Bad Medicine Lake: Water Quality and Biotic Assessment (2017-2019): Brief summary of findings

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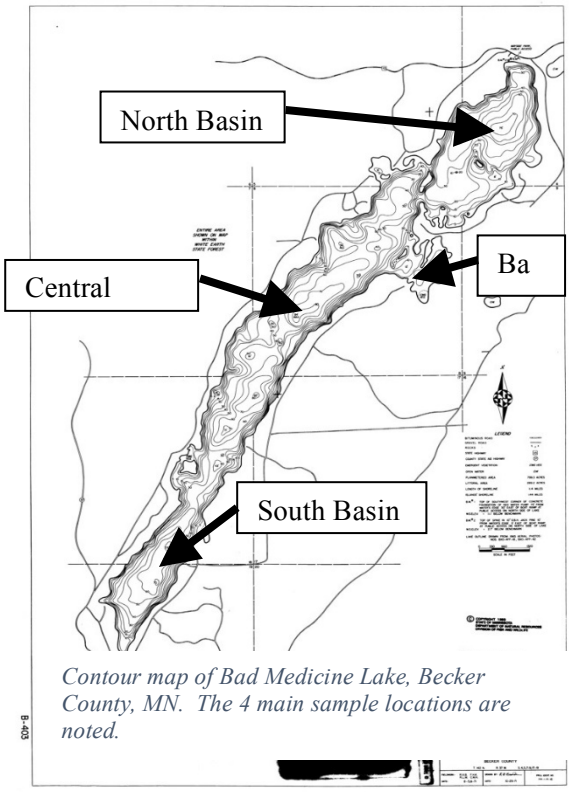
Bemidji State University students Claire Hansen and Katie Gunter sampling for water quality on Bad Medicine Lake.

Introduction

We are conducting a comprehensive assessment of water quality and biology of Bad Medicine Lake, Becker County, MN. Results from this study will provide a baseline with which to compare future data, and can be compared with the (limited) data previously collected as a means to assess recent changes in lake quality.

Bad Medicine Lake is of particular interest because of its susceptibility to water quality changes. As a spring fed lake, water levels fluctuate with regional water tables and the lake traps nutrients and other chemicals that enter. As a deep, cold water lake, a 2-tiered food web culminating in cold water bottom fishery (Rainbow trout, cisco) and warmer water surface fish (walleye, bass, perch) makes this particular lake quite distinct from other lakes in the surrounding region.

Bad Medicine Lake remains an oligotrophic lake (i.e. low algal production and high water transparency) despite undergoing significant changes in its ecology in recent decades… the full extent of which are not yet known. Dramatic increase in native crayfish reduced aquatic plant populations in early 1970s, decreasing fish habitat, and increased nutrients resulting in more algal growth. Annual stocking of rainbow trout (1977 to present) and more recent stockings of walleye by MnDNR created important game fisheries have likely impacted lake ecology further. Significant rising of lake levels in 1990s and subsequent slow declines have altered nutrient loading (especially of phosphorus) and changed patterns of water clarity and plankton communities in ways not yet determined.



Contour map of Bad Medicine Lake, Becker County, MN. The 4 main sample locations are noted.

Project overview

Water quality assessment occurred during ice-free season in 2017, 2018 and 2019 at time intervals of 1-2 weeks. Sampling occurred at deepest points in the 3 main basins (South Basin, Central Basin, and North Basin) and the eastern bay. Though wind driven water exchange occurs to some extent throughout the lake, the North Basin is somewhat isolated due to an island with shallow, narrow passages on either side separating it from the Central Basin. Physical (water temperature, transparency), chemical (nitrogen and phosphorus content) and biological (algae and zooplankton) were assessed biweekly during the ice-free periods (May-November).

Summary of Findings

All of our findings suggest that Bad Medicine Lake is a healthy, clear water, oligotrophic lake.

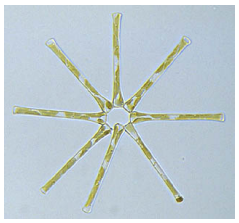
Nutrient concentrations ranged from <1–3 *u*g phosphate L^{-1} and 90–270 *u*g nitrate L^{-1}. Seasonal and spatial variations suggest that the system is responsive to even minor and localized fluctuations in nutrient availability. Efforts should be made to maintain low nutrient inputs into these waters, especially in regards to phosphorus.

Lake ***water temperature*** changes slowly with the seasons. Bad Medicine Lake exhibits a pattern of stratification (temperature layering) typical to deep lakes of the region. Warming water during summer, creates an increasingly warmer (up to ~75^{o}F) layer of surface water (epilimnion) over colder (~40^{o}F) deeper water (hypolimnion). The layer of transition (thermocline) becomes very pronounced at 9-12 meters depth as summer progresses.

Dissolved oxygen concentrations in Bad Medicine Lake ranged from 0 (near bottom) to ~15 mg/L (above thermocline). The epilimnion (surface layer) remained well oxygenated throughout the years, with highest DO readings from just above the thermoclines (super saturated on most dates), suggesting healthy levels of algal production. Water below the thermocline had lower oxygen levels throughout the sampling periods. Anoxic conditions were confined to near sediment waters in May, but rose to within 13m of the surface as summer progressed. Oxygen stress to biota is evident in deeper waters of Bad Medicine by late summer/fall, especially in the North Basin. Fish likely respond by shifting to shallower positions. Cold water fish like cisco and trout become constrained between low oxygen levels in deep water and warmer temperatures in surface water. Longer ice-free seasons will worsen this scenario. Lake turnover, occurring in late November, resets higher oxygen levels in deeper waters.

Water transparency (secchi disc) in Bad Medicine Lake ranged from 3.2-8.0 m (10-26 ft) and tended to be greatest in June and lowest in early August. Photosynthesis is supported to depths of 10-25 m (33-82 ft), suggesting that a significant part of the lake has potential for periphyton (attached algae) and macrophyte growth, though these also remain nutrient limited under current conditions.

Algal biomass ranged from 0.1 to 25 ug chlorophyll L^{-1} and are typical for oligotrophic (low nutrient), clear water lakes. Diatoms dominant the algal community, especially in spring and fall, with episodic risings of green algae and bluegreen at some areas of the lake. Temporary blooms of bluegreen algae have occur lake wide during each of our sampling years as phosphate is released from deeper water, but such cycles are natural, and their extent create no negative impact. In an oligotrophic lake like Bad Medicine, phytoplankton would likely respond fast to any increases in nutrient availability. No apparent concerns were found with our sampling, though the fragility of the system is apparent.



Asterionella. A common diatom of Bad Medicine Lake

Zooplankton communities in Bad Medicine are productive and support a strong fisheries. *Daphnia*, in particular predominate and are a favored food resource for many fish, including Rainbow trout. Daily vertical migration of zooplankton is being assessed this year (2019) through 24-hour each month and suggest active movement in communities driven by predation pressure from fish. This is especially prevalent in large zooplankton which hide in deep waters during the day, moving to near surface waters to graze overnight.

Daphnia. A common zooplankton in Bad Medicine Lake