As Lake Berryessa Turns!

Temperature and Fishing in a Warm, Monomictic Lake

By Peter Kilkus

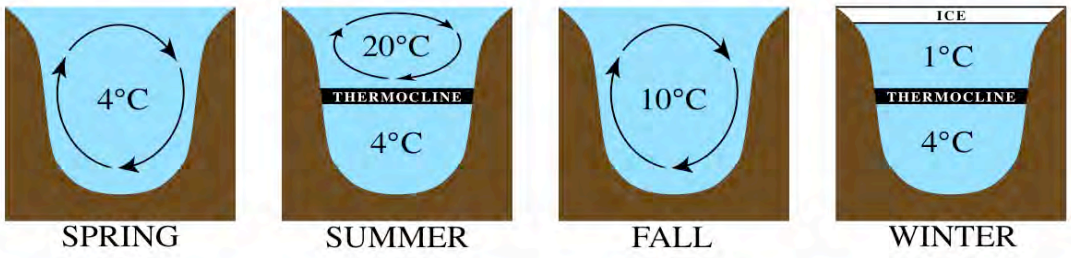
The phenomenon called “turnover” is well-known to anglers, but not so much to other lake visitors. Some people think that Lake Berryessa turns in both spring and fall. But scientific data shows that the lake only turns once per year - in the fall.

Turnover is essentially what it sounds like. The water on the bottom of the lake goes to the top, and the water on the top of the lake goes to the bottom. Although the turning of a lake is partly due to temperature and density differences in the layers, the major cause for the turnover (or mixing) is the wind. The wind causes full mixing of the lake when the temperature of the water is the same at all depths and there are no layers.

Thermal stratification of lakes is the separation of lakes into three layers caused by temperature differences among the layers:

1. Epilimnion - top of the lake.
2. Metalimnion (or Thermocline) - middle layer that may change depth throughout the day.
3. Hypolimnion - the bottom layer.

For ease of understanding, I’ll call these the top layer, middle layer, and bottom layer. When layers mix and change places, a lake is said to turn over. Lakes that turn over once a year are said to be monomictic. Lakes that turn over twice a year, once in spring and once in fall, are called dimictic. Dimictic lakes usually freeze over during the winter. The reasons for both the spring and fall turnover in lakes that freeze are easy to understand so, with the help of the diagram below, I’ll discuss them first.



In late summer lake surface waters of both monomictic and dimictic lakes have reached their annual maximum temperatures. At this time in a sufficiently deep lake, you will find a definite layering of water temperatures. Warmest, and therefore least dense, waters lie on top, and the water temperature decreases with depth, reaching its minimum temperature at the greatest lake depths. How cold the lake bottom water becomes depends on the lake depth and other characteristics, but it will never fall below 4 deg C (39 deg F) unless the lake freezes solid.

Summer breezes blowing over the lake generally keep the top layer stirred by pushing a quantity of surface water downwind. This draws a flow of deeper water upward (upwelling) along the lee shore to replace the pushed waters. But this upwelling is not coming from the deepest layer, only from the lower part of the top layer. As a result, top layer waters mix, producing generally warm temperatures and high oxygen content (important to fish and other creatures) throughout the top layer. The middle thermocline layer has minimal mixing, and what does occur is slow, thus isolating the bottom waters below it from the surface zone.

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In fall, the surface water cools. Its drop in temperature eventually matches the temperature of the middle layer. When these top layer waters reach about 10 deg C (50 deg F), they sink into the middle layer waters below, erasing the temperature stratification between the top and middle layers that had built during summer. As fall air temperatures continue to drop, this new upper layer cools to the temperature of the bottom layer. The full water mass of the lake has now reached a uniform temperature, and the surface winds mix the full water body in the "fall turnover". The water temperatures then continue to decrease into the winter months.

For lakes that fall below 39 degrees and finally freeze, the surface becomes colder than the bottom, but this cold water now "floats" on top of the "warmer" water. (See above diagram) The colder surface water is now actually lighter than the warmer water and floats on it until it actually turns to floating ice. The key to this unusual process is how water density varies with water temperature.

Water is most dense (heaviest) at 39º F (4º C) and as temperature increases or decreases from 39º F, it becomes increasingly less dense (lighter). Thus, at 39 degrees and below, less dense but colder water is now at the surface and more dense but warmer water is now near the bottom.

During spring, the process reverses itself. The ice melts and surface waters warm and sink until the water temperature at all depths reaches approximately 39º F. When this occurs, winds blowing over the lake again set up a full circulation system, this mixing known as "spring turnover". As the warming continues into the summer, the top water layer becomes much warmer and less dense. The warm surface layer now "floats" on the cooler lower layers. Over time into the summer the three water layers again become established, and our cycle has been completed.

Since Lake Berryessa water temperatures never get below 39 degrees, it is classified as a warm, monomictic lake. During winter, the surface waters cool to a temperature equal to the bottom waters. But lacking significant thermal stratification, since the water never gets below 39 degrees, much less freeze, these lakes mix thoroughly each winter from top to bottom and continue to mix until spring.

This situation is graphically illustrated by the following 2008-2009 charts from the Solano County Water Agency. SCWA maintains a thermistor chain of sensors to a depth of 70-ft near Monticello Dam. The charts below show 1-year's worth of data indicating that Lake Berryessa experiences one mix per year.

In 2008 mixing occurred in November followed by several months where the lake was well mixed. The stratification began again in March, 2009. For Water Year 2010, there was a similar pattern where Lake Berryessa became well mixed in mid November.

The thermocline is usually around 40 feet deep, but there are not enough temperature sensors to say with absolute certainty without finer resolution. Anglers with good depth finders can usually find the thermocline quite easily because algae and protoplankton will form a layer there, and the deeper, colder water is much more dense.

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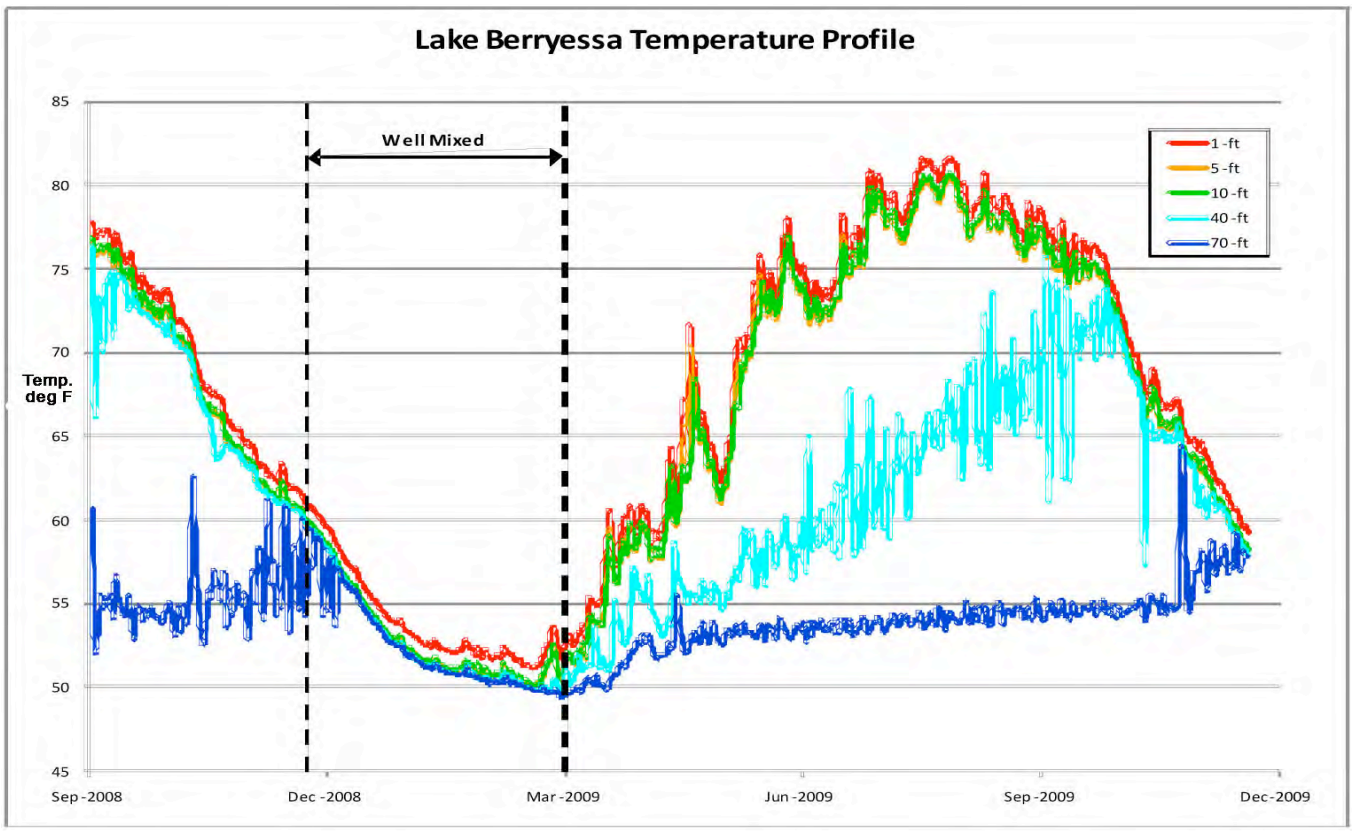
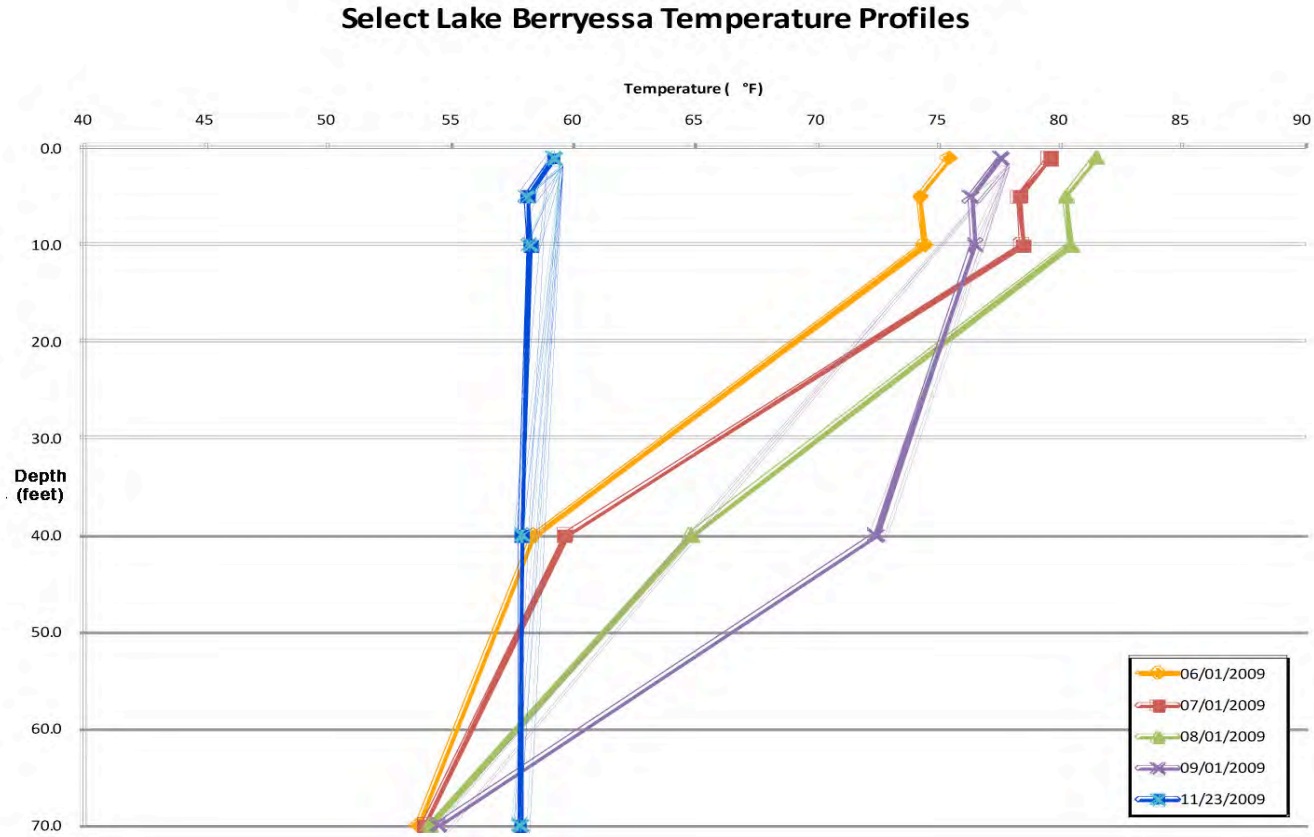

Lake Berryessa Temperature Profile
Well Mixed
1 -ft
5 -ft
10 -ft
40 -ft
70 -ft
Temp. deg F
85
80
75
70
65
60
55
50
45
Sep -2008
Dec -2008
Mar -2009
Jun -2009
Sep -2009
Dec -2009


Select Lake Berryessa Temperature Profiles
Temperature (°F)
40
45
50
55
60
65
70
75
80
85
90
Depth (feet)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
06/01/2009
07/01/2009
08/01/2009
09/01/2009
11/23/2009

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The classic description of lake turnover is describing “dimictic” lakes or those having two mixes per year. Many larger lakes and reservoirs are “monomictic” - having only one mix per year. Without ice formation and the colder, less dense water rising to the top, reservoirs such as Lake Berryessa will not experience a spring turnover.

Winds in the Lake Berryessa region also play a large role in keeping the lake well mixed or de-stratified until summer when surface water temperatures are significantly different, allowing the stratification into the epilimnion, metalimnion and hypolimnion.

The fishermen at Lake Berryessa probably have the best data regarding the lake turnovers and where the metalimnion demarcation typically is located because that is where the fish feed on the zooplankton accumulating at the density gradient. Different arms of the lake may behave differently due to the wind fetch, sun exposure and interflows from streams.

Remember also that the total depth in the vicinity of the dam is almost 250 feet. The lower depths are pretty consistent, VERY COLD. Another interesting fact is that the Monticello Dam is what is called a “hypolimnetic discharge”, meaning that water discharged downstream is drawn off the lower portion of the water volume so it is very cold and very nutrient rich. These nutrients support the large biomass of aquatic plants (and algae) in Lake Solano which is predominately Myriophyllum sp., also known as Eurasian Milfoil.

The Bureau of Reclamation rangers monitor some of the biological impacts of lake turnover. They have a thermometer down at their boat dock in about 1.5 feet in the water. On November 20, 2009, for example, it read 60 degrees, roughly the same temperature since the beginning of the month. Typically, the lake turns in the fall sometime in November, but they've never noticed too dramatic a drop on any given day, or week for that matter. Usually by January it's around 50 degrees. The lowest they've seen it is 48 degrees.

The big, noticeable change in the spring relates more to direct sunlight on the lake surface, warming water temperatures, and the biological processes that "kick into gear." During this time phytoplankton/algae become more numerous, changing the water from clear to cloudy green - "The Spring Bloom". In response to the algae growth, small invertebrates (i.e. copepods, tiny shrimp-like critters, and insect larva) become abundant followed by increased feeding and reproductive activity by larger aquatic animals like fish and frogs. The fishermen respond to all this new fish activity and spawning in the early spring - which may be the source of the “spring turnover” concept among anglers at Lake Berryessa.

By late spring, nutrients typically become depleted from the lake and planktonic populations crash, causing the lake to clear a bit and fishing activity to taper-off. The summer is a period of "lake exhaustion", when food becomes scarce and only the hardiest aquatic creatures survive. All the dead organisms sink to the bottom of the lake becoming food for decomposers like bacteria. The biological processes of bacteria can deplete deep water O2 supplies which make the fall turnover especially important, not only for recycling nutrients through the water column but also in restoring deep water O2 levels.

Upwelling in the fall can cause planktonic blooms, but they are usually short-lived because water temperatures are too low and the days lengths too short to sustain much photosynthetic activity. Sometimes when deepwater decomposition is anaerobic, toxic byproducts are produced (for example, hydrogen sulfide) that are brought to the lake surface. If undiluted, these byproducts along with O2-starved water from the deeper parts of the lake can become a lethal combination for fish, but this typically does not happen at Lake Berryessa.

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Fishing and Turnover

Fish have a metabolic rate dependent on water temperature. This dependence on water temperature also affects their immune system, wound healing, and digestion. Each fish has a different range of water temperature in which it can survive. Although fish cannot always find the exact temperature they prefer, they are usually found in water close to that temperature.

Trout, for example, will actively seek 64-degrees or the closest temperature to it. Sixty-four degrees is the optimal temperature for a trout body to function at its peak. Below 50-degrees the trout will start to shut down. Above 70-degrees the trout will also start to shut down. So, you can safely guess that trout actively feeding and swimming will be found where water temperatures are in the 55-65 degree range.

Species and their preferred temperatures:

Brown Trout	60-65 F
Lake Trout	48-52 F
Rainbow Trout	55-60 F
Chinook Salmon	48-55 F
Coho Salmon	48-55 F
Largemouth Bass	68-78 F
Smallmouth Bass	67-71 F
Striped Bass	60-70 F
Bluegill	75-80 F
Crappie	70-75 F

The angler should know how to locate fish by temperature. Probe a lake's depth with a thermistor on a calibrated cord. The thermistor registers instant temperatures and the cord marks the depth. There are newer models out which also register oxygen content, pH, and water clarity. Simply find the depth corresponding to the preferred temperature range of the fish species you are seeking. Then identify the ideal temperature-depth which coincides with the lake's bottom structures that produce both food and cover. This is a likely spot to find actively foraging fish. Other factors such as light intensity, water clarity, pH, and oxygen content influence the fish by forcing them to migrate where these factors are favorable.

During summer, the surface of a lake the water will be very warm and stays warm down to a certain level. As the Lake Berryessa chart above shows, the surface might be at its maximum of 82 degrees in August, while 40 feet deep it is 70 degrees. At 70 feet the water is about 55 degrees and it will stay that cool all summer. Lake Berryessa bottom water temperatures never go below about 50 degrees.

After turnover the whole lake has good oxygen content and fish can move anywhere. They are hard to pattern because they roam a lot for a few weeks before setting up on deeper winter structure.

Some professional anglers are unsure what happens to bass during the turnover, but they agree that the fish are affected, almost like a cold front situation. It disorients them a little bit and they can get somewhat "goofy" about that time. Before the turnover, fishing tends to improve with the cooling water conditions. During and after the turnover, however, fishing tapers off.

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