6 and 7. More detailed data are in Table 3 in the Appendix.

The pattern of abundance was similar at both stations with large populations present at lake turnover and small populations during the summer months. Bacillariophyta (Diatoms) were the dominant group for most of the year at both stations. Dominant genera in the spring were *Fragilaria* and *Stephanodiscus* at both stations. Chlorophyta (Greens), especially *Oedogonium*, was very abundant at LA-03 in November. *Ulothrix* was also very common at both stations.There were significant amounts of Cyanobacteria (Blue-greens) present at both stations during the summer. Most common genera were *Lyngbya* and *Anabaena*.
No recent data are available from DWR for phytoplankton, so no comparison with historical data can be made at this time. The composition of genera present is characteristic of meso-trophic or eutrophic lakes.

Zooplankton were collected along with the phytoplankton and results are presented in Figures 8 and 9. More detailed data are in Table 4 in the

Figure 6. Major Phytoplankton Groups at Lake Almanor, Station LA-02 in 2009

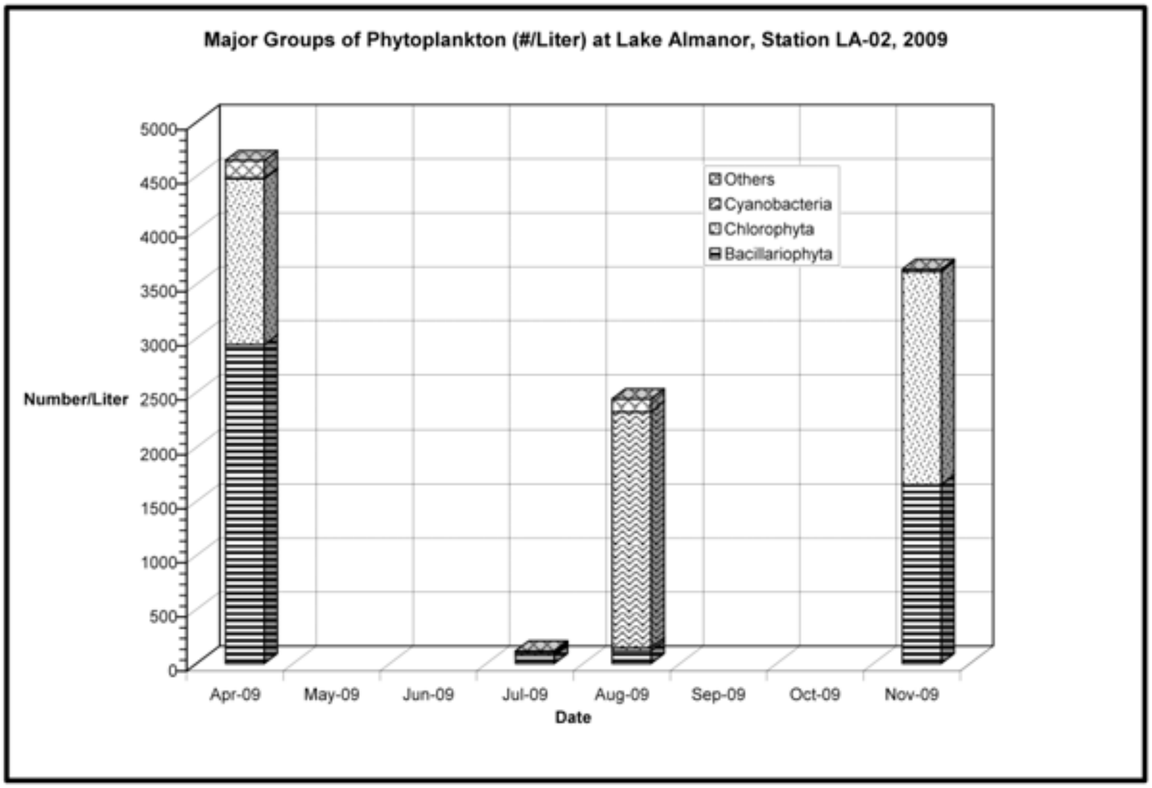


Figure 7. Major Phytoplankton Groups at Lake Almanor, Station LA-03 in 2009

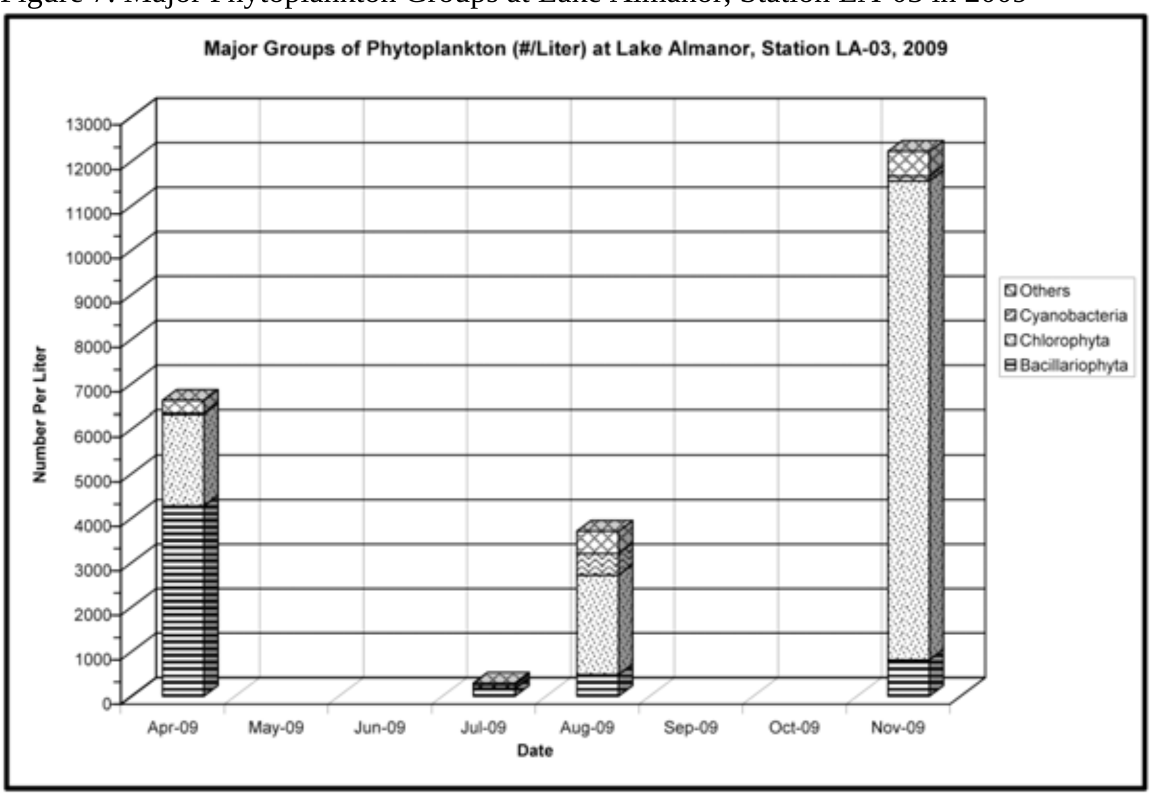


Figure 8. Major Zooplankton Groups at Lake Almanor, Station LA-02, in 2009

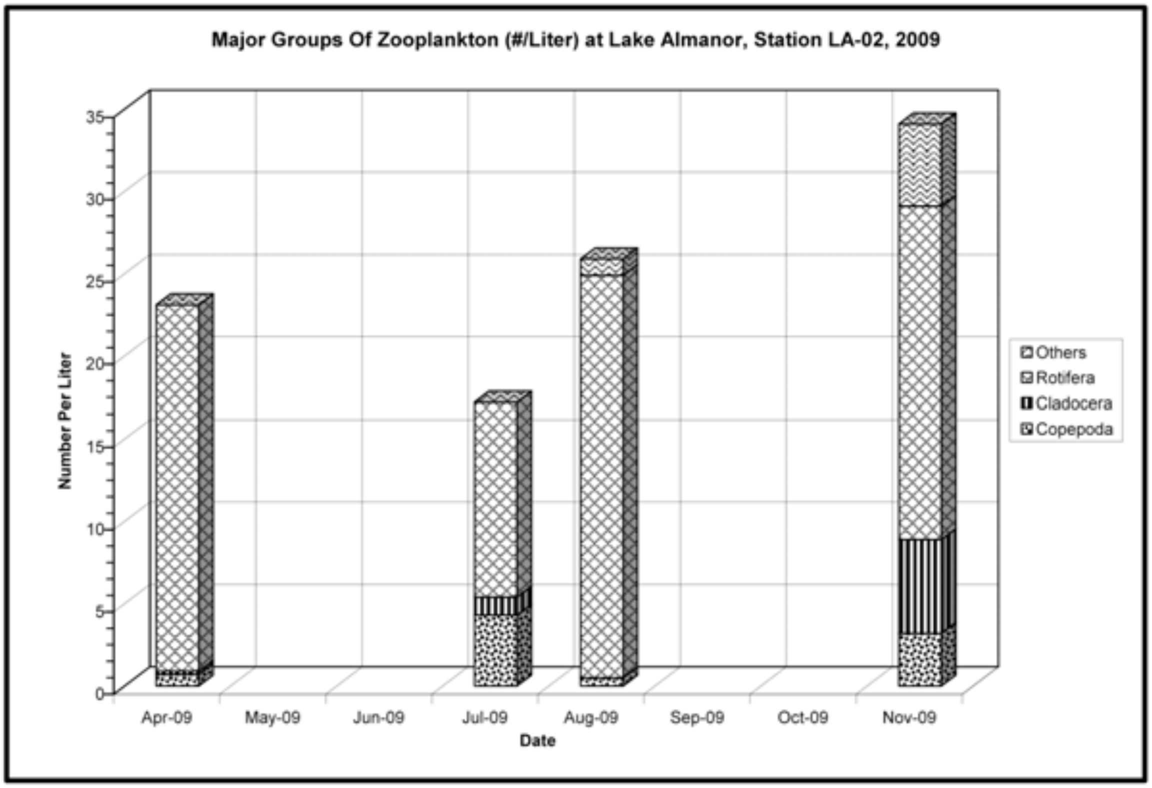
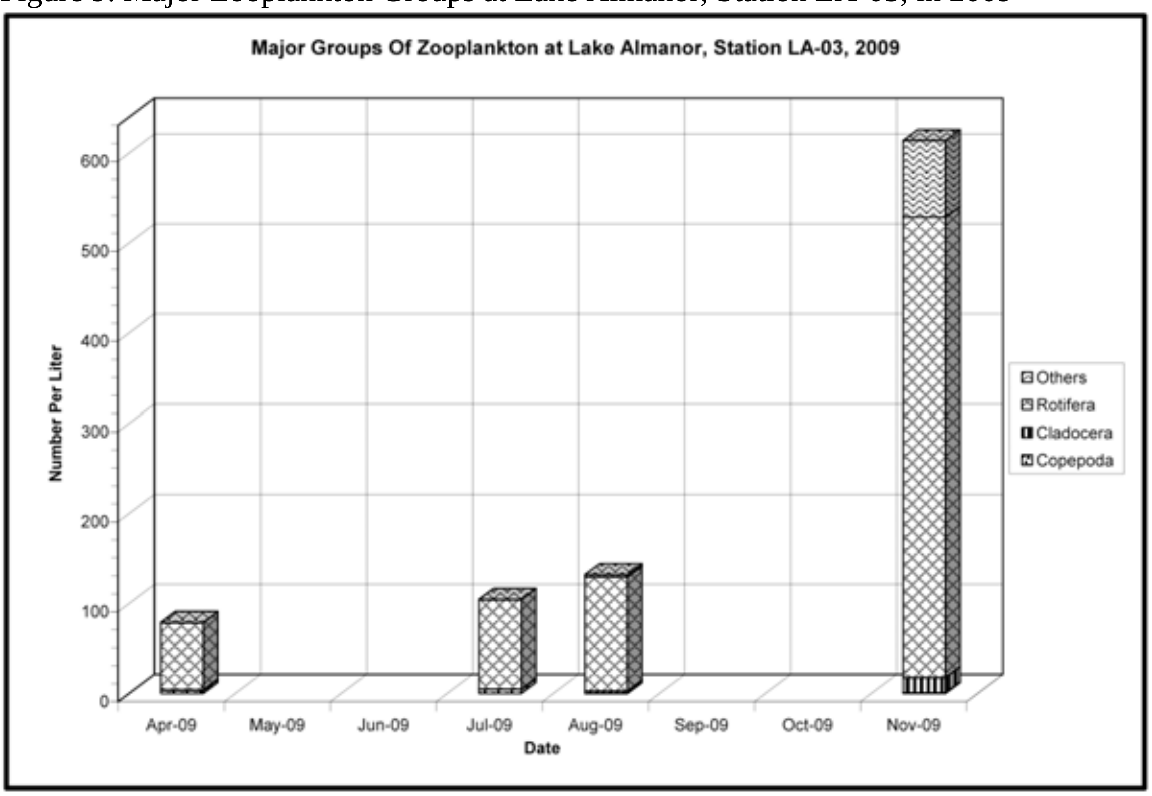


Figure 9. Major Zooplankton Groups at Lake Almanor, Station LA-03, in 2009



Appendix. By far the most abundant group was the Rotifera, with very few Copepoda and Cladocera present. Their low numbers might have been due to heavy predation by small fish, which tend to eat these larger zooplankton. Rotifera are generally small and are not subject to predation by fish. The most common genera were *Keratella* and *Polyarthra* at both stations.

Conclusion

Lake Almanor is a fairly rich reservoir with a diverse assemblage of plankton. It is capable of supporting large populations of fish. However, the low levels of oxygen in the hypolimnion during the summer probably stress certain fish species and prevent optimal growth. Monitoring of other stations in the lake will provide information about where there is suitable habitat for fish.

Large populations of phytoplankton develop during lake overturn in the spring and fall. This suggests that the lake water contains adequate nutrients to support these populations. The low levels of these nutrients in the lake may be due to high rates of uptake by the phytoplankton. Measurement of nutrient concentrations during the summer in the hypolimnion may indicate how much is being released by decomposition or by release from the sediments as they become de-oxygenated.
There are some “nuisance” species of phytoplankton present (most common are *Lyngbya* and *Anabaena*) and their populations should be monitored. Several of the Cyanobacteria, commonly called “bluegreens” , produce toxins that can affect humans and pets.

Because of the lake’s recreational importance, monitoring of water quality should be continued and expanded, if possible. An additional station off the southwestern shore would provide more information about the western lobe of the lake.

References

1. California Department of Water Resources data base for Lake Almanor, obtained from Almanor Basin Watershed Advisory Committee records.
2. Lake Almanor Watershed Water Quality Report. April 2006. CH2MHILL, Redding, CA
3. Raleigh, Robert F., Terry Hickman, R. Charles Solomon and Patrick C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. U.S Fish and Wildlife Service, U.S. Department of the Interior. http/www.nwrc.usgs.gov/wdb/pub/hsi/hsi-060.pdf