Yellowstone River Radio-Telemetry & Intake Passage Summary 2020

Jordan Pesik and Mathew Rugg

Montana Fish, Wildlife & Parks

March 2021

ABSTRACT

Construction on the Lower Yellowstone Intake Diversion Dam Fish Passage Project was into its second year in 2020 and is expected to take three years to complete. The first of its kind, this highly anticipated project is expected to improve fish passage upstream at Intake Diversion Dam, particularly for the federally endangered Pallid Sturgeon. With the closure of the historic Joe's Island Side Channel circumventing Intake dam in 2019, fish passage will be limited to over the dam or via translocation for the duration of construction. Blue Sucker, Paddlefish, Shovelnose Sturgeon and hatchery-origin Pallid Sturgeon all had upstream passages over the dam in 2020. Additionally, ten Pallid Sturgeon individuals were translocated upstream in 2020, including two male and one female wild-origin Pallid Sturgeon. Of the four telemetered species with active tags, only Pallid Sturgeon demonstrated tributary use during the 2020 spawning period. Use of the Yellowstone River upstream of the Powder River confluence and the Tongue River by both hatchery- and wild-origin Pallid Sturgeon provided new insights to habitat preferences with potential implications for reproductive success in the future. Telemetry efforts for the remainder of the construction period will be focused on reimplanting Pallid Sturgeon carrying transmitters with an expiring battery and preparing for the second phase of the overarching study: post-construction evaluation of the success of the bypass channel.

Abbreviations/Acronyms

cfs – cubic feet per second

FWP – Montana Fish, Wildlife and Parks

HOPS – Hatchery-Origin Pallid Sturgeon

JISC – Joe's Island Side Channel

MBC – Muggli Bypass Channel

PDR – Powder River

RM – river mile(s)

RPMA2 – Pallid Sturgeon Recovery Priority Management Area II

TNG – Tongue River

USACE – United States Army Corps of Engineers

USBR – United States Bureau of Reclamation

USGS – United States Geological Survey

WOPS – Wild-Origin Pallid Sturgeon

YSR – Yellowstone River

INTRODUCTION

With litigation struggles now in the past, construction on the Intake Diversion Dam (Intake) fish passage bypass channel and new concrete weir project on the Yellowstone River went into its second year in 2020. Excavation and rock layering of the main body of the bypass channel, and construction of the southern half of the new concrete weir were completed by the end of 2020. Completion of the northern half of the concrete weir is expected in 2021, with the finishing touches to the bypass channel being fulfilled thereafter.

Located 16 miles northeast of Glendive, MT, this contentious project was proposed by the U.S. Bureau of Reclamation (USBR) and U.S. Army Corps of Engineers (USACE) in response to the listing of Pallid Sturgeon (*Scaphirhynchus albus*) as a federally endangered species in 1990. Pallid Sturgeon once inhabited and readily accessed the warm water reaches of the Yellowstone River from its confluence with the Missouri River to the confluence of the Bighorn River almost 300 river miles upstream (Nelson and Jaeger 2006). Following the completion of Intake in 1909, spawning migrations of Pallid Sturgeon (and other native species) up the Yellowstone River have been greatly limited by Intake. Low levels of Pallid Sturgeon reproduction have been consistently documented almost every year since 2011 within the lower ten miles of the Yellowstone River, but no known recruitment has resulted from those spawning events. The current theory of why there has been no documentable recruitment of Pallid Sturgeon in the Yellowstone River since their listing is the lack of drift distance between spawning locations downstream of Intake and the anoxic headwaters of Lake Sakakawea on the Missouri River. In recent years, those Pallid Sturgeon residing, translocated (since 2017), or able to naturally pass above Intake have demonstrated wide use of the available habitats in the Yellowstone River, and an affinity for the Powder River during the spawning window. Spawning in the Powder River or Yellowstone River above the Powder River confluence would greatly increase the drifting distance for larvae, which may provide enough developmental time for recruitment.

From 2014 to 2019, wild-origin adult Pallid Sturgeon (WOPS) and hatchery-origin Pallid Sturgeon (HOPS) were occasionally documented using Joe's Island Side Channel (JISC) to swim up and around Intake, and only once had they traversed up over the dam (Pesik et al., 2020). Since adult Pallid Sturgeon have been relocated frequently in the river below and up to Intake, increasing upstream passage past Intake presents itself as a viable solution to the problem of Pallid Sturgeon recruitment.

Since other species in the Yellowstone River may also be affected by Intake, four native species besides Pallid Sturgeon, including Blue Sucker (*Cycleptus elongatus*), Paddlefish (*Polyodon spathula*), Shovelnose Sturgeon (*Scaphirhynchus platorynchus*), and Sauger (*Sander canadensis*), were included in the four-year pre-bypass channel construction analysis of fish passage at Intake. These species were all found to pass Intake, but with varying degrees of success and route preference. Paddlefish mostly passed via JISC, Blue Sucker preferred to pass over the dam, and both Shovelnose Sturgeon and Sauger showed no preference of passage route. Movements from all species but Blue Sucker indicated Intake was a barrier to upstream movements (Rugg et al., 2019). Therefore, increased upstream passage past Intake will likely have beneficial ramifications not limited to Pallid Sturgeon.

The highly anticipated bypass channel is expected to improve upstream passage past Intake by Pallid Sturgeon and other native species. While construction is underway, telemetry efforts will focus on monitoring Pallid Sturgeon activities upstream of Intake in the Yellowstone and Powder Rivers, replacing

the expiring radio transmitters in WOPS, and preparing for the second phase of the study: the post-construction analysis of the success of the bypass channel. The purpose of this report is to summarize telemetry data from 2020: construction year two.

METHODS

Intake is located at river mile (RM) 71 on the Yellowstone River, which is only a portion of the geographic area concerning this population of Pallid Sturgeon. Pallid Sturgeon Recovery Management Priority Area II (RPMA2) includes the Missouri River from Fort Peck dam downstream to the headwaters of Lake Sakakawea, the Yellowstone River, and the tributaries in these river reaches (Figure 1). Management and telemetry efforts are in action on the Missouri River, but they will not be included in this summary.

Montana Fish, Wildlife & Parks (FWP) Fisheries Region 7, USBR, and U.S. Geological Survey (USGS) crews monitored Lotek Wireless Inc. radio-implanted Pallid Sturgeon (*Scaphirhynchus albus*), Blue Sucker (*Cycleptus elongatus*), Paddlefish (*Polyodon spathula*), Shovelnose Sturgeon (*Scaphirhynchus platorynchus*), and Sauger (*Sander canadensis*) with ground-based receiver stations and manual relocation operations via boat or aircraft. In 2020, FWP crews managed an array of 10 receiver stations between Seven Sisters Fisheries Access Site (Yellowstone River [YSR] RM 39) and the Bighorn River confluence (YSR RM 295), which included a second station at Intake to monitor Pallid Sturgeon radio-tag frequencies. In years past, a station on the Powder River at Locate, MT (Powder River [PDR] RM 31), was also monitored by FWP crews. However, low flows in the Powder River during 2020 hindered the use of this tributary by radio-tagged fish and precluded the need for this station. Data from three telemetry station locations in the lower ten river miles of the Yellowstone River and one station at the Powder River Confluence managed by USGS were included in this report. Manual relocations of fish in the Yellowstone River and its tributaries occurred from early-March through mid-October in 2020.

Opportunity for fish passage through the historic Joe's Island Side Channel (JISC) ceased in 2019 when excavation material from the soon-to-be bypass channel was used to fill the historic side channel. In 2020, fish were able to pass over Intake dam and USBR crews translocated Pallid Sturgeon over Intake dam during the May pre-high-water period. This was the fourth consecutive year that USBR translocated Pallid Sturgeon from the reach immediately downstream of Intake. The capture reach downstream of Intake was extended an additional mile downstream (to YSR RM 69) in 2020 (similar to 2019) to atone for expected reduced natural passage during the bypass channel construction years.

RESULTS

Hydrograph

Yellowstone River discharge in 2020 near Glendive, MT, was above the historic median daily discharge from ice-out in early-March to the spring rise in early-May. Thereon, the discharge curve followed the historic trend, peaking at 56,300 cfs on June 5, 2020. The descending limb of the hydrograph occurred about two weeks early than normal and was over 2,000 cfs below the historical

median by September. From September through the end of the sampling season in early November the hydrograph slowly gained back to the historical median daily discharge (Figure 2).

Powder River discharge in 2020 near Locate, MT, mirrored the median daily discharge curve from late-March through late-May. However, the typical early summer peak in discharge came 2-3 weeks earlier than normal on 24 May 2020 and topped out at 1,100 cfs. The hydrograph remained over 500 cfs lower than the median daily discharge for much of the remainder of the year (Figure 3).

Tongue River discharge in 2020 in Miles City, MT, followed the median daily discharge curve from mid-March to May. The early summer pulse in the hydrograph occurred during a smaller timeframe than normal. The pulse began 2-3 weeks later than the median, peaked at 1,060 cfs on 5 June 2020, and began dropping 2-3 weeks earlier than normal. The hydrograph remained lower than the median daily discharge for much of the remainder of the year, with the notable exception resulting from a pulse beginning in mid-August and lasting into September (Figure 4).

Hatchery-Origin Pallid Sturgeon

Ninety-eight radio-tagged HOPS were relocated in the waters of the Yellowstone River during 2020 (Table 1). Of those 98, 13 were newly radio-tagged HOPS in 2020, including six individuals upstream of Intake. Ten individuals (codes 149.620-40, 149.620-98, 149.620-112, 149.620-133, 149.760-313 [formerly 149.620-143], 149.620-147, 149.620-155, 149.620-158, 149.620-177, and 149.760-190) began the year in the Yellowstone River upstream of Intake, with seven of the ten individuals overwintering between Intake (YSR RM 71) and the Powder River confluence (YSR RM 147). Codes 149.620-202, 149.620-204, 149.620-205, 149.760-305, 149.760-312, and 149.760-314 were tagged between YSR RM 122 (just downstream from Fallon) and the Powder River confluence during the last week of August and the first week of September (Figure 5). Seventeen Pallid Sturgeon encountered Intake during 2020 and three natural upstream passages were documented in late-July (codes 149.620-113, 149.760-310 [formerly 149.620-136], and 149.620-173) under Yellowstone River discharges between 9,000 – 12,000 cfs. Seven HOPS (codes 149.620-28, 149.620-66, 149.620-142, 149.620-156, 149.620-167, 149.620-170, and 149.760-306 [formerly 149.620-154]) were translocated from the 2.3-mile reach below Intake to Stipek Fishing Access Site (YSR RM 83) by the USBR. Twenty-four of the twenty-six HOPS upstream Intake in 2020 spent some time in the reach between Intake and the Powder River confluence, with eight of the twenty-four venturing upriver to the Powder River confluence (YSR RM 147; codes 149.620-98, 149.620-113, 149.620-155, 149.620-173 149.620-177, 149.760-190, 149.760-305, and 149.760-314) and six of the eight (all codes previous except 149.760-305 and 149.760-314) moving further upstream. Two individuals (codes 149.620-40 and 149.620-112) overwintered in the reach between the Powder and Tongue River confluences. Seven of the eight individuals who spent time between the Powder and Tongue River confluences in 2020 swam up to and beyond the Tongue River confluence. One of the seven individuals spent time in the Tongue River (code 149.620-177) as far up as RM 11.4. The remaining six individuals were recorded in the Yellowstone River as far as RM 196 (code 149.620-40), RM 219 (code 149.620-98), RM 221 (code 149.760-190), RM 223 (code 149.620-113), RM 228 (code 149.620-173), and the Cartersville diversion dam at RM 235 (code 149.620-112). By the end of October, eight HOPS had been documented having moved downstream over Intake (codes 149.620-28, 149.620-66, 149.620-113, 149.620-147, 149.620-156, 149.620-167, 149.620-170, and 149.620-177) and three additional HOPS were presumed to have journeyed downstream of Intake based on our inability

to relocate these individuals upstream of Intake and the proximity to Intake of their last sightings (codes 149.620-40, 149.620-133, and 149.760-306). Large upstream migrations (>50 river miles) from mid-July to October were documented from six HOPS in 2020, three of which were by the natural Intake passage individuals (codes 149.620-113, 149.620-173, and 149.760-310), two were by individuals exclusively downstream of Intake (codes 149.620-45 and 149.620-177), and one was by an individual exclusively upstream of Intake (code 149.760-190).

Wild-Origin Pallid Sturgeon

There were 44 radio-tagged WOPS relocated in the Yellowstone River during 2020 (Table 2), and only five fish swam up to Intake. Three of the five fish (one female, code 149.760-109; two males, codes 149.760-71 and 149.760-227 [formerly 149.760-11]) were translocated upstream of Intake (YSR RM 71) to Stipek Fishing Access Site (YSR RM 83) by the USBR in late-May (Figure 6). Only code 149.760-11 was translocated in previous years (2017, 2018, 2019) of this study. One WOPS male (code 149.760-131) overwintered upstream of Intake near Terry, MT, (YSR RM 134), and spent the entire spring in the 20-mile reach downstream of the Powder River confluence (YSR RM 147). Two of the three translocated individuals (codes 149.760-109 and 149.760-227) continued their upstream migrations to and beyond the Tongue River confluence (YSR RM 183). Code 149.760-227 moved up into the Tongue River as far as RM 13 during the approximately ten-day period in early-June when he resided in the Tongue River. Code 149.760-109 stayed in the Yellowstone River, moving up to RM 197, dropping down to RM 120 and migrating back upstream to RM 163 during this same approximate timeframe. All WOPS upstream of Intake in 2020 passed downstream over the diversion dam between June 21-23, 2020, when Yellowstone River discharge had dropped below 28,000 cfs. The majority of WOPS had exited the Yellowstone River by August, but one individual (male, code 149.760-28) residing in the lower four river miles through July and August made a 30-mile run up the Lower Yellowstone River in September.

Blue Sucker

Of the 28 radio-tagged Blue Sucker swimming in the waters of the Yellowstone River during 2020, only two of those individuals began the year upstream Intake (Table 3). No new Blue Sucker were tagged this year. All 24 Blue Suckers that encountered Intake from downstream swam upstream over the dam (100% passage). Intake upstream passages occurred from early-April through late-July in Yellowstone River discharges ranging from 8,480 cfs to 49,000 cfs (Figure 7). Nineteen fish swam as far upstream as the Powder River confluence (YSR RM 147), eleven up to the Tongue River confluence (YSR RM 183), including one individual who overwintered from 2019 in the reach between the Powder and Tongue Rivers, and eleven beyond the Tongue River confluence, including one individual who overwintered from 2019 in the reach upstream of the Tongue River. The furthest documented upstream extent of Blue Sucker in 2020 was YSR RM 238, approximately 2.5 miles upstream of the Cartersville diversion dam. Blue Sucker began migrating down over Intake dam in August, though most activity occurred in October.

Paddlefish

Fifty-two Paddlefish were relocated in the Yellowstone River in 2020 (Table 4). No new radio transmitters were implanted into paddlefish in the Yellowstone River this year. Thirty fish swam upstream to Intake, but only one fish passed upstream (3.3% passage). This one fish swam up over the dam on 31 May 2020 when Yellowstone River discharge was at 32,500 cfs (Figure 8). This lone fish swam as far upstream as the Powder River confluence (YSR RM 147) on 23 June 2020 and swam back downstream over Intake dam on 25 June 2020 once discharge had dropped to about 25,000 cfs.

Shovelnose Sturgeon

There were 25 Shovelnose Sturgeon relocated in the Yellowstone River in 2020 (Table 5). No new Shovelnose Sturgeon were radio tagged this year. Seven fish encountered Intake during the year, but only one fish passed upstream (14.3% passage) over the dam under a Yellowstone River discharge of 9,000 cfs on 31 July 2020 (Figure 9). Ten Shovelnose Sturgeon, including the one natural passage upstream over the dam, were relocated upstream of Intake in 2020. Throughout the year, seven individuals spent time in the reach between Intake (YSR RM 71) and the Powder River confluence (YSR RM 147), three individuals spent time in the reach between the Powder River confluence and the Tongue River confluence (YSR RM 183), and two individuals spent time in the reach upstream of the Tongue River confluence. The farthest upstream Shovelnose Sturgeon were relocated was YSR RM 218, and no telemetered individuals were documented within any of the Yellowstone River tributaries in 2020. Moderate upstream migrations (>30 river miles) during the August to October timeframe were observed in three individuals in 2020: one natural Intake passage individual and the other two resided exclusively upstream of Intake in 2020.

Sauger

None of the Sauger tags implanted from past years were still active by the beginning of the 2020 sampling year and no new Sauger were implanted with radio tags in 2020.

DISCUSSION

Fish Passage at Intake

During 2020, three HOPS Pallid Sturgeon passed upstream over Intake Diversion Dam of their own free will, producing a HOPS natural passage rate of 27.3% (excludes encounters resulting in translocation upstream). This was unprecedented given the findings from the past five years of study (Rugg et al., 2019; Pesik et al., 2020) in which only one HOPS Pallid Sturgeon had navigated upstream through the rock crib of Intake dam in 44 encounters (excludes encounters resulting in translocation upstream), resulting in an annual passage rate of 2.2 ± 2.2% (mean ± standard error). Including data from 2020, the results changed to 4 fish passages in 55 encounters, and an annual upstream passage rate over the dam of 6.4 ± 4.6%. While available, the historic Joe's Island Side Channel was the most used passage route by Pallid Sturgeon from 2015-2019, accounting for 90% of HOPS natural passages and 100% of WOPS natural passages (total of 93.3% of all Pallid Sturgeon passages).

Starting 1 July 2020, a rock causeway was built across the southern half of the main river channel at Intake for the construction of the southern half of the new concrete weir. With the closure of an alternate route around Intake dam in 2019 and in-channel construction of the new dam (July – December 2020) on the Yellowstone River limiting passage route opportunities, there was the expectation of reduced (little to none) passage by Pallid Sturgeon (or sturgeon in general) during the new dam and bypass channel construction period. However, three natural HOPS passages and one Shovelnose Sturgeon passage occurred in late-July, 2020, subsequent to the construction of the rock causeway despite individuals being present at Intake prior.

Shovelnose Sturgeon have been used as study surrogates for inferences of Pallid Sturgeon behaviors due to many similar characteristics. Turbulent flows and high velocities over and around large substrates have been shown to hinder Shovelnose Sturgeon movements in laboratory settings (White and Mefford, 2002) and these findings were expected to translate to Pallid Sturgeon as well; Intake passage data of both Shovelnose and Pallid Sturgeon from the past five years has validated those findings. Furthermore, in the White and Mefford (2002) study Shovelnose Sturgeon passage through test fishways almost always occurred along the same routes, even when multiple options were present, indicating flow velocities and conditions are preferentially selected and sought out for movements through a highly variable flow environment. It has been speculated that Shovelnose and Pallid Sturgeon passing over Intake must have found a suitable route through the turbulent waters of the boulder crib (there may be only a handful of possibilities at most in a given year), and the route may change every year as a result of two primary factors: 1) shifting boulders caused by annual ice-out activity and 2) the addition of new boulders to the top of the crib to maintain water depth for the irrigation canal (will no longer be implemented as a consequence of the new weir construction). Simply finding a suitable route is likely more than half the battle for sturgeon trying to navigate Intake dam; however, following the construction of the temporary causeway the restriction of flow to half the original channel width may have increased the likelihood of sturgeon finding a suitable passage route through the turbulent waters by reducing the number of optional paths culminating in “dead ends” that motivated individuals would have to seek and test out. Both the 2020 HOPS, noted above, and Shovelnose passage data appear to support this hypothesis. Though 2020 Shovelnose Sturgeon passage data (14.3% passage) was near the five-year annual average of 12.0 ± 4.1% of encounters culminating in over-Intake passage annually (2015-2019), our original hypothesis was an expected reduced passage rate due to limited routes.

Translocation efforts by USBR the past two years have resulted in more fish translocated than the first two years of the project. Almost as many Pallid Sturgeon (HOPS and WOPS combined) were translocated in 2020 (10) as 2019 (12), which together is almost double the cumulative results of five individuals in 2017 and seven individuals in 2018. Five of those Pallid Sturgeon (HOPS codes 149.620-66, 149.620-156, 149.620-167, 149.760-306, and WOPS code 149.760-227) had been translocated in prior years. There are several reasons for this difference. First, the timeframe during which Pallid Sturgeon can be captured for translocated is from May 1 to June 15 each year. However, river conditions including debris load and discharge dictate the feasibility of netting for fish. Consequently, USBR crews were only able to sample for 25 days and 17 days in 2017 and 2018, respectively, and 35 and 40 days in 2019 and 2020, respectively. This is a difference of 79% more days of sampling in the latter two years vs. the former two years. Second, efficiency of capture and crew assignments have arguably improved since the first years of this activity. The number of Pallid Sturgeon within the catch zone during the 45-day timeframe were 18, 17, 14 and 14 from 2017-2020, respectively. Finally, in 2019 and 2020 the catch

zone was increased by approximately a mile downstream. Seven of the twelve translocated fish in 2019 and six of the ten translocated fish in 2020 were captured in the extended portion of the catch zone. Altogether, these reasons likely explain the observed trend in numbers of Pallid Sturgeon translocated.

Passage by the remaining two species with active radio tags in 2020 varied by species. Blue Sucker, which were known from the pre-construction study to primarily pass upstream over the dam (annual average of 89.2% over the dam vs. 10.8% via JISC from 2015-2018), showed no difference in passage rates from prior years (average total annual passage rate of 98.6 ± 0.8% from 2015-2019) and successfully passed at 100% of Intake encounters in 2020. The majority of Blue Sucker migrate upstream over Intake in the Spring and early Summer. With half the concrete weir now completed, and construction of the causeway for the northern half of the river not permitted until 1 July 2021, Blue Sucker passage at Intake will likely be unhindered in 2021.

Average annual Paddlefish passage upstream of Intake via either route from 2015-2019 (23.3 ± 7.9% of Intake encounters) was greater than what was documented in 2020 (3.3% of Intake encounters). It was predicted that total Paddlefish passage rates would be reduced during the construction years (Pesik et al., 2020). However, even with the main channel completely unimpeded well beyond the normal migration timeframe of Paddlefish up the Yellowstone River (no causeway until 1 July 2020), passage over the dam was still lower than what was expected from 2015-2019 (9.0 ± 3.0% of encounters). From the pre-construction study, a discharge of ~30,000 cfs was found to be the lower threshold required for Paddlefish passage over the dam (Rugg et al., 2019). In 2020, Yellowstone River discharge exceeded 30,000 cfs on four occasions: three periods were for two-days each and one period was for 13-days from 31 May 2020 through 12 June 2020. During this 13-day period 25 Paddlefish made it to Intake, but only one individual passed upstream. Although this early-summer rise in water level was roughly half the duration of a typical year, we expected a slightly higher passage rate than what we observed. Therefore, it's possible that additional factors played a role in the reduced passage of Intake in 2020.

Telemetry Upstream Intake

Telemetered Blue Sucker, Paddlefish and Shovelnose Sturgeon behaved similarly as during previous years of study, and there was no documented use of tributaries to the Yellowstone by any telemetered individuals of these species during 2020, though non-telemetered Shovelnose Sturgeon were observed in the Tongue River around mid-June. Blue sucker showed extensive use of the Yellowstone River upstream of Intake and one navigated upstream over the Cartersville diversion dam (YSR RM 235). Blue Sucker passage at Cartersville dam is not well understood because only a handful of individuals migrate that far upstream each year, and we may only do a handful of tracking runs upstream of Cartersville dam in a given year. However, Blue Sucker passages of Cartersville dam were also documented in 2015 (two individuals) and 2018 (one individual) and individuals travelled as far as RM 272 and RM 295, respectively. The single telemetered Paddlefish to migrate upstream in 2020 resided in the river bend downstream from the Powder River, a known congregation spot, for much of June before heading back downstream in late-June. Finally, few telemetered Shovelnose Sturgeon were present in the system during 2020 and relocation priority was given to telemetered Pallid Sturgeon and Paddlefish. Over the past six years, a number of Shovelnose Sturgeon individuals each year have made late-Summer upstream migrations, sometimes comparable in distance to late-Spring presumed

spawning migrations. This behavior has also been observed in a handful of HOPS Pallid Sturgeon in the Yellowstone River upstream of Intake since 2018. Large upstream migrations in the Fall have been documented in the Lower Missouri River by several reproductively mature female Pallid Sturgeon as preemptively migrating closer to spawning areas for the following Spring (DeLonay et al., 2016b), but has not been documented in Pallid Sturgeon in RPMA 2. It is possible that the Shovelnose Sturgeon observed in the Yellowstone River are exhibiting this same type of staging behavior, though sex and maturity are unknown for most telemetered Shovelnose Sturgeon. Sex and maturity of many HOPS are still unknown at this time, but their behavior may be similarly driven. Too little data has been collected to really address the question of these migrations, but we may receive some clarity as HOPS begin to mature in the coming years and attempt to reproduce.

Unlike the other three telemetered species, Pallid Sturgeon exhibited new behaviors during 2020, including extensive use of the Yellowstone River upstream of the Powder River by WOPS, and use of the Tongue River by both HOPS and WOPS. Flows from the Powder River were nonexistent when two translocated and actively migrating WOPS (male code 149.760-227 and gravid female code 149.760-109 [15 May 2020 capture: 16.5 kg, black eggs present]) reached it. Without any attraction flows emanating from the Powder River, these fish continued their upstream course in the Yellowstone River. Historical documentation notes WOPS were present in the Yellowstone River at least as far as the Tongue River confluence (YSR RM 183; Brown, 1971), and possibly as far as the Bighorn River confluence (YSR RM 295; Nelson and Jaeger, 2006). Upstream movement in the Yellowstone River beyond the Powder River had not been documented in telemetered WOPS until this year. Both WOPS migrated up to the Tongue River where flows were enough to attract the male WOPS and an unknown sex HOPS (code 149.620-177) into the Tongue River for a period of about ten days. This is the first documented use of the Tongue River by telemetered Pallid Sturgeon. Attempts were made to net around these individuals in the Tongue River to capture any untagged Pallid Sturgeon individuals present. No Pallid Sturgeon were captured though several Shovelnose Sturgeon were captured. Across from the mouth of the Tongue River there is a side channel that, if taken, would prevent access to the Tongue River. If code 149.760-109 travelled upstream through the side channel and she would have never encountered the Tongue River Confluence and never had the choice to migrate up the tributary as did codes 149.760-227 and 149.620-177. While this is a possible explanation for her differing behavior, the resolution of our telemetry data makes her route choice unclear, though inferences can be made on her route based on her considerable preference for the main channel along most of her upstream migration. After passing the Tongue River confluence, the female WOPS continued upstream in the Yellowstone an additional 15 river miles to YSR RM 197 (7 June 2020) before turning around and heading quickly downstream to Fallon, MT, (YSR RM 120, 11 June 2020). It was suspected that this female had spawned upstream of the Tongue River, so she was targeted for recaptured and assessment. On 11 June 2020, she was captured and weighed 14.4 kg (12.7% weight loss from initial capture), had a soft abdomen with visible rash, but black eggs were still present. Histological examination of egg samples taken 11 June 2020 indicated the female was still ripe. Code 149.760-109 made another run up the Yellowstone River past the Powder River and stopped about halfway between the Powder River confluence and the Tongue River confluence (YSR RM 163, 17 June 2020). After pausing for a day, she turned around and headed downstream to the lower Yellowstone River (RM 4, 22 June 2020) along with the other WOPS upstream Intake. She was recaptured a third time to reassess spawning (RM 2, 2 July 2020), where she weighed 13.3 kg (19.4% weight loss from initial capture) and histology results indicated she was post-ovulatory. To this point, migrations by reproductively active and even immature Pallid Sturgeon in the Yellowstone River upstream Intake have

largely been single apex, like what is seen in the Lower Missouri River downstream from the Kansas River (DeLonay et al., 2012). The complex, and often multiple-apex migration behavior that code 149.760-109 demonstrated in 2020 is a characteristic of individuals in the lower Yellowstone River and thought to be a result of the upstream impediment of Intake diversion dam (Fuller et al., 2008). Females who exhibit a complex migration behavior tend to spawn later or go atretic in comparison to individuals exhibiting the single-apex migration behavior (DeLonay et al., 2012). For example, in 2020 another reproductively ready female, code 149.760-43, also made several large migrations up and down the lower Yellowstone River (RMs 0-68), yet she never spawned and was found to be atretic when captured and assessed on 2 July 2020 (YSR RM 13). Code 149.760-43 has had a high incidence of atresia in the past, but little knowledge is available on the direct causes of atresia in Pallid Sturgeon. Additionally, there has been no documentation of multiple spawning events over a protracted time period. Hopefully, the peculiar spawning behavior of code 149.760-109 in 2020 is not an indicator that this individual may turn atretic in the future. With only a single documentation of a gravid female Pallid Sturgeon migrating to this extent in the Yellowstone River it is difficult to make any conclusions as to why this behavior was observed.

The added drift distance above the hypoxic zone of Lake Sakakawea gives hope that larvae produced from a successful spawning event in upstream reaches of the Yellowstone River and its tributaries would survive and recruit to the population, something not currently seen from reproduction in the lower Yellowstone River (RM 3-7). This is the motivation behind the bypass channel construction project at Intake, but up to this year it was unknown whether reproductively active Pallid Sturgeon would use tributaries or habitats of the Yellowstone River beyond the Powder River. Reproductively active Pallid Sturgeon using river reaches upstream of the Powder River confluence strongly indicates suitable spawning habitats are present at multiple locations in the Yellowstone River system upstream Intake and possible reproduction is not relegated solely to the Powder River, which may be unsuitable some years.

Female Pallid Sturgeon typically spawn on 2-4 year cycles, while males spawn every 1-3 years across their range (Albers et al., 2013; Holmquist et al., 2018). Within the RPMA2, females spawn most commonly on two-year cycles, though three-year cycles are documented occasionally (Fuller et al., 2008; DeLonay et al., 2016a). Code 149.760-131, a male WOPS, was the first telemetered WOPS documented to overwinter upstream Intake. Despite making an extensive foray into the Powder River in 2019, this individual did not appear to show any interest in migrating upstream alongside the two translocated WOPS mentioned previous and may not have had reproductively mature gametes during 2020.

Moving Forward

Telemetry efforts upstream Intake will continue to be a high priority for the duration of the Intake Project construction period and will continue into the post-construction phase of the study. A concerted effort is also underway during the interim to reimplant Pallid Sturgeon, particularly WOPS, with new radio tags in preparation for the second phase: post-construction evaluation. The reasons behind replacing radio tags in Pallid Sturgeon are two-fold. First, many radios are nearing or at the end of their battery life expectancy. Due to the rarity of these fish, failure to replace the radio tags before the current radios expire reduces the likelihood of recapture to almost nonexistent and valuable data is

lost. Therefore, reimplantation of as many radio tags in Pallid Sturgeon (especially WOPS, who number around 100 individuals remaining in the whole system) as possible during these interim years is requisite to be able to evaluate the success of the completed bypass channel. Even with a functioning radio tag, recapture is not guaranteed and may take several days of effort from multiple crews to capture a single targeted fish. Second, we required four radio frequencies of tags during the pre-construction study phase to encompass all five species, including two specifically designated for Pallid Sturgeon. The time required to cycle through all the frequencies when tracking fish proved to be inefficient and costly as it resulted in missed fish. This was especially true for station receivers which had the added step of cycling through each antenna before switching to the next frequency. To combat this issue, we plan on using a different code-set of radio tags, one that has 728 unique identification numbers (IDs) per frequency as opposed to the 212 unique IDs in the current code-set. This change will allow us to reduce the number of frequencies down to two (one frequency for Pallid Sturgeon and the other for all other species), cutting cycling time in half. However, work during the code-set transition period will prove time consuming, not only in tag replacement, but also for tracking fish since our current receivers can only identify tags from frequencies in a single code-set at a given time. Telemetry efforts for Pallid Sturgeon will require a minimum of two receivers, one per code-set, with the potential need for a second crew to relocate the other native species with non-Pallid radio tag frequencies. Work the next few years will be tedious but should increase telemetry efficiency in the years that follow.

Documentation of Pallid Sturgeon using the Tongue River in 2020 demonstrates a need to reevaluate and initiate discussions with partners about future modifications to the Muggli Bypass Channel (MBC) on the Tongue River at T&Y Dam (RM 20). Despite being very successful at improving upstream passage for a host of fish species, Shovelnose Sturgeon have failed to navigate the bypass channel since its completion in 2008 (Bollman, 2019). Monitoring efforts of MBC needed to investigate potential modifications to the passageway are now relevant and warranted for Pallid Sturgeon migrations since passage at T&Y Dam would increase potential sturgeon migrations into the Tongue River, currently limited to the lower 20 river miles, up to 188 miles of free-flowing river.

LITERATURE CITED

Albers, J., M. Wildhaber and A. DeLonay. 2013. Gonadosomatic index and fecundity of lower Missouri and Middle Mississippi River endangered pallid sturgeon estimated using minimally invasive techniques. Journal of Applied Ichthyology 29:968-977. http://dx.doi.org/10.1111/jai.12231.

Bollman, C. 2019. Southeastern Montana Warm-water Streams Investigation. Annual Federal Aid Job Progress Report F-113. Montana Fish, Wildlife & Parks. Miles City, Montana.

Brown, C. 1971. Fishes of Montana. Big Sky Books. Bozeman, Montana.

DeLonay, A., R. Jacobson, D. Papoulias, M. Wildhaber, K. Chojnacki, E. Pherigo, J. Haas and G. Mestl. 2012. Ecological requirements for pallid sturgeon reproduction and recruitment in the Lower Missouri River—Annual report 2010. Open-File Report 2012–1009. U.S. Geological Survey. Reston, Virginia.

DeLonay, A., K. Chojnacki, R. Jacobson, P. Braaten, K. Buhl, C. Elliot, S. Erwin, J. Faulkner, J. Candrl, D. Fuller, K. Backes, T. Haddix, M. Rugg, C. Wesolek, B. Eder and G. Mestl. 2016a. Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River—Annual report 2014. Open-File Report 2016–1013. U.S. Geological Survey. Reston, Virginia.

DeLonay, A., R. Jacobson, K. Chojnacki, P. Braaten, E. Bulliner, C. Elliot, S. Erwin, D. Fuller, J. Haas, H. Ladd, G. Mestl, D. Papoulias and M. Wildhaber. 2016b. Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River—A synthesis of science, 2005-2012. Scientific Investigations Report 2015-5145. U.S. Geological Survey. Reston, Virginia.

Fuller, D., M. Jaeger and M. Webb. 2008. Spawning and associated movement patterns of pallid sturgeon in the lower Yellowstone River. Report submitted to the Western Area Power Administration, Upper basin pallid sturgeon work group. Montana Fish, Wildlife and Parks. Helena, Montana.

Holmquist, L., C. Guy, A. Tews and M. Webb. 2019. First maturity and spawning periodicity of hatchery-origin pallid sturgeon in the upper Missouri River above Fort Peck Reservoir, Montana. Journal of Applied Ichthyology 35(1):138-148. https://doi.org/10.1111/jai.13751.

Nelson, M., and M. Jaeger. 2006. Historical distribution of pallid sturgeon in the Yellowstone River: an oral retrospective. Montana Fish, Wildlife and Parks. Glendive, Montana.

Pesik, J., M. Rugg, E. Best, T. Gust and D. Trimpe. 2020. Yellowstone River Radio-Telemetry & Intake Passage 2019. Agreement No. R18AP00281. U.S. Bureau of Reclamation. Billings, Montana.

Rugg, M., J. Pesik and D. Trimpe. 2019. An Evaluation of Fish Passage at Intake Diversion Dam: Bypass Channel Pre-Construction. Agreement No. R18AP00281. U.S. Bureau of Reclamation. Billings, Montana.

White, R. and B. Mefford. 2002. Assessment of behavior and swimming ability of Yellowstone River sturgeon for design of fish passage devices. U.S. Bureau of Reclamation. Denver, Colorado.

TABLES

Table 1. Summary of hatchery-origin Pallid Sturgeon (HOPS) upstream movements in the Yellowstone River in 2020. Totals represent the number of individuals who demonstrated an upstream movement relative to a landmark or spent time in a reach.

Upstream Movements	Total	Farthest Upstream Extent (RM)	Date Range
Recorded in Yellowstone River	**98**		
To Intake	18		
Moved Past Intake	10		
Via Joe's Island Side Channel	*N/A*		*N/A*
Over Dam	*3*		*7/21/2020-7/29/2020*
Translocated	*7*		*5/5/2020-5/28/2020*
Total Recorded Upstream of Intake	**26**	**235.4**	
Recorded Between Intake/Powder River	24		
To Powder River	8		
Into Powder River	0		N/A
Moved Past Powder River	6		
Recorded Between Powder/Tongue Rivers	8		
To Tongue River	7		
Into Tongue River	1	11.4	6/5/2020-6/13/2020
Moved Past Tongue River	6		
Recorded Upstream of Tongue River	6	235.4	

Table 2. Summary of wild-origin Pallid Sturgeon (WOPS) upstream movements in the Yellowstone River in 2020. Totals represent the number of individuals who demonstrated an upstream movement relative to a landmark or spent time in a reach.

Upstream Movements	Total	Farthest Upstream Extent (RM)	Date Range
Recorded in Yellowstone River	**44**		
To Intake	5		
Move Past Intake	3		
Via Joe's Island Side Channel	*N/A*		*N/A*
Over Dam	*0*		*N/A*
Translocated	*3*		*5/24/2020-5/28/2020*
Total Recorded Upstream Intake	**4**		
Recorded Between Intake/Powder River	4		
To Powder River	3		
Into Powder River	0		N/A
Move Past Powder River	2		
Recorded Between Powder/Tongue Rivers	2		
To Tongue River	2		
Into Tongue River	1	13.0	6/5/2020-6/15/2020
Move Past Tongue River	1		
Recorded Upstream Tongue River	1	197.0	

Table 3. Summary of Blue Sucker upstream movements in the Yellowstone River in 2020. Totals represent the number of individuals who demonstrated an upstream movement relative to a landmark or spent time in a reach.

Upstream Movements	Total	Farthest Upstream Extent (RM)	Date Range
Recorded in Yellowstone River	**28**		
To Intake	24		
Moved Past Intake	24		
Via Joe's Island Side Channel	*N/A*		*N/A*
Over Dam	*24*		*4/7/2020-7/31/2020*
Total Recorded Upstream Intake	**26**		
Recorded Between Intake/Powder River	24		
To Powder River	19		
Into Powder River	0		N/A
Moved Past Powder River	15		
Recorded Between Powder/Tongue Rivers	16		
To Tongue River	11		
Into Tongue River	0		N/A
Moved Past Tongue River	10		
Recorded Upstream Tongue River	11	237.8	

Table 4. Summary of Paddlefish upstream movements in the Yellowstone River in 2020. Totals represent the number of individuals who demonstrated an upstream movement relative to a landmark or spent time in a reach.

Upstream Movements	Total	Farthest Upstream Extent (RM)	Date Range
Recorded in Yellowstone River	**52**		
To Intake	30		
Moved Past Intake	1		
Via Joe's Island Side Channel	*N/A*		*N/A*
Over Dam	*1*		*5/31/2020*
Recorded Upstream of Intake	**1**		
Recorded Between Intake/Powder River	1		
To Powder River	1	146.8	
Into Powder River	0		N/A
Moved Past Powder River	0		
Recorded Upstream of Powder River	0		

Table 5. Summary of Shovelnose Sturgeon upstream movements in the Yellowstone River in 2020. Totals represent the number of individuals who demonstrated an upstream movement relative to a landmark or spent time in a reach.

Upstream Movements	Total	Farthest Upstream Extent (RM)	Date Range
Recorded in Yellowstone River	**25**		
To Intake	7		
Moved Past Intake	1		
Via Joe's Island Side Channel	*N/A*		*N/A*
Over Dam	*1*		*7/31/2020*
Total Recorded Upstream of Intake	**10**		
Recorded Between Intake/Powder River	7		
To Powder River	1		
Into Powder River	0		N/A
Moved Past Powder River	0		
Recorded Between Powder/Tongue Rivers	3		
To Tongue River	2		
Into Tongue River	0		N/A
Moved Past Tongue River	2		
Recorded Upstream of Tongue River	2	218.4	

FIGURES

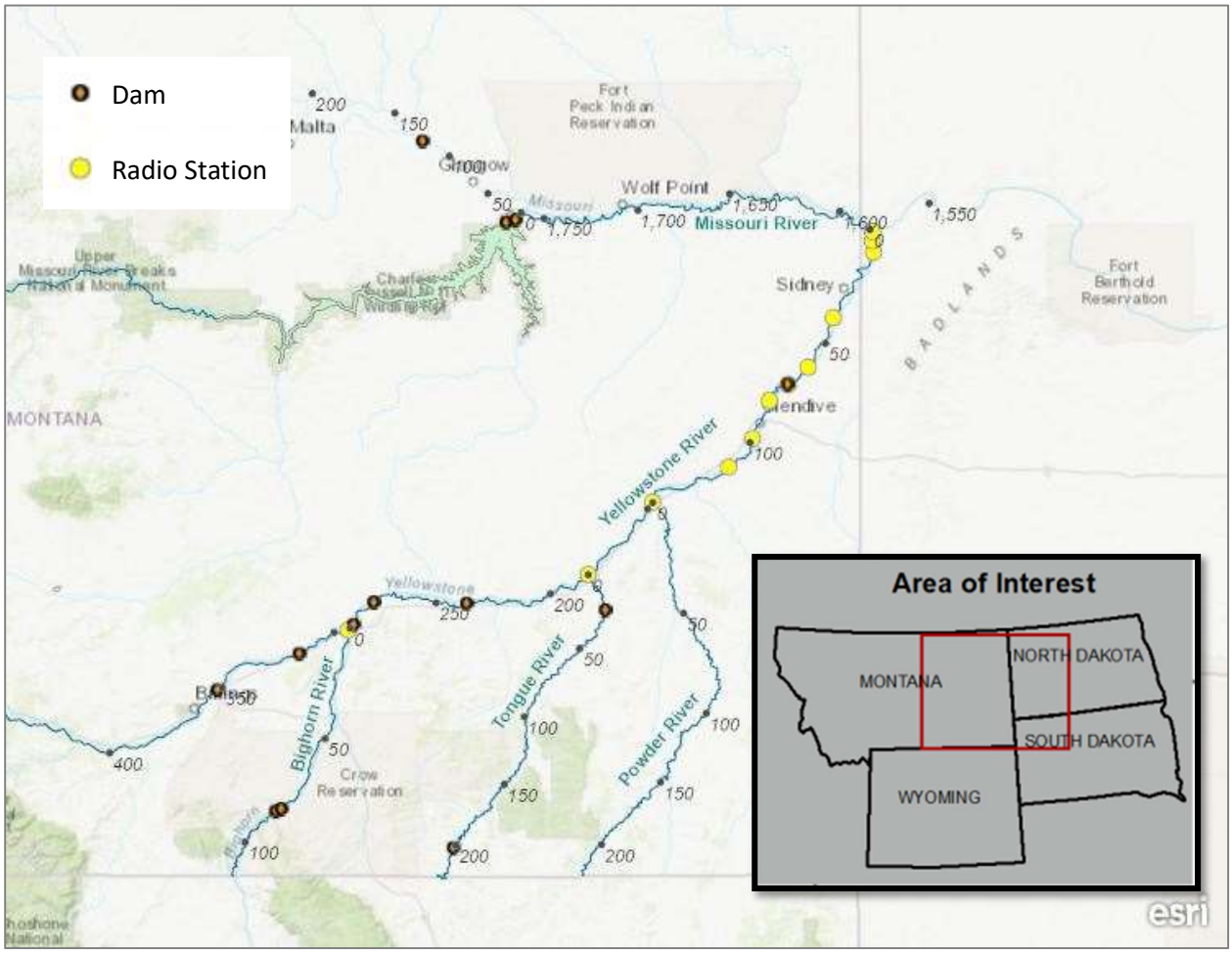

Figure 1. Map of Yellowstone River and major tributaries with river mile markers. Dams and 2020 radio-station receivers are plotted.

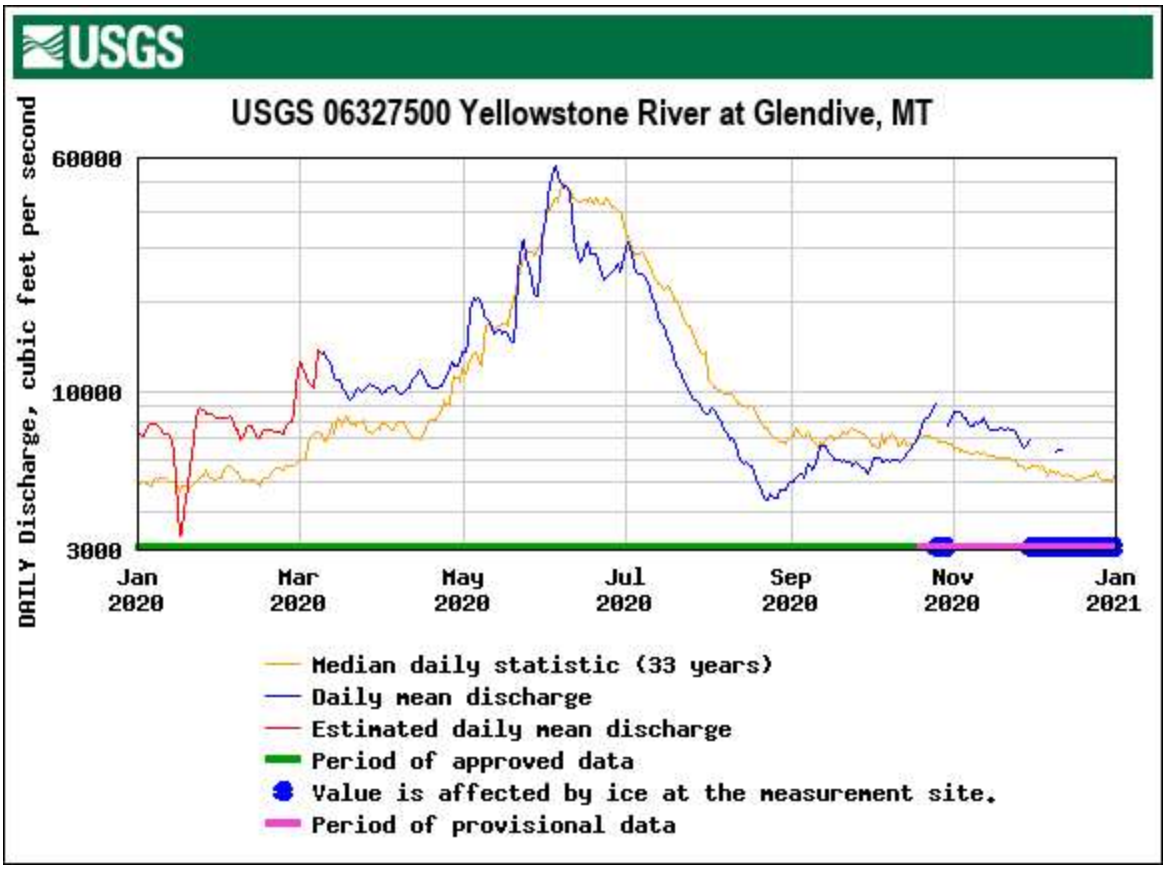

Figure 2. Yellowstone River (YSR) hydrograph of mean daily discharge (cubic feet per second, cfs) in 2020 (red and blue lines) and historic median daily discharge (cfs, orange line) at Glendive, MT, USGS stream-gauging station (Gauge No. 06327500; YSR RM 92).

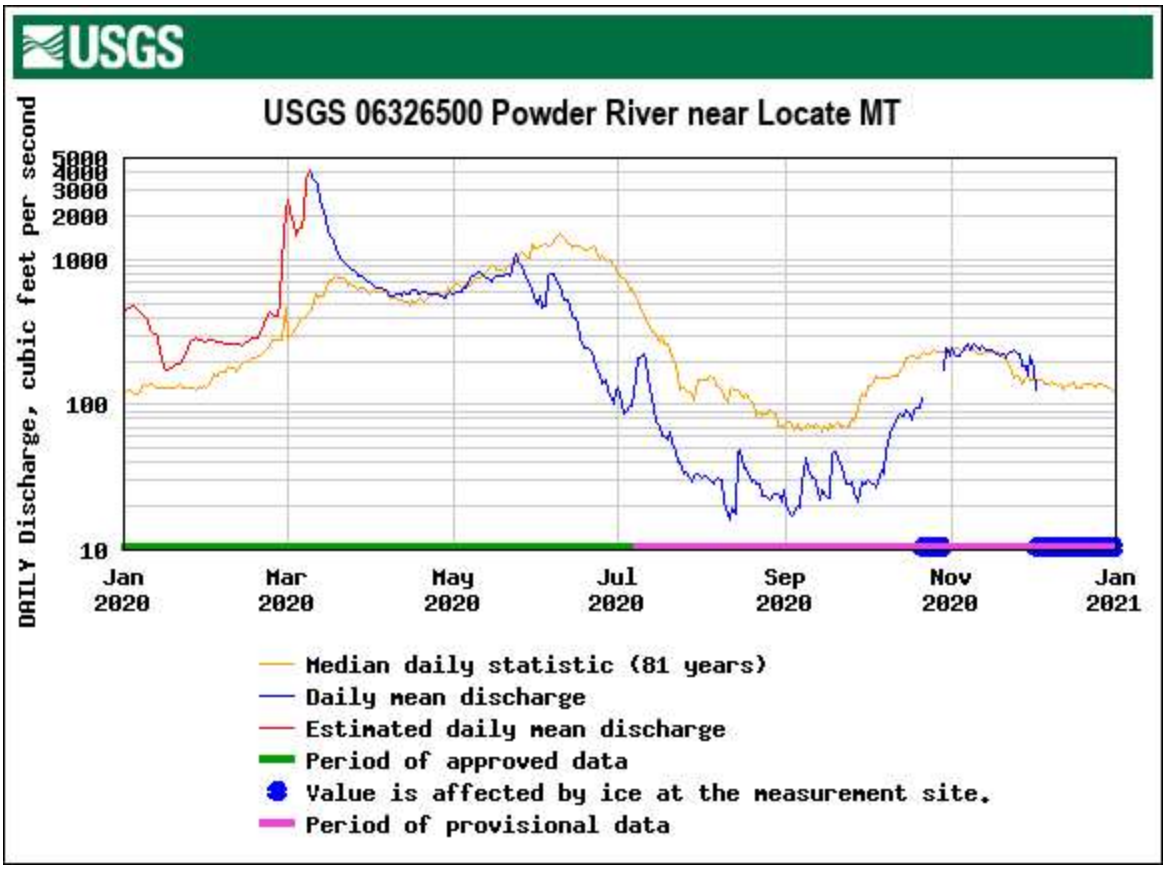

Figure 3. Powder River (PDR) hydrograph of mean daily discharge (cubic feet per second, cfs) in 2020 (red and blue lines) and historic median daily discharge (cfs, orange line) at Locate, MT, USGS stream-gauging station (Gauge No. 06326500; PDR RM 31).

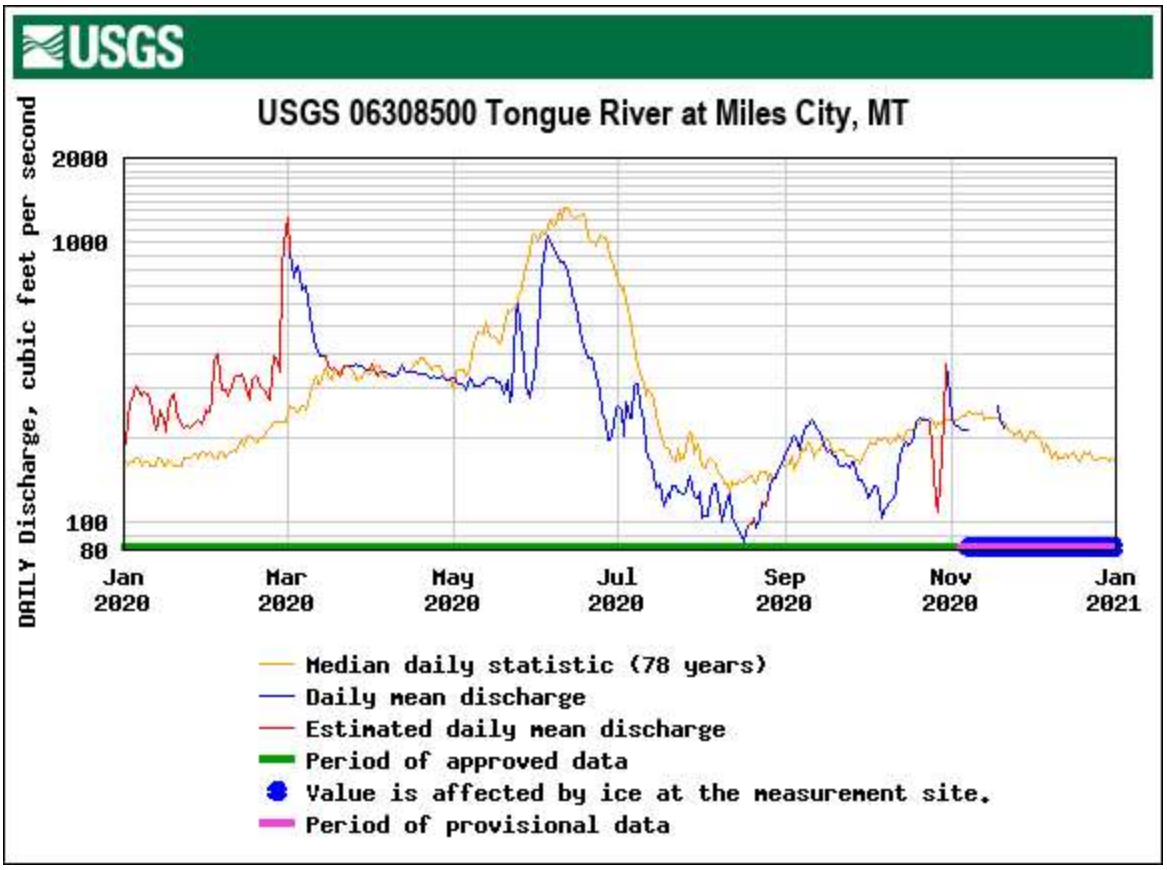

Figure 4. Tongue River (TNG) hydrograph of mean daily discharge (cubic feet per second, cfs) in 2020 (red and blue lines) and historic median daily discharge (cfs, orange line) at Miles City, MT, USGS stream-gauging station (Gauge No. 06308500; TNG RM 2).

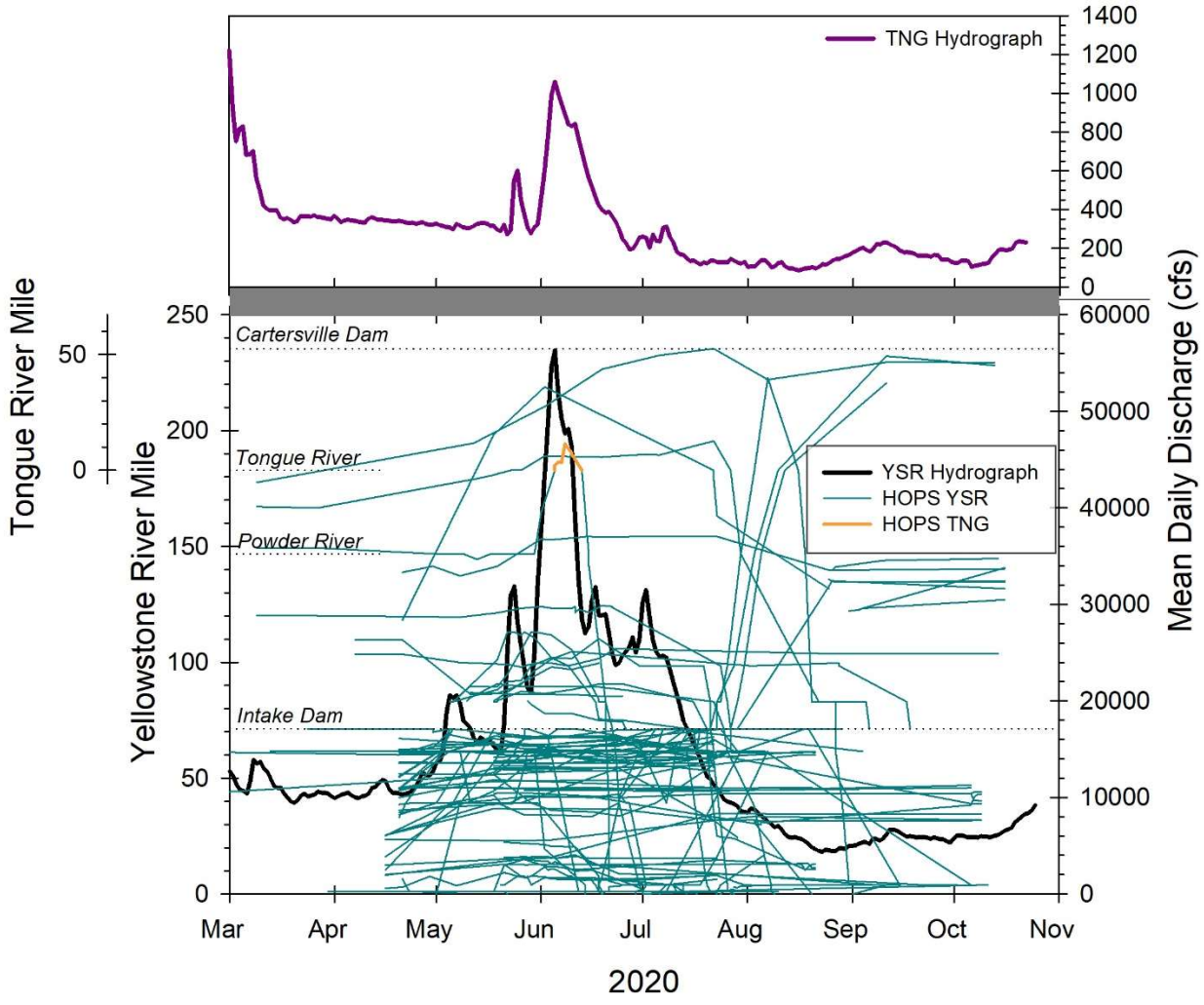

Figure 5. Hatchery-origin Pallid Sturgeon (HOPS) movements in the Yellowstone (YSR, teal lines) and Tongue (TNG, orange line) rivers superimposed on the mean daily discharge (cubic feet per second, cfs) of the YSR at Glendive, MT, (black line) during 2020. Mean daily discharge (cfs) of the TNG at Miles City, MT, (purple line) is shown at top. Various YSR landmarks are posted at their respective river miles.

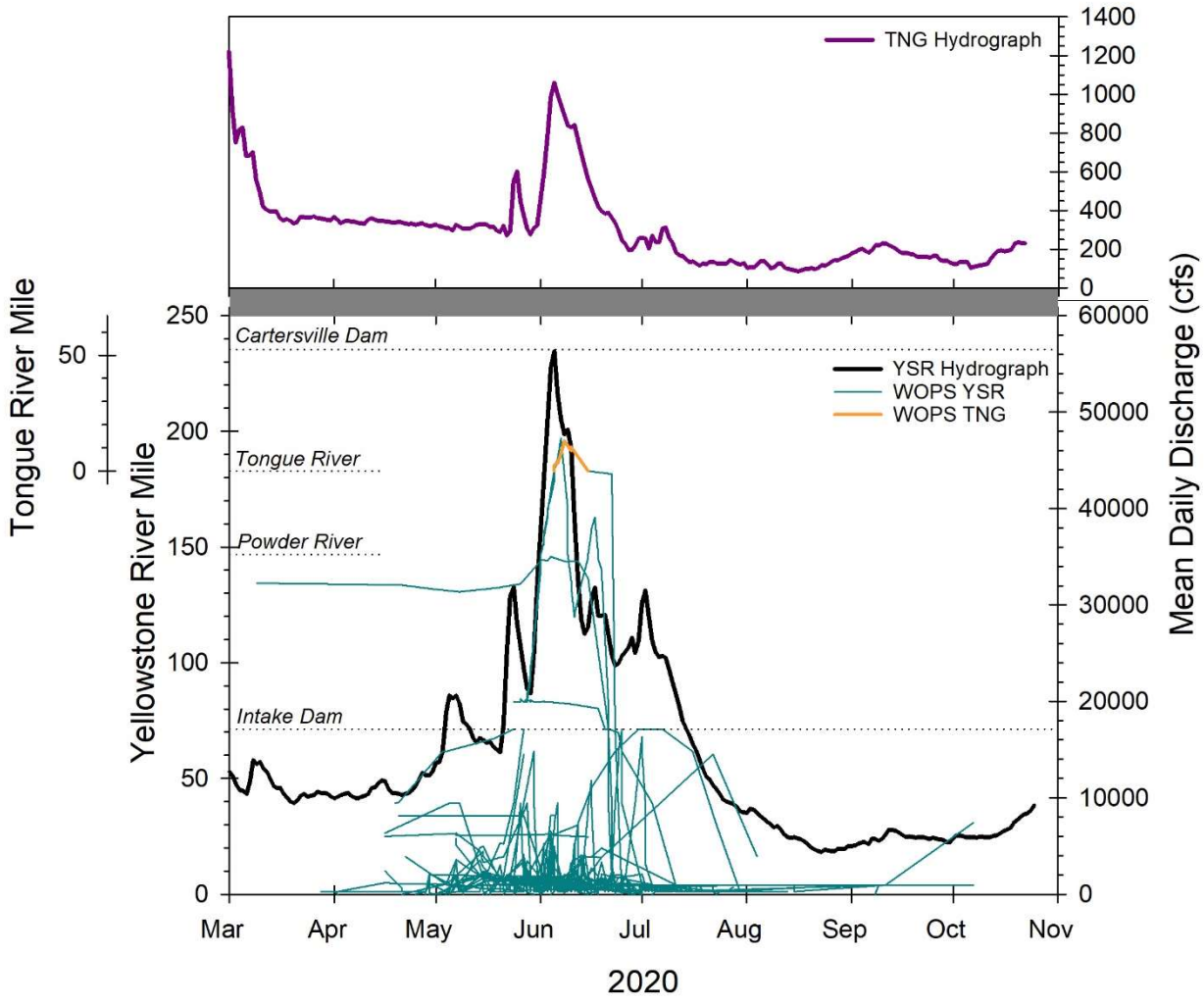

Figure 6. Wild-origin Pallid Sturgeon (WOPS) movements in the Yellowstone (YSR, teal lines) and Tongue (TNG, orange line) rivers superimposed on the mean daily discharge (cubic feet per second, cfs) of the YSR at Glendive, MT, (black line) during 2020. Mean daily discharge (cfs) of the TNG at Miles City, MT, (purple line) is shown at top. Various YSR landmarks are posted at their respective river miles.

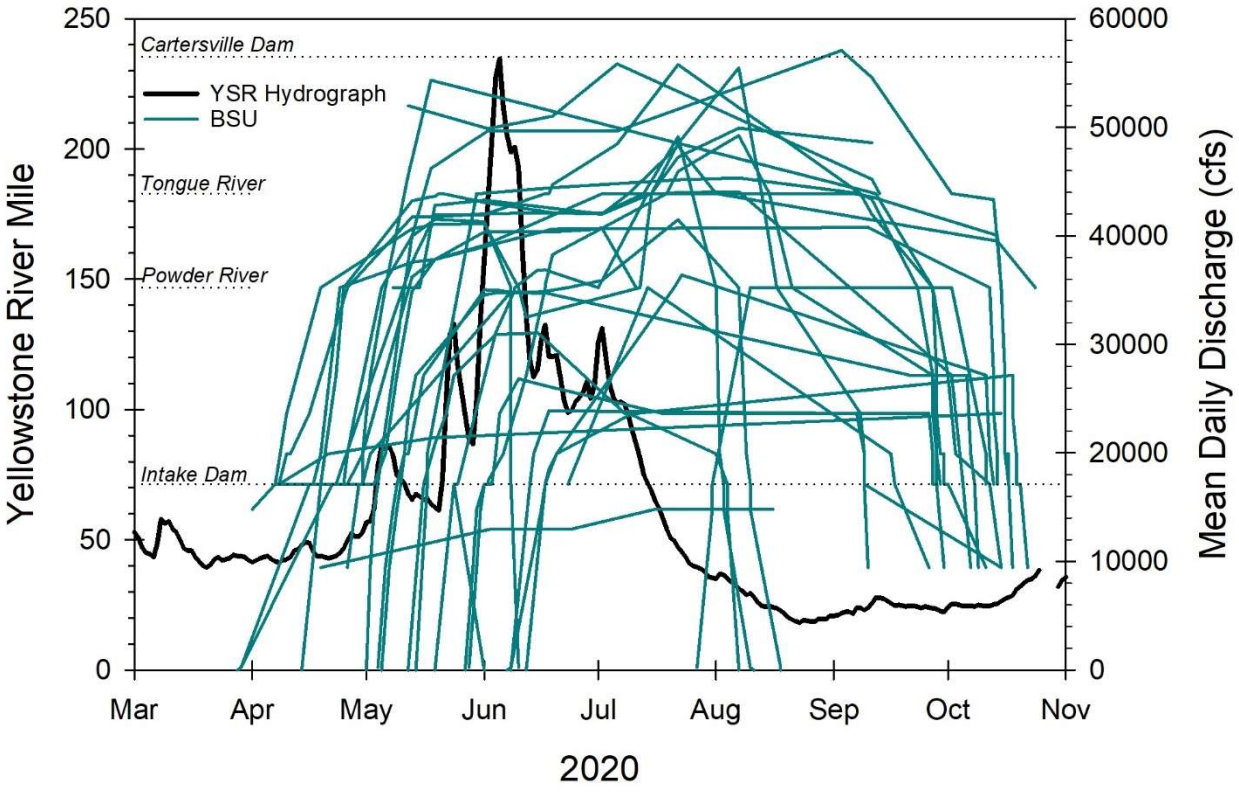

Figure 7. Blue Sucker movements (B SU, teal lines) in the Yellowstone River (YSR) superimposed on the mean daily discharge (cubic feet per second, cfs) of the YSR at Glendive, MT, (black line) during 2020. Various YSR landmarks are posted at their respective river miles.

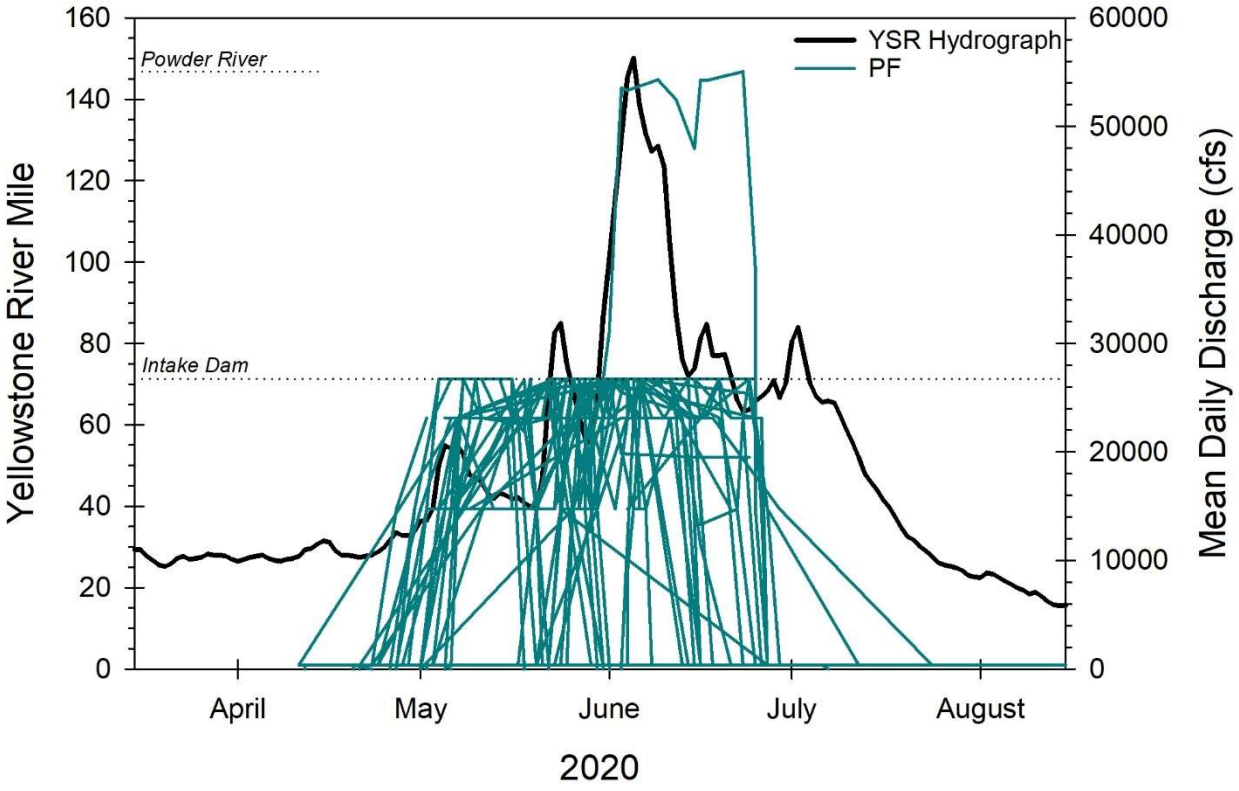

Figure 8. Paddlefish movements (PF, teal lines) in the Yellowstone River (YSR) superimposed on the mean daily discharge (cubic feet per second, cfs) of the YSR at Glendive, MT, (black line) during 2020. Various YSR landmarks are posted at their respective river miles.

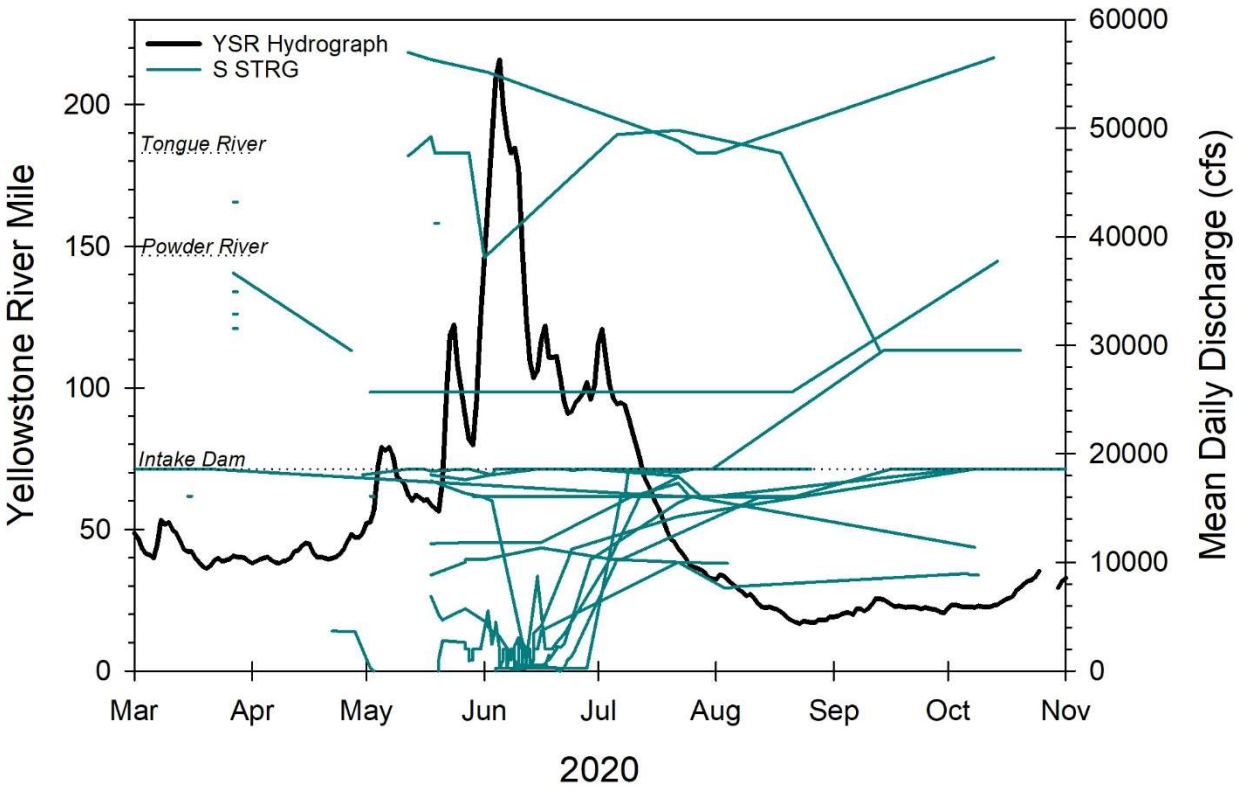

Figure 9. Shovelnose Sturgeon movements (S STRG, teal lines) in the Yellowstone River (YSR) superimposed on the mean daily discharge (cubic feet per second, cfs) of the YSR at Glendive, MT, (black line) during 2020. Various YSR landmarks are posted at their respective river miles.