Lake Almanor Water Quality Report, 2015

Prepared for

Lake Almanor Watershed Group
Sierra Institute for Community and Environment
Plumas County Board of Supervisors

By

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Submitted February 2016

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Introduction and Project Overview

A water quality monitoring program for Lake Almanor was conducted during 2015, combining the protocol used by California Department of Water Resources in previous years and that used by Dr. Gina Johnston in 2009-2013. The Sierra Institute for Community and Environment and the Lake Almanor Watershed Group (LAWG) provided oversight for the contract. Due to the limited funds available for this project, LAWG 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 to provide a look at lake health: during spring turnover (April), the period of heavy recreational use (July and October) and fall turnover (November). Three stations in the lake were selected: LA-01 near the Intake Tower, LA-02 in the east arm, and LA-03 in the west arm. A station in Chester (NFFR-1) was selected for monitoring the North Fork of the Feather River just prior to discharge into the lake. Additional stations around the reservoir perimeter were also monitored: North Fork Feather River near Canyon Dam (NFFR-2), Bailey Creek at Highway 36 (BC-5), Hamilton Branch downstream of Mountain Meadows Dam (HB-01C), Hamilton Branch upstream of Lake Almanor (HB-01B) and Hamilton Branch at Lake Almanor (HB-01A). Lake and major tributary sampling stations are shown in Figure 1.

Parameters that were monitored included:

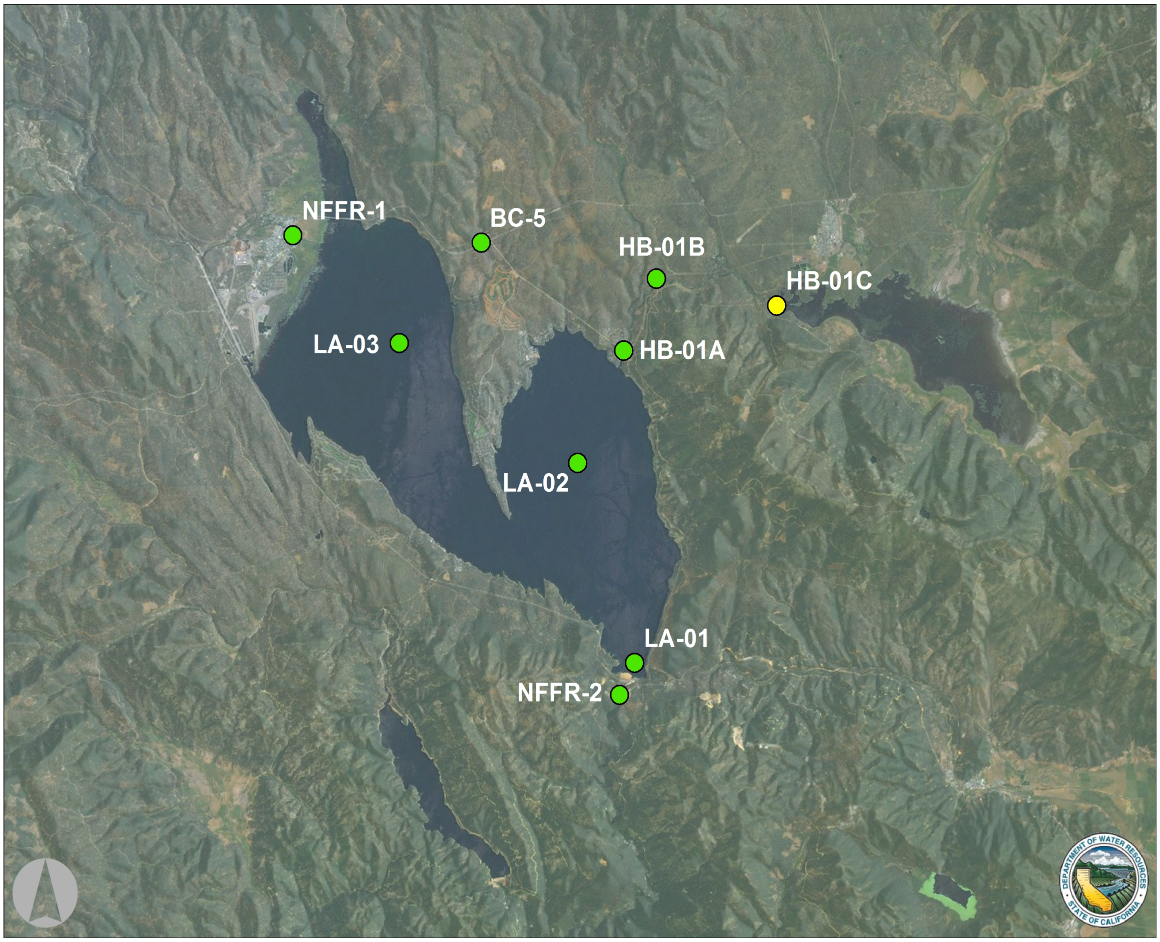
1. Physical: temperature, dissolved oxygen, Secchi depth (where applicable), electrical conductivity, pH and turbidity.
2. Chemical: an analysis of many inorganic and organic elements and compounds, including nutrients.
3. Biological: phytoplankton and zooplankton at LA-02 and LA-03.

Methods Used for Sampling and Analysis

Field Parameters— Stream- Basic water quality parameters, including dissolved oxygen, conductivity, pH, and turbidity, were measured with properly calibrated field instrumentation at each visit to every monitoring station. Stream samples or measurements were collected about one foot below the surface in flowing, well-mixed riffle or run areas. Water temperature, conductivity, dissolved oxygen, and pH was measured in streams with a YSI Pro handheld multi-parameter meter with a 3-meter cable. The meter was calibrated within 3 days prior to sampling following the instrument manual. Turbidity was measured with a nephelometer (Hach P2100 Turbidimeter) from the bulk sample used to filter dissolved chemistry samples.

Continuous stream water temperatures were recorded at 15-minute intervals at each stream station using Onset Hobo Pro V2 dataloggers. These loggers were deployed at the sampling locations housed in a 6 in length of 2 inch diameter galvanized fence pipe, and attached to an onshore anchor site with an appropriate length of coated, stainless steel cable and a padlock to discourage theft of the equipment. The Bailey Creek data logger was removed when the

Figure 1. Lake and Tributary Sampling Station Locations in Lake Almanor Watershed used in 2015 study. (Map provided by Scott McReynolds, DWR)



stream went dry between the April and July sampling event.

Field Parameters— Lake- Water temperature, conductivity, dissolved oxygen, and pH in lakes was measured at one meter intervals from the surface to the bottom using the same, calibrated YSI Pro meter and 30 meter cable assembly to access any potential depth in Lake Almanor. Turbidity was measured with a Hach P2100 Turbidimeter from samples collected using the van Dorn water bottle.

Continuous lake water temperature and oxygen were recorded at 15-minute intervals using dataloggers at station LA-01 near the Canyon Dam Intake Tower on a buoy deployed by PG&E with funds from LAWG. Two loggers were deployed from this buoy at ten and fifteen meters below the water surface on segmented lengths of stainless steel cable and a padlock to discourage theft of the equipment. All data was reported relative to the surface, (i.e. depth from surface remained constant, but distance from bottom changed as the lake level fluctuated up and down through the year). These loggers were deployed in June 2015.

Inorganic Chemistry—Water inorganic chemistry was assessed since these parameters influence beneficial uses of water and may become elevated due to contamination, which often results in deleterious effects to aquatic life and other beneficial uses. Limnological processes in lakes may alter the chemical state of some parameters, and include potential release of soluble metals from bottom sediments and methylation of mercury due to warmer water and organic content in Lake Almanor. Inorganic chemistry samples were collected approximately 0.5 meters below the surface and approximately 0.5 meters above the bottom with a Van Dorn water bottle and appropriate volumes dispensed into the sample containers.

Inorganic chemical analyses include minerals (calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity), nutrients (nitrate plus nitrite, ammonia, dissolved orthophosphate, total and dissolved organic carbon, and total phosphorus), and metals (aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc). For all metals except mercury, samples were collected for both total recoverable and dissolved metals. Mercury samples include total recoverable fractions. Total and suspended solids and hardness were also analyzed from samples collected at each site.

Samples for chemical analyses from streams were collected by wading into the channel and dipping sample containers to a depth of approximately one foot into the well-mixed channel flow. Mineral and nutrient samples were collected into clean polyethylene containers. Samples for trace metals analyses at water quality criteria levels were collected into polyethylene or glass (mercury only) bottles according to U.S. EPA Method 1669 (two-person, gloved, "clean hands/dirty hands" method). Surface samples for mineral, nutrient, and metal analyses from Lake Almanor were collected from the surface by dipping an inverted container to approximately 0.5 meters below the surface. Water samples at greater depths were collected with a van Dorn water bottle for minerals and nutrients, and pre-cleaned, Teflon Kemmerer style bottles for trace metals.

Chemical analyses of minerals, nutrients, and metals were performed at the DWR Bryte Chemical Laboratory in West Sacramento using U.S. EPA approved techniques, equipment, and methods.

Biological Parameters -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. 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 Lugol's 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 had water quality significance. (Again, certain genera are indicators of lake health and it would be important to know their abundance.)

Results and Discussion

1. Physical Parameters

a. Temperature

The temperature data are shown in graphic form for each lake station (See figures 2, 3 and 4, as well as Table 1 in Appendix). . In April 2015 LA-01 and LA-02 and LA-03 were well mixed with little temperature difference between surface and bottom. At LA-01 temperature at the surface was nearly 11 °C (52 °F), and at the bottom it was around 8 °C (46 °F). LA-02 was slightly cooler with surface about 10 °C (50 °F) and the bottom was at 9.5 °C. LA-03 was isothermal at around 11 °C (52 °F).

By July 2015 stations LA-01 and LA-02 were thermally stratified. The epilimnion was about 23 °C (73 °F). The metalimnion was between 8 and 14 meters. At LA-03 the temperature difference from top to bottom was about 1 degree, so it was not stratified. The surface temperature at all three stations was about 23 °C, which was about the same as 2014.

The next sampling date was not until October 7, 2015, almost a month later than in previous years. The epilimnion extended down to 11-14 meters depth and was about 17 °C (63 °F). The temperature in the hypolimnion at LA-01 was 12-13 °C (54-55 °F). At LA-02 it had warmed to 14 °C (57 °F). LA-03 was well mixed, with a temperature of 16 °C (61 °F) throughout.

By November 2015 the lake was no longer thermally stratified at any station. Water temperature at LA-01 and LA-02 was about 7 °C (45 °F) throughout. LA -03 was 11.5 °C.

Water temperatures were generally higher than in 2012 and 2013. This was probably due to the lack of spring precipitation and decreased inflow from tributaries. High water clarity also allowed for deeper light penetration.

In summary, the lake warms up over the summer as it absorbs solar radiation and the heat energy gets distributed through the water column primarily by wind mixing. The wind is not strong enough to mix deeper than about 10 meters, as marked by the depth the top of the metalimnion. Below the metalimnion, the hypolimnion is stable and cool. LA-03 is only 7-9 meters deep, so water can be fully mixed by wind action. By late summer most of the lake volume is 15 °C (59 °F) or warmer and only the deeper parts of the eastern basin have water temperatures cooler than 12 °C (54 °F). By July of 2014 and 2015 only LA-01 had a water temperature below 12 °C and that was in the deepest region of the lake.

Temperature in the North Fork of the Feather River at Chester, CA (Station NFFR-1) followed a similar seasonal pattern to the lake, although it was generally cooler than the lake temperature. The highest temperature was in July at over 20 °C (68 °F), which was 4 °C (7 °F) warmer than in 2014 and almost 6 (11 °F) degrees warmer than in 2012. (See Figure 5, as well as Table 1 and Figure 2 in the Appendix.) The river temperature was showing the effect of decreased snowmelt and runoff.

Data for Hamilton Branch at Lake Almanor are shown in Figure 6. Temperature in July and September was about 12 °C (54 °F), making it 4 °C (8 °F) cooler than the NFFR and the epilimnion of Lake Almanor. Physical data for other tributaries are in the Appendix , Table 1. A graphical depiction of the variation in temperature for all major tributaries is shown in Figure 2 in the Appendix. Of particular interest is the difference between Hamilton Branch at Mountain Meadows and where it enters Lake Almanor. There is more than a 7°C (13 °F) drop in temperature along this creek during the summer, probably due to spring inflow. This again shows the importance of the lower portion of Hamilton Branch as a coldwater refuge. Also of note is the effect of continued drought on temperature in the North Fork Feather River at Chester CA. In 2014 only in July did the water temperature exceed 20 °C (68 °F). In 2015 water temperature exceeded 20 °C for most of June as well as July.

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 lower the pressure, the less oxygen can be dissolved. Thus, alpine lakes and streams have less dissolved oxygen than their counterparts at sea level (where the atmosphere pressure is higher) when they are at the same temperature. Biological processes also affect the oxygen concentration. Photosynthesis produces oxygen and respiration, including decomposition, consumes oxygen. . Near the surface of a lake, photosynthesis generally exceeds respiration and dissolved oxygen concentration is high. In the deeper part of a lake, respiration exceeds photosynthesis and dissolved oxygen decreases. The amount of mixing with the atmosphere (usually due to wind action in a lake or turbulence in a stream) can affect oxygen concentration. All of these factors must be considered when trying to interpret the change in oxygen concentration from the surface of a lake to the bottom or the change from season to season.

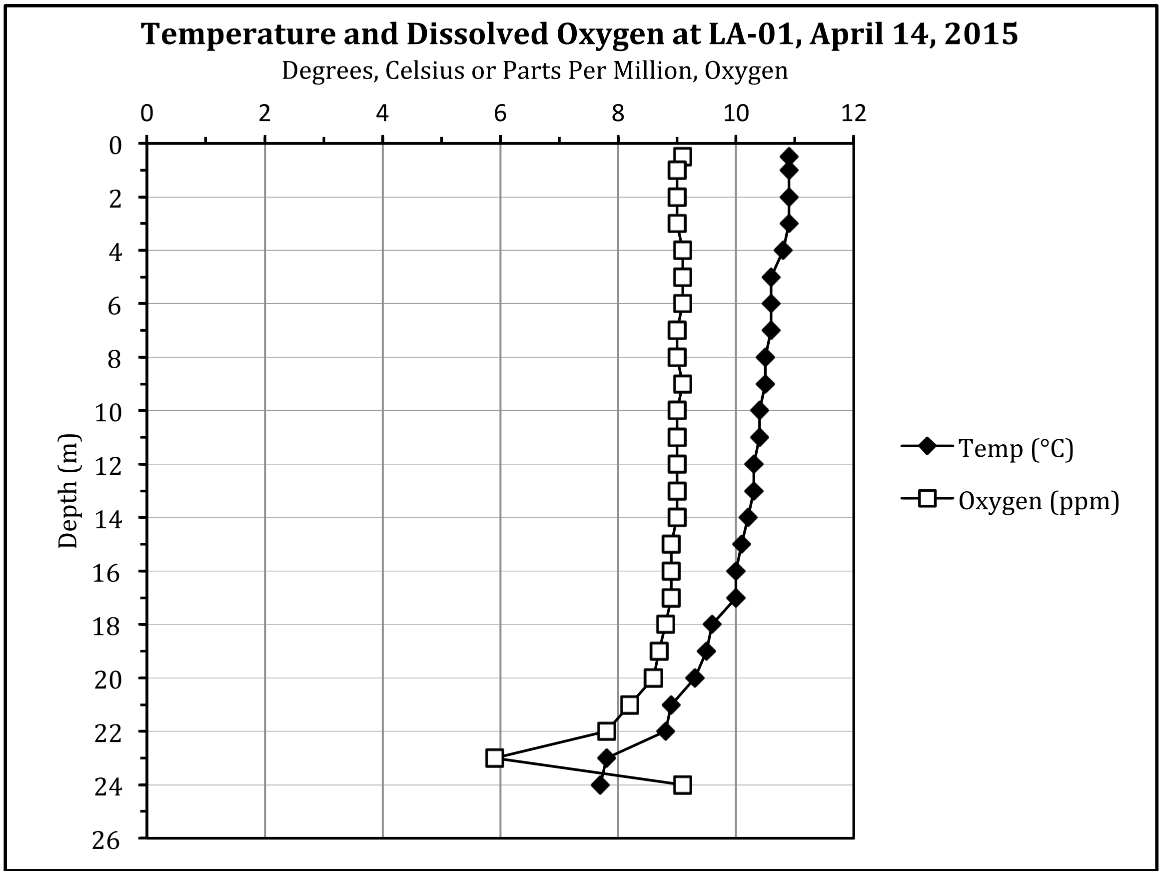
In April 2015 the oxygen concentration at all three lake stations was about 9 parts per million (ppm) throughout the water column. This was approximately the maximum that could be dissolved at that water temperature (10-11 ºC) and the existing atmospheric pressure and wind conditions.

In July 2015 oxygen concentration in the epilimnion at LA-01 and LA-02 was 6-7 ppm, and the epilimnion water temperature was 23 ºC (73 °F). Due to the shallow conditions at LA-03, oxygen was 8 ppm throughout. In the upper metalimnion (depth of 7-10 meters) at LA-01 and LA-02, oxygen levels increased as the temperature decreased. (Colder water can hold more dissolved oxygen.) However, below 10 meters the oxygen decreased even though temperature continued to decrease. In the hypolimnion at these two stations, oxygen levels dropped to zero. Once the lake was stratified, the deeper portion of the lake (hypolimnion) was isolated from the effects of wind mixing. Also, oxygen was consumed by decomposition at a faster rate than photosynthesis could produce it, so oxygen levels dropped. Below 12 meters at LA-01 and LA-02, there was no oxygen. In the previous three years, there had been some oxygen at this depth.

By October, thermal stratification was starting to break down and oxygen was still near 7 ppm in the epilimnion of LA-01 and LA-02, and 6- 8 ppm throughout the water column at LA-03. Mixing by the wind and cooling of the surface waters resulted in the epilimnion extending down to a depth of 11-14 meters. Below this depth at LA-01 and LA-02, oxygen levels dropped off very abruptly to zero. Below 12 meters, the hypolimnion at both stations was essentially still devoid of oxygen. These conditions were similar to 2014, but more severe.
As the lake cooled in the autumn, the thermal stratification disappeared. By November, all stations were again well mixed and oxygen levels were above 9 ppm throughout.

Data presented in Figure 1 in the Appendix shows the results of the continuous temperature/oxygen data loggers installed at 10 meters and 15 meters at LA-01. This gives a more precise look at the development of thermal stratification in July 2015 and the gradual breakdown of that stratification until the lake is isothermal by the end of October 2015. It also shows the depletion of oxygen at 15 meters depth by July 19. Oxygen did not increase until mid-October. Even at 10 meters, oxygen levels were often less than 5 ppm. This was the first time that this data have been collected at LA-01 and allows us to document the loss of coldwater fish habitat in the lake during the summer.

Figure 2. Temperature and Dissolved Oxygen at Lake Almanor Station LA-01, 2015


Temperature and Dissolved Oxygen at LA-01, April 14, 2015

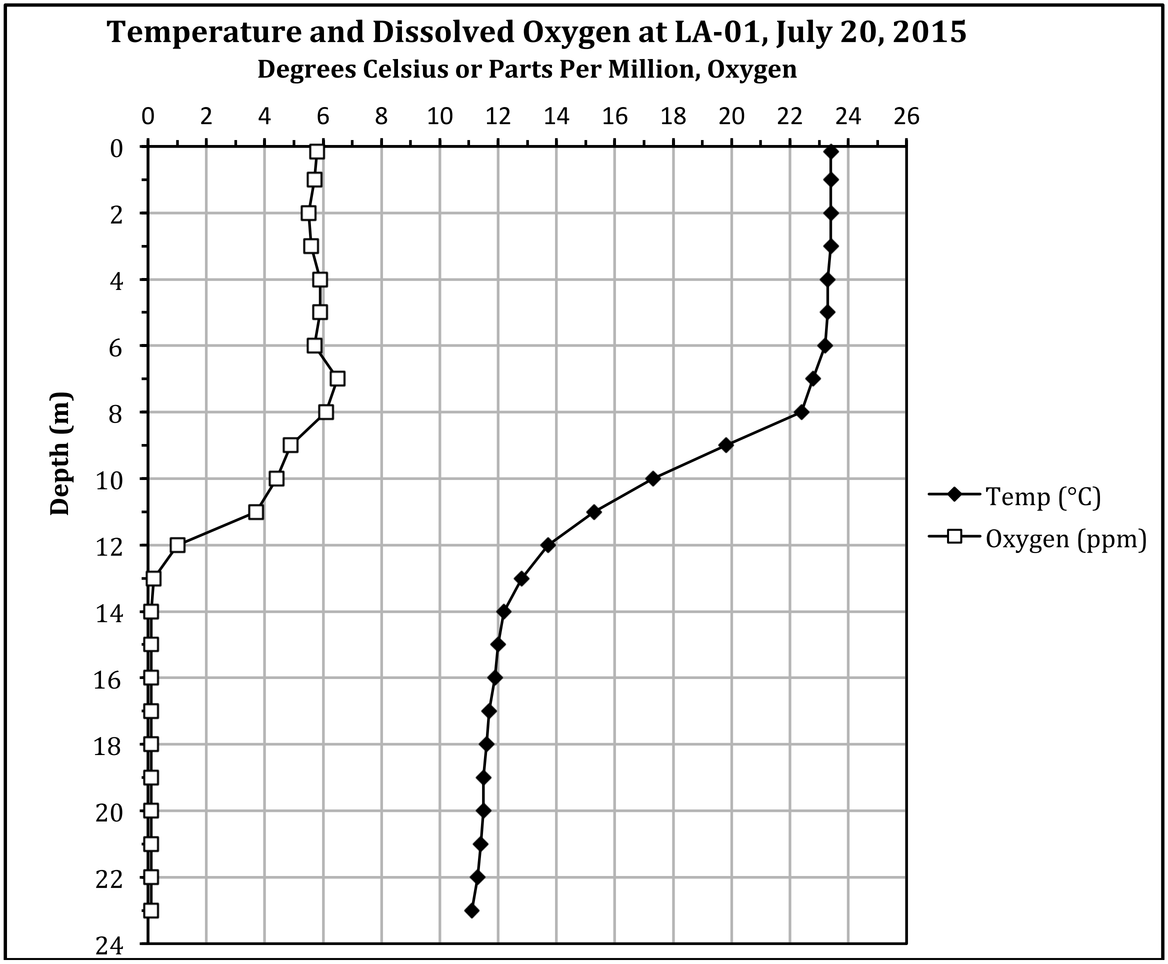
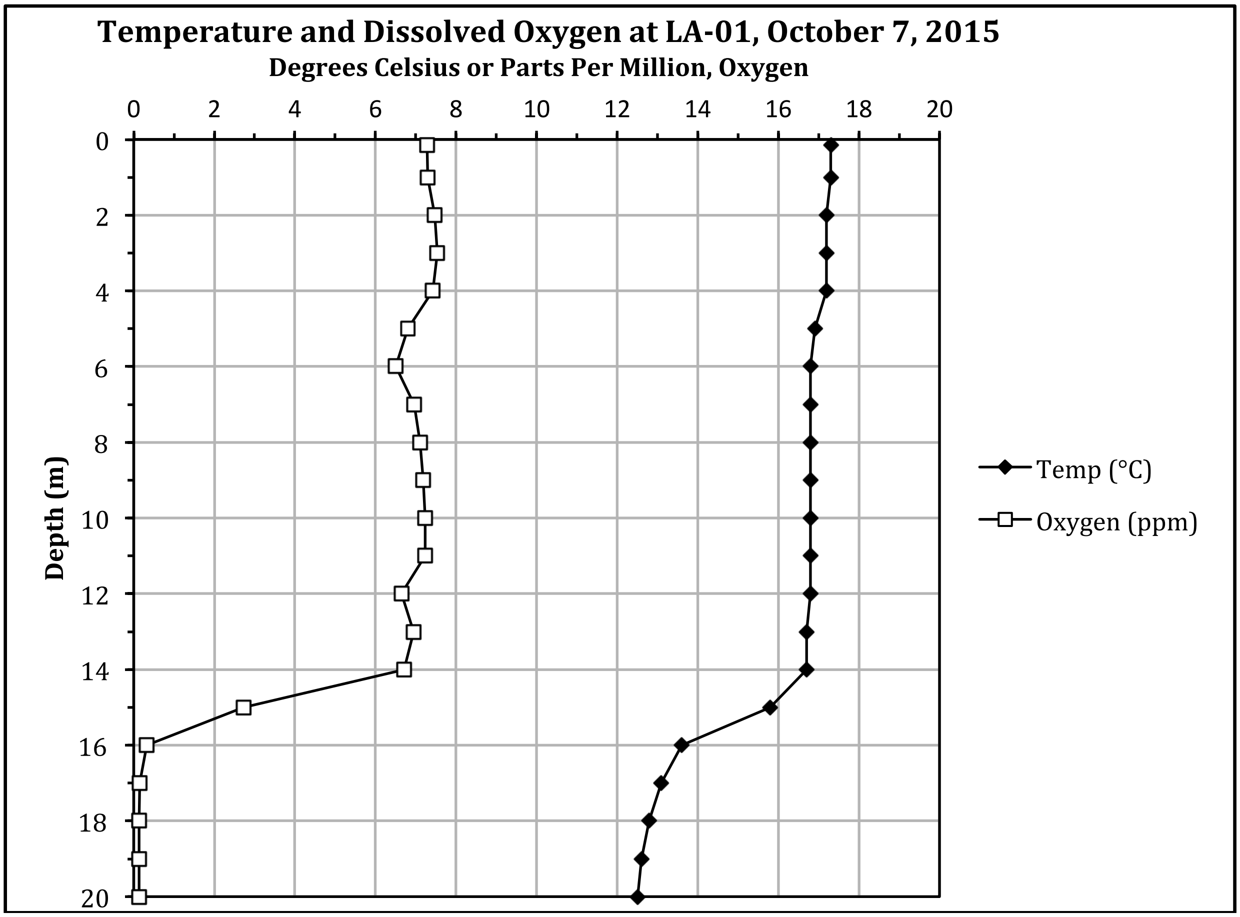

Temperature and Dissolved Oxygen at LA-01, July 20, 2015

Figure 2 (cont.). Temperature and Dissolved Oxygen at Lake Almanor Station LA-01, 2015



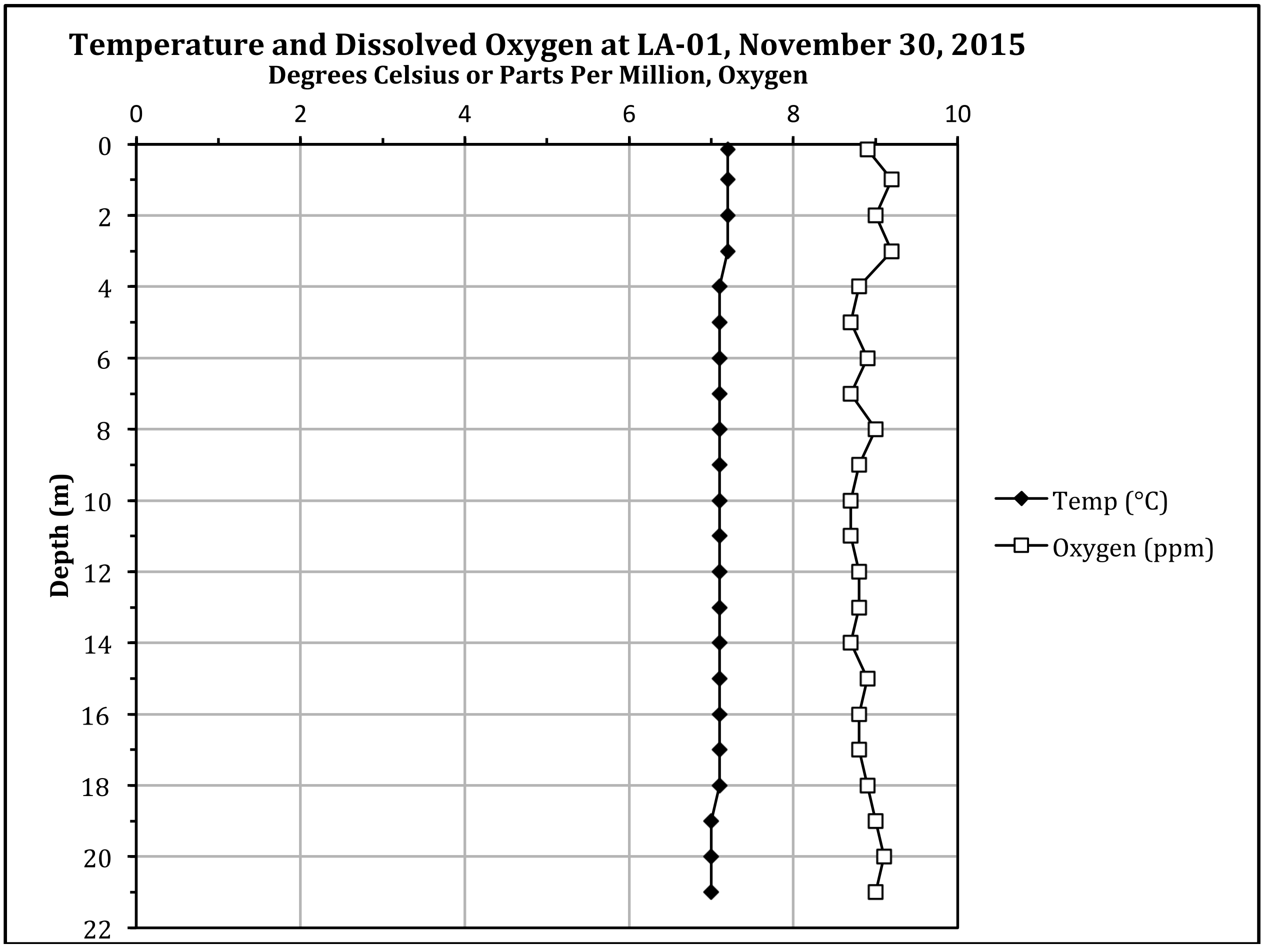
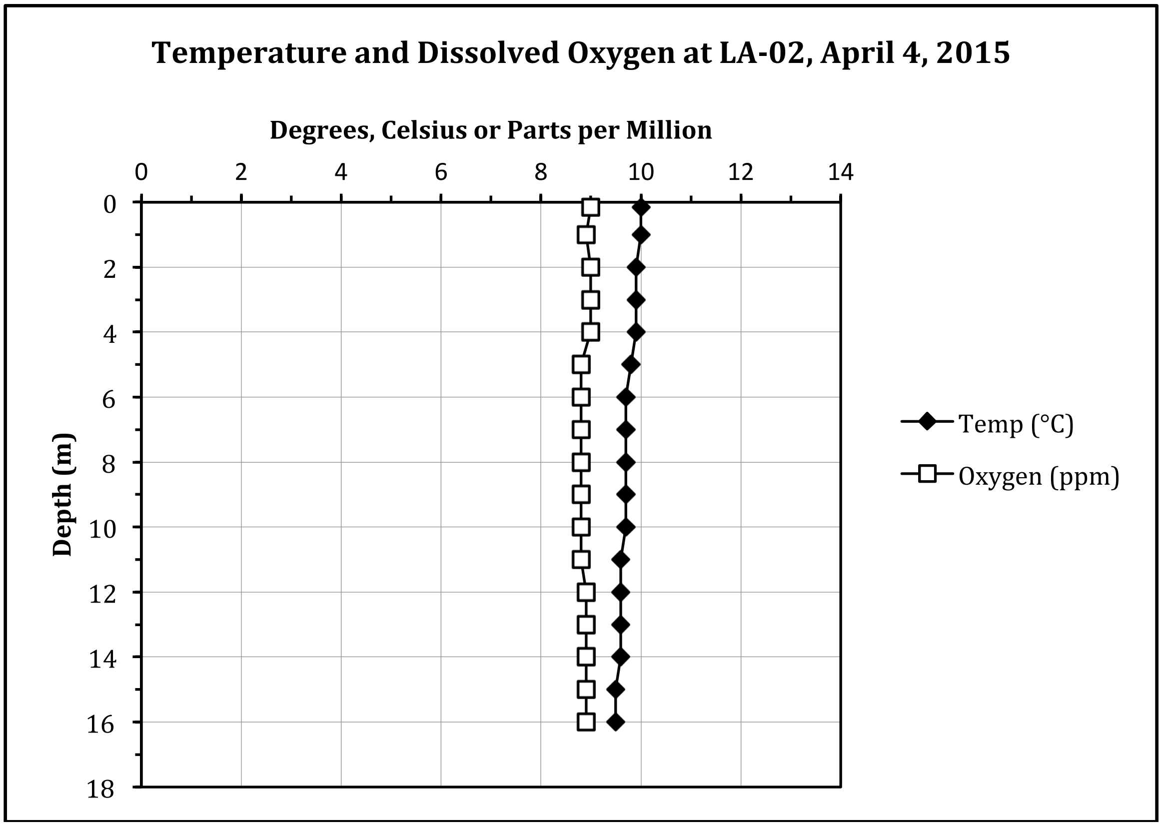


Figure 3. Temperature and Dissolved Oxygen at Lake Almanor Station LA-02, 2015



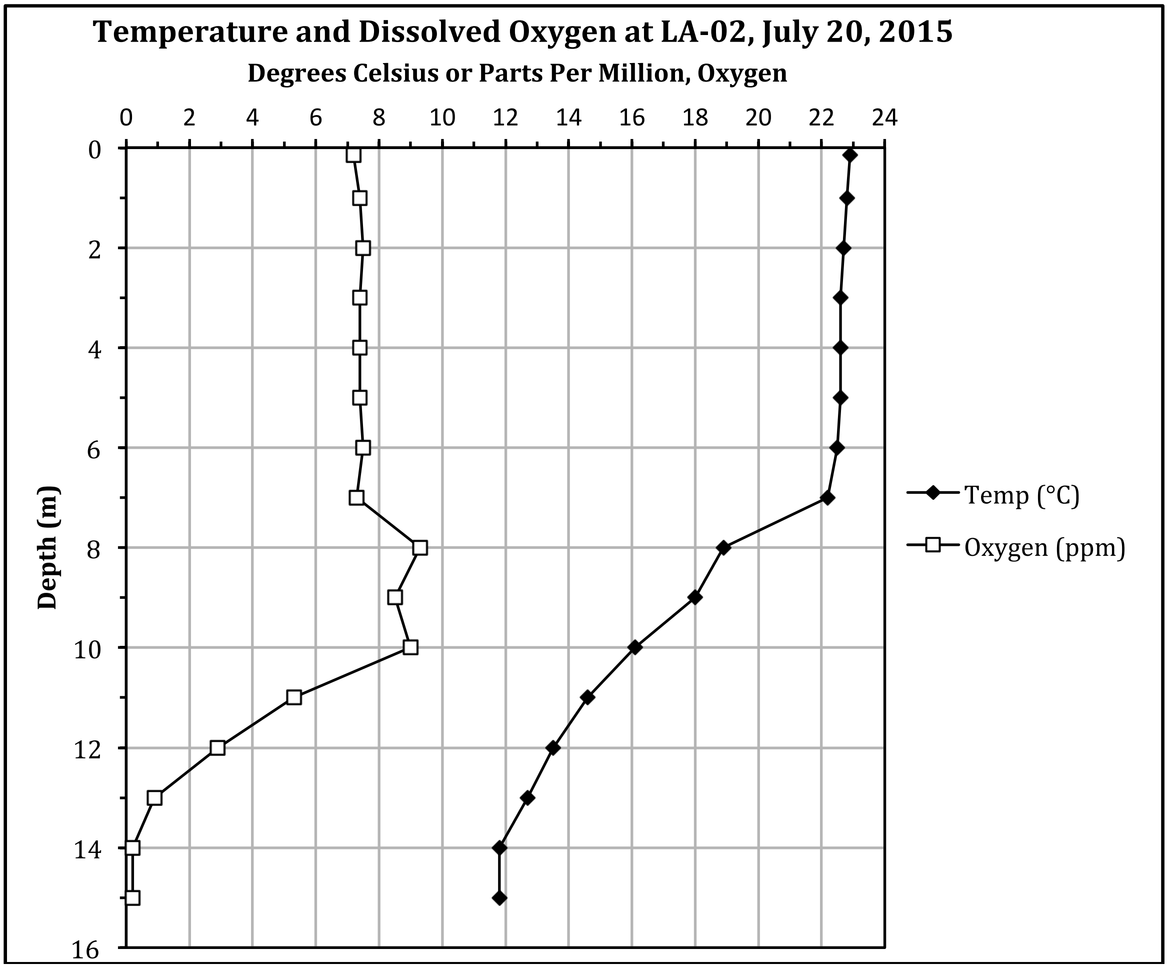
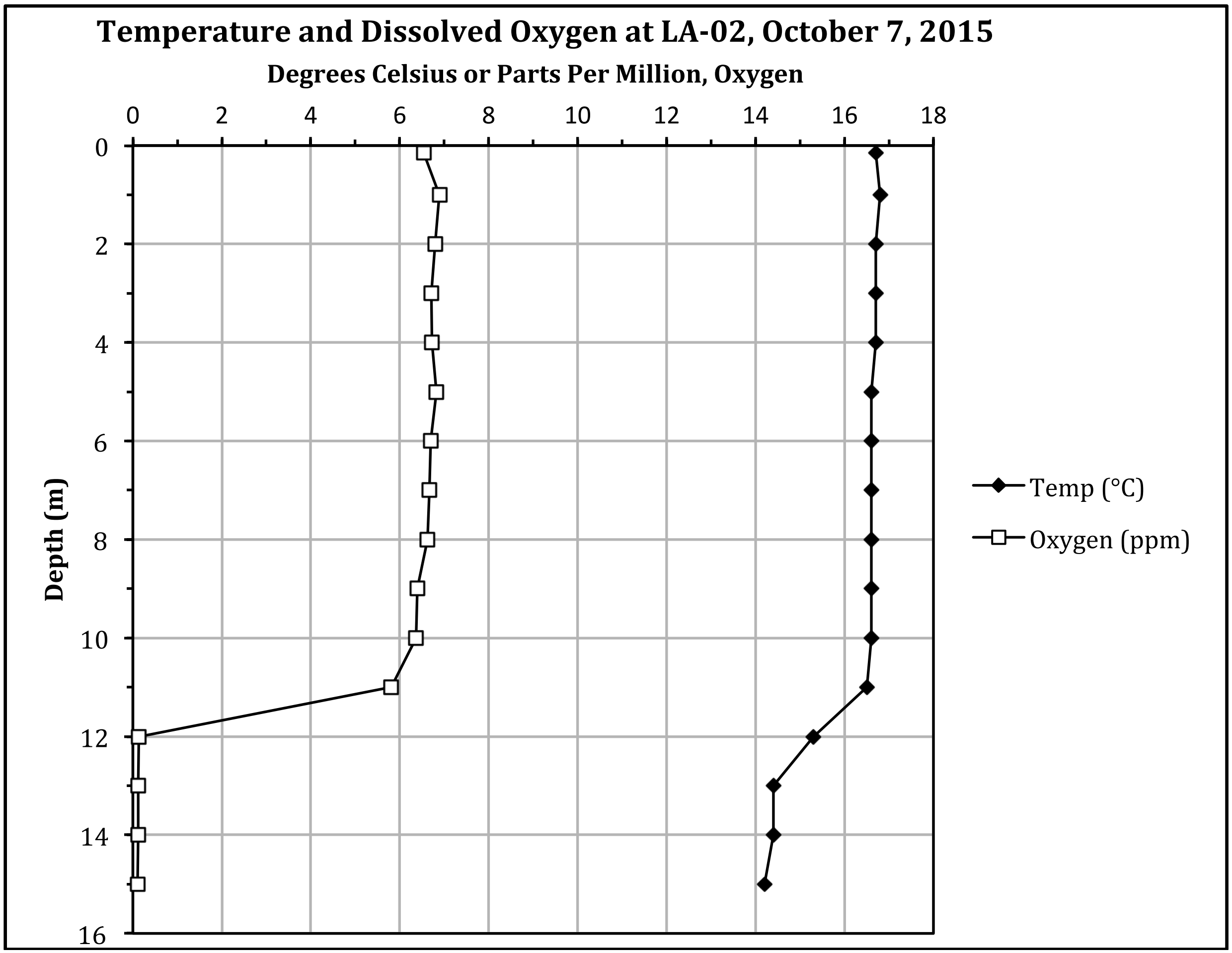


Figure 3 (cont.). Temperature and Dissolved Oxygen at Lake Almanor Station LA-02, 2015



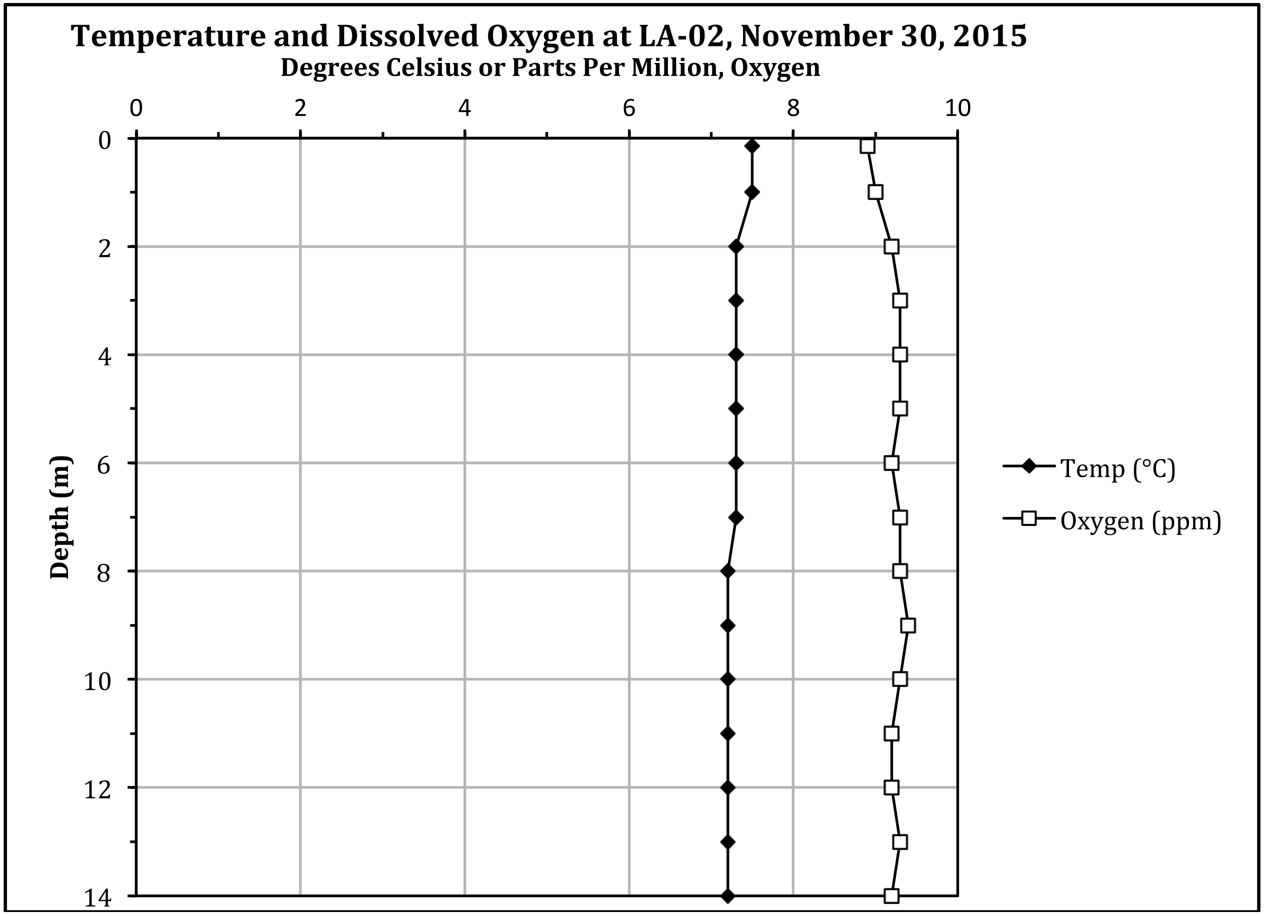
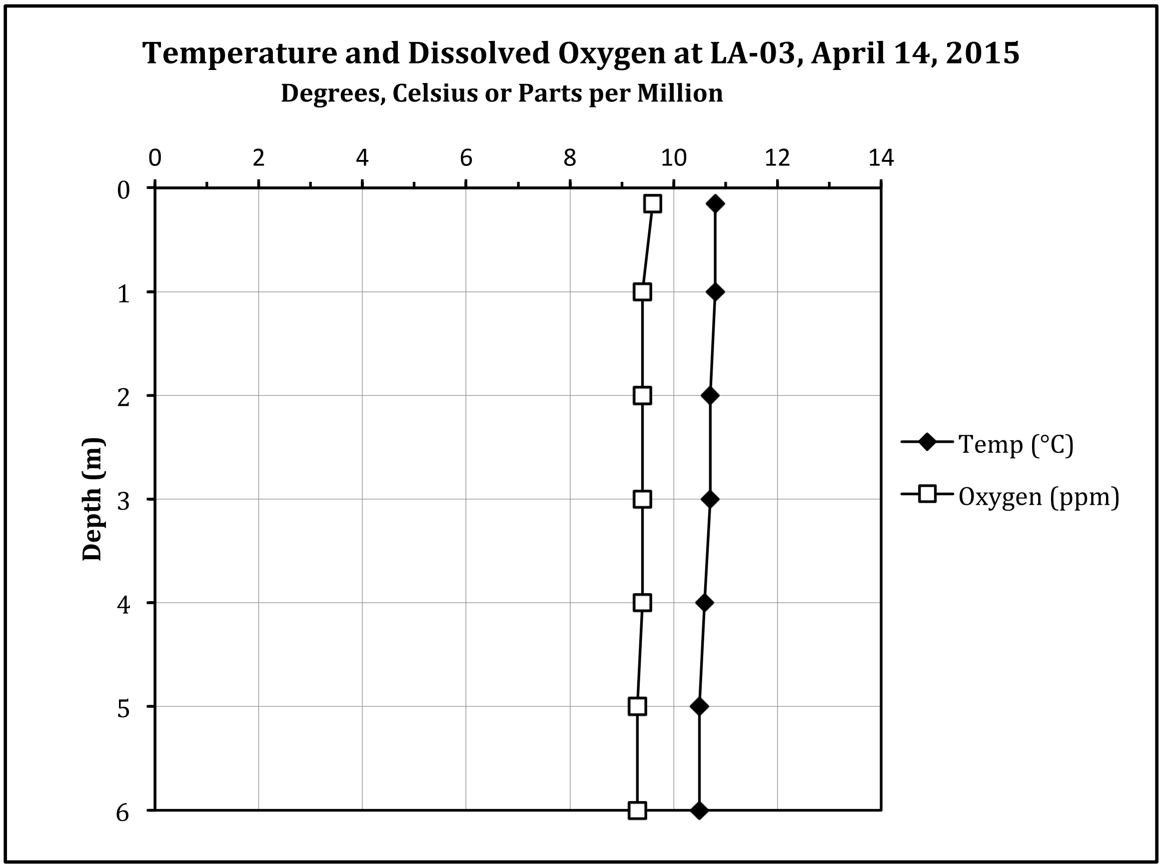


Figure 4. Temperature and Dissolved Oxygen at Lake Almanor, Station LA-03, 2015



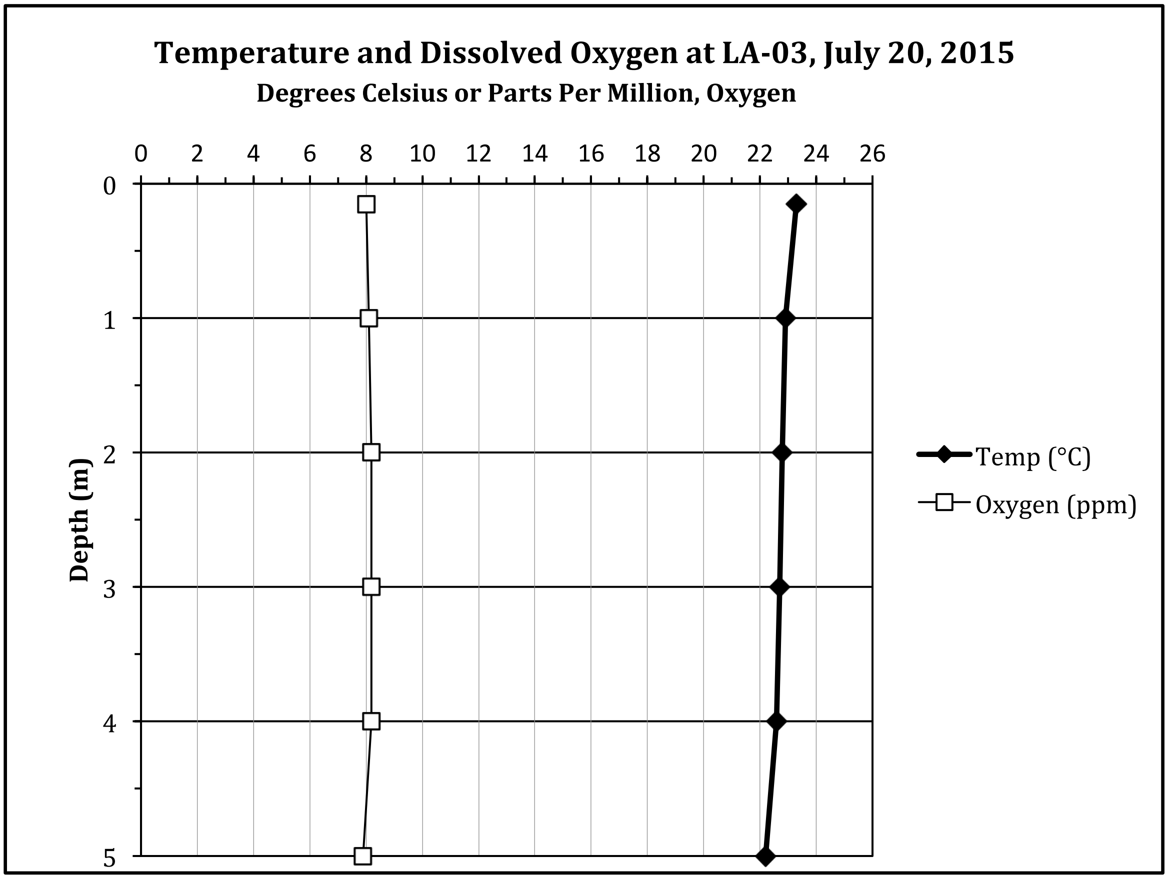
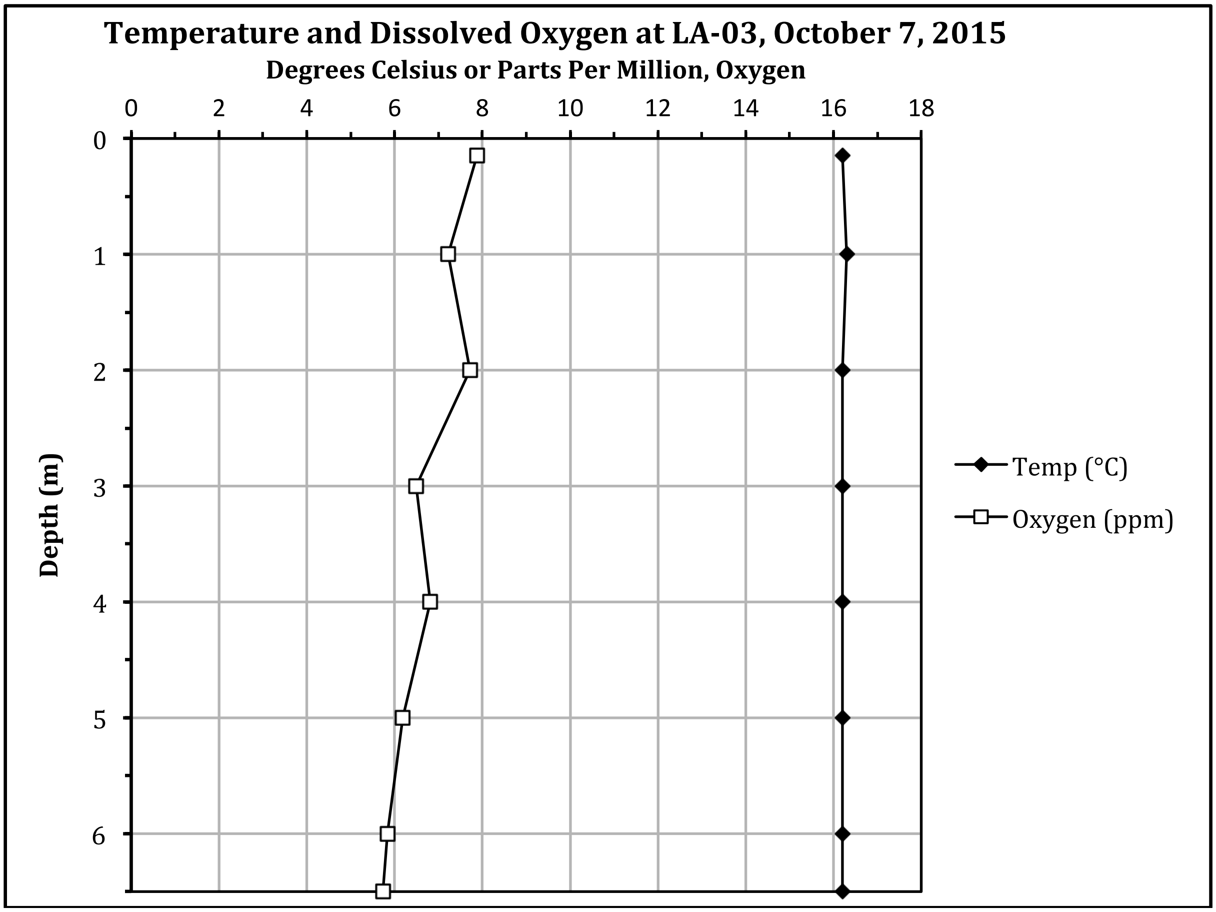


Figure 4 (cont.). Temperature and Dissolved Oxygen at Lake Almanor, Station LA-03, 2015



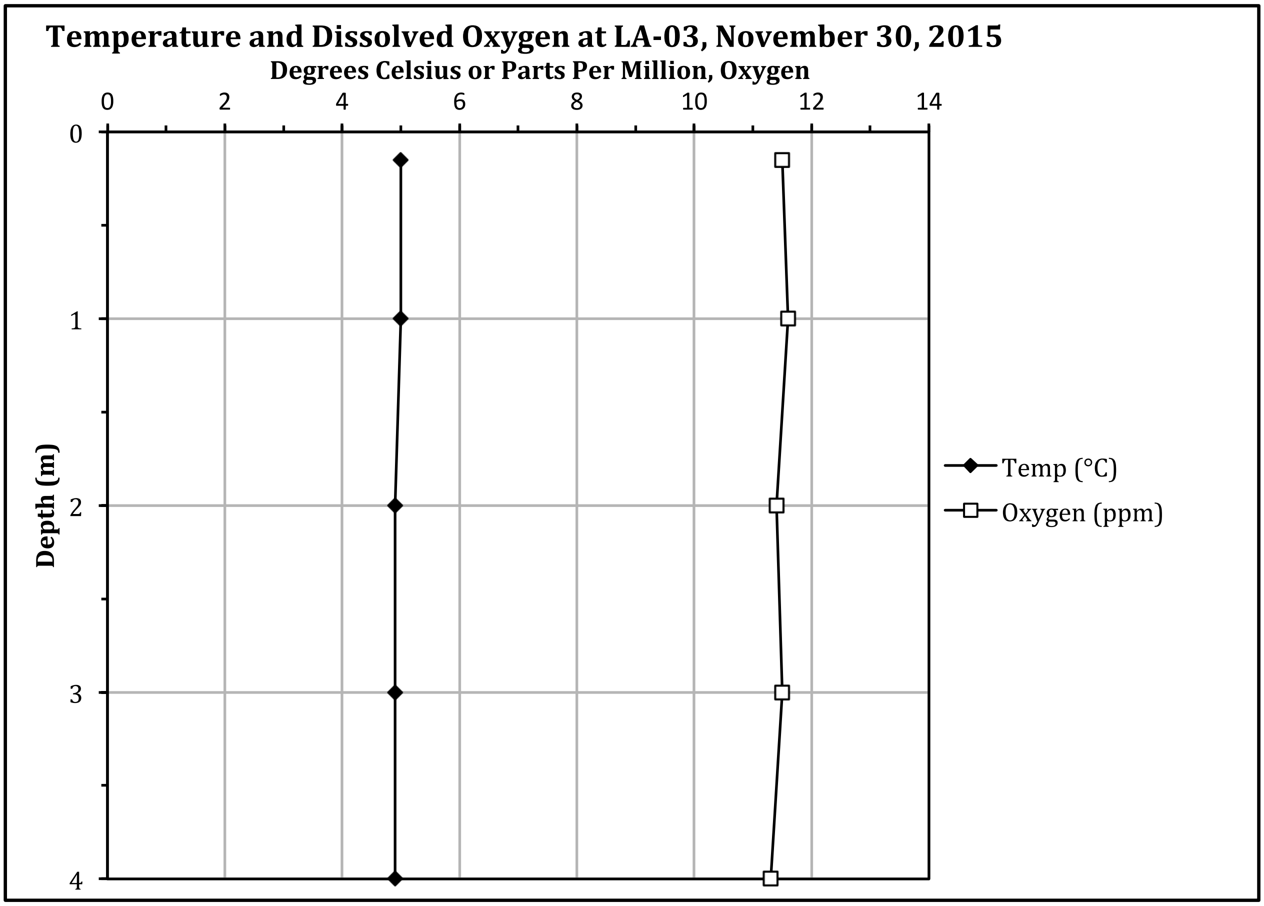


Figure 5. Temperature and Dissolved Oxygen at Chester, Station (NFFR-1) During 2015

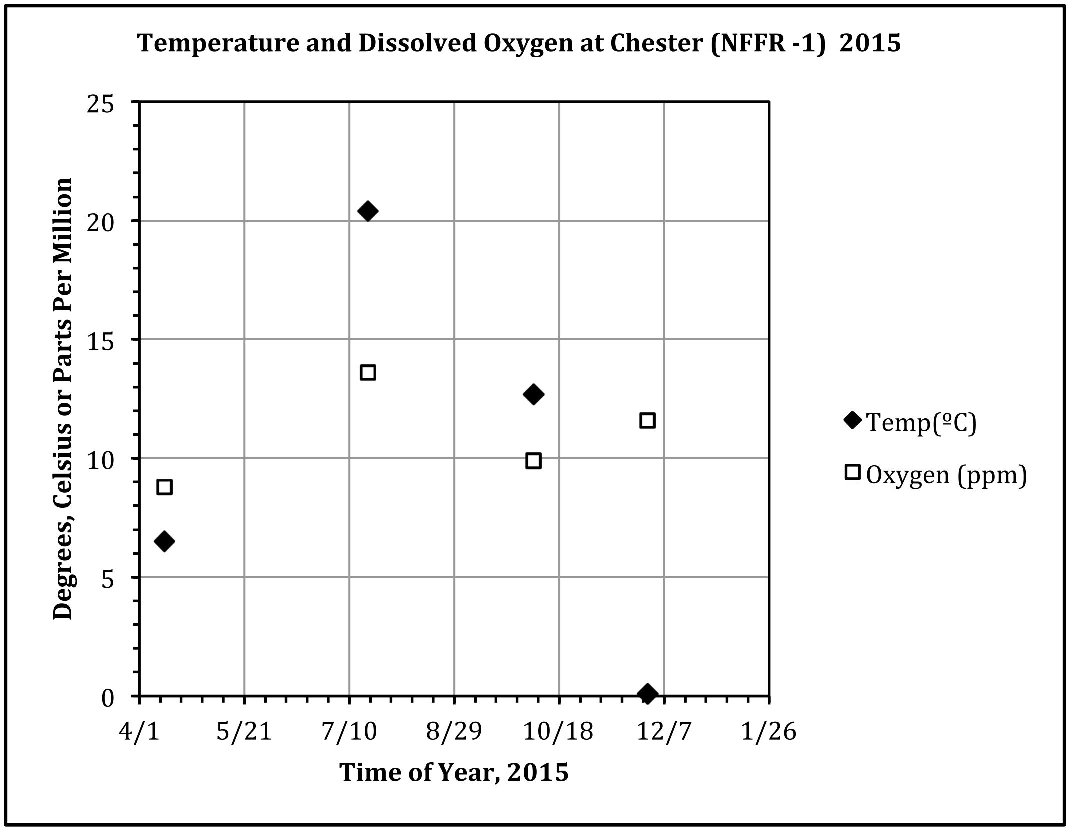


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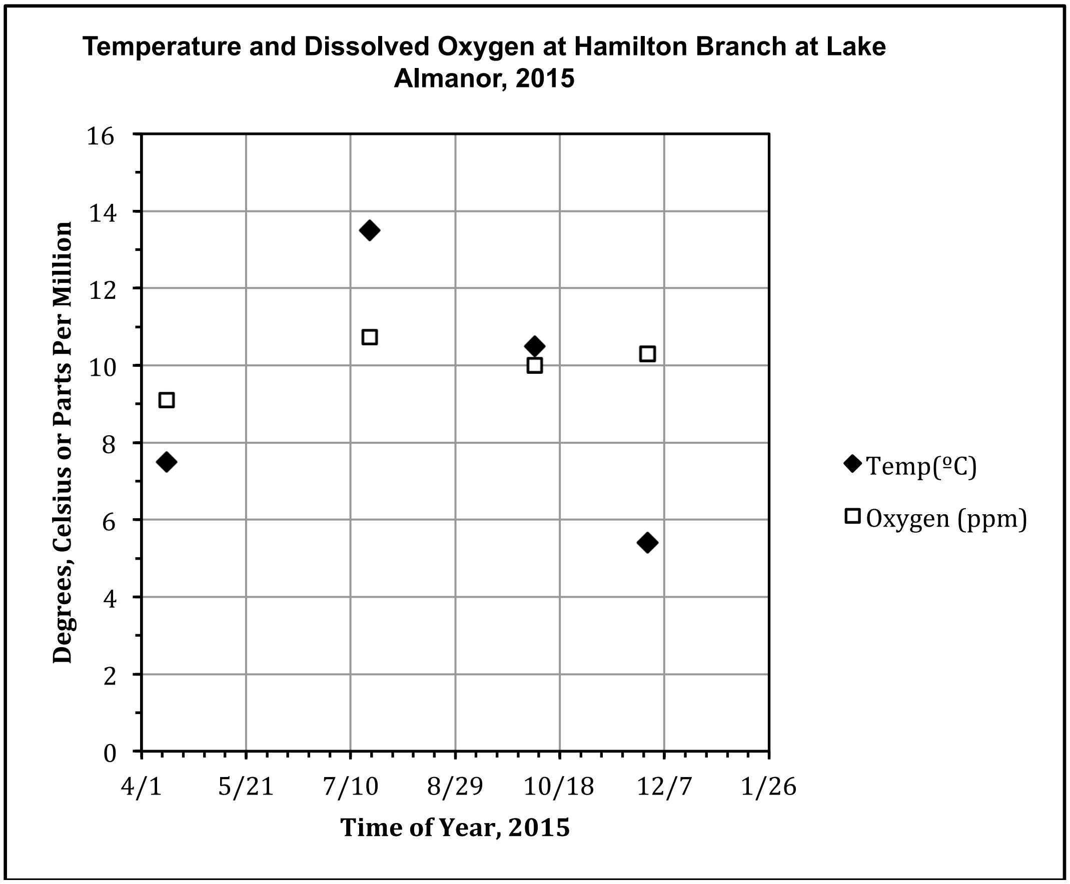
Figure 6. Temperature and Dissolved Oxygen at Hamilton Branch at Lake Almanor (HB-01A) During 2015



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” for most of summer. However, during drought years, thermal stratification is established earlier and the temperature of the water in the deeper parts of the lake is warmer than in years with more normal precipitation. This is probably due to lack of snowmelt entering from streams or runoff in the spring. The result is very low or zero oxygen concentration in the hypolimnion from July through September.

As discussed in earlier reports, the low levels of oxygen stress the cold-water fish species in the lake, since the regions where both temperature and oxygen preferences are met become scarce. In dry years such as 2012-2015, the region of suitable temperature and oxygen may not be present at all from late July to late September.

Oxygen levels in the Feather River are always higher than in the lake, primarily because of the colder water temperature and the turbulence of the water (See Figure 5). In July 2015 the oxygen level was 13 ppm, even though the temperature was high at over 20 °C.
The coolest water with high dissolved oxygen was Hamilton Branch at Lake Almanor (Figure 6). Temperature was about 14 °C and oxygen above 10 ppm in July. This cool oxygenated inflow provided a refuge for cold-water fish, although they were probably subject to higher rates of predation.

c. Electrical Conductivity

Electrical or specific conductivity is a measure of the dissolved salts in water. The data for all stations are presented in Table 1 in the Appendix. Values ranged from 95-140 micro-mhos/cm at the lake stations and from 72-102 micro- mhos/cm in the Feather 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 database for 1989-2004. The values have been gradually increasing since 2011 due to the decreased precipitation in the watershed. The highest values at LA-01 and LA-02 were in the deep hypolimnion in October. This was due to the anoxic conditions and release of compounds from the sediments.
Bailey Creek had the lowest conductivity (27 μmhos/cm), although it stopped flowing after the April sampling. Hamilton Branch downstream of the Mountain Meadows Dam generally had the highest value (95-540 μmhos/cm). The highest value (October) was following the emptying of Mountain Meadows Reservoir in September 2015.

d. Secchi Depth and Turbidity

Secchi depth is an indication of suspended particles in the water column. Data for Secchi depth is presented in Table 1 in the Appendix. For LA-01 and LA-02 Secchi depth was about 5-6 meters and at LA-03 it was 4.4 meters in April. It increased to 11 meters at LA-02 in July. In October it was 3-4 meters at LA-01 and LA-02 and 2.5 at LA-03. It was 3-3.5 at all three stations in November. Variation is probably related to sediment carried by inflowing streams (usually lower values in April, but not this year), as well as phytoplankton (lower values in November due to higher population). Values were generally in agreement with those in the DWR database and with the 2009 - 2014 studies.

Turbidity was generally low in the tributaries and in the lake, since there was little runoff this year. The highest reading was in October in Hamilton Branch downstream of Mountain Meadows Dam (74 ntu).

2. Chemical Parameters: Nutrients

The results of all chemical analyses are presented in the Appendix, Table 4. Only the nutrient data for certain stations are shown and discussed below. Nitrate plus nitrite nitrogen and total phosphorus are summarized in Table 1 below for NFFR-1 at Chester, Hamilton Branch downstream of Mountain Meadows Dam (HB-01C), Hamilton Branch at Lake Almanor (HB-01A), LA-01, LA-02 and LA-03 for the four dates in 2015.
The data show that although the lake stations are generally low in nutrients, Hamilton Branch is usually higher in nutrients, especially just below Mountain Meadows Dam. 2015 was another dry year with low inflows. In a wet year Hamilton Branch probably contributes greater amounts of nutrients to the lake.

The data for October 7, 2015 also shows that nutrients increase in the deeper portions of the LA-01 and LA-02, due to their release from the sediments under anoxic conditions. These nutrients then become available to the phytoplankton when the lake “overturns” and plankton populations increase. All nutrient values were well below limits for drinking water, but were typical of those found in mesotrophic lakes.

The general chemistry data (Appendix, Table 4) show that high levels of metals, particularly iron and manganese, but also aluminum, lead and nickel, are present in Hamilton Branch below Mountain Meadows Dam. These values were very high in October, following the emptying of Mountain Meadows Reservoir. Higher amounts of these metals were also present in deep water samples from LA-01 and LA-02, as these substances were released from the sediments under anoxic conditions.

Table 1. Nutrient Concentration (mg/L) for Selected Stations At Lake Almanor, 2015

Date: April 14, 2015		
Station	**Nitrate +Nitrite (mg/L as N)**	**Total Phosphorus (mg/L as P)**
NFFR at Chester CA	<0.01	0.04
Ham Brnch DS Mountain Meadows Dam	0.08	0.04
Ham Brnch @ Lake Almanor	0.08	0.02
Lake Almanor @ IT Tower Dam (LA-01) 27 meters	0.02	0.01
Lake Almanor East Arm (LA-02) 18 meters	<0.01	<0.01
Lake Alman West Arm (LA-03) 8 meters	<0.01	0.02

Date: July 20, 2015		
Station	**Nitrate +Nitrite (mg/L as N)**	**Total Phosphorus (mg/L as P)**
NFFR at Chester CA	<0.01	0.04
Ham Brnch DS Mountain Meadows Dam	0.09	0.18
Ham Brnch @ Lake Almanor	0.05	0.02
Lake Almanor @ IT Tower Dam (LA-01) 27 meters	N/A	N/A
Lake Almanor East Arm (LA-02) 18 meters	N/A	N/A
Lake Almanor West Arm (LA-03) 8 meters	N/A	N/A

Date: October 7, 2015		
Station	**Nitrate +Nitrite (mg/L as N)**	**Total Phosphorus (mg/L as P)**
NFFR at Chester CA	<0.01	0.03
Ham Brnch DS Mountain Meadows Dam	<0.01	0.25
Ham Brnch @ Lake Almanor	0.1	0.02
Lake Almanor @ IT Tower Dam (LA-01) 27 meters	0.02	0.04
Lake Alman East Arm (LA-02) 18 meters	0.02	0.04
Lake Alman W Arm 8 meters	0.02	0.02

Table 1 (continued). Nutrient Concentration (mg/L) for Selected Stations At Lake Almanor, 2015

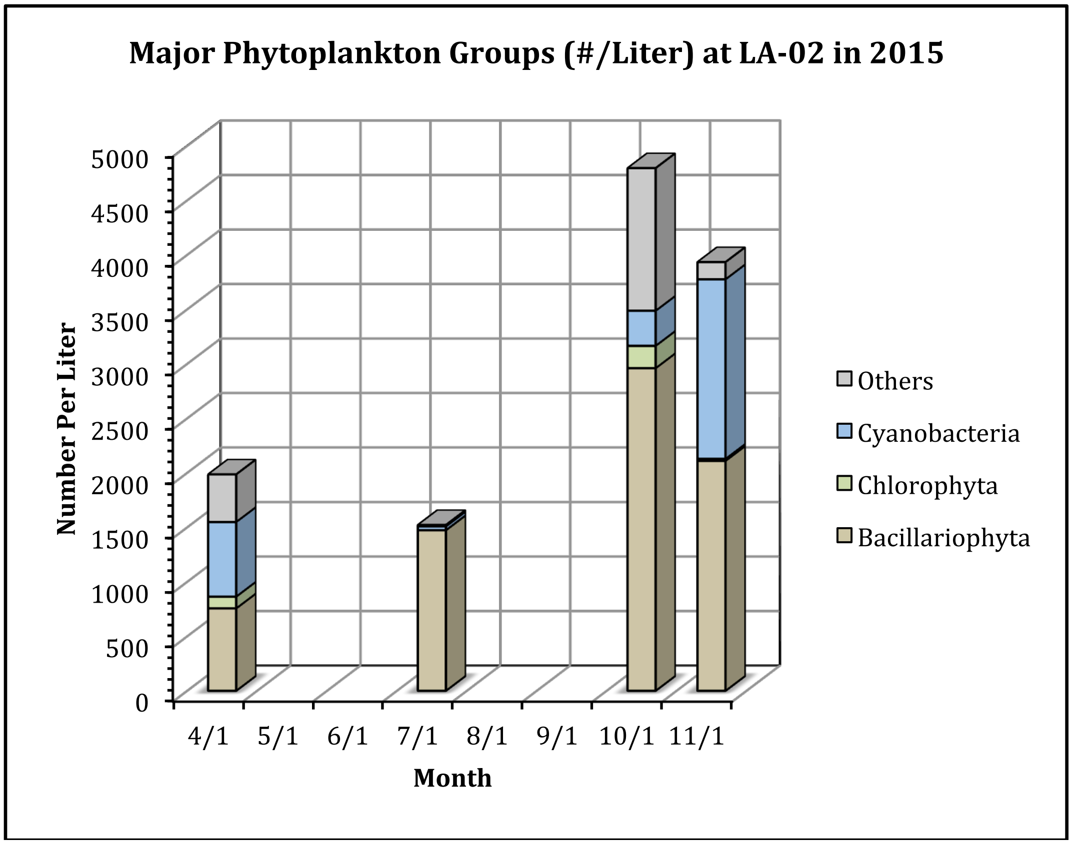
Date: November 30, 2015		
Station	**Nitrate +Nitrite (mg/L as N)**	**Total Phosphorus (mg/L as P)**
NFFR at Chester CA	<0.01	0.03
Ham Brnch DS Mountain Meadows Dam	N/A (frozen)	N/A (frozen)
Ham Brnch @ Lake Almanor	0.1	0.02
Lake Almanor @ IT Tower Dam (LA-01) 27 meters	<0.01	0.01
Lake Almanor East Arm (LA-02) 18 meters	<0.01	0.01
Lake Almanor West Arm (LA-03) 8 meters	0.02	0.03

3. Phytoplankton and Zooplankton

Phytoplankton samples 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 7 and 8. More detailed data are in the Appendix, Table 2. The data are presented in two different graphs for each station. The first graph shows the number of algal cells or colonies per liter of lake water. The second graph shows the volume of algal cells per milliliter of lake water (cubic microns per milliliter). This way of showing the data is more representative of the amount of algae present, since the size of individuals varies greatly. The number of cells per liter treats small and large cells equally. (Please be aware that the range for the vertical scale is not the same for LA-02 and LA-03.)

In April diatoms (Bacillariophyta) were the dominant form at both LA-02 and LA-03, particularly *Fragilaria, Asterionella* and *Stephanodiscus.* There were almost as many bluegreen algae, primarily *Aphanizomenon*. This was also true at LA-03. By July the total volume of algae had dropped at LA-02, but increased at LA-03, where the bluegreen (Cyanophyta) *Lyngbya*, was abundant. In October and November these genera were joined by more bluegreens: *Aphanizomenon* and *Anabaena*. Diatoms (Bacillariophyta) were the most abundant in November at both stations. LA-02 had its greatest amount of phytoplankton in October. This may have been due to the later sampling date (October instead of September) and the partial mixing of the nutrient rich deeper water with the surface water. It could also be due to the effect of Mountain Meadows Reservoir emptying. There was less phytoplankton at LA-03 than in 2014.

Figure 7. Major Phytoplankton Groups at Lake Almanor, By Number/Liter and By Volume (cubic microns/milliliter), Station LA-02 in 2015


Major Phytoplankton Groups (#/Liter) at LA-02 in 2015

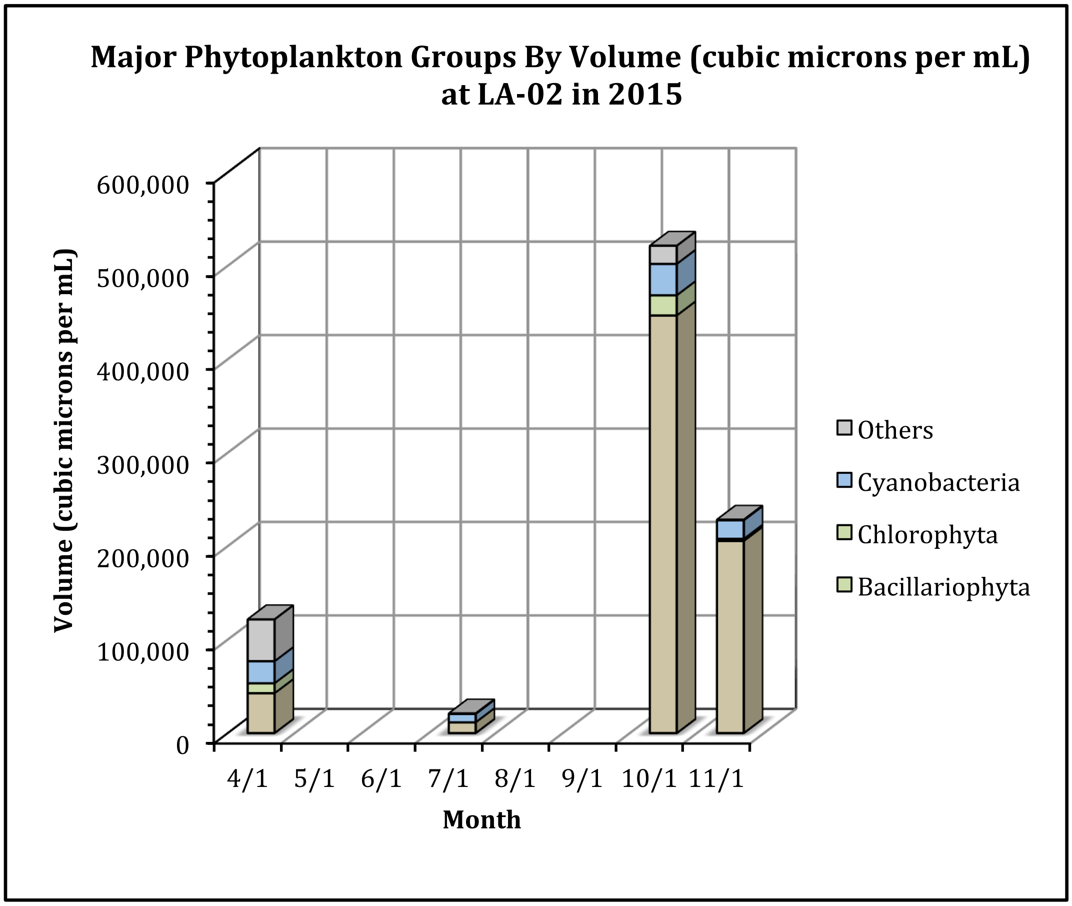
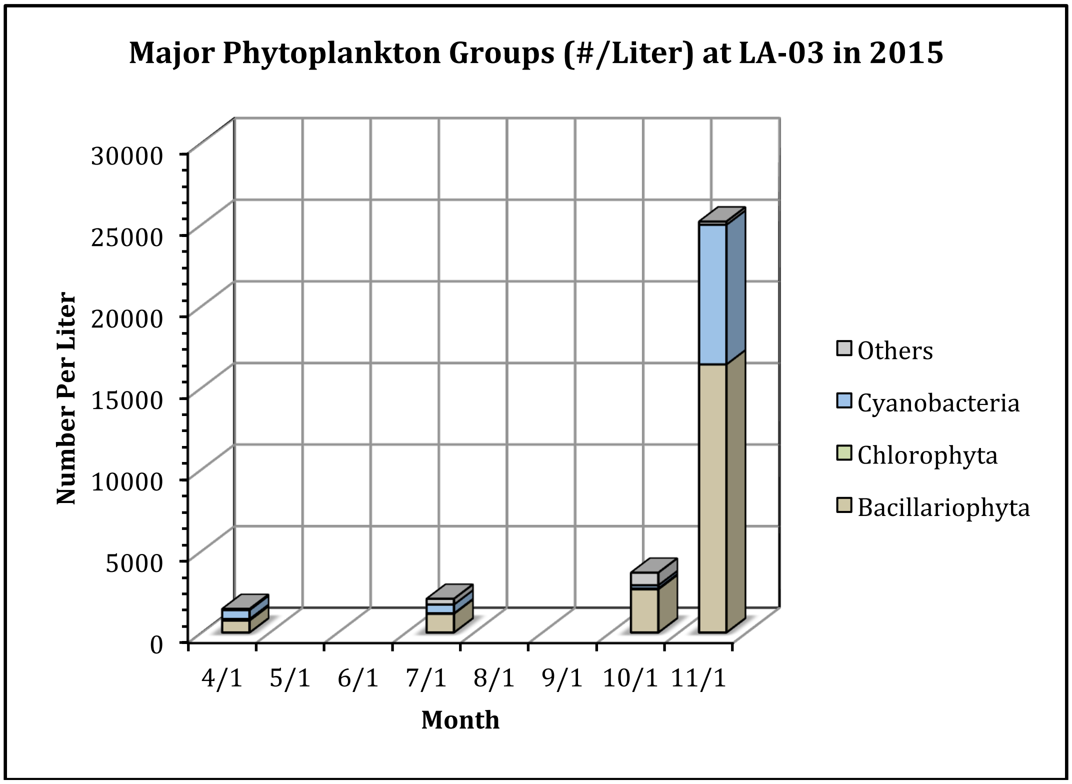

Major Phytoplankton Groups By Volume (cubic microns per mL) at LA-02 in 2015

Figure 8. Major Phytoplankton Groups at Lake Almanor, By Number/Liter and By Volume (cubic microns/milliliter), Station LA-03 in 2015



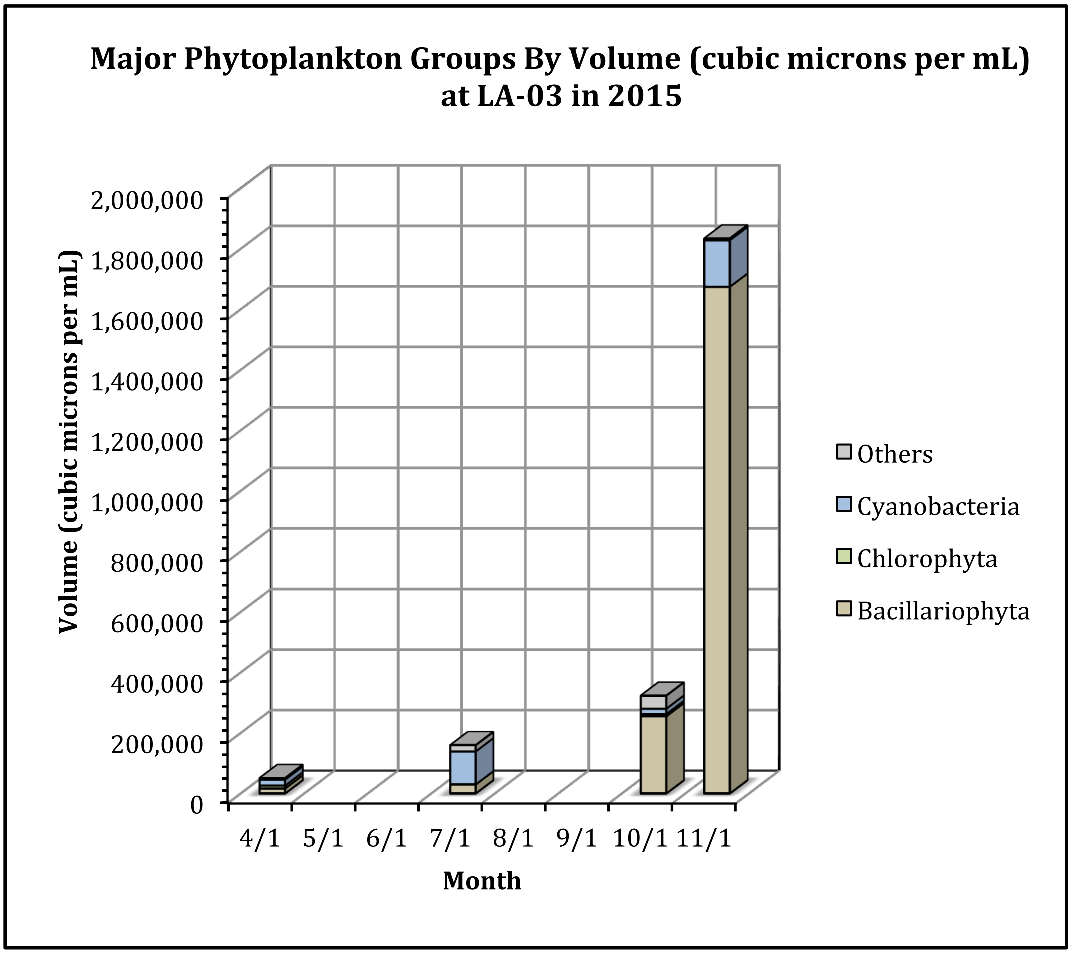
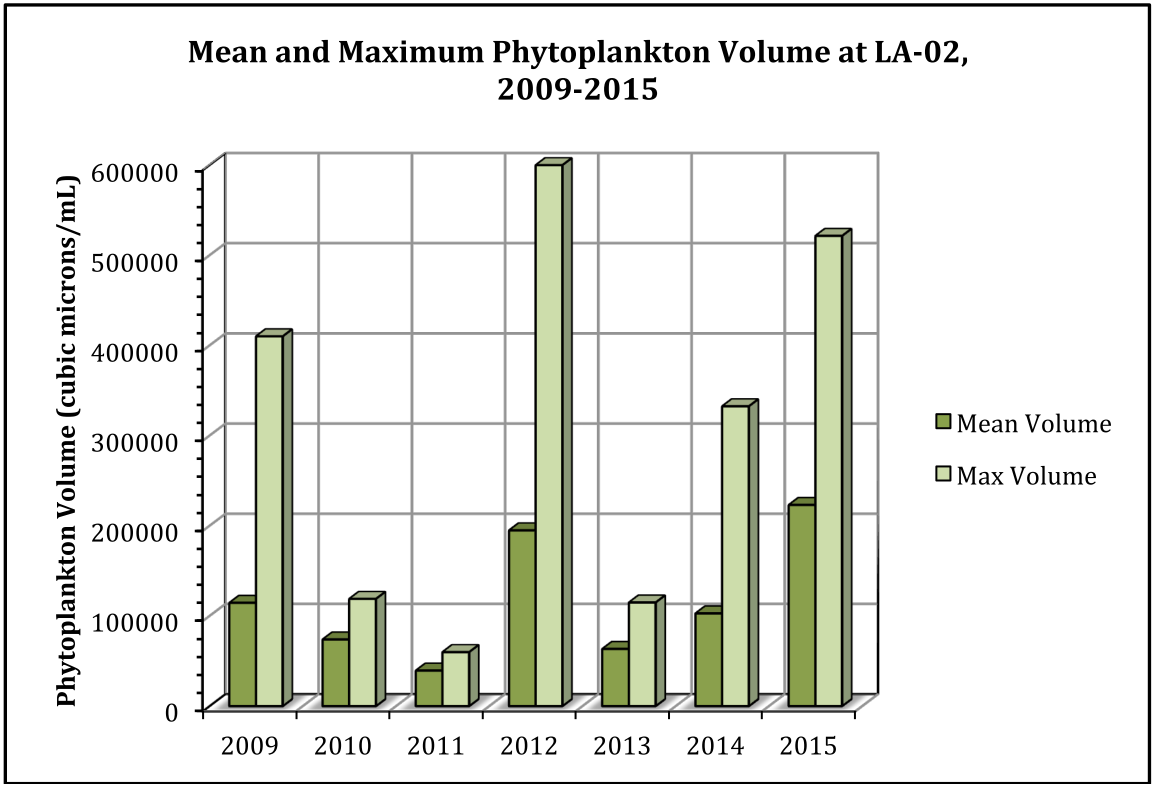


Figure 9 shows the maximum amount of phytoplankton by volume at LA-02 and LA-03 from 2009 to 2015.The maximum was generally in November, but at LA-02 the greatest amount was in October, 2015, as discussed previously. At LA-02 the amount of algae has been increasing since 2013. At LA -03 the greatest volume in 2014 was six times the highest level in 2013 and was the highest in the last five years. In 2015 values were only about 2/3 of those in 2014. Bluegreen algae continued to be numerous in the late summer and fall, but diatoms (Bacillariophyta) were the most numerous in fall. The increasing amount of algae overall was probably due to warmer and clearer water.

There are no recent data from DWR concerning the phytoplankton, but some tables from the 1970's show that many of the same species were present then. The assemblage of genera is characteristic of meso-trophic lakes.

Zooplankton were collected along with the phytoplankton and results are presented in Figures 10 and 11. More detailed data are in the Appendix, Table 3. The most abundant group at both stations was the Rotifera, with few Copepoda and Cladocera present. Most likely, their small size limits predation by small fish, whereas Copepoda and Cladocera are readily eaten. The most common genera were *Keratella* and *Polyarthra* at both stations. Populations were higher in April and July at LA-02, even though phytoplankton abundance was low. By October and November populations were lower. This corresponded to high phytoplankton abundance.

Figure 9. Mean and Maximum Phytoplankton Volume at LA-02 and LA-03, 2009 -2015



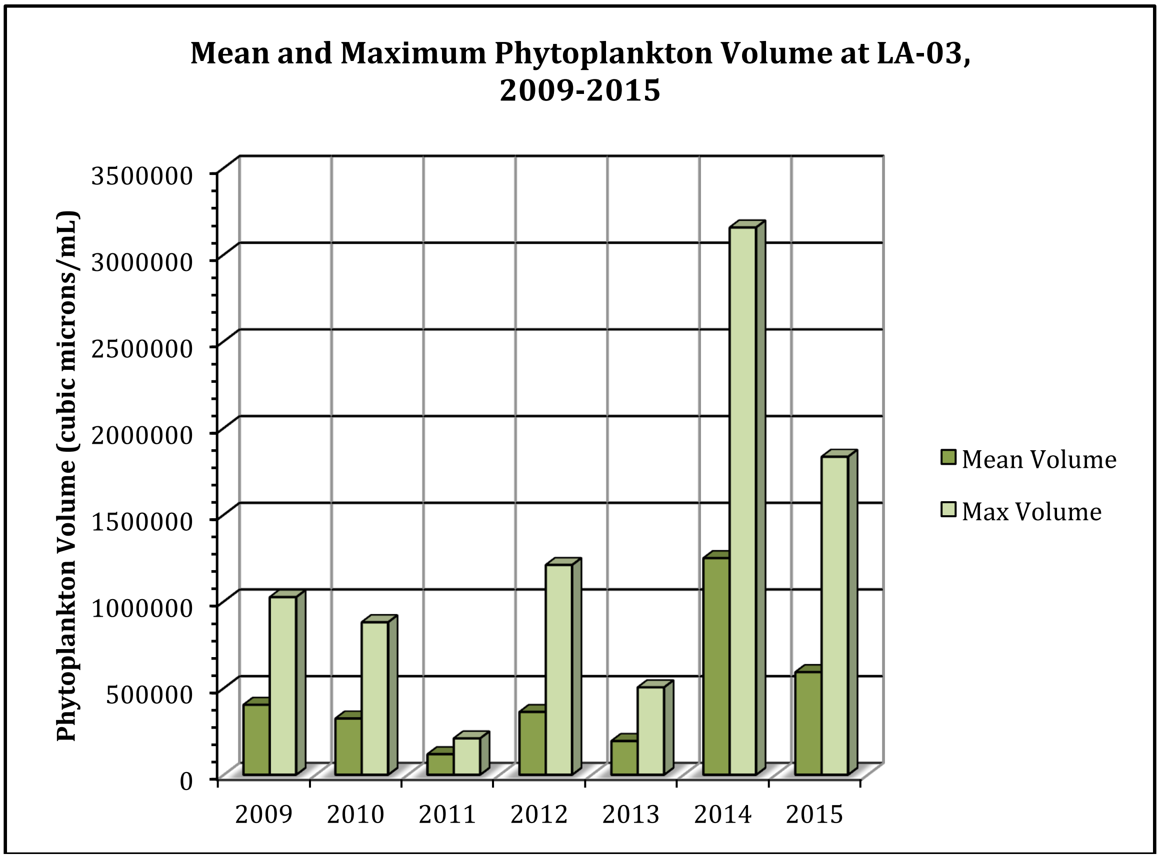


Figure 10. Major Zooplankton Groups (#/Liter) at Lake Almanor, Station LA- 02, 2015

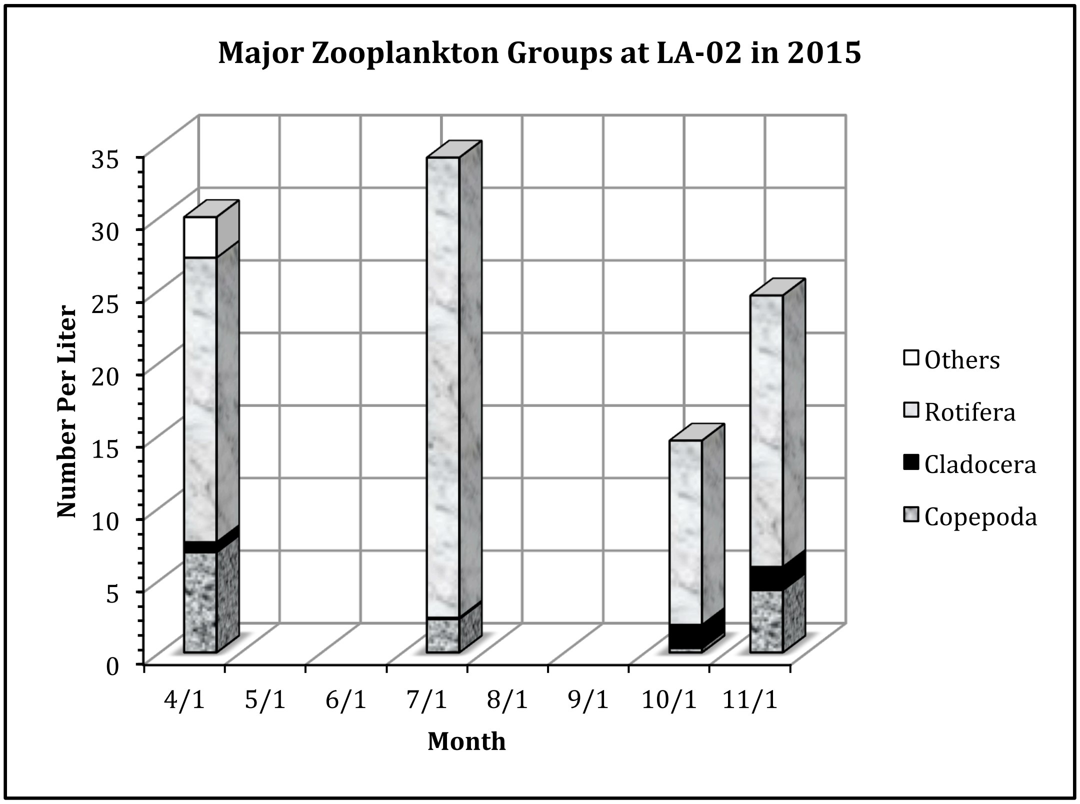
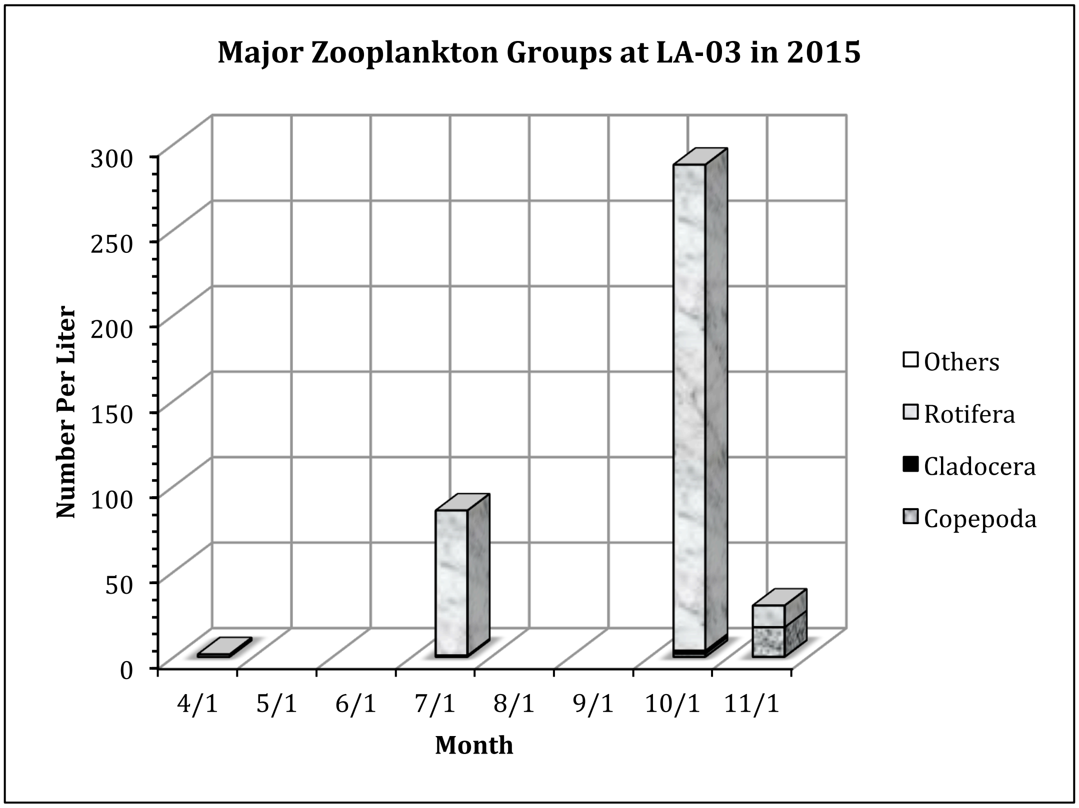


Figure 11. Major Zooplankton Groups (#/Liter) at Lake Almanor, Station LA-03, in 2015



Conclusion

Lake Almanor is a reservoir that is already undergoing many changes. Because of the lake’s high elevation, the cooler water temperature and the short growing season limit some plant growth. However, the western basin is shallow and the water is warm in the summer. Phytoplankton and larger aquatic plants can become very numerous at this time of year. There are enough nutrients coming in from the river, streams or from human activities (septic tanks, golf courses, lawns) to support abundant plant growth. As more homes are built in the watershed, the nutrient input will increase.

An extensive sampling program undertaken by DWR provided physical, chemical and biological data for three lake stations and major tributaries.
2015 was the fourth warm, dry year in a row. The physical data showed that there were higher water temperatures and less dissolved oxygen in the epilimnion than in the previous five years. Dissolved oxygen in the metalimnion dropped to zero and the hypolimnion was devoid of oxygen earlier in the year at LA-01 and LA-02 than in previous studies. Suitable coldwater fish habitat would have been at a minimum or non-existent by August of 2015.

Warmer water temperatures resulted in higher than average algal abundance in October and November at both LA-02 and LA-03. Algal abundance at LA-02 was much higher than in recent years.

Chemical and nutrient analyses showed that Mountain Meadows Reservoir is probably a significant source of metals and nutrients. This could be confirmed in a year with higher inflows. Because precipitation was so low, it was not possible to determine if other tributaries were significant nutrient sources.

Additional sampling is needed to document ongoing water quality changes. Hopefully, a similar program of monitoring can be continued in 2016. The installation of an additional temperature/oxygen continuous data logger has given us more precise information about the depletion of oxygen in the deeper regions of the lake and the effect of this on available fish habitat. We can now document the loss of coldwater fish habitat during the summer months. The effect of drought years has been to lengthen the period of time when coldwater fish are stressed.