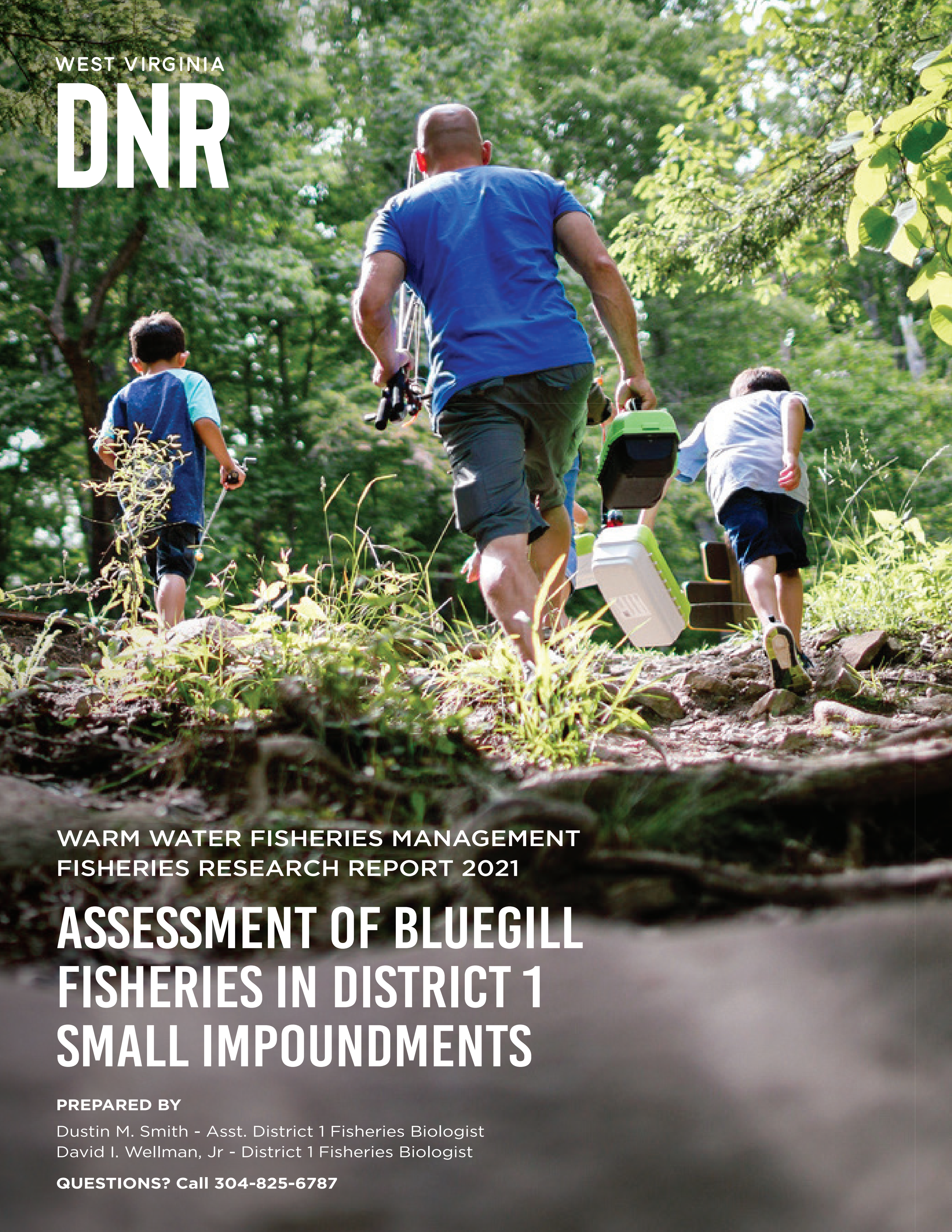


WEST VIRGINIA
DNR

WARM WATER FISHERIES MANAGEMENT
FISHERIES RESEARCH REPORT 2021

ASSESSMENT OF BLUEGILL FISHERIES IN DISTRICT 1 SMALL IMPOUNDMENTS

PREPARED BY

Dustin M. Smith - Asst. District 1 Fisheries Biologist
David I. Wellman, Jr - District 1 Fisheries Biologist

QUESTIONS? Call 304-825-6787

EXECUTIVE SUMMARY

INTRODUCTION

- Although Bluegill are one of the most popular species targeted by anglers, little research has been conducted on Bluegill fisheries in West Virginia.
- Given the popularity of Bluegill with anglers, WVDNR Fish Management staff sought to evaluate existing and potential Bluegill fisheries in several District 1 small impoundments.
- Specifically, five small impoundments (Dents Run, Dixon, Dunkard Fork, Mason, and Teter Creek Lakes) were evaluated for suitability for management improvements to Bluegill fisheries.

OBJECTIVES

- Identify one or more small impoundments with the potential for enhanced Bluegill fisheries.
- Determine factors important in structuring Bluegill populations relating to size structure, age structure, and abundance.
- Utilize results to determine the most effective management strategies to enhance current Bluegill fisheries.

METHODS

- Spring and Fall night boat electrofishing were used to collect Bluegill and other species.
- Otoliths were removed from a sub-sample of Bluegill from each lake to determine age and growth.
- Relative abundance, total annual mortality, size structure, age structure, and growth of Bluegill were calculated.
- Aquatic habitat surveys were conducted for each impoundment.
- Angler surveys were conducted to determine angler attitudes and opinions towards the fisheries and potential management actions.

DUNKARD FORK LAKE

Dunkard Fork Lake was determined to provide poor Bluegill fishing opportunities and to be unsuitable for management actions.

- In comparison to other lakes, Bluegill in this lake displayed moderately low total annual mortality (45%) and older age structure, but slow growth and poor size structure.
- Slow growth is likely due to the high density of Gizzard Shad and Common Carp in this lake which compete with Bluegill for resources and lead to decreased predation on Bluegill by Largemouth Bass.
- This lake is currently managed for quality Largemouth Bass (currently Catch & Release) and is best suited for this management strategy into the future.

DIXON LAKE

Dixon Lake was determined to provide good Bluegill fishing opportunities but is unsuitable for additional management actions.

- The lake is currently managed as Catch & Release for all species and only barbless hooks are permitted, specifically to provide for high catch rates for children and families.
- Under its current management strategy, Bluegill growth and size structure is not excellent, but is still considered good. Total annual mortality was the lowest among the study lakes (42%), likely due to current special regulations.
- High densities of Largemouth Bass reduce densities of small Bluegill (< 5 inches) and facilitate fast Bluegill growth at young ages.
- The absence of angler harvest may contribute to high densities of intermediate size Bluegill (5-7 inches) and reduce growth at these sizes due to competition.
- The lake is small (6 acres), and it would be difficult to allow harvest without the potential for overharvest to occur.
- Anglers are very satisfied with the special regulations currently in place.

DENTS RUN LAKE

Dents Run Lake was determined to provide very good Bluegill fishing opportunities and is suitable for additional management actions.

- Bluegill in this lake displayed fast growth to age-4 and good size structure with an abundance of "preferred" size fish (≥ 8 inches).
- Growth after age-4 was limited and Bluegill rarely grew larger than 8.5 inches despite only moderate total annual mortality (53%) and older age structure.
- Lack of forage diversity and high density of young Bluegill may limit total attainable growth.
- Presence of other prey (i.e., Yellow Perch) for Largemouth Bass may also contribute to limited maximum growth.
- Due to walk-in access only, lower fishing pressure, and only moderate mortality, special regulations are not recommended at this time.

- Aquatic habitat management (woody debris additions, aquatic vegetation control, etc.) is recommended as a potentially beneficial management action to increase forage diversity and increase mortality of young Bluegill via predation.
- Additionally, introduction of other predator species (i.e., Hybrid Striped Bass, Walleye) could be considered should young Bluegill density become a concern.

MASON AND TETER CREEK LAKES

Mason and Teter Creek Lakes were determined to provide fair Bluegill fishing opportunities and are both suitable for additional management actions, including special regulations.

- Bluegill in these lakes displayed fast growth to age-4 (~ 8 inches) and moderate growth after age-4 with the potential for large sizes (> 9 inches).
- Bluegill in these lakes displayed fair size structure but few fish ≥ 8 inches are available.
- Likewise, few Bluegill survive past age-4 in these lakes and both have high total annual mortality compared to other lakes (Mason Lake = 80%, Teter Creek Lake = 65%, other lakes = 42 – 53%).
- Low abundances of older, larger Bluegill despite good growth and high total mortality rates may indicate higher angler harvest of these fish.
- Angler surveys indicated these impoundments received the highest fishing pressure during the study.
- Most anglers interviewed for this study (90%) supported special Bluegill regulations to improve size structure of Bluegill populations.
- As a result of this study, we implemented special regulations to limit harvest of Bluegill to increase abundance and availability of larger, older fish to anglers within Mason and Teter Creek Lakes.
- The resulting special regulation was a 10-fish daily limit on Bluegill and other sunfish species in aggregate, of which only 5-fish may be 8 inches or longer on Mason Lake and Teter Creek Lake.
- This special regulation should limit overall harvest of Bluegill and should also conserve older, larger Bluegill and potentially increase the abundance and availability of these larger fish to anglers in these lakes.
- This regulation has the potential to create special opportunities for anglers to catch large Bluegill and harvest quality fish.
- An evaluation of the success of this regulation will occur after a period of 5 years to determine if changes are necessary.

INTRODUCTION

Bluegill (*Lepomis macrochirus*) and other sunfish species (*Lepomis spp.*) are popular sportfish for anglers throughout North America and West Virginia. A report on West Virginia anglers found that approximately 23% of anglers targeted panfish species, behind only black bass (43%) and trout (38%) (USFWS 2011). Bluegill are often targeted by novice anglers due to their abundance, limited gear necessary to pursue them and their relative ease of being caught. However, there are also experienced anglers that specifically target Bluegill, often pursuing large individuals either for consumption or for the excitement of catching a memorable sized fish.

Despite their popularity, the West Virginia Division of Natural Resources (WVDNR) has conducted little research or management actions geared toward sunfish populations. West Virginia has many small impoundments and reservoirs that already support healthy sunfish populations or have the potential to support quality fisheries. With appropriate management actions and presence of favorable small impoundment characteristics, quality fisheries could be improved further or fisheries with high potential could yield more productive results. Potential management actions to improve sunfish fisheries could include regulatory changes, habitat enhancement, or predator population management.

Recognizing the potential for Bluegill fisheries and current lack of management strategies, WVDNR District 1 Fish Management staff initiated a research project examining the potential for enhanced Bluegill fisheries in five small impoundments in northern West Virginia. Impoundments were chosen that had varying current management strategies, habitat, and accessibility. Objectives for this project were to: 1). Identify one or more small impoundments with the potential for enhanced Bluegill fisheries, 2). Determine factors that impact size structure, age structure, and abundance of Bluegill populations, 3). Utilize results to determine the most effective management strategies to enhance current Bluegill fisheries.

STUDY AREAS

Five small impoundments in northern West Virginia were selected for evaluation of current Bluegill populations (Figure 1). These small impoundments were: Dents Run Lake (29 acres; Marion County), Dixon Lake (6 acres; Monongalia County), Dunkard Fork Lake (30 acres; Marshall County), Mason Lake (9 acres; Monongalia County), and Teter Creek Lake (36 acres; Barbour County). All impoundments were located on WVDNR Wildlife Management Areas in District 1. Each of the impoundments varied in current management practices, habitat, and accessibility.

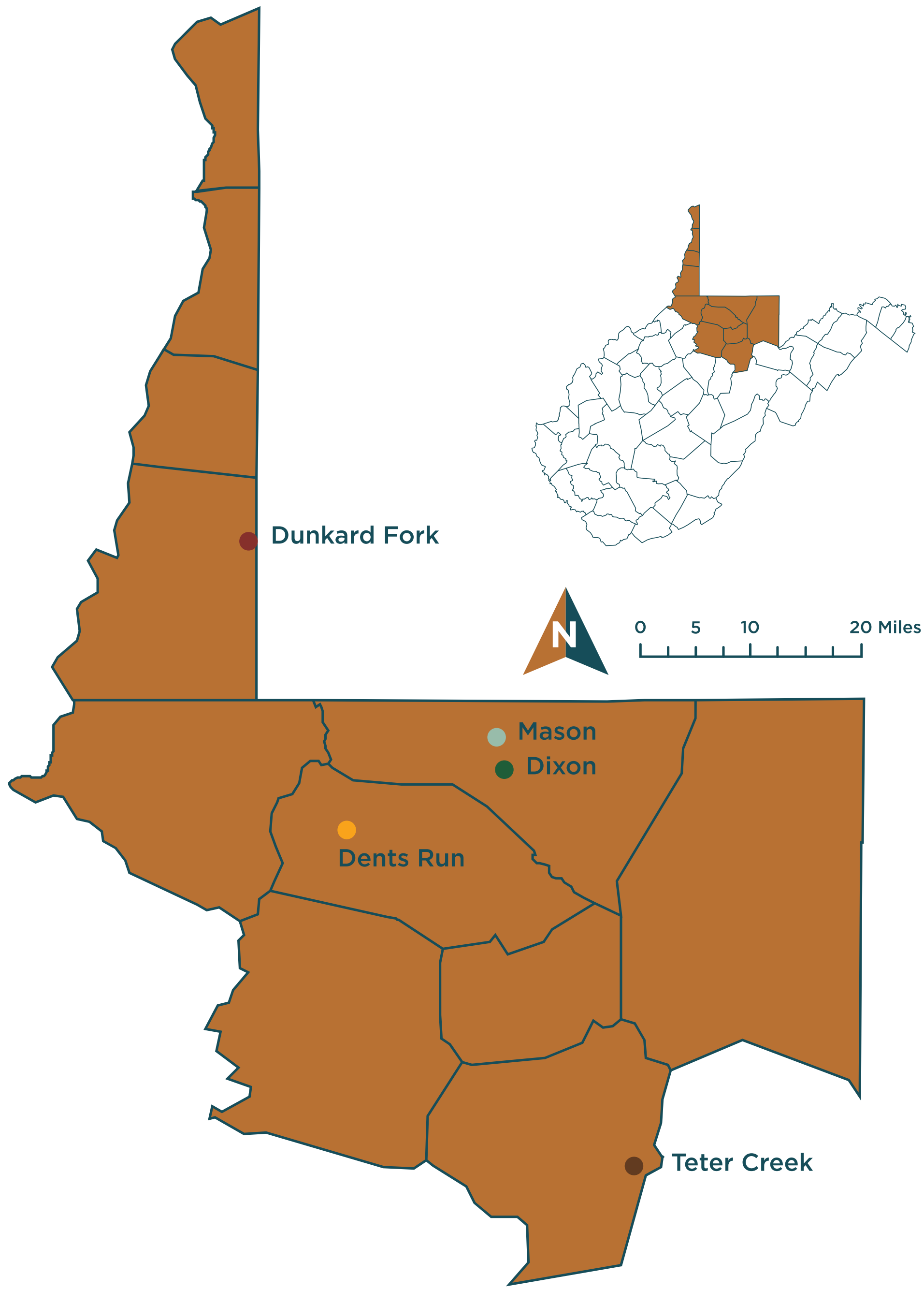


FIGURE 1. Location of the five District 1 Bluegill study impoundments.

Dents Run Lake is 29 acres in size with a maximum depth of 40 feet, is narrow and long in shape, with steep sided banks and relatively clear water conditions. Dents Run Lake supports populations of Bluegill, Largemouth Bass, Yellow Perch, Black Crappie, and Channel Catfish. The lake is not stocked with trout. Primary aquatic habitat includes dense stands of narrow leaf pondweed to a depth of 10-14 feet. Due to the steep sloped banks of the lake and resulting limited littoral area, vegetation does not cover a large portion of the lake but does encompass most areas of the eastern cove and the head of the lake. There is little submerged large woody debris within the lake, but much of the shoreline is bordered by partially submerged shrubs which provide overhanging cover. Dents Run Lake is only accessible by foot, as anglers must park near the base of the dam and walk approximately 350 yards to the lake. Shoreline fishing is available for approximately 60% of the lake. Dents Run Lake is managed by general regulations for all species of fish within it.

Dixon Lake is 6 acres in size with a maximum depth of 14 feet, is a simple basin shape, with gradual banks and moderately turbid water conditions. Dixon Lake supports populations of Bluegill, Largemouth Bass, and Channel Catfish. The lake is not stocked with trout. Primary aquatic habitat includes moderate coverage of broad-leaf pondweed and water nymph. Due to its shallow depth, a significant portion of the western end of the lake is covered by vegetation. There is little submerged large woody debris within the lake. Dixon Lake is highly accessible, having multiple parking lots and a trail that encircles the lake. Dixon Lake is managed with special regulations, with catch and release for all species within it and only barbless hooks are permitted.

Dunkard Fork Lake is 30 acres in size with a maximum depth of 14 feet, has gradually sloping banks and turbid water conditions. Dunkard Fork Lake supports populations of Bluegill, Largemouth Bass, White Crappie, and Channel Catfish, and has high densities of Common Carp and Gizzard Shad. During the sampling period, this lake was stocked with trout. However, trout stocking has since been discontinued. Primary aquatic habitat includes standing timber and limited densities of Eurasian watermilfoil. Dunkard Fork Lake has high levels of sedimentation and consequently, approximately 16 acres of the southern end have been filled in to non-boatable levels with sediment. Dunkard Fork Lake is moderately accessible with a parking lot and shoreline fishing covering approximately 50% of the lake. A debris deflector to prevent large woody material from damaging the riser was installed by the impoundment's owner which limits boaters from utilizing the lower seven acres near the dam. Dunkard Fork Lake is managed by a combination of special and general regulations. The lake is catch and release for Largemouth Bass, but general regulations for all other species.

Mason Lake is 9 acres in size with a maximum depth of 35 feet, has steep sloping banks and clear water conditions. Mason Lake supports populations of Bluegill, Largemouth Bass, Black Crappie, Muskellunge, and Channel Catfish. Mason Lake is currently stocked monthly with trout, January – May. Aquatic habitat includes extensive standing timber and other large woody debris. There are also some areas of the lake with moderate densities of water nymph and broad leaf pondweed. Mason Lake is highly accessible with a parking lot and fisherman's trail that provides shoreline fishing for approximately 50% of the lake. Mason Lake is managed with general regulations for all species.

Teter Creek Lake is 36 acres in size with a maximum depth of 22 feet, has moderately sloping banks and moderately clear water conditions. Teter Creek Lake supports populations of Bluegill, Largemouth Bass, Black Crappie, Yellow Perch, Muskellunge, and Channel Catfish. Teter Creek Lake is stocked bi-weekly with trout January – May. Aquatic habitat includes moderate densities of aquatic vegetation including broad leaf pondweed, watershield, water lily, and water nymph. There is limited large woody debris. Teter Creek Lake is highly accessible with a parking lot and fisherman's trail that provides shoreline angling for nearly the entire lake. Teter Creek Lake is managed with general regulations for all species.

METHODS

From 2016 – 2018, Bluegill and other species were sampled in small impoundments via nighttime boat electrofishing in spring and fall. Spring surveys were utilized for standard population assessment measures (i.e., CPUE, PSD, etc.) while fall surveys were specifically utilized to collect age and growth information. Nighttime boat electrofishing surveys were conducted along the shoreline of each impoundment in depths no greater than 8 feet to maximize capture efficiency. Dependent on impoundment size, 3 – 5 ten minute transects were conducted with two dip netters capturing fish. All species were collected but Bluegill and Largemouth Bass were specifically targeted. After collection, fish were identified to species and enumerated, measured for total length, weighed (in fall only), and in the fall a sub-sample (target of 10 Bluegill from each one-inch size class) of Bluegill were retained for age and growth analysis.

In addition to sampling fish populations in target small impoundments, angler creel surveys were also conducted on all study impoundments (except Dunkard Fork Lake) during Summer 2018 (May – August) to gather information on angler opinions and harvest behavior. Due to creel clerk availability, angler surveys were only conducted from May – August, which did not encompass the majority of the trout stocking season for those waters in which stocking occurs. Therefore, angler survey information is limited to summer fishing patterns. A survey clerk visited each small impoundment 3 days per week (2 weekdays and 1 weekend day) with 4 hours spent each day visited. Due to safety concerns, creel clerks were not present during the first and last hours of daylight during survey days. Angler responses were summarized to determine the most popular species targeted, satisfaction with current fishing conditions, harvest behavior (species harvested, sizes harvested), and opinions on future regulations.

Bluegill retained for age and growth analysis were processed in the laboratory. Sagittal otoliths were removed from each fish for aging. Otoliths were either read whole under a dissecting microscope or cracked, polished with sandpaper, and subsequently read. Two independent readers aged fish by counting visible annuli. If readers disagreed, otolith examination was done in concert until an agreement was made If no agreement occurred, the otolith was removed from the sample.

To describe overall relative abundance, estimates of catch-per-unit effort (CPUE) by species were calculated for each lake. CPUE was measured as the number of fish captured per hour of electrofishing (fish/hr.). CPUE was calculated for both Bluegill and Largemouth Bass in each small impoundment.

We described size structure of Bluegill populations using length-frequency distributions, calculations of proportional size distribution (PSD), mean length (for stock size and larger Bluegills) and size specific estimates of CPUE for each impoundment. Length-frequency histograms were constructed using 1.0 inch-group intervals (Neumann et al. 2012). We estimated proportional size distributions (Gabelhouse 1984; Neumann et al. 2012) using the following length categories originally described by Gabelhouse (1984); stock (3.0 – 5.9 in), quality (6.0 – 7.9 in), preferred (8.0 – 9.9 in), memorable (10 – 11.9 in), and trophy (≥ 12 in). In addition to the Gabelhouse categories, we also estimated proportion of Bluegills ≥ 9.0 inches (PSD-9). CPUE was calculated for each PSD category as well as a calculation of CPUE for Bluegills ≥ 9.0 inches.

Bluegill growth was described using estimates of mean length at age and the von Bertalanffy growth model fitted to length at age data. The von Bertalanffy growth model describes length at age t as:

$$L(t) = L\infty[1 - \exp(-k(t-t0))]$$

where L∞ is average maximum length, k represents how quickly L∞ is reached, and t0 is the theoretical age when length is equal to zero (Quist et al. 2012). Growth rates were compared among study impoundments using analysis of covariance of log10 (total length) – age regressions (Sammons et al. 2006). We also compared Bluegill growth in our study impoundments to North American Bluegill growth standards published by Jackson et al. (2008). We calculated a relative growth index (RGI) using the equation RGI = (Lt / Ls) x 100, where Lt represents observed length at age and Ls represents the predicted age-specific standard length (Jackson et al. 2008). An RGI of 100 indicates that growth is similar to the average growth across North America, whereas values < 100 indicate below average growth and values > 100 indicate above average growth (Jackson et al. 2008). We also determined the percentile rank of Bluegill length at age utilizing the system presented in Jackson et al. (2008).

We described age structure and mortality of Bluegill populations using catch at age data and a corresponding age-length key calculated from catch at age data. Age-frequency distributions were calculated for each impoundment to describe overall age structure. Age-frequency distributions were compared across lakes using Kolmogorov-Smirnov tests (Sammons et al. 2006). Additionally, to describe prevalence of older age fish, estimates of CPUE and proportion of age-4 and older Bluegill were calculated. We used age class data and catch curve linear regression to estimate instantaneous mortality rate (Z) and total annual mortality (A) for Bluegill populations. Mortality rates were compared for statistical differences across lakes using analysis of covariance (Sammons et al. 2006). We conducted all analyses using the Fisheries Analysis and Modeling Simulator (FAMS version 1.64; Slipke and Maceina 2014) and R version 3.6.1 (R Core Development Team 2019).

RESULTS

We collected 3,382 Bluegill across five small impoundments from 2016 – 2018. Bluegill CPUE (fish ≥ 3 inches) was highest in Dents Run Lake (350 fish/hr.) and Dixon Lake (311 fish/hr.). In contrast, Bluegill CPUE was lowest in Teter Creek Lake (99 fish/hr.) and Mason Lake (139 fish/hr.). Dunkard Fork Lake had an intermediate Bluegill CPUE (256 fish/hr.).

Mean length of Bluegill was greatest in Mason Lake (5.6 inches), followed by Dixon Lake (5.4 inches), Dents Run Lake (5.3 inches), Teter Creek Lake (5.1 inches) and Dunkard Fork Lake (4.7 inches). Mean maximum total length (mean length of 10 longest fish; Rypel 2015) of Bluegill was greatest in Dents Run Lake (8.6 inches), followed by Dixon Lake (8.0 inches), Mason Lake (8.0 inches), Teter Creek Lake (7.5 inches), and Dunkard Fork Lake (6.9 inches). Length-frequency distributions were significantly different ($p < 0.05$) across all lake comparisons, except for between Mason and Dixon Lakes. These two lakes had statistically similar length-frequency distributions. CPUE of preferred length Bluegill (≥ 8 inches) was highest in Dents Run Lake (44.6/hr.), followed by Dixon Lake (16.9/hr.), Mason Lake (10.8/hr.), Teter Creek Lake (9.5/hr.), and Dunkard Fork Lake (0/hr.) (Figure 2). CPUE of Bluegill ≥ 9 inches followed a similar rank order (Figure 3). Dents Run Lake and Dixon Lake had the greatest relative abundance of Bluegill ≥ 9 inches (3.6/hr. and 2.3/hr., respectively), while no Bluegill ≥ 9 inches were captured in Dunkard Fork Lake (Figure 3). Teter Creek Lake had a greater relative abundance of ≥ 9 inch Bluegill (1.4/hr.) compared to Mason Lake (0.9/hr.) (Figure 3). Lakes also varied with respect to PSD values and results are reported in Table 1.

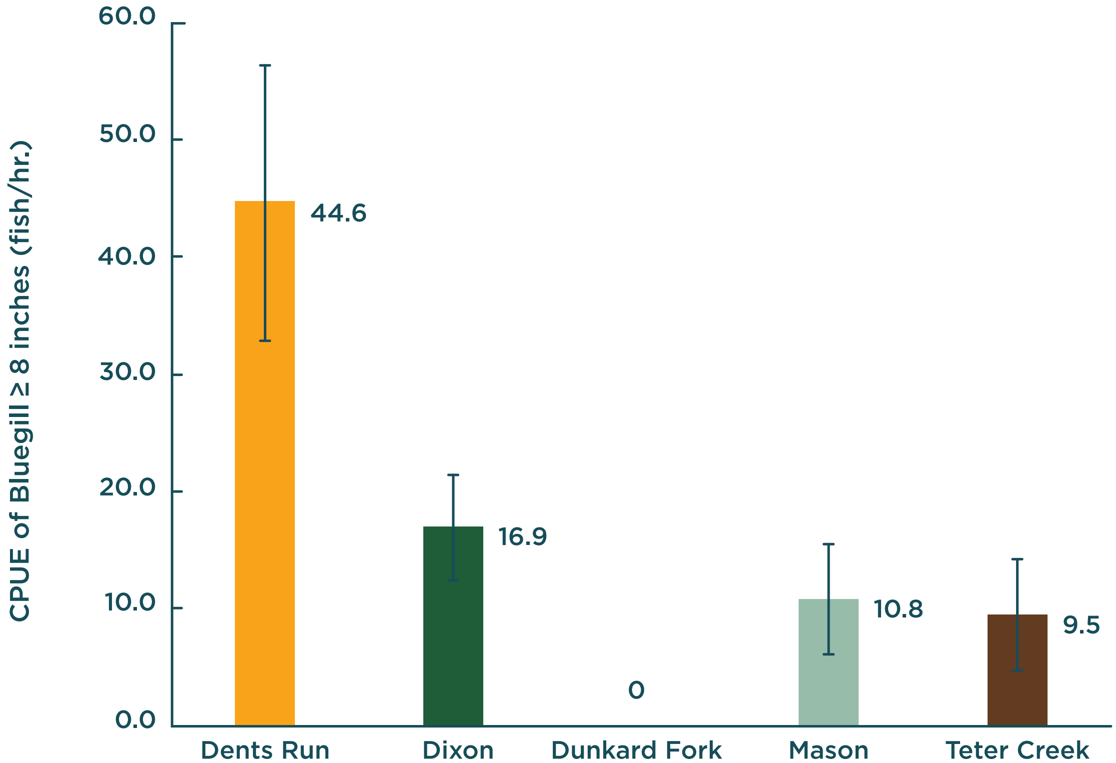


FIGURE 2. CPUE (fish/hr.) of Bluegill ≥ 8 inches across the five study impoundments. Error bars are ± 1 SE.

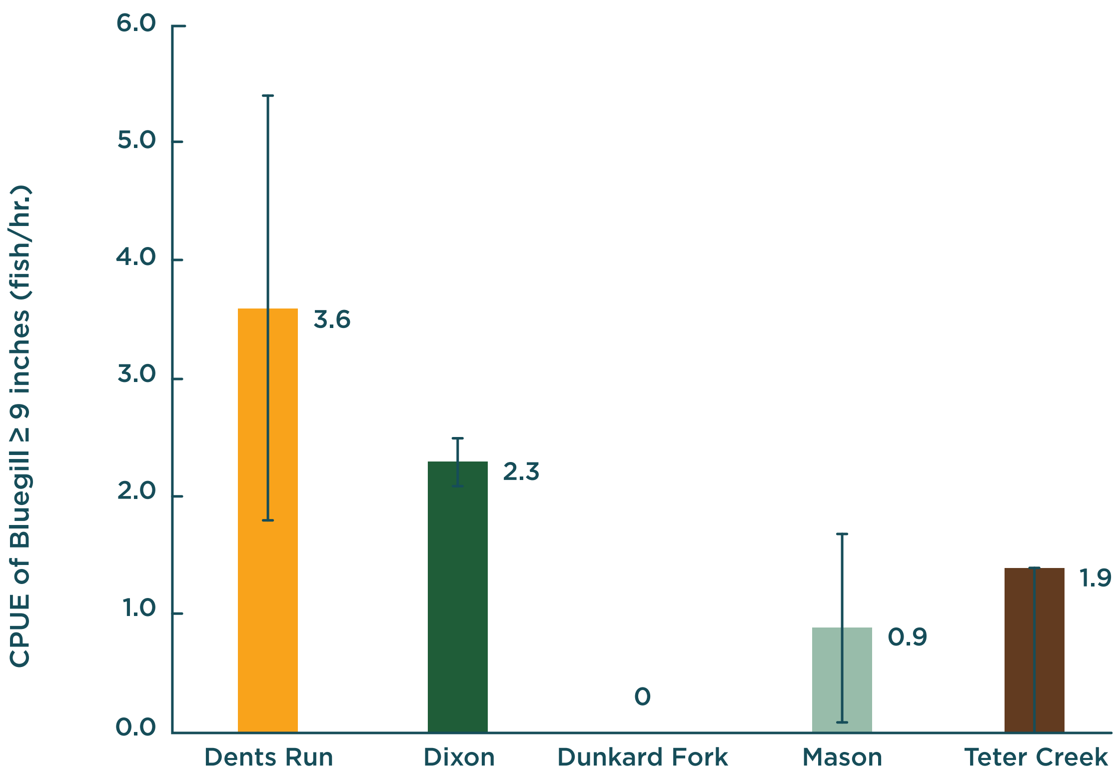


FIGURE 3. CPUE (fish/hr.) of Bluegill ≥ 9 inches across the five study impoundments. Error bars are ± 1 SE.

Lake	PSD	PSD
Dents Run	43	18
Dixon	56	8
Dunkard Fork	12	0
Mason	54	11
Teter Creek	41	20

TABLE 1. Bluegill PSD (proportion of stock length and larger Bluegill ≥ 6 inches) and PSD-P (proportion of stock length and larger Bluegill ≥ 8 inches) values for study impoundments.

We estimated ages of 561 Bluegill using sagittal otoliths across all small impoundments. Bluegill collected in surveys ranged in age from 0 – 9 across impoundments. The oldest Bluegill (age-9) were captured in both Dents Run Lake and Dixon Lake. Bluegill up to age-7 were captured in Dunkard Fork Lake and Teter Creek Lake, while Bluegill up to age-6 were captured in Mason Lake. Most age-frequency distributions were significantly different ($p < 0.05$) across lake comparisons. Age-frequency distribution comparisons between Dents Run Lake and Dixon Lake, and Dents Run Lake and Mason Lake were not statistically different. Additionally, age-frequency distribution comparisons between Teter Creek Lake and Dixon Lake, and Teter Creek Lake and Mason Lake were not statistically different. Age-2 Bluegill were most abundant and catch-curve regressions were calculated from age-2 to the oldest age per impoundment. Resulting estimates of total annual mortality ranged from 42 – 80% and mortality was significantly different across lakes ($p < 0.001$) (Figure 4). Mason and Teter Creek Lakes had the highest total annual mortalities of 80% and 65%, respectively (Figure 4). Dixon Lake had the lowest total annual mortality of 42%.

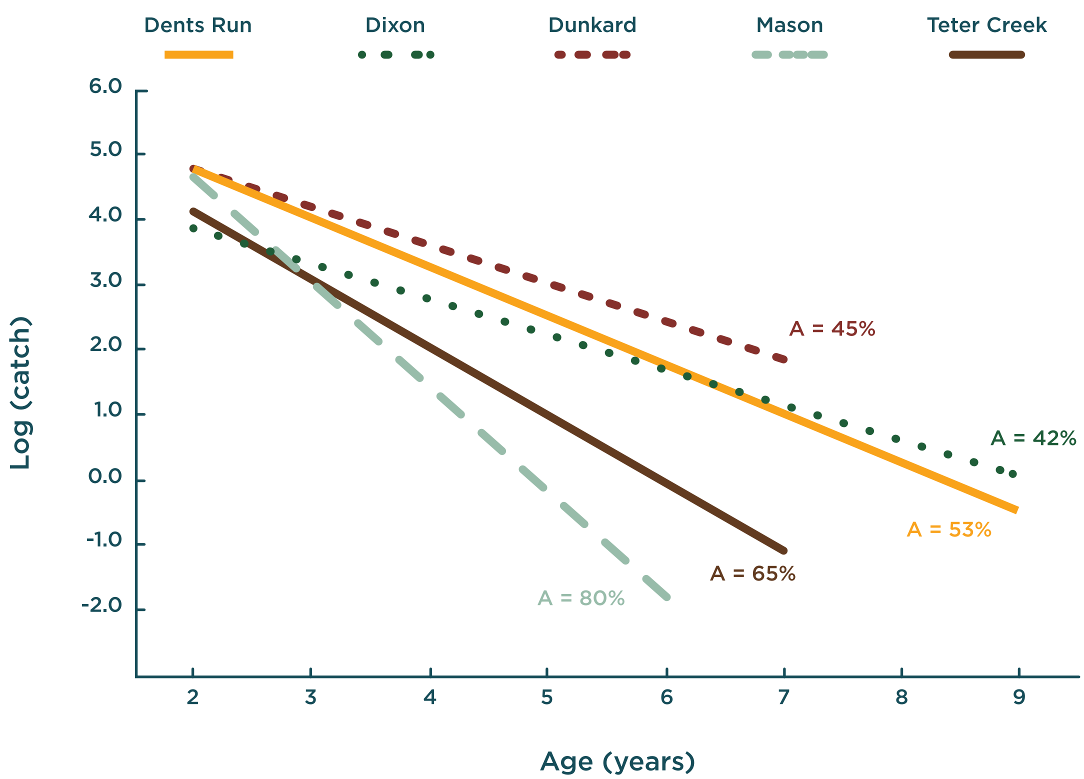


FIGURE 4. Catch-curves (total annual mortality, A) for Bluegill across the five study impoundments.

Dunkard Fork Lake had a similarly low total annual mortality to Dixon Lake (45%). Dents Run Lake had intermediate total annual mortality of 53%. Age data suggest that the prevalence old age Bluegill (≥ age 4) varied across impoundments (Figure 5). Bluegill only reached age-9 in two impoundments, Dixon and Dents Run Lake. Proportion of age-4 and older Bluegill was highest in Dunkard Fork Lake (29.9%), Dents Run Lake (12.3%), and Dixon Lake (12.9%) (Figure 5). Age-4 and older Bluegill were less common in Teter Creek Lake (3.8%) and Mason Lake (2.4%) (Figure 5).

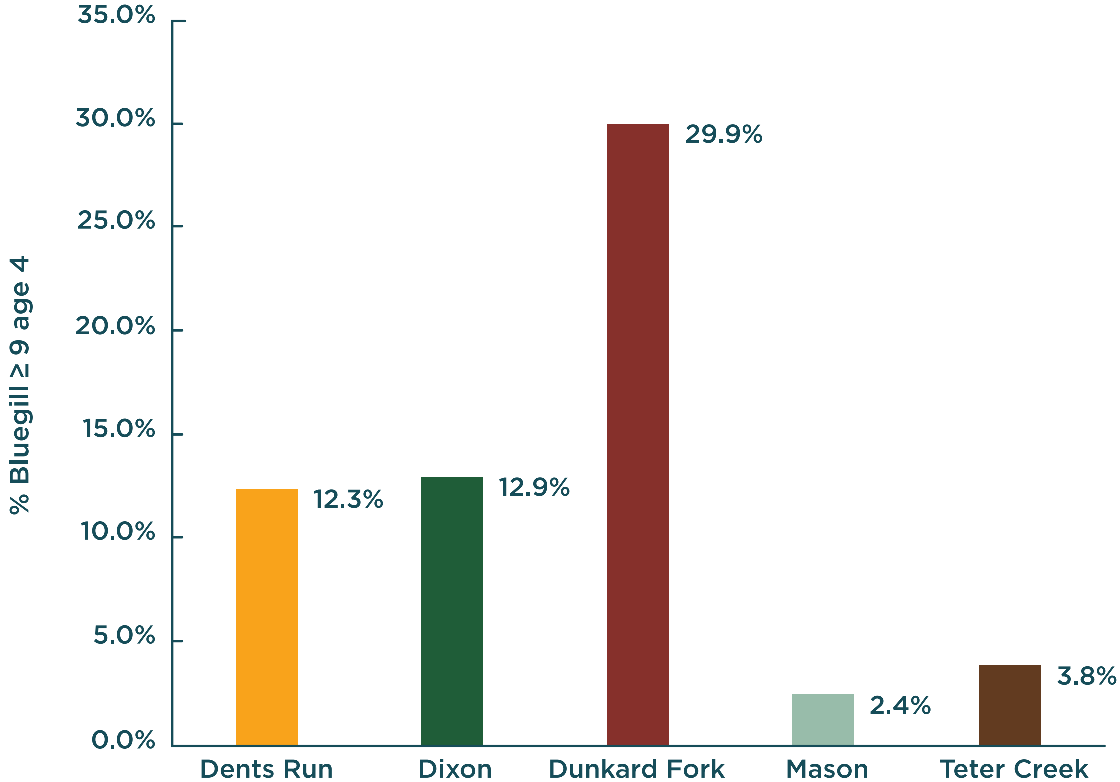


FIGURE 5. Proportion of Bluegill ≥ age-4 across the five study impoundments.

Growth and growth potential varied across small impoundments and at different age classes among Bluegill. Growth was significantly different across lakes ($p < 0.001$). Growth to age-4 was fastest in Mason Lake and Dents Run Lake where length at age-4 averaged approximately 8 inches in both impoundments (Figure 6). Bluegill in Teter Creek Lake averaged 7.8 inches by age-4 followed by Dixon Lake where length at age-4 averaged 6.8 inches (Figure 6). Bluegill in Dunkard Fork Lake exhibited the slowest growth with length at age-4 averaging 5.6 inches (Figure 6). By age-5, Bluegill in all impoundments except Dunkard Fork Lake averaged over 8 inches in length (Figure 6). According to the von-Bertalanffy growth modeling results, Bluegill in Mason Lake were predicted to reach 9 inches faster than the other populations and were predicted to reach 10 inches by age-9 (Figure 7). Bluegill in Dents Run and Teter Creek Lake were predicted to reach 9 inches but at a slower rate than Bluegill in Mason Lake (Figure 7). Additionally, Bluegill in Mason, Teter Creek and Dents Run Lakes exhibited above average growth compared to North American populations, while Bluegill in Dixon Lake exhibited approximately average growth and Bluegill in Dunkard Fork Lake exhibited below average growth (Figure 6).

Largemouth Bass population characteristics also varied across lakes (Table 2). CPUE ranged from 88.2 bass/hr. (Teter Creek Lake) to 372.3 bass/hr. (Dixon Lake) (Table 2). Mason Lake and Dixon Lake bass were smallest on average across lakes (mean length = 8.3 inches) while Dunkard Fork Lake bass were largest on average (mean length = 12.2 inches) (Table 2). Of all stock length (8 inches) and greater fish, Dixon Lake had the smallest size structure with few fish making it to preferred size (15 inches) (Table 2). In contrast, Dunkard Fork Lake had the largest size structure with over 30% of stock length and greater fish considered preferred size (Table 2).

Lake	CPUE (fish/hour)	Mean Length (inches)	PSD	PSD-P	PSD-M
Dents Run	133.4 (9.5)	10.6 (0.31)	55	14	1
Dixon	372.3 (32.0)	8.34 (0.34)	10	6	2
Dunkard Fork	99.3 (24.1)	12.2 (0.39)	62	32	4
Mason	128.7 (10.1)	8.3 (0.38)	25	3	0
Teter Creek	88.2 (11.2)	11.5 (0.53)	78	5	0

TABLE 2. Values of cpue (catch per unit effort; fish/hr.), mean length, PSD, PSD-P, and PSD-M for Largemouth Bass in study impoundments. Standard error (± 1 SE) is presented in parentheses for cpue and mean length.

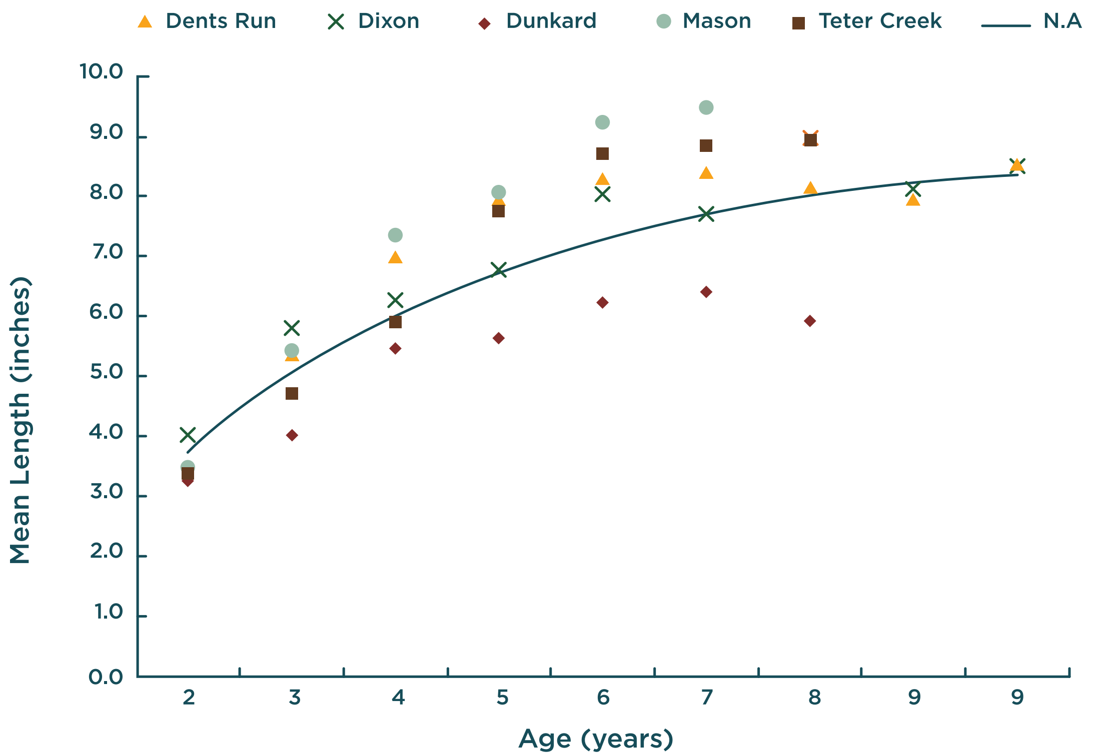
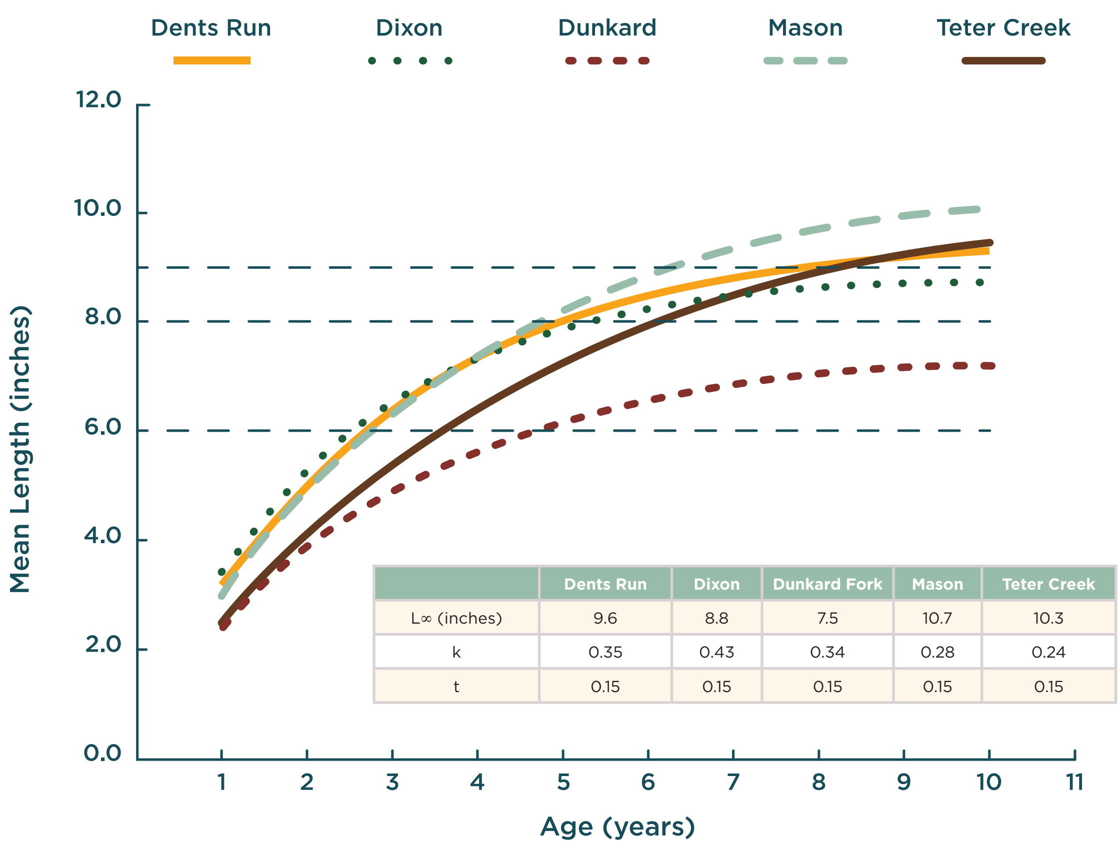


FIGURE 6. Mean length-at-age of Bluegill across the five study impoundments and the North American (N.A.) average length-at-age (Jackson et al. 2008).



	Dents Run	Dixon	Dunkard Fork	Mason	Teter Creek
L∞ (inches)	9.6	8.8	7.5	10.7	10.3
k	0.35	0.43	0.34	0.28	0.24
t	0.15	0.15	0.15	0.15	0.15

FIGURE 7. von-Bertalanffy growth curves and parameters generated for Bluegill populations in each study impoundment. Horizontal dashed lines represent thresholds for growth comparisons at 6 inches, 8 inches, and 9 inches, respectively.

Creel surveys in 2018 resulted in 586 angler interviews, with Teter Creek Lake and Mason Lake receiving the most angling effort followed by Dixon and Dents Run lakes. Due to seasonal limitations (lack of data from trout stocking season) and limited completed trip information (i.e., absence of clerks during last hours of day when anglers likely finished trips, inconsistency contacting anglers after trips were complete, etc.) conclusive harvest data are lacking from creel surveys. However, adequate angler attitude and opinion data were gathered. On average, 30.5% of anglers interviewed were targeting either Bluegill or any species they could catch. Most anglers were targeting either Largemouth Bass (44.3%) or trout (34.5%). Of all interviewed anglers, 59% indicated that they would harvest Bluegill. However, when removing Dixon Lake, which is under catch and release regulations, this number increases to 76% of anglers willing to harvest Bluegill. On average, anglers indicated that the minimum length of Bluegill they prefer to harvest is 7.1 inches. Most anglers (90%) indicated that they would support Bluegill regulations designed to improve size structure of Bluegill fisheries.

DISCUSSION

Results of this study indicated substantial differences in the population demographics of Bluegill populations in several northern WV small impoundments. Specifically, Bluegill demographics varied in relative abundance, growth, age structure, size structure, and mortality. Bluegill growth, size structure, age structure and mortality appeared to correspond to density and size structure of competitors and predators, angler accessibility and pressure, and current regulations.

Dents Run Lake, which at the time of the study provided the best Bluegill fishing opportunities in terms of abundance of preferred size individuals (≥ 8 inches), is also the lake with the most difficult accessibility and lowest amount of angling pressure. Additionally, no trout stocking occurs in this impoundment which also likely lessens angler pressure. While Dents Run Lake had high abundances of preferred size Bluegill, Bluegill growth was limited after reaching 8 inches. Although Dents Run Lake had moderately high densities of Largemouth Bass smaller than 15 inches to serve as predators on young Bluegill, presence of other prey (Yellow Perch, Black Crappie) may limit their predatory impacts. High densities of young Bluegill may suppress early growth potential and limit ability for Bluegill to reach larger maximum sizes. Despite these limitations, opportunities to catch preferred size Bluegill in Dents Run Lake remain excellent.

The lake with the poorest Bluegill fishing opportunities (Dunkard Fork Lake) provided fair accessibility and was stocked with trout during this study, however, these attributes were likely not determining factors in structuring the demographics of this population. Dunkard Fork Lake had high densities of Gizzard Shad and Common Carp which are known to reduce growth in Bluegill via competition for food and through redirection of Largemouth Bass predation (Aday et al. 2003; Wolfe et al. 2009; Wahl et al. 2011). Additionally, this lake has been managed for quality Largemouth Bass and the prevalence of large bass (>15 inches) likely contributed to the mortality of any Bluegills that attain quality size. Given these factors, Dunkard Fork Lake would not be expected to provide good Bluegill opportunities with any realistic management actions. The lake is better managed under its current strategy as a destination for quality Largemouth Bass fishing.

The only study lake with special regulations in place for Bluegill during the study was Dixon Lake. Dixon Lake has been managed under a catch and release regulation for all fish species, including Bluegill. Bluegill fishing opportunities in Dixon Lake were found to be good, but less so than opportunities at Dents Run Lake. Bluegill growth in Dixon Lake was fast at early ages, likely as a result of reduced densities of small Bluegill due to Largemouth Bass predation. However, growth slowed at intermediate lengths. This may be attributed to stockpiling at these sizes due to productive conditions, an absence of angler harvest and lack of predators large enough to eat fish of this size. However, Bluegill were still able to reach preferred sizes and provide good opportunities for anglers. Therefore, it would not be expected for additional management actions to drastically improve this fishery.

Two lakes in this study were found to be most suitable for regulatory management action. Mason Lake and Teter Creek Lake both were found to provide fair Bluegill fishing opportunities. Bluegill grew fast in these impoundments and had potential to reach large maximum sizes (> 9 inches). However, density of large Bluegill in these lakes was low despite fast growth. Additionally, total annual mortality in these lakes significantly exceeded mortality in other study lakes. These two lakes had excellent angler accessibility and were also stocked with trout, which likely increases angling pressure. Consequently, angler effort was observed during angler surveys to be much higher in these two lakes than the other study lakes. The relatively high mortality of Bluegill and lack of large individuals despite fast growth may indicate elevated angler harvest. Given fast growth, large maximum size potential, and evidence of angler suppression of large fish, harvest regulations may be effective at improving Bluegill size structure on these lakes. Specifically, regulations that limit overall harvest of Bluegill and also conserve large (> 8 inches) Bluegill may be effective at improving availability of large fish to anglers.

Regulations have been used successfully in other states to improve Bluegill fisheries (Jacobson 2005; Rypel 2015). Most successful regulations have focused on minimizing harvest of large Bluegill via creel limits and/or size restrictions (Jacobson 2005; Rypel 2015; Hansen and Wolter 2016). Studies by Jacobson (2005) and Rypel (2015) found that harvest regulations were able to increase mean length and maximum length in Bluegill populations. Data from these studies suggest that after implementation of harvest regulations, Bluegill attained older average ages which presumably related to larger sizes (Jacobson 2005; Rypel 2015). Additionally, other states have recently seen increases in Bluegill size structure as a result of management programs designed to improve Bluegill fishing via similar harvest regulations (Quality Bluegill Initiative, Minnesota Department of Natural Resources). However, effective regulations for Bluegill typically have not included traditional minimum length limits (MLL). MLL's are frequently used in management of sportfish populations (Gwinn et al. 2015). However, MLL's are known to sometimes truncate age and size structure of populations, especially under conditions of high fishing mortality (Gwinn et al. 2015). This can be especially problematic for Bluegill populations which exhibit specialized sexual selection. Typically, the largest individuals in a Bluegill population are parental males (Gross and Chernov 1980; Gross 1982; Rypel 2015). These individuals are also the most frequently targeted by anglers because of their catchability during spawning season due to aggressive nest guarding behavior (Coble 1988; Crawford and Allen 2006; Rypel 2015). In contrast to parental males, some male Bluegill exhibit cuckoldry and utilize either a "sneaker" strategy or a "female mimic" strategy for reproduction (Gross and Chernov 1980; Gross 1982). Males that utilize these strategies typically do not reach large sizes and die at a younger age (Gross and Chernov 1980; Gross 1982; Rypel 2015). Therefore, it is believed that targeted harvest of parental males by anglers could lead to a disproportionate abundance of smaller, cuckolder males in a fishery and exacerbate size structure reductions (Crawford and Allen 2006; Rypel 2015; Neuswanger et al. 2016). Consequently, recent regulations have been aimed at reducing overall harvest, specifically of large Bluegill to counteract this angling tendency (Jacobson 2005; Rypel 2015; Hansen and Wolter 2016).

MANAGEMENT IMPLICATIONS

The results of this research provided important implications for each of the small impoundments and the future management of their respective Bluegill populations. Based on the data gathered and visible trends, suggested management actions included proposed harvest regulations, habitat manipulation, or no further action.

NO ADDITIONAL MANAGEMENT ACTIONS

Given the results, no management actions were recommended for the Bluegill population in Dunkard Fork Lake. The Bluegill in Dunkard Fork Lake had moderate recruitment, poor size structure, slow growth, and moderately low mortality. Given the moderately low mortality of Bluegill, angler harvest did not appear to be a limiting factor for this population. Additionally, Bluegill seldom reach what are considered harvestable sizes in this impoundment. Instead, this population exhibited characteristics suggesting competitive pressure from high densities of Common Carp and Gizzard Shad. Common Carp and Gizzard Shad are known to be potentially inhibitive of quality panfish populations (Aday et al. 2003; Wolfe et al. 2009; Wahl et al. 2011). Common Carp disrupt Bluegill nests and possibly consume eggs and fry, while also competing for food with Bluegill (Wahl et al. 2011). Common Carp also damage aquatic vegetation important for Bluegill cover and increase lake turbidity limiting foraging opportunities (Wahl et al. 2011). Similar to Common Carp, Gizzard Shad also compete with Bluegill for food (Aday et al. 2003). Additionally, presence of Gizzard Shad may alter the predator-prey relationship between Largemouth Bass and Bluegill. Specifically, Largemouth Bass may prefer Gizzard Shad as forage and therefore consume fewer Bluegill leading to an increase in intraspecific competition. These factors most likely influenced the poor size structure and slow growth of Bluegill in Dunkard Fork Lake. Given the difficulties in altering such systems, Dunkard Fork Lake was not considered an optimum candidate for Bluegill Management.

Similar to Dunkard Fork Lake, no management actions were recommended for the Bluegill population in Dixon Lake, albeit for differing reasons. Dixon Lake Bluegill exhibited high recruitment, lower total mortality, good size structure, and moderate growth. Dixon Lake has been managed as a catch and release lake for all species. This regulation not only allows large Bluegill to persist in the population, but also leads to high densities of Largemouth Bass. These high densities and crowded bass population leads to a high predation rate of small Bluegill. Growth of young Bluegill was excellent as a result. Growth of intermediate size Bluegill was reduced, possibly as a result of the lack of angler harvest and resulting increased interspecific competition. However, once individuals reached preferred size, growth continued, and large sizes were reached. Dixon Lake had the highest CPUE of quality size (6 – 7.9 inches) Bluegill in the study. Due to the popularity of the special regulation with anglers, no further management actions were recommended. Additionally, the small size and excellent accessibility of this impoundment would make control of angler harvest difficult if allowed. The lake already supported a quality Bluegill fishery, and the high abundance of fish is beneficial for novice anglers.

NON-REGULATORY MANAGEMENT ACTIONS

Dents Run Lake supported the best preferred size (8 – 9.9 inches) Bluegill fishery among the five lakes. However, data suggested that there were potential management actions that could improve the fishery. Specifically, although Bluegill growth was fast to age-4 in Dents Run Lake, little growth occurs after age-4. Additionally, Bluegill recruitment was high in Dents Run Lake and the presence of Yellow Perch may reduce predation on young Bluegill. To enhance this Bluegill fishery, habitat manipulation techniques may offer benefits to size structure. First, aquatic vegetation has historically been dense in two large areas of the lake. Chemical treatment of vegetation in one of the areas could be employed to decrease cover for young bluegill and increase predation by Largemouth Bass. This reduction in young Bluegill could enhance growth of Bluegill by reducing competition for forage. Addition of large woody debris could encourage colonization of macroinvertebrates, providing more diverse, high energy food items for Bluegill forage. If concern about density of young Bluegill increases, predatory species such as Hybrid Striped Bass or Walleye could be introduced to help control young Bluegill abundance.

REGULATORY MANAGEMENT ACTIONS

Teter Creek Lake and Mason Lake Bluegill exhibited fast growth but had the highest mortality rates of the five impoundments. These lakes also had low overall CPUE of Bluegill, suggesting that predators are effective at reducing numbers of smaller individuals. Dixon Lake, Dunkard Fork Lake, and Dents Run Lake, all had substantially lower total mortality rates (42%, 45%, and 53%, respectively). We would assume that mortality in Dixon Lake would be attributed primarily to natural mortality given it is managed by catch and release, albeit some illegal harvest likely occurs. Teter Creek Lake and Mason Lake total mortality rates were 65% and 80%, respectively. Additionally, Bluegill age-4 and older were uncommon in Teter Creek and Mason Lakes, accounting for only 3.8 % and 2.4 % of the catch, respectively. In contrast, Bluegill age-4 and older comprised approximately 12.9 %, 12.3 %, and 29.9 % of the catch in Dixon Lake, Dents Run Lake, and Dunkard Fork Lake, respectively. Fast growth and missing older age classes are sometimes indicative of heavy angler exploitation of older age classes. Both Mason Lake and Teter Creek Lake had excellent accessibility by shoreline and boat anglers and have been very popular stocked trout lakes. Given the population demographic data, as well as the characteristics of the impoundments, it is possible that anglers significantly lower the abundance of large Bluegill via harvest. This would suggest that more restrictive regulations on harvest of larger Bluegill may lead to increased abundances of fish in these size classes. Anglers were strongly supportive of regulations that would improve Bluegill size structure. Given the population data collected and the angler support measured, harvest regulations were suggested for Teter Creek Lake and Mason Lake. Options for effective regulations would include size-based restrictions (restrict harvest of large fish), reductions in overall creel limits, or a combination of both. Additionally, low densities of Bluegill and limited productivity of Mason Lake and Teter Creek Lake lessens the risk of creating an overabundance of Bluegill due to overall creel limit reductions. Consequently, a combined creel limit reduction and size-based restriction was recommended. Given these factors, we implemented a 10-fish daily limit for Bluegill and other sunfish species in aggregate, of which only 5-fish may be 8 inches or longer for Mason and Teter Creek Lakes.

CONCLUSIONS

The results of this study provided important implications for the future management of the Bluegill populations in these small impoundments. We outlined several management action alternatives for each of the small impoundments aimed at maximizing the potential of each fishery based on the results from this study. We will evaluate changes as a result of these proposed management actions approximately 5 years after implementation. To evaluate any significant population changes we will utilize the same abundance, size structure and age structure metrics that we detailed in this study. Specifically, we will be interested in determining if management actions result in significant alterations to current Bluegill densities, Bluegill growth, Bluegill size structure, and Bluegill age structure. Future evaluations will help determine if further changes to management actions are necessary for the benefit of these fisheries and the anglers that that utilize them.

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