Burbot Activity in Relation to Light Penetration on Lake Bemidji, MN

Hunter Weidenborner and Josh Janecek
Aquatic Biology Program
Bemidji State University

Burbot *Lota lota* is the only freshwater member of the family Gadidae and has a circumpolar distribution in cold-water regions. Information related to Burbot biology is limited in comparison to most fishes. Snow pack depth and ice conditions influence light penetration and therefore primary production levels. Primary production can have cascading effects on higher trophic levels. Therefore, the objective of this study was to observe if light levels penetrating through cleared and covered ice has an effect on Burbot activity in Lake Bemidji, MN. Angling for Burbot occurred for a minimum of 30 four hour sample periods at both cleared and snow covered ice and fish caught per hour was then used as a measure of Burbot activity. There was no significant difference in catch per unit effort (fish/hr) between cleared and covered ice ($W = 241.5$, $P = 0.24$). Photosynthetic photon flux fluence rate (µmol/m²/s) between cleared and covered ice was found to have a significant difference ($W = 0$, $P = 0.029$). Burbot activity was not related to light penetration through cleared and snow covered ice. Thus a longer study duration is suggested to observe cascading effects from light penetration on Burbot activity.

Faculty Sponsor: Dr. Andrew W. Hafs

Introduction

Little is known about Burbot *Lota lota* habits in northern lakes. Burbot are rapidly becoming a popular sport fish and information on managing this elusive species will be valuable for future fisheries management. Along with Northern Pike *Esox lucius*, Burbot have the largest distribution of any freshwater fish in the world (Van Houdt et al. 2005). In the United States, 8 of 25 states reported having "secure" Burbot populations. Eleven states reported that populations were either imperiled or vulnerable to extinction, and Burbot have been extirpated from Kansas and Nebraska (Stapanian et al. 2010).

Burbot spawn in winter and early spring under the ice. Spawning season usually lasts from two to three weeks and is highly synchronized (McPhail et al. 2000). In lakes, spawning usually occurs over near-shore shallows (1.5-10 m deep) or over shallow off-shore reefs or shoals and substrate is usually sand, gravel, or cobble (McPhail et al. 2000). Burbot spawn at temperatures around 1-4 °C (McPhail et al. 2000). These temperatures are observed throughout winter months under the ice, thus, light availability is likely a significantly factor influencing Burbot activity.

For most of the year Burbot are a solitary species. However, during the late winter months in northern mesotrophic lakes Burbot become active due to warming waters and light level increases. For example, Muller (1973) observed an increase in nocturnal activity related to spawning in February as the light levels and air temperatures began to rise.

Previous studies have shown that Burbot are affected by changing light levels, however, limited research has been done on how light penetration through snow pack and ice depth affects Burbot activity. Therefore, the objective of this study was to observe if light levels penetrating through snow covered ice and cleared ice had an effect on Burbot activity in Lake Bemidji, MN.

Methods

Study area

Lake Bemidji, Minnesota is a glacially formed mesotrophic lake and has a maximum depth of 21.3 m and has an area of 2800 ha. Lake Bemidji is located close to the southern extent of the Burbot distribution.

Sampling

Burbot for this study were angled from Lake Bemidji using the hook and line method. Navionics Boating U.S. and Canada application (version 9.0.1) was used to locate structure. Vexilars were used to measure depth and the lures used were green glowing Big Nasty trout n pout spoons tipped with Fathead Minnows *Pimephales promelas*. Trout n pout spoons were charged with a blue UV flashlight for 30 seconds before being dropped down to the benthic zone. Burbot sampling occurred from 1 January - 15 March 2018. Angling for Burbot occurred for a minimum of 30 four hour sample periods at both cleared ice and snow covered ice locations. Night time sampling occurred from 1 January - 28 February 2018. Starting 1 March 2018 nighttime and daytime sampling periods were conducted because of increase in daylight hours, temperature, and the onset of the spawning season found in observations by McPhail et al. (2000).

Sampling locations were chosen on near-shore shallows (1.5-10 m deep) or over shallow off-shore reefs or shoals where substrate was typically sand, gravel, or muck. Each sampling location had two 25 m^2 plots. One study plot was cleared of all snow prior to sampling and was continuously cleared of snow after every snowfall and labeled as cleared ice. The other plot had no snow removed throughout the whole study and was labeled as covered ice. Study sites were moved as needed to maximize catch per unit effort (CPUE; fish/hr) and if ice conditions became unsafe. Cleared and covered study sites had the same depth and were always within 10 m of each other.

Photosynthetic photon flux fluence rate (PPFFR; µmol/m²/s) was measured randomly four times over the duration of the study using a light sensor (Li-cor, Li-250A) under both cleared ice and snow covered sampling sites. Light levels were measured between the hours of 1200 and 1600.

Data Analysis

A Wilcox test was used to determine if there was a significant difference in CPUE or light penetration between cleared and covered ice sample locations. A Wilcox test was selected because CPUE data was non-normally distributed.

Results

CPUE between cleared and covered ice was not significantly different (W = 241.5, *P* = 0.24; Figure 1). Median CPUE for cleared ice was zero (range 0 to 2). Median CPUE for covered ice was zero (range 0 to 7). There was a significant difference in PPFFR between cleared and snow covered ice (W = 0, *P* = 0.03; Figure 2). Median PPFFR on cleared ice was -10.69 (range -13.70 to 3.01). The median for PPFFR on covered ice equaled 12.05 with a range from 3.21 to 19.41.

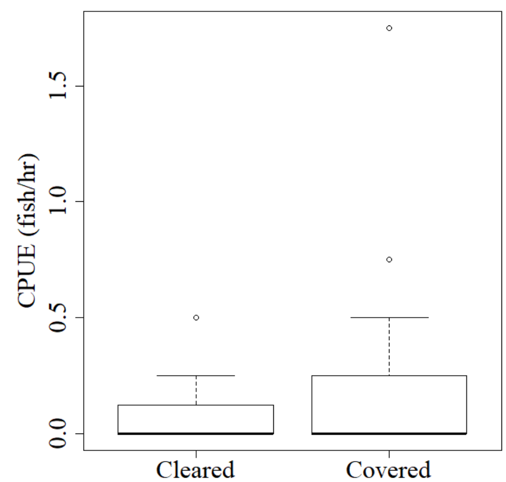

Figure 1. Burbot catch per unit effort (CPUE) on cleared and covered ice on Lake Bemidji, MN from 1 January - 15 March 2018. The graph shows that CPUE between cleared and covered ice was not significantly different (W = 241.5, *P* = 0.24).

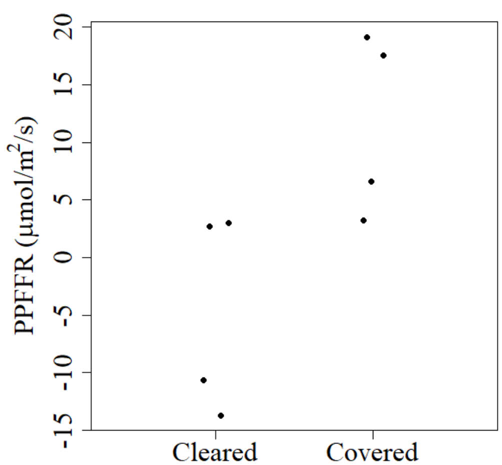

Figure 2. Photosynthetic photon flux fluence rate (PPFFR; µmol/m²/s) below cleared and covered ice on Lake Bemidji, MN from 1 January - 15 March 2018.The graph shows that there was a significant difference (W = 0, *P* = 0.029) between cleared and covered ice.

Discussion

According to the data collected it appears Burbot activity was not related to light penetration through cleared and snow covered ice, even though light penetration was significantly different between cleared and covered ice. One possible explanation for Burbot activity not being related to light penetration is that Burbot are a nocturnal benthic fish usually staying near the deepest parts of the aquatic systems where light levels are almost non-existent. In lakes, adult Burbot are strongly associated with the bottom. In the summer, Burbot are usually always found below the thermocline (McPhail et al. 2000). Another possible explanation for the results of this study could be that the light meter used could only measure light levels down to 2 m. Burbot being a benthic fish, are rarely found in the epilimnion where PPFFR was measured. For future studies we suggest using a light meter that can measure light levels at the benthic zone where Burbot are typically located (Ryder et al. 1992).

Difference in snow cover and ice depth over time affects the light penetration which drives productivity in the system. More snow cover and ice depth means less light will penetrate down through the water column leading to less productivity. Heavy snow pack on the ice significantly diminished light penetration into the water and effectively prevented phytoplankton growth under the ice in three lakes in the greater Yellowstone ecosystem (Interlandi et al. 1999). This relationship between snow levels and productivity can affect all trophic levels potentially influencing Burbot activity by increasing or decreasing food availability. Changes in the density of zooplankton result in changes in density, species composition, and behavior of zooplanktivorous fishes which in turn can have cascading results on large piscivorous fishes (Carpenter et al. 1985).

With limited research on Burbot more studies should be done on light level changes in relation to snow and ice conditions and how Burbot respond to the light availability when they begin phase shift movements. Information related to light penetration and the affects it has on Burbot activity can help managers better understand the habits and biology of this growing sport fishery.

Acknowledgements

We want to thank Dr. Richard Koch for helping us with our light sensor measurements. To our friends and families for allowing us to use their permanent ice houses and helping to move study sites.

References

Carpenter, S. R., J. F. Kitchell, and J. R. Hodgson. 1985. Cascading trophic interactions and Lake Productivity. Bioscience 35:634-639.

Interlandi, S. J. and S. S. Kilham. 1999. Responses of phytoplankton to varied resource availability in large lakes of the greater Yellowstone ecosystem. American Society of the Limnology and Oceanography 44:668-682

McPhail, J. and V. Paragamian. 2000. Burbot biology and life history. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section 1:11-23.

Muller, O. and P. Fischer. 2004. Distribution and onshore migration behavior of Burbot larvae in Lake Constance, Germany. Journal of Fish Biology 64:874–886.

Muller, O. 1973. Seasonal phase shift and the duration of activity time in the Burbot (*Lota lota*). Journal of Comparative Physiology 84:357-359.

Ryder, R. A. and J. Pesendorfer. 1992. Food, growth, habitat, and community interactions of young-of-the-year Burbot, *Lota lota* L., in a Precambrian shield lake. Hydrobiologia 243:211-227.

Stapanian, M. A., V. L. Paragamian, C. P. Madenjian, J. R. Jackson, J. Lappalainen, M. J. Evenson, and M. D. Neufeld. 2010. Worldwide status of Burbot and conservation measures. Fish and Fisheries 11:34-56.

Van Houdt, J. K. J., L. de Cleyn, A. Perretti, and F. A. M. Volckaert, 2005. A mitogenic view on the evolutionary history of the Holarctic freshwater gadoid, Burbot (*Lota lota*). Molecular Ecology 14:2445-2457.