Effects of Cooler Northern Waters on Growth Rates in Bluegill and Pumpkinseed Sunfish

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The Centrarchidae family range spans all across the United States making them a favorite target for many recreational anglers. In northern Minnesota, most water bodies do not reach optimal growth temperatures for the sunfishes, putting them right on the edge of their suitable range and potentially slowing overall growth. Therefore, the main objectives of this study were to 1) determine if sunfish growth rates respond to the severity of winter and 2) investigate growth differences between two sunfish species. Growth rates of bluegill (*Lepomis macrochirus*) and pumpkinseed (*Lepomis gibbosus*) were estimated from Big Sugar Bush Lake, MN, by backcalculating length at age from scale samples obtained by angling fish throughout the summer of 2014. Scales were measured and aged in lab; all fish lengths were backcalculated to age-1 and age-2. Growth from age-1 to age-2 ranged from 10.6 to 30.9 mm. The average growth for all species was 19.3 mm. There was evidence to suggest growth of all species increased with an earlier ice out date and decreased when ice persisting longer into the spring (p-value = 0.03, $R^2 = 0.77$).

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Introduction

The ubiquity of sunfish species in many of North America's lakes has led to them being a popular fishing target for anglers, as well as a favorite of researchers attempting to show ecological interactions influencing growth rates. This has led to relationships between sunfish growth and many nonsocial limiting factors (food quality, water chemistry, lake morphometry, and water quality) to be well established in literature (Schneider 1975; Wetzel 1975; Tomcko and Pierce 2001). Sunfish growth has also been associated with social interactions such as competition and predation (Werner et al. 1983; Osenberg et al. 1988; Belk and Hales 1993; Osenberg et al. 1994; Snow and Staggs 1994).

In northern Minnesota, most water bodies do not reach 30 °C, the optimal growth temperature of most sunfish species (Coutant 1977). With water temperatures not reaching the optimum, the growing season shortens and growth rates in sunfish species should be slowed in cooler waters (Tomcko and Pierce 1997). The length of time the ice is present is related to the lake's water temperature. Productivity of the lake can significantly drop if ice stays around too long, potentially decreasing growth rates in regions where ice is formed in the winter (Reimers 1963; Bustard and Narver 1975).

The influence of cooler waters on sunfish species has rarely been examined; therefore the objectives of this study were to 1) determine growth rates for two common sunfish species, 2) investigate differences in growth rates among sunfish species, 3) evaluate if sunfish growth rates respond to the length of winter over the past several years, and 4) compare sunfish growth in Big Sugar Bush to previous studies.

Methods

Sampling and Aging

Bluegill (*Lepomis macrochirus*) and pumpkinseed (*Lepomis gibbosus*) from Big Sugar Bush Lake in Becker County, MN, were captured from May to September 2014. The lake is 174 ha in size and located 34 km north of Detroit Lakes, MN. It is a clear lake (4.6-5.2 m Secchi depth) with a maximum depth of 12.8 m. The fish community is dominated by Centrarchidae, with largemouth bass (*Micropterus salmoides*) and sunfish being the favorite of anglers fishing the lake.

All fish were captured and released by angling at many locations around the lake using worms or a fly-rod. At time of capture, species was identified,

total length (mm) was measured, and a scale sample was taken. Scale samples were collected from the left side of each fish near the pectoral fin. At least three scales were taken from each fish. Samples were put in an envelope labeled with an ID number and species.

Lengths and growth rates

Scales were examined under a dissecting scope, where a picture was taken to later measure annuli distances. First and second annuli distances were measured and recorded using one nonregenerated scale from each fish. Backcalculated lengths and growth from age-1 to age-2 were determined from measurements using the Lee direct proportion method (Carlander 1981). Validation of the scale method for aging sunfish came from Reiger (1962) who justified its accuracy from New York samples. The scale method seems to be a viable option for aging sunfish ages 1-2.

Data Analysis

Yearly ice out date was found using the Minnesota DNR ice out date website[1]. To determine if growth rates of sunfish were affected by ice out dates; a regression analysis was run. A two factor ANOVA was used to test for differences in growth among species and year. Because a Shapiro-Wilk test provided evidence to suggest growth was non-normally distributed, growth was log transformed before performing the two factor ANOVA. Pairwise t-tests, with Bonferroni corrections, were run if a significant difference was found for either species or year effects.

Results

In all, 119 sunfish scale samples were backcalculated for age-1 and age-2 growth. Of those 119 samples; 82 were bluegill, 26 were pumpkinseed, and 11 were hybrids. Nine percent of the sunfish sampled were hybrids. In Big Sugar Bush Lake, sunfish growth from age-1 to 2 varied considerably, from 10.6 to 30.9 mm with a mean 19.3 mm. The population of hybrid sunfish showed the highest growth, with a mean of 20.3 mm followed by bluegill and pumpkinseed at 19.4 and 18.8 mm, respectively. Bluegill growth rates varied from 13.6 to 30.6 mm and pumpkinseed from 10.6 to 24.3 mm. There was not enough evidence to suggest that growth rate differed by species ($F = 0.70$; $df = 2, 112$; p-value = 0.49).

Although species did not have any effect on growth, there was enough evidence to suggest the growth of sunfish was slower when ice out date was later (Figure 1; p-value = 0.03; $R^2 = 0.77$). Mean growth rates slowed considerably for years that experienced ice longer. The average mean growth from age-1 to age-2 was highest when the ice was off the lake by 22 March (22.5 mm) and lowest (18.1 mm) when ice was off the latest day, 2 May.

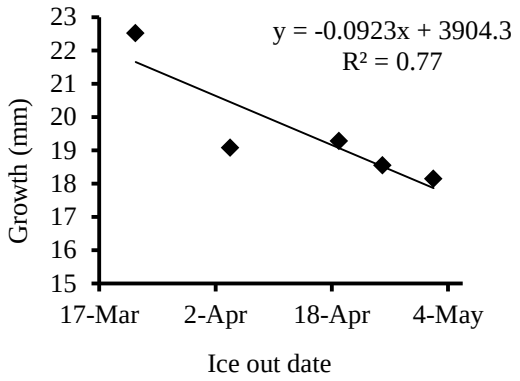

Figure 1 – Relationship between ice out date and mean sunfish growth from age 1 to 2 (p-value = 0.03). Fish were captured from Big Sugar Bush Lake, MN during the summer of 2014.

There was enough evidence to suggest that year influenced growth rates (Figure 2; $F = 2.68$; $df = 4, 112$; p-value 0.04). The pairwise t-test, with inputs of growth and year, showed evidence for a significant change in growth taking place between 2011 and 2012 (Table 1; p-value = 0.02).

Table 1 – Results (p-values) of Bonferroni corrected pairwise comparisons of sunfish growth against ice out year.

Year	2008	2009	2010	2011
2009	1	-	-	-
2010	1	1	-	-
2011	1	1	1	-
2012	0.127	0.114	0.053	0.023

Discussion

Results of this study provided evidence to suggest earlier ice out dates allow for higher growth rates in sunfish species from northern latitudes. Evidence of ice out date having an effect on growth is apparent when looking at its effects on water temperature. Ice present on lakes later into the year significantly drops water temperatures. The colder temperatures, and shorter growing season that results, is the mostly likely explanation for the differences in sunfish growth

[1] http://www.dnr.state.mn.us/ice_out/index.html

observed in this study. Tomcko and Pierce (1997) reported that water temperature can affect sunfish growth in the spring and summer months. In their study, sunfish experienced poor year classes due to below average water temperature. Shorter growing seasons can also affect species other than sunfish as evident from Le Cren (1958), who found that yellow perch (*Perca flavescens*) exhibit most of their growth from June to September. In northern Minnesota water temperatures do not get a chance to reach optimal ranges of 30°C when ice is present longer than average. In this study there was a significant change in growth from 2011 to 2012. This was due to the fact that the ice out date was a lot earlier in 2012 than previous years allowing for water temperature to warm up earlier in the season.

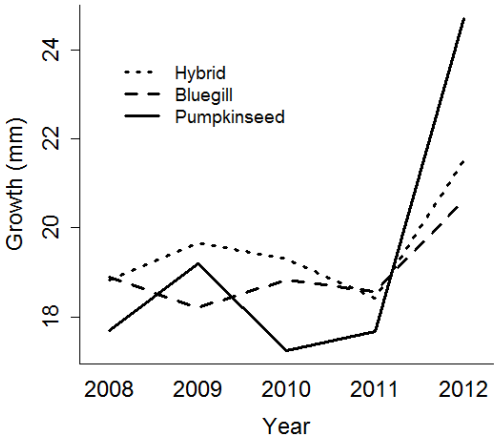

Figure 2 – Growth (mm) for each species of sunfish captured from Big Sugar Bush Lake plotted against year showing significant change from 2011 to 2012 (p- value = 0.04).

After the completion of this study, it was evident that there was no statistical difference in growth rates between the sunfish species of Big Sugar Bush Lake, MN. Sunfish of Big Sugar Bush Lake had age-1 lengths which were comparable to bluegills captured during New Jersey lake inventories (NJDFW 2015), but age-2 lengths were substantially lower (Figure 3). Mean lengths of sunfish from Arkansas also expressed similar age-1 lengths but significantly higher age-2 lengths when compared to sunfish of Big Sugar Bush Lake (Figure 3; Hogue and Kilambi 1975). The lower age-2 lengths from the current study are most likely attributed to the fact that New Jersey and Arkansas studies took place at lower latitudes. It is generally assumed that fish growth dramatically increases with a decrease in latitude (Eschmeyer 1940) associated with a longer growing season (Gerking 1966).

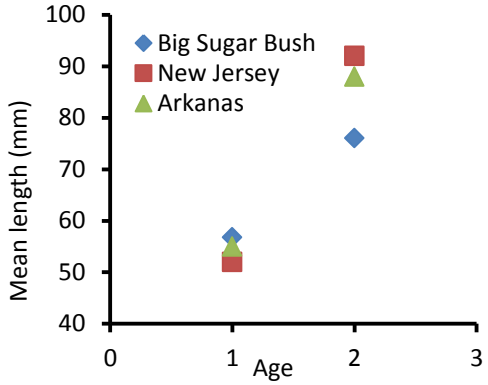

Figure 3 – Mean lengths for all sunfish sampled in Big Sugar Bush Lake and two lower latitude studies plotted against age.

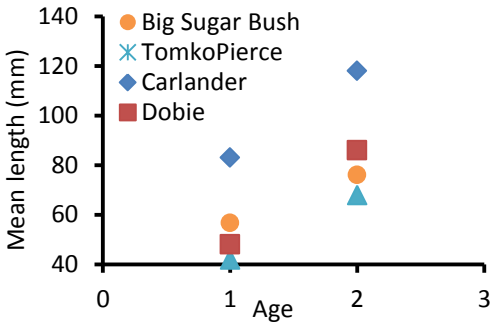

Figure 4 – Mean lengths for all sunfish sampled in Big Sugar Bush Lake and three previous studies from Minnesota plotted against age.

Mean lengths estimated from backcalculations were higher than the Minnesota statewide standard for age-1, but lower at age-2 (Dobie 1970). Means lengths calculated by Carlander (1977) were several millimeters more in length than sunfish of Big Sugar Bush (Figure 4). Overall, sunfish growth rates from Big Sugar Bush Lake express a similar trend as those previously reported for Minnesota (Dobie 1970; Carlander 1977; Tomcko and Pierce 1997).

Knowing now that sunfish growth is significantly influenced by ice out date in northern waters, it can confidently be suggested that in the near future global warming will have an effect on the sunfish growth rates. The effects of global warming are currently raising average temperatures in Minnesota (NOAA 2015). These warming trends will allow for shorter ice time and longer growing seasons for sunfish, increasing growth patterns over time.

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