Density and Biomass Estimates of Flathead Catfish in Two Southeastern South Dakota Waters

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Abstract – *Pylodictus olivaris* Rafinesque (Flathead Catfish) provide a unique, trophy angling opportunity in select South Dakota rivers and lentic systems. Monitoring valuable recreational fish populations can provide insight into important ecological trends and for assessing the potential impacts of future system-wide changes. This study aimed to estimate Flathead Catfish density and biomass of an established riverine population in the lower James River, SD and an unauthorized, introduced population in Lake Mitchell, SD. We developed density and biomass estimates for the lower James River and for Lake Mitchell using a Chapman-modified Schnabel population estimator. A total of 240 Flathead Catfish ≥305 mm received dangler tags and full adipose clips from May–June 2018 on the James River, and we recaptured 20 fish during the May–June sampling. We used an August sampling event to assess fish movement on the James River and observed no movement between sample reaches from 34 recaptures. Density and biomass estimates (95% confidence intervals [CI]) in the lower James River were 43.3 (28.8–68.0) fish/river km (rkm) and 105.0 (69.8–165.0) kg/rkm. A total of 366 fish (101 fish ≥305 mm) received full adipose clips in June–July 2021 in Lake Mitchell, and we recaptured 37 fish (17 fish ≥305 mm). Density and biomass estimates (95% CI) in Lake Mitchell for all Flathead Catfish were 5.7 (4.2–8.0) fish/ha and 4.2 (3.1–6.0) kg/ha and for Flathead Catfish ≥305mm were 1.0 (0.7–1.7) fish/ha and 2.5 (1.6–4.1) kg/ha. The James River estimates provide important baseline metrics for future comparisons following system changes or with other Flathead Catfish populations, particularly in the northern part of their range. The Lake Mitchell estimates represent novel information about an introduced population in the persistence phase of the invasion curve in inland lentic habitat, where limited published density and biomass estimates are available.

Introduction

Pylodictus olivaris Rafinesque (Flathead Catfish) offer a unique angling opportunity, given their ability to reach large sizes, and a majority of Flathead Catfish anglers across the U.S. showed a preference for trophy angling (Arterburn et al. 2002). However, Flathead Catfish are also considered one of the most damaging invasive fish species in portions of North America (Fuller et al. 1999), as their introductions have been linked to substantial declines in native fish species in a variety of waters (Guier et al. 1981, Lucchesi et al. 2017). Flathead Catfish populations have long been established and were likely native to eastern South Dakota tributaries to the Missouri River (Hoagstrom et al. 2006). The lower portions of these Missouri River tributaries provide popular fisheries for Flathead Catfish (Doorenbos et al. 1996, 1999). Flathead Catfish anglers fishing eastern South Dakota rivers tended to be harvest-oriented in the mid-1990s (Doorenbos et al. 1996), but recent data on tagged fish in the lower James River, SD indicated that fewer than 40% of reported angler-caught Flathead Catfish were harvested and that estimated exploitation was less than 1% (Schall and Lucchesi 2021). In 2020, strong public interest in protecting trophy-sized fish resulted in the addition of a regulation restricting the harvest of Flathead Catfish over 76 cm (30 inches) to one fish daily on all South Dakota inland waters.

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Despite the increasing research efforts to understand Flathead Catfish populations (Montague and Shoup 2021), there remains a paucity of information about Flathead Catfish density and biomass in the northern portions of their range. Periodic estimates of population characteristics are needed to gauge the impacts of factors such as changing angler use, environmental conditions, and introduction status. Catfish size structure and recruitment have been modeled and observed to decline at high levels of harvest (Bonvechio et al. 2011, Chestnut-Faull et al. 2021, Pitlo 1997), but regulation models also suggest that restrictive regulations would have little effect on improving size structure when exploitation rates are low (Muhlbauer and Krogman 2021, Oliver et al. 2021, Schall and Lucchesi 2021). Environmental changes, including aquatic invasive species introductions, climate change, and habitat restorations, can also influence population demographics. Population estimates for introduced Flathead Catfish populations have also shown substantial declines following an initial expansion, and this subsequent contraction to a stabilized density (i.e., the boom-and-bust cycle) has been observed with many introduced fish populations (Kaeser et al. 2011, Kwak et al. 2004).

Recent research has attempted to better understand Flathead Catfish populations in eastern South Dakota waters by evaluating population dynamics. Flathead Catfish populations in eastern South Dakota are primarily confined to rivers. However, Flathead Catfish were first sampled in Lake Mitchell in 2007 and are presumed to have originated from an unauthorized introduction from the nearby James River. Flathead Catfish were common in Lake Mitchell during nighttime electrofishing in 2011 and 2012, providing evidence of an established population (Lucchesi et al. 2017). Investigations into the population dynamics of Flathead Catfish in the lower James River in 2018 (Schall and Lucchesi 2021) and Lake Mitchell in 2013–2015 (Lucchesi et al. 2017) suggest consistent natural recruitment and moderate mortality in both populations, with slow growth in the James River and moderately-fast growth in Lake Mitchell. Density and biomass estimates have been developed for numerous Flathead Catfish populations across their range (Daugherty and Sutton 2005a, Granfors 2014), but estimates near the northern edge are limited and have not been conducted for populations on any of the three eastern South Dakota tributaries to the Missouri River. Flathead Catfish density in Lake Mitchell was estimated to be 4.97 (95% CI=1.69–5.37) fish/ha in 2014 and 4.42 (95% CI=3.44–5.39) fish/ha in 2015 (Lucchesi et al. 2017). However, Lucchesi et al. (2017) suggested this population may continue to increase, warranting further sampling. Additionally, lentic estimates of Flathead Catfish density and biomass are rare, particularly for introduced populations. Therefore, the objective of this study was to estimate density and biomass of Flathead Catfish in the lower James River and provide current density and biomass estimates for the Lake Mitchell population.

Materials and Methods

Study Sites

The James River extends 1,202 river kilometers (rkm) from central North Dakota to its confluence with the Missouri River in southeastern South Dakota (Benson 1983). The James River contains the largest watershed of any tributary to the Missouri River in eastern North Dakota and South Dakota and flows mostly unimpounded through glaciated drift prairie. Sampling for Flathead Catfish occurred at three reaches in the lower 105 rkm (rkm 0 is the James River confluence with the Missouri River): Olivet (rkm 97–105), north of the Shramm access (hereafter called North Shramm; rkm 40–50), and south of the Shramm access (hereafter called South Shramm; rkm 27–40; Fig. 1). The lower James River has numerous low-head dams that may limit fish movement, and the study area was bounded by a low-head dam at the downstream end of the South Shramm access (rkm 27) and upstream of Olivet at the Wolf Creek confluence (rkm 128).

Lake Mitchell is a 271-ha impoundment on Firesteel Creek in eastern South Dakota with a mean depth of 3.7 m and a maximum depth of 8.8 m (Fig. 1). The lake is owned and operated by the City of Mitchell to provide a domestic water supply and recreational opportunities, and the fishery is managed by the South Dakota Department of Game, Fish, and Parks. Additional common fish species in Lake Mitchell include *Lepomis machrochirus* Rafinesque (Bluegill), *Ictalurus punctatus* Rafinesque (Channel Catfish), *Cyprinus carpio* Linnaeus (Common Carp), *Pomoxis nigromaculatus* Lesueur in Cuvier and Valenciennes (Black Crappie), *Pomoxis annularis* Rafinesque (White Crappie), *Aplodinotus grunniens* Rafinesque (Freshwater Drum), *Micropterus salmoides* Lacepède (Largemouth Bass), and *Carpoides carpio* Rafinesque (River Carpsucker).

Fish Sampling

James River. Fish sampling and tagging occurred during May–June in 2018 on the James River. We collected and tagged fish over four days from May 17 to June 18 at Olivet, four

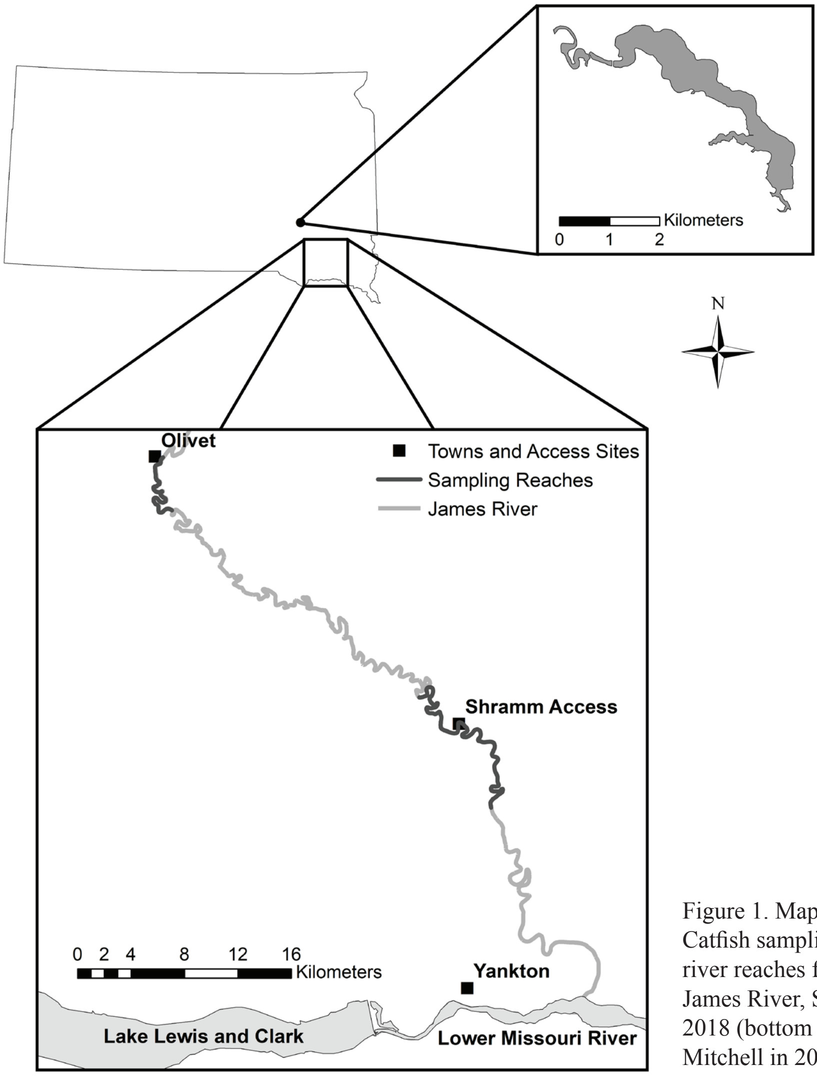

Figure 1. Map of the Flathead Catfish sampling areas, including river reaches from the lower James River, South Dakota in 2018 (bottom left) and Lake Mitchell in 2021 (upper right).

days from June 11 to June 14 at North Shramm, and five days from June 4 to June 19 at South Shramm. We sampled Flathead Catfish on the James River using low-frequency boat electrofishing and trotlines. Boat electrofishing consisted of pulsed-DC at 500 V, 2–4 amps, 15 pulses per second, and 20–50% of power output. Two dip netters collected fish from the front of the electrofishing boat, and a chase boat with one dip netter collected fish surfacing behind or outside the reach of the netters on the electrofishing boat. Electrofishing events occurred across the full length of the reach during each sampling event on three days at Olivet, two days at North Shramm, and three days at South Shramm. Trotlines consisted of a 11-m long main line with 10 dropper lines spaced at 1.0-m intervals. Dropper lines were 0.3-m long with a randomly selected 3/0, 5/0, or 8/0 circle hook. We baited trotlines with live *Ameiurus melas* Rafinesque (Black Bullheads), allowed them to fish overnight, and retrieved them within 24 hours. We fished trotlines on one day at Olivet (n=9), two days at North Shramm (n=12 per day), and three days at South Shramm (n=9 per day).

We measured all unique Flathead Catfish for total length (TL; mm) and weight (g). Weight was not recorded on one fish collected at South Shramm, so we assigned a weight value using the length-weight regression developed from the entire lower James River sample in 2018 (Schall and Lucchesi 2021). All live fish ≥305 mm TL had individually numbered Carlin dangler discs secured between the dorsal pterygiophores using stainless steel wire. We used a minimum TL of 305 mm when tagging Flathead Catfish in the James River because that is the minimum suggested harvestable size (Stewart et al. 2016, Travnichek 2004), and angling tag returns were concurrently utilized to estimate exploitation on this population (Schall and Lucchesi 2021). We used complete adipose fin clips as a secondary mark to assess tag loss. We released captured fish within the same sampling reach where they were collected. Because the Carlin dangler tags included reward values for angler returns (Schall and Lucchesi 2021), we removed any fish from analysis that was reported to be caught and harvested before the completion of all sampling events in 2018.

We performed a post-hoc analysis of fish movement to assess the assumption of a closed population by using recapture data from a mid-August low-frequency electrofishing sample on the lower James River. From August 13–17, 2018, we conducted one day of low-frequency electrofishing at each reach to capture Flathead Catfish. We recorded all recaptured individuals and compared the tagging reach location to the recapture location to assess movement beyond the period for the population estimate sample.

Lake Mitchell. Sampling on Lake Mitchell occurred over five days in 2021 from June 21 to July 12. We collected Flathead Catfish using low-frequency boat electrofishing with similar settings and number of netters to those used on the James River and a chase boat. We sampled the entire shoreline accessible to the electrofishing boat on approximately half of the lake during each sampling event and sampled the remaining shoreline in the consecutive sample. We randomly selected the direction to sample from the boat ramp during the first sampling event and alternated sampling between reservoir halves in each subsequent sample. All unique fish were measured for TL (mm) and weight (g) and were marked with a complete adipose fin clip.

Density and Biomass Estimates

We derived population estimates from the mark-recapture data on Flathead Catfish ≥305 mm in the James River and for two size groups in Lake Mitchell: all lengths and fish ≥305 mm. We used a Chapman-modified Schnabel estimate from mark-recapture summaries for the James River and for Lake Mitchell to estimate population size and associated 95% confidence intervals (CI; Ricker 1975). We estimated population size in the James River using a closed population model since similar studies have shown limited short-term movement of fish following tagging (Barabe

2009, Skains and Jackson 1995, Travnichek 2004). Limited short-term movement was observed, based on electrofishing and angler recaptures in the James River (Schall and Lucchesi 2021), and sampling occurred during a short timeframe. For the James River sample, we adjusted the number of recaptures and the subsequent population estimates and CIs to account for any observed tag loss on fish with a clipped adipose fin within each sample (Pine et al. 2003). We used the FSA package (Ogle et al. 2020) in R (R Core Team 2020) to compute estimates of population size. We calculated density estimates by dividing the population estimates by the total length sampled in all three reaches on the James River and the lake surface area (ha) of Lake Mitchell.

We used weight data from each waterbody and the estimated population size to calculate biomass estimates for the James River and separately for all Flathead Catfish and fish ≥305 mm in Lake Mitchell. We developed length-frequency histograms for the James River and Lake Mitchell using 10-mm length intervals, and then calculated the proportion of the total catch, excluding recaptures, within each interval for each sample site. We multiplied each proportion by the estimated population estimate and 95% confident interval estimates to determine the proportion of the estimated population size within each length interval. Raw proportions were not rounded to the nearest whole fish to reduce rounding error. We calculated mean weights for each length interval and multiplied by the corresponding proportion of the estimated population size and 95% CI estimates, and total biomass was the sum of estimates from each 10-mm length interval (Sass et al. 2010). Similar to the density estimates, we divided total biomass estimates by the total length sampled on the James River and by the surface area (ha) of Lake Mitchell.

Results

James River

We tagged 240 Flathead Catfish among the three river reaches: 75 at Olivet, 77 at North Shramm, and 88 at South Shramm. We recaptured >8% (*N*=20) of the Flathead Catfish tagged during this study and recorded recaptures at Olivet (n=4), North Shramm (n=4), and South Shramm (n=12). We sampled 182 fish using low-frequency electrofishing and 58 using trotlines. One fish tagged at Olivet was removed from analysis after being harvested within the study timeframe. Overall tag retention was >99% during the May–June sampling period, and we corrected for one tag loss observed in the Olivet reach. Mean ± standard error [SE] TL of marked Flathead Catfish was 537 ± 11 mm, and individual TL ranged from 305 mm to 1,130 mm (Fig. 2). Mean ± SE weight of marked Flathead Catfish was 2,423 ± 168 g, and individual weights ranged from 249 g to 21,700 g. The density (95% CI) estimate of Flathead Catfish in the James River was 43.3 (28.8–68.0) fish/rkm. The biomass estimate (95% CI) was 105.0 (69.8–165.0) kg/rkm. During the August sampling event we recaptured a total of 34 Flathead Catfish with missing adipose fins, and Carlin tags were intact on 29 fish (85% retention). We caught all 29 fish within the same sampling reach where they were originally tagged.

Lake Mitchell

We fin clipped a total of 366 Flathead Catfish in Lake Mitchell, with 101 individuals ≥305 mm. We recaptured >10% (*N*=37) of the total number of tagged individuals, and we recaptured >16% (*N*=37) of the tagged fish ≥305 mm. Individual TLs ranged from 87 mm to 1,030 mm (Fig. 2). Mean ± SE TL of all fish was 299 ± 9 mm, and mean ± SE TL of fish ≥305 mm was 503 ± 19 mm. Individual weights ranged from 5 g to 17,900 g. Mean ± SE weight of all fish was 747 ± 112 g, and mean ± SE weight of fish ≥305 mm was 2,385 ± 356 g. Density (95% CI) estimates in Lake Mitchell were 5.7 (4.2–8.0) fish/ha for all Flathead Catfish and 1.0 (0.7–1.7) fish/ha for fish ≥305 mm. Biomass (95% CI) estimates were 4.2 (3.1–6.0) kg/ha for all Flathead Catfish and 2.5 (1.6–4.1) kg/ha for fish ≥305 mm.

Discussion

Flathead Catfish density in the James River appeared to be moderate when compared with other established riverine populations. Direct comparison between density estimates from other studies can be challenging because the minimum size tagged has varied based on the study objectives, but general comparisons to density estimates can still be made by accounting for the size structure of the sample included in the estimate. Density estimates are scarce for lotic Flathead Catfish populations near the northern edge of their range, but density appeared similar to the estimate from the St. Joseph River, MI (145 fish/rkm [95% CI=106.0–193.5]; Daugherty and Sutton 2005a) which included all lengths of Flathead Catfish and where 80% of the sample was composed of fish <300 mm. When compared to southern populations, density in the James River appeared to be slightly higher than in the Cape Fear River, NC (4–31 fish >125 mm per rkm; Kwak et al. 2004) and similar to densities in the Pascagoula River, MS (38 fish >250 mm per rkm [95% CI=12.4–62.2]; Barabe 2009) and the Apalachicola River, FL (35–58 fish >380 mm per rkm; Dobbins et al. 1999). Density and biomass estimates of Flathead Catfish ≥305 mm were comparable (on a per rkm basis) to the Altamaha River, GA and higher than the Flint River, GA estimates (Kaeser et al. 2011). The density and biomass estimates for the James River reflect moderate values consistent with other well-established populations. Although established populations can experience declines in biomass as exploitation increases (Sakaris et al. 2006), exploitation of this population was low (<1%; Schall and Lucchesi 2021). Therefore, these density and biomass estimates provide a useful baseline for comparisons with other populations,

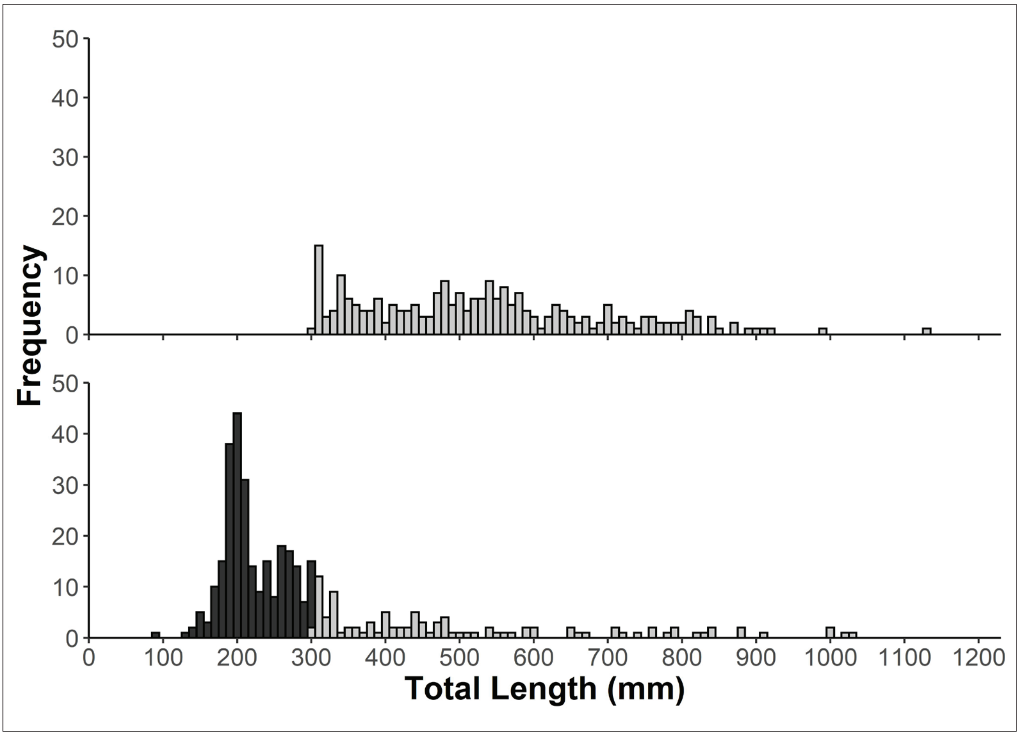

Figure 2. Length-frequency histogram of Flathead Catfish collected in the lower James River, South Dakota in 2018 (top) and Lake Mitchell, South Dakota in 2021 (bottom). Fish ≥305 mm are indicated in light gray, and fish <305 mm are indicated in dark gray.

particularly in northern areas of their range where similar estimates are limited. A variety of factors, including changing population dynamics, influence of invasive species, or varying in available habitats, should be assessed if differences in estimates are observed with other populations or future assessments of the James River population.

The density estimate of Flathead Catfish in Lake Mitchell was slightly higher than the estimates derived in 2014 and 2015, but the difference was likely not biologically meaningful. The estimated 5.7 fish/ha exceeded the upper 95% CIs observed in 2014 and 2015, but there was overlap between the CIs in this study and the previous estimates (Lucchesi et al. 2017). Flathead Catfish densities in newly invaded lotic systems have been documented to experience a growth phase for the first 10–15 years after establishment (Kaeser et al. 2011), and maximum age estimates from samples collected in 2014–2015 and 2021 confirm that Flathead Catfish were introduced into the lake as early as 2000 (Lucchesi et al. 2017; B. Schall, South Dakota Game, Fish and Parks, Sioux Falls, SD, 2021 unpubl. data). The variations in density between 2014–2015 and 2021 are likely the result of natural fluctuations of a population which has leveled-off in the persistence phase of the invasive curve (Geburzi and McCarthy 2018).

Similar to lotic populations, limited density estimates are available on northern Flathead Catfish populations in lentic waters, and this study represents one of the first reservoir biomass estimates of Flathead Catfish in the northern portion of its range. The Lake Mitchell density estimate falls between the estimates for Pawnee Reservoir, NE (2.0–3.4 fish/ha; Katt 2016a) and Branched Oak Reservoir, NE (7.4 fish >250 mm/ha; Katt 2016b). Compared to southern populations, the Lake Mitchell density estimate of ≥305 mm fish was lower than in Diamond Valley Lake, CA (3.6–3.8 fish >350 mm [95% CI ~ 2.9–4.8]; Granfors 2014), and biomass estimates were lower than in Lake Carl Blackwell, OK (2.8–5.6 kg/ha for fish >550 mm; Summerfelt et al. 1972). Introduced riverine Flathead Catfish populations have been known to dominate the total fish biomass within 15 years of introduction (Guier et al. 1981). There is limited information available about the impact of introduced Flathead Catfish populations in lentic systems, but Lucchesi et al. (2017) suggested that declines in the centrarchid community in Lake Mitchell were likely linked to increasing Flathead Catfish abundance. While Flathead Catfish can offer unique angling opportunities in lentic systems, managers must consider the impact these top-level predators can have on existing fish communities before authorizing introductions outside their native range.

Accurate population estimates require that the assumptions of the Schnabel population estimator are met. We assumed that the population was closed on the James River given that similar studies have shown limited short-term movement of fish following tagging (Barabe 2009, Skains and Jackson 1995, Travnichek 2004). Limited short-term movement was observed based on electrofishing and angler recaptures in the James River (Schall and Lucchesi 2021), sampling occurred during a short timeframe, and limited harvest was reported. Additionally, all fish recaptured in August were in the same reach where they were tagged, and all recaptured individuals with intact tags during the May–June sample were collected within the reach where they were tagged, except one fish tagged and released near the boundary between the North and South Shramm reaches. Similarly, sampling on Lake Mitchell was assumed to be closed given the short sampling time frame and the lack of outflow during the study period due to low water conditions. Also, given the short sampling time frame, there was little evidence that exploitation or tag loss affected the assumption of closed populations. While Flathead Catfish in the James River were tagged with a combination of reward and non-reward tags (Schall and Lucchesi 2021), we only removed one fish from analysis that was reported harvested. We assumed limited harvest occurred on the Lake Mitchell population given the under-utilized nature of South Dakota reservoir catfish populations (Lucchesi et al. 2015, Stevens 2013) and the low exploitation estimates (<1%) for the nearby James River Flathead Catfish population (Schall and Lucchesi 2021). If limited movement were to have occurred, a violation of this assumption would result in our estimates underrepresenting the density of fish in these systems and make them conservative compared to actual densities. We also assumed that tag loss did not affect our estimates. The sampling timeframe was short enough that adipose fin clips would not have regenerated for fish in either the James River or Lake Mitchell (Neely et al. 2017), and we were able to correct for the one dangler tag loss in the Olivet reach.

The density and biomass estimates of Flathead Catfish in the James River provide a baseline against which to compare future estimates following system changes and to other populations at the northern edge of their range. Many rivers in the upper Great Plains, including the James River, experienced extreme flooding during 2019 that likely impacted available habitat in the river. Floods are known to promote habitat similarity in rivers (Hajdukiewicz et al. 2016, Thomaz et al. 2007) and mobilize large woody debris (Mao et al. 2013). Changes in habitat complexity, particularly the presence of woody debris, could affect Flathead Catfish abundance (Daugherty and Sutton 2005b, Pennington et al. 1983), but the relationship between habitat complexity and Flathead Catfish density and biomass needs greater evaluation. Average streamflow in lotic systems across the upper Great Plains is predicted to increase over time and be subject to greater frequency of extreme events due to the effects of land use and climate change (Ahiablame et al. 2017, Conant et al. 2018). Changes in water level and land use are also likely to impact the amount of available habitat and, subsequently, the abundance of Flathead Catfish (Paukert and Makinster 2008). Additionally, potential connectivity projects, such as low-head dam removal, may improve fish passage during low water periods, as removal of low-head dams have been shown to improve migratory movement of a variety of species, including Flathead Catfish (Raabe and Hightower 2014). By establishing baseline estimates of population density and biomass, long-term monitoring of the James River population can provide information about the impacts of system changes to populations of Flathead Catfish near the northern edge of their range.

Reservoirs are dynamic systems in which fish populations can be influenced by a variety of mechanisms. Flathead Catfish in lentic systems near the northern edge of their range may be impacted following the implementation of reservoir restoration projects, changes in the aquatic community, and shoreline development. Large-scale habitat manipulation can be used to slow the reservoir aging process (Pegg et al. 2015). Changes to in-reservoir habitat and accompanying shorelines may require extended drawdowns that negatively impact fish survival (Gaboury and Patalas 1984, Nagrodski et al. 2012), but reservoir habitat improvement projects generally result in increased productivity (Pegg et al. 2015). Lentic communities can also be impacted by the introduction of aquatic invasive species such as *Dreissena polymorpha* Pallas (zebra mussels), *Bythotrephes cederströmii* Schödler (spiny waterflea), *Myriophyllum spicatum* Linnaeus (European watermilfoil) (Hansen et al. 2020, Lyons 1989, McEachran et al. 2019), or *Potamogeton crispus* Linnaeus (curly-leaf pondweed) (Valley et al. 2004), or by the impacts of changing climate patterns (Hansen et al. 2017). Potential habitat modifications, including the addition of retention ponds and dredging, have been discussed for Lake Mitchell, but the impacts of improvements on the Flathead Catfish population may be confounded by the establishment of zebra mussels in 2021. The myriad of abiotic, biotic, and physical habitat changes seen in Lake Mitchell reflect changes occurring in lentic systems throughout the United States, and baseline results from this study can act as a useful management tool for understanding and predicting the elasticity of Flathead Catfish populations to change.

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