Changes in Water Clarity at Lake Tahoe

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The optical clarity of water plays an important role in our casual judgments about water quality**.** Clarity is often used by the layperson as a basis for judging potability as well as the safety of water contact. In pristine water bodies, both freshwater and marine, optical clarity can also be an important aesthetic characteristic.

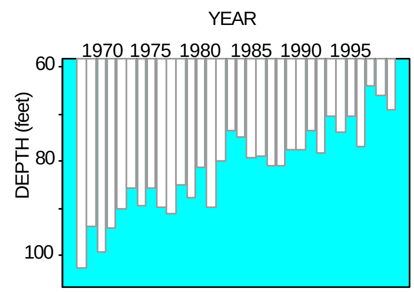
The *Secchi depth* is one common measure of optical clarity in lakes and the oceans. It is simply the depth at which an 8 or 10-inch white disc disappears from view at the surface when lowered into the water. Secchi depth measurements have been collected from many locations around the world for more than a century. Because of its apparent simplicity, the Secchi disk is sometimes dismissed as an "archaic" instrument by the novice. Quite to the contrary, it has a number of important and desirable features. First, Secchi depth is a reproducible measurement of clarity when carefully executed, more precise in fact than some electronic measures of light scattering. Second, the physics of Secchi depth measurement is well understood and Secchi depth can therefore be incorporated into rigorous predictive models. Third, Secchi depth quantifies clarity as perceived by the human visual system and is accordingly a highly suitable management endpoint for lakes. Finally, it is the only consistent optical measurement made in Lake Tahoe (and many other water bodies) that dates back several decades and can therefore be used to detect trends.

A Secchi disk just below the water surface, on its way down to check water clarity

Large clarity declines have occurred over the last few decades in some of our most transparent water bodies, including Lake Tahoe. Secchi depths of over 120 feet were recorded in the early years of the measurement program at Lake Tahoe and still occasionally exceed 90 feet. The long-term decline, though, is a matter of great concern. Overall, the decrease in Secchi depth regardless of season has averaged almost one foot per year. Because of Tahoe's unique beauty, protection of its water clarity has become an issue of pressing concern for watershed residents and the millions of annual recreational visitors.

Lake Tahoe waters have been losing transparency at an average of about one foot each year since the late 1960s.

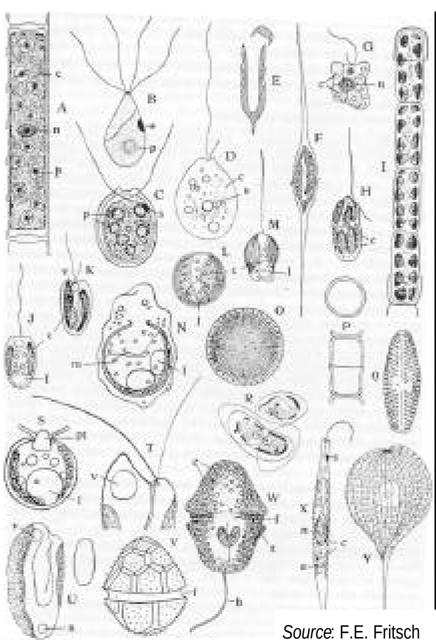
The decline in transparency is due to increases in both algae and mineral particles. Attached algae around the lake margins has proliferated over the past few decades, and microscopic drifting algae called *phytoplankton* living in the open waters has also increased. These increases have been fueled by nitrogen and phosphorus falling on the lake from the atmosphere and washing in from the watershed. In addition to these nutrients, clay and silt particles are also carried in by streams. These mineral particles, like the phytoplankton, cause light to scatter and decrease water clarity. The relative roles of phytoplankton and mineral particles are important because they determine whether the focus should be on controlling phytoplankton growth, mineral particles, or both.



The depth at which a white disk can be seen from the surface changes from year to year but generally has become shallower over the decades.

Transparency declines are due to both phytoplankton increases and to clay and silt particles washed in from the watershed.

The long time series of Secchi depth for Lake Tahoe not only records trends in water clarity but enables us to distinguish the underlying causes. Secchi depth has been measured in Lake Tahoe an average of every 12 days since July 1967. There is a marked seasonal pattern with a minimum (i.e., low clarity) in June and in December. The June low is due to accumulation of mineral particles carried in by the melting snow pack; a spring increase of phytoplankton also contributes. Generally speaking, the larger the snow pack, the bigger the decline in clarity. The December low results from the deeper and deeper mixing of the lake that starts in autumn. As the waters mix, layers of phytoplankton and other particles far below the surface are carried into upper waters where they lower the transparency. This December drop in clarity was almost nonexistent when measurements began in 1967 but it has become stronger over the years as phytoplankton growth and mineral particle inputs have increased. It is not yet fully understood how much of this long-term decrease is due to phytoplankton and how much to clay and silt. Based on the available measurements and physical considerations, both categories probably play a significant role of roughly similar magnitude.



Source: F.E. Fritsch

Microscopic phytoplankton take many unique and beautiful forms. Their exact contribution to the clarity decrease depends on their size, shape, and chemical composition, as well as their abundance.

Because of the large funds to be spent in the Tahoe Basin for protecting water quality, the relative importance of phytoplankton and mineral particles needs to be resolved more precisely. Management strategies to control algae and to control soil erosion are quite different. In addition, the size distribution of particles entering and within the lake needs to be determined. Long-term clarity losses due to mineral particles are dependent on a certain size fraction, namely the fraction that will be retained in the lake and contribute to a buildup of light-scattering particles. It will be of no help to control 99% of erosion if the microscopic particles most responsible for the clarity decline are still entering the lake. Finally, the time it takes for mineral particles to clear from the lake – their *residence time* – needs to be determined. Insofar as mineral particles contribute to the long-term loss of clarity, the recovery time for the lake is dependent on this residence time. All of these issues are part of the current focus of the Tahoe Research Group at UC Davis.

The relative importance of phytoplankton and mineral particles needs to be resolved for an effective management strategy.

Additional scientific information can be found in the following publications:

Goldman, C. R. 1988. Primary productivity, nutrients, and transparency during the early onset of eutrophication in ultra-oligotrophic Lake Tahoe, California-Nevada. Limnol. Oceanogr. **33:** 1321-1333.

Jassby, A.D., C.R. Goldman, and J.E. Reuter. 1995. Long-term change in Lake Tahoe (California-Nevada, USA) and its relation to atmospheric deposition of algal nutrients. *Archiv für Hydrobiologie* 135:1-21.

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Jassby, A.D., C.R. Goldman, J.E. Reuter, and R.C. Richards. 1999. Origins and scale-dependence of temporal variability in transparency of Lake Tahoe, California-Nevada (USA). *Limnology & Oceanography* 44:282-294.

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