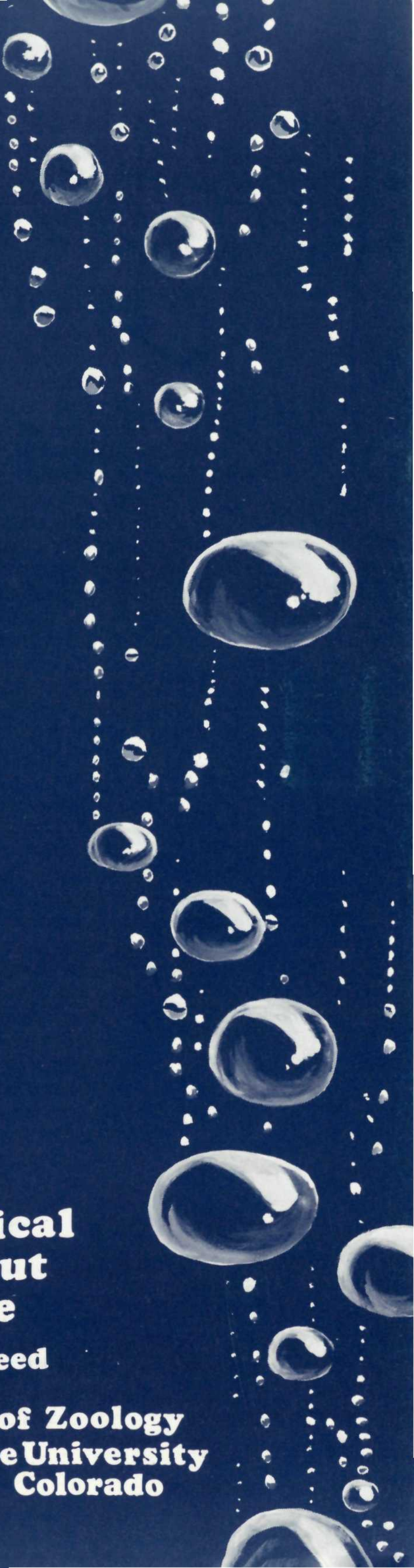

# Limnological Notes about Bear Lake

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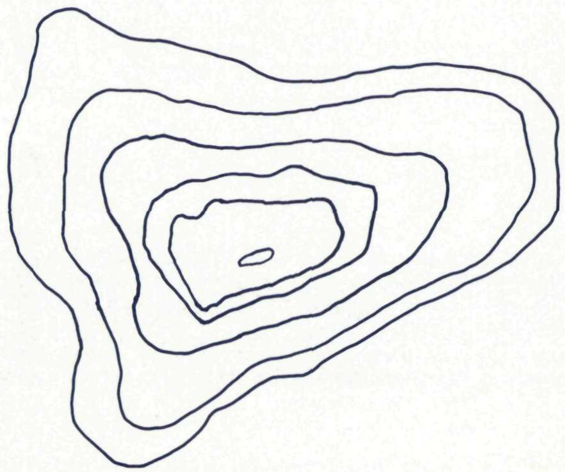
In 1962 in cooperation with the National Park Service *limnological studies of several lakes in Rocky Mountain* Park were initiated. Limnologists are the inland counterparts of oceanographers and as such are interested in the physical, chemical and biological factors that determine the ability of inland waters to produce organic material.

Most limnological studies begin with the preparation of a bathymetric map, made by plotting many depth soundings on an outline map of the lake. The submerged contours are then drawn; volumes of different depth strata and their areas can be figured. These data enable the limnologist to make quantitative estimates of the amount of heat, dissolved and suspended materials in the lake.



BATHYMETRIC MAP OF BEAR LAKE

Bear Lake is 4.8 hectares (a little less than 12 acres) in area. Its maximum depth is 11 meters (36 feet); the mean depth is 3.9 meters (12.8 feet). The volume is 187,800 cubic meters (153 acre-feet).

The penetration of solar radiation into a lake is of fundamental importance to the organisms dwelling there. Solar radiation is the overwhelming source of heat to warm the waters of Bear Lake. It, or course, supplies the energy to drive the process of photosynthesis in which plants elaborate organic substances that in turn supply, directly or indirectly, the energy requirements of all animals.

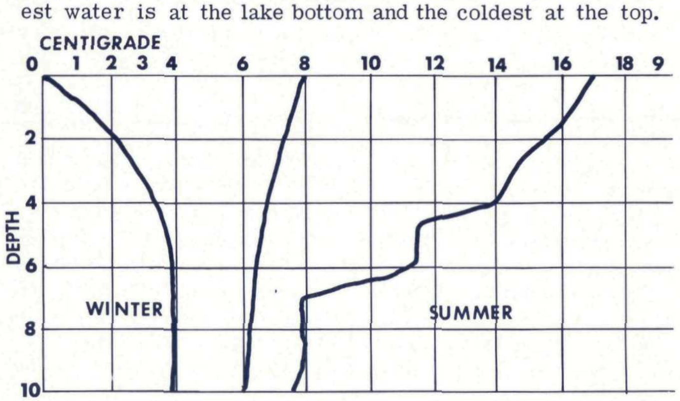
Solar radiation includes not only the wave lengths which we call light, but also shorter (ultraviolet) and longer (infrared). The infrared waves are very important limnologically, for they supply, on the average, about one half the radiant energy that is converted to heat in lakes. Limnologists use photocells (much like the photographer's light meter) in watertight cases to measure the penetration of visible light into the water. Lake water does not absorb (turn to heat) equally all wave lengths of solar radiation. Water molecules very quickly absorb infrared, about 90% fails to penetrate the first meter. Colored substances dissolved *in the water tend to reflect their own colors and* absorb other wave lengths. Materials in suspension tend to absorb all wave lengths more or less unselectively. Thus solar radiation is rapidly decreased in intensity as it penetrates lake water and is also changed in spectral composition. Lakes with little dissolved matter and little suspended materials appear blue; those with moderate amounts of dissolved organic matter appear greenish or yellowish.

On a cloudless summer day, near noon, less than 1% of the visible sunlight penetrating the surface of Bear Lake reaches a depth of 8 meters. Bear Lake frequently appears brownish; this is due mostly to light reflected from the substrate in shallow water. The presence of dissolved materials is particularly evident in the deep water during summer stratification.

One may regard the amount of heat in the water of a lake as a sort of bank account. Solar radiation, plus other, usually minor sources, adds to the account; whereas long wave radiation from the surface and conduction to the basin detract from it; the result of the interplay of these processes is the balance at any moment. The minimum mean temperature of Bear Lake in the winter is about 2C (36F) and the summer maximum is around 17C (62F).

The fact that water can exist as a gas, a liquid and a solid at temperatures compatible with life makes it an unique mineral. In fact water and mercury are the only naturally occurring liquids not of biological origin. Water on passing from a liquid to a solid expands, something that no other material does. Due to its peculiar molecular properties pure water as a liquid is most dense at a temperature of 3.8C (39F). Water in cooling from 3.8 to 0C loses density, and as it passes from a liquid at 0C to a solid at 0C, the density decrease is very marked. Water on being warmed from 3.8 to 100C becomes less dense, not linearly, but more rapidly with increasing temperature.

Persons living at any latitude away from the equator are familiar with the progression of seasons and accompanying patterns of changing length of day. Thus it is that Bear Lake also shows a seasonal pattern in temperature. In winter under an ice cover that reaches a depth of about 60 cm (22 inches) and persists from around November 1 to May 1, the water is inversely stratified, that is, the warmest water is at the lake bottom and the coldest at the top.




This follows from the temperature-density relationships. *In spring, increased solar radiation melts the ice and* warms the upper layers. The water column will circulate by gravity alone until the lake is homothermous at 4C. At higher temperatures wind generated circulation can mix the warm, less dense surface water into the cooler, more dense deeper water until the lake is homothermous at some temperature greater than 4C. Finally the upper layers become so warmed that the wind can no longer mix them into the deeper layers. The lake is now in direct thermal stratification - warmest, least dense water on top separated from the coldest, densest layer by a band in which temperature changes rapidly with depth.

When the lake is homothermous and consequently of uniform density, the wind can easily stir and circulate the entire water mass. The periods of circulation are called the spring and fall overturns. During circulation dissolved and suspended materials tend to be uniformly distributed in the water mass.

Year in and year out, Bear Lake contains about 25 milligrams of dissolved substance per liter of water (if you wish, 25 pounds of dissolved matter per 1,000,000 pounds of water). About one half is organic and comes from materials liberated into the water by the organisms living there, along with soluble organic detritus washed and blown into the lake. A world wide average of dissolved solids in lakes and rivers is about 100mg/1. The low content in Bear Lake is chiefly due to the very low solubility of the igneous and metamorphic rocks of the area.

The two gases of most biological importance are oxygen and carbon dioxide. Oxygen is necessary in the respiration of almost all organisms living in the lake, and carbon dioxide is a primary nutrient of photosynthetic plants. These gases tend to be inversely related in lake waters, that is, when the concentration of oxygen is great carbon dioxide tends to be low and vice versa. During vernal and autumnal circulation, oxygen tends to be evenly distributed in the water, the amount depending primarily on the water temperature and the partial pressure of oxygen in the atmosphere at the lake surface. In periods of stratification, the oxygen becomes depleted in the deeper layers of Bear Lake. For example, in late winter the oxygen concentration near the bottom of Bear Lake may be less than 2 mg/1; temperature and pressure indicate that if saturated the water could hold about 9 mg/1. In summer the oxygen value may drop to 2 or 3 mg/1 in the deepest water; at this time the saturation value is near 8 mg/1. Carbon dioxide, resulting mostly from bacterial respiration, can rise as high as 30-35 mg/1 in the lowest layers in winter.

Suspended in the water are many kinds of tiny plants and animals; these small organisms drifting freely with the currents or at best making feeble swimming movements are the plankton. Suspended with the plankton is a hodgepodge of non-living particles, both organic and inorganic. Organic particles include carcasses of former plankters and bits of debris carried in by wind and water. Inorganic particles may also arrive in the lake via wind and water or may originate from wave disturbances along shore. The whole mish-mash, plankton and non-living particles, is referred to as seston.

The limnologist draws samples of water from all depths to determine the amount of seston. Seston is removed from the water by centrifugation or by use of filters with very small pores (one micron or less). Tedious microscopic examination is required to tell plankton from the rest of the seston and is necessary for some studies. However, for routine quantitative analyses the limnologist is more likely to dry and weigh the seston samples; they are then burned and the ashes weighed. The loss on burning approximates the organic fraction. Except during the overturns, the seston is not uniformly distributed vertically in the water. In winter and summer periods of stratification, the most seston is found usually in the deeper water in Bear Lake. Reduced oxygen suggests that the seston in the deepest layer is decomposing and microscropic examination confirms this. Surface waters of high mountain lakes are frequently poor in plankton. Intense ultraviolet light is thought to be at least partly responsible. Thus most plankters, plant and animal, live at some intermediate depth where light, temperature, nutrients and other conditions are suitable.

Limnologists frequently express the standing crop of seston as the amount under a unit of surface area. For Bear Lake the dry weight of the seston in kilograms/hectare during one year was as follows: (multiply by .89 to obtain pounds/acre)

| | | | | | |
|---|---|---|---|---|---|
| July 14, 1967 | 54 | Nov. 12 | 56 | Mar. 13 | 63 |
| Aug. 7 | 60 | Dec. 3 | 77 | Apr. 6 | 24 |
| Sept. 11 | 51 | Jan. 9, 1968 | 50 | May 3 | 35 |
| Oct. no data | | Feb. 3 | 59 | June 6 | 55 |

Thus the yearly mean crop in Bear Lake is 53 kg/ha. Many lakes are reported to have crops four or five times larger. However nearby Mills Lake contains a crop less than one half of that in Bear Lake. A little more than two thirds of the dry weight of Bear Lake seston seem to be due to organic matter. On the average, there are about two tons of live plankton in Bear Lake at any given moment.

The plants and animals making up the plankton vary in species as well as quantity throughout the year. As yet we have not made a careful listing of all the algae, single celled plants - "the grass of the water" as they have been called. Pigmented flagellates such as *Dinobryon* and *Volvox* are particularly noticeable in winter and late spring. The most abundant zooplankters are several species of rotifers, microscopic multicellular animals, and small crustaceans. A species of copepod, *Diaptomus nudus*, breeds in Bear Lake during most of the year. This animal lives by filtering algal cells and tiny bits of organic detritus from the water, thereby converting plant material to animal flesh. It in turn is eaten by larger animals such as small Brook trout. Species of predaceous copepods appear in some seasons as does *Daphnia*, another filter feeding crustacean. The seasonal progression of species in the plankton is a well known fact, but causes of seasonal appearance and disappearance remain incompletely elucidated. Possible factors are exhaustion of nutrients, temperature and light (either too little or too much), predation, accumulation of waste products and the presence of incompatible species.

The disappearance of plants and animals from the plankton does not mean that they have gone completely from the lake. Most planktonic species can produce some dormant stage - resting eggs, spores, cysts, etc., in which to pass periods of adverse conditions. Then when the environment again becomes suitable, dormancy is broken and the species reappear in the plankton.

## Further Reading

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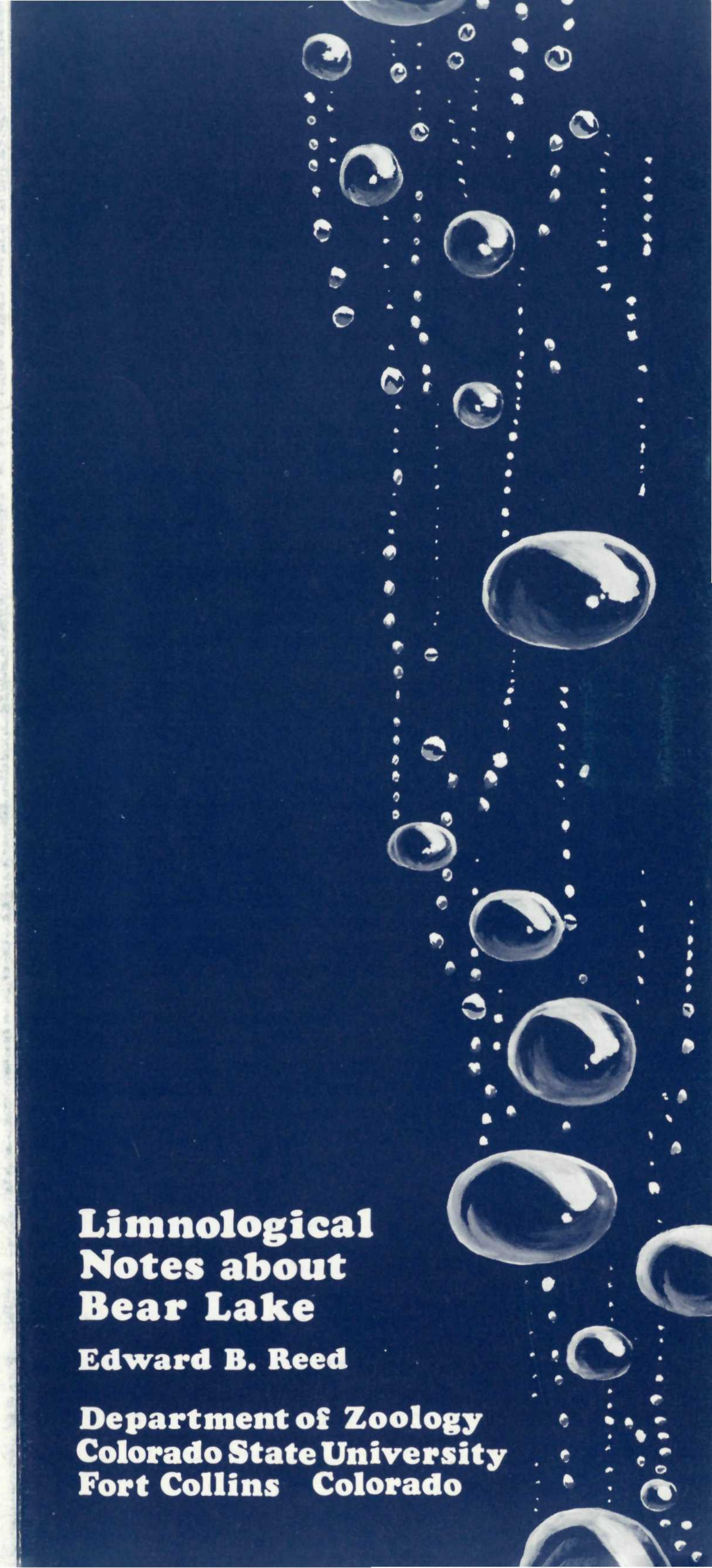

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