Fall 2019

Monongahela River, WV Channel Catfish Population Assessment

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MONONGAHELA RIVER, WV CHANNEL CATFISH POPULATION ASSESSMENT

A Master's Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Biology

By

Kristen Lee Chestnut-Faull

December 2019

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Biology

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ABSTRACT

Channel Catfish *Ictalurus punctatus* populations have been evaluated using many sampling gears in rivers. However, a consensus has not been reached on which gear or gears produce the most reliable population demographics. Specifically, this study compares population demographics of Channel Catfish throughout the Monongahela River, WV using multiple gear types. Fish were sampled seasonally during 2018 using baited hoop nets, low- frequency electrofishing, and trotlines. Firstly, too few fish were collected using electrofishing and were excluded from all analyses. In terms of relative abundance, fish sampled with hoop nets had higher catch rates (mean SCPUE = 5.8, SE = 0.4) than trotlines (mean SCPUE = 3.1, SE = 0.1). Both gear types also produced differing length- frequencies (n= 560, KSa= 3.71, Pr <KSa <0.0001). Specifically, the size distribution collected by hoop nets was more equally distributed than trotlines. Trotlines on average captured larger fish (mean length = 532-mm, SE = 4.7), while the mean length of catfish captured in hoop nets was smaller (457-mm, SE = 6.8). Given the discrepancies observed between catch rates and length frequency distributions, hoop nets produced the most representative sample of the Channel Catfish population. Furthermore, throughout all seasons hoop net catch rates did not vary (F< 4, df = 39). With these results, the WVDNR can develop a long-term sampling program for Channel Catfish in the Monongahela River using hoop nets as they provide more biologically reliable results compared to electrofishing and trotlines. Additionally, fish collected during 2018 and 2019 via hoop nets were used to estimate population dynamics. Length, weight, sex, fecundity, and age data were obtained from collected individuals. Population characteristics (e.g., relative abundance, size structure, age structure, growth, etc.) were modeled under three various length limits of 300-mm, 375-mm, and 450-mm. Simulation results indicated that growth overfishing may occur when exploitation rates reach 36% under a 300-mm length limit. Furthermore, recruitment overfishing began to occur at 40% exploitation under a 300-mm length limit. Additionally, simulations suggest that no recruitment or growth overfishing occur at length limits of 375-mm or 450-mm until extremely high exploitation levels are reached. Thus, we suggest the WVDNR implement a 375-mm length limit of Channel Catfish in the Monongahela River to prevent growth and recruitment overfishing while also ensuring anglers are still able to harvest fish.

KEYWORDS: Channel Catfish, gear efficiency, population dynamics, hoop nets, trotlines, electrofishing, river, West Virginia

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December 2019

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ACKNOWLEDGEMENTS

Firstly, I would like to thank my husband, Ben, for supporting me through the trying times of grad school. I'm not sure I would have made it without you! I would also like to thank my dog Brutus for keeping me sane and loving me unconditionally every day even when I was away for months at a time. Additionally, my family for supporting me through many sporadic decisions throughout my college life.

Secondly, I would like to thank the staff at the West Virginia Division of Natural Resources, especially Dave Wellman and Dustin Smith, for making this project possible and for teaching me so much about fish management as well as many life lessons over the past couple of years. I am forever grateful for my time in the District 1 office and for all of the opportunity's you guys have provided me with. Thank you both for being such great mentors. I would also like to thank my advisor, Dr. Quinton Phelps.

I am also very thankful for all of the people who volunteered their time helping both in the lab and in the field.

I dedicate this thesis to the Monongahela River catfish population

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CHAPTER 1: OVERVIEW

The following thesis examines the Channel Catfish population in the Monongahela River of West Virginia, in two chapters that are designed to be independently publishable units. Chapter 2 assesses various methods for collecting representative population samples for Channel Catfish in riverine systems. Chapter 3 examines population dynamics of Channel Catfish in the Monongahela River, WV and models a variety of minimum length limit effects on the population. All individuals were collected in association with West Virginia Division of Natural Resources District 1 Fisheries Biologists under West Virginia University IACUC Protocol #1810018491 approved March 1, 2019.

CHAPTER 2: EVALUATION OF 3 GEAR TYPES FOR ESTIMATING POPULATION DEMOGRAPHICS OF CHANNEL CATFISH IN A MID-SIZE, WV RIVER

Introduction

Channel Catfish *Ictalurus punctatus* are a highly sought-after sportfish targeted by anglers throughout their range. This increase in interest over time has led many state agencies to focus more on catfish management (Michaletz and Dillard 1999, Arterburn et al. 2002). However, different gears frequently produce various size selectivity's of fish resulting in misrepresentation of the population (e.g., Ricker 1969, 1975; Beamesderfer and Rieman 1988; Bayley and Austen 2002), leading to errors in management. In fact, catfish managers ranked adequate knowledge of sampling gears and methods as a major concern regarding appropriate management (Michaletz and Dillard 1999). In addition, most attribute gear bias as their greatest limiting factor when managing ictalurids (Brown 2009). Over the past 20 years many studies and two symposiums have aimed to identify the most efficient sampling gears and methods (Bodine et al. 2013). Although various methods have since been studied, little consensus has been met on which gear or gears produce the most reliable population demographics (i.e. recruitment, growth, and mortality) for Channel Catfish in various systems. Hoop nets (Gerhardt and Hubert 1989; Pugibet and Jackson 1991; Holland and Peters 1992; Stopha 1994; Robinson 1999; Sullivan and Gale 1999; Vokoun and Rabeni 1999; Jackson 2004) and electrofishing (Jacobs and Swink 1982; Santucci et al. 1999; Vokoun and Rabeni 1999) are among the top ranked gears used for evaluating Channel Catfish populations (Bodine et al 2013). Although differences in efficiency (Heidinger et al. 1983) and size selectivity (Reynolds 1996; Santucci et al. 1999) have been measured among these gears. While trotlines have also been used to assess catfish populations, specific protocols are poorly understood (White 1961; Stauffer et al. 1996; Michaletz and Dillard 1999). Additionally, trotlines are often used to supplement other gears including hoop nets and electrofishing (Topp et al. 1994; Stauffer et al. 1996). Managers use trotlines to capture larger fish in a population, which other gears fail to sample. However, construction methods vary greatly and few guidelines including hook and bait type exist (Johnson 1987). Multi-gear approaches have been suggested for use (Colombo et al. 2008), however this is often unfeasible for managers given money, time, and personnel constraints.

The West Virginia Division of Natural Resources (WVDNR) has recently recognized an increased interest in catfishing by its anglers. Given the increased interest, state biologists and managers have addressed the need to collect population information on these catfish species, Channel Catfish, Flathead Catfish *Pylodictis olivaris*, and Blue Catfish *Ictalurus. furcatus*. The WVDNR has been collecting data on catfishes in large rivers such as Ohio and Kanawha Rivers. Significant work has also been conducted on Atlantic Slope rivers in the eastern panhandle of the state. However, the WVDNR currently has no set protocols for sampling these species in most of its mid-size lotic systems. Furthermore, little to no information exists for sampling recovering populations in impaired systems.

Thus, the objective of this study is to develop sampling methods specifically for Channel Catfish in mid-size, West Virginia rivers. Although literature can be found on catfish sampling in rivers, there is no real consensus on which methods work best in the Eastern United States. As such, this study aims to develop long term standardized protocols for assessing Channel Catfish population demographics in mid-size rivers in West Virginia.

Methods

Study Site. The Monongahela River (Figure 1) is formed by the confluence of the Tygart and West Fork rivers near Fairmont, WV. It flows approximately 225 km north to Pittsburgh, Pennsylvania where it joins the Allegheny River and forms the Ohio River. The study site was located in the uppermost 58 km of the Monongahela River, which represents its entirety in West Virginia. This reach of the Monongahela River is partially impounded by a series of four, U.S. Army Corps of Engineer navigational locks and dams. Sampling sites were located in the lowermost pool in WV (formed by the Point Marion lock and dam) and the uppermost pool in WV (formed by the Opekiska lock and dam).

The Monongahela River has historically been heavily impacted by acid mine drainage from bituminous coal mining. In the 1960's pH levels often ranged from 3-4 (Sotak 1968). Although since improved, this impact once led to low biodiversity through-out the river and many of its tributaries. Specifically, the primary catfishes found in the river during these years were tolerant bullhead (*Ameiurus spp.)* species (WVDNR unpublished data). Furthermore, little is known about the recoveries of many affected populations within this river, including the Channel Catfish population.

Sampling Methods. Two pools of the Monongahela River were surveyed seasonally (May- October) during 2018. Seasons were defined as Spring (May), early Summer pre-spawn (June), late Summer during/ post-spawn (July/ August), and Fall (October). Seasons generally correlated with water temperature and river stage. Water temperatures ranged from 12.8°C to 17.8°C during Spring, 21.1°C to 24.0°C during early Summer, 24.4°C to 26.9°C during late Summer, and 12.2°C to 21.7°C during Fall. Five sites were selected for sampling measures in each pool. At each site catfish were collected using one 25-mm bar mesh baited hoop net, three 30.5-meter trotlines, and 30 collective minutes of pulsed DC electrofishing. Hoop nets were 3-m long consisting of seven wooden hoops spanning 1-m in diameter with 25-mm bar mesh. Throats were equipped with three, 165-mm copper rings to prevent turtle bycatch. Hoop nets were set parallel to the flow with the open end facing upstream. Anchors were attached at each end to stabilize the net and a buoy was attached at the open end. Nets were soaked for 48 hours and baited with Zote© soap. Low- frequency electrofishing (15pps/ 2 amps) consisted of two, 15-minute transects located approximately 6 –9-meters from shore on each descending riverbank at each site. A chase boat was utilized to ensure capture of surfaced fish. Trotlines were soaked for 24 hours and varied by bait type. Five trotlines per pool were baited with Gizzard Shad (*Dorosoma cepedianum*) and Canadian Nightcrawlers. Lines were set perpendicular to the shoreline and equipped with three 2.2-kg weights placed every five hooks and a 9-kg weight at the end. Standardized catch per unit effort (SCPUE) was calculated by fish per sampling event. Units of effort were considered to be equal (in terms of personnel time) among gears such that 1 trotline was equal to 1 hoop net was equal to 1, 15-minute electrofishing run (Phelps et al. 2011). Fish were collected under West Virginia University IACUC Protocol #1810018491 (Appendix).

Analyses. Total length was measured on all Channel Catfish to the nearest millimeter. Proportional size distribution (PSD; [number of fish ≥ quality length/ number of fish ≥ stock length] × 100) and relative stock density (PSD-P; [number of fish ≥ preferred length/number of fish ≥ stock length] × 100) indices were calculated by using the length-classes defined by Gablehouse (1984). To estimate statistical precision of the index, 95% confidence intervals (CIs) were calculated for PSD (Gustafson 1988).

Fish were collected and subsequently transported back to the lab for otolith extraction. Lapillus otoliths were removed to obtain ages. Otoliths were then mounted on a microscope slide and sanded accordingly to count annuli (Buckmeier et al. 2002). Each fish was aged using two independent readers. When readers disagreed, mutual examination of the otolith was conducted by the readers to attempt to reach a consensus. When consensus was not met, the fish was removed from the sample. Prior to data analyses, age classes were removed from the gear type if they contained less than five individuals, to reduce variation resulting from fish less susceptible to that gear (Van Den Avyle and Hayward 1999). Mean SCPUE of each gear was compared using a two-sample t-test. Length frequency distributions were compared using a Kolmogorov-Smirnov nonparametrics test (KS). Alpha was held at 0.05 for all statistical tests.

Results

In total, 225 units of effort were deployed over four sampling seasons collecting 594 Channel Catfish during 2018. Forty hoop nets collected 232 fish (39.1% of overall catch), while 105 trotlines collected 331 fish (55.7%) over 105 net nights. Only 34 fish (5.7%) were collected via low-frequency electrofishing and therefore will be excluded from further analyses (Table 1).

Hoop nets had an average SCPUE of 5.8 fish per sampling event (SE = 0.4), while trotlines collectively had an average SCPUE of 3.1 fish per sampling event (SE = 0.1). SCPUE was significantly different between gears ($t = 3.59$, $df = 143$, $p < 0.001$). Length frequency distributions of catfish sampled with trotlines ($n= 560$, $KSa= 3.71$, $Pr < KSa < 0.0001$) significantly differed from those sampled with hoop nets. Trotlines sampled larger fish than hoop nets (Figure 2). Trotlines collected fish between 319-795-mm (mean length = 532-mm), while hoop nets collected fish from 230-694-mm (mean length = 457-mm). Hoop nets sampled more small Channel Catfish than trotlines while also sampling similar numbers of large fish >500-mm. Specifically, 7% of hoop net catch was < 300-mm, whereas trotlines did not collect fish under 300-mm. Additionally, hoop nets still collected fish >500-mm (38%) representing these larger size classes. Although trotlines captured the largest fish, they likely underestimated the abundance of fish less than 300-mm. Hoop nets were successful in sampling fish with a more uniform length-frequency distribution. Given the discrepancies associated with the length-frequency distributions by gear, size distribution indices also varied. Trotline surveys resulted in a higher PSD (92) compared to hoop nets (72). This indicates trotlines captured a greater proportion of quality size fish while hoop nets captured a greater proportion of stock size fish. In contrast, hoop net surveys resulted in a higher PSD-P (23) compared to trotlines (19). This indicates hoop nets captured a greater proportion of preferred size fish compared to trotlines.

Furthermore, hoop net SCPUE was highest in early summer (mean = 9.3, SE = 0.9), followed by fall (mean = 7.2, SE = 0.6) and late summer (mean = 4.1, SE = 0.7). Hoop net SCPUE was lowest in spring (mean = 1.2, SE = 0.9). However, these seasonal differences were not determined to be statistically significant (ANOVA, $F < 4$, $df = 39$).

A total of 229 fish were collected for aging via hoop nets and trotlines. Readers reached consensus 99% (227/229) of the time. Two fish were removed from the sample due to disagreements. Hoop nets captured the widest age range (Figure 3) of catfish spanning from 2-32 years old, while trotlines collected fish from a smaller age range (4-21 years). Thus, hoop net catches resulted in a more representative sample of the population.

Discussion

Given the lack of data on gear effectiveness to capture Channel Catfish in the eastern United States, this study provided an opportunity to evaluate potential gear bias. Specifically, we were able to evaluate the effectiveness of hoop nets and trotlines in capturing Channel Catfish and estimating population demographics in lotic systems. Both hoop nets and trotlines proved to be effective in sampling adult Channel Catfish ≥ 300-mm in riverine systems. However, low-frequency electrofishing was found to be extremely inefficient in collecting Channel Catfish relative to other gears. Similarly, Bodine et al. (2013) found that electrofishing was not ranked among the top gears for estimating abundance or size related metrics accurately.

While size selectivity of hoop nets and trotlines was somewhat similar, it is likely that trotlines underestimated fish ≤ 300-mm and overestimated fish ≥600-mm. Although low-frequency electrofishing was the only gear to sample fish ≤200-mm, it underestimated fish ≥500-mm compared to hoop nets and trotlines. Hoop net results are comparable to Michaletz and Sullivan (2002), who found that hoop nets accurately sampled fish between 250 and 529-mm. Similarly, Buckmeier and Schlechte (2009) found that hoop nets also accurately sampled fish from 250- 556-mm. Hoop nets also collected the widest age range of fish compared to trotlines. Trotlines may have potentially misrepresented the range of ages in the system, while hoop nets seemed to capture a more robust representation of the ages present in the population of interest. Furthermore, the catch efficiency of hoop nets was similar across all seasons. This is similar to the findings of Buckmeier and Schlechte (2009), who also found hoop net catch rates to be similar across sampling seasons.

Using an appropriate gear for sampling the population is important in obtaining an accurate representation of the population as management decisions are based on these results. In a study by Bertignac and Pontual (2007), they found that overestimation of fish ages led to incorrect von Bertalanffy growth estimates as well as incorrect mortality estimates. Sampling bias leads to inaccurate population dynamics which in turn leads to ineffective management. The mismanagement of populations could potentially have serious long-lasting impacts such as growth or recruitment overfishing (Hubert and Quist 2010).

The data collected in this study provides valuable information for future management of catfish in West Virginia rivers. The WVDNR currently has no regulations for Channel Catfish in the Monongahela River and will need accurate sampling gear to have the best data to determine if regulations are necessary. In addition, due to limited time and personnel constraints, agency staff need a sampling methodology that will provide the most accurate results in the most efficient manner. Although trotlines caught more catfish, it took considerably more effort to do so. Moreover, trotlines targeted larger individuals and underrepresented smaller fish. Missing younger fish in surveys could impact inference about natural reproduction, mortality, etc. and could lead to unnecessary or counterproductive management actions related to stocking, regulations, etc. Due to these differences in catch rates and length frequency distributions produced by each gear, we recommend using hoop nets to sample Channel Catfish in the Monongahela River, West Virginia as they collected a representative sample of fish from multiple size and age classes, in turn producing the most biologically reliable results for management decisions. These results are similar to results found by Vokoun and Rabeni (1999), who also suggested hoop nets for assessing population demographics of Channel Catfish in lotic systems. Furthermore, we recommend sampling during the growing season (May-October) as catch rates did not vary across seasons. This will provide managers with more opportunities to conduct sampling given time and personnel constraints.

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Figure 1. Map of the Monongahela River (bold), which flows north from Fairmont, West Virginia to Pittsburgh, Pennsylvania.

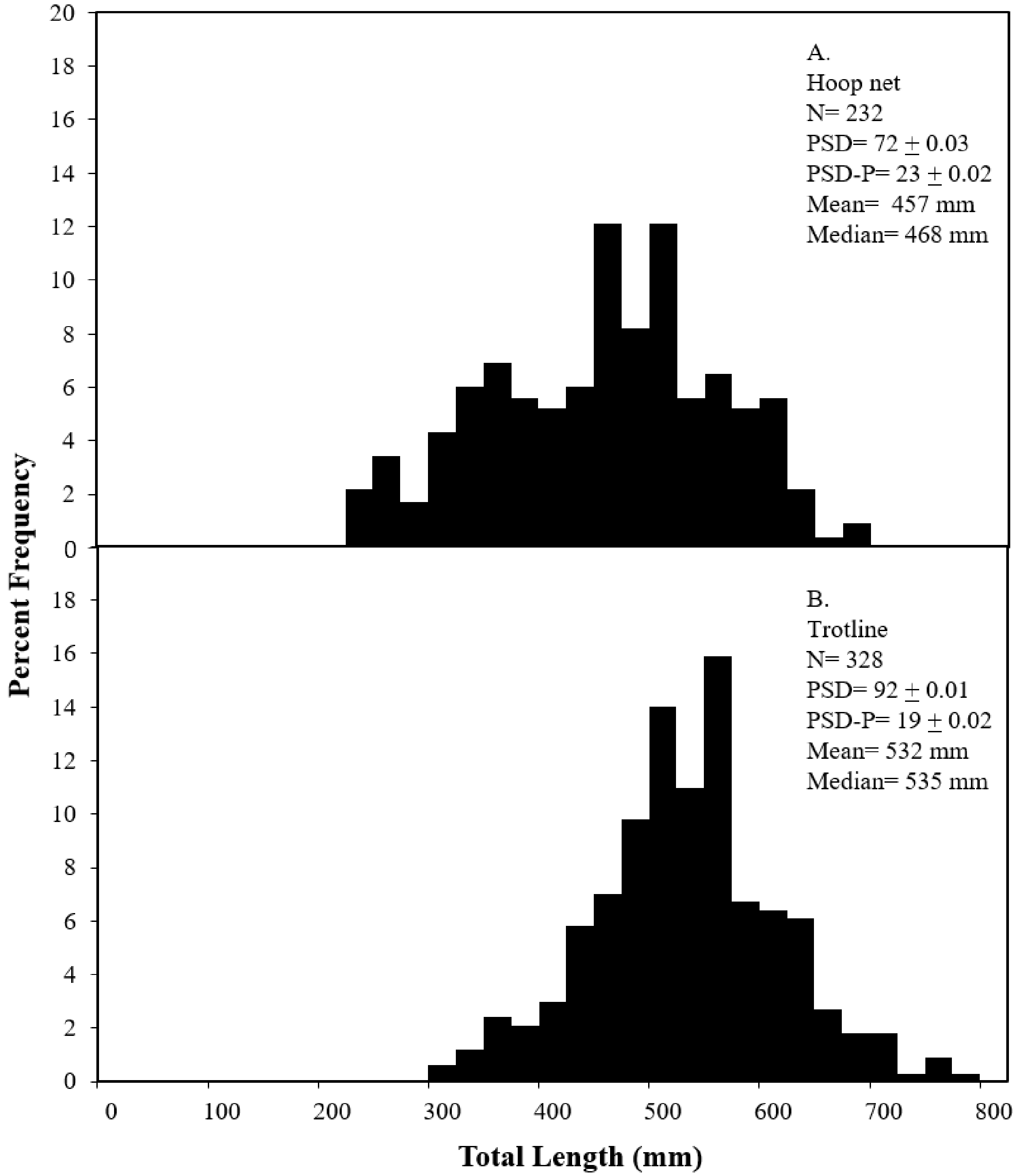

Figure 2. Length –frequency distributions for Channel Catfish sampled with (A) 25-mm hoop nets and (B) trotlines in the Monongahela River during 2018. Ninety-five percent confidence intervals are given for PSD and PSD-P.

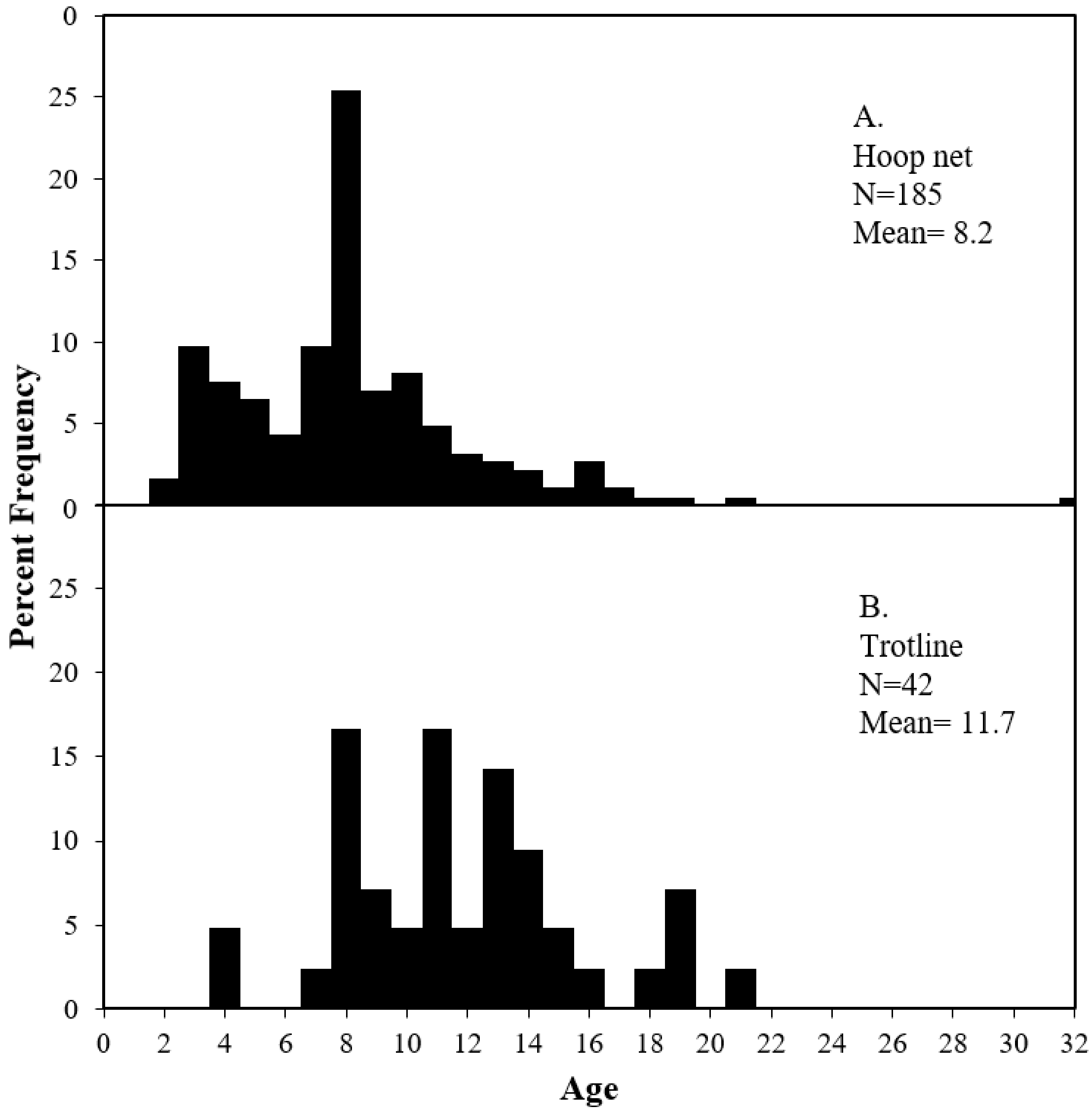

Figure 3. Age frequency distributions for Channel Catfish sampled with (A) hoop nets, and (B) trotlines in the Monongahela River during 2018.

CHAPTER 3: POPULATION DYNAMICS OF CHANNEL CATFISH IN THE MONONGAHELA RIVER, WV

Introduction

Channel Catfish *Ictalurus punctatus* have been gaining in popularity by anglers throughout their range over the past 20 years (Arterburn et al. 2002). Although Channel Catfish regulations vary across North America, most state agencies do recognize the need for potential management (Michaletz and Dillard 1999). In 2014, 20 states implemented some type of minimum length limit for Channel Catfish fisheries. However, of the minimum length limits imposed, only five were statewide regulations (Eder et al. 2016), suggesting various regional growth of Channel Catfish populations. Although minimum length limits are often implemented to slow growth overfishing in commercial catfish fisheries (Hesse 1994; Pitlo 1997; Slipke et al. 2002) and to prevent growth overfishing in other sportfish fisheries such as Sauger *Sander canadensis* in the Tennessee River (Maceina et al. 1998), regulations targeting recreational catfish fisheries are sparse, even though anglers have demonstrated support for restrictive regulations (Arterburn et al. 2002; Reitz and Travnichek 2004).

Few studies have addressed population dynamics of catfish species throughout time (Quinn 1993). Population demographics are rarely stable and often change over time (Hutchings 2005) due to natural or anthropogenic disturbances (Phelps et al. 2011). Although it is impossible to predict environmental stochasticity, anthropogenic disturbances such as overexploitation can be avoided via harvest regulations and continual monitoring (Myers et al. 1995). Long term monitoring of these long-lived populations is critical for identifying natural fluctuations over time. Additionally, population dynamics are important for ensuring proper management of populations (Phelps et al. 2011).

Modeling simulations rely on knowledge of population dynamics such as recruitment, growth, mortality and exploitation (Slipke and Maceina 2010). In comparison to recruitment, growth and mortality, exploitation estimates are much more difficult to obtain. Exploitation estimates have previously been calculated using intensive tagging studies. However, many agencies do not have the time, money and/or personnel to implement these labor-intensive studies. Therefore, agencies often estimate this parameter in alternate ways such as with modeling software. Modeling software provides a cost and time effective approach for managers to predict population response to various harvest regulations to ensure sustainable management practices (Johnson 1995; Slipke and Maceina 2010). Simulations are often conducted before implementing length limits to maximize yield and prevent growth overfishing.

The West Virginia Division of Natural Resources (WVDNR) has recently recognized an increased interest in catfishing by its anglers. Given this increased interest, efforts have been established throughout the state to identify potential management needs of catfish populations. Regulations have recently been imposed on the Ohio and Kanawha Rivers to conserve and enhance populations. WVDNR has also identified a potential need for management on the Monongahela River, a large tributary of the Ohio River. The Monongahela River has a prominent history with acid mine drainage and pollution dating back to the 1800's (Sotak 1968), which ultimately led to a decrease in species population abundance, (Klarberg and Benson 1975) resulting in low-biodiversity (Sotak 1968). However, with the passing of new environmental legislation during the 1960's and 70's, pollution began to decrease, subsequently leading to an increase in water quality and ultimately the return of many fish populations.

Few studies have been conducted assessing population dynamics of impacted species within this river, which can potentially lead to management concerns. Thus, this study aims to identify population dynamics of Channel Catfish within the Monongahela River, West Virginia and model potential regulations to help prevent growth and recruitment overfishing from occurring within the population.

Study Site. The Monongahela River (Figure 1) is located in the Mississippi River basin. The river flows north from Fairmont, WV to Pittsburgh, PA where it confluences with the Allegheny River and begins the Ohio River eventually draining into the Gulf of Mexico. Dams were installed during the 1800's for navigation and the transportation of coal. The upper 58-km section of the river located in West Virginia is segmented by four U. S. Army Corps of Engineers' lock and dams.

Sampling sites were located in each of the four pools of the Monongahela River located within WV. These pools include (from upstream to downstream) the Opekiska Pool formed by the Opekiska Lock and Dam, the Hildebrand Pool formed by the Hildebrand Lock and Dam, the Morgantown Pool formed by the Morgantown Lock and Dam, and the Point Marion Pool formed by the Point Marion Lock and Dam. All pools are similar in habitat but do differ in size with lengths of 20.9 km (Opekiska), 11.3 km (Hildebrand), 9.7 km (Morgantown), and 16.1 km (Point Marion).

Methods

Field Sampling Methods. Channel Catfish were collected seasonally (spring, summer, fall) throughout 2018 and in June of 2019 using hoop nets (Chapter 1). Fish were collected from each pool to obtain a representative sample of the river. We set five hoop nets per pool per survey in 2018 and 10 nets per pool per survey in 2019 to target Channel Catfish. Nets were baited with two mesh bags of Zote Soap© per net to increase catch. Hoop nets were fished in depths ranging from 3-5-m for 48 hours. Fish collected in the field were sacrificed (using a cranial pith and immediately placed in an ice bath) and brought back to the lab for further examination. Fish were collected under West Virginia University IACUC Protocol #1810018491 (Appendix).

Laboratory Methods. Once in the lab, fish were weighed to the nearest gram (g), measured to the nearest millimeter (mm) (total length), sex was determined, eggs were removed, and otoliths extracted. A subsample of eggs was weighed and enumerated to estimate fecundity. Lapillus otoliths were removed via cranial dissection. Otoliths are arguably the best method for estimating ages of catfishes greater than 2 years old (Buckmeier et al. 2002). Once dried, otoliths were mounted onto a dissecting slide using crystal bond with the anterior placed down. Otoliths were then sanded down using dampened 600- grit sandpaper until the nucleus was visible (Buckmeier et al. 2002).

Analysis. Mean length and age were calculated for each of the four pools separately. Age and growth were also modeled using Fisheries Analysis and Modeling Simulator (FAMS 1.0; Slipke and Maceina 2010). Age classes with fewer than five fish were removed to ensure similar numbers from each age class (Isely and Grabowski 2007). Fish ages 4-18 were used to develop growth equations. Weight- length ratios were calculated using $\log_{10}$ transformed data.

Channel Catfish predicted response to various regulations was modeled using river wide population characteristics. Three various minimum length limits were modeled, and yield was used to identify exploitation levels leading to potential growth overfishing of the population at the three minimum length limits. In addition, the spawning potential ratio was used to identify exploitation levels leading to recruitment overfishing of the three minimum length limits.

All modeling was conducted using FAMS. FAMS uses a yield-per-recruit (YPR) model and a static spawning potential ratio (SPR) to predict population response for various exploitation rates in 5% intervals, with fish of varying target harvest lengths, (i.e. minimum length limits of 300-mm, 375-mm, and 450-mm) (Slipke and Maceina 2010). All simulations were ran with an initial population of 1,000 recruits assuming fixed recruitment. This model evaluated multiple exploitation levels simultaneously (5-95%) (Slipke and Maceina 2010). Rates of natural and fishing mortality and length limits are varied using the YPR model. The YPR model is useful when exploitation rates are unknown or variable within systems. Input parameters required for the YPR model (Table 1) include conditional fishing mortality (cf), conditional natural mortality (cnm), number of fish in the initial population (N_0), the intercept of the weight length regression (a), the slope of the weight length regression (b), the theoretical maximum age (L_∞), the von Bertalanffy growth coefficient (k), age at length zero (t_0), and the theoretical maximum weight (W_∞), calculated from the weight-length regression. A beginning population of 1,000 individuals was used for both models. The Hoenig method in FAMS was used to select conditional natural mortality (cnm) (Hoenig 1983). When modeling populations using various length limits, the model produces six predicted variables in addition to mortality rates to determine harvest potential.

Furthermore, the critical SPR, an index used to identify the critical number of adult females required to sustain recruitment in the population, was held at 0.2 to represent the maximum level for recruitment overfishing in resilient populations (Goodyear 1993; Slipke et al.

2002), such as Channel Catfish populations. Age at maturation was found to be 4 with 50% of the population being females and 100% of the female population ages 4-18 spawning annually.

Three minimum length limit regulations were simulated for the entire West Virginia reach of the Monongahela River collectively; 300-mm, 375-mm, and 450-mm.

Results

In total, 456 Channel Catfish were sampled throughout 2018 and 2019 with sizes ranging from 230 to 694-mm with a mean length of 488-mm (SE=4.6; Figure 2). A total of 397 Channel Catfish were collected for aging purposes and ages were estimated for 395 fish. Two fish were removed from the sample due to reader differences. Ages spanned from 2- 32 years with a mean length of 447-mm (SE= 4.8) at the most frequent age of 8 years (N=54; Figure 3). Total annual mortality was 23% while conditional natural mortality was 21%.

Both the YPR and SPR models were simulated using three various length limits, 300-mm, 375-mm, and 450-mm, to determine when exploitation rates began to impact growth and or recruitment overfishing. The YPR simulation model determined that growth overfishing can occur at a 300-mm length limit when exploitation rates exceed 36% (Figure 4). When simulating the 375-mm and 450-mm length limits, growth overfishing does not occur until exploitation rates reach extremely high levels greater than 90%. In addition to YPR, the simulation model output determined that recruitment overfishing may occur at exploitation levels of 40% when a 300-mm length limit is implemented (Figure 5) and SPR falls below 20%, the critical threshold needed to sustain recruitment for resilient populations. Additionally, neither a 375-mm nor a 450-mm length limit reach levels of recruitment overfishing until exploitation rates reach over 90%.

Discussion

There is currently no minimum length limit for Channel Catfish in the Monongahela River. However, many similar rivers have instituted minimum length limits for this species. For example, Indiana currently has a statewide minimum length limit of 13-inches for Channel Catfish in rivers. Under various modeling simulations we found that under a 300-mm minimum length limit growth overfishing can occur when exploitation rates reach 36%. Furthermore, under a 300-mm minimum length limit the population can experience recruitment overfishing shortly after experiencing growth overfishing at 40% exploitation rates. Additionally, under a 375-mm and 450-mm minimum length limit our modeling simulations suggest that regardless of angler exploitation levels (5-95%) there would be no influence on the population.

The Monongahela River Channel Catfish population is a recovering fishery, impacted by years of acid mine drainage. Although exploitation rates are assumed to be low due to years of pollution, as this population has recovered, angler interest in catfishing has increased. Given this new interest, anglers have the potential to increase exploitation rates subsequentially impacting the sustainability of the fishery. Thus, management is needed to ensure sustainability of previously vulnerable populations. A common management strategy for ensuring sustainability of populations is to ensure continual recruitment, which is needed for self-sustaining wild populations (Hubert and Quist 2010). This is often achieved by implementing minimum length limits to prohibit recruitment overfishing of the population (Hubert and Quist 2010).

Many similar large rivers have implemented minimum length limits for Channel Catfish. In the Upper Mississippi River (UMR) studies found that under a 330-mm length limit the Channel Catfish population did experience growth overfishing at exploitation rates 50-70%, however, they found that the decrease in yield was more affected by recruitment overfishing

(Slipke et al. 2002). Furthermore, after raising the minimum length limit to 381-mm, they found that the population was no longer experiencing overexploitation (Slipke et al. 2002). In addition, a decline in commercial harvest of Channel Catfish in the Middle Mississippi River (MMR) was previously thought to be attributed to a low minimum length limit, however Bueltmann and Phelps (2015) found that when modeling length limit simulations for the population no growth overfishing was occurring until exploitation rates reached 50-70%. Moreover, recruitment overfishing was not occurring in the population as SPR rates remained between 10-20% while exploitation rates were between 45-80% (Bueltmann and Phelps 2015).

When managing for a sustainable fishery it is extremely important to understand the current population status. An incorrect understanding of the population could potentially lead to mismanagement of the population, in turn leading to undesirable conditions (McCain et al. 2011). Current trends are identified by conducting frequent standardized sampling events. These assessments should be conducted regularly especially after habitat modifications, length limit changes, and decreases in yield are observed as these all have the potential to alter population dynamics (Bueltmann and Phelps 2015). However, length limits have the ability to strengthen populations to ultimately provide sustainable fisheries. Thus, harvest regulations are crucial in maintaining self-sustaining populations under frequent monitoring.

Considering the exploitation rates for Channel Catfish within the Monongahela River are largely unknown, we suggest the WVDNR adopt a 15-inch minimum length limit for the Channel Catfish population in this river. This regulation will prevent growth and recruitment overfishing from occurring should harvest levels currently or in the future exceed critical levels. At the same time, this regulation also ensures that anglers have the ability to adequately harvest fish. As with any regulation, should WVDNR implement such a regulation, it would be prudent to continue to monitor this fishery in the future to determine its impact and if any further changes are warranted.

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Table 1. Population dynamic parameters used in FAMS for the Monongahela River 2018 and 2019 Channel Catfish population.

Parameter	Value
Von Bertalanffy growth coefficients	L_∞= 564-mm; K= 0.202 ; t0= -0.497
Maximum age	18
Conditional natural mortality	0.21
Conditional fishing mortality	0.05-0.95
Log10(weight) :log 10(length) coefficients	intercept= -5.872 ; slope = 3.311
Age at sexual maturation	4
Fecundity-to-length relation	log10 (fecundity) = 2.2645 × log10 (TL) = -2.2862
Percent of fish that are females	50
Percent of females that spawn annually	100
Minimum length limits (mm)	300, 375, 450

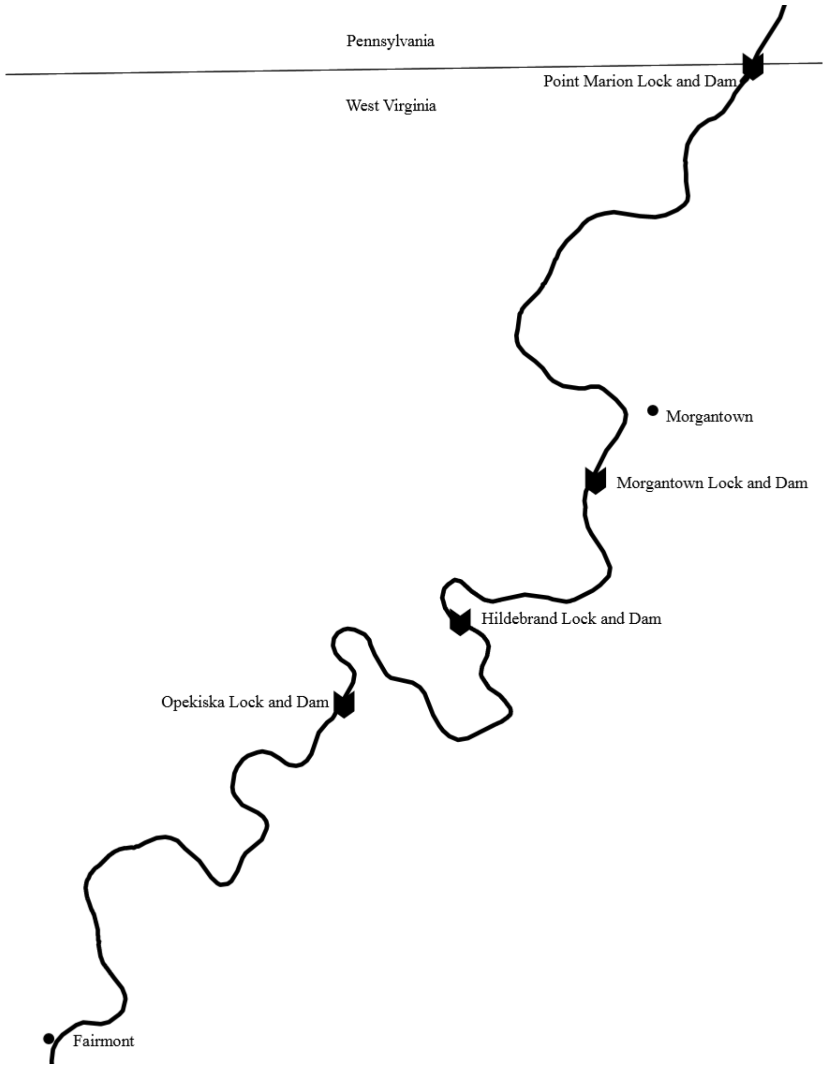

Figure 1. Map of the four pools of the Monongahela River in West Virginia. The river flows from Fairmont, West Virginia to Pittsburgh, Pennsylvania. Pools are named after the downstream lock and dam.

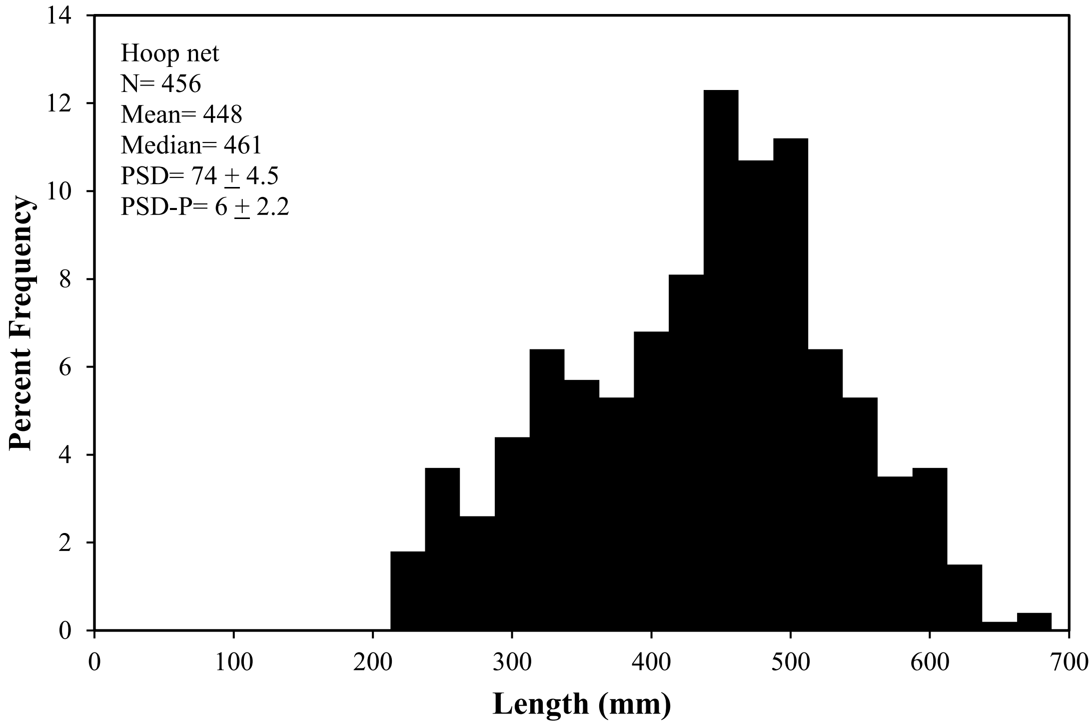

Figure 2. Length frequency distribution of Channel Catfish sampled from the Monongahela River using hoop nets during 2018 and 2019.

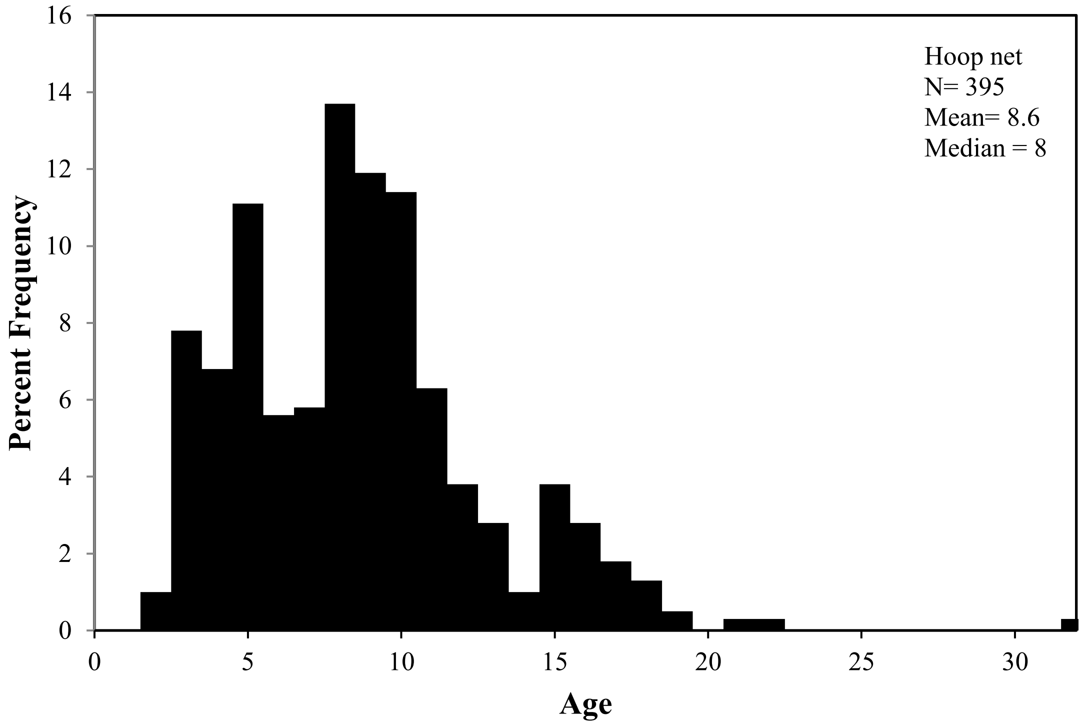

Figure 3. Age frequency distribution of Channel Catfish sampled in the Monongahela River using hoop nets during 2018 and 2019.

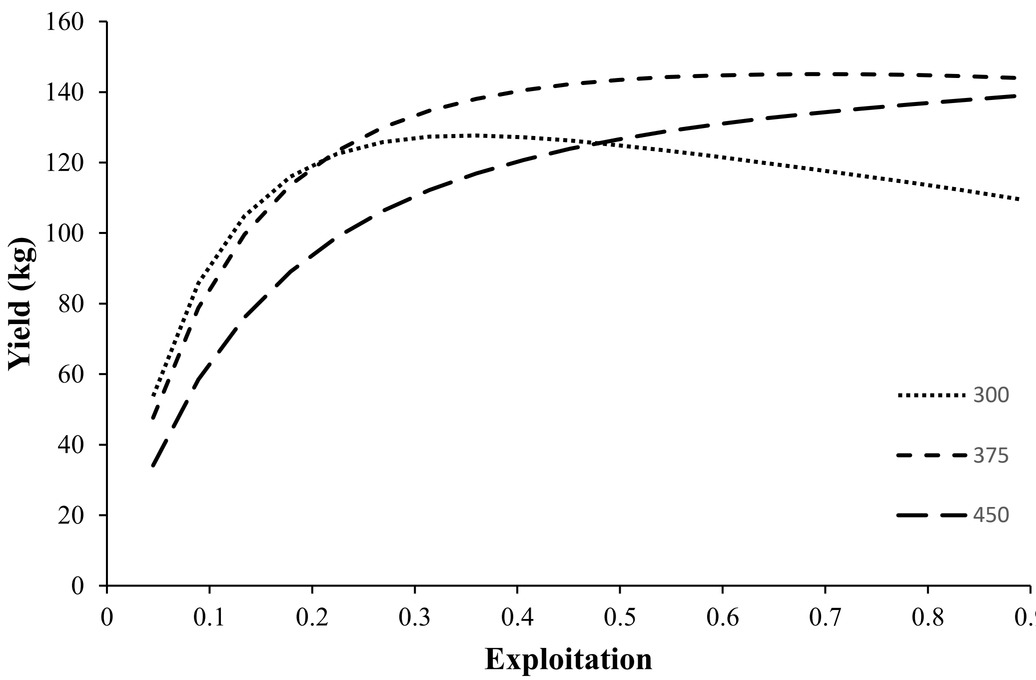

Figure 4. Predicted yield (per 1,000 recruits) for various exploitation rates and three minimum length limits (mm) for Channel Catfish in the Monongahela River, WV.

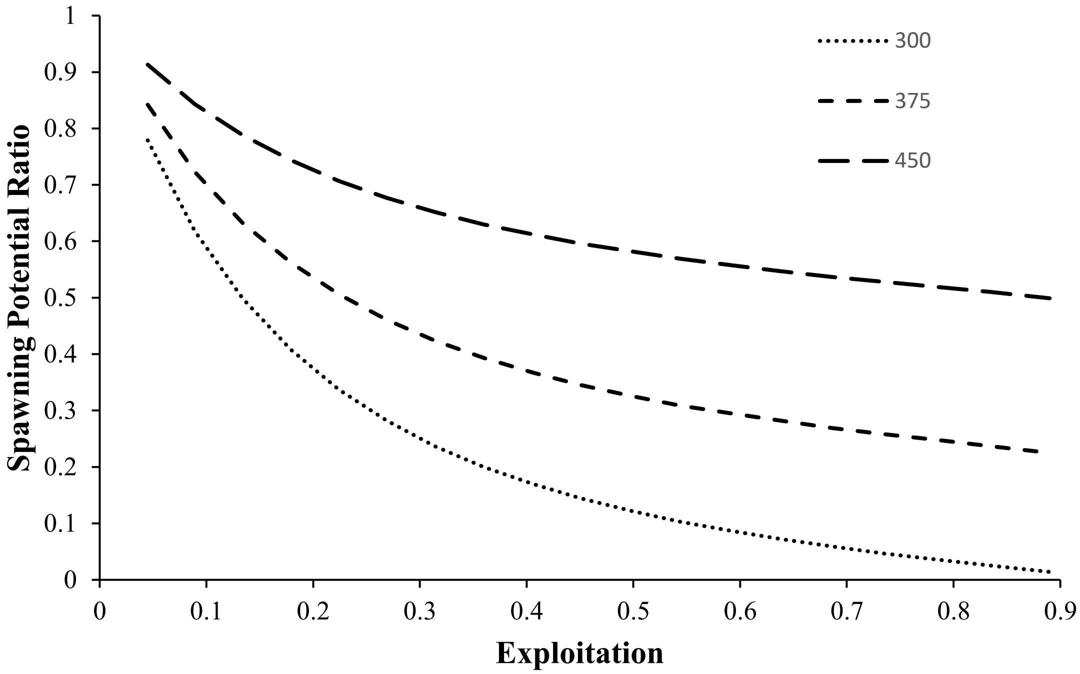

Figure 5. Predicted spawning potential ratio (per 1,000 recruits) for various exploitation rates and three minimum length limits (mm) for Channel Catfish in the Monongahela River, WV.

CHAPTER 4: SUMMARY

No previous research has studied the Channel Catfish population in the Monongahela River, WV. The findings in this thesis suggest that standardized population assessments should be conducted frequently using hoop nets. In addition, the West Virginia Division of Natural Resources should consider implementing a 15-inch minimum length limit for Channel Catfish in the Monongahela River, WV to prevent growth and recruitment overfishing from occurring within this population.

APPENDIX

West Virginia University
Institutional Animal Care and Use Committee

WVU Assurance A3597-01
New #D16-00362

Date: Mar 1, 2019

IACUC PROTOCOL APPROVAL NOTICE TO THE INVESTIGATOR

Investigator: Quinton Phelps **IACUC Protocol #:** 1810018491

Project Title: Ohio River Basin Fisheries Project

Type of approval: New Replacing protocol #:

Comments: Please ensure all applicable state and federal scientific collecting permits are in place before work begins. Please send to the IACUC upon receipt.

Funding Agency: WV DNR

The West Virginia University Animal Care and Use Committee (WVU IACUC) has granted approval for the above referenced project. Approval was based on review of the protocol and, if appropriate, an inspection of the laboratory/facility space where procedures on animals are done. Should any modifications be necessary, you must obtain prior approval from the WVU IACUC by submitting an amendment.

PIs are reminded that they are responsible for adhering to all relevant IACUC and OLAR policies and SOPs as they are written at the time of protocol approval and as they may be revised from time to time. Every effort will be made to ensure PIs are notified of policy changes that impact their research activities, but PIs and their personnel are required to remain current on procedures.

Initial Approval Date: Mar 1, 2019 **Protocol Expiration Date:** 2/28/2022

Number of animals: 5250 Species: Fish (wildlife)

○ Acquisition of your animals MUST be through OLAR

◉ Acquisition of your animals does NOT need to be through OLAR

USDA Pain Category: Cat D

○ **Animals will be taken out of the animal facility for all surgical procedures OR are USDA-regulated animals that will be taken out of the animal facility for any procedure.** Therefore, procedure rooms associated with this protocol will be monitored every 6 months & you will be contacted to schedule a laboratory inspection every 6 months.

◉ **Animals are not taken out of the vivarium OR this is an agricultural or wildlife protocol OR non-USDA-regulated species will be taken out of the animal facility for non-surgical procedures.** These areas are subject to inspection on a routine basis.

PLEASE NOTE:

1. *Any laboratory can be inspected at any time for any reason.*
2. *A copy of the approved protocol, including any amendments, must be present in the laboratory & made available to all study personnel.*
3. *ALL personnel on IACUC protocols MUST be up to date with CITI training (good for 3 years) & the Occupational Health Questionnaire (good for 1 year).*

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