Why did the Walleye Cross the Reservoir? Explaining Adult Walleye Use of the Missouri River Upstream of Canyon Ferry Reservoir to Toston Dam

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WHY DID THE WALLEYE CROSS THE RESERVOIR? EXPLAINING ADULT WALLEYE USE OF THE MISSOURI RIVER UPSTREAM OF CANYON FERRY RESERVOIR TO TOSTON DAM

By

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ABSTRACT

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Faculty Mentor: Lisa Eby

Over the last decade, walleye (*Sander vitreus*) have been increasingly using the Missouri River upstream of Canyon Ferry Reservoir to Toston Dam, and Montana Fish, Wildlife, and Parks wants to understand why these walleye are moving upstream and how it could impact the existing fish community in the river. To understand if this expansion of habitat could be associated with spawning and/or foraging, we examined the composition and distribution of juvenile fish in the area. Specifically, the presence of juvenile walleye would indicate that adult walleye were using the river to spawn and/or if there were abundant prey fish available then adults might be increasingly using the river to feed. To ensure a representative data set, we divided the 23-mile-long stretch of river into three sampling sections. In each section, juvenile fish were sampled using beach seines and mini-fyke nets across pool, riffle, run, and backwater habitats. Each section was sampled twice during the summer of 2016, once in late July or early August and again in mid-August. We captured 26,510 fish, with yellow perch (*Perca flavescens*), white sucker (*Catostomus catostomus*) and longnose dace (*Rhinichthys cataractae*) being the most common species captured. Only 16 of these fish were juvenile walleye, all coming from sampling locations at the interface of the river floodplain and the reservoir; no juvenile walleye were found in the river upstream of this interface. Based on these results, it appears that walleye did not use the river to spawn. However high densities of yellow perch, one of the walleye's favorite prey items, suggests that adult walleye are using this stretch of river to feed. Additionally, classification and regression tree results of habitat associations indicate that perch occurred in habitat with characteristics preferred by walleye, suggesting that walleye may impact the perch population the most in the future.

Why did the Walleye Cross the Reservoir? Explaining Adult Walleye Use of the Missouri River Upstream of Canyon Ferry Reservoir to Toston Dam

Introduction

The expansion of non-native fish species has become a common phenomenon across the globe as humans have taken certain species out of their native ranges and introduced them, both legally and illegally, into new aquatic ecosystems, most often for the purpose of creating new recreational fisheries in these systems (Rahel, 2000). These expansions can have negative impacts on the existing fishery in a system, and lead to homogenizations of fish communities (Rahel, 2002). However, these introductions may provide new benefits to society by adding new species to a fishery (Gozlan, 2008). One such example of a novel species being illegally introduced into new aquatic ecosystems is the walleye (*Sander vitreus*), which has been introduced into many water bodies in the Pacific Northwest (Rahel, 2000). Popular sport fisheries often develop in locations where illegally introduced walleye establish, but increased populations of this highly piscivorous fish species can lead to declines in existing fish populations (McMahon and Bennett, 1996).

Canyon Ferry Reservoir, Montana is one example of a fishery that experienced both positive and negative changes after the illegal introduction of walleye. According to Montana Fish, Wildlife, and Parks (FWP) (2010), walleye were first detected in Canyon Ferry in 1989, and began expanding rapidly in the mid-1990's. Prior to this expansion, Canyon Ferry Reservoir was primarily managed as a wild yellow perch (*Perca flavescens*) and stocked rainbow trout (*Oncorhynchus mykiss*) fishery (Montana FWP, 2010). As walleye numbers increased, perch numbers began to decline, reaching record low numbers of less than one perch per net in FWP's annual gillnetting series in the reservoir during the mid-2000's (compared to a record high of 79 perch per net in 1964, and an average of 47 per net as recently as 1999) (Montana FWP, 2010). Additionally, to maintain the stocked rainbow trout fishery, FWP was forced to begin stocking larger rainbows that could avoid walleye predation (Montana FWP, 2010). However, as walleye numbers increased, so did the number of people who fished on Canyon Ferry, and today the reservoir is one of the most popular walleye fisheries in the state of Montana (Montana FWP, 2010).

Over the last decade, FWP has received an increased number of reports from anglers catching walleye in the stretch of the Missouri River extending 37 kilometers upstream from

Canyon Ferry Reservoir to Toston Dam (Montana FWP, 2010). FWP primarily manages this stretch of river as a wild rainbow trout and brown trout (*Salmo trutta*) fishery, and walleye expansion into the river could reduce the populations of both trout species, as well as the populations of other river-dwelling species, through predation (Montana FWP, 2010). In 2015, FWP began a multi-year radio telemetry study looking into the movements of walleye between Canyon Ferry Reservoir and the Missouri River upstream to Toston Dam to examine the extent and timing of walleye migrations from the reservoir into the river, and how these migrations could impact the existing river fishery. During the first year of the study, most of the 18 walleye tagged by FWP technicians were observed travelling upstream into the river during the spring, remaining in the river over the summer, and returning to the reservoir in the fall (A. Strainer, personal communication). This movement of adult walleye into the river during the spring coincides with the typical spawning period of walleye (McMahon et al., 1984). Additionally, McMahon (1992) had previously identified this stretch of river as suitable spawning habitat for walleye, leading FWP to hypothesize that walleye were using this stretch of river to spawn.

The purpose of our study was to use juvenile fish sampling in the Missouri River upstream of Canyon Ferry Reservoir to Toston Dam to help explain seasonal use of the river by adult walleye. Specifically, the presence of juvenile walleye in the river would indicate that adult walleye are using the river to spawn. Additionally, this stretch of river has never been sampled for juvenile fish, and FWP wanted to know which species reside in the river, as well as how the juvenile fish assemblages of the river and reservoir differ. The presence of known walleye prey species could indicate that adult walleye are using the river to feed, and differences between river and reservoir assemblages could help explain why walleye are leaving the reservoir and moving into the river. Finally, knowing the current juvenile fish assemblage will help FWP measure the impacts of continued walleye expansion on the river fish community in the future, and allow us to determine which species will most likely be impacted by this expansion.

<u>Study Questions</u>

1. Are walleye using the Missouri River upstream of Canyon Ferry Reservoir to Toston Dam for spawning?
2. What juvenile fish species live in the river?
3. Does the juvenile fish assemblage differ between the river and the reservoir?

4. Do the species found in the river overlap with species known to exist in walleye diets in other systems?

5. Based on habitat associations, which species will be most impacted by continued walleye expansion into the river?

Study Area

The section of the Missouri River sampled begins at Toston Dam, approximately 6 kilometers south-southeast of the town of Toston, Montana, and flows north-northwest for 37 kilometers through Broadwater County before reaching its confluence with Canyon Ferry Reservoir just north of Townsend (Figure 1). U.S. Highway 287 runs adjacent to the lower 30 kilometers of this section of river. Toston Dam is a 15.7-meter-tall, 214.9-meter-wide concrete run-of-the-river dam owned by the Montana Department of Natural Resources and Conservation (DNRC) and operated as both a hydropower facility as well as an irrigation diversion for agricultural use in Broadwater County (Montana DNRC, 2014).

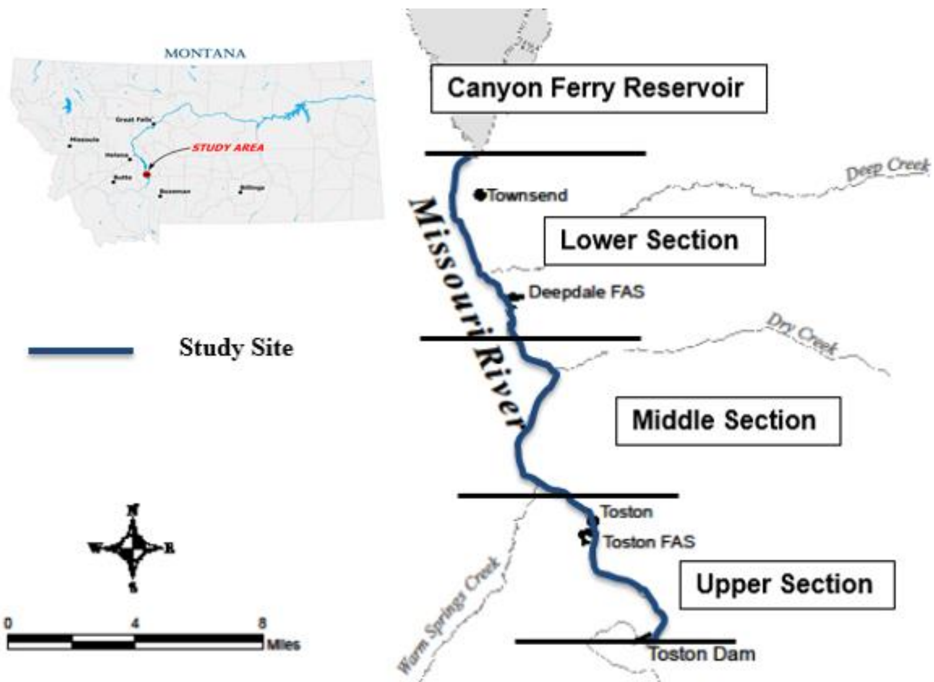

Figure 1. Study area. Image from Montana Fish, Wildlife, and Parks.

Methods

The river was divided into three roughly equal sampling sections, each approximately 12 kilometers in length (Figure 1). We sampled each section twice, once in late July or early August and again in mid-August. Within each section, different gear types were used to sample different habitat types in the river. Beach seines measuring 7.6 meters long and 1.2 meters tall with 9.5-

millimeter diameter mesh were used to sample shallow main and side-channel pool habitats; 10 seines were pulled per section during each sampling event (Figure 2). Mini-fyke nets measuring 4.5 meters long and 0.76 meters tall with 6.3-millimeter diameter mesh were used to sample deeper pool habitats in both the main and side river channels; 4 mini-fyke nets were run per section during each sampling event (Figure 3). Each mini-fyke net was set for approximately 24 hours. Hoop nets measuring 45.7 centimeters long and 12.7 centimeters tall with 6.3-millimeter diameter mesh baited with cut white sucker (*Catostomus commersonii*) meat were used to sample main channel riffle and run habitats; 6 baited hoop nets were run per section during the first sampling event, but were ineffective at capturing juvenile fish and were discontinued during the second sampling event.

At each sampling location, individual fish were sorted by species, counted, and released back into the river. We kept one individual of each species captured during the study for reference and stored these individuals in jars of ethanol. All adult (age 1+) fish captured were counted separately from juveniles of the same species. At each beach seining location, we recorded the pull time, pull temperature, average depth, substrate type, presence/absence of aquatic vegetation, and location in the river (main or side channel) where the sample was taken. At mini-fyke net and baited hoop net locations, we recorded the set time, pull time, set temperature, pull temperature, and average depth of each location. For all gear types, we also recorded the date each sample was taken, as well as the GPS coordinates for each sampling location.

We used the beach seine and mini-fyke net data to generally describe the composition of the river fish assemblage in the different sections using bar graphs. To compare the juvenile fish assemblages of the river and the reservoir, we ran a non-metric multidimensional scaling (NMDS) using the "vegan" package in R, version 2.4-3 (Oksanen *et al*., 2017). We used juvenile fish data from our beach seining locations as well as data from FWP beach seining in Canyon Ferry Reservoir in late August 2016 to run the NMDS. Only the beach seines from our second sampling event (n = 25) were used in the NMDS to match the timing of FWP sampling in the reservoir (n = 38) as closely as possible. Species used in the NMDS (yellow perch, white sucker, longnose dace (*Rhinichthys cataractae*), and fathead minnow (*Pimephales promelas*)) were those that were found in both the river and the reservoir, with at least one site in each habitat containing greater than one individual of that species. Sites containing no individuals of these species were removed from the analysis. The NMDS was run on the relative proportions of these species rather than raw numbers of fish captured due to decreased seining efficiency in certain areas of the river reducing the total number of fish captured at these locations. The NMDS was run using Bray-Curtis dissimilarity in two dimensions (stress = 0.06) because the stress of a two-dimensional NMDS was well below the maximum stress threshold of 0.2 recommended by Clarke (1993) and because the rate of decrease in stress associated with additional dimensions declined rapidly after two (Appendix 3).

To determine which juvenile fish species will be most impacted by continued walleye expansion, we used our beach seining data to created regression trees for the most common species captured (yellow perch, white suckers, longnose dace, and fathead minnows) showing the number of fish per beach seine separated by different habitat parameters using the "rpart" package in R, version 4.1-10 (Therneau *et al.*, 2015). We used seining data to create the regression trees as seining sites covered a variety of habitat types, whereas mini-fyke nets were typically placed in very similar habitats.

All statistical analyses used in this study were produced using the statistical software R, version 3.3.3 (R Core Team, 2017).

Figure 2. Beach seining

Figure 3. Mini-fyke net. Image from
http://wwx.inhs.illinois.edu/fieldstations/irbs/research/emiquon/

Results

Are walleye using the river to spawn?

Including adult fish, we captured a total of 26,510 fish in beach seines and mini-fyke nets during the study (Appendices 1 and 2). Only 16 of these fish were juvenile walleye, all of which were captured at the two farthest downstream sampling sites on the edge of the reservoir boundary (Figure 4). During the first sampling event we captured 15 juvenile walleye at the farthest beach seining site, and during the second sampling event we captured one juvenile walleye in a mini-fyke net. No juvenile walleye were captured upstream of these sampling points.

Both sites with walleye (beach seine 7L and mini-fyke net LF4) were located at the downstream interface of the river and reservoir. During the months of April and May (the typical period of walleye spawning and egg incubation), Canyon Ferry Reservoir fills very rapidly, water levels rise, and the sites we detected juvenile walleye become inundated, making them difficult to distinguish from the reservoir at this time (McMahon, 1992). Given this, as well as the fact that we did not find any juvenile walleye upstream of this interface, it appears that walleye did not use the Missouri River upstream of Canyon Ferry Reservoir to spawn in 2016.

Figure 4. Sites where juvenile walleye were captured.

<u>What juvenile fish species live in the river?</u>

We captured 15 total species of fish in our beach seines and mini-fyke nets (Appendices 1 and 2). Of these 15 species, we only captured adults of sculpins (*Cottus* sp.), longnose suckers (*Catostomus catostomus*), stonecats (*Noturus flavus*), burbot (*Lota lota*) and brown trout. The most common species of juvenile fish captured were yellow perch (11,184 individuals between both gear types, making up 42.2% of the total catch), white suckers (7,466 individuals, 28.2% of the total catch), longnose dace (6,486 individuals, 24.5% of the total catch), and fathead minnows (966 individuals, 3.6% of the total catch). Mini-fyke nets were overall the most effective means of capturing juvenile fish; 20,200 fish (about 76% of the total catch) were captured with mini-fyke nets, compared to 6,310 fish (24% of the total catch) in the beach seines. Species composition in the river varied by river section, as well as by gear type within each section (Figures 5 and 6).

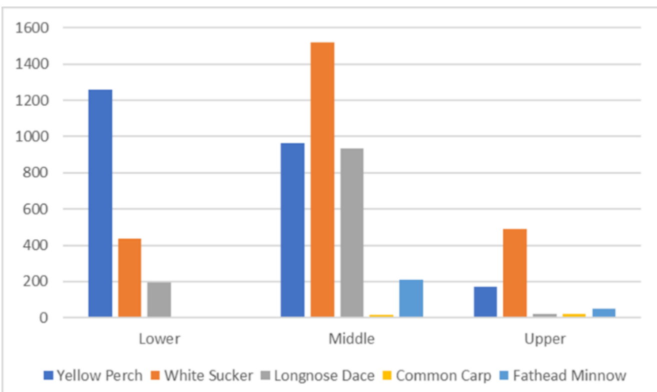

Figure 5. Composition of the most common species of fish captured in each section of the river using beach seines.

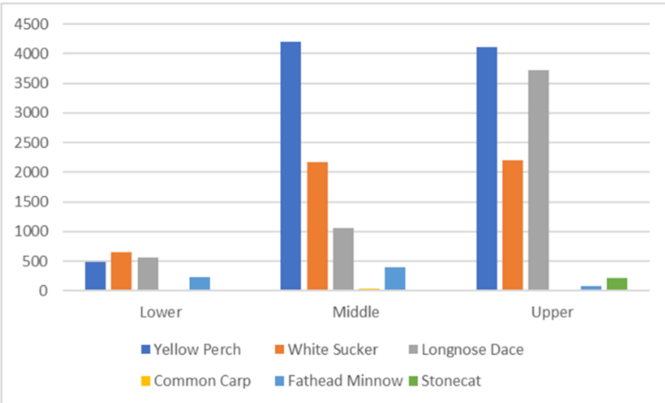

Figure 6. Composition of the most common species of fish captured in each section of the river using mini-fyke nets.

<u>Do juvenile fish assemblages differ between the river and the reservoir?</u>

River and reservoir beach seines did differ in their juvenile fish compositions. River locations contained higher proportions of white suckers and longnose dace, reservoir locations contained higher proportions of fathead minnows, and sites in both habitats contained high proportions of yellow perch (Figure 7).

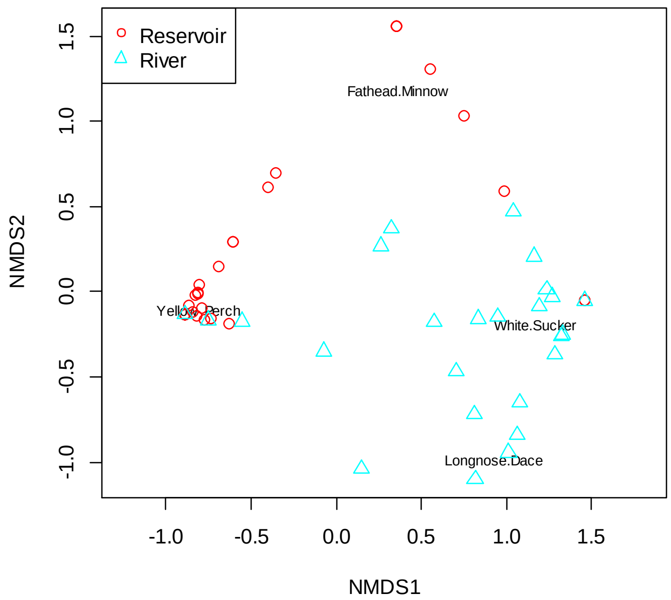

Figure 7. NMDS showing differences in fish compositions from beach seines in river and reservoir sites.

Do walleye prey on the species we found?

Several of the juvenile fish species we captured during the study are known to exist in walleye diets in other systems. The yellow perch in particular is one of the walleye's all-time favorite prey items (McMahon and Bennett, 1996). In Canyon Ferry Reservoir, FWP (2010) found that perch comprised 49% of walleye diets from 1994 to 2008. FWP (2010) also detected white suckers in walleye stomachs during the early years of walleye expansion in the reservoir, making them a likely prey item of walleye in the river as well. Farther downstream, in the stretch of the Missouri River below Holter Dam, Grisak *et al.* (2012) also detected suckers in walleye stomachs, in addition to Cyprinid (minnow) species such as the fathead minnow, which could also be preyed upon by walleye in the river upstream of Canyon Ferry.

Which species will be most impacted by continued walleye expansion into the river?

We used regression trees to look for overlaps between habitats that contained high numbers of the four most common juvenile fish species captured in our beach seines and habitats that adult walleye are known to occupy in rivers (Figures 8-11). The most notable observation from these regression trees is that the greatest number of yellow perch per beach seine occurred in side channel habitats, which contained an average of 113 perch per seine, although variation around the mean was high (n = 8, mean square error = 51,073.98) (Figure 8 and Appendix 4). Walleye will often use side channel habitats to wait for potential prey to drift out of the main river channel, meaning walleye are likely occupying these habitats in the study area as well (Paragamian, 1989). As previously discussed, yellow perch are one of the walleye's favorite prey items, and are already commonly observed in walleye diets in Canyon Ferry Reservoir (Montana FWP, 2010). Based on this habitat overlap and the know preference of yellow perch as a walleye prey item, yellow perch in the river will likely be highly impacted by continued walleye expansion in the river.

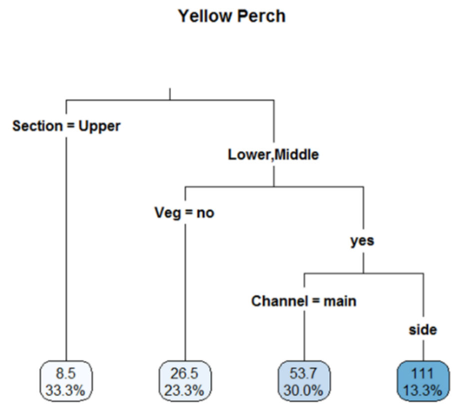

Figure 8. Regression tree showing the average number of yellow perch per beach seine at sites with different habitat characteristics.

No other juvenile fish species captured in our beach seines had a node (or split) in their regression trees based on where they were captured in the river channel (Figures 9-11 and Appendices 5-7). However, mini-fyke nets were almost always placed in either side-channel habitats or pools on the edge of the current in the main river channel, both of which are habitats that walleye will use to wait for potential prey (Paragamian, 1989). The two most common species captured in mini-fyke nets were yellow perch and white suckers, which, as previously discussed, both occur in walleye diets in Canyon Ferry Reservoir (Montana FWP, 2010). This would suggest that, in addition to yellow perch, white suckers will also likely be impacted by continued walleye expansion in the river. However, FWP (2010) has found that walleye tend to greatly prefer yellow perch over other species as prey when multiple options are present in a system, a finding consistent with studies elsewhere (Forney, 1974). Therefore, while some predation on other juvenile fish species in the river, such as white suckers, likely does (and will continue to) occur, yellow perch will be most impacted by continued walleye expansion into the river.

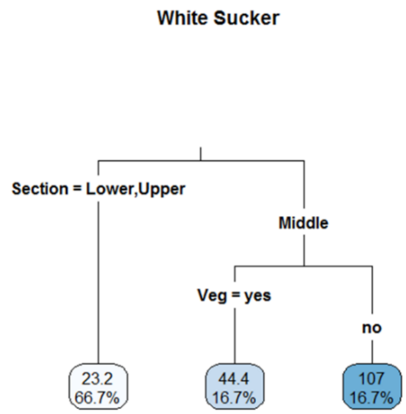

Figure 9. Regression tree showing the average number of white suckers per beach seine at sites with different habitat characteristics.

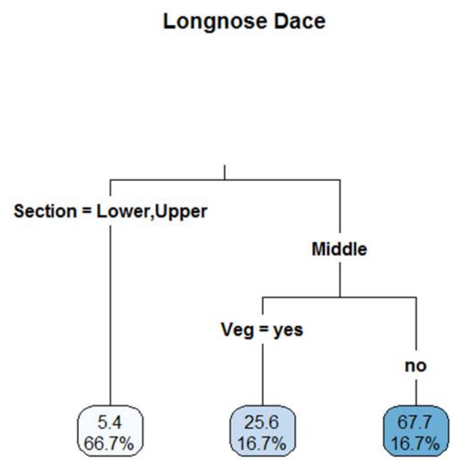

Figure 10. Regression tree showing the average number of longnose dace per beach seine at sites with different habitat characteristics.

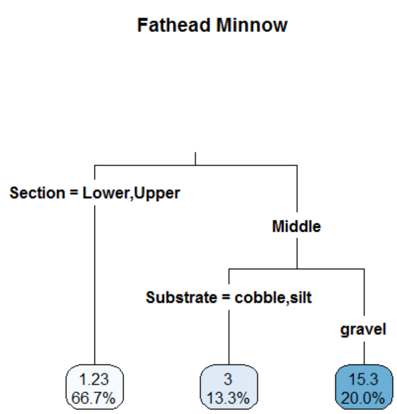

Figure 11. Regression tree showing the average number of longnose dace per beach seine at sites with different habitat characteristics.

Discussion

Our findings indicate that walleye did not use the Missouri River upstream of Canyon Ferry Reservoir to Toston Dam to spawn in 2016. However, we did capture large numbers of other species of juvenile fish, including yellow perch, white suckers, and fathead minnows. Walleye are known to prey upon many of these species in other systems, including Canyon Ferry Reservoir, indicating that the large numbers of potential forage fish are driving walleye into the river during the summer to feed. Yellow perch and white suckers occupy side channel and main channel pool habitats where adult walleye are known to feed, suggesting that both species, but particularly perch, will be most susceptible to increased predation as walleye continue to expand in the river.

We were somewhat surprised that we did not find any juvenile walleye in the river upstream of its interface with Canyon Ferry Reservoir, as this stretch of river has previously been identified as possessing suitable walleye spawning habitat (McMahon, 1992). Walleye spawning can be highly variable from year to year, particularly in systems influenced by dams where sudden water withdrawals can flush walleye eggs and larvae downstream, suggesting that walleye may have attempted to spawn in the river during the summer of 2016, but were unsuccessful (McMahon, 1992). We were also surprised by the large number of juvenile yellow perch we sampled, as yellow perch typically live in lentic (or still) habitats such as lakes or reservoirs (Kitchell *et al.*, 1977). However, yellow perch have been documented elsewhere in lotic (or fast-moving) systems when these systems contain a suitable amount of backwater habitats with large amounts of aquatic vegetation (Weber and Les, 1982). Many of the locations we sampled in the Missouri matched this description, and as our regression tree for yellow perch shows, the highest number of perch per seine occurred in this habitat type (Figure 8). Canyon Ferry Reservoir typically lacks in aquatic vegetation, suggesting that perch may prefer to spawn in the river rather than the reservoir in these vegetated backwater bays (McMahon, 1992).

When considering the impacts of continued walleye expansion on the existing fish assemblage in this stretch of river, it is also important to consider the potential of an expanding walleye fishery for anglers in the system. FWP (2010) currently manages this stretch of river primarily as a wild rainbow trout and brown trout fishery, but populations of both species have declined in recent years due to drought conditions in the area (Montana FWP, 2010). Walleye expansion into trout-dominated rivers has often led to declines in trout populations in these systems due to predation by walleye on juvenile trout and competition between walleye and adult trout, suggesting that walleye expansion could lead to even more declines in trout populations over time (McMahon, 1992). However, as more and more anglers begin to fish for walleye in this stretch of the Missouri, FWP will need to consider the increased value of maintaining the walleye fishery along with what remains of the trout fishery when developing management goals for the system in the future.

Going forward, FWP should continue to track walleye movements between Canyon Ferry Reservoir and the Missouri River upstream to Toston Dam to learn more about how walleye use the system and to look for any yearly variation in these movements as a result of varying environmental conditions. If possible, periodic juvenile fish surveys in the river should continue to track any changes in the fish assemblage over time, and to determine if walleye successfully spawn in the river in the future. Additionally, capturing and taking stomach samples from adult walleye in the river could tell FWP more about which juvenile fish species walleye prey upon in the river, whether there is predation on juvenile trout, and how the river assemblage will be most impacted by future walleye expansion. Using radio telemetry to track the movements of adult yellow perch in the river could also be a valuable tool in determining the timing and extent of perch migrations in the river and could help FWP determine what sites in the river perch use to spawn. Learning more about perch reproduction in the river could help FWP protect a potential source of perch recruitment into Canyon Ferry Reservoir, where the yellow perch fishery remains popular but populations have declined due to walleye predation (Montana FWP, 2010). Ultimately, filling some of these key gaps in understanding about the different species of fish in the Missouri River upstream of Canyon Ferry Reservoir and how these species interact will help FWP manage the river and the reservoir as multi-species species fisheries that provide angling opportunities for trout, walleye, perch, and the other species that call the system home.

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Appendix 1: Fish captured at beach seining sites.

Mo	Day	Yr	LOC	YP	WSU	LN DC	CARP	FH MN	WE	COT	L. CHUB	NOTES
7	14	16	1L	34	7	12	0	0	0	0	0	FISH THRU NET
7	14	16	2L	77	2	0	0	1	0	0	0	FISH THRU NET
7	14	16	3L	41	29	0	0	0	0	0	0	FISH THRU NET
7	14	16	4L	100	39	5	0	0	0	0	0	FISH THRU NET
7	14	16	5L	170	55	70	0	0	0	0	0	FISH THRU NET
7	14	16	6L	11	8	2	0	0	0	0	0	FISH THRU NET
7	19	16	7L	705	7	0	0	0	15	0	0	FISH THRU NET
7	19	16	8L	0	104	15	2	0	0	0	0	FISH THRU NET
7	19	16	9L	0	25	4	2	0	0	0	0	FISH THRU NET
7	19	16	10L	31	16	2	0	0	0	0	0	FISH THRU NET
7	20	16	10M	82	4	13	3	0	0	0	0	FISH THRU NET
7	21	16	9M	204	50	5	3	0	0	0	0	FISH THRU NET
7	21	16	8M	16	5	3	0	0	0	0	0	FISH THRU NET
7	21	16	7M	4	5	3	0	0	0	0	0	FISH THRU NET
7	21	16	6M	20	91	30	1	5	0	0	0	FISH THRU NET
7	21	16	5M	373	82	6	2	1	0	0	0	FISH THRU NET
7	21	16	4M	2	173	62	0	25	0	0	0	FISH THRU NET
7	21	16	3M	1	13	13	0	2	0	0	0	FISH THRU NET
7	21	16	2M	27	100	38	0	21	0	0	0	FISH THRU NET
7	21	16	1M	7	40	47	0	3	0	0	0	FISH THRU NET
8	2	16	1U	1	7	0	0	0	0	0	0	FISH THRU NET
8	2	16	2U	0	0	0	0	0	0	0	0	FISH THRU NET
8	2	16	3U	0	1	0	0	0	0	0	0	FISH THRU NET
8	2	16	4U	3	21	0	1	0	0	0	0	FISH THRU NET
8	2	16	5U	43	23	1	0	0	0	0	0	FISH THRU NET
8	2	16	6U	66	101	7	13	20	0	0	0	FISH THRU NET
8	3	16	7U	0	1	0	0	0	0	0	0	FISH THRU NET
8	3	16	8U	0	0	0	0	0	0	0	0	FISH THRU NET
8	3	16	9U	0	0	0	0	0	0	0	0	FISH THRU NET
8	3	16	10U	1	4	0	0	0	0	0	0	FISH THRU NET
8	9	16	1M	0	43	0	2	14	0	0	0	FISH THRU NET
8	9	16	2M	6	6	1	1	8	0	0	0	FISH THRU NET
8	9	16	3M	97	89	4	1	87	0	0	0	FISH THRU NET
8	9	16	4M	0	150	29	1	0	0	0	0	FISH THRU NET
8	9	16	5M	30	80	72	3	35	0	0	0	FISH THRU NET
8	9	16	6M	48	20	104	0	0	0	1	0	ADULT COT, FISH THRU NET
8	9	16	8M	13	525	425	0	5	0	0	0	FISH THRU NET
8	9	16	7M	0	3	4	0	0	0	0	0	FISH THRU NET
8	9	16	9M	2	24	65	0	2	0	0	0	FISH THRU NET
8	9	16	10M	32	15	9	1	0	0	0	0	FISH THRU NET
8	9	16	10L	4	10	0	0	0	0	0	0	FISH THRU NET
8	9	16	9L	0	0	0	0	0	0	0	0	FISH THRU NET
8	9	16	8L	33	2	0	0	0	0	0	0	FISH THRU NET
8	9	16	7L	0	0	0	1	0	0	0	0	FISH THRU NET
8	9	16	6L	16	67	59	1	0	0	0	0	FISH THRU NET
8	10	16	5L	0	11	2	0	0	0	0	0	FISH THRU NET
8	10	16	4L	0	10	3	0	0	0	0	0	FISH THRU NET
8	10	16	3L	0	21	22	1	0	0	0	0	FISH THRU NET
8	10	16	2L	36	6	0	0	0	0	0	0	FISH THRU NET
8	10	16	1L	0	19	0	0	0	0	0	0	FISH THRU NET
8	11	16	6U	0	0	0	0	0	0	0	0	FISH THRU NET
8	11	16	5U	0	47	2	1	6	0	0	0	FISH THRU NET
8	11	16	4U	1	5	0	0	0	0	0	0	FISH THRU NET
8	11	16	3U	52	198	8	0	9	0	0	4	FISH THRU NET
8	11	16	2U	0	41	2	6	6	0	0	0	FISH THRU NET
8	11	16	1U	0	7	0	0	5	0	0	1	FISH THRU NET
8	11	16	7U	1	0	0	0	0	0	0	0	FISH THRU NET
8	11	16	8U	2	33	0	0	2	0	0	0	FISH THRU NET
8	11	16	9U	0	0	0	0	0	0	0	0	FISH THRU NET
8	11	16	10U	0	0	0	0	0	0	0	0	FISH THRU NET

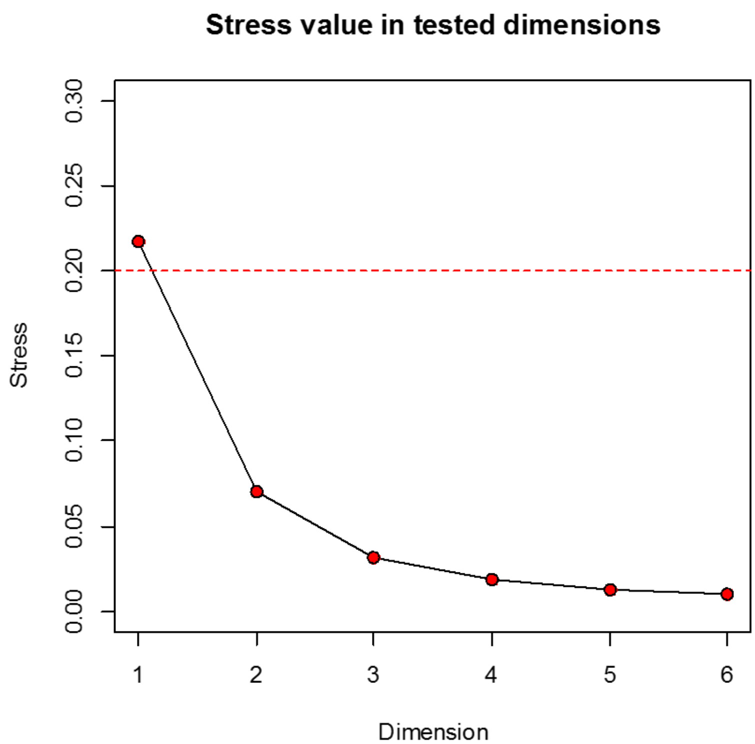
YP = yellow perch. WSU = white sucker. LN DC = longnose dace. CARP = common carp. FH MN = fathead minnow. WE = walleye. COT = sculpin. L CHUB = lake chub.

Appendix 2: Fish captured in mini-fyke nets.

Mo	Day	Yr	LOC	YP	WSU	LN DC	CARP	FH MN	WE	COT	L. CHUB	RB	BG	LN SU	U CHUB	LL	SCAT	LING	NOTES
7	20	16	LF1	85	366	115	0	116	0	0	0	1	0	0	0	0	0	0	
7	20	16	LF2	252	136	72	0	100	0	0	0	0	0	0	0	0	0	0	
7	20	16	LF3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	NET COLLAPSED OVERNIGHT
7	20	16	LF4	5	3	3	0	0	1	1	0	0	0	0	0	0	0	0	WE WAS AN ADULT (8.5")
7	21	16	MF1	70	93	53	21	30	0	0	0	0	0	0	0	0	0	0	
7	21	16	MF2	460	232	27	0	13	0	1	0	2	1	0	0	0	0	0	BG WAS AN ADULT (1+)
7	21	16	MF3	250	120	175	0	32	0	0	0	1	0	1	0	0	0	0	RB & LNSU WERE ADULTS
7	21	16	MF4	3010	1400	750	0	315	0	0	0	8	0	0	0	0	0	0	
8	3	16	UF1	46	0	0	0	0	0	0	0	0	0	0	1	0	34	0	SCATS WERE ADULTS, LENGTHS AVAILABLE
8	3	16	UF2	27	250	58	0	9	0	0	4	0	0	0	0	0	1	0	SCATS WAS AN ADULT
8	3	16	UF3	161	930	3070	0	15	0	0	0	0	0	0	0	0	16	0	SCATS WERE ADULTS, LENGTHS AVAILABLE
8	3	16	UF4	3480	885	489	5	41	0	0	0	0	0	0	0	1	33	0	SCATS WERE ADULTS, LENGTHS AVAILABLE
8	10	16	LF1	15	100	330	0	1	0	0	0	0	0	0	2	0	9	0	SCATS WERE ADULTS
8	10	16	LF2	4	8	26	0	5	0	0	0	1	0	0	0	0	0	0	RB WAS AN ADULT (19.1")
8	10	16	LF3	74	17	4	0	4	1	0	0	0	0	0	0	0	0	0	WE WAS AN ADULT (11.3")
8	10	16	LF4	48	23	10	0	0	1	0	0	1	0	0	0	0	0	1	RB & LING WERE ADULTS, LENGTHS AVAILABLE
8	10	16	MF1	135	225	15	13	3	1	0	3	0	0	0	0	0	1	1	1 CARP, LING AND WE WERE ADULTS
8	10	16	MF2	5	3	5	0	5	0	0	0	0	2	0	0	0	9	0	2 YP, 2 WSU, AND ALL SCATS WERE ADULTS
8	10	16	MF3	75	35	17	0	0	0	1	1	1	0	0	0	0	2	0	RB & SCATS WERE ADULTS
8	10	16	MF4	198	65	11	3	0	0	0	0	1	0	0	0	0	0	0	
8	11	16	UF1	296	0	2	0	0	0	0	0	0	0	0	0	0	56	0	SCATS WERE ALL ADULTS
8	11	16	UF2	34	101	10	2	8	0	0	0	0	0	0	0	0	13	1	SCATS & LING WERE ADULTS
8	11	16	UF3	0	5	15	0	0	0	0	8	0	0	0	0	0	20	0	SCATS WERE ADULTS
8	11	16	UF4	62	23	80	0	12	0	0	10	0	0	0	0	0	42	1	SCATS & LING WERE ADULTS

YP = yellow perch. WSU = white sucker. LN DC = longnose dace. CARP = common carp. FH MN = fathead minnow. WE = walleye. COT = sculpin. L CHUB = lake chub. RB = rainbow trout. BG = bluegill. LN SU = longnose sucker. U CHUB = Utah chub. LL = brown trout. SCAT = stonecat. LING = burbot.

Appendix 3. Stress versus dimensionality plot for data used in the NMDS comparing river and reservoir fish assemblages.



Appendix 4. Statistical summary of the regression tree for yellow perch. Nodes numbered from left to right.

Node	Mean	MSE	n
1	8.5	374.05	20
2	26.5	2259.107	14
3	53.67	22229.39	18
4	110.625	51073.98	8

Appendix 5. Statistical summary of the regression tree for white suckers. Nodes numbered from left to right.

Node	Mean	MSE	n
1	23.175	1422.844	40
2	44.4	1021.24	10
3	107.4	22953.64	10

Appendix 6. Statistical summary of the regression tree for longnose dace. Nodes numbered from left to right.

Node	Mean	MSE	n
1	5.4	206.29	40
2	25.6	682.04	10
3	67.7	15141.21	10

Appendix 7. Statistical summary of the regression tree for fathead minnows. Nodes numbered from left to right.

Node	Mean	MSE	n
1	1.225	13.07	40
2	3	20.25	8
3	15.33	594.39	12