ASSESSMENT OF THE WALLEYE FISHERY AT BROOKVILLE RESERVOIR WITH SIMULATED EFFECTS OF VARIOUS MINIMUM LENGTH LIMITS

Union and Franklin Counties

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Aaron J. Cole

Assistant Fisheries Biologist

INDIANA DIVISION OF
FISH&WILDLIFE

Fisheries Section
Indiana Department of Natural Resources
Division of Fish and Wildlife
I.G.C. South, Room W273
402 W. Washington Street
Indianapolis, Indiana 46204

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EXECUTIVE SUMMARY

- Brookville Reservoir is a 5,260-acre impoundment on the East Fork of the Whitewater River in Franklin and Union counties in eastern Indiana.

- Insight was needed to manage the Brookville Reservoir walleye fishery due to its importance to the State of Indiana as a brood source lake and sport fishery.

- Population modeling was conducted to simulate the effects of 14-in, 16-in, and 18-in minimum length limits (MLLs) and determine if the current 14-in MLL is adequately preventing growth overfishing and recruitment overfishing.

- Modest growth overfishing was evident with the current 14-in MLL when exploitation exceeded 35% at low conditional mortality (*cm*). Yield was slightly higher with the 16-in and 18-in MLLs when exploitation exceeded 25% at low *cm*. At high *cm*, differences in yield were indistinguishable amongst the three MLLs.

- Mean length of harvested fish was lowest with the 14-in MLL under low and high *cm*, and increased with more restrictive MLLs.

- Slight improvements in yield and mean length of walleye harvested with the 16-in and 18-in MLLs would be overshadowed by the concurrent reduction in number of fish harvested compared to the 14-in MLL.

- Recruitment overfishing occurred with all three MLLs at low *cm*, and occurred with the 14-in and 16-in MLLs at high *cm*. However, these results should be considered conservative estimates because the size bias associated with the gill nets likely underestimated these results.

- The size structure of walleye collected with gill nets was significantly different than fish harvested by recreational anglers in the 2009 creel survey (KSa = 17.10, P = <0.0001). It is assumed the size structure from angler-harvested walleye was a closer representation of the true Brookville walleye size structure.

- The Brookville walleye fishery should continue to be regulated with the 14-in MLL and six fish daily bag limit. They appear to be effectively maintaining the Brookville walleye fishery while providing high angler harvest (in terms of both number and yield), yet maintaining a good size structure.

- Experimental gill nets should be set throughout the entire lake to get a better representation of the size and age structures in future walleye evaluations aimed at population modeling.

- An exploitation study should be considered if another comprehensive evaluation of the Brookville walleye fishery is conducted.

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INTRODUCTION

Walleye (*Sander vitreus*) fisheries are a highly regarded recreational resource throughout the State of Indiana. As such, the Indiana Division of Fish and Wildlife (DFW) has created numerous angling opportunities for walleye across the state through their intensive walleye stocking and management programs. The Indiana walleye stocking program is also very popular among anglers; in a recent survey, licensed Indiana anglers indicated they preferred the DFW to stock walleye over any other species (Broussard and Haley 2005). Stocking plays a vital role with walleye recruitment in Indiana, since most walleye fisheries throughout the state are incapable of natural reproduction and are maintained solely through stocking. Each year the DFW stocks approximately 22 million walleye into Indiana public water bodies (R. Lang, Indiana Hatcheries Supervisor, personal communication). The majority of those fish are stocked as fry; however, approximately one million fingerlings and 45,000 advanced fingerlings are stocked each year. All walleye fry and fingerlings stocked by the DFW originate from Brookville Reservoir, which serves as Indiana's only walleye brood source lake. Walleye are collected and spawned from Brookville Reservoir by DFW personnel every year from late March to early April. From 2000 to 2011 the annual Brookville walleye egg take yielded an average of 34.4 million eggs (SE = 1.3 million). The Brookville Reservoir walleye population is not only a very important component to the Indiana walleye stocking program, but is also an extremely valuable recreational fishery that attracts many resident and nonresident anglers. The estimated economic value of the entire Brookville sport fishery from April 10, 2000 to October 31, 2000 was $2.4 million, as reported by Sapp and Ball (2001). Walleye are very popular among Brookville anglers also, as they are the third most sought after fish in Brookville, only behind crappie and black bass (Ball 1993; Sapp and Ball 2001; 2009 Brookville Reservoir creel survey – *unpublished data*).

With the popularity of the Brookville walleye fishery among anglers and its importance to the State of Indiana as the primary source of walleye egg production, insight was needed to manage this valuable resource. Therefore, the objectives of this study were to 1) assess the walleye population in Brookville Reservoir in terms of its age structure, size structure, growth rates, and mortality rates; 2) perform population modeling to simulate the effects of various minimum length limits (MLLs) and determine if the current 14-in MLL is adequately preventing

growth overfishing and recruitment overfishing; and 3) investigate any possible changes in regulations or management that could improve the current status or overall yield of the fishery.

METHODS

Study Area

Brookville Reservoir is a 5,260-acre impoundment on the East Fork of the Whitewater River in Franklin and Union counties in eastern Indiana (Figure 1). The dam was built in 1974 and is operated by the U.S. Army Corps of Engineers for the purpose of flood control. The average depth of the reservoir is approximately 30 ft at summer pool (U.S. Army Corps of Engineers 1980) and has an annual regulated water level fluctuation of 8 ft between summer and winter pools. Brookville Reservoir supports a diverse fish community, but the most recent fish community survey was largely comprised of channel catfish, bluegill, and gizzard shad (Smyth 2008). The DFW has stocked walleye into Brookville Reservoir since 1974 to create a recreational fishery and to utilize the abundant gizzard shad forage base.

Due to its importance as a walleye brood source, the DFW annually stocks 10.5 million walleye fry (2,000/acre) into Brookville to maintain a suitable brood fish population and to provide a sport fishery. Since 1996, the Brookville walleye fishery has been managed with a 14-in MLL and a six fish daily bag limit. Prior to that there was a six fish daily limit with no minimum length limit regulation.

Field and Laboratory

Walleye were collected from March 27, 2009 to April 8, 2009 with standard 6 x 200 ft, 2.25-in (bar measure) mesh size gill nets during annual broodstock collection. Gill nets (n = 128 total) were set parallel to shore along the face of the dam and also along the western shoreline. Nets (n = 8) were set each night at dusk, checked at 2400 h, and then pulled at 0800 h. Short duration net sets were used to keep any adult fish alive so they could be utilized as hatchery broodfish. Fish used as hatchery broodfish were brought to the Mounds Egg Taking Station (METS). All walleye brought to the METS were measured to the nearest 0.1 in TL and sexed. Five fish of each sex were subsampled per 0.5 in length group, weighed to the nearest ounce, and sacrificed for otolith removal. Any fish not used at the METS for spawning (e.g., spent females, extra males) were sexed and subsequently released in the field. Lengths of the sexed, but

unmeasured fish were assigned lengths based on the length frequency distribution of the male and female fish that were measured. Sagital otoliths (n = 249) were aged by being submerged in glycerin, and viewed against a black background with reflected light under a stereo microscope (Donabauer 2010). Digital images of the otoliths were taken with a trinocular-mounted camera and digital imaging software (SigmaScan Pro 5.0, Richmond, California). The images were uploaded into Microsoft PowerPoint® (Microsoft Corporation, Redmond, Washington) and three readers independently aged each otolith, and then collectively formed a consensus age.

Population Modeling

Population modeling was performed using the Beverton-Holt yield-per-recruit modeling option in Fishery Analysis and Modeling Simulator (FAMS) software (Slipke and Maceina 2010). A studentized residual plot was used to identify any outliers regarding length and weight. Any observation in the $\log_{10}$ length–$\log_{10}$ weight regression with a studentized residual greater than +3 or less than –3 was considered a recording error and discarded from analyses (n = 2). Age structure for both sexes was then determined using age-length keys with 0.5 in bins. The von Bertalanffy (1938) growth model was determined using mean length at age data from both sexes pooled. Due to the lack of age-0 and age-1 fish, an illogical t_0 was derived when the von Bertalanffy model was fitted only to those ages sampled in gill nets. Consequently, unsexed age-1 walleye collected by electrofishing during the same week for a concurrent study by Donabauer (2010) were included in the von Bertalanffy growth model used for modeling. Also, an insufficient number of larger and perhaps older fish were collected to accurately estimate length infinity (L_{inf}) or maximum age. Therefore, L_{inf} was held constant at 30 in, because walleye have been captured up to this size from Brookville Reservoir and the maximum age was set at 11.9 years, which was the theoretical maximum age from the catch curve regression. To further describe growth, the time (years) required to reach 14 in, 16 in, and 18 in TL were estimated with the von Bertalanffy growth model.

Instantaneous mortality (Z) and survival ($S = e^{-Z}$) were estimated using a catch curve regression fitted to those ages fully recruited to the gear (i.e., age 4 and older). Instantaneous natural mortality rates (M) were estimated in FAMS using the methods of Hoenig (1983), Jensen (1996), Peterson and Wroblewski (1984), and Quinn and Deriso (1999; Table 1). Conditional natural mortality rates (*cm*; i.e., the mortality that would occur in the absence of fishing

mortality) were computed with the equation $1-e^{-M}$. Overall means of M and *cm* were calculated from these four methods. A buffer of 0.05 was applied to the mean *cm* to get two levels of *cm* used for modeling.

Modeling simulations were performed at each level of *cm* under three MLLs: 14-in TL, which is the current regulation, 16-in TL, and 18-in TL (Table 2). All modeling was conducted with an initial population of 100 recruits. Yield, number of fish harvested, and mean TL of harvested fish were simulated with exploitation rates ranging from 0% to 60%. The likelihood of growth overfishing was evaluated by plotting yield over the range of exploitation rates. Growth overfishing occurs when yield decreases with progressively higher levels of exploitation, because fish are harvested before they reach their full growth potential (Slipke and Maceina 2010).

Although the Brookville walleye fishery is a stocked population, all walleye stocked into Brookville are of Brookville progeny; therefore, the possibility of recruitment overfishing was also examined. Recruitment overfishing is considered more serious than growth overfishing, and occurs when fish are harvested at a rate greater than they are replacing themselves, thus leading to a decline in the population. Recruitment overfishing would not only cause a decrease in the Brookville walleye population, but would also affect the efficiency of annual walleye broodstock collection and perhaps statewide walleye stocking. Recruitment overfishing was examined by assessing the reproductive potential of the Brookville walleye population with the spawning potential ratio (SPR; Goodyear 1993). The SPR is the ratio of the lifetime egg production of an average recruit in an exploited population compared to that of an unexploited population. An unexploited population will have an SPR of 100%, and will decrease as exploitation increases. Recruitment overfishing was considered to have occurred if the SPR was less than 20% (Goodyear 1993). The SPR modeling was simulated under the three MLLs with the same range of exploitation and levels of *cm* as all other yield modeling simulations. Fecundity data for SPR modeling were not available for the Brookville walleye population, so the length-fecundity relationship for walleye developed by Carlander (1997): $\log_{10}(\text{fecundity}) = -5.293 + 3.829 \log_{10}(\text{length})$, was used for this analysis. A 1:1 sex ratio was used for the SPR simulation, and all females were assumed to be fully matured at age 3, and spawn every year.

A creel survey was conducted on Brookville Reservoir from April to October 2009. The survey was conducted using a non-uniform probability design in which two creel clerks worked simultaneously each day at different locations. Seasonal trends in walleye harvest were

described by determining the relative and cumulative percentage of walleye harvest each month during the creel survey. All walleye measured by creel clerks were used to formulate a length frequency histogram to estimate the size structure of harvested walleye. A Kolmogorov-Smirnov two-sample test was conducted using the NPAR1WAY procedure in the Statistical Analysis System version 9.2 (SAS Institute, Cary, North Carolina) to test for differences in the size distributions between walleye harvested in the creel survey to those collected with gill nets (Neumann and Allen 2007).

RESULTS

Population Characteristics

During the 2009 walleye spawning operation, 1,512 walleye were collected, 811 of which were female and 701 male (Figure 2). Of the female walleye, 590 were measured and 134 of those were also aged; the remaining 677 were assigned ages with 221 of those also assigned a length based on length frequency of measured females. For male walleye, 346 were measured and 96 of those were also aged; the remaining 605 were assigned ages with 355 of those also assigned a length based on length frequency of measured males.

Ages ranged from 3 to 8 for female walleye and 2 to 8 for male walleye (Figures 3 & 4). However, 95% of female fish and 80% of male fish were less than age 6 (Tables 3 & 4). Male walleye appeared to be fully recruited to the gear at age 3, whereas female walleye were not recruited until age 4. Survival of male walleye estimated from the catch curve regression was 56.8% ($Z = -0.57$, $r^2 = 0.91$; Figure 3). In contrast, annual survival of female walleye was slightly less, as S was 38.5% ($Z = -0.95$, $r^2 = 0.95$; Figure 4). The catch curve regression used for modeling, fitted to age-4 to age-8 fish (sexes pooled), estimated S at 44.3% ($Z= -0.81$, $r^2= 0.99$; Figure 5). Conditional mortality estimates ranged from 0.20 to 0.32 and had a mean of 0.27 (Table 1). A buffer of 0.05 was applied to the mean to get the two levels of *cm* used for modeling (i.e., 0.22 & 0.32; Table 2).

Mean length at age for females was greater than that of male fish across all ages collected (Figure 6). It took approximately 1.8 years for the average Brookville walleye to reach legal size under a 14-in MLL regulation, 2.5 years with a 16-in MLL, and 3.3 years with an 18-in MLL (Figure 7).

Population Modeling

Yield per 100 recruits did not differ among MLLs at the low level of *cm* (i.e., 0.22) when exploitation ranged from 0% to 20% (Figure 8). However, modest growth overfishing was evident with the current 14-in MLL when exploitation exceeded 35% at the low level of *cm*. At exploitation rates between 25% and 60% the 16-in MLL increased yields by 5% to 15% over the current 14-in MLL. Similarly, yields increased 7% to 26% with the 18-in MLL compared to the 14-in MLL when exploitation ranged from 25% to 60%. The number of fish harvested decreased ~16% over the entire range of exploitation with the 16-in MLL and ~32% with the 18-in MLL from the number harvested with the current 14-in MLL (Figure 9). As expected, mean length of harvested fish was lowest with the 14-in MLL under both levels of *cm* (Figure 10). Mean length increased 4% to 10% with the 16-in MLL, and 8% to 20% with the 18-in MLL over the entire range of exploitation. Recruitment overfishing (i.e., SPR < 20%) was simulated under the current 14-in MLL regulation when exploitation exceeded 30% (Figure 11). The 16-in MLL delayed recruitment overfishing only until exploitation exceeded 35%, whereas the 18-in MLL prevented recruitment overfishing to exploitation rates as high as 54%.

Only subtle differences in yields were apparent when *cm* was modeled at 0.32 (Figure 8). Yield was greatest with the 14-in MLL when exploitation was less than 30%, and was greatest with the 16-in MLL when exploitation ranged from 30% to 60%. Differences in yield with the 16-in MLL were within 8% or less from the predicted yield with the current 14-in MLL over the entire range of exploitation. Similarly, when exploitation ranged from 25% to 60%, differences in yields with the 18-in MLL were within 8% of the 14-in MLL; however, when exploitation was less than 20%, yield was 10% to 19% less with the 18-in MLL. The number of fish harvested was greatest with the 14-in MLL over the entire range of exploitation; the number harvested was reduced ~23% with the 16-in MLL and ~44% with the 18-in MLL (Figure 9). Mean length of harvested fish was lowest with the 14-in MLL, but was 5% to 11% higher with the 16-in MLL and 11% to 21% higher with the 18-in MLL over the current 14-in MLL (Figure 10). Recruitment overfishing was also evident at the high level of *cm* with the 14-in MLL when exploitation exceeded 33% (Figure 11). Recruitment overfishing was less likely with the 16-in MLL and did not occur until exploitation levels exceeded 44%. The 18-in MLL prevented recruitment overfishing over the entire range of exploitation rates.

With all of the MLLs modeled, only a small percentage of the fish collected with gill nets would have been protected under any of the proposed regulations. The current, 14-in MLL only prevented the harvest of 0.1% (n = 2) of the walleye sampled. The 16-in MLL would protect 0.7% (n = 10) of the walleye sampled. The most restrictive, 18-in MLL, would have prevented the harvest of only 7.3% (n = 111) of the walleye collected.

During the 2009 Brookville Reservoir creel survey, 579 walleye were observed to be harvested by anglers (Figure 12). The majority (63%) of the walleye harvest during the creel period occurred during the month of May (Figure 13). Based on the length frequency distribution of walleye harvested by anglers in 2009, the three simulated MLLs would have provided considerably more protection to (i.e., reduced the harvest of) Brookville walleyes. Hence, the 16-in MLL would have caused a 69.3% reduction in the number of walleye harvested during the 2009 creel survey, and the 18-in MLL would have reduced harvest by 87.6%.

The length frequency distribution of walleye harvested by anglers was significantly different than fish collected with gill nets (KSa = 17.10, P = <0.0001; Figure 14). The length frequency histogram of gill net catch data resembled a normal distribution with a mean length of 20.4 in (SE = 0.05) and a median of 20 in; whereas the length frequency distribution for angled walleye was positively skewed. In general, fish collected with gill nets were larger than those harvested by anglers. The greatest difference between the size structure of fish collected with gill nets and those caught by anglers occurred between the range of 14 and 20 in TL; specifically, anglers caught fish within that size range, whereas the gill nets did not effectively sample that size range.

DISCUSSION

Based on the population modeling from this study, the Brookville Reservoir walleye population experienced slight growth-overfishing only when exploitation exceeded 35% at the low level of *cm*. Replacing the current 14-in regulation with a 16-in or 18-in MLL would improve yield, albeit minimally, only at low levels of *cm* when exploitation exceeds 20%, but would have negligible effects on yield at high levels of *cm*. Both of the more restrictive length limits modeled in this study would also increase the mean length of walleye harvested. However, these slight improvements in both yield and mean length of walleye would likely be overshadowed by the concurrent reduction in number of fish harvested. Therefore, the subtle

differences in yield simulated with the three MLLs would not justify a regulation change, especially when considering the possible reduction in number of fish harvested.

Furthermore, more restrictive MLLs would provide little protection (in terms of time) to Brookville walleyes because of their relatively fast growth. For instance, Brookville walleyes would only be protected an additional 1.5 years (on average) with the 18-in MLL than versus the current 14-in MLL, and less than one year (0.7 year) extra with the 16-in MLL (Figure 7). Raising the length limit to either the 16-in or 18-in MLL would also allow natural mortality that much longer to act on the remaining individuals before they are available to harvest, which would ultimately reduce the number of harvestable-size walleye available to anglers. Due to the harvest-oriented nature of this fishery, more restrictive length limits (e.g., 20-in MLL) or more restrictive daily bag limits were not investigated, because of anticipated angler disapproval with such regulations.

According to the SPR simulations, the potential for recruitment overfishing occurred with the current 14-in MLL when exploitation exceeded ~30% (Figure 11). Similarly, the 16-in and 18-in MLLs also exhibited the potential for some degree of recruitment overfishing, and essentially only delayed the onset of recruitment overfishing. In spite of all of this, due to the low catch of small fish, the SPR results from this study should be considered as very conservative estimates and used cautiously. Since few small walleye were collected, the size structure was undoubtedly overestimated. Therefore, it was primarily the large, highly-fecund females that were harvested in the SPR modeling, and the smaller walleye that were underrepresented in the gill net sample were also disproportionately underrepresented in SPR modeling. Thus, fish with more eggs were disproportionately removed from the population than what would typically occur, which ultimately reduced the SPR values.

In general, the size structure with gill nets was much greater than what was harvested by recreational anglers. It is assumed that the size structure from angler-harvested walleye was a closer representation of the true size structure of the Brookville walleye population. In a typical length frequency histogram, much of the population will be composed of the smaller, younger fish; which is similar to the length frequency histogram for harvested walleye. The gill nets used in this study appeared to be most effective at capturing walleye that ranged from 18 to 22 in TL. Therefore, the nets did not effectively sample the smallest or largest walleye. The nets used to collect walleye were standard (i.e., non-experimental) mesh gill nets. Although their large mesh

effectively collected walleye for brood fish collection, they likely played a role in the low catches of the smallest and largest walleye, because gill nets are considered to be size selective for walleye (Vandergoot et al. 2011). Few large and perhaps older fish were captured with this study. It was evident from the catch-curve regressions the oldest walleye were not effectively collected (Figures 3, 4, & 5). The theoretical maximum age (i.e., x-intercept of catch curve regression line) of each catch curve was much older than what was collected in the gill nets.

Likewise, the size selectivity associated with the gill nets undoubtedly affected the catch of the smallest fish. It should also be noted that sexual maturity may have played a role in the low catch of smaller, immature walleye. With the catch curve (sexes pooled) used for modeling, walleye were not considered to be recruited to the gear until age 4 (Figure 5). However, when looking at each sex, male were smaller than female walleye yet males were recruited to the gear one year earlier than female walleye (Figures 3 & 4). Earlier recruitment to the gill nets by the shorter male walleye is likely attributed to male walleye maturing sooner than female walleye (Henderson and Morgan 2002). It is assumed that the majority of walleyes located along the riprap-lined shoreline of the dam during that period are there for spawning purposes. Therefore, small and immature walleye would potentially be underrepresented with even experimental gill nets during spring walleye evaluations. Thus, in order to get size and age distributions more representative of the true population, it is recommended that future surveys of the Brookville walleye population be conducted using experimental gill nets throughout the entire lake. In addition, all walleye should be measured in the future to avoid assigning lengths based from length frequency histograms.

While the exploitation rate of walleye was modeled up to 60% in the present study, it is unlikely the Brookville walleye population would typically be subjected to such high exploitation; especially considering total annual mortality was only 55.7%. However, Quist et al. (2010) documented an exploitation rate that accounted for tag loss and non-reporting of 68.3% for walleye in a Kansas reservoir, and estimated the absolute minimum exploitation rate (i.e., that did not account for tag loss or non-reporting) to be 46.6%. Therefore, modeling the Brookville walleye fishery to 60% exploitation should still be considered a good prediction of the response to high exploitation-scenarios. In contrast, Baccante and Colby (1996) summarized exploitation estimates for 46 walleye fisheries throughout North America and reported that exploitation rates ranged from 3.0% to 55.6%, averaged 19.6% (SE = 1.6), and had a median of

21%. Only four populations in their study had exploitation rates greater than 30% and two of which had an exploitation rate in excess of 50%. Although the exploitation rate in the present study was unknown, emphasis from the modeling should be placed closer to the low to middle range of the exploitation rates modeled.

A future exploitation study on the Brookville walleye population would provide valuable insight and give managers a better understanding of a more definitive level of exploitation. Information garnered from such a study would assist in determining the relative contributions of both fishing mortality and natural mortality, which is considered more informative than harvest estimates from creel surveys (Isermann et al. 2007). This information would ultimately aid in determining the effectiveness of any regulation changes. If most of the total annual mortality is from natural mortality, then implementing a more restrictive length limit would not improve the fishery, but would only unnecessarily limit harvest by anglers. Although it is recognized that anglers are often supportive of more restrictive walleye regulations despite ambiguous results from length limit evaluations (Quinn 1992; Isermann 2007), the goal of a more restrictive regulation should be to improve the fishery. However, typically length limit regulations are best suited for populations that have fast growth, low natural mortality, and high exploitation.

The walleye fishery at Brookville Reservoir is a harvest-oriented fishery and it is thought that most anglers who pursue walleye do so with the intention of harvesting them. It is unknown whether Brookville Reservoir walleye anglers would prefer to catch and keep more, smaller fish or fewer, larger fish. It is recommended to include such a question in future Brookville creel surveys. Determining angler preferences would aid in deciding possible changes with length limits for the fishery.

The current Brookville walleye management strategy appears to be effectively maintaining the fishery while allowing for high angler harvest (in terms of both number and yield), yet maintaining a good size structure. Therefore, the Brookville Reservoir walleye fishery should continue to be stocked annually with 10.5 million walleye fry (2,000/acre) to maintain a suitable brood population and maintain the sport fishery. Also, the fishery should continue to be regulated with the 14-in MLL and six fish daily bag limit regulations. More restrictive regulations should not be considered at this time.

RECOMMENDATIONS

- Continue regulating the Brookville walleye fishery with the current 14-in MLL and six fish daily bag limit.

- Continue stocking 10.5 million walleye fry (2,000/acre) to maintain a suitable brood population and maintain the sport fishery.

- In future Brookville walleye surveys aimed at population modeling, experimental gill nets should be set throughout the entire lake to get a better representation of the size and age structures.

- An exploitation study should be considered if another comprehensive evaluation of the Brookville walleye fishery is conducted.

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Submitted by: Aaron J. Cole, Assistant Fisheries Biologist
Date: March 23, 2013

Approved by: J. Rhett Wisener, Fisheries Biologist

Approved by: Brian M. Schoenung, Fisheries Supervisor

Date: March 28, 2012

Table 1. Estimates of instantaneous natural mortality (M) and conditional mortality (*cm*) based on population demographics of Brookville Reservoir walleye. The overall means of M and *cm* were 0.32 and 0.27, respectively. Max_{age} = the maximum age (11.9 years); k = growth coefficient from the von Bertalanffy growth model; Max_{wt} = the standard weight of a 30-in (L_{inf}) walleye from the walleye standard weight equation (Murphy et al. 1990); Ps = the proportion of fish surviving to the maximum age (set at 0.01).

Method	Equation	M	*cm*
Hoenig (1983)	$1.46 - 1.01*\log_e(Max_{age})$	0.35	0.30
Jensen (1996)	1.50*k	0.29	0.25
Peterson and Wroblewski (1984)	$1.92*(Max_{wt}^{-0.25})$	0.23	0.20
Quinn and Deriso (1999)	$Log_e(Ps)/Max_{age}$	0.39	0.32

Table 2. Life history parameters used to model the Brookville Reservoir, Indiana walleye population with the yield per recruit option in Fishery Modeling and Analysis Simulator (FAMS; Slipke and Maceina 2010).

Parameter	Value
Von Bertalanffy growth coefficients	
L_{inf} (in)	30
k	0.192
t_0	-1.441
Maximum age (years)	11.9
Conditional natural mortality (*cm*) rates	0.22 & 0.32
Exploitation (%)	0–60%
Log_{10} weight(g)– Log_{10} length(mm) regression coefficients	
Intercept	-5.627
Slope	3.225
Minimum length limits (in)	14, 16, 18
Initial population	100

Table 3. Catch, age, and mean length (with SE and 95% confidence limits) for female walleye from Brookville Reservoir, 2009.

Age	n	Mean TL (in)	SE	95% LCL	95% UCL
1	-	-	-	-	-
2	-	-	-	-	-
3	159	19.9	0.07	19.7	20.0
4	423	21.1	0.06	21.0	21.3
5	165	23.2	0.12	23.0	23.5
6	29	25.5	0.17	25.1	25.8
7	26	26.1	0.18	25.7	26.4
8	9	26.2	0.33	25.5	26.8

Table 4. Catch, age, and mean length (with SE and 95% confidence limits) for male walleye from Brookville Reservoir, 2009.

Age	n	Mean TL (in)	SE	95% LCL	95% UCL
1	-	-	-	-	-
2	15	15.1	0.41	14.2	15.9
3	255	18.5	0.05	18.4	18.6
4	149	19.2	0.09	19.0	19.3
5	142	20.3	0.06	20.1	20.4
6	98	21.3	0.10	21.1	21.5
7	29	21.3	0.22	20.9	21.8
8	14	20.6	0.24	20.1	21.1

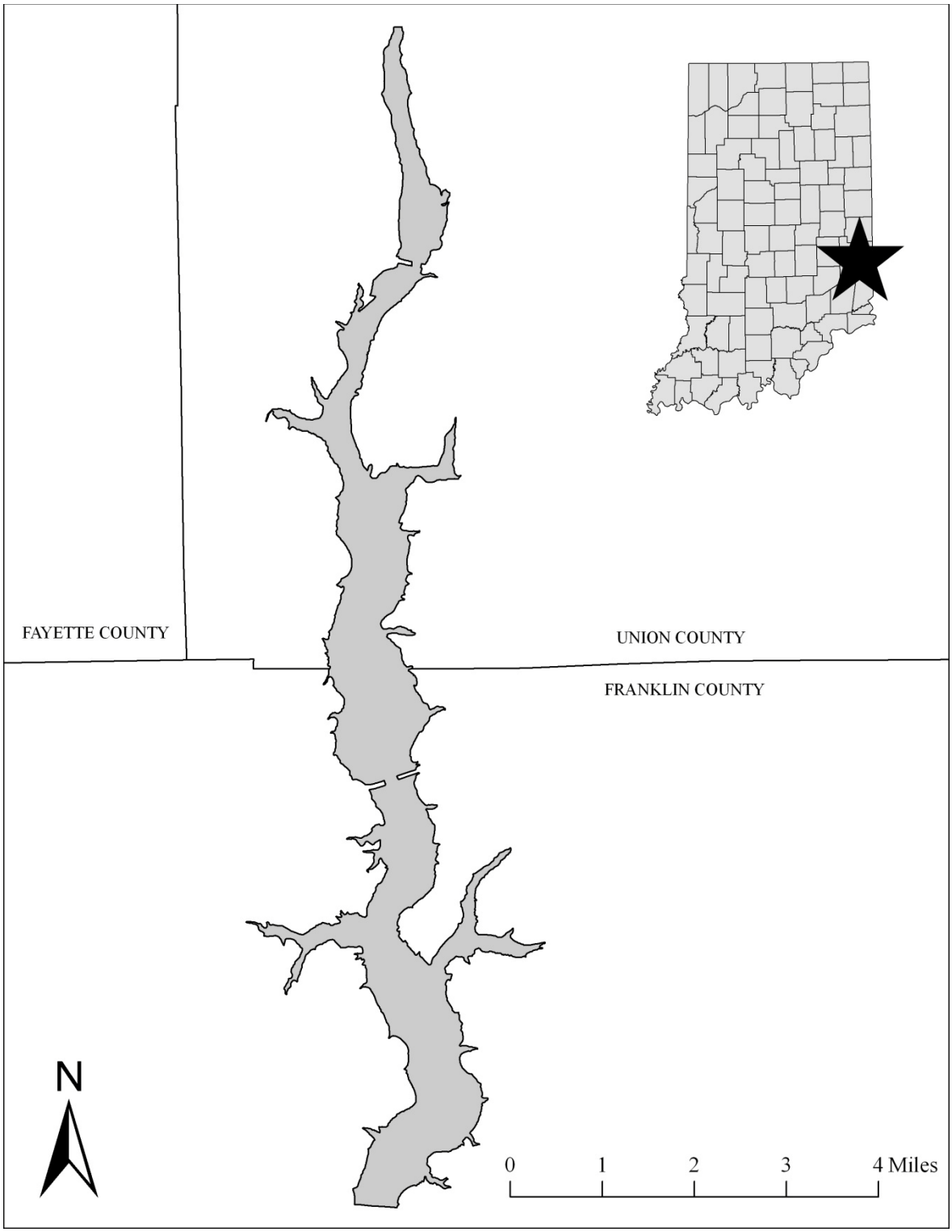

Figure 1. Map of Brookville Reservoir, Indiana.

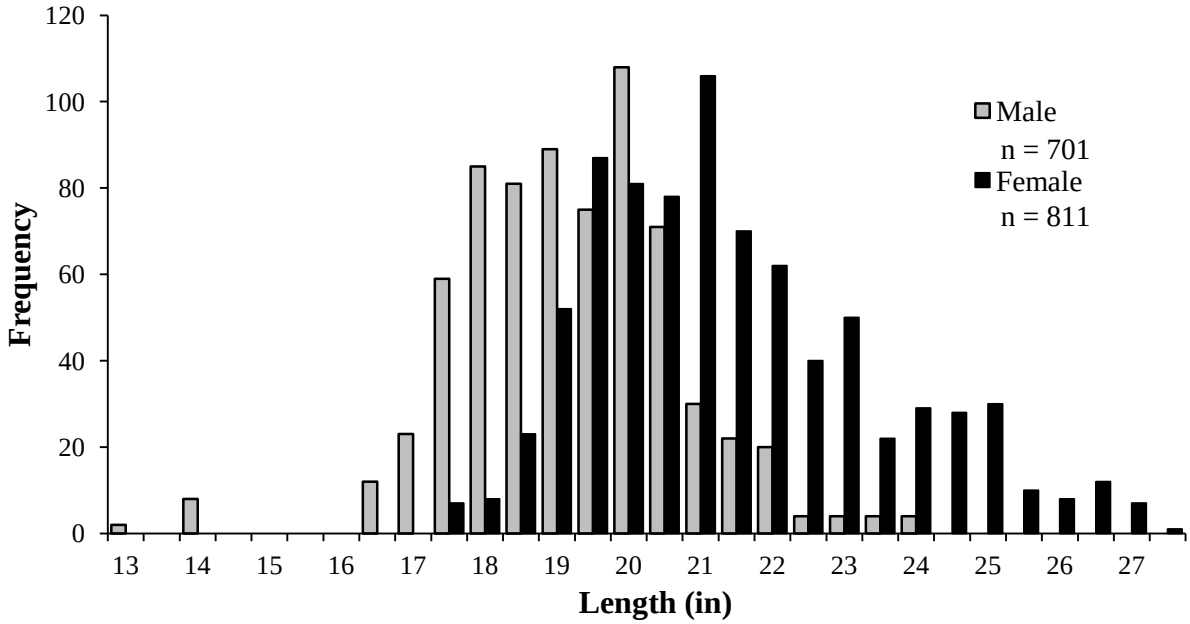

Figure 2. Length-frequency distribution of male (n = 701) and female (n = 811) walleye collected from Brookville Reservoir in spring 2009.

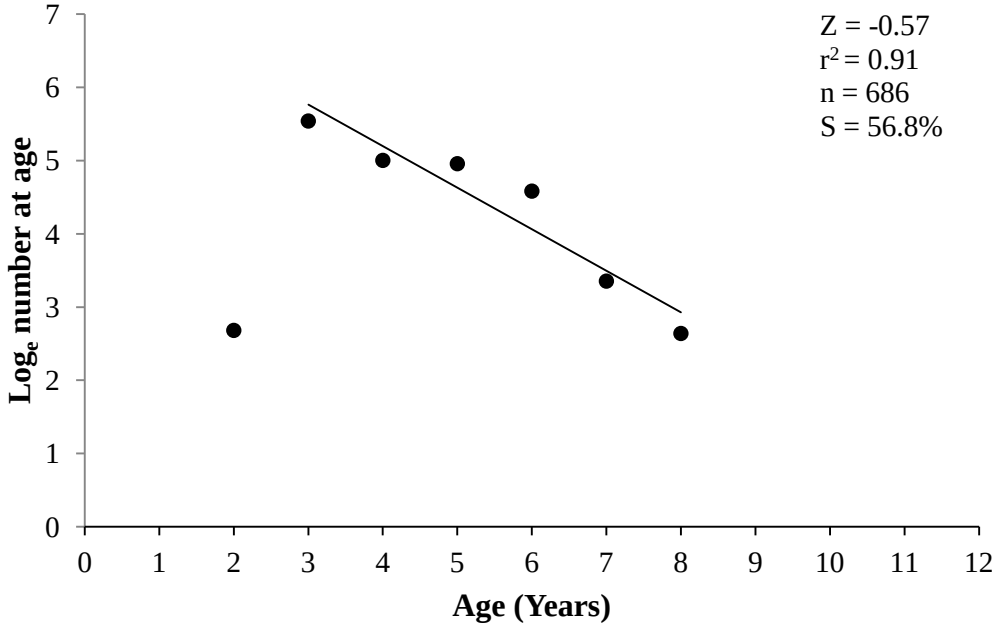

Figure 3. Number at age for male walleye collected from Brookville Reservoir, Indiana in 2009. A catch-curve regression estimated instantaneous annual mortality (Z) and survival (S). Age-2 walleye were omitted from the regression.

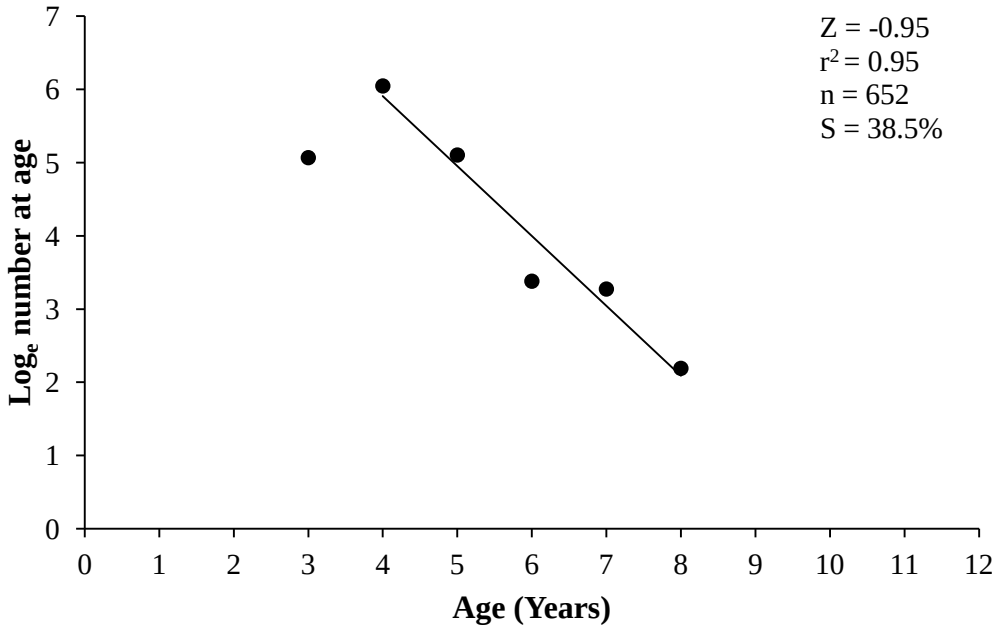

Figure 4. Number at age for female walleye collected from Brookville Reservoir, Indiana in 2009. A catch-curve regression estimated instantaneous annual mortality (Z) and survival (S). Age-3 walleye were omitted from the regression.

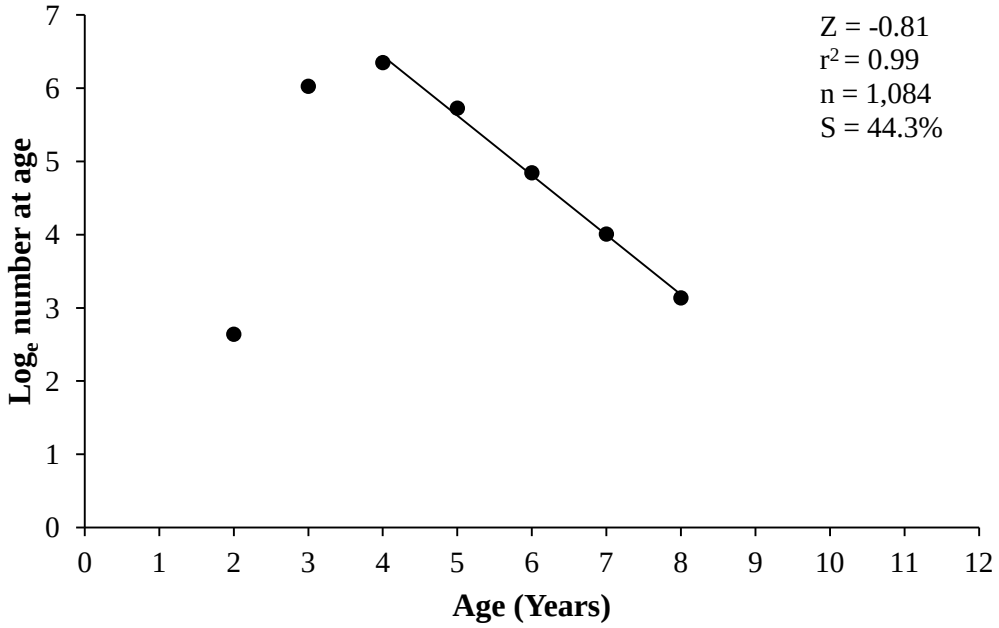

Figure 5. Number at age for Brookville Reservoir walleyes (sexes pooled) collected in 2009. A catch-curve regression estimated instantaneous annual mortality (Z) and survival (S). Age-2 and age-3 walleye were omitted from the regression.

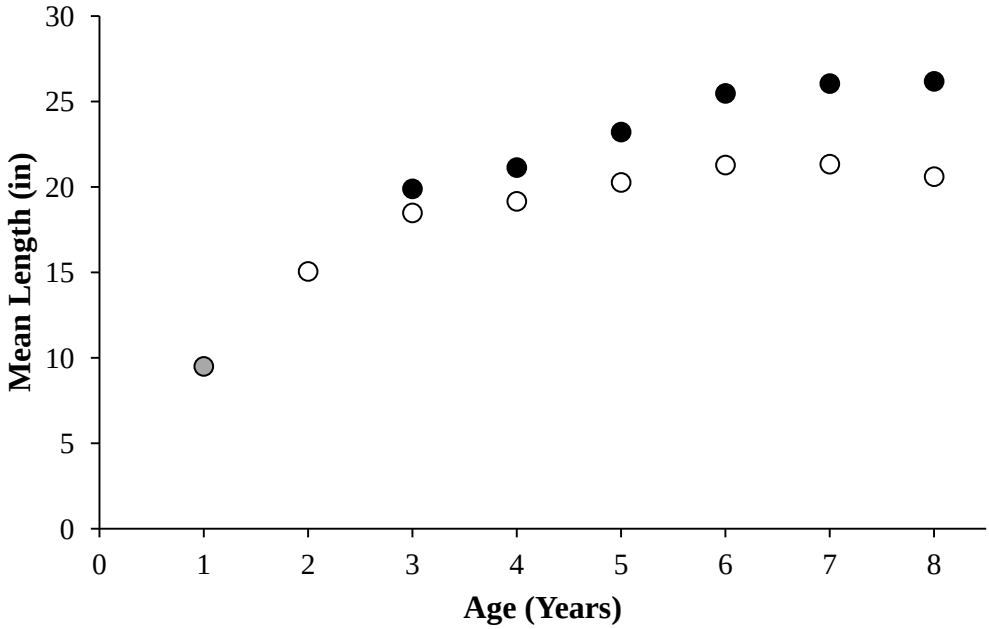

Figure 6. Mean lengths-at-age for female (solid black circles), male (open circles), and unknown sex (shaded gray circle) walleyes collected from Brookville Reservoir, 2009.

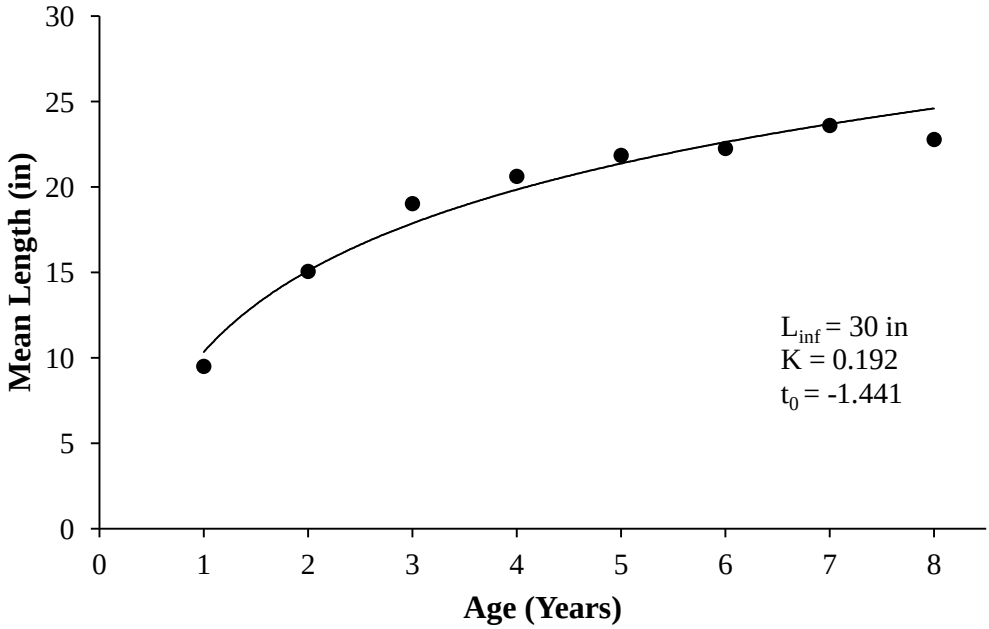

Figure 7. Mean lengths at age and the growth rate predicted by the von Bertalanffy growth equation for Brookville Reservoir walleye. L_{inf} = theoretical maximum length, k = growth coefficient, and t_0 = time at which length is zero.

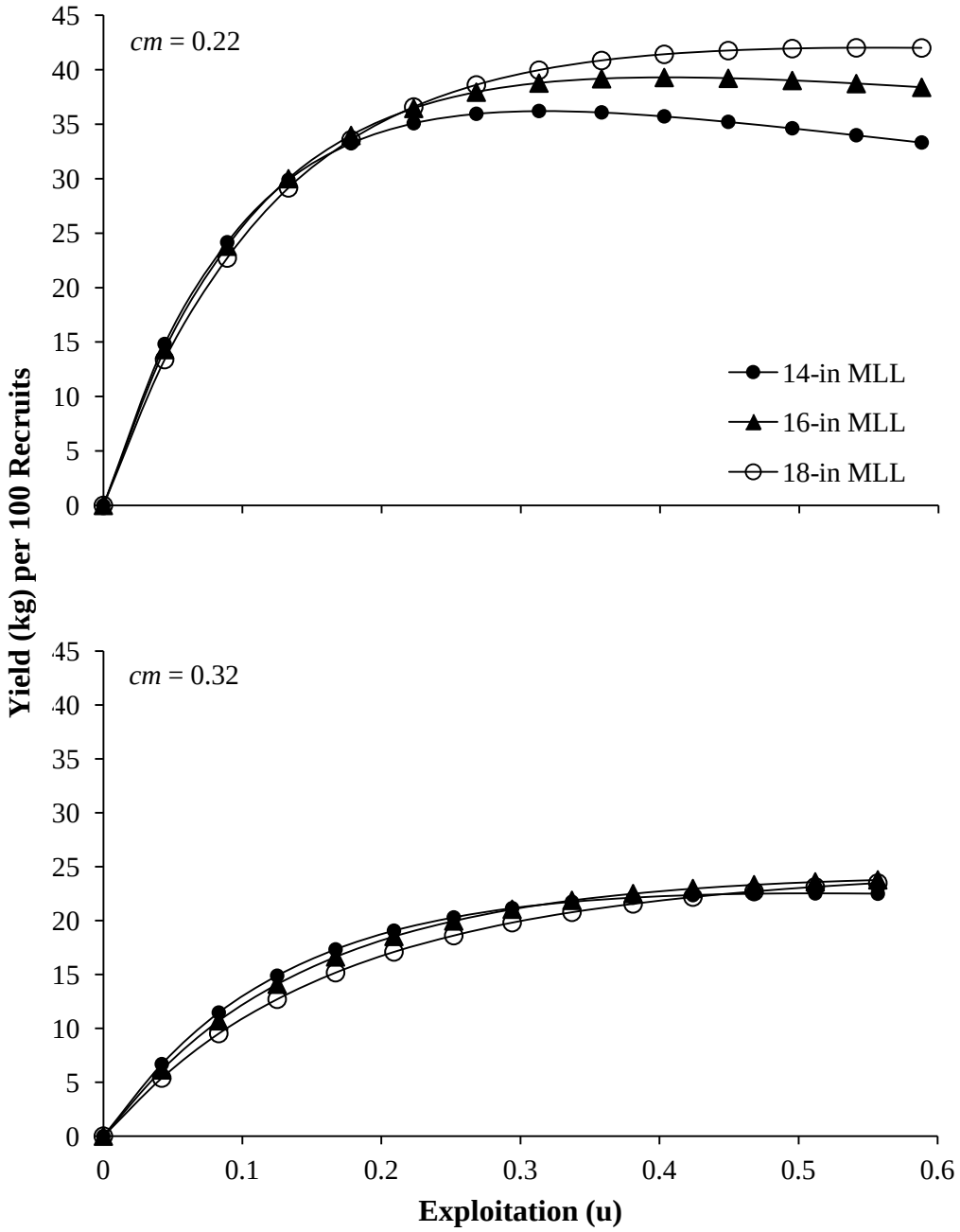

Figure 8. Predicted yields of walleye in Brookville Reservoir, Indiana, at two levels of conditional mortality (*cm*) with minimum length limits (MLLs) of 14-in, 16-in, and 18-in TL. The simulations were conducted with an initial population of 100 recruits.

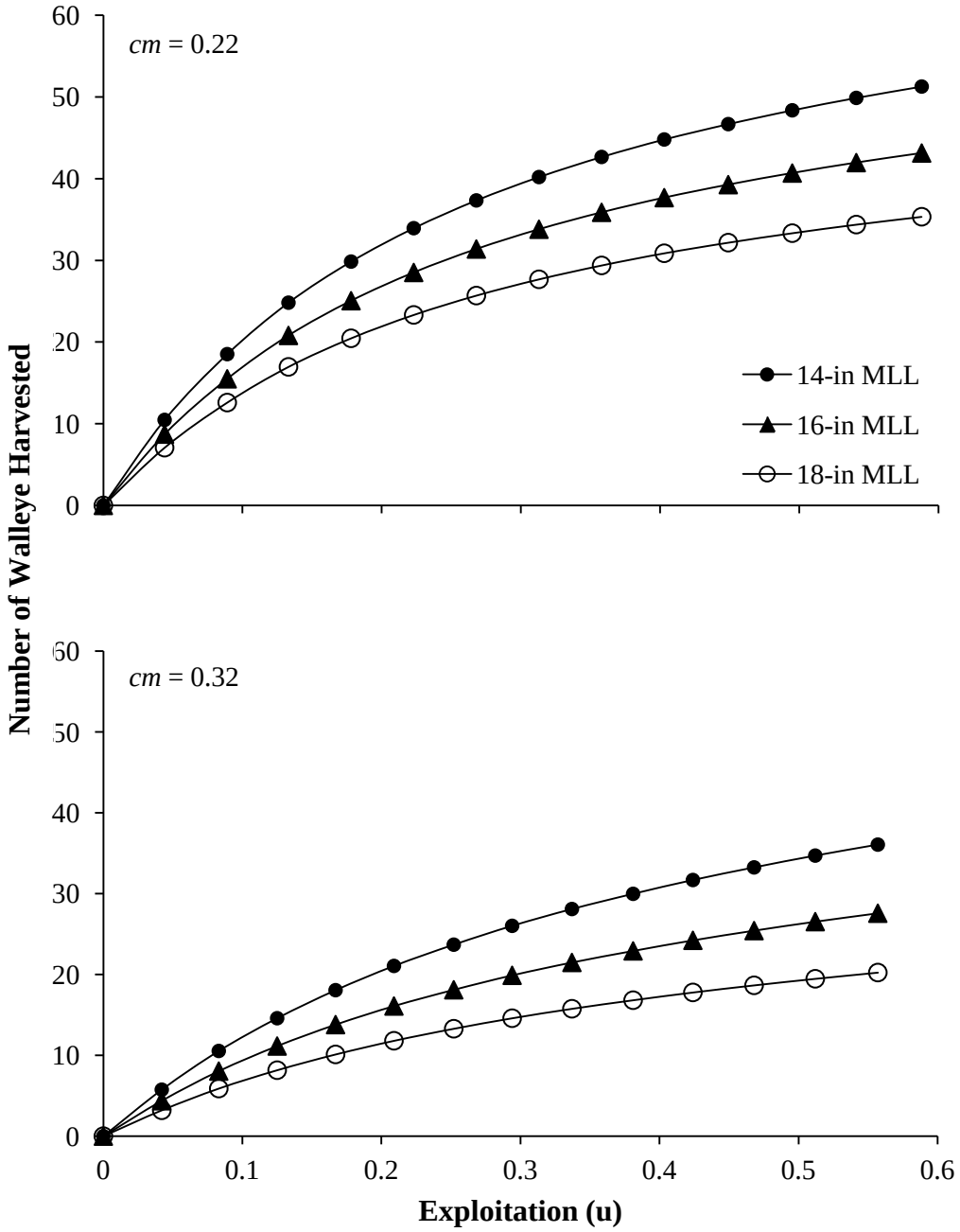

Figure 9. Predicted number of walleye harvested from Brookville Reservoir, Indiana, at two levels of conditional mortality (*cm*) with minimum length limits (MLLs) of 14-in, 16-in, and 18-in TL. The simulations were conducted with an initial population of 100 recruits.

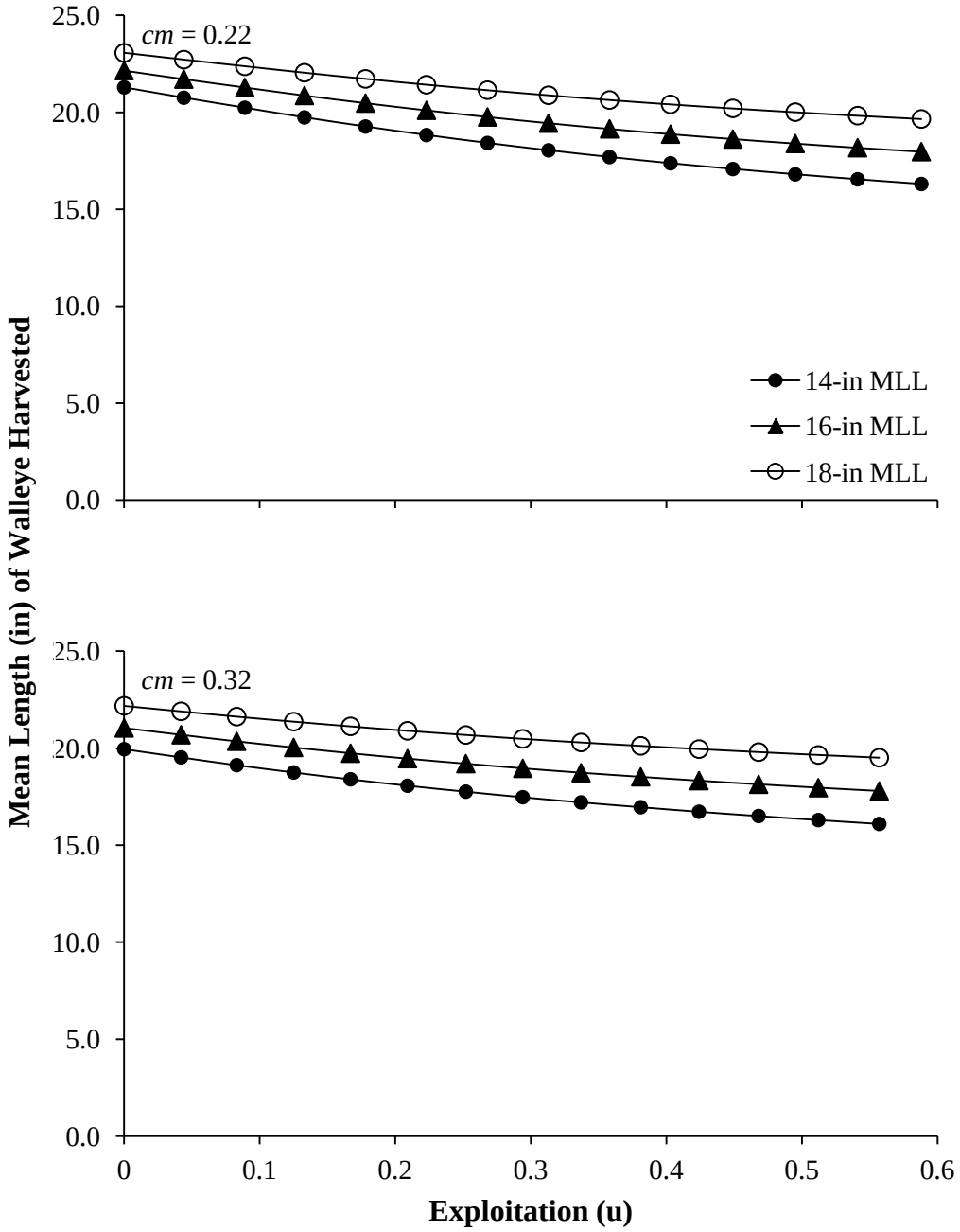

Figure 10. Simulated mean length of walleye in Brookville Reservoir, Indiana, at two levels of conditional mortality (*cm*) with minimum length limits (MLLs) of 14-in, 16-in, and 18-in TL. The simulations were conducted with an initial population of 100 recruits.

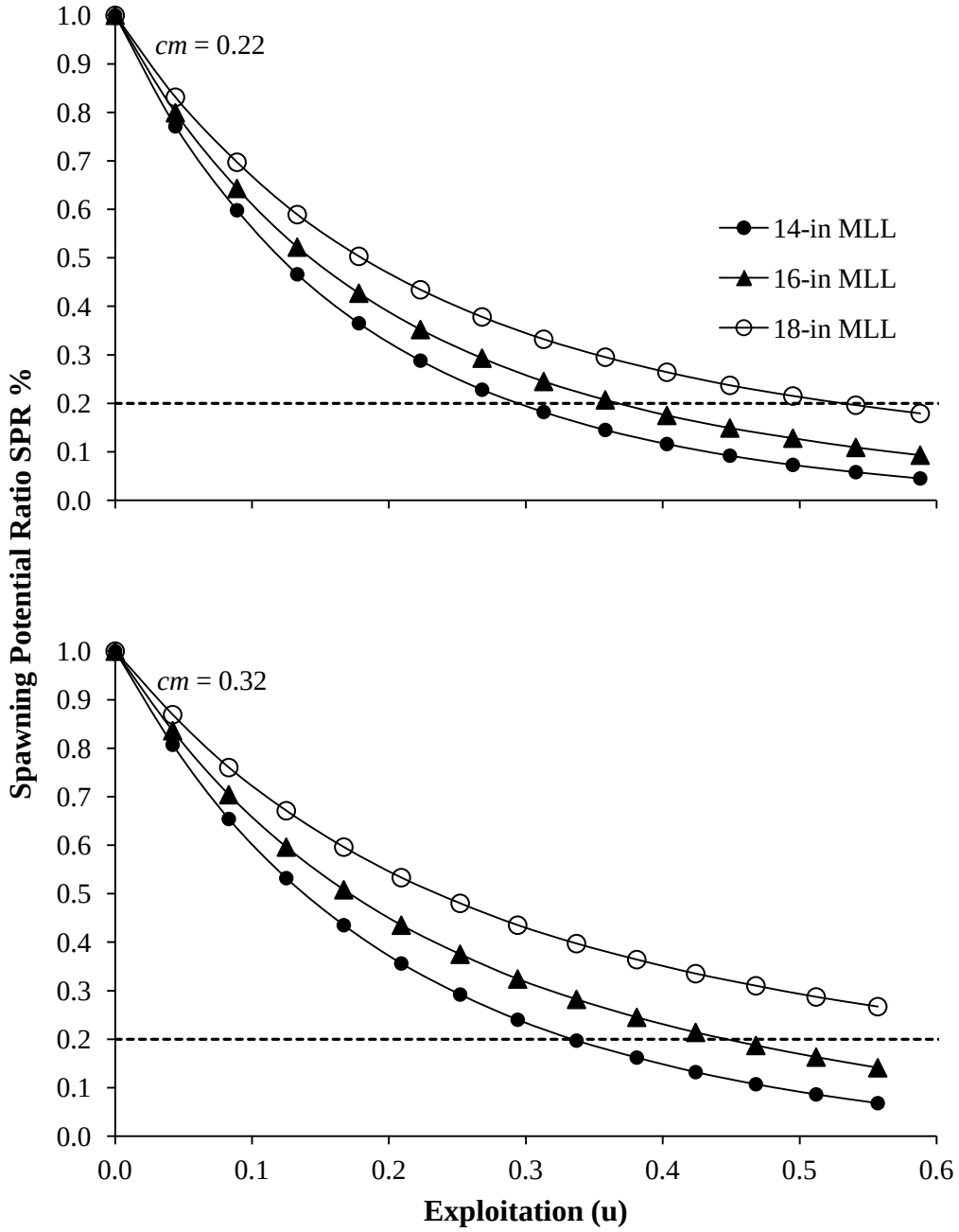

Figure 11. Simulated spawning potential ratio (SPR) for walleye in Brookville Reservoir, Indiana, at two levels of conditional mortality (*cm*) with minimum length limits (MLLs) of 14-in, 16-in, and 18-in TL. The horizontal dashed line represents the recruitment overfishing threshold of 20%.

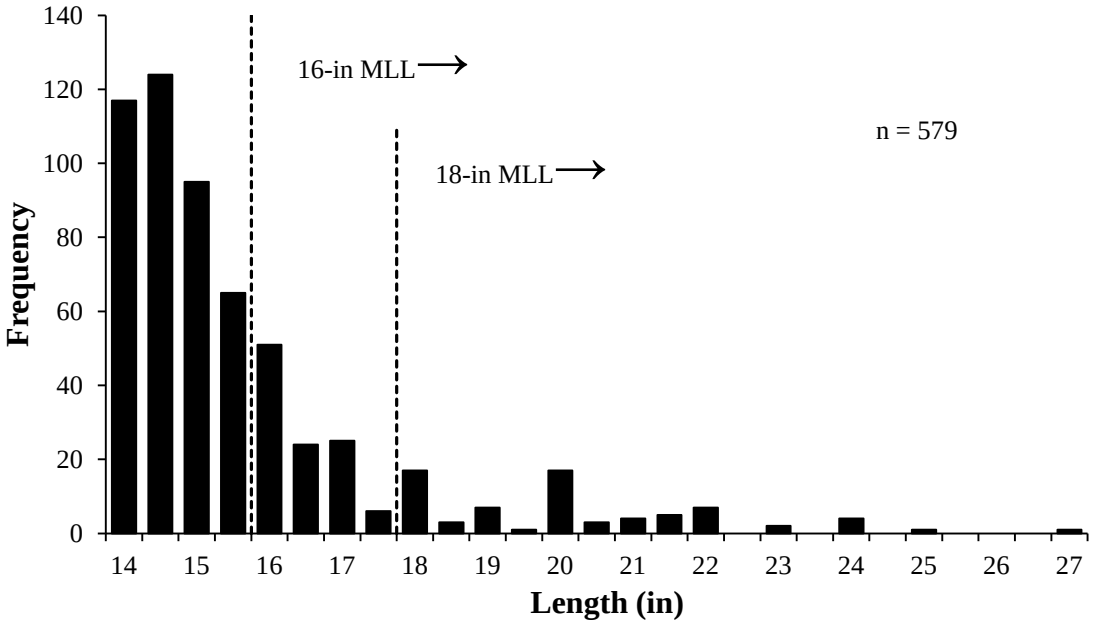

Figure 12. Length-frequency distribution of walleyes harvested (n = 579) from Brookville Reservoir, Indiana during the 2009 creel survey. Vertical dashed lines represent the number of fish available to harvest under the 16-in and 18-in minimum length limits (MLLs).

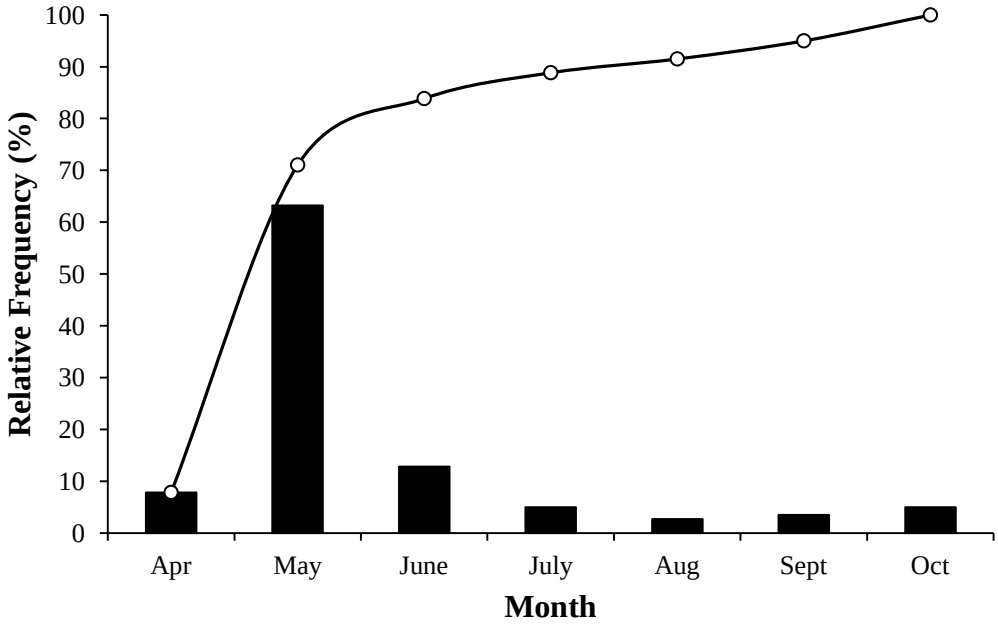

Figure 13. Harvest of Brookville Reservoir walleye during the 2009 creel survey. Vertical bars represent the relative frequency of harvest each month, and the line represents the cumulative relative frequency of walleye harvested from April-October 2009.

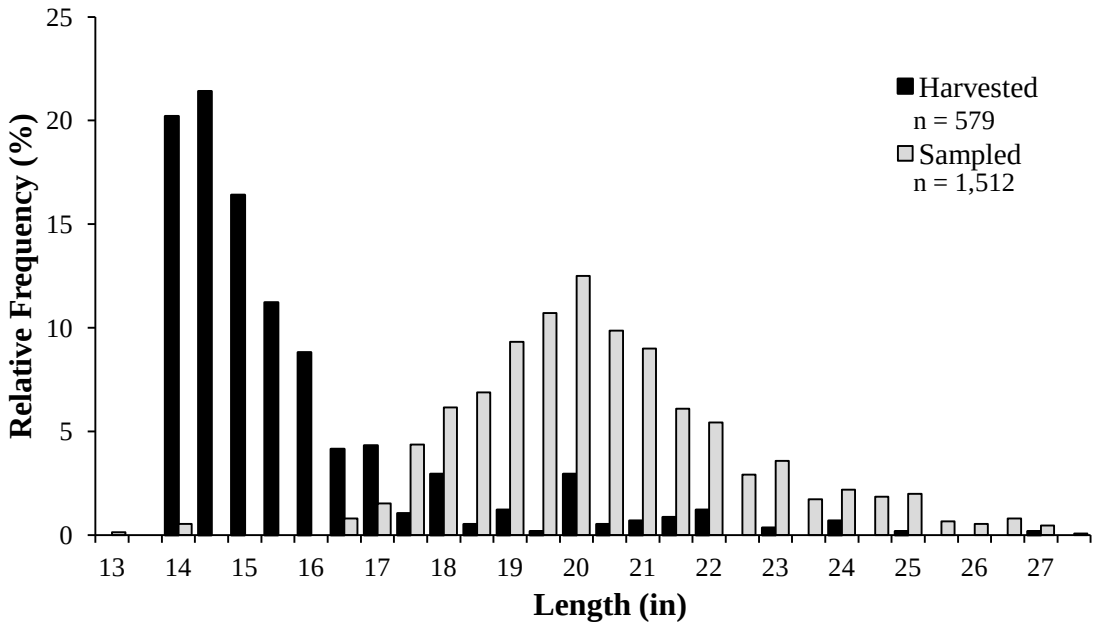

Figure 14. Relative length-frequency distributions of walleyes harvested during the 2009 creel survey (n = 579; dark bars) and walleye collected from spring 2009 gill netting (n = 1,512; gray bars) from Brookville Reservoir, Indiana.