WISCONSIN DEPARTMENT OF NATURAL RESOURCES

FISHERIES SURVEY REPORT

Population Characteristics of the Ashland Walleye Stock in Chequamegon Bay, Lake Superior

by

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Photo Credit: Wisconsin DNR

INTRODUCTION

Chequamegon Bay is a 13,750-hectare embayment on Lake Superior's south shore, a shallower (mean depth 8.5 meters) and more productive area of the lake that is suitable for harboring a diverse assemblage of fishes and supporting recreational and subsistence fisheries. Walleye (*Sander vitreus*) are a popular target for anglers and a main predator in the bay for species such as yellow perch (*Perca flavescens*) and rainbow smelt (*Osmerus mordax*).

Historically, walleye populations in Chequamegon Bay were maintained by natural reproduction in the Kakagon River and associated sloughs. However, declines in natural reproduction prompted Wisconsin DNR and the Bad River Band of Lake Superior Chippewa Natural Resource Department to begin stocking fingerlings and fry near Ashland, WI and the Kakagon River, respectively (DNR, 1980-2000, 2009-present; Bad River, 2001-present) to continue supporting important recreational and subsistence fisheries.

This report summarizes the key population demographics of Ashland walleye with the following goals:

- Characterize recruitment, growth and mortality of an ecologically, culturally and recreationally important fishery
- Investigate trends in the Ashland walleye population over time
- Assess the Ashland walleye DNR stocking program

METHODS

We surveyed spawning walleye along the Ashland shoreline shortly after ice-out in the spring of 1994, 2006, 2011, 2018, 2019 and 2022. Four stations were surveyed from 2011 to 2022, while two additional stations were surveyed each in 1994 and 2006 (Figure 1). Each station was sampled with 5-foot fyke nets (2-inch stretch mesh; 4 hoops) with 75- or 100-foot leads. We recorded the length, sex and spawning stage (immature, green, ripe or spent) of each fish and tagged them with uniquely numbered Floy tags and a year-specific fin clip (2018-2019) for individual identification in later surveys and angler returns. In addition, we collected dorsal spines from a subset of fish (approximately 5 individuals of each sex per 0.5-inch length bin) for later aging.

Walleye were grouped by year and sex for demographic analyses. We used age-length keys to assign ages to all unaged individuals to assess population demographics over time (changes in age frequencies of males and females; Isermann and Knight, 2005; Ogle, 2017). We compared ages and lengths between male and female fish and among years with nonparametric Kolmogorov-Smirnov tests to detect any differences in distributions that could indicate temporal shifts in population composition or sex-specific growth.

To assess current individual growth (2018-2022), we fitted von Bertalanffy growth curves to aged fish with nonlinear least squares regression models and bootstrapped 95% confidence intervals. This allowed us to visualize the average predicted growth of male and female walleye across the study period and identify variability in growth between sexes. In addition, we plotted mean length of walleye at age 7, selecting this age as the point of full recruitment to the sampling gear, from 1994 to 2022 to determine if size at gear recruitment has changed over time.

We recorded tag numbers in each survey and calculated tag loss over one-year and multi-year intervals. Tag loss was determined by dividing the number of fish with a year-specific fin clip that lacked tags by the total number of fin-clipped fish captured in that survey.

Finally, total instantaneous mortality *Z* and total annual mortality *A* were estimated for pooled walleye catches from all years (1994 – 2022) and the three most recent survey years (2018, 2019, and 2022) using a weighted linear regression on the descending limb of the catch curve (Ogle, 2016, 2017). We performed all analyses in program R (version 4.4.3).

RESULTS

Overall Catch

We collected biological data from 11,552 walleye [62% females (n = 7,167); 36% males (n = 4,124); 2% unknown/not checked (n = 261)] across the six survey years (including recaptures). Total catches were highest in 2019, followed by 2022, 2006, 1994, 2018, and 2011 (Table 1). Total lengths ranged from 6.5 inches to 31.9 inches. Notably, we observed total catches with sex ratios that were biased toward females in the most recent surveys (2018-2022; Table 1).

Size Structure

Male walleye total length averaged 19.06 inches ± 0.04 SE over all sampled years (minimum = 10.9 in; maximum = 28.8 inches), and females averaged 21.70 inches ± 0.03 SE (minimum = 10.2 in; maximum = 31.9 inches). The length distribution and average lengths of male and female walleye differed significantly between years (Figure 2). Size distributions initially increased from 1994 to 2011 but subsequently declined between 2011 and 2018, when mean length decreased from 22.16 ± 0.13 inches to 18.4 ± 0.14 inches for males and from 23.85 ± 0.27 inches to 20.6 ± 0.08 inches for females.

Stocking and Recruitment

The observed increase in walleye length distributions from 1994 to 2011 reflected a shift toward an aging population with few younger recruits entering the population, and thus, age distributions in 2006 and 2011 contained the highest proportions of old fish (age 13+). While 2018-2022 surveys also contained a few older individuals, distributions were concentrated around younger age classes (Figure 3). The mean ages of male and female Ashland walleye surveyed in 2022 were 5.9 (min = 2, max = 13) and 7.7 (min = 3, max = 14), respectively. We did not record any fish over 14 years old in 2022 but observed the greatest proportion of fish ≤6 years old in this year. The recent shift to a younger age structure likely reflects increased recruitment of young fish.

We classified DNR stocking activities since 1980 into five categories based on stocking magnitude, ranging from lowest to highest:

- None: No stocking
- Consistent: Regular stocking of approximately 25,000 to 100,000 fish
- Variable: Regular stocking of approximately 5,000 to 350,000 fish with substantial year-to-year variation
- Moderate: Regular stocking of approximately 150,000 to 450,000 fish with some year-to-year variation
- High: Stocking exceeding 450,000 fish

Population age structure strongly corresponded with stocking history over time. The most abundant age classes in 2018 and 2019 (approximately 4-9 years old in 2018 and 5-10 years old in 2019) corresponded with the years of moderate stocking of small fingerlings during 2009-2014 (Figure 4). The period of no stocking (2001-2008) was also apparent with the lack of younger cohorts (e.g., < 10 years) in the 2011 survey and lack of older cohorts (e.g., > 10 years) in the 2018-2019 surveys (Figure 4). Ultimately, only weak or non-existent cohorts were present in Ashland walleye samples from years when stocking did not occur, and age compositions throughout the years suggest that the Ashland walleye population is closely associated with Wisconsin DNR stocking. In other words, within the age compositions, we did not observe substantial evidence of natural reproduction along the Ashland shoreline that would meaningfully contribute to overall recruitment of walleye in Chequamegon Bay.

Growth

Growth patterns (L_∞ and K) varied between years and sexes (Table 2), partly due to differences in the age compositions of captured fish (e.g., absence of older or younger cohorts). We compared mean length at age 7 through time for male and female walleye after applying an age-length key to individual fish (Figure 5). Between 1994 and 2022, age-7 female walleye measured between 21.4 and 19.3 inches, and males measured between 20.5 and 18.4 inches. Despite some natural variation from year to year, we found little to no change in mean age-7 lengths over time.

Female and male mean lengths-at-age diverged with age, especially in fish ages 13 and older. Across recent years (2018-2022), females grew faster and reached larger maximum sizes than males (L_∞: 24.92 ± 0.42 SE inches for males, 29.39 ± 0.78 SE inches for females; Figure 6). Mean length-at-age of surveyed fish showed the same pattern, with females consistently outgrowing males at all ages (Figure 7). This sex-specific growth is well-documented, having been observed in other northern walleye stocks and in previous Lake Superior surveys in the St. Louis River (Olson et al., 2018). Due to size-specific regulations and harvest preferences, these growth differences could have management implications for the fishery. Current regulations include a bag limit of 5 with a 15-inch minimum length limit, but only one walleye may be over 20 inches. In addition, anglers in similar fisheries like the St. Louis River typically prefer to harvest walleye less than 22 inches (Varian et al. 2016). Based on our growth models, male walleye typically reach 20 inches around 8 years old and females at approximately 6.5

years old. Therefore, male walleye remain vulnerable to harvest longer than females and may experience higher mortality on average.

Mortality

We calculated instantaneous mortality *Z* and total annual mortality *A* of Ashland walleye using a weighted catch-curve regression as described by Ogle (2016, 2017) after pooling sample years to dampen the influence of semi-variable recruitment. Analysis of the three most recent survey years pooled (2018, 2019 and 2022) returned a total annual mortality estimate of 28.7%. This is on the low end of North American walleye populations (Bozek et al. 2011) and well below the level recommended by the Great Lakes Fishery Commission and others to maintain a sustainable, recovering fishery (45%; Hoff, 2002; Olson et al., 2018). However, mean annual mortality differed significantly between males and females across these three years (ANCOVA, $p = 0.02$), with males exhibiting higher mean mortality (42.3% for males vs 26.0% for females; Figure 8).

For all survey years combined (1994, 2006, 2011, 2018, 2019 and 2022), the population mean *A* was 20% (95% CI: 16.6 – 23.2%) and *Z* was 0.22 (95% CI: 0.18 – 0.26). There was no difference between male and female mortality (20.3% for males vs 26.4% for females). Comparing these estimates to the mortality rates from 2018 – 2022 suggests the Ashland walleye stock is experiencing slightly higher total mortality than the historical average.

Tag Retention

First-year Floy tag retention among Ashland walleye was 79% (288/365 fish retained tags), comparable to the rate observed in Lake Winnebago walleye (78.1%; Koenigs et al., 2013). Over an extended period (3–4 years), mean tag retention decreased to 53% (393/735 fish retained tags). Similar declines in tag retention over time were documented by Colborne et al. (2024) in Great Lakes walleye, where T-bar tag retention decreased from 63–73% at one year to less than 26% at four years. These rates indicate that anchor tags are an effective identifier for individual walleye for one to two years. However, the decrease in retention beyond three years suggests alternative tagging methods, such as jaw tags or loop tags, would be beneficial for long-term monitoring efforts.

DISCUSSION

Based on age compositions, we did not observe evidence of natural reproduction from walleye spawning along the Ashland shoreline, and the cohorts present in the Ashland spawning stock were closely associated with DNR stocking inputs. In addition, a subsample of 50 Ashland spawning walleye surveyed in 2019 were genetically tested and confirmed to be of the same origin as the DNR-stocked strain (Cristan 2025). Sex ratios of spawning aggregations of walleye and other fishes are most often skewed toward males, so the high female to male ratio in recent surveys likely indicates recently stocked cohorts were dominated by females, which was similarly observed in Minocqua chain of lakes (Sass et al. 2022). Cristan (2025) also genetically differentiated walleye from the three local Lake Superior origins including DNR stocking, the Kakagon/Bad River system and the St. Louis River. This project further used the genetic data to identify the origins of walleye captured during the non-spawning seasons across Wisconsin waters of Lake Superior. A few findings from this project are relevant to this work (Cristan 2025):

- During the summer and fall, DNR-stocked fish composed the majority of walleye sampled in the Ashland region of Chequamegon Bay, about half of walleye sampled in the Washburn region of Chequamegon Bay (Bono Creek to Houghton Point), and very few of the walleye sampled in the eastern region of Chequamegon Bay (near Oak Point).
- Few DNR-stocked walleye were detected outside Chequamegon Bay, and very few St. Louis River walleye were detected inside Chequamegon Bay.
- Some DNR-stocked walleye genetics were detected in the Kakagon River spawning stock.

Overall, these results highlight the importance of the DNR stocking program for supporting the recreational fishery in Chequamegon Bay, which provides accessible opportunities for shore-based and small-craft anglers in Ashland and Washburn as well as ice anglers. As future ice conditions in Lake Superior become more variable, maintaining this opportunity in the areas with most consistent ice conditions will remain important for local anglers. In addition, the DNR stocking program in Chequamegon Bay is unlikely to affect management goals of the St. Louis River stock due to limited straying of stocked walleye from the bay. Lastly, following the DNR genetics guidelines for stocking (Simonson et al. 2022) and using appropriate sources of within-basin walleye, or preferably within-lake walleye, will remain critical for preserving the genetic integrity of local stocks of naturally reproducing walleye in the region (Cristan 2025).

Though we observed temporal changes in size and age structure of Ashland walleye in recent survey years, this appeared to be primarily driven by differences in stocking strategies. The most notable change from the 2006-2011 period to the recent 2018-2022 period was a shift from a larger, older spawning stock to a smaller, younger spawning stock. The absence of fish older than 14 years in the 2022 survey, combined with the higher proportion of younger fish, suggests increased turnover in the population, more successful recent recruitment and, assumedly, an increase in abundance, owing to a consistent, moderate level of stocking. Likewise, the shift toward younger age classes we observed between 2011 and 2022 also reflects slightly increased harvest pressure and exploitation.

Total annual mortality estimated from recent survey years (2018, 2019 and 2022) reached 28%, which is below the threshold recommended for a sustainable walleye fishery (Hoff 2002) but likely slightly higher than previous decades. Male walleye experienced higher total mortality than females, likely owing to a few reasons including the longer time males remain vulnerable to harvest before reaching the one-over-20-inch size regulation, angler preferences toward harvesting smaller walleye (Varian et al. 2016), and a smaller number of males being stocked into the system recently relative to females. Therefore, if future sex ratios of the Ashland walleye stock return closer to 50/50, total mortality rates may change as a result. Overall, current harvest levels appear maintainable when paired with stocking, but continued monitoring of both sex-specific harvest rates and stocking efforts is necessary to ensure that mortality and exploitation do not reach unsustainable levels.

Growth analyses revealed sex-specific patterns expected with walleye, with larger, faster-growing females and smaller, slower-growing males. Overall, growth and size of Ashland walleye were comparable to those of other walleye stocks in Lake Superior, such as Black Bay and the St. Louis River (Olson et al. 2018). The observed variation in growth parameters among survey years likely reflects differences in prey availability, environmental conditions, and the age composition of sampled fish. The relatively stable asymptotic lengths we modeled suggest that conditions in Chequamegon Bay remain favorable for walleye growth; however, these lengths are based on measurements of captured fish and may be biased by gear selectivity and sample size.

The data collected through this long-term monitoring effort offers valuable insights into key demographics of the Ashland walleye population and the efficacy of the Chequamegon Bay DNR walleye stocking program. Continued surveys, recommended every 4-5 years, will be necessary for tracking future changes in population dynamics and evaluating the effectiveness of ongoing management strategies to continue to provide a sustainable fishery.

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Tables

Table 1. Summary of catches from spring fyke net surveys of spawning walleye along the Ashland shoreline of Lake Superior. Surveys were conducted from 1994 to 2022 but did not occur every year.

Year	Female	Male	Unknown	Total
1994	553	1,275	16	**1,844**
2006	1,134	874	61	**2,069**
2011	215	326	64	**605**
2018	574	238	35	**847**
2019	3,132	401	21	**3,554**
2022	1,559	1,010	64	**2,633**
Total	**7,167**	**4,124**	**261**	**11,552**

Table 2. Estimated L-infinity (L∞), Brody growth coefficient (K) and their associated 95% confidence intervals for Ashland walleye, derived from von Bertalanffy growth curves. The 1994 model for female walleye failed to converge.

Year	Sex	L∞	L∞ 95% CI (LWR, UPR)	K	K 95% CI (LWR, UPR)
1994	M	21.37	(21.08, 21.66)	0.31	(0.28, 0.34)
	F	--	--	--	--
2006	M	22.48	(21.83, 23.50)	0.14	(0.10, 0.19)
	F	27.45	(26.71, 28.38)	0.13	(0.10, 0.16)
2011	M	23.22	(22.90, 23.60)	0.26	(0.21, 0.33)
	F	27.12	(26.52, 27.84)	0.18	(0.14, 0.22)
2018	M	24.92	(23.90, 26.25)	0.15	(0.12, 0.19)
	F	28.87	(25.98, 33.83)	0.10	(0.06, 0.15)
2019	M	24.77	(23.82, 25.78)	0.14	(0.12, 0.16)
	F	25.66	(24.25, 25.11)	0.22	(0.19, 0.25)
2022	M	23.48	(22.95, 24.12)	0.22	(0.19, 0.25)
	F	32.17	(27.28, 47.71)	0.12	(0.04, 0.19)

Figures

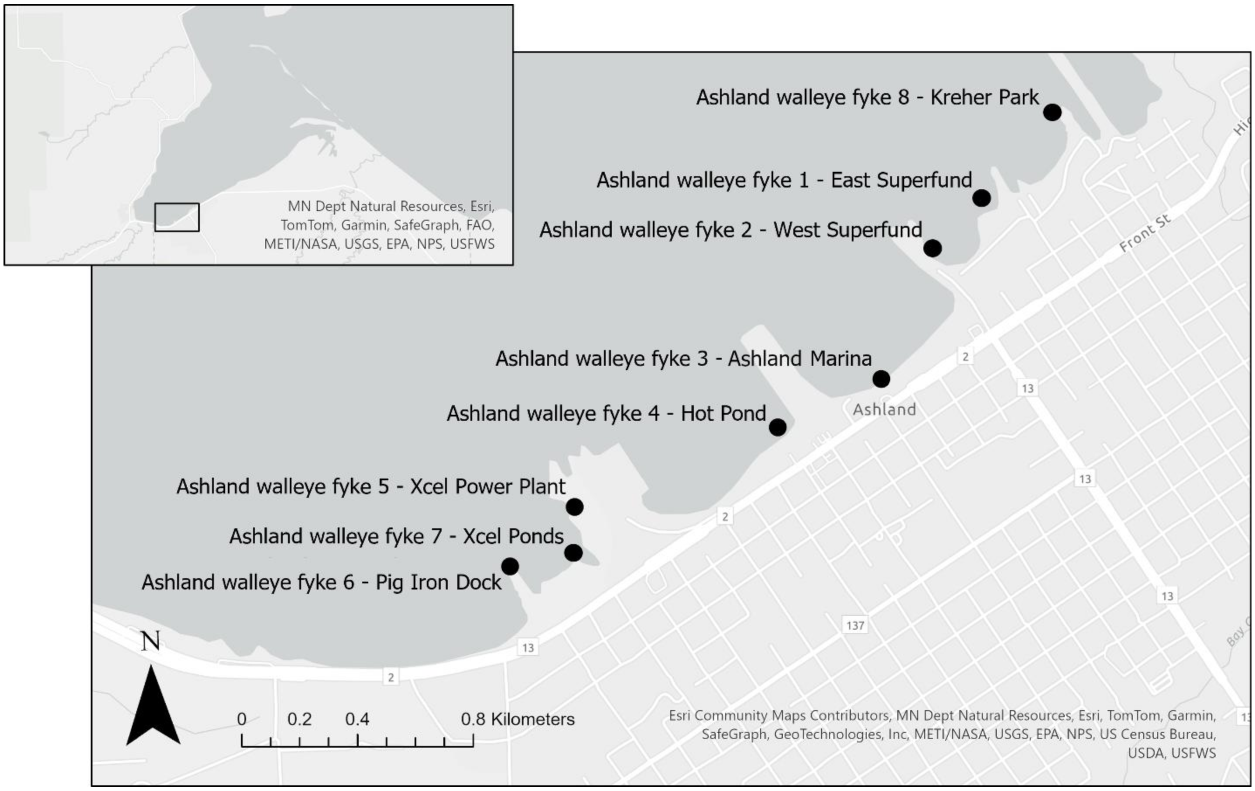

Figure 1. Location of fyke nets used for walleye sampling in Chequamegon Bay, Lake Superior, Wisconsin from 1994 to 2022. Most fish were captured at fyke 5 (37.3%; n = 4308), followed by fyke 3 (20.1%; n = 2325), fyke 4 (18.0%; n = 2083), fyke 6 (16.8%; n = 1946), fyke 2 (3.9%, n = 449), fyke 1 (3.1%, n = 361), fyke 7 (0.5%, n = 63), and fyke 8 (0.1%, n = 17).

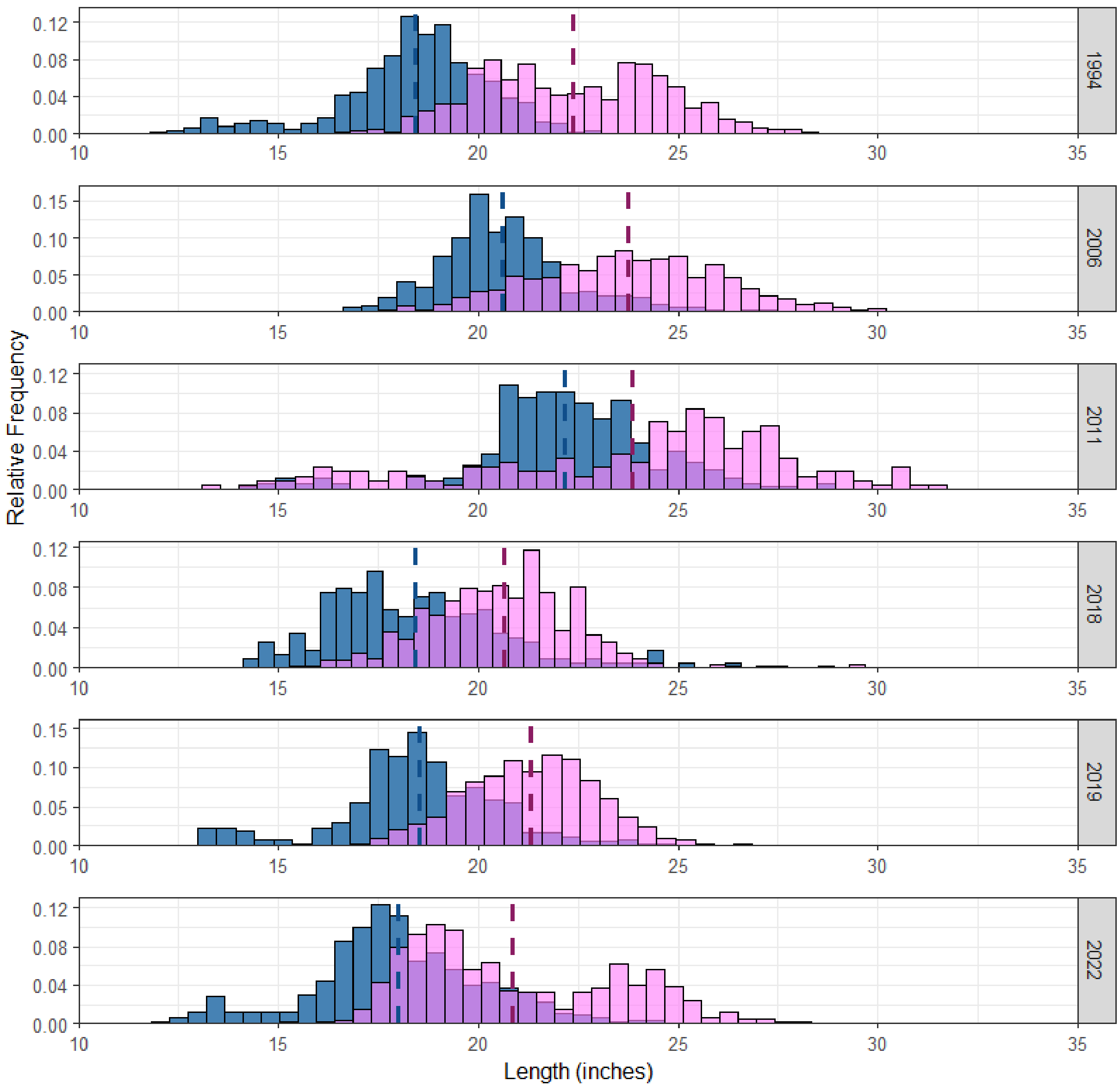

Figure 2. Male (blue) and female (pink) Ashland walleye length distributions for each survey year. The y-axis shows the relative frequency of each length bin (0.5-inch) in the total catch by sex. Vertical dashed lines indicate mean length for males (blue) and females (red) in each survey year.

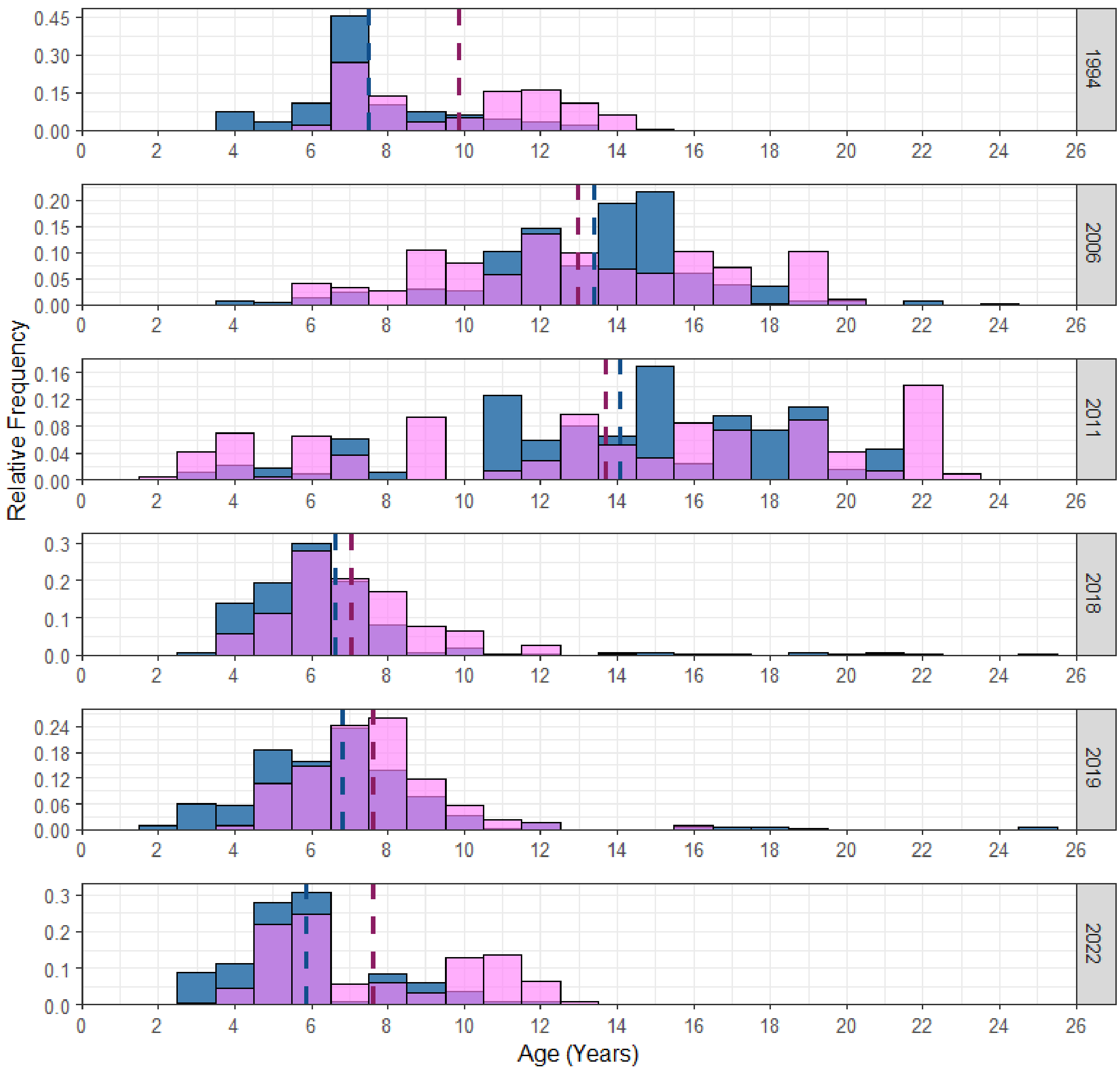

Figure 3. Age distributions of male (blue) and female (pink) walleye from Chequamegon Bay for each survey year. Ages were assigned to unaged individuals with sex- and year-specific age-length keys. The y-axis shows the relative frequency of each age class of the total catch by sex. Vertical dashed lines indicate mean age for males (blue) and females (red) in each survey year.

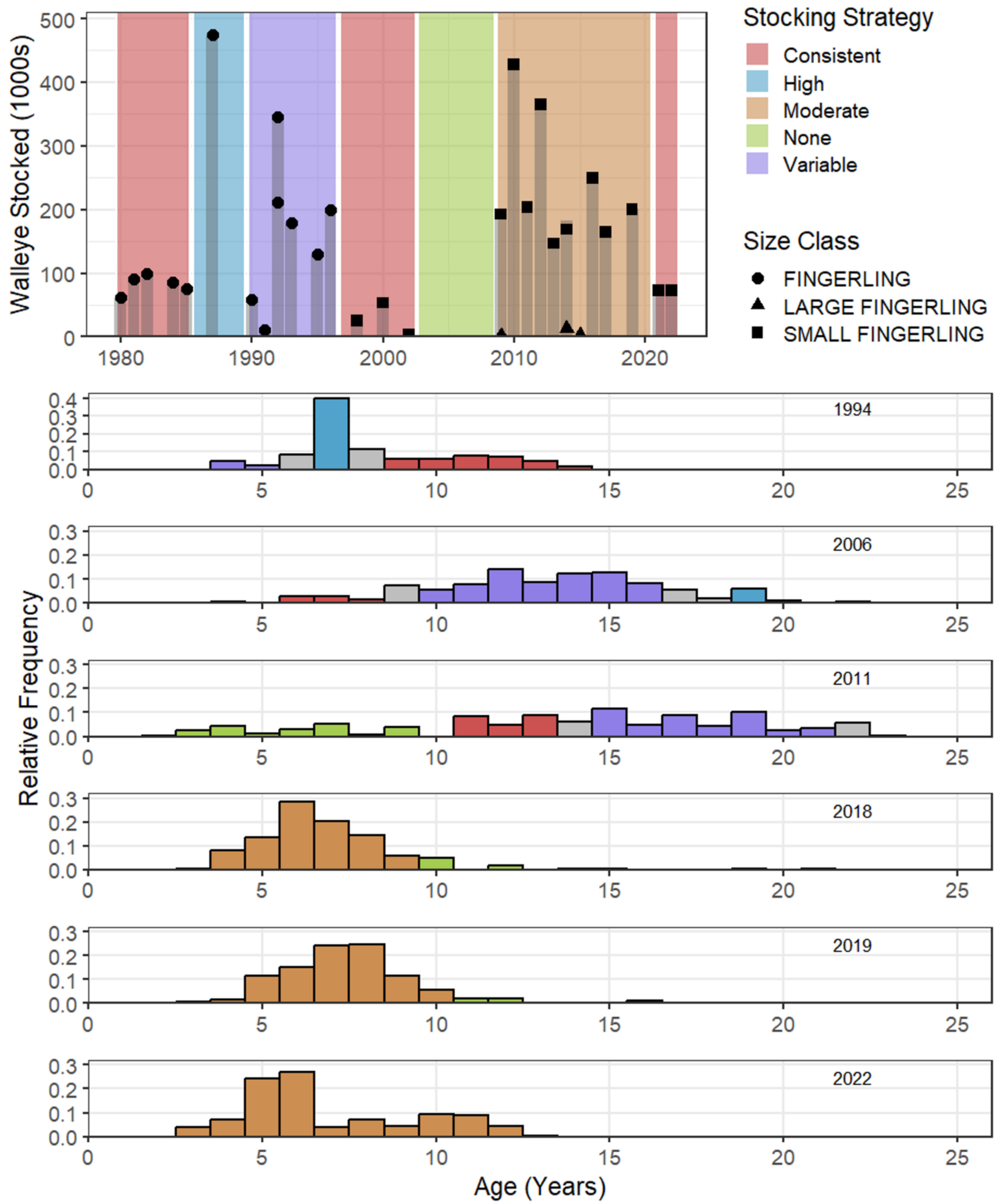

Figure 4. Top panel: DNR walleye stocking history from 1980 to 2022. Point shapes indicate size class at stocking and colors correspond to stocking strategy categories. **Bottom panel:** Age-frequency distribution of walleye captured in annual surveys. Bar colors match the stocking strategy colors in the top panel, indicating the stocking cohorts represented by each age class.

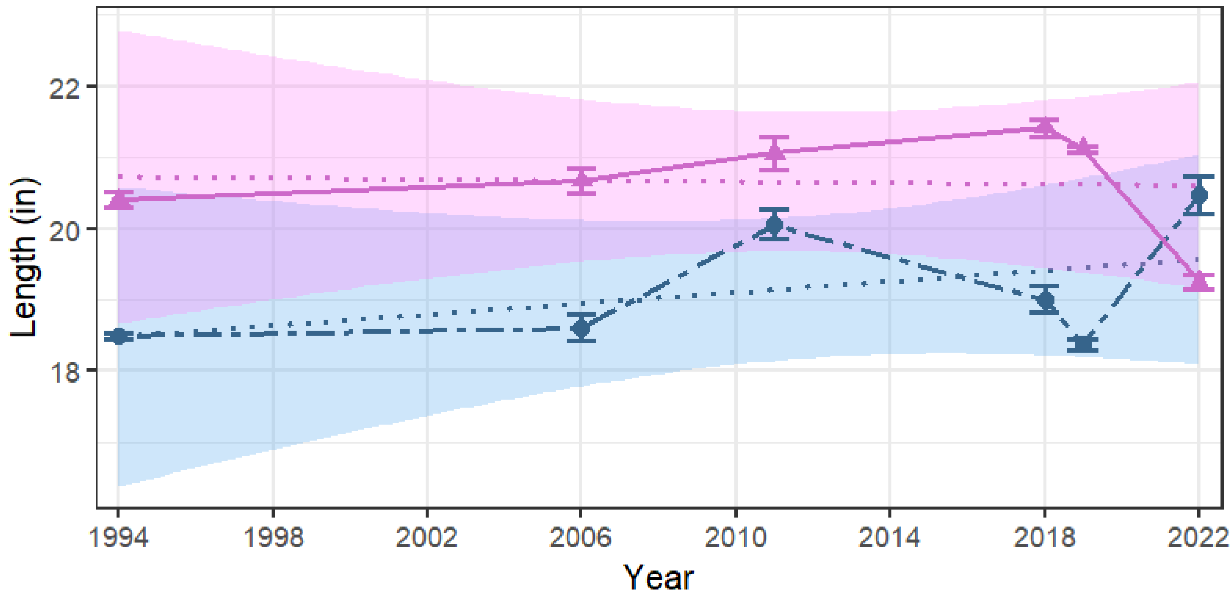

Figure 5. Mean length at age 7 for male (blue) and female (pink) Ashland walleye with standard error measurements. Dashed lines represent the linear trend in length over time with shaded 95% confidence bands. Walleye are fully recruited to the sampling gear at this age. Length-at-age was calculated for all individual fish after applying age-length keys.

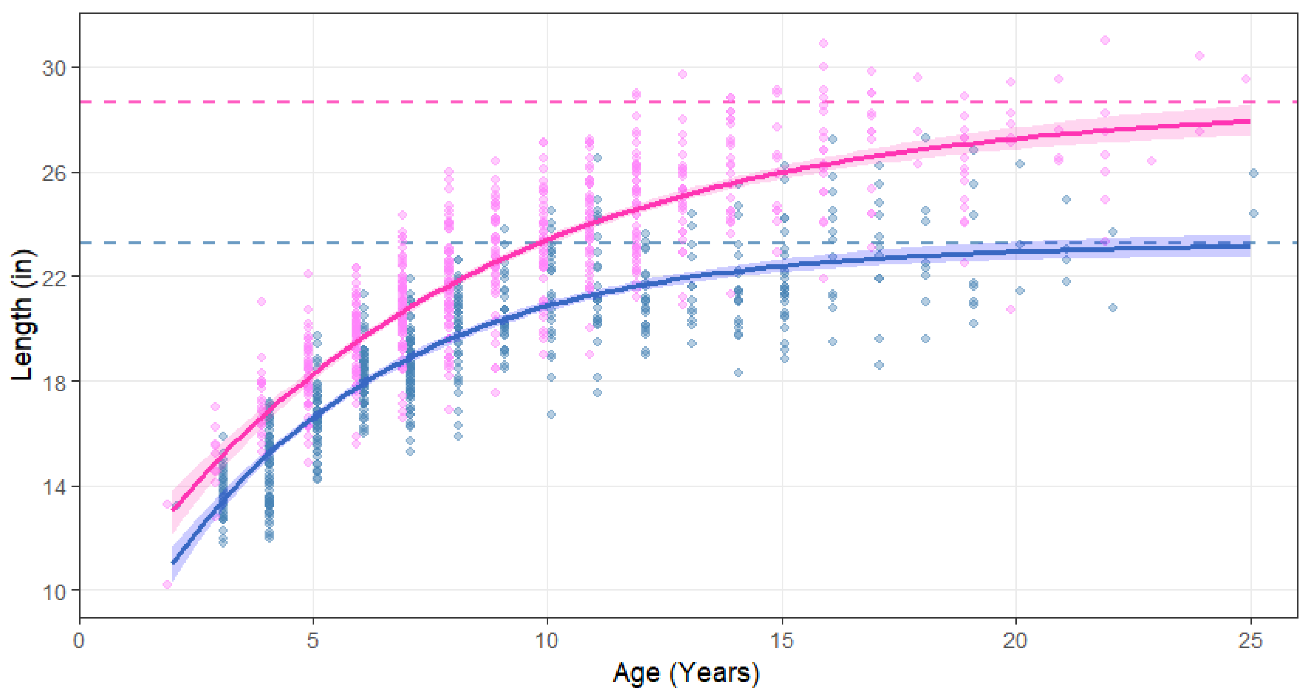

Figure 6. Von Bertalanffy growth curves for male (blue) and female (pink) walleye from 2018, 2019 and 2022 with associated 95% confidence intervals. Dashed horizontal lines indicate the modeled L∞ of each sex, which represents the average maximum length for the population.

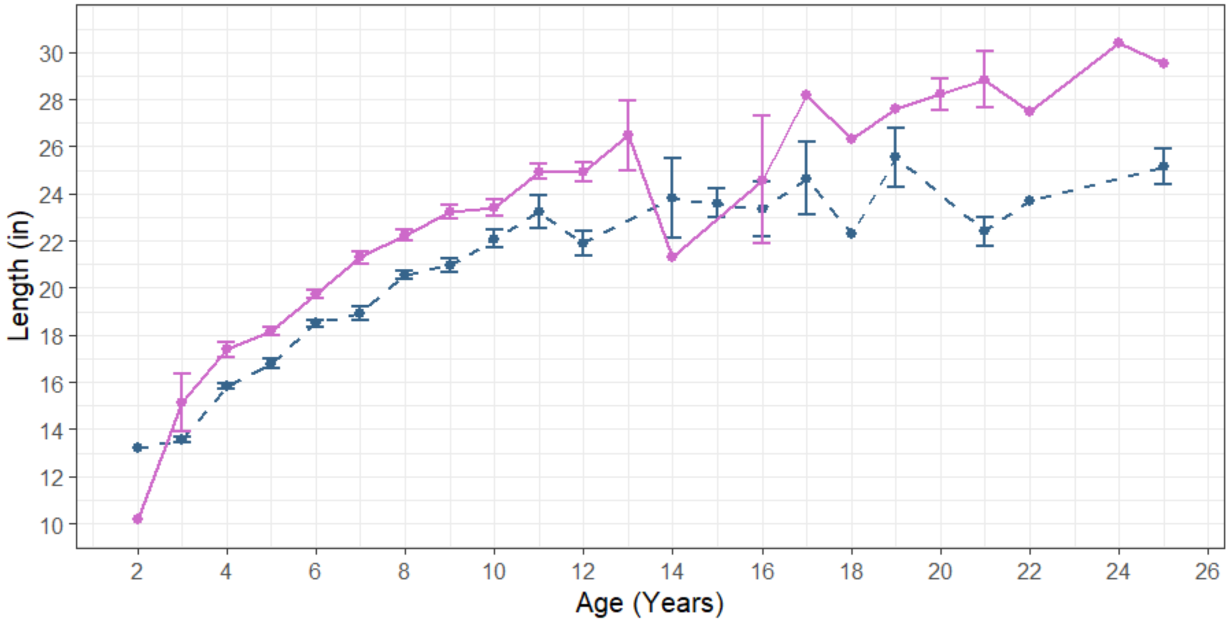

Figure 7. Mean length-at-age and standard error measurements of captured male (blue, dashed) and female (pink, solid) Ashland walleye from 2018, 2019 and 2022.

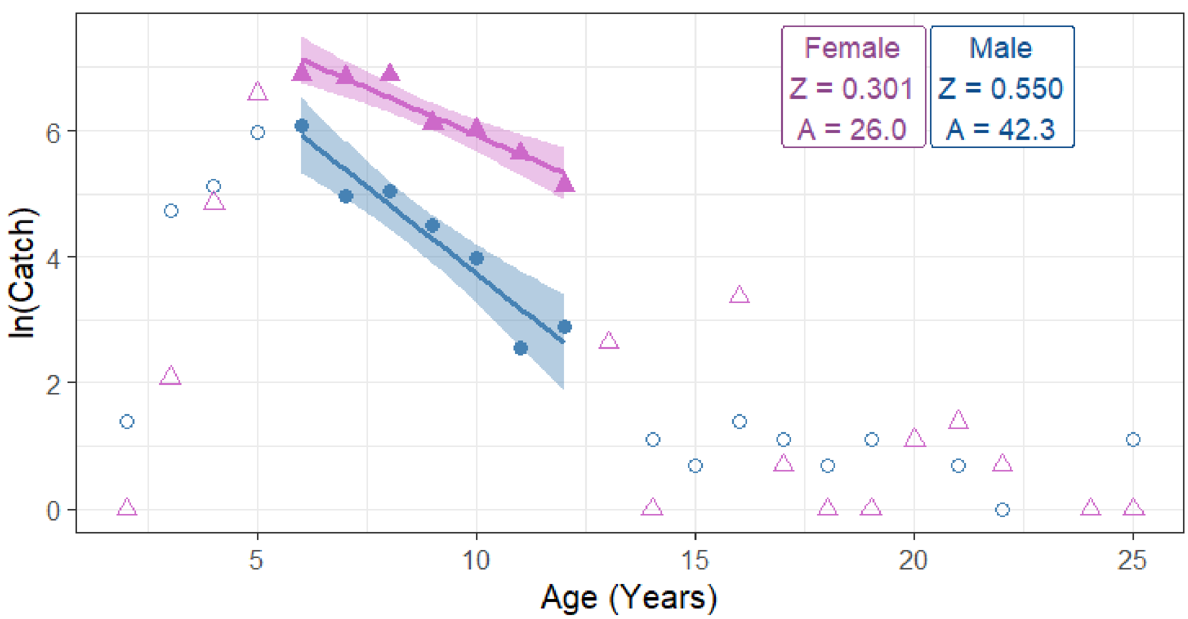

Figure 8. Weighted regression of the catch curve used to estimate total annual mortality *(A)* and instantaneous mortality *(Z)* of male (blue) and female (pink) Ashland walleye across the three most recent sampling years (2018, 2019, 2022). The descending limb represents fully recruited age classes with assumed constant catchability. Points were weighted by sample size to account for varying precision in age-class abundance.

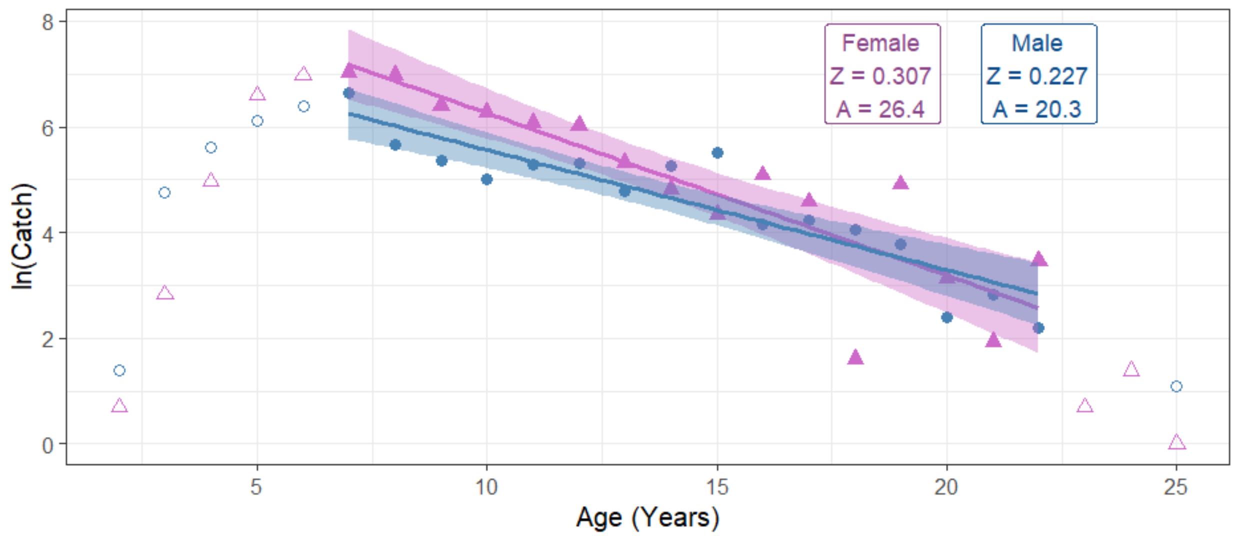

Figure 9. Weighted regression of the catch curve to estimate total annual mortality *(A)* and instantaneous mortality *(Z)* of male (blue) and female (pink) Ashland walleye across all sampling years (1994, 2006, 2011, 2018, 2019 and 2022). The descending limb represents fully recruited age classes with assumed constant catchability. Points were weighted by sample size to account for varying precision in age-class abundance.