

Magee's Memos

Beginner's Guide to Thermoclines

A thermocline is where the water temperature suddenly changes from a warm surface temperature to a colder bottom temperature in a relatively short space in the vertical water column. Frequently, it'll change between 20-30 deg F in just the space of 1'-3', a phenomena that definitely gets a descending diver's attention! Thermoclines are a common phenomena that lake and deep quarry divers have become familiar with. However, non-divers and new divers may never have experienced or heard of them before.

A thermocline forms due to the summer sun, which heats the surface's water. Due to the density difference between warm and cold water, the cold water sinks down while the warm water rises. Pretty soon a strong separation boundary exists between the two bodies of water with a gradient, the thermocline, in between. This gradient is caused by heat transfer, mass diffusion, and slight mixing effects. The thermocline starts at the beginning of the summer at a relatively shallow depth with little temperature difference across it. As the summer progresses, however, and more surface water is heated, the thermocline's temperature difference and depth both increase. The bottom water warms slightly due to heat transfer from the above waters, but overall the bottom water is less affected.

At the peak of summer, the thermocline will be deepest and will have the strongest temperature change across it. However, as the summer wanes, the lack of a driving thermal input from the sun to the top waters causes the thermocline system to become unstable. At some point as the surface waters cool down and disturbing effects from winds and storms become stronger, the lake will suddenly "turn over" and mix, causing the thermocline to disappear and the water temperature to become a uniform average temperature from top to bottom.

Divers care about thermoclines not just because of the temperature change, but also because it can dramatically affect water visibility. Generally speaking, in the spring the visibility is average but consistent everywhere. As the summer progresses and the thermocline develops, the silt drops out of the undisturbed colder water, and it becomes clearer. Meanwhile, algae starts to grow in the warm upper sunlit layers, causing their visibility to decrease. After a while, the visibility becomes much better below the thermocline than above. After the lake turns over, however, visibility dramatically decreases at the bottom as the top water's algae is mixed everywhere, effectively ending the diving season.

However, the statement that the water below a thermocline is always clearer than the top water is not always true. Oxygen-poor bottom water can kill a lot of the fish and mussel life, then anaerobic bacteria start thriving and can perversely cause the bottom water to have less visibility than the top water. Sometimes it can be very hard to predict whether the viz will improve or decrease below the thermocline. In actuality, thermoclines are complex and hard to predict. At different points of the lake several miles apart on the same day, the depth, thickness, and temperature of the thermocline can vary significantly. Not all of the causes and reasons for these variations are known, but they can be caused by winds, currents, and other dynamic forces. To add to this complexity, multiple thermoclines can also be experienced if the water is deep enough.

One interesting fact is that you'll never find a temperature lower than 38 deg F below a thermocline. This is because liquid water is densest at this temperature, and the density begins to decrease again from 32-38 deg F. Colder water will rise above 38 deg. F water. In fact, it is this unique property of water which allows thermoclines to form in the first place and segregate temperature so dramatically. Without this phenomena, it would be very likely that water would just form a constant gradient of warmest to coldest from top to bottom. This constant gradient from top to bottom is present early in the spring when the water in below 38 deg F, but once the water warms up to this temperature, a thermocline begins to form.

