WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Common Carp and Bigmouth Buffalo Population Assessment and Contract Removals in Yellowstone Lake, 2022-2023

Waterbody Identification Code (WBIC): 903700

Timothy Parks - DNR Fisheries Biologist
Dan Walchak - DNR Fisheries Technician
2024

Table Of Contents

Executive Summary

Managing detrimental fish populations in Yellowstone Lake has been a long-term challenge. Currently, public concerns of roughfish proliferation have been on the rise and recent survey data have confirmed high abundances of common carp and bigmouth buffalo. This prompted the DNR to further investigate the magnitude and potential impact of common carp and bigmouth buffalo populations and to determine if a roughfish removal contract would be necessary. In the Fall of 2022, the DNR established an experimental roughfish contract with contract fisherman to survey carp and buffalo in Yellowstone Lake and estimate their density and biomass. This contract also allowed for the initial contracted removals of common carp and bigmouth buffalo to assess the efficiency of fish removal efforts and describe population magnitude.

In the fall of 2022 and the spring of 2023, bigmouth buffalo and common carp populations were sampled using contracted seining efforts via an Experimental Rough Fish Contract. Seine samples indicated that 65% of the bigmouth buffalo population were ≥ 15” and 45% of the population were fish ≥ 20” (n = 768). Total population biomass of bigmouth buffalo was estimated as 3,839.1 lbs./acre (95% CI: 2,945.3-5,101.8 lbs./acre), based on a density estimate of 619.5 fish/acre (95% CI: 475.3-823.3 fish/acre) and modeled weight characteristics. Seine samples indicated that 98% of the common carp population were fish ≥ 15” and 67% of the population were fish ≥ 20” (n = 115). Total biomass of the common carp population was estimated as 329.0 lbs./acre (95% CI: 229.1-491.2), based on a density estimate of 63.4 fish/acre (95% CI: 44.2-94.7 fish/acre) and modeled weight characteristics.

Contract fishermen reported harvesting a total of 322,670 lbs. (712.3 lbs./acre) of bigmouth buffalo and 39,625 lbs. (87.5 lbs./acre) of common carp throughout 14 harvest events during 2022 and 2023. After the mark-recapture survey completion (i.e., latter 12 harvest events), it was estimated that 14.7% of bigmouth buffalo population biomass (563.6 lbs./acre) was removed along with 13.2% of common carp population biomass (43.2 lbs./acre). All common carp were removed and marketable-sized bigmouth buffalo (fish ≥ 16.5” or fish ≥ 3 lbs.) were selectively removed during harvest events.

This assessment confirmed that bigmouth buffalo were more abundant than common carp. Although bigmouth buffalo biomass was assumed to be very high, biomass estimates from other waterbodies were not comparable to Yellowstone Lake, which suggests the Yellowstone Lake population estimate may be inaccurate. Unequal capture vulnerability from poor survival of marked bigmouth buffalo may have contributed to a low recapture rate and a subsequent high population estimate. Commercial fishermen also indicated that the buffalo biomass estimate seemed unrealistically high after they reported declines in catches of marketable fish during Fall of 2023. Further contracted fish removal may not be feasible with such low

anticipated harvests. Based on unreliable population estimates, a Roughfish Contract should not be considered at this time.

Recommendations

1. Continue ongoing annual efforts to monitor fish populations and water quality measures in Yellowstone Lake to better understand response to common carp and bigmouth buffalo removals for the next five years (2024-2029).

2. Avoid using the bigmouth buffalo population density, biomass and exploitation rate estimates from this assessment for future management purposes due to overestimation issues.

3. Do not pursue roughfish removal contracts for Yellowstone Lake at this time.

4. Use future results from annual monitoring efforts to determine if further common carp and buffalo removals are feasible and-or necessary.

Introduction

Yellowstone lake is a relatively shallow (maximum depth = 14 ft) 453-acre reservoir situated in an agriculturally dominated watershed (70% of land area) in northeast Lafayette County. This man-made lake was created in 1954 to provide recreational opportunities for visitors of Yellowstone Lake State Park and Yellowstone State Wildlife Area, which surrounds the lake. This type of impoundment has a high water-residence time (i.e., 140 days), making it more lake-like and less riverine due to less water flowing through the impoundment. Similar to other reservoirs in agricultural landscapes, Yellowstone Lake is turbid with warmwater thermal habitat containing a complex fish assemblage (3 or more gamefish species). This fish assemblage is primarily composed of black crappie, walleye, muskellunge, channel catfish, largemouth bass, bluegill, bigmouth buffalo and common carp. Most fish populations in the lake are sustained through natural reproduction, except for Muskellunge and walleye, which are maintained through stocking.

Managing Yellowstone Lake for desirable fishery, habitat and water quality characteristics has always been a challenge due to issues largely involving watershed land use, reservoir type/morphology and detrimental fish species. Generally, reservoirs are a product of their landscapes since they act as a conduit as well as a collection point for all drainage from a watershed. This is why reservoirs in agriculturally dominated watersheds (e.g., Yellowstone Lake) tend to be more prone habitat degradation and water quality impacts. In the past, managing for watershed agriculture and other human land use was often difficult for many reasons, such as the lack of Best Management Practices (BMPs) for soil conservation and limited landowner cooperation. Rather than tackling difficult watershed management

challenges, it was more feasible for DNR to focus their efforts on whole lake renovations and biomanipulation actions to manage fisheries and water quality.

Whole lake renovation and biomanipulation were two different management actions performed in Yellowstone Lake, yet both involved the control of detrimental and undesirable fish species. These early control actions focused on reducing detrimental benthivorous fish species (e.g., common carp) and other undesirable roughfish species (e.g., bullhead and white suckers), often associated with poor water quality and fishery characteristics. Whole lake renovations were the earliest management actions performed in Yellowstone Lake, which occurred in 1968 and then again 1983. These whole lake renovations involved a near-total drawdown the entire reservoir followed by the chemical eradication of the remnant fish populations and removal of common carp from the reservoir. Whole lake renovations also included some physical modification of the habitat, including the scour, transport and consolidation of accumulated reservoir sediments during the drawdown. While the resulting benefits of these whole lake renovations were never permanent, it allowed for approximately 10 years of favorable water clarity and fishery conditions.

Biomanipulation actions in Yellowstone Lake were similar to the Whole Lake Renovations but tended to be more cost-effective by focusing solely on manipulating fish populations to improve the fishery and water quality. Biomanipulation included the physical removal of fish as well the stocking predator fish species to have top-down control of detrimental common carp and other undesirable fish species. These initial biomanipulations actions were contracted and cooperative fish removals, which started in the 1970s. By the 1980s, a variety of top predator fish species were stocked into Yellowstone Lake and restrictive harvest regulations were implemented to maintain high abundances of these predators for top-down control of detrimental fish species. By the late 1990s into the 2000s, biomanipulation actions and other watershed improvement practices were used together in an attempt to improve water quality and the fishery in Yellowstone Lake (Lange et al. 2007). Prior to this report, an average of 128.3 lbs./acre (17.8-319.9 lbs./acre) of common carp were removed annually during 1998-2005.

Following each of these biomanipulation actions, fishery improvements were noted by resource managers and public stakeholders. Survey data were sometimes limited and often only able to report short-term fishery improvements. No estimates of common carp abundance or biomass were completed to document the exploitation of the carp population from removal efforts or to set realistic harvest goals to impact carp population productivity. Regardless of the reporting limitations, the optics of these biomanipulation practices remained very popular among public stakeholders.

In the last 5 years, local stakeholder concerns have grown about the proliferation of common carp and how this might be impacting desirable fish populations in Yellowstone Lake. Interestingly, a late-spring electrofishing survey in 2022 revealed that common carp were not as abundant as previously thought and that bigmouth

buffalo were about 15x more abundant than carp in the sample. These survey findings suggest that stakeholders may have been confusing bigmouth buffalo for common carp, which is not surprising because these species have a similar appearance.

Bigmouth buffalo are often perceived to be the same as common carp, but they are ecologically different. Bigmouth buffalo are a native sucker species that occur in open water habitats and filter feed on zooplankton (i.e., planktivores). Common carp are a nonnative invasive minnow species that have detrimental bottom-feeding habits (i.e., a benthivore) causing turbidity in waterbodies by stirring up sediments and destroying submerged plant beds. Common carp are known to be a keystone species since they can be detrimental to lakes at relatively low abundances. In comparison, planktivorous species (not limited to bigmouth buffalo) generally must be fairly abundant to impact food web dynamics and cause algal blooms (Carpenter et al. 1985). Currently, it is unclear if native bigmouth buffalo are having a detrimental impact on the lake. Bigmouth buffalo often receive equal blame with common carp for turbidity issues when they co-occur in lakes and impoundments. Bigmouth buffalo populations can be highly prolific in turbid impoundments (Edwards 1983), which may be a symptom of turbid water environments rather than the cause of turbidity. Still, many anglers have the perception that bigmouth buffalo and other native “rough fishes” are the cause of underperforming sport fisheries. Despite many unknowns, the unexpected increase in bigmouth buffalo abundance in Yellowstone Lake has raised public concerns about whether buffalo could be impacting gamefish populations and water clarity.

Bigmouth buffalo are native to the Yellowstone River and found throughout the Pecatonica River Basin but have never been reported upstream of the Yellowstone Lake dam prior to the mid-2000s. A suspected translocation occurred during the mid-2000s when contract fishermen may have introduced bigmouth buffalo into the impoundment. These fish were live-harvested from the downstream Yellowstone River and were stored in net-pens in Yellowstone Lake. It is unknown if fish accidentally escaped the net-pens or were intentionally released into Yellowstone Lake. Unfortunately, historic survey data on bigmouth buffalo are limited. Nongame fish species were not recorded prior to 2018, so it is difficult to precisely pinpoint when bigmouth buffalo became so abundant in the lake.

In response to these concerns, DNR staff established an Experimental Roughfish Contract with contract fishermen to determine the abundance and biomass of common carp and bigmouth buffalo populations and perform initial removals of these species in Yellowstone Lake. By estimating the amount of biomass of these species in the lake and performing initial removals, the DNR could determine whether further contract roughfish removals will be necessary in the lake. Additionally, performing these initial removals provides an opportunity for DNR to monitor the effects of these biomanipulations on gamefish species and water quality into the future. Therefore, the purpose of this report was to estimate the population

size of both common carp and bigmouth buffalo and document their removals for future projects.

Methods

SURVEY EFFORT AND DESIGN

DNR staff and cooperating contract fishermen used seines to sample and harvest common carp and bigmouth buffalo during the Fall of 2022 and Spring and Fall of 2023. The seines used in this survey were 10 ft in depth, varied from 3000 to 5000 ft in length and had a 2.5" bar-mesh with a stretch no wider than 6". In each seine haul event, seines were deployed from shore in a large U-shape to cover a large area of the lake and maximize the capture of fish. Once deployed, the seine was then hauled back into the shoreline by deployment boat and hauled in via a motorized net hauler. Seine hauls occurred throughout the lake, avoiding known snags and other large woody debris. The fish collected in each seine haul were corralled into net-pens for further processing. Any gamefish collected in the seine haul were removed from the pen and returned to the lake prior to carp and buffalo processing.

Single census mark-recapture sampling was performed during these initial seining events to estimate abundance. We utilized a mark-recapture process similar to Welke and Derks (2015) for this survey. The initial marking period occurred over two days starting immediately after the first seining event. Buffalo and carp were corralled into a smaller area specifically for marking. Since common carp often exhibit evasive behaviors when corralled in the net-pen, buffalo were marked first and then released back into the lake on day one. Carp were marked and released on the second day. All marked buffalo and carp received a right ventral (RV) clip and were enumerated (number marked or M). Total length (TL) and weights from a subsample of the marked fish were collected to characterize the population and aid with biomass estimation. DNR staff attempted mark a minimum of 2000 individuals of each species sampled. A minimum sample goal of 500 fish lengths (i.e., total length) were to be measured to the nearest 0.5-inch for each species. Fish weights were measured to nearest 0.1 pound and were subsampled by collecting a minimum of five fish weights per each 0.5-inch length increment represented in the sample. Once fish were measured, marked and released back into the lake, the marked fish were allowed to mix back into the population for minimum of one week before performing the recapture seining. The recapture period followed the same process as the 2-day marking period for both species, except that a larger sample size of fish was inspected for marks. All buffalo and carp individuals that were inspected for marks were enumerated (number captured or C). Of that sample number, all marked fish recaptured in the sample were enumerated (number recaptured or R). To ensure a precise estimate, we attempted to examine a sample of fish that was larger than the marking sample.

DATA ANALYSIS

Population size structure of each species was evaluated using length frequency distributions and percent size distribution metrics. Size structure was analyzed using carp and buffalo total length data collected during Fall seining. Length frequency distributions were plotted by summarizing the number of fish measured in each 0.5-inch length bin. Proportional size distribution (PSD) metrics were also used to describe broad patterns in length frequency data by describing segments of the population representing various size categories. The PSD metrics for this assessment described the percentage of the population ≥ 15", ≥ 20", ≥ 25" and ≥ 30" for each species. The same PSD length categories were used for carp and buffalo since both populations had similar length ranges in Yellowstone Lake.

Weight and biomass characteristics of common carp and bigmouth buffalo populations were derived from model-estimated weights based on weight-length relationships. Individual fish weight and length data were log-transformed to fit a linear weight-length regression model. This linear model is typically expressed as log10(weight) = a + b (log10(total length)), where a = model intercept and b = slope. The equations from these fitted linear regression models were then used to predict weights for all fish length data that lacked weight data. Predicted weight data were then summarized to estimate mean individual fish weight, total sample biomass and to describe the relative biomass distribution across the length range of each species.

Population abundance was estimated using Chapman's modification of the Lincoln-Peterson estimator: N = (((M+1) x (C+1)) / (R+1)) – 1, where N = population abundance estimate, M = number marked during the marking period, C = number of fish examined for marks during the recapture period and R = number of marked fish recaptured during recapture period. Abundance was estimated along with a recapture rate (R/C) and a 95% confidence interval to describe the precision of the estimate. For comparative purposes, we estimated the population density (fish/acre) of both species, which is the population abundance estimate (N) estimate divided lake surface area (453 acres). Population biomass (lbs.) was estimated for both species by multiplying the population abundance by the mean weight of fish and then dividing by lake surface area (lbs./acre). This simplified biomass equation is based on the expression: B/N = b/n, where the rate of population biomass (B) to population abundance (N) is proportional to the rate of total sample biomass (b) to sample abundance (n; number of fish with predicted weights). Additionally, the sample biomass to abundance rate (b/n) is equal to the mean individual fish weight.

Results

Initially, the mark-recapture survey was intended to occur in Fall of 2022. Due to logistical considerations with contract fishermen and early an ice-on date, seining was only performed once on 10/18/2022. Mark-recapture sampling was then moved to the following spring and occurred during 3/28/2023 to 4/07/2023. Contract fish

removals occurred during each of these seining surveys and continued after survey completion throughout Spring and Fall of 2023. Contract fish harvest ended after 11/18/2023.

BIGMOUTH BUFFALO

Bigmouth buffalo in Yellowstone Lake showed considerable size diversity based on the lengths of 768 individuals sampled during initial fall seining efforts in 2022. Bigmouth buffalo lengths ranged from 11.5-35.5" (Figure 1 and Table 1) with a mean length of 19.3" (n = 768). The size structure of the population was comprised of 65% of fish ≥ 15", 45% of fish ≥ 20", 22% of fish ≥ 25" and 6% of fish ≥ 30". Although larger-sized fish made up a sizeable portion of the population, fish smaller than 15" still represented 45% of the population.

Bigmouth buffalo weight and biomass were characterized using modeled weight data derived from weight-length relationships (Appendix 1). On average, bigmouth buffalo weighed 6.2 lbs. and individual weights varied 0.8-28.6 lbs. (n = 768). The total biomass of the sample was estimated at 759.1 lbs. based on the sum of the individual predicted weights. An estimated 90% of the population biomass was fish ≥ 15", 81% of biomass was fish ≥ 20", 52% of biomass was fish ≥ 25" and 21% of biomass was fish ≥ 30" (Figure 2).

The mark-recapture survey resulted in a very large, precise estimate of bigmouth buffalo abundance and biomass. Of the 2,907 buffalo marked, only 52 of the 5,114 fish examined were recaptured (Table 2), resulting in a low recapture rate (R/C = 1%). Mark-recapture abundance of bigmouth buffalo was estimated as 280,648 fish (95% CI: 215,311-372,956), with a high level of precision (CV = 13.5%). Bigmouth buffalo density was estimated as 619.5 fish/acre (95% CI: 475.3-823.3 fish/acre). Population biomass was estimated as 3,839.1 lbs./acre (95% CI: 2,945.3-5,101.8 lbs./acre) after factoring individual mean weight by the population density.

COMMON CARP

The common carp population showed less size diversity than what was observed with bigmouth buffalo. Common carp length ranged from 11.5-35.5 inches (n = 115) with a mean length of 22.3" (Figure 3 and Table 1). This population was primarily composed of larger sized individuals, with only 2% of common carp < 15". Specifically, size structure was comprised of 98% of fish ≥ 15", 67% of fish ≥ 20", 27% of fish ≥ 25", % of fish ≥ 30".

Common carp weight and biomass were characterized by analyzing the modeled weights derived from weight-length relationships (Appendix 1). Common carp weight varied from 0.6 to 11.8 lbs. (n = 115) with a mean weight of 5.2 lbs. The total biomass of the sample was 596.4 lbs. The majority of this biomass was contained in larger carp, primarily 20 to 30" fish (Figure 4). Specifically, 99% of the population biomass was

fish ≥ 15”, 80% of biomass was fish ≥ 20”, 41% of biomass was fish ≥ 25” and 2% of biomass was fish ≥ 30”.

The mark-recapture estimate for common carp abundance in Yellowstone Lake was much lower than big buffalo yet had similar precision (Table 2). Of the 1,084 carp marked at large in Yellowstone Lake, 26 of the 714 that were examined for marks were recaptured, resulting in a low recapture rate (R/C = 4%). Mark-recapture abundance of common carp was estimated as 28,731 (95% CI: 20,007-42,905) with a high level of precision (CV = 18.5%). Common carp density was estimated as 63.4 fish/acre (95% CI: 44.2-94.7 fish/acre). Common carp population biomass was estimated as 329.0 lbs./acre (95% CI: 229.1-491.2 lbs./acre) after factoring individual mean weight with the population density.

CONTRACT FISH REMOVALS

According to harvest reports, contract fishermen performed seining once in Fall of 2022, eight times in Spring of 2023 and five times in Fall of 2023 (Appendix 2). Bigmouth buffalo were removed during 13 of the 14 events and common carp were removed during 8 of the 14 events. The biomass removed, as reported from each seine haul, was variable for both species, with no apparent harvest trends over time. Bigmouth buffalo removal records did show an inconsistent decline in biomass removals from spring to fall, but these numbers only accounted for selectively harvested buffalo from each seine haul. An unknown amount of bigmouth buffalo were released from every seine haul because the contract fisherman specifically targeted marketable-size bigmouth buffalo (fish ≥ 16.5” or fish ≥ 3 lbs.) for removal. Selective harvest was not allowed for common carp. All carp captured in seines were reported and removed, except for the carp in the mark-recapture sample.

In total, 322,670 lbs. (712.3 lbs./acre) of bigmouth buffalo and 39,625 lbs. (87.5 lbs./acre) of common carp were removed from the lake during all seining events in 2022-2023 (Table 3). Following the completion of mark-recapture survey, contract fisherman removed 563.6 lbs./acre of bigmouth buffalo. This indicated that 14.7% of bigmouth buffalo population biomass were exploited based on the post-mark-recapture removals. Contract fisherman also removed 43.2 lbs./acre of common carp following the mark-recapture survey, indicating that 13.2% of its population biomass were exploited.

Discussion

Both bigmouth buffalo and common carp had sizeable populations in Yellowstone Lake based on population estimates and the magnitude of fish removed by contract fisherman. Bigmouth buffalo were more abundant than common carp. Bigmouth buffalo outnumbered common carp 10 to 1 and outweighed common carp biomass 12 to 1. Besides having a lower abundance, common carp size structure indicated

potential signs of recruitment limitations because few smaller and younger fish were present in the population. On the other hand, bigmouth buffalo size structure showed a greater diversity of sizes with signs of consistent recruitment of juvenile fish to the population. Based on recent research on statewide bigmouth buffalo age and growth dynamics, the bigmouth buffalo of Yellowstone Lake were found to be a relatively young population (age range = 1-15 years) with faster growth and several strong year-classes (R. Bohen, unpublished data, University of Wisconsin – Stevens Point). The strong recruitment and growth dynamics indicate a high level of productivity for this buffalo population. Productivity of this bigmouth buffalo population will likely change naturally over time as this introduced population ages and increases its longevity. With increased removal of adult bigmouth buffalo, the population productivity is assumed to decline. The same can be said for common carp which appear to be considerably less productive than bigmouth buffalo in Yellowstone Lake.

Little is currently known about the ecology and management of bigmouth buffalo, particularly that of translocated populations that have recently proliferated in reservoirs like Yellowstone Lake. It is not clear whether abundant bigmouth buffalo populations are symptomatic of turbid habitat conditions (Becker 1983; Edwards 1983) or if turbid conditions are the result of high bigmouth buffalo abundance (Carpenter et al. 1985; Robertson et al. 2000). With detrimental common carp still prevalent and a myriad of complex disturbances (e.g., watershed land use and internal nutrient loading) impacting Yellowstone Lake, it may be difficult to evaluate the effect of bigmouth buffalo removals on water quality. A recent study on bigmouth buffalo and common carp removals in Iowa showed that these removals showed little to no influence on gamefish populations and water quality measures (Simonson et al. 2023). Simonson et al. (2023) noted that more intensive long-term removal efforts could have positive effect on overall lake restoration, but that might not be feasible unless other nutrient reduction strategies are also implemented. DNR should continue to monitor for potential changes in the fish populations or water quality in the next 5 years in Yellowstone Lake following these bigmouth buffalo and common carp removals. Ultimately, the DNR may consider bigmouth buffalo removals in Yellowstone Lake if the current removals improve fish populations and water quality.

Undoubtably, bigmouth buffalo had a sizeable population in Yellowstone Lake, which raises questions about the validity of the density and biomass estimates. It was surprising that Yellowstone Lake had the capacity to support a bigmouth buffalo biomass of 3,839.1 lbs./acre. This biomass estimate was higher than most other midwestern bigmouth buffalo populations, which typically range from 0.5-1,144.0 lbs./acre in lakes and reservoirs (Carlander 1955; Mitzner 1972; Moen 1974; Colvin et al. 2015; Kramer et al. 2019). Further, reservoirs similar to Yellowstone Lake have a typical total fish standing stock biomass (i.e., for all fish species) range of 357-478 lbs./acre (Parisek et al. 2024). Additionally, the maximum limit for potential total standing stock fish biomass in U.S. reservoirs was 1,942.2 lbs./acre (Parisek et al. (2024). Population biomass estimates exceeding this maximum are probably rare or

unlikely. Yellowstone Lake likely has a high bigmouth buffalo biomass, but it is unlikely that this reservoir has the capacity to support 3,839.1 lbs./acre when most reservoirs in the USA can only support a fraction of this total biomass.

These high estimates of bigmouth buffalo density and biomass were attributed to a low recapture rate (R/C) during the mark-recapture survey. Initially, we thought all of the assumptions of the mark-recapture model were satisfied, but potential changes in sampling vulnerability may have influenced this low recapture rate. The recapture rate may have decreased during the survey if 1) marked fish died as a result of netting and therefore could not mix back into the population; 2) marked fish could have emigrated and-or avoided the areas of seining as a behavioral response; or 3) not enough time was allowed for marked fish to mix back in the population (Ricker 1975). For this mark-recapture survey, we suspected that marked bigmouth buffalo mortality occurred as result of netting stress, based on the prevalence of injured buffalo observed during contracted seining events. This was further confirmed after observing stressed and injured bigmouth buffalo during spring fyke netting and electrofishing surveys completed in 2023. With this in mind, we believe our abundance estimates for bigmouth buffalo were likely overestimated. It is unknown whether the abundance estimates for common carp were also impacted. Until these mark-recapture methodological issues are addressed, we do not recommend relying on these estimates (abundance, density and biomass) and exploitation rates to set realistic harvest goals for bigmouth buffalo in future Roughfish Contracts. As an alternative, we recommend annual monitoring of bigmouth buffalo and common carp populations using existing electrofishing methods as described by existing DNR lake survey protocols, Bajer and Sorenson (2012) and Annear et al. (2023).

Yellowstone Lake common carp were less numerous compared to bigmouth buffalo yet were still fairly abundant in the lake. Despite the accuracy issues with the buffalo population estimates, it was unknown if common carp density and biomass were also overestimated. Common carp appeared to be fairly abundant in the lake, but the population exhibited low recruitment. Common carp harvest was a small fraction of the total fish biomass removed by contract fisherman. Nonetheless, common carp biomass still exceeded 90 lbs./acre, a threshold known to be detrimental to water quality and habitat. However, when compared to other impacts such as nutrient loading and sediment accumulation from watershed land use, the impact of common carp may be relatively small. Common carp removals could be a practical management strategy in Yellowstone Lake, but only if other water quality impacts are minimized as well.

The 2022-2023 contract removal of common carp and bigmouth buffalo represented the largest annual amount of fish biomass removed from Yellowstone Lake in the last 20-30 years. Monitoring the biomanipulation effects of this fish removal on gamefish populations and water quality will be necessary to determine the utility of these removal efforts for fish management purposes. Stakeholders have noted that previous removal efforts in the early-2000s resulted in improved water clarity and

fishery quality. If these stakeholder observations hold true, the magnitude of this fish removal should result in changes to Yellowstone Lake. Regardless, additional monitoring and evaluation will be required before pursuing further fish removal actions.

Surprisingly, contract fishermen reported a decline in the number of harvestable buffalo and carp biomass during their final seining efforts in fall of 2023, which was on average lower than their previous harvest reports. Estimates of biomass exploitation for bigmouth buffalo (14.7%) and common carp (13.2%) were much lower than the contract fishermen expected. The contract fishermen thought exploitation rates would be closer to 50% for both fish species. Since biomass estimates were potentially overestimated, it is likely that these exploitation rates were higher. Contract fishermen were concerned that attempting to achieve future harvest goals for buffalo and carp would not be economically feasible, based on these population estimates and their diminishing harvests.

The DNR recognizes the concerns of contract fisherman, but it should be noted that contract fishermen selectively focused their removal efforts more on marketable-sized bigmouth buffalo (fish ≥ 20”) and less on smaller buffalo and common carp. Although all common carp captured were removed, they were less desired by contract fisherman due to a limited market; common carp often yield a lower price than buffalo. Market prices for carp and buffalo tended to control the harvest intensity of contract fisherman, who attempted to maintain market prices by selling smaller loads over time rather than flooding the market with all the marketable size buffalo at one time. Some states incentivize contract fisherman to intensively harvest more detrimental fishes, but surprisingly, that has not resulted in increased harvest (Simonson et al. 2023). Contract fisherman also tended to limit the removal of bigmouth buffalo in order to provide future harvest opportunities. Contract fishermen and DNR goals are not often aligned because sustainable fishing effort may not accomplish resource management goals. If commercial harvest does not maximize exploitation of detrimental fishes, it will be difficult to achieve management success. Due to the lack of reliable population estimates and various concerns related to contract fishing, pursuing a Rough Fish Removal Contract is not recommended at this time. A better understanding of the effectiveness and feasibility of these partial removals is needed before considering future contracts.

Recommendations

1. Continue ongoing annual efforts to monitor fish populations and water quality measures in Yellowstone Lake to better understand response to common carp and bigmouth buffalo removals for the next five years (2024-2029).

2. Avoid using the bigmouth buffalo population density and biomass estimates from this assessment for management purposes due to potential overestimation issues.

3. Do not pursue roughfish removal contracts for Yellowstone Lake at this time.

4. Use future results from annual monitoring efforts to determine if further common carp and buffalo removals are feasible and-or necessary.

References

Annear, A.R., M.A. Simonson, P.M. Dixon, and M.J. Weber. 2023. Intra-annual variability of common carp and bigmouth buffalo electrofishing data in shallow lakes. North American Journal of Fisheries Management, 43: 556-568.

Bajer, P. G., and P. W. Sorensen. 2012. Using Boat Electrofishing to Estimate the Abundance of Invasive Common Carp in Small Midwestern Lakes, North American Journal of Fisheries Management, 32(5): 817-822.

Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press. 1025 pp.

Carpenter, S.R., J.F. Kitchell, and J. R. Hodgson. 1985. Cascading trophic interactions and lake productivity. BioScience, 35: 634-39.

Colvin, M.E., T.W. Stewart, and C.L. Pierce. 2015. A food web modelling analysis of a Midwestern, USA eutrophic lake dominated by non-native Common Carp and Zebra Mussels. Ecological Modelling, 32: 26-40.

Edwards, E.A. 1983. Habitat suitability index models: Bigmouth Buffalo. U.S. Fish and Wildlife Service, Department of the Interior, Washington, DC. Report FWS/OBS82/10.34 September 1983. 19 pp.

Kramer, N., Q.E. Phelps, C.L. Pierce, and M.E. Colvin. 2019. A Food Web Modelling Assessment of Asian Carp Impacts in the Middle and Upper Mississippi River. Food Webs. https://doi.org/10.1016/j.fooweb.2019.e00120

Lange, R.J., A. Wright, and B. Simms. 2007. Yellowstone Lake Watershed improvement project. Final Report July 1998 through December 2006 for Wisconsin DNR River Management Grant, LPT-111. 13 pp.

Mitzner, L. 1972. Population studies of bigmouth buffalo in Coralville Reservoir with special reference to commercial harvest. Iowa Conservation Commission, Des Moines, Iowa. 37pp.

Moen, T.E. 1974. Population trends, growth, and movement of Bigmouth Buffalo, Ictiobus cyprinellus, in Lake Oahe, 1963-70. Technical Papers of the U.S. Fish and Wildlife Service. Report #78. 20 pp.

Ricker, W.E. 1976 Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 191. 382 pp.

Robertson, D.M., G.L. Goddard, Daniel Helsel, and K.L. MacKinnon. 2000. Rehabilitation of Delevan Lake, Wisconsin. Lake and Reservoir Management, 16 (3): 155-176.

Simonson, M.A., M.J. Weber, G.M. Wilkinson and A.R. Annear.2023. Annual changes in water quality and sportfish community structure following commercial harvest of common carp and bigmouth buffalo, Lake and Reservoir Management, DOI: 10.1080/10402381.2023.2209780

Welke, K., and J. Derks. 2015. Common carp and the Cherokee Marsh: population and biomass estimate for evaluation of management strategies. Wisconsin DNR Fisheries Survey Report. 16 pp.

Tables and Figures

Table 1. Size structure summary of bigmouth buffalo and common carp populations in Yellowstone Lake, Lafayette County, during contracted seining in Fall of 2022.

SPECIES	TOTAL NUMBER MEASURED	AVERAGE LENGTH (inches)	LENGTH RANGE (inches)	PERCENT OF FISH ≥ 15"	PERCENT OF FISH ≥ 20"	PERCENT OF FISH ≥ 25	PERCENT OF FISH ≥ 30"
Bigmouth buffalo	768	19.3	11.5-35.5	65	45	22	6
Common carp	115	22.3	9.5-31.5	98	67	27	2

Table 2. Summary of mark-recapture statistics and the population estimates of bigmouth buffalo and common carp in Yellowstone Lake, Lafayette County, during contracted seining events in Spring of 2023. These population estimates include abundance, density and biomass (i.e., derived from density estimates). Values in parentheses represents the 95% confidence intervals for each type of population estimate.

SPECIES	NUMBER MARKED	NUMBER CAPTURED	NUMBER RECAPTURED	ABUNDANCE (NUMBER OF FISH)	DENSITY (FISH/ACRE)	BIOMASS (POUNDS/ACRE)
Bigmouth buffalo	2,907	5,114	52	280,648.4 (215,311.4-372,955.7)	619.5 (475.3-823.3)	3,839.1 (2,945.3-5,101.8)
Common carp	1,084	714	26	28,731.4 (20,007.5-42,905.3)	63.4 (44.2—94.7)	329.0 (229.1-491.2)

Table 3. Summary of harvest and exploitation rate of bigmouth buffalo and common carp biomass removed during contracting seining events in Yellowstone Lake, Lafayette County, 2022-2023. Total biomass harvested was calculated for the entire Experimental Contract period and after completion of the mark-recapture survey. Biomass exploitation rate is the percentage of population biomass harvested by contract fishermen after completion of the mark-recapture survey.

SPECIES	Total Biomass Harvested During Entire Contract Period (pounds/acre)	Total Biomass Harvested After Mark-Recapture Survey (pounds/acre)	Biomass Exploitation Rate (%)
Bigmouth buffalo	712.3	563.6	14.7%
Common carp	87.5	43.3	13.2%

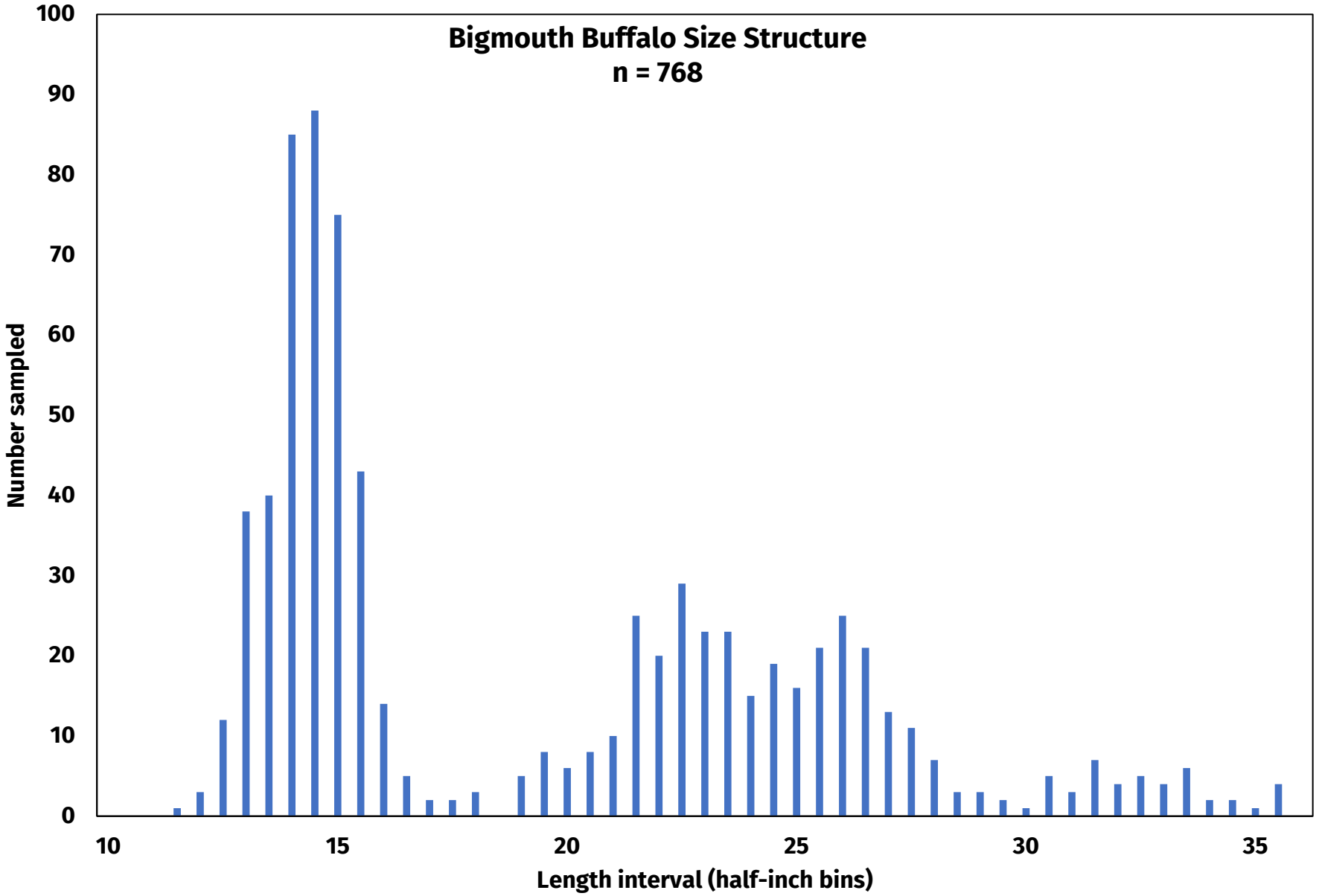


Figure 1. Length frequency distribution of bigmouth buffalo sampled during initial contract seining event in Fall of 2022, in Yellowstone Lake, Lafayette County.

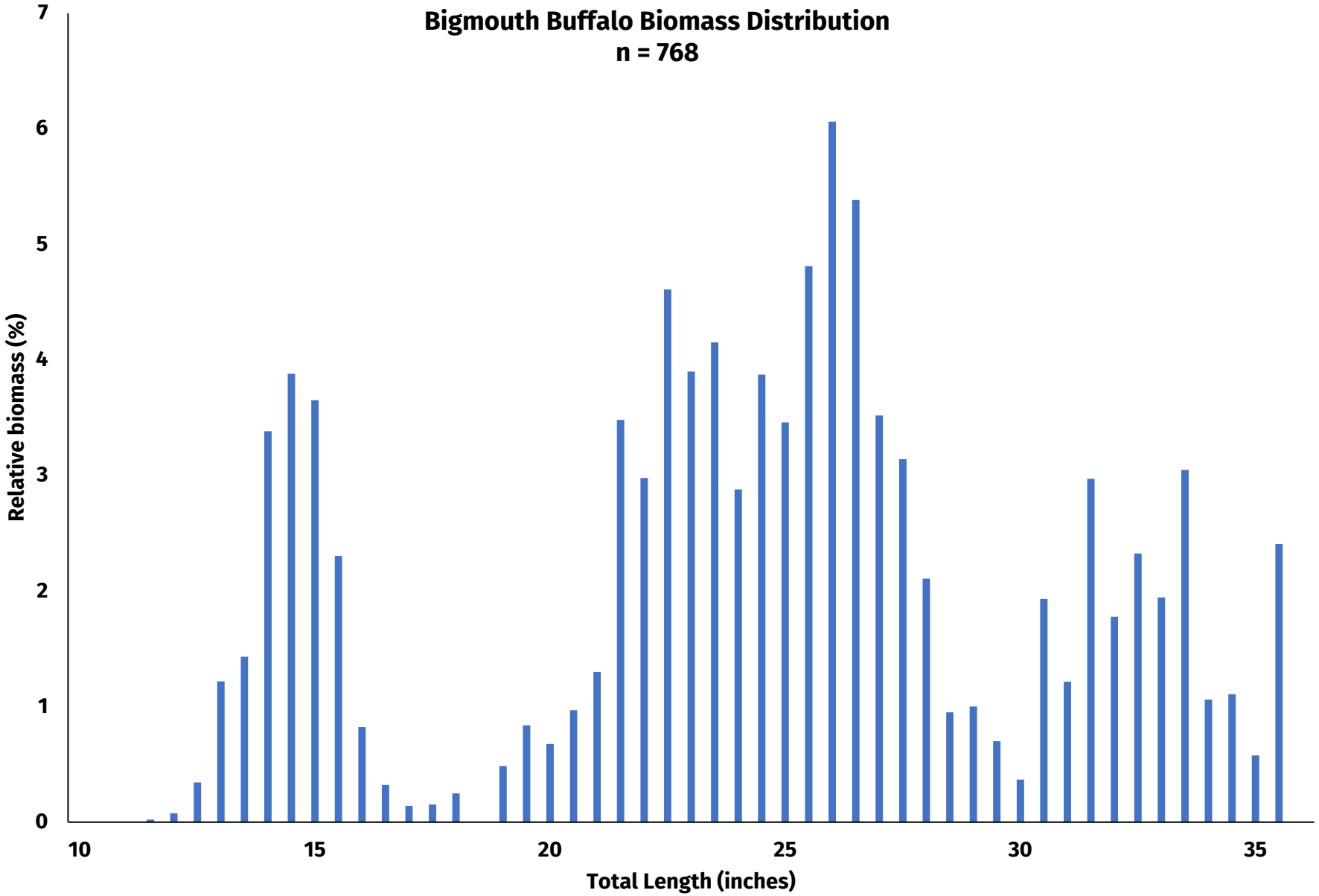


Figure 2. Relative biomass (%) distribution of bigmouth buffalo across its length range. Bigmouth buffalo population data collected during contract seining events in Fall of 2022, in Yellowstone Lake, Lafayette County.

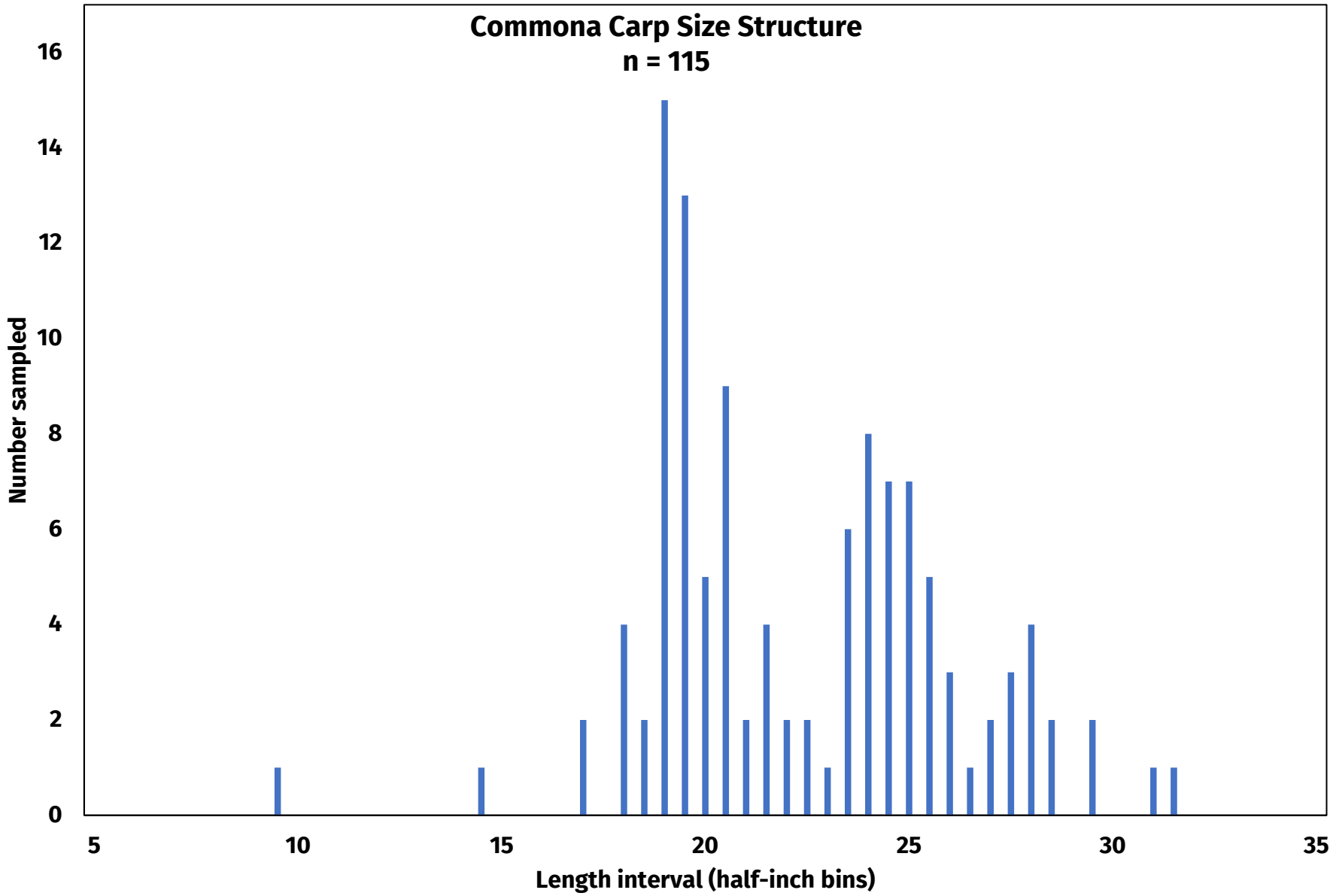


Figure 3. Length frequency of common carp sampled during initial contract seining event in Fall of 2022, in Yellowstone Lake, Lafayette County.

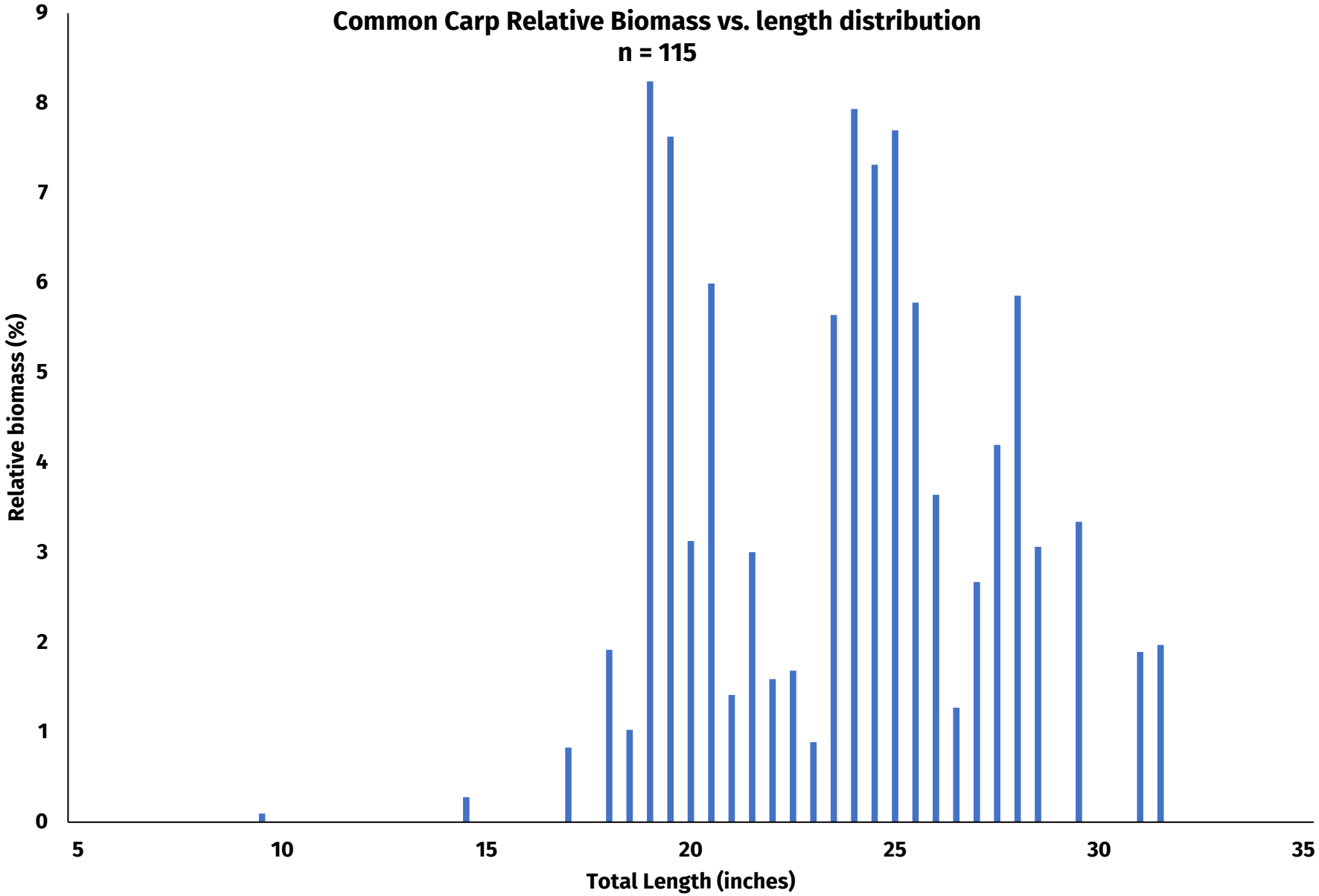
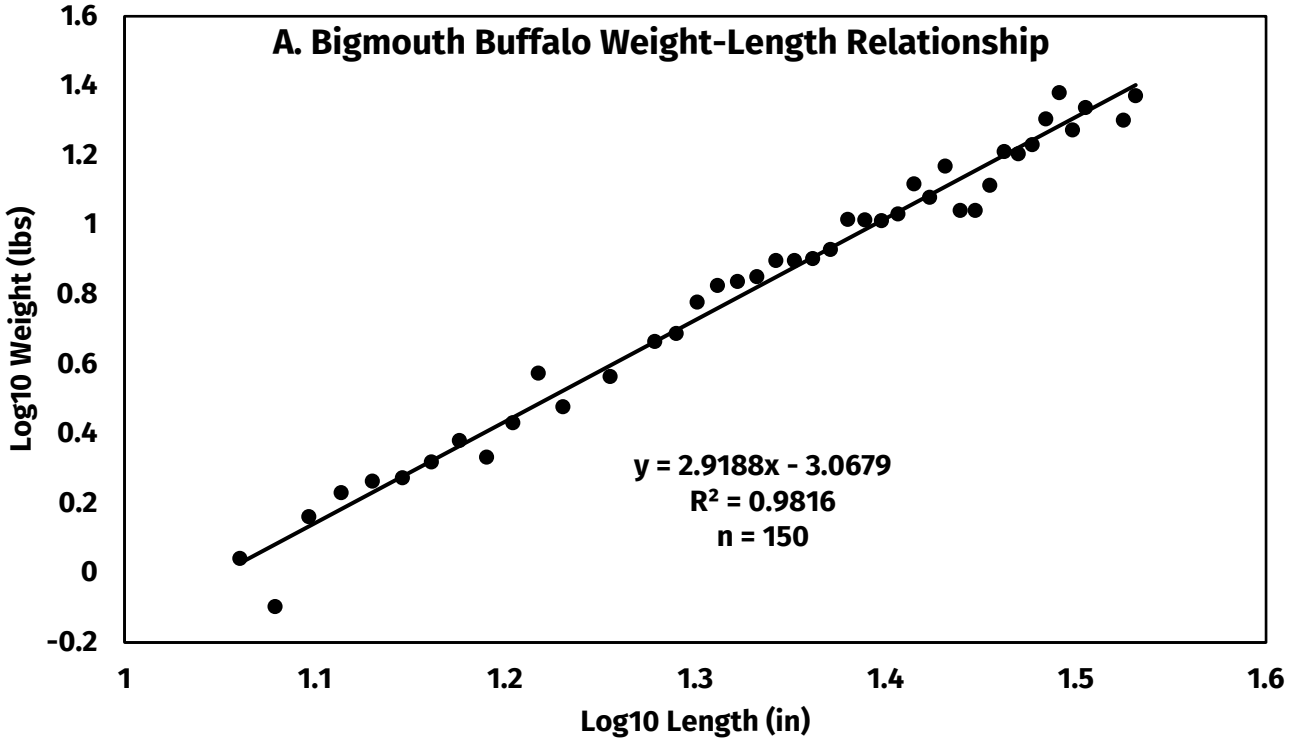
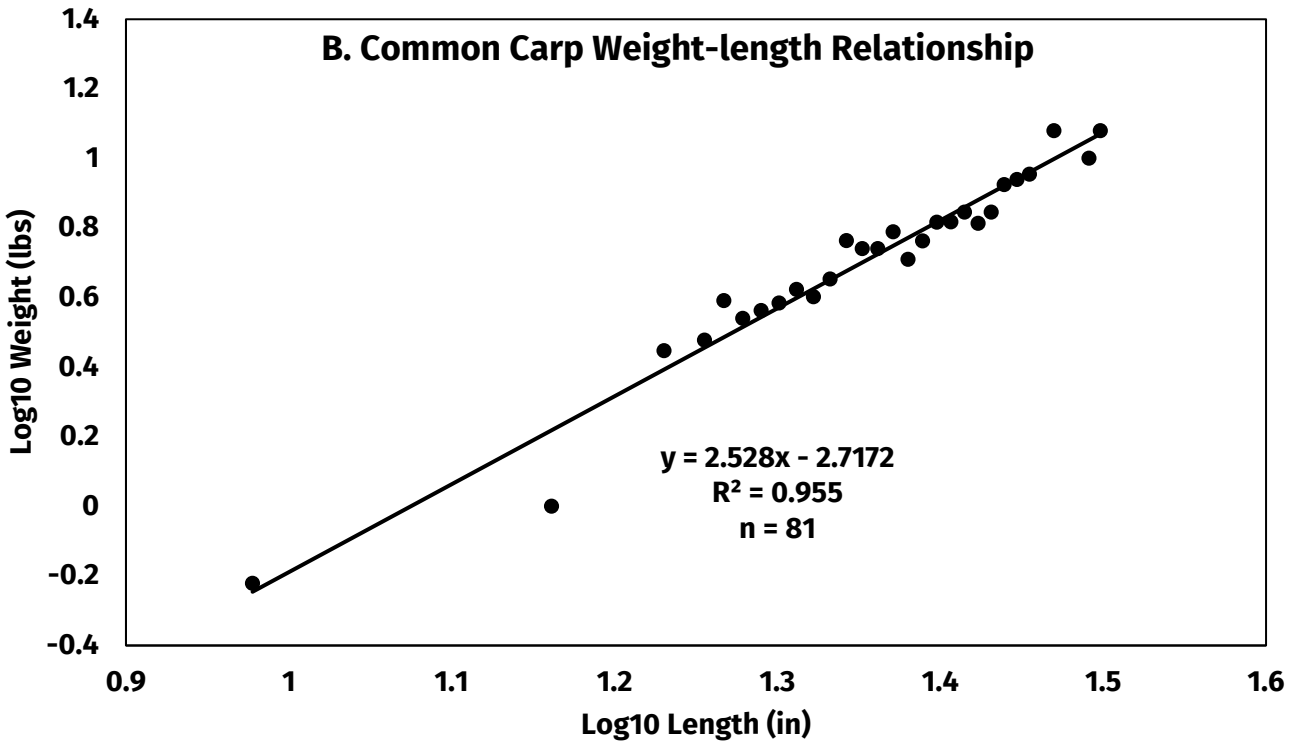


Figure 4. Relative biomass (%) distribution of common carp across its length range. Common carp population data collected during contract seining events in Fall of 2022, in Yellowstone Lake, Lafayette County.

Appendix 1. Fish weight-length relationships.

Plots and regression equations describing the weight-length relationship of A) bigmouth buffalo and B) common carp in Yellowstone Lake, collected during contracted seining events in fall of 2022. Weight (pounds) and length (inches) data were Log-transformed (base-10) to meet assumptions of the linear model. Weight represents an average per half-inch length bin, so sample size (n) of number of individuals measured is actually greater than what datapoints appear on the plot.





Appendix 2. Contract fish removal summary.

	BIGMOUTH BUFFALO				COMMON CARP			
HARVEST DATE	BIOMASS REMOVED (lbs.)	CUMULATIVE BIOMASS REMOVED (LBS/ACRE)	CUMULATIVE BIOMASS REMOVED AFTER MARK-RECAPTURE SURVEY (LBS/ACRE)	PERCENT OF POPULATION BIOMASS REMOVED	BIOMASS REMOVED (lbs.)	CUMULATIVE BIOMASS REMOVED (LBS/ACRE)	CUMULATIVE BIOMASS REMOVED AFTER MARK-RECAPTURE SURVEY (LBS/ACRE)	PERCENT OF POPULATION BIOMASS REMOVED
10/18/2022	18,700.0	41.3	0.0	0.0	0.0	0.0	0.0	0.0
3/29/2023	48,670.0	148.7	0.0	0.0	20,000.0	44.2	0.0	0.0
4/2/2023	41,810.0	241.0	92.3	2.4	4,000.0	53.0	8.8	2.7
4/7/2023	41,020.0	331.6	182.8	4.8	0.0	53.0	8.8	2.7
4/14/2023	18,370.0	372.1	223.4	5.8	0.0	53.0	8.8	2.7
4/24/2023	18,800.0	413.6	264.9	6.9	3,500.0	60.7	16.6	5.0
4/28/2023	20,150.0	458.1	309.4	8.1	0.0	60.7	16.6	5.0
5/2/2023	20,000.0	502.3	353.5	9.2	6,500.0	75.1	30.9	9.4
5/5/2023	17,500.0	540.9	392.2	10.2	75.0	75.2	31.1	9.4
9/15/2023	29,000.0	604.9	456.2	11.9	300.0	75.9	31.7	9.6
9/26/2023	13,650.0	635.0	486.3	12.7	350.0	76.7	32.5	9.9
9/28/2023	15,400.0	669.0	520.3	13.6	400.0	77.5	33.4	10.1
10/18/2023	0.0	669.0	520.3	13.6	0.0	77.5	33.4	10.1
11/25/2023	19,600.0	712.3	563.6	14.7	4,500.0	87.5	43.3	13.2