Age and Growth of Muskellunge in Glazier Lake, Maine

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SUMMARY

Muskellunge are an invasive fish species in Maine that pose threats to wild and native coldwater fish, but also attract a locally popular sport fishery where they occur. Though the Maine Department of Inland Fisheries and Wildlife (MDIFW) does not actively manage the species with size or bag limits, ongoing efforts aim to increase our understanding of these populations. Cleithral bones were collected from 60 Muskellunge in Glazier Lake between 2004 and 2019 to determine age structure and fish growth. The current Muskellunge population in Glazier Lake is characterized by slow growing fish with the potential to reach a maximum length of less than 40 inches. Due to this low growth potential, it is unlikely that restrictive angling regulations would result in a meaningful change in the number of trophy Muskellunge present in the fishery.

INTRODUCTION

The Muskellunge (*Esox masquinongy*, also referred to as 'Muskie') is an invasive fish species in Maine. Muskellunge became established in the upper St. John River watershed shortly after being introduced to a headwater lake in Quebec in 1970. In the ensuing decades, Muskies have spread throughout most of the suitable habitat in the St. John River and its major tributaries where barriers to movement were not present. Muskies are known as a large predatory fish, and their establishment has resulted in negative impacts to native Brook Trout *(Salvelinus fontinalis*), wild Landlocked Salmon (*Salmo salar*), and other fish species present in the waters where they occur. At the same time, a popular sport fishery has developed for Muskellunge in the St. John River valley, and some anglers have requested that MDIFW begin managing the species as a sportfish with restrictive size and bag limits. To better understand the age and growth of Muskellunge in Maine, we used cleithra to assign ages and back-calculate length at age for Muskellunge collected from Glazier Lake between 2004 and 2019.

STUDY AREA

Glazier Lake is a 1,000-acre oligotrophic lake (maximum depth 118 feet) located on the border between Maine and New Brunswick and supports one of Maine's most popular Muskie fisheries. Despite its remote setting in the woods of far northern Maine, distant from any population center, the lake does receive a moderate level of angling pressure relative to other area waters, with an estimated 400-500 angler days during the ice fishing season, and a similar level of angler use during the summer season. Muskellunge migrated into the St. Francis River and Glazier Lake following a 1970's introduction in the headwaters of the St. John River in Quebec, and were first confirmed in Glazier Lake in the early 1990's. During early population establishment, Muskies in Glazier grew at exceptional rates, and anglers caught several state record fish. In more recent years, Muskellunge have become abundant in Glazier and growth appears to have stabilized as fish have fully colonized the lake's available habitat and now compete for limited food resources.

METHODS

MDIFW fisheries staff collected cleithral bones (the large bones that form the posterior edge of a fish's gill chambers, also referred to as cleithra) from Muskellunge in Glazier Lake via angler creel surveys, experimental angling, gill netting and voluntary angler contributions at various times between 2004 and 2019. Fish in temperate climates can be aged using mineralized body parts (e.g., scales, fin rays, bones) because growth slows during winter, creating visible growth rings. Cleithra were removed from fish, total fish length was recorded, and ages were interpreted using methods similar to those described by Mackay et al. (1990). Given the known linear relationship between cleithral growth and overall length of Muskellunge (Casselman 1990), length-at-age was assigned for fish at each readily-identifiable annulus (growth ring) based on its distance between the focus (center) and outer edge. In cases where annuli were obscured by calcified growth (particularly the first year in larger, older fish), only length-at-age data for visible annuli were recorded. Length at age data were used to compute average and 95% confidence limits of length at each age identified. Data were compared to those from Muskellunge populations in other parts of the species' range.

RESULTS

Cleithra were collected from a total of 60 Muskellunge from Glazier Lake between 2004 and 2019 (Table 1). Fish ranged in age between 4 and 17, with the majority between 5 and 7 years old (Figure 1). The age frequency data show a decreasing number of Muskellunge with increasing age, with the exception of a spike in fish numbers at age 10. Muskellunge exhibited rapid growth early in life and a decreasing growth rate beginning around age 4 (Figure 2), likely coinciding with the onset of sexual maturity. Growth rate appeared to flatten around age 10, and fish averaged 35-38 inches long between ages 10 and 15.

Table 1. Number of Muskellunge sampled for cleithral aging by method, 2004-2019.

Year	Method	# of fish
2004	Experimental angling	3
2013	Gillnetting	19
2014	Creel survey	6
2015	Voluntary angler	3
2018	Voluntary angler	9
2019	Creel survey	22

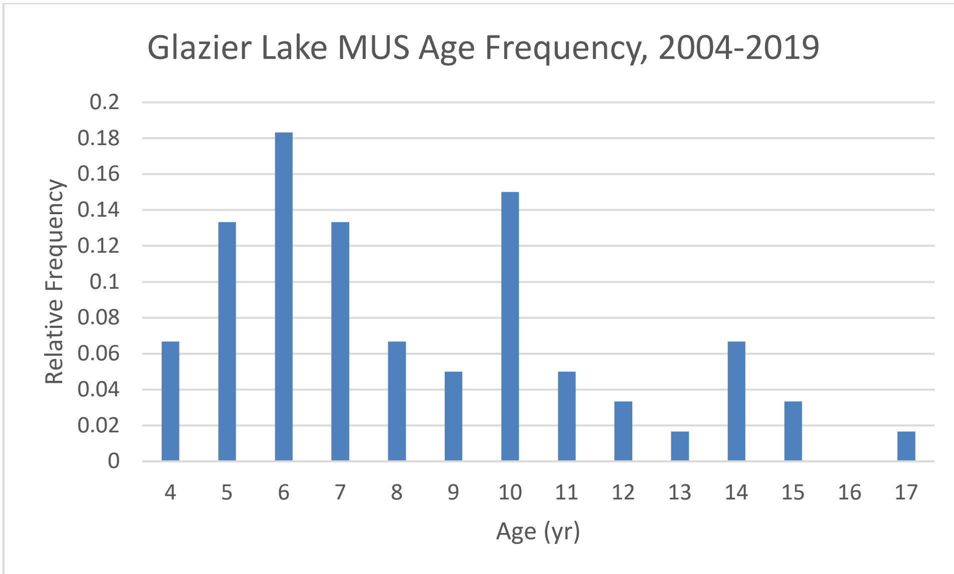

Figure 1. Age frequency of Muskellunge sampled and aged by cleithra from 2004-2019.

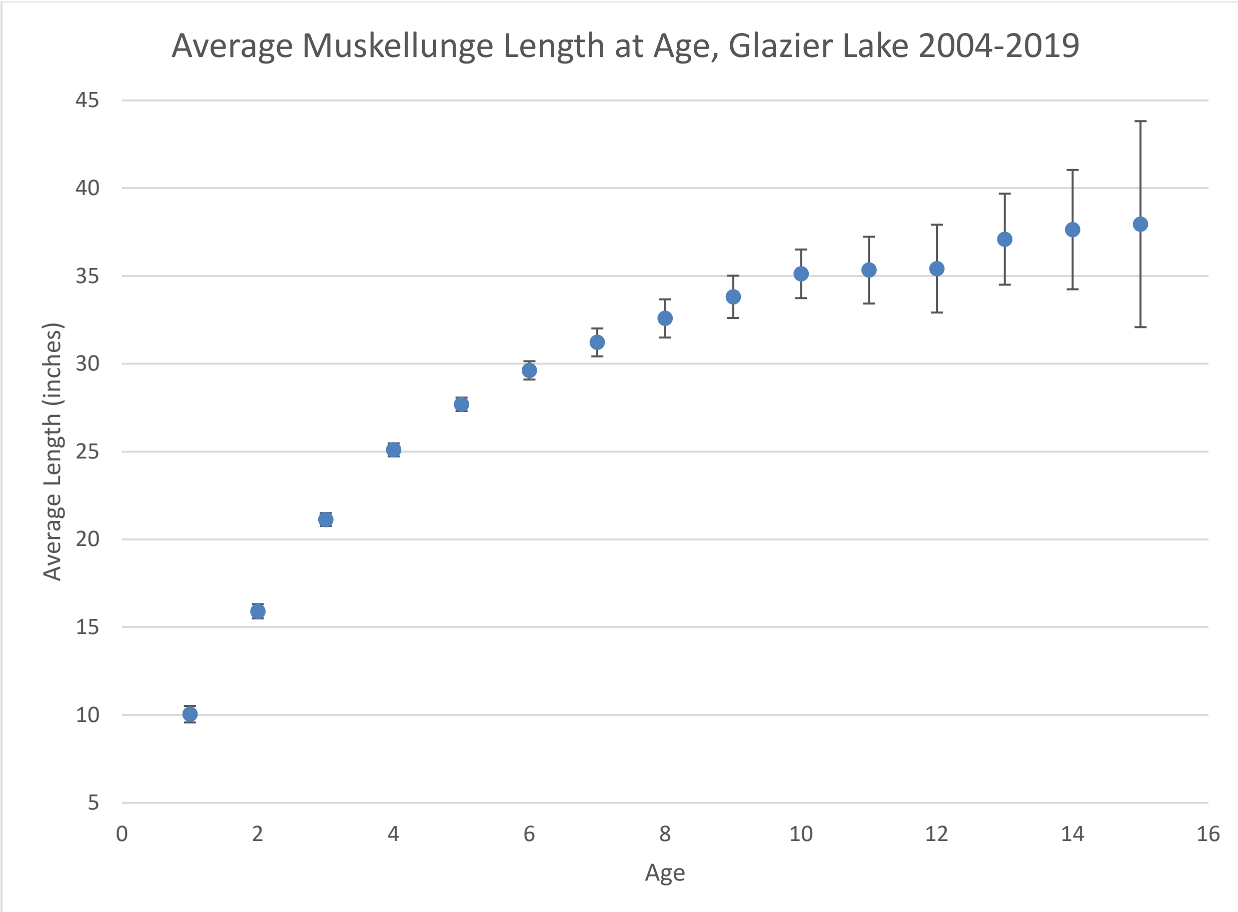

Figure 2. Average length at age for Glazier Lake Muskellunge based on back-calculated cleithral aging, 2004-2019. Error bars represent 95% confidence interval.

DISCUSSION

Muskellunge are an invasive species in Maine and are managed with no size or bag limits and liberal season lengths (Brautigam and Lucas 2008). Despite this, the species is popular among a passionate group of anglers in the local communities and anglers that travel long distances to target them. Many anglers have expressed concern about the quality of the fishery, and a desire to manage for more larger fish. Though MDIFW has no plans to actively manage the species, efforts are ongoing to collect biological data and better understand Muskellunge populations in the area. The data presented here provide the opportunity to discuss the current state of Muskellunge age and growth in northern Maine, particularly in Glazier Lake. These data provide insight into a well-established Muskie population under no active management, experiencing low to moderate angling pressure.

Glazier Lake Muskellunge exhibited a pattern of rapid growth early in life, followed by a slowdown coinciding with the onset of sexual maturity, and a steadily declining growth rate with increasing age, typical of most Muskellunge populations throughout the species' range (Casselman et al. 1999). The initial slowdown in growth occurred when fish reached approximately 30 inches. Maximum length in our sample occurred at approximately 38 inches. Anglers report catching Muskies exceeding 40 inches here occasionally, but none of these fish were present in our 60 fish sample.

The age structure of our Glazier Lake Muskellunge sample was characterized by an abundance of age-5 through age-7 fish, with another high frequency of fish at age-10. Age structure data are difficult to obtain in Muskellunge populations because fish are present in low densities and relatively few are captured during routine fish sampling. Additionally, accurate age information requires sacrificing the fish to obtain cleithral bones (which we did in this study). Work in other areas has often relied on scale aging (Fitzgerald et al. 2007) or obtaining samples of trophy fish kept by anglers (Casselman and Crossman 1986), both of which present problems for making accurate comparisons to our data. Shaw et al. (2019) presented age structure information for Muskies in Escanaba Lake, Wisconsin during both high harvest and low harvest periods in the fishery between 1956-2016. Our age structure data from Glazier Lake appears to be somewhere in between their estimates for the two time periods.

Early growth of Glazier Lake Muskellunge was typical of populations elsewhere in the species' range. Growth from age-1 through age-4 was virtually identical to a sample of more than 5,000 Muskellunge sampled in Wisconsin from 1947-1992 (Simonson 2012). Growth beyond age-4 slowed considerably in our sample, however, and the maximum length achieved in Glazier Lake was considerably smaller than that seen in other studies (Casselman et al. 1999; Farrell et al. 2003; Harrison and Hadley 1979; Lorantas and Kristine 2013; Simonson 2012; but see Shaw et al. 2019).

Growth potential within a Muskellunge population varies by water body and is typically affected by waterbody size (Simonson 2012), available food resources (Cornelius and Margenau 1999), and genetics (Miller et al. 2017). The growth characteristics of each population can be used to predict a mean ultimate length, or the hypothetical length that can be reached by a fish with no limit on life span (Casselman 2007). Mean ultimate length can vary substantially between populations (35-43" in Escanaba Lake, WI: Shaw et al 2019, 43-45" in Pennsylvania: Lorantas and Kristine 2013, 45-50" in the St. Lawrence River: Farrell et al. 2003, 56" in Wisconsin: Simonson 2012). Simonson (2012) used lake size to explain nearly 70% of variability in mean ultimate length of Muskellunge in Wisconsin. Using his equation, a 1,000-acre lake, the size of Glazier, should support a Muskellunge population with a mean ultimate length of around 46" in Wisconsin. However, our Glazier Lake growth curve produces a mean ultimate length just under 38". Growth in Glazier is likely slower due to its northern latitude, high altitude, and shorter growing season than found in Wisconsin lakes. Glazier is an oligotrophic lake with low productivity. Though genetics and population abundance may play a role in influencing growth here, it is more likely that lake size, growing season length, and primary productivity are the factors driving growth.

During the early years of the Glazier Lake Muskellunge fishery, anglers caught several trophy sized Muskies in the lake, including a state record fish at 48" long in 2009. These fish were in Glazier during the initial invasion period, when Muskellunge densities were extremely low and food availability was relatively high. It appears that this period of extremely rapid growth that produced several state record fish reached its end around the time most of the data were collected for this study. The existing Muskellunge population in Glazier is characterized by much slower growing fish with few fish exceeding 40”.

In general, Muskellunge fisheries have been characterized by an early period of high harvest, transitioning to a modern-day voluntary catch and release fishery with little to no harvest (Fayram 2003; Gilbert and Sass 2016; Simonson and Hewett 1999). Muskellunge are a relatively new fish in northern Maine waters, and the fishery in Glazier Lake and nearby areas contains both anglers who harvest every Muskie they catch and those who practice strict catch and release, putting this fishery somewhere between the two ends of the spectrum. Harvest rate has been shown to be an important driver of the size and age structure of Muskellunge populations. In fact, the virtual elimination of harvest in many fisheries appears to have resulted in increases in mean age as well as the frequency of larger fish (Casselman et al. 2017).

Muskellunge are managed as a trophy fish throughout much of the species’ range, with minimum length and bag limits common in most places. The effectiveness of harvest limitations at increasing the presence of trophy sized fish depends on existing angling pressure and the growth potential of the population. Northern Maine Muskellunge populations receive relatively low angling pressure, but a high incidence of harvest by anglers who fish for them.

Using a long-term dataset from trophy Muskellunge harvested in Ontario, Casselman (2007) suggested management of Muskie fisheries using minimum length limits derived from growth trajectories of individual waters. He proposed using ‘minimum ultimate size’ (the projected length that 99% of the fish would reach if they lived indefinitely) to develop minimum length limits in a fishery. A rough calculation of our data put ‘minimum ultimate size’ of Glazier Lake Muskellunge at around 30 inches. However, our data are limited by the small sample size of older fish and lack of sex differentiation in the sample, as females exhibit higher growth potential than males (Casselman and Crossman 1986; Casselman et al. 1999).

The age structure and proportion of larger fish in Muskellunge populations appears to have improved in many fisheries following trends toward higher release rates and lower harvest (Casselman et al. 2017). Also inherent to most fisheries with reduced harvest is an expected increase in fish densities. Higher densities are commonly the cause of decreasing fish growth (Cornelius and Margenau 1999; Lorenzen and Enberg 2002) and could lead to a lower mean ultimate length in the population. We know that Muskellunge growth rates have slowed considerably in Glazier Lake as density increased with population establishment. However, Shaw et al (2019) did not observe a change in fish growth with a substantial reduction in angler harvest.

The question of whether Muskellunge age and growth in northern Maine could be manipulated via angling regulations is an important one, particularly considering the frequent requests from anglers to manage the species with restrictive bag and length limits. Answering this question requires a better understanding of the fish, its habitat, and the anglers targeting the population. Considering the age structure and growth rates in our dataset, combined with the relatively low rate of fishing pressure in Glazier Lake, it is currently considered unlikely that restrictive fishing regulations would result in a meaningful increase in the number of trophy sized Muskellunge in the population.

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COOPERATIVE

STATE FEDERAL

PROJECT

This report has been funded in part by the Federal Aid in Sport Fish Restoration Program. This is a cooperative effort involving federal and state government agencies. The program is designed to increase sport fishing and boating opportunities through the wise investment of angler's and boater's tax dollars in state sport fishery projects. This program which was founded in 1950 was named the Dingell-Johnson Act in recognition of the congressmen who spearheaded this effort. In 1984 this act was amended through the Wallop Breaux Amendment (also named for the congressional sponsors) and provided a threefold increase in Federal monies for sportfish restoration, aquatic education, and motorboat access.

The program is an outstanding example of a "user pays-user benefits" or "user fee" program. In this case, anglers and boaters are the users. Briefly, anglers and boaters are responsible for payment of fishing tackle, excise taxes, motorboat fuel taxes, and import duties on tackle and boats. These monies are collected by the sport fishing industry, deposited in the Department of Treasury, and are allocated the year following collection to state fishery agencies for sport fisheries and boating access projects. Generally, each project must be evaluated and approved by the U.S. Fish and Wildlife Service (USFWS). The benefits provided by these projects to users complete the cycle between "user pays – user benefits."

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