# Abiotic Factors Effect on Summertime Fish Sampling

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Fish surveys are vital in understanding various information about a fishery. Surveys lay the groundwork to how an agency views the status of the fishery, are used to set appropriate regulations, and manage stocking. Understanding which areas of a fishery holds the greatest density of fish is key to achieving the most accurate sample that reflects the fishery. The objective of this study was to track fish densities throughout the summer of 2021 and establish if there is a relationship between high fish density locations and specific water column characteristics. Fish density, temperature, and dissolved oxygen were measured bimonthly at various depths on St. Olaf Lake. Fish were most abundant in Late May through early June with 3-13 fishes per 3-m circumference, with highest densities found in 0.5-3 m of water. Densities during mid-July ranged from 2-6 fishes per 3-m circumference with highest densities found in 1-3 m of water. Dissolved oxygen and temperature were stratified from 23 May 2021 until 23 October 2021. Dissolved oxygen was highest in the epilimnion and peaked at 11.90 mg/L on 23 May 2021. Dissolved oxygen was never present above 0.50 mg/L below 5 m after 6 June 2021 until lake turnover. Temperature peaked at 28.0° C on 4 July 2021. Hopefully, these results will help area fishery managers better understand trends in this lake.

Faculty Sponsor: Dr. Andrew W. Hafs

## Introduction

The collection of data about area lakes and streams through fish surveys is crucial to laying the foundation of fish management activity. Fisheries surveys provide a wealth of information including, indices of relative abundance, size and age of the population, and assessment of habitat conditions (Wagner et al. 2013). This knowledge helps improve fishing through better stocking and gaining a better understanding of fish populations and the overall health of the fishery. To conduct surveys gill and seine netting are commonly used to collect fishes. Understanding which areas of a lake or stream hold the greatest number and diversity of fishes is critical in getting the most accurate representation of a fishery.

Large scale studies done on fish movements have emphasized abiotic factors as most important (Jackson et al. 2001). Abiotic factors can be divided into physical or chemical factors. The most important physical factor is temperature whereas the most important chemical factor is dissolved oxygen content. Changes in dissolved oxygen can lead to habitat shifts (Hasler et al. 2009). High temperatures can increase physiological demands and stress on fishes while also decreasing oxygen saturation of water (Jackson et al. 2001). Increased temperature, nutrients, and daylight during summer months leads to algal blooms which can decrease photosynthesis and oxygen levels by clouding up the water. Low temperatures can limit the distribution and composition of fish communities (Magnuson et al. 1979). The great deal of variation in temperature and dissolved oxygen during summer may greatly affect fish movements.

Therefore, the objective of this study is to assess the spatial and temporal variation in dissolved oxygen and temperature within St. Olaf Lake to determine how those abiotic factors affect fish concentration and density around the lake. Detailed measurements on these two key abiotic factors could help inform managers on which habitats are best suited for fish in this system during the summer months and therefore allow them to focus sampling efforts in those areas.

## Methods

Fish sampling, dissolved oxygen, and temperature measurements were taken bimonthly during the summer of 2021 on St. Olaf Lake (43°54.180'N, 93°25.055'W) with sampling occurring on approximately the 7$^{th}$ and 21$^{st}$ of each

month, May through September. Sampling began 23 May 2021 and ended on 23 October 2021. Access onto the lake was by boat.

Dissolved oxygen (mg/L) and temperature (°C) were measured using a YSI Professional Plus Meter. Dissolved oxygen and temperature were measured every meter beginning at the surface. Sampling concluded at 8 m for a total of 9 readings each sampling period.

To observe fish density a Garmin Panoptix and Vexilar camera were used. Only juvenile and adult fish were counted towards the overall density, to keep the data from becoming skewed towards areas of high fish fry hatching throughout the summer. To measure fish density, St. Olaf Lake was divided into five zones, each zone consisted of 2 m. Zone one was 0-2 m deep, zone two was 2-4, and so on all the way up to zone five. Using the Panoptix and the underwater camera, numbers of individual fish were counted and recorded in zone one. This process was repeated for each zone.

All data was collected and arranged chronologically, starting with 23 May 2021, and ending on 23 October 2021. Filled contour plots were created for dissolved oxygen, temperature, and fish density, with depth on the y-axis and date on the x-axis.

**Results**

The lowest fish densities were observed during mid-summer when water temperatures reached their highest and the thermocline was also at its highest in the water column at just 4.5 m below the surface (Figure 1). Fish density peaked on 6 June 2021 at 13 fish in a 3 m circumference in zone 1 (0-2 m), zero fish were recorded at depths below 6 m throughout the summer but during the lake turn over fish occupied the entire water column. (Figure 1). Fish density fluctuated throughout the sampling period with the highest densities found in the epilimnion and upper metalimnion.

During the sampling period dissolved oxygen and temperature were stratified with the highest dissolved oxygen reading being 11.9 mg/L in the epilimnion and steadily decreased with increasing depth to a lowest reading of 0.07 mg/L in the hypolimnion (Figure 1). Temperature peaked at 28°C on 4 July 2021 and reached its lowest recorded temperature of 9.5°C on 23 May 2021 (Figure 1). Dissolved oxygen was most stratified on 23 May 2021 when reading ranged from 0.10 to 11.9 mg/L. Temperature was stratified the greatest on 4 July 2021 when temperatures ranged from 9.7°C in the hypolimnion to 28°C in the epilimnion (Figure 1). Temperature and dissolved oxygen were least stratified during lake turn over which saw dissolved oxygen roughly between 6.3-4.75 mg/L from top to bottom and temperature between 13.6-12.9°C on 23 October.

**Discussion**

There were never substantial amounts of dissolved oxygen below 5 m over the course of the summer. According to Doudoroff and Warren (1965), Largemouth Bass become greatly impaired when dissolved oxygen concentrations drop below 3 mg/L. This may hint as to why there was never any fish found occupying depths greater than 5 m from 18 July to 14 August. During this time dissolved oxygen below 5 m was less than 1 mg/L.

Fish densities during the summer were highest in the epilimnion. There are many factors that could influence why the greatest density of fishes occupied areas in the epilimnion. Factors like habitat, forage, dissolved oxygen, etc. The epilimnion coincides with the photic zone, which makes plant growth possible (Bornette and Puijalon 2010). This growth provides habitat and shelter for fishes and an area with high amounts of forage. The epilimnion also is where the highest dissolved oxygen concentrations were found.

Water temperatures peaked in July; thus, fish sampling methods should be avoided during the month of July on St. Olaf Lake. According to Jensen and Brunson (1992), some fish are harvested most successfully when water temperatures are less than 65°F or 18°C. Sampling when water temperatures are high can result in increased chance of fish mortality (Gingerich et al. 2007). High water temperatures are associated with increased physiological disturbances in fish (Gingerich et al. 2007). This coupled with high recreational traffic, increased stress levels, and fish spoiling in gill nets makes it unwise to sample during this time. July is also the month when algae blooms are running rampant, and the fish are hunkered down and not doing daily movements from deep water to the shallows to feed.

After lake stratification breaks down fish distribution changes. During the entire sampling period from late May through mid-October fish were never recorded occupying depths greater than 5 m. During this time dissolved oxygen was never present in survivable amounts below 5 m. Once dissolved oxygen stratification broke down during lake turnover there was sufficient oxygen occupying all depths of water. Fish were found occupying all depths with more being found deeper rather than shallower for the first time during the sampling period. Gebhart et al. (1976), also found that fish depth distribution increased after fall turnover.

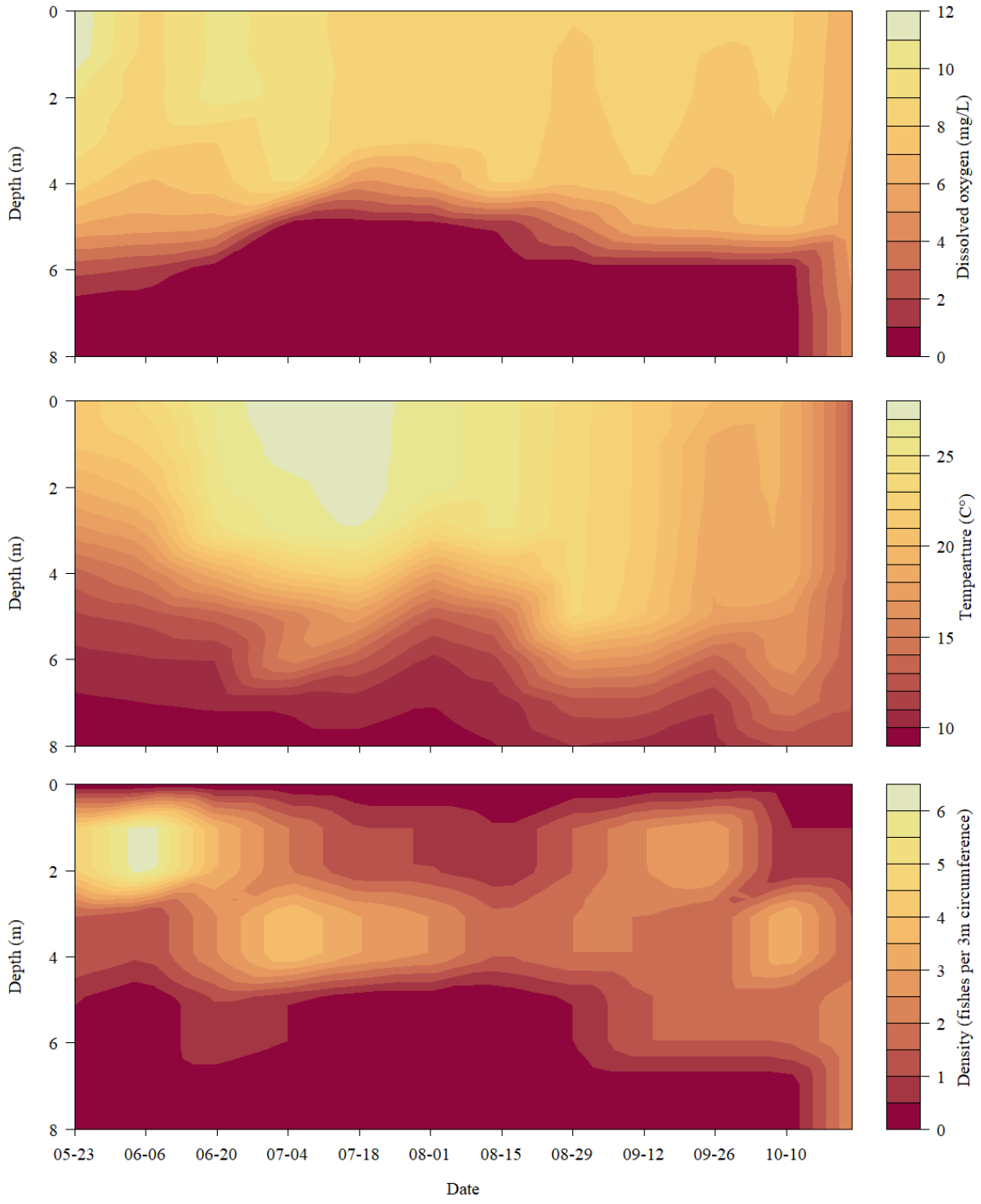


**Figure 1**. Dissolved oxygen, temperature, and fish densities measured on St. Olaf Lake from 23 May 2021 – 23 October 2021.

This would hint that dissolved oxygen has a major influence on fish movements and understanding which areas of a lake are most likely to see higher concentrations of fish.

Garmin Panoptix was successfully used to observe fish movements in St. Olaf Lake. Throughout the summer the use of a Garmin Panoptix successfully showed individual fishes and

the areas they were occupying and how that changed throughout the duration of the summer. A study done by Nordin (2020), also successfully used a Garmin Panoptix to help detect fish passages of salmonid species in rivers. The use of the Panoptix successfully allowed Nordin to count individual fish to achieve a passage per hour estimate. Garmin Panoptix is a relatively new technology released in 2018 that could become an amazing tool in observing fish movements in various systems.

**Acknowledgements**

I would like to thank my family for assisting me with data collection throughout the summer, as well as Bemidji State University Biology Department for materials making this study possible.

**References**

Bornette, G. and S. Puijalon. 2010. Response of aquatic plants to abiotic factors: a review. Aquatic Sciences 73:1-14.

Doudoroff, P. and C.E. Warren. 1965. Environmental requirements of fishes and wildlife: dissolved oxygen requirements of fishes. Oregon Agricultural Experiment Station, pp 40.

Gingerich, A.J., S.J. Cooke, K.C. Hanson, M.R. Donaldson, C.T. Hasler, C.D. Suski, and R. Arlinghaus. 2007. Evaluation of the interactive effects of air exposure duration and water temperature on the condition and survival of angled and released fish. Fisheries Research 86:169-178.

Gebhart, G.E. and R.C. Summerfelt. 1976. Effects of destratification on depth distribution of fish. Journal of the Environmental Engineering Division 102:1215-1228.

Hasler, C.T., C.D. Suski, K.C. Hanson, S.J. Cooke., and B.K. Tufts. 2009. The influence of dissolved oxygen on winter habitat selection by Largemouth Bass: an integration of field biotelemetry studies and laboratory experiments. Physiological and Biochemical. Zoology: Ecological and Evolutionary Approaches 82:143-152.

Jackson, D.A., P.R. Peres-Neto., and J.D. Olden. 2001. What controls who is where in freshwater fish communities-the roles of biotic, abiotic, and spatial factors. Canadian Journal of Fisheries and Aquatic Sciences 58:157-170.

Jensen, G.L. and M.W. Brunson. 1992. Harvesting warmwater fish. Southern Regional Aquaculture Center. Publication Number 393, Stoneville, Mississippi.

Jonathan, N. 2020. Highway to hell: can a bubble barrier guide descending salmonid kelt to safety? Ecology 1:1-14.

Magnuson, J.J., L.B. Crowder., and P.A. Medvick. 1979. Temperature as an ecological resource. American Zoologist 19:331–343.

Wagner, T., B.J. Irwin., J.R. Bence., and D.B. Hayes. 2013. Detecting temporal trends in freshwater fisheries surveys: statistical power and the important linkages between management questions and monitoring objectives. Fisheries 38:309-319.