Intensive Sampling Reveals Underreported Use of Great-River Tributaries by Large-River Fishes in Missouri

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Abstract - Large tributaries may help sustain large-river fish populations by mitigating fish-habitat losses within the highly modified great rivers of the Mississippi River basin. These tributaries are likely most beneficial for fish species specializing on non-degraded large-river habitat for some portion of their life histories. Few great-river tributaries, however, have been surveyed using methods that comprehensively target all fish species, resulting in uncertainty or bias in the reported composition of many tributary fish assemblages. We report important distributional records, including 23 new accounts, for 12 large-river specialist fishes in Missouri—*Alosa alabamae* (Alabama Shad), *Cycleptus elongatus* (Blue Sucker), *Pimephales vigilax* (Bullhead Minnow), *Notropis wickliffi* (Channel Shiner), *Polyodon spathula* (Paddlefish), *Hybognathus placitus* (Plains Minnow), *N. blennius* (River Shiner), *Macrhybopsis hyostoma* (Shoal Chub), *Scaphirhynchus platorynchus* (Shovelnose Sturgeon), *M. storeriana* (Silver Chub), *Ichthyomyzon unicuspis* (Silver Lamprey), and *Alosa chrysochloris* (Skipjack Herring)—following 38 comprehensive fish surveys in tributaries of the Missouri and Mississippi rivers. New accounts collectively demonstrate tributaries support more large-river specialists than historically documented and thus may be currently undervalued sources of habitat for large-river fishes.

Introduction

The Mississippi and Missouri rivers support rich fish assemblages including a group of species with specialized life histories dependent on large-river habitat, hereafter regarded as large-river specialist fishes ("big river fishes"; Galat et al. 2005, Pflieger 1997). Recent surveys throughout the Mississippi and Missouri rivers (hereafter, "great rivers") document changes to these fish assemblages following habitat degradation from impoundments, flow regulation, dredging, and channelization (Galat et al. 2005, Janvrin 2005). With continued management of both great rivers for navigation and flood abatement, relatively unaltered large tributaries are increasingly viewed as refugia, providing spawning, foraging, and rearing habitat for large-river specialist fishes (Pracheil et al. 2013). Our goal is to report distributional records for 12 large-river specialists inhabiting tributaries of the great rivers following recent extensive sampling in Missouri. Our surveys revealed that previous sampling underreported use of tributaries by several large-river specialists. Given many of these species range throughout the Mississippi River basin, our findings may be generalizable to other areas with inadequately surveyed great-river tributaries, including much of the southeastern United States.

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Methods

From 2014 to 2016, we completed 38 fish surveys across 11 sites in 2 regions of Missouri (Fig. 1). Rivers in the Ozark Plateau (Ozarks) have high biodiversity and are generally described as moderate gradient and clear, with predominantly rocky substrates and physicochemical conditions often buffered by ground water. In contrast, rivers in the Interior Plains (Plains) have lower biodiversity and highly variable seasonal physicochemical conditions and are typically lower relief, turbid, and dominated by fine sediments.

The length of each site was 50 times mean-wetted-channel width (MWCW), measured from satellite imagery in spring before sampling. The total effort per survey was consistently proportional to the size of each site (i.e., 50 MWCW) causing absolute effort per gear to vary among sites: 0.5–4.0 km (boat electrofishing), 0.5–2.5 km (trawling), and 0.2–0.8 km (seining). We also deployed 5 hoop, trammel, and mini-fyke nets over a single night per survey (i.e., 15 total nets and net-nights per survey). Nine of the 11 sites were surveyed at least once per season (spring, summer, fall) to document seasonal occurrences of species within tributaries. Further details of the sampling protocol are in Dunn and Paukert (2018). Unless otherwise noted, we predominantly collected large-bodied species by electrofishing, and hoop and trammel nets, and small-bodied species by seining, trawling, and mini-fyke nets. Vouchered small-bodied fishes have been thoroughly inspected to confirm field identifications and are currently housed at the University of Missouri-Columbia.

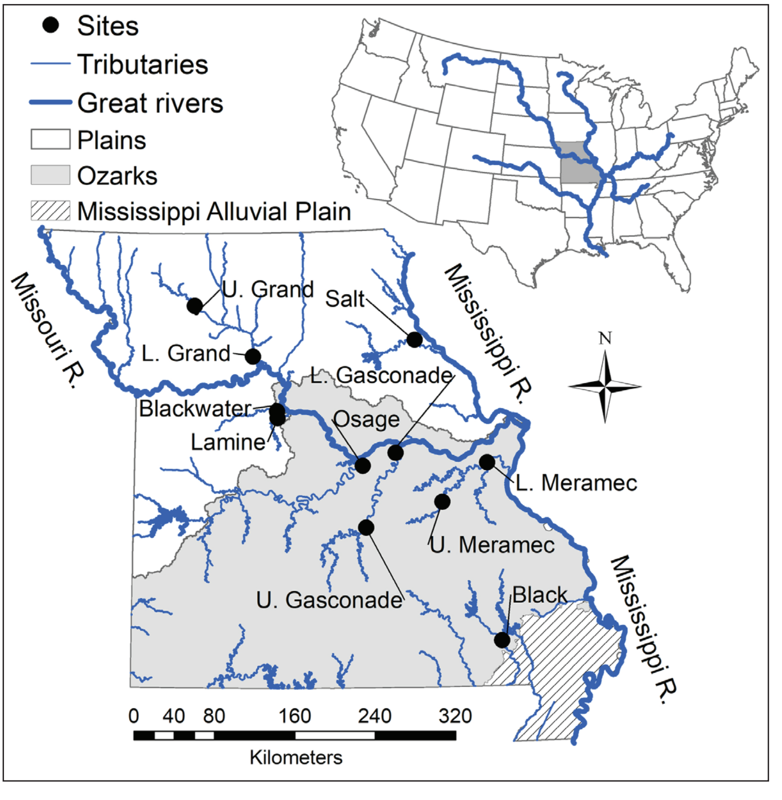

Figure 1. Sites sampled 2014–2016 in 11 large tributaries of the Missouri or Mississippi rivers in Missouri: Black River, Blackwater River, Lamine River, Lower Gasconade River, Upper Gasconade River, Lower Grand River, Upper Grand R.iver, Lower Meramec River, Upper Meramec River, Osage River, and Salt River. Latitude and longitude coordinates for all sites given in Table 1.

Results and Discussion

In total we report records for 12 large-river specialists, including 13 new distributional accounts to each tributary system and 10 new upriver accounts within each system (Table 1). All new distributional accounts likely resulted from our intensive sampling rather than range expansions, except for *Pimephales vigilax* (Baird and Girard) (Bullhead Minnow) and *Alosa chrysochloris* (Rafinesque) (Skipjack Herring), which may have recently expanded into the Missouri River basin (Galat et al. 2005). New distributional accounts collectively support the notion that use of great-river tributaries by large-river specialists may be underreported. We provide further commentary on 8 of these 12 species in which records have particular conservation value. Records for the remaining 4 large-river specialists—*Polyodon spathula* (Walbaum) (Paddlefish), *Notropis wickliffi* Trautman (Channel Shiner), *N. blennius* (Girard) (River Shiner), and Bullhead Minnow—are still included in Table 1.

Ichthyomyzon unicuspis Hubbs and Trautman (Silver Lamprey). We collected the first accounts of Silver Lamprey in the Meramec (1 site) and Gasconade (2 sites) rivers. Moreover, our records of Silver Lamprey in the Gasconade River are the farthest downriver in the Missouri River basin. In the southern portion of the Mississippi River, the Silver Lamprey is rare and historically considered restricted to the mainstem Mississippi River (Pflieger 1997). However, our discovery of Silver Lamprey in the Meramec River (a Mississippi River tributary) is consistent with Robison et al. (2011), who recently confirmed the presence of Silver Lamprey at multiple locations within the White River system, a tributary of the Mississippi River in Arkansas. These recent findings suggest Silver Lamprey may be more widespread, albeit still rare, in southern Mississippi River tributaries than historically documented.

Scaphirhynchus platorynchus (Rafinesque) (Shovelnose Sturgeon). We collected Shovelnose Sturgeon from 4 sites, 3 of which were in the lower sections of 3 large tributaries (18–53 km upriver of the tributary mouths), including the first account in the Meramec River system. The Shovelnose Sturgeon has declined throughout portions of the Mississippi (Janvrin 2005, Keenlyne 1997, Phelps et al. 2016) and Missouri rivers (Galat et al. 2005), and disappeared entirely from many tributaries of the Missouri River in neighboring Kansas (Haslouer et al. 2005, Kansas Fishes Committee 2014).

The overall importance of tributaries for sustaining Shovelnose Sturgeon populations is unknown (DeLonay et al. 2009, Keenlyne 1997). Although we cannot definitively infer from our collections the specific activities of Shovelnose Sturgeon within tributaries, the 4 sites (3 rivers) where we collected the species were only occupied by that fish coinciding with periods of documented overwintering and spawning (late fall–early summer) (Goodman et al. 2013, Phelps et al. 2016, Quist et al. 1999, Richards et al. 2014). Our observations of seasonally variable use of tributaries were also consistent with movement patterns reported by DeLonay et al. (2009), who documented upriver dispersal by Shovelnose Sturgeon in the Big Sioux (IA, SD) and Missouri rivers for suspected spawning in spring. Overall, our records demonstrate seasonally dependent use of the lower sections of large tributaries by Shovelnose Sturgeon.

Table 1. Raw abundances of 12 large-river specialist fishes sampled from 2014 to 2016 and characteristics of 11 sites within 8 tributaries of the Missouri or Mississippi rivers: Black River (36°54'35"N, 90°29'12"W), Blackwater River (38°58'18"N, 92°58'24"W), Lamine River (38°54'24"N, 92°58'12"W), Lower Gasconade River (38°36'3"N, 91°36'7"W), Upper Gasconade River (37°56'53"N, 91°59'37"W), Lower Grand River (39°29'43"N, 93°16'36"W), Upper Grand R.iver (39°55'30"N, 93°56'14"W), Lower Meramec River (38°31'5"N, 90°36'45"W), Upper Meramec River (38°8'55"N, 91°7'35"W), Osage River (38°32'11"N, 92°1'45"W), and Salt River (39°36'20"N, 91°22'42"W). O = Ozarks, P = Plains. *New distributional account for a system; †New upriver account within a system.

	Rivers										
Species	Osage	Lower Gasconade	Lamine	Blackwater	Lower Grand	Lower Meramec	Salt	Upper Grand	Upper Gasconade	Upper Meramec	Black
Distance to great river (km)	10	18	23	24	30	53	55	144	164	192	784
Mean-wetted channel width	200	92	42	31	78	84	60	50	75	52	53
Times sampled	1	5	4	1	4	4	4	4	4	3	4
Physiographic region	O	O	P	P	P	O	P	P	O	O	O
Ichthyomyzon unicuspis (Silver Lamprey)		*1				*1			†1		
Scaphirhynchus platorynchus (Shovelnose Sturgeon)		7			23	*1		†3			
Polyodon spathula (Paddlefish)			†1		1						
Alosa alabamae (Alabama Shad)		20				27				†7	
Alosa chrysochloris (Skipjack Herring)	1				*1	1	*1				
Hybognathus placitus (Plains Minnow)					19			21			
Macrhybopsis hyostoma (Shoal Chub)		*9	*7	†1	127	2	*1	39			
Macrhybopsis storeriana (Silver Chub)	8	30	*4	†1	82	8	10	41			
Notropis blennius (River Shiner)			*1		13						
Notropis wickliffi (Channel Shiner)	636	*505				†3315	*49				
Pimephales vigilax (Bullhead Minnow)	180	982	*924	†49	94	307	162	†314			84
Cycleptus elongatus (Blue Sucker)		*8			62	5		13			†4

Alosa alabamae Jordan and Evermann (Alabama Shad). We captured Alabama Shad from 3 sites in 2 unimpounded Ozark rivers, including an account that extended its known range upriver in the Meramec River system by 10 km. Alabama Shad use tributaries for spawning and nursery habitat before migrating downriver through the great rivers to foraging habitat in the Gulf of Mexico and Atlantic Ocean (Pflieger 1997). Impoundments may have contributed to the decline of Alabama Shad throughout the species' geographic range (Mettee and O'Neil 2003), including its likely extirpation from the Mississippi River upriver of Melvin Price Locks and Dam (no. 26) 8 km upriver of the Missouri-Mississippi River confluence (Schramm et al. 2016). Assuming Alabama Shad is extirpated from the upper Mississippi River, Missouri's Ozark tributaries are now the northernmost systems providing spawning and rearing habitat for this imperiled species.

We collected Alabama Shad midsummer–late fall, and all individuals were likely age-0 juveniles (total length <166 mm) that were fertilized in spring and early summer. These records indicate age-0 Alabama Shad reside in Missouri tributaries longer than previously reported. For example, Pflieger (1997) reported the latest record of Alabama Shad in Missouri was 4 October, yet we collected individuals in our latest surveys from the Gasconade River on 25 October 2014 and 6 November 2015, and in the Meramec River on 22 October 2015. Although the timing of emigration may vary annually, absences from historical surveys in late fall may also be an artifact of imperfect detection induced by ontogenetic habitat shifts. We readily collected age-0 Alabama Shad by seining and benthic trawling in shallow shoals in summer. By late fall, however, Alabama Shad had shifted to deep, swift shoals and race pools that were only effectively sampled by boat electrofishing.

Alosa chrysochloris (Rafinesque) (Skipjack Herring). We collected Skipjack Herring from 4 rivers, including the first accounts in the Grand and Salt rivers. Although still common in parts of its range, the Skipjack Herring has been severely impacted in the upper and middle sections of the Mississippi River due to channel modifications and the creation of a series of lock-and-dam structures benefitting barge navigation (Janvrin 2005, Mettee and O'Neil 2003). Both individuals collected within the Meramec and Salt rivers were juveniles, demonstrating these systems provide spawning habitat. Therefore, our records in the Meramec and Salt rivers, and recent records within the Des Moines River of Iowa (Neebling and Quist 2008), indicate tributaries may be important for the viability of Skipjack Herring in the highly fragmented middle and upper sections of the Mississippi River where the species is seemingly most imperiled.

Macrhybopsis spp. We collected *M. hyostoma* (Gilbert) (Shoal Chub) and *M. storeriana* (Kirtland) (Silver Chub) from the lower sections of most tributaries. We documented the first accounts of Shoal Chub in the Gasconade, Lamine, Blackwater, and Salt rivers, and the first accounts of Silver Chub in the Blackwater and Lamine rivers.

Both species have extensive geographic ranges and are distributed throughout the great rivers of the Mississippi River basin and other Gulf drainages. In Missouri, they are the most common of the 4 *Macrhybopsis* spp. inhabiting the Missouri and Mississippi rivers, and both species currently may be more abundant in the lower Missouri River than documented by historical surveys in the 1940s (Galat et al. 2005). However, peripheral populations of Silver Chub and especially Shoal Chub have been severely impacted by river fragmentation in multiple regions across North America (Boschung and Mayden 2004, Kansas Fishes Committee 2014, Trautman 1981), likely due to these species' dependency on large expanses of unimpounded river for successful development of their drifting early life-history stages (Perkin and Gido 2011). Herzog et al. (2005) noted the efficacy of the benthic trawl for detecting *Macrhybopsis* spp. in the Mississippi River. Our surveys were similarly aided by the benthic trawl, which effectively sampled deep pools and other nonwadeable areas inhabited by both species in tributaries. However, we failed to collect *M. meeki* (Jordan and Evermann) (Sicklefin Chub) and *M. gelida* (Girard) (Sturgeon Chub), indicating these congeners may be more difficult to detect or may not similarly range into tributaries in Missouri, a pattern that is consistent with Pracheil et al. (2013).

Hybognathus placitus Girard (Plains Minnow). We collected 40 Plains Minnows across both sites in the Grand River, indicating the species is still widely distributed within the system. Plains Minnow was historically abundant in the lower Missouri River but had declined to the extent that Pflieger (1997) speculated the species might become extirpated in Missouri. Similar declines have been reported throughout much of the Great Plains (Gido et al. 2010, Steffensen et al. 2014) owing to the species' prolonged drifting early life-stages, which pre-dispose the species to river fragmentation, water withdrawals, and flow regulation (Perkin and Gido 2011). Persistence of Plains Minnow in the Grand River system demonstrates this heavily modified yet unimpounded tributary to the Missouri River may serve as a refugium for this otherwise disappearing large-river species.

Cycleptus elongatus (Lesueur) (Blue Sucker). We collected Blue Sucker in 4 rivers, including the only account from the Gasconade River and the first in the Meramec River since 1963. Blue Sucker temporarily occupied many sites in spring and early summer where most individuals were collected from large shoals, which are habitats typically used for spawning (Coker 1930, Vokoun et al. 2003). Occurrence patterns were consistent with documented upriver dispersal before and during spawning season in spring, followed by downriver dispersal in summer following spawning (Neely et al. 2009, Vokoun et al. 2003). Similarly, Blue Suckers have been documented spawning in tributaries throughout much of the species' range (Bednarski and Scarnecchia 2006, Eitzmann et al. 2007, Vokoun et al. 2003), and habitat within tributaries may even help mitigate degraded conditions within the great rivers. For example, a large tributary of the Missouri River, the Niobrara River, NE, provided sufficient habitat to maintain allelic diversity and a large population interspaced between mainstem impoundments on the Missouri River (Bessert and Ortí 2008).

Conclusion

High numbers of new accounts collectively highlight existing uncertainty in the composition of fish assemblages within great-river tributaries in Missouri. New accounts in our collections may have primarily resulted from 2 sources: sparse historical surveying of our focal rivers, and our use of a survey design that comprehensively targeted all major large-river habitat types. General facets of the survey design that could be incorporated within existing monitoring protocols to improve detection of more large-river specialists include large spatial extents and diversification of gears employed. Further, repeated sampling of sites provided the necessary temporal resolution to capture seasonally dependent use of tributaries by large-river specialists. Altogether, these surveys revealed historically underreported, yet likely meaningful, linkages between the great rivers and their tributaries (Pracheil et al. 2013). Identifying the specific life-history functions provided by tributaries will be beneficial to ongoing efforts to conserve and restore many large-river fishes. However, these efforts will undoubtedly be aided by better documentation of fish assemblages in tributaries, which will require more surveys using representative methodologies.

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