Size Structure, Age, Growth, and Mortality of Flathead Catfish in the Robert C. Byrd Pool of the Ohio and Kanawha Rivers

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Abstract: Flathead catfish (*Pylodictis olivaris*) were sampled in the Robert C. Byrd Pool of the Ohio and Kanawha rivers, West Virginia, to inform management decisions based on population characteristics of size structure, age, growth, and mortality. Sampling was conducted with low-frequency boat electrofishing during late May to early June over a four-year period (2017–2020). We examined size structure using proportional size distribution indices. Growth was evaluated using otolith-derived ages, a von Bertalanffy growth curve, and mean length at age data, including comparisons to published mean length at age data of other populations. Annual mortality was estimated with a weighted catch curve. We documented a high-density population (mean CPUE = 49 fish h^{-1}) with low mortality (A = 11.8%), characterized by slow growing individuals with a maximum recorded age of 36. Our results further demonstrate that this population is characterized by a broad size structure that likely is maintained only through low harvest and high rates of catch and release by anglers.

Key words: *Pylodictis olivaris*, von Bertalanffy, length at age, catch curve

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The flathead catfish (*Pylodictis olivaris*) is a large bodied apex predator native to the Mississippi River and several other Gulf Coast drainages, where it occurs commonly in large rivers or reservoirs (Jackson 1999, Page and Burr 2011, Fuller and Whelan 2018). Flathead catfish are targeted by recreational anglers, trophy anglers, and commercial fishers (Quinn 1993, Arterburn et al. 2002, Krogman et al. 2011, Winders and McMullen 2021). Given anglers interest in flathead catfish, natural resource agencies have been increasingly interested in understanding its population characteristics (Irwin and Hubert 1999, Kwak et al. 2011, Montague and Shoup 2021). Data on size and age structure of flathead catfish populations are commonly collected by researchers for estimating rates of growth and mortality (Mayo and Schramm 1999, Porter et al. 2011, Schall and Lucchesi 2021). Size information, age data, and associated parameter estimates for growth and mortality are useful for understanding trends in population characteristics, as well as current population status, all of which can inform management decisions for flathead catfish fisheries.

Age and growth studies of flathead catfish in rivers and reservoirs have been conducted across a wide geographic range encompassing native and nonnative populations (e.g., Mayhew 1969, Young and Marsh 1990, Daugherty and Sutton 2005a, Stubbs et al. 2014). Age determination was traditionally based on pectoral spines (reviewed by Nash and Irwin [1999] and Koch et al. [2011]), but more recently otolith-based age estimates have been used due to increased precision and accuracy, particularly for individuals older than age 5 (Maceina and Sammons 2006, Olive et al. 2011). Growth rates are generally similar between sexes (Munger et al. 1994, Marshall et al. 2009, Steuck and Schnitzler 2011), but flathead catfish from reservoir and non-native populations may grow at faster rates than native riverine populations (Grabowski et al. 2004, Kwak et al. 2006, Sakaris et al. 2006; but see Rypel 2011, Massie et al. 2018). Flathead catfish in some native populations are long-lived with relatively slow growth rates in older individuals (Nash 1999, Kwak et al. 2006, Jolley and Irwin 2011, Bodine et al. 2016). Consequently, managers concerned about exploitation rates have considered or implemented creel limits or length limits to reduce impacts of harvest on size and age structure or to protect older, slow-growing individuals (Jackson 1999, Donabauer 2009, Marshall et al. 2009).

The native population of flathead catfish in the Robert C. Byrd Pool (RCBP) of the Ohio and Kanawha Rivers, West Virginia, provides a popular regional recreational fishery, but commercial harvest is prohibited within West Virginia waters (West Virginia

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Division of Natural Resources [WVDNR] 2022). Channel catfish (*Ictalurus punctatus*) and blue catfish (*Ictalurus furcatus*) are also present in the pool, the latter represents a maturing reestablished population. The RCBP and other West Virginia sections of the Ohio and Kanawha rivers are managed through regulations allowing an angler to harvest four flathead catfish per day, including a length limit of only one individual exceeding 889 mm (WVDNR 2022). Despite the popularity of this fishery, little work has been conducted on age, growth, and mortality of this species for the RCBP, or other West Virginia sections of the Ohio or Kanawha rivers.

In this study, we examined RCBP flathead catfish population characteristics to guide future management decisions and fill a regional knowledge gap on the ecology of the species. Study objectives were to (1) examine size structure of flathead catfish from the RCBP of the Ohio and Kanawha rivers; (2) evaluate growth using von Bertalanffy regression; and (3) estimate mortality via catch-curve analysis.

Study Area

The RCBP consists of a 61-km reach of the middle Ohio River, between the Racine and Robert C. Byrd locks and dams, as well as the lower 51 km of the Kanawha River downstream of Winfield Lock and Dam. The Kanawha River flows into the Ohio River near the town of Point Pleasant, West Virginia. Habitat and water quality of the RCBP has a long history of degradation (ORSANCO 1962, Trautman 1981, Pearson and Krumholz 1984, Messinger 1997), including habitat alteration by locks and dams. A minimum depth of 2.74 m is maintained by the U.S. Army Corps of Engineers to accommodate freight barges. Within the study area, both the Ohio and Kanawha rivers average 8 m in depth and are low gradient with predominately sand, silt, and clay substrates (ORSANCO 2013). The rivers are separated from their floodplains by levees and steep banks, but there is an abundance of large woody debris along sections of shorelines. Revetments are common along riparian areas, particularly near urban and industrial centers. Water quality has generally improved since the mid-20th century (Pearson and Krumholz 1984, Messinger 1997), but consumption advisories remain in effect for many fishes due to historical water contaminant issues. The current consumption advisory for flathead catfish is one meal per month because of polychlorinated biphenyls contamination (WVDNR 2022). Water clarity during our surveys ranged from high turbidity to a clarity of approximately 0.5-m Secchi depth.

Methods

Flathead catfish were sampled using low frequency boat electrofishing (Smith Root GPP 5.0, 15 Hz, low voltage range of 0–500 V, 20–30% duty cycle, 2–3 average amps), a common method with proven efficiency for sampling riverine flathead catfish (Ford et al. 2011, McCain et al. 2011, Travnichek 2011, Bodine et al. 2013, Montague 2021). We sampled over a four-year period (2017–2020) during late May to early June, coinciding with pre-spawning or spawning periods. Surveys were repeated annually at 10 fixed sites throughout the pool, targeting outside bends, rip-rap banks, steep drop offs, creek mouths, and tailwaters. Two sites per day were sampled late morning to afternoon, where four 15-min transects were conducted per site while motoring the electrofishing boat downstream approximately 10 m from the bank. A chase boat was used to increase catch rates (Daugherty and Sutton 2005b, Pritt et al. 2022).

For age analysis, we removed lapilli otoliths from four randomly selected flathead catfish from each electrofishing transect during 2019. The total number of flathead catfish per transect was entered into a random number generator, which returned four numbers, known only to the data recorder. Fish were selected for aging based on the order in which they were removed from the livewell, with the random numbers unknown to the processing investigator. This method was used in lieu of size bins to ensure equal representation of the 10 survey locations in our data, while also providing an unbiased sample.

We extracted otoliths and assigned ages to individual fish following methods presented by Buckmeier et al. (2002) with several modifications. To reduce risk of obscuring the annuli, we did not brown otoliths on a hot plate prior to mounting, a modification shown not to reduce aging accuracy in flathead catfish (Waters et al. 2019). Using a camera mounted on a dissecting microscope, a series of incremental photographs of each otolith were taken during the sanding process. Mounted otoliths were submerged in water for photographs, providing contrast between annuli. Two independent readers estimated age by counting annuli from the photographic images, reconciling disagreements via concert readings. Unaged fish were assigned an age using a conditional probability-based age-length key (10-mm size bins).

Flathead catfish were measured (TL, mm) and annual CPUE was calculated as number of fish per hour (fish h^{-1}). Size structure was examined by calculating proportional size distribution indices (PSD, PSD-P, PSD-M, and PSD-T) using size bins defined by Quinn (1991) as follows: sub-stock, <350 mm; stock, 350 mm; quality, 510 mm; preferred, 710 mm; memorable, 865 mm; trophy, ≥1020 mm. Indices and associated 95% CIs were calculated with the Fisheries Stock Analysis R package (FSA; Ogle et al. 2022) for each year. We modeled growth by estimating parameters of the von Bertalanffy (1938) equation. Mean length (TL, mm) at age and mortality rates were examined using FSA. A weighted catch curve (catchCurve function of FSA) was used to estimate instantaneous total mortality rate (Z) and survival ($S = e^{-Z}$; Ricker 1975). The data fit the catch-curve regression reasonably well ($r^2 = 0.69$), with four notable low residuals. We assumed fish were fully recruited to the gear by age 3 and restricted the catch-curve analysis to ages 3–23 due to low sample sizes of older otolith-aged individuals. Estimated mean values of natural mortality rate (M) and conditional natural mortality rate (cm) were calculated using rate estimates produced by eight estimators from the Fisheries Analysis and Modeling Simulator (FAMS; Slipke and Maceina 2014).

Results

A total of 1893 flathead catfish were captured using electrofishing (Figure 1). Mean total CPUE was 49 (95% CI: 39–59) fish h^{-1}, varying from 30 fish h^{-1} to 81 fish h^{-1} across years (Table 1). We collected all size classes each year with exception of trophy-sized individuals in 2018. Sub-stock individuals composed 56% of the total catch, and PSD, PSD-P, and PSD-M were all relatively high every year (Table 1).

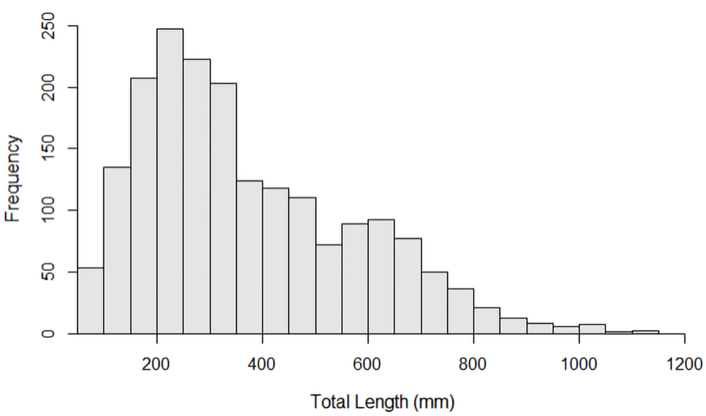

Figure 1. Length frequency pooled across years for flathead catfish collected from the Robert C. Byrd Pool of the Ohio and Kanawha rivers, West Virginia.

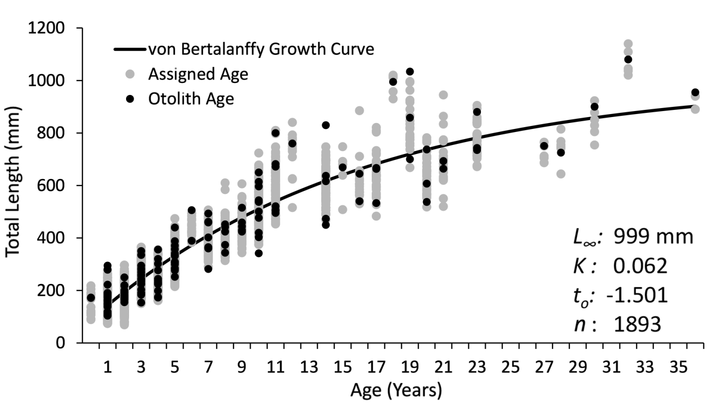

Figure 2. The fitted von Bertalanffy growth curve for flathead catfish collected from the Robert C. Byrd Pool of the Ohio and Kanawha rivers, West Virginia, with parameter estimates and sample size. Otolith-aged and assigned-aged individuals are denoted by black and grey dots, respectively.

Ages were determined for 143 individuals and ranged from 0 to 36 years (Table 2). The von Bertalanffy growth curve parameter estimates were $L_\infty = 999$ (SE = 22) mm, $k = 0.062$ (0.003), and $t_o = -1.501$ (0.100) (Figure 2). The catch curve predicted low annual mortality in the population, with Z = 0.126 (95% CI: 0.045–0.206) and A = 11.8% (4.5–18.7%). Means of natural mortality (M) and conditional natural mortality (cm) estimates were 0.126 (range 0.089–0.194) and 12% (range 8–18%), respectively.

Table 1. Annual size structure indices of flathead catfish captured by low-frequency boat electrofishing during late May to early June 2017–2020 from sections of the Robert C. Byrd Pool, Ohio and Kanawha rivers, West Virginia. Values in parentheses are 95% CIs. Size classes (mm TL) followed Quinn (1991): <350 mm for sub-stock, 350 mm for stock, 510 mm for quality, 710 mm for preferred (P), 865 mm for memorable (M), and ≥1020 mm for trophy (T).

Year	CPUE	PSD	PSD-P	PSD-M	PSD-T
2017	40 (30–50)	50 (46–61)	15 (8–22)	4 (0–8)	1 (0–2)
2018	30 (20–40)	60 (48–72)	15 (6–23)	2 (0–5)	0
2019	41 (27–55)	57 (45–69)	16 (7–25)	6 (0–11)	1 (0–4)
2020	81 (59–103)	57 (48–66)	17 (10–24)	4 (0–7)	1 (0–3)
Total	49 (39–59)	56 (50–61)	16 (12–20)	4 (2–6)	1 (0–2)

Table 2. Mean (SE) of TL (mm) at age for flathead catfish captured by low-frequency boat electrofishing during late May to early June 2019 from sections of the Robert C. Byrd Pool, Ohio and Kanawha rivers, West Virginia; $n = 143$.

Age	Mean TL	Number
0	173 (1)	2
1	168 (13)	18
2	191 (7)	13
3	249 (13)	17
4	247 (16)	12
5	326 (12)	16
6	448 (59)	2
7	403 (28)	7
8	407 (21)	5
9	454 (16)	5
10	508 (31)	10
11	597 (46)	7
12	760	1
14	601 (68)	5
15	669	1
16	593 (53)	2
17	621 (44)	3
18	995	1
19	864 (96)	3
20	627 (59)	3
21	679 (15)	2
23	786 (47)	3
27	751	1
28	725	1
30	900	1
32	1080	1
36	955	1

Discussion

An evaluation of size structure, age, growth, and mortality improved our understanding of population characteristics of flathead catfish in the RCBP of the Ohio and Kanawha rivers. We documented a robust population, characterized by long-lived and slow-growing individuals within a stable, high-density population experiencing low mortality. The broad size structure of the population is encouraging considering the long history of habitat alterations and water quality issues of the Ohio and Kanawha Rivers (ORSANCO 1962, Pearson and Krumholz 1984, Messinger 1997). The oldest individual was estimated to be 36 years old, which may be the oldest reported individual from a native population (see Marshall et al. 2009, Bonvechio et al. 2015).

The size structure was similar among survey years, with high index values that were consistent with those expected of a theoretical population with constant recruitment and mortality (Neumann et al. 2012). These consistent rates suggest a population not undergoing any major fluctuations. A high catch rate of sub-stock individuals in the 2020 electrofishing survey may reflect one or more substantial year classes recruiting into the fishery. Conversely, four age classes were poorly represented in our age data, leading to low assignment and high residuals in our catch curve. This indicates the population experienced occasional years with low recruitment, however these events were rare and had little effect on the overall size structure.

The large decrease from PSD (56) to PSD-P (16) and larger size indices could be associated with gear bias. Few studies have specifically addressed size selectivity of low-frequency boat electrofishing, but this method may select against flathead catfish over 600 mm (Bodine et al. 2013, Snow et al. 2019). Other gears such as hoop nets and trotlines may increase catch of larger individuals (Ford et al. 2011, Gelwicks and Steuck 2011, Dickinson et al. 2017, but see Oliver 2021).

Mean length at age values represented below average growth compared to published data from other native, riverine populations with otolith-based age estimates. Specifically, mean length at age of the RCBP population was generally less than those of populations from the Mississippi River in Iowa (Steuck and Schnitzler 2011), and the Missouri River in Missouri (Robinson 1997), but similar to values from a Tallapoosa River population in Alabama (Nash 1999). Based on high electrofishing catch rates, the slow growth observed in the RCBP population may reflect density dependence. Interspecific competition with channel catfish or blue catfish could also influence growth rates of flathead catfish, but these species often partition habitats in riverine systems (Driscoll et al. 1999, Miranda and Killgore 2011). Although the growing season is relatively short in the RCBP compared to more southerly populations, flathead catfish growth does not seem to be greatly affected by the length of growing season as some northern populations exhibit faster growth than southern ones (Swingle 1954, Nash 1999, Steuck and Schnitzler 2011). Latitudinal countergradients may explain this north-south difference in flathead catfish growth (Rypel 2011).

The RCBP population exhibited highly variable mean lengths for individuals aged 10 and older, where ages 12, 18, and 19 demonstrated higher values closer to populations from Iowa and Missouri. This variation was also seen in our von Bertalanffy curve residuals. Variation in growth in older flathead catfish from the Mississippi River, Iowa, was attributed to a low sample size of older fish of ages 12–26 (Steuck and Schnitzler 2011). Sample size within this age range, however, does not fully address the observed variation in the RCBP, which could be driven by annual fluctuations of hydrologic or other environmental factors that influence growth during critical periods in certain cohorts (Jones and Noltie 2007, Rypel 2011), or individual behavioral factors such as variable predatory success or dominance hierarchies. Annual variability in prey availability or competition could also lead to growth variation among older individuals, which is an area of interest for future studies.

Our estimated annual total mortality rate (11.8%) was among the lowest reported in published studies. Annual mortality estimates for this species range from 11.9% from the Coosa River, Alabama (Jolley and Irwin 2011) to 45.2% from the Satilla River, Georgia (Sakaris et al. 2006). Our estimate of low annual mortality for the RCBP is commensurate with the wide range of ages and presence of older individuals and is consistent with those reported from other native populations with long-lived individuals (Jolley and Irwin 2011, Bodine et al. 2016). In contrast, higher mortality estimates are often found from studies where population structure is truncated due to high exploitation rates or other undetermined biotic or abiotic regulatory mechanisms. In some cases, estimates of mortality may be high for non-native populations due to the timing of introduction where older individuals are rare or not yet present (Kwak et al. 2006, Hilling et al. 2019).

Natural mortality was approximately equal to total annual mortality. This supports our suspicions of low fishing mortality in the population, despite the fishery's popularity with anglers. Based on our observations and anecdotal information, we believe that fishing mortality is low in the RCBP population because anglers often practice catch and release fishing, potentially driven by a combination of consumption advisories and an interest in maintaining a trophy fishery.

A management goal for the flathead catfish population of the RCBP is to promote angler satisfaction through maintaining a robust and sustainable population with opportunities for catch and release or harvest of trophy-sized individuals. The population is currently managed by a creel limit (four fish per day), and a length limit of only one individual exceeding 889 mm, allowing for limited harvest of memorable- and trophy-sized individuals. Based on our results, the relatively high abundance of flathead catfish in the RCBP population, along with the wide range of age classes and long-lived individuals, provide anglers with opportunities for catching a broad range of size classes, as well as trophy-sized individuals. Low estimates of Z and M suggests that fishing mortality is low for this population, which reduce the ability for harvest regulations to shape population structure (Slipke and Maceina 2014). Although creel and angler surveys could be used to further assess this fishery, our data indicating high densities, low mortality, and slow growth rates could be considered for management decisions of the RCB flathead catfish fishery, particularly relative to its trophy fishery potential.

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