Growth Rate and Hatch Date of Age-0 Fishes on Leech Lake, Minnesota Before Zebra Mussel Establishment

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The introduction of an invasive species to an ecosystem is considered a very severe environmental problem. Zebra Mussel veligers *Dreissena polymorpha* have recently been found in Leech Lake, Minnesota, and are likely going to have a large influence on this ecosystem. Zebra Mussels are filter-feeders that rely on phytoplankton and zooplankton as their main source of energy. A shift in populations of plankton due to Zebra Mussels may affect the growth rates of larval fish. Median hatch dates and growth rates were estimated from four age-0 fish species (Yellow Perch *Perca flavescens*, Walleye *Sander vitreus*, Smallmouth Bass *Micropterus dolomieu*, and Largemouth Bass *Micropterus salmoides*). Median hatch dates ranged from 7 May to 11 June 2017. Walleye had the earliest median hatch date (7 May 2017), followed by Yellow Perch (17 May 2017), Largemouth Bass (3 June 2017), and Smallmouth Bass (11 June 2017). Growth rates ranged from 0.07 to 0.88 mm/d, with Yellow Perch having the slowest growth rate (0.07 mm/d), followed by Walleye (0.14 mm/d), Largemouth Bass (0.60 mm/d), and Smallmouth Bass (0.88 mm/d). Results from this study will provide baseline data which will allow Leech Lake managers to estimate how Zebra Mussels influence the system in the future.

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Introduction

The introduction of invasive species to freshwater ecosystems is considered a consequential environmental problem to aquatic systems (Richter et al. 1997). Zebra Mussels *Dreissena polymorpha*, native to southwestern Russia, are a recognized, established, and invasive species in the United States (Ludyanskiy et al. 1993). In 1986, Zebra Mussels were introduced into the Great Lakes from the ballast tanks of ships (MacIsaac 1996). From the tanks, Zebra Mussels settled and began to colonize on hard substrates such as rocks and clam shells (Berkman et al. 1998). However, in Lake Erie, colonies have been found on soft substrates such as sand and mud, allowing Zebra Mussels to maximize habitat utilization (Berkman et al. 1998).

Zebra Mussels are filter-feeders that rely on phytoplankton, zooplankton, and bacteria as their energy source (Strayer et al. 1999). Zebra Mussels have filtration rates measuring up to 7 m^3 m^{-2} d^{-1} (Strayer et al. 1999). The rapid filtration by Zebra Mussels limits zooplankton as a food source for planktivorous fish (Thayer et al. 2011). Larval fish rely on plankton as their main source of food in their early stages of life (Turner 1984). Prout et al. (1990) found that prey abundance, type and size directly affect fish growth. A shift in populations of plankton due to Zebra Mussels may affect the growth rates of larval fish (Thayer et al. 2011).

Baseline data is used to assess the impact of management implications or disturbances to an ecosystem (Underwood 2000). Without prior information about the system, it is difficult to determine if a change is due to natural events such as population dynamics, invasive species, natural disasters, or if changes occurred due to human disturbances (Underwood 2000). Therefore, the objective of this study is to create a baseline data set of growth rates and hatch dates of age-0 fishes prior to Zebra Mussel establishment.

Methods

Study sites

All sites were based on the Leech Lake management plan (Pedersen 2016). Five seining locations (Whipholt Beach, Stony Point, Traders Bay, Ottertail Point, and Five Mile Point) and three trawling locations were sampled from Leech Lake, Minnesota (Figure 1). Seining sites were chosen based on sampling availability due to wind conditions. Seine hauls were completed on 17 July 2017. All trawls were done approximately one month later (15 and 24 Aug 2017). Three long-term stations were sampled by trawls (Figure 1). A total of 20 trawls were taken (eight trawls at Five Mile Point and six trawls at both Whipholt Beach and Goose Island).

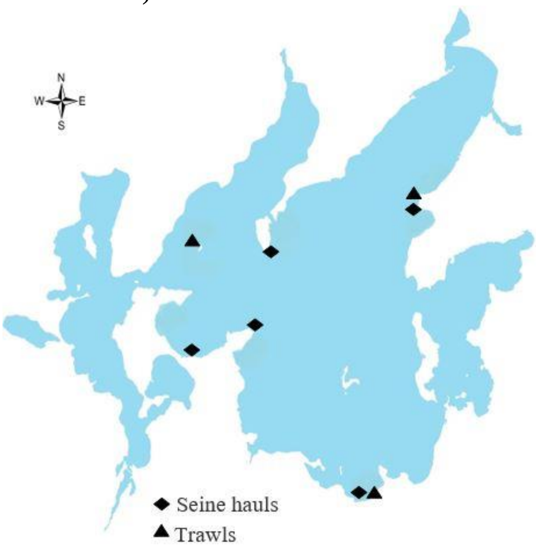

Figure 1. Seine haul and trawl locations on Leech Lake, Minnesota.

Data collection

All seine hauls and trawls followed large lake sampling methods protocol for Leech Lake, Minnesota (Pederson 2016). Each of the seine haul sites consisted of two hauls parallel to shore with a 30.5 m seine, hauled for 45.7 m, with a mesh size of 6.4 mm. A semi-balloon bottom trawl (7.6 m headrope, 6.4 mm mesh cod end liner) was towed for five minutes at a speed of 5.6 kilometers per hour (kph) ranging from 1.8-3.7 m in depth. All fish were counted after each seine or trawl. All age-0 Largemouth Bass *Micropterus salmoides* and Smallmouth Bass *Micropterus dolomieu* were placed in a plastic bag labeled with date, site, and seine or trawl number. Thirty age-0 Walleye *Sander vitreus* and 30 age-0 Yellow Perch *Perca flavescens* were collected per site. Each fish was given a serial number, then length and weight were measured from all fishes. Fish were then placed in individual compartments of a tackle box along with small jar lid indicating the serial number of that fish and then frozen until sagittal otoliths were removed.

Otolith preparation

Sagittal otoliths were removed under an Olympus VMZ 1x-4x dissection microscope. Using fine tip, dissection forceps, the gills were removed to provide a clear view of the otoliths. Forceps were inserted into one side of the inner ear and the otolith was extracted and placed into small, dark colored bottle cap filled with water. Procedure was repeated for retrieval of the second otolith. The membranous sac was then removed from the otolith using two dissection probes, while the otoliths were submerged in water. Afterwards, they were placed on a paper towel to dry, and super glued concave side up to opposite ends of a glass slide labeled with their serial number. Two small dots of glue were placed near the otoliths and smeared around the otolith with probes to minimize the amount of glue on-top of the otolith. Super glue was allowed to dry at least two hours before otoliths were sanded down with wet 1500 grit sandpaper. The slides were turned otolith side down and moved in a circular motion with light pressure to ensure even sanding across the otolith. Mineral oil was applied to the sanded side of the otolith to aid in the visibility of the rings.

Otoliths were examined under an Olympus BX41 microscope at 10x magnification with a Micrometrics U-CMAD3 camera attached to enhance ring visibility. The microscope image was displayed on a computer screen for ease of aging. Two readers aged throughout this study and each fish was aged by one reader. Otoliths were counted in four directions starting from the first visible ring and counted to the last visible ring. Counts were taken on a desktop tally counter and recorded for later use.

Data analysis

Ages estimated from each direction were plotted against all other directions to determine if there was a change in ages based on the direction aged. If an aging direction looked off compared to the other directions when plotted, the coefficient of variation (CV) was calculated with and without that direction included in the CV estimate. According to Campana (2001), if CV differed by more than 5% there was a significant difference in the ages of an otolith. All directions not resulting in a CV over 5% were averaged and used as the final age of the fish. Hatch dates were calculated by subtracting the final age of the fish from the collection date.

A linear regression model was used to determine growth rate of each species based on total length-age relationships.

Results

Hatch dates ranged from 14 April to 7 July 2017 (Figure 2). Each species hatch date ranged from 6-8 weeks. Yellow Perch had the longest hatching period (8 weeks and 2 days), while Walleye had the shortest hatching period (6 weeks and 5 days). Walleyes also had the earliest median hatch date (7 May 2017, IQR = 30 April - 10 May 2017; Figure

2) and Smallmouth Bass had the latest median hatch date (11 June 2017, IQR = 7 June - 16 June 2017; Figure 2).

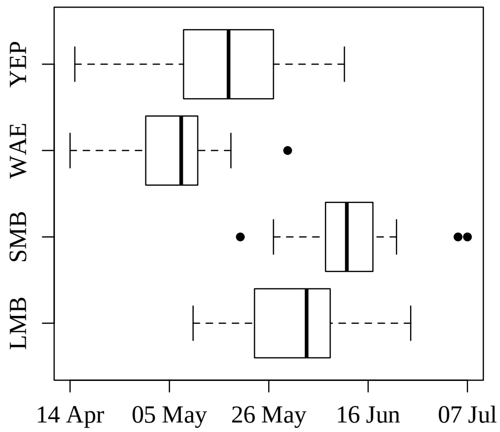

Figure 2. Median hatch dates for Yellow Perch, Walleye, Smallmouth Bass, and Largemouth Bass sampled between April and June 2017.

Although Smallmouth and Largemouth Bass had later hatch dates, they had higher growth rates than Walleye and Yellow Perch. Growth rates varied greatly between species. Smallmouth Bass had the highest growth rates at 0.88 mm/d (0.59-1.16 95% CI; Figure 3), followed by Largemouth Bass (0.60 mm/d, 0.38-0.82 95% CI; Figure 4), Walleye (0.14 mm/d, -0.24-0.51 95% CI; Figure 5), and Yellow Perch (0.07 mm/d, -0.02-0.15 95% CI; Figure 6).

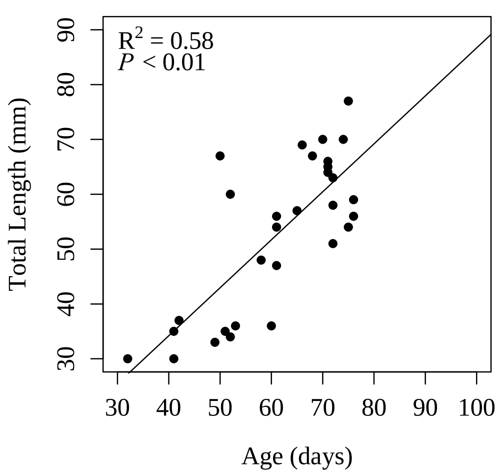

Figure 3. Growth rates of age-0 Smallmouth Bass from Leech Lake, Minnesota sampled on 15 and 24 August 2017 (y=0.88x-0.81).

Discussion

Growth rates are not consistent across all game fish species. According to Weber et al. (2011), late-hatching fish had a shorter growing period, leading to higher growth rates and a uniform size distribution. Our results are consistent with the finding of Weber et al. (2011). Walleye and Yellow Perch spawn in early spring, whereas bass spawn in early summer. Due to bass having a shorter growing period, they have higher growth rates to make up for the size difference.

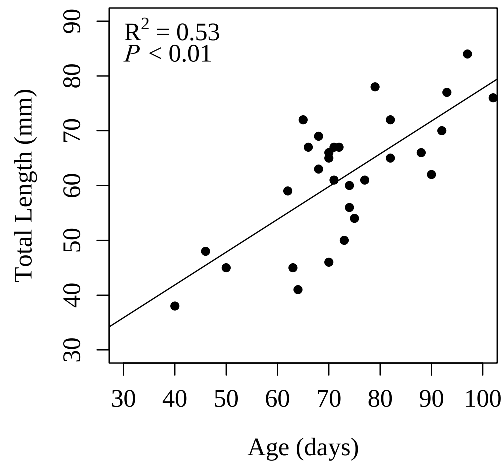

Figure 4. Growth rates of age-0 Largemouth Bass from Leech Lake, Minnesota sampled on 17 July, 15 August and 24 August 2017 (y=0.60x+17.93).

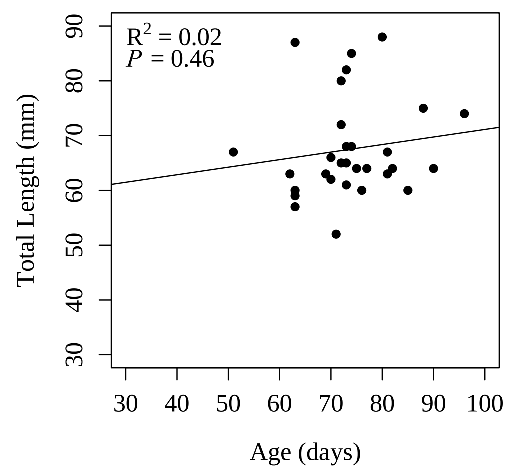

Figure 5. Growth rates of age-0 Walleye from Leech Lake, Minnesota sampled on 17 July 2017 (y=0.14x+57.35).

Yellow Perch had the slowest growth rates in this study. The age-0 Yellow Perch growth rate (0.07 mm/d) was comparable to Yellow Perch in Lake Michigan, which was and is a Zebra Mussel infested lake. Lake Michigan perch had growth rates of 0.03, 0.06, and 0.03 mm/d, during 2004-2006, respectively (Weber et al. 2011). Mayer et al. (2000) found that age-0 Yellow Perch growth rates increased in association with Zebra Mussel introduction, likely due to higher densities of larger zooplankton being more abundant than smaller zooplankton.

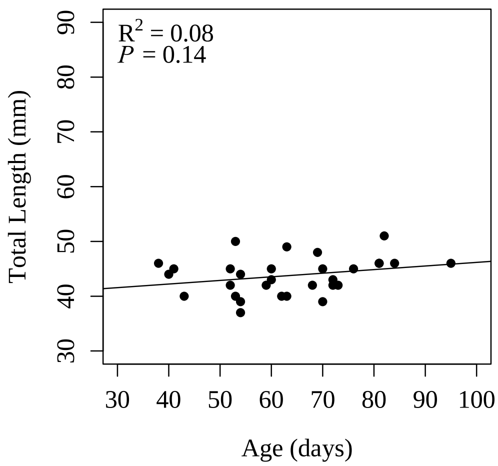

Figure 6. Growth rates of age-0 Yellow Perch from Leech Lake, Minnesota sampled on 17 July 2017 (y=0.07x+39.58).

Walleye had the second slowest growth rates at 0.14 mm/d. In a study done by Hoxmeier et al. (2006), age-0 Walleye grew by 4 mm over a four month time period (September-December) in four different Illinois lakes not infested with Zebra Mussels. Walleye in Leech Lake had higher growth rates than in the Hoxmeier et al. (2006) study. This was likely because sampling took place in different seasons.

Largemouth and Smallmouth Bass had the fastest growth rate of the four species. Few recent and relevant studies were found on Largemouth or Smallmouth Bass making comparisons of growth rates difficult. One study found Largemouth Bass had growth rates of 0.036 g/d in Hargus Lake (Garvey et al. 1998). For Smallmouth Bass, growth rates on Lake Erie were 1.2, 0.85, 0.73 and 0.58 mm/d in 2000, 1970, 1950, and 1940, respectively (Steinhart et al. 2004). Growth rates found in the Steinhart et al. (2004) study are similar to Smallmouth Bass in this study (0.88 mm/d). Zebra Mussels were not present in Hargus Lake or in Lake Erie prior to the growth rates of 2000.

The hatch dates of these four game species had large variation, ranging 12 weeks in total, from the first hatch date of Walleyes to the last hatch date of Smallmouth Bass. Walleye hatch dates on the Red Lakes were 9-29 May in 1960 (Smith and Pycha 1960). The duration of hatch dates (3-5 weeks) are similar to this study from 14 April to 18 May 2017. Hanchin et al. (2003) found that Yellow Perch hatch dates occurred between 28 April to 13 May 2000 and 7-10 May 2001 in Lake Madison, South Dakota. Yellow Perch hatch dates from this study were 15 April to 11 June 2017. Largemouth Bass from several lakes in Michigan started hatching on 4 June 1991 and 14 June 1992 (Olson 1996). Smallmouth Bass initial hatch date in Lake Opeongo, Ontario was 18 June 1995 (Vander Zanden and Hulshof 1998). Both Largemouth and Smallmouth Bass in this study started hatching roughly one month before those in the studies done by Olson (1996) and Vander Zanden and Hulshof (1988). The ranges of hatch dates and the first hatch date for all species are likely dependent on water temperatures and weather conditions (Ward et al. 2004). Although these comparison lakes were not infested with Zebra Mussels, it is difficult to compare hatch dates between systems from dissimilar locations and sizes.

It is likely that growth rates will increase, and hatch dates will be earlier after the establishment of Zebra Mussels due to larger prey options and clearer water. According to Gunn et al. (2001), water clarity may affect the water temperature in smaller, shallower systems. Although Leech Lake is not a small system, 51% of the total area is comprised of littoral zone suggesting a potential change in water temperature overtime (Gunn et al. 2001, Pedersen 2016). A continuation of this study is needed to determine if Zebra Mussel establishment has an impact on hatch dates and growth rates of age-0 fishes. Future recommendations for this study is to have a larger sample size and collect all fish within the same week. Findings from this study and future studies can be used to help implement management procedures.

References

Berkman, P.A., M.A. Haltuch, E. Tichich, D.W. Garton, G.W. Kennedy, J.E. Gannon, S.D. Mackey, J.A. Fuller, and D.L. Liebenthal. 1998. Zebra Mussels invade Lake Erie muds. Nature 393:27-28.

Campana, S.E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. Journal of Fish Biology 59:197-242.

Garvey, J.E., R.A. Wright, and R.A. Stein. 1998. Overwinter growth and survival of age-0 Largemouth Bass (*Micropterus salmoides*): revisiting the role of body size. Canadian Journal of Fisheries and Aquatic Sciences 55:2414-2424.

Gunn, J.M., E. Snucins, N.D. Yan, and M.T. Arts. 2001. Use of water clarity to monitor the effects of climate change and other stressors on oligotrophic lakes. Environmental Monitoring and Assessment 67:69-88.

Hanchin, P.A., D.A. Willis, and T.R. St. Sauver. 2003. Influence of introduced spawning habitat on Yellow Perch reproduction in Lake Madison, South Dakota. Journal of Freshwater Ecology 18:291-297.

Hoxmeier, R.J.H., D.H. Wahl, R.C. Brooks, and R.C. Heidinger. 2006. Growth and survival of age-0 Walleye (*Sander vitreus*): interactions among Walleye size, prey availability, predation, and abiotic factors. Canadian Journal of Fisheries and Aquatic Sciences 63:2173-2182.

Ludyanskiy, M.L., D. McDonald, and D. MacNeill. 1993. Impact of the Zebra Mussel, a bivalve invader. BioScience 43:533-544.

MacIsaac, H.J. 1996. Potential abiotic and biotic impacts of Zebra Mussels on the inland waters of North America. American Zoologist 36:287-299.

Mayer, C.M., A.J. VanDeValk., J.L. Forney, L.G. Rudstam, and E.L. Mills. 2000. Response of Yellow Perch (*Perca flavescens*) in Oneida Lake, New York, to the establishment of Zebra Mussels (*Dreissena polymorpha*). Canadian Journal of Fisheries and Aquatic Sciences 57:742-754.

Olson, M.H. 1996. Ontogenetic niche shifts in Largemouth Bass: Variability and consequences for first-year growth. Ecology 77:179-190.

Pedersen, C. 2016. Large lake sampling program completion report for Leech Lake: 2016. Minnesota Department of Natural Resources, Section of Fisheries, Completion Report, F15AF00162.

Prout, M.W., E.L. Mills, and J.L. Forney. 1990. Diet growth, and potential competitive interactions between age-0 White Perch and Yellow Perch in Oneida Lake, New York. Transactions of the American Fisheries Society 199:966-975.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081-1093.

Smith, L.L. and R.L. Pycha. 1960. First-year growth of the Walleye, *Stiozstedion vitreum* (Mitchill), and association factors in the Red Lakes, Minnesota. Limnology and Oceanography 5:281-290.

Steinhart, G.B. R.A. Stein, and E.A. Marschall. 2004. High growth rate of young-of-the-year Smallmouth Bass in Lake Erie: A result of the Round Goby invasion? Journal of Great Lakes Research 30:381-389.

Strayer, D.L., N.F. Caraco, J.J. Cole, S. Findlay, and M.L. Pace. 1999. Transformation of freshwater ecosystems by bivalves, a case study of Zebra Mussels in the Hudson River. BioScience 49:19-27.

Thayer, S.A., R.C. Haas, R.D. Hunter, and R.H. Kushler. 2011. Zebra Mussel (*Dreissena polymorpha*) effects on sediment, other zoobenthos, and the diet and growth of adult Yellow Perch (*Perca flavescens*) in pond enclosures. Canadian Journal of Fisheries and Aquatic Science 54:1902-1915.

Turner, J.F. 1984. The feeding ecology of some zooplankters that are important prey items of larval fish. NOAA Technical Reports NMFS 7.

Underwood, A.J. 2000. Importance of experimental design in detecting and measuring stresses in marine populations. Journal of Aquatic Ecosystem Stress and Recovery 7:3-24.

Vander Zanden, M.J. and M. Hulshop. 1998. Application of stable isotope techniques to Trophic studies of age-0 Smallmouth Bass. Transactions of the American Fisheries Society 127:729-739.

Ward, M.J., M.R. Anderson, S.J. Fisher, D.A. Isermann, Q.E. Phelps, and D.W. Willis. 2004. Relations between climatological variables and larval Yellow Perch abundance in eastern South Dakota glacial lakes. Journal of Freshwater Ecology 19:213-218.

Weber, M.J., J.M. Detmers, and D.H. Wahl. 2011. Growth and survival of age-0 Yellow Perch across habitats in southwestern Lake Michigan: Early life history in a large freshwater environment. Transactions of the American Fisheries Society 140:1172-1185.