

Original Research Paper

Paddlefish movement and dam passage in the Ohio and Kanawha Rivers, West Virginia

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Abstract: The Paddlefish (*Polyodon spathula*), a large-bodied and highly migratory species of large river systems, has experienced population declines or extirpation in parts of its native range. As an effort to reestablish a Paddlefish population in the Ohio River of West Virginia, the West Virginia Division of Natural Resources has stocked fingerling Paddlefish in the previous two decades. Post-stocking studies could assess the status of the reintroduced population, which includes collecting information on their seasonal movements and dam passage frequency through navigation dams of the Ohio and Kanawha Rivers. Using acoustic telemetry techniques, we monitored seasonal movements and assessed dam passage of five Paddlefish in the Robert C. Byrd Pool of the Ohio and Kanawha rivers. Paddlefish were highly mobile with two individuals using the entire R.C. Byrd Pool during the 11-month study period. Most movements occurred during the expected spawning period of April and May, where all individuals frequented the upper section of the pool in the Kanawha River. Downstream passage was documented for one individual at the R.C. Byrd lock during July 2023, but no evidence of upstream passage was documented for the locks at Racine (Ohio River) or Winfield (Kanawha River). Tagging of additional Paddlefish would be beneficial to increase sample size for future assessments and continue efforts toward the long-term conservation and management of Ohio River Paddlefish.

Keywords: Paddlefish, Dam passage, Movement ecology, Large river.

Introduction

Paddlefish (*Polyodon spathula*), a large-bodied and highly migratory species of large river systems, has experienced population declines or extirpation in parts of its range (Jennings and Zigler 2009, Bettoli et al. 2009). Poor water quality conditions may have contributed to Paddlefish population declines (Jennings and Zigler 2000), as large river systems in the Paddlefish's native range have a long history of degradation (Pearson and Krumholz 1984, Turner

and Rabalais 2003). Additionally, population declines may be attributed to restrictions on migratory movements and access to suitable spawning habitats owing to dams constructed for flood control and navigation beginning in the early 1900s (Firehammer et al. 2006, Firehammer and Scarnechia 2007, Gerken and Paukert 2009, Gary et al. 2023). In most rivers with historical or current Paddlefish populations, environmental laws post-1970 have led to improved water quality (NRC 2008, Keiser and Shapiro 2019), but the presence of dams

continue to present passage issues for Paddlefish.

To address localized population declines, some state agencies have stocked Paddlefish to supplement or restore populations (Argent et al. 2009, Grady and Elkington 2009, Argent et al. 2016, Hoover et al. 2019). As an effort to reestablish Paddlefish populations in the Ohio River of West Virginia, the West Virginia Division of Natural Resources (WVDNR) stocked approximately 50,000 fingerling Paddlefish in several Ohio and Kanawha river pools from 1999–2014. Post-stocking studies could provide information on the success of this reintroduction by increasing our understanding of (1) seasonal and spawning movements and (2) the frequency of passage through navigation dams of the Ohio River. Commercial and recreational harvest of Paddlefish occurs in parts of the species range (Devine et al. 2020), but fishing regulations prohibit harvest of Paddlefish for the Ohio River and associated tributaries within West Virginia.

The work reported herein is specifically focused on the movements of Paddlefish in the R.C. Byrd Pool of the Ohio and Kanawha rivers of West Virginia. Study objectives were to (1) monitor and quantify seasonal movements of tagged Paddlefish, and (2) determine if dam passage occurs using telemetry techniques.

Materials and Methods

Study area

The study was conducted within the R.C. Byrd Pool and associated tributaries of the Ohio and Kanawha rivers in West Virginia. The pool (approximately 5100 ha) extends 55.8 km along the Ohio River from mile marker 237.5 at the R.C. Byrd Locks and Dam to mile marker 279.2 at the Racine Locks and Dam (ORSANCO 2020). Upper and lower Ohio River sections of the R.C. Byrd Pool are designated as upstream and downstream of the Kanawha River confluence, respectively. The R.C. Byrd Pool also includes a 49.9 km section of the Kanawha River from its mouth upstream to the Winfield Locks and Dam.

Fish sampling

Paddlefish were collected with floating gillnets from the mouth of Raccoon Creek, an Ohio tributary of the R.C. Byrd Pool of the Ohio River during fall 2022 (Figure 1). Gillnets were 45.7 m (150 ft)

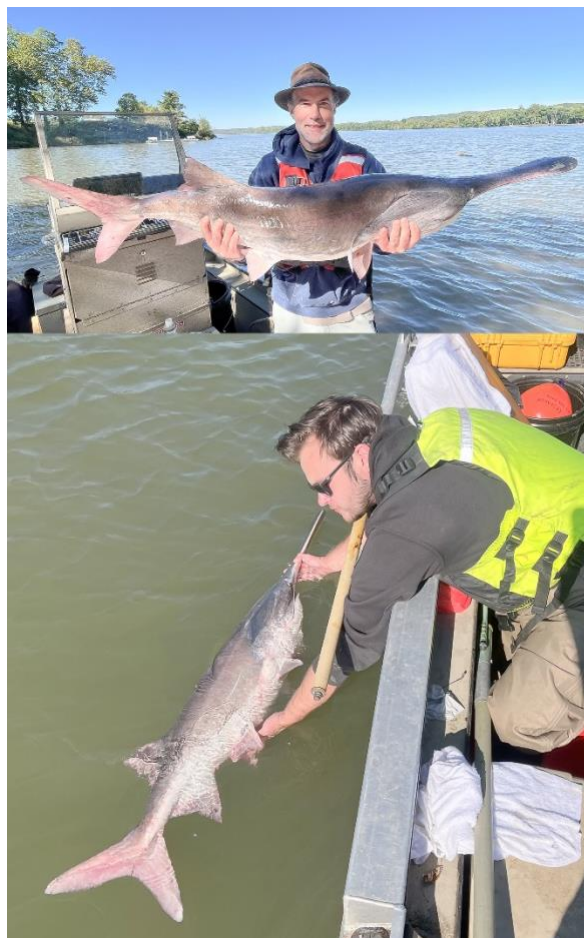


Figure 1. Paddlefish (*Polyodon spathula*) collected, tagged, and released at the mouth of Raccoon Creek of Robert C. Byrd Pool, Ohio River. Photo credits: Andrew Peters (top), Stuart Welsh (bottom).

long x 7.3 m (24 ft) deep with 12.7 cm (5 in) square mesh of 8-Ply monofilament netting. Gillnets were fished for one to two hours to avoid gear-induced or post-tagging mortality. Paddlefish were anesthetized, and surgically implanted with ultrasonic transmitters (Vemco V16-6x-A69-9001) using methods described in Tripp et al. (2019). Fish length was measured from the eye to the caudal fin fork (eye-to-fork length, EFL) in millimeters. The sex of the fish was not determined.

Telemetry data collection

Movements and dam passage of tagged Paddlefish were monitored within the R.C. Byrd Pool using an array of stationary receivers (Vemco VR2W and VR2T, Figure 2). The receivers are owned and managed by USFWS and WVDNR and deployed for additional ongoing telemetry projects. Multiple

receivers are located at both R.C. Byrd and Racine Locks and Dams on the Ohio River, but none are located at the Winfield Lock and Dam on the Kanawha River. Data were downloaded by USFWS and WVDNR and shared with the authors. For this study, receiver data were provided from October 2022 to August 2023 with a few additional records from receivers at Raccoon Creek and R.C. Byrd Dam from September and October of 2023.

Data analysis

Movements were determined based on the distance moved between stationary receivers in one 24-hr period (km/day). For example, if receivers A and B were 10 km apart, and a tagged fish was recorded on receivers A and B on consecutive days, then the movement rate would be recorded as 10 km/day. The number of consecutive days, i.e. length of stay or residence time, that a tagged fish was recorded by a receiver was also determined. Movements likely occurred beyond the detection range of the stationary receiver arrays, and thus we considered the receiver data to represent “minimal” movements.

Results

During fall 2022, five Paddlefish were collected and implanted with transmitters at the mouth of Raccoon Creek. Collection date, tag number, and EFL are as follows: 3 Oct 2022, tag 4680, length 1041 mm; 3 Oct 2022, 4672, 978 mm; 4 Oct 2022, 4681, 991 mm; 4 Oct 2022, 4671, 870 mm; 4 Nov 2022, 4678, 1029 mm. All five Paddlefish survived capture and surgical procedures. The array of receivers within R.C. Byrd pool was effective for monitoring movement patterns of Paddlefish, although three fish (4672, 4678, and 4680) went undetected when passing by the receiver at Arbuckle. Paddlefish movements differed seasonally, where reduced movements occurred during colder months. No movements were observed during February. Movement rates were highest during April and May (Figure 3).

Two of the five tagged Paddlefish (fish 4672 and 4678) used the entire R.C. Byrd Pool during the 11-month study period (Figure 4). Fish 4671, 4680, and 4681 used sections of the Ohio River between R.C. Byrd Dam and Point Pleasant, and the Kanawha River section from the mouth upstream to Winfield, WV, but they did not use the Ohio River upstream of

Point Pleasant (Figure 4). Fish 4671 traveled to the

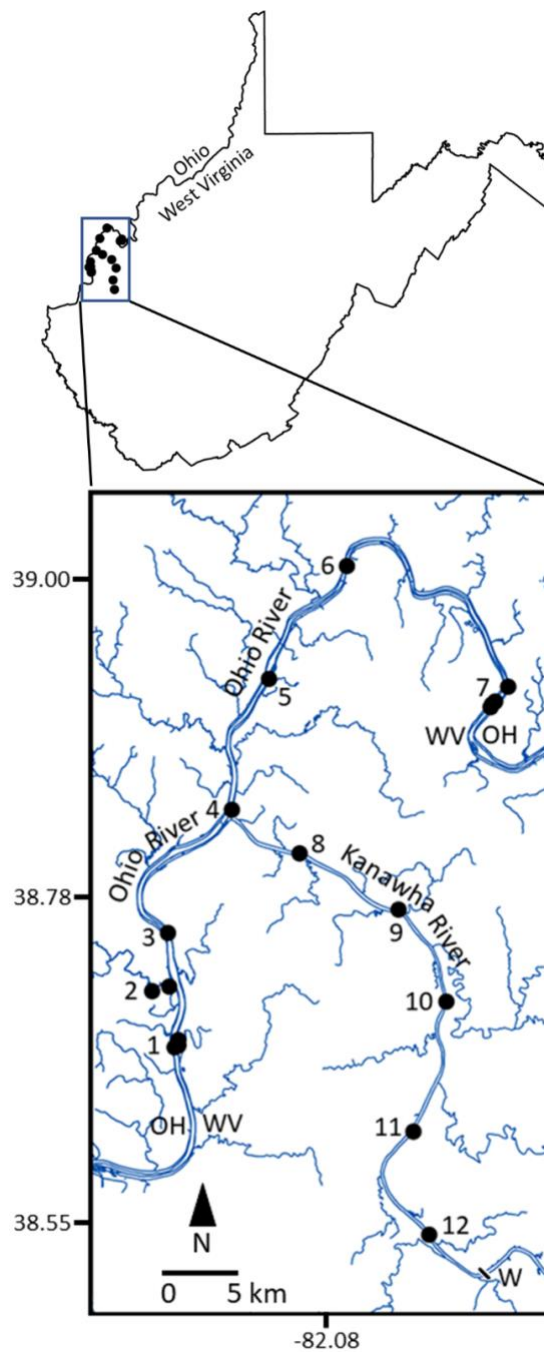


Figure 2. Locations of stationary receivers in the R.C. Byrd Pool of the Ohio and Kanawha rivers. Receiver locations (Ohio River) include: (1) R.C. Byrd Dam, (2) Raccoon Creek (n=2), (3) Gallipolis Ferry, (4) Point Pleasant, (5) Eightmile Island, (6) Mason Bridge, and (7) Racine Dam (n=4). Receiver locations (Kanawha River) include: (8) Ambrosia, (9) Tenmile Creek, (10) Arbuckle, (11) Grimms Landing, and (12) Winfield. W = location of the

Winfield Locks and Dam on Kanawha River. West Virginia = WV, Ohio = OH.

upper Kanawha River section during March-May, spending most of its time moving back and forth between the Grimms Landing and Winfield receivers. From late May through late July, fish 4671 resided in the lower Kanawha River between Point Pleasant and Arbuckle. Fish 4672 moved upstream on the Ohio River reaching the Racine Dam on 2 April 2023, and then moved at a rate of 89 km/day to

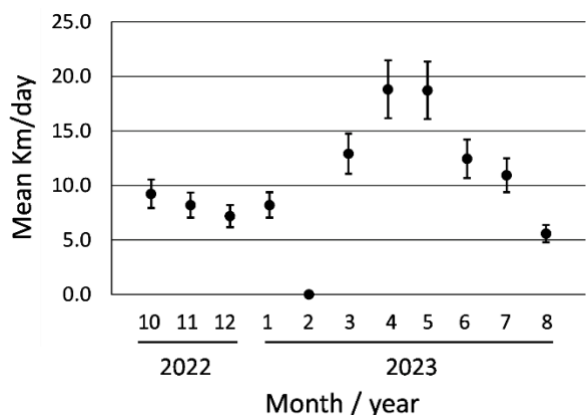


Figure 3. Movements of five tagged Paddlefish in the Robert C. Byrd Pool of the Ohio and Kanawha rivers analyzed as mean kilometers per day \pm standard error for each month. The period of data collection runs from October 2022 to August 2023. No movements were observed during February 2023.

reach the Winfield receiver on the Kanawha River on 3 April 2023, which was the fastest rate of movement recorded during this study. Fish 4672 moved back and forth between the Kanawha and upper Ohio River sections of R.C. Byrd Pool during April and May, exhibiting the most movements of all study fish. Average movement rates for fish 4671, 4672, 4678, 4680, and 4681 were 9.3, 22.1, 19.6, 15.3, and 10.5 km/day, respectively. Fish 4672 primarily resided in the lower Ohio River section during June 2023. Fish 4678 moved upstream during spring, reaching the Mason Bridge receiver on Ohio River by 30 March 2023, and then moved up the Kanawha River to Winfield by 19 April 2023. Fish 4678 subsequently went back to the upper Ohio River section reaching the Racine Dam by 24 April 2023, but subsequently moved downstream to the lower section of the Ohio River in mid-May, before passing downstream through the R.C. Byrd Lock and Dam on

3 July 2023. Fish 4680 moved upstream during spring reaching the Winfield receiver by 29 March 2023, where it remained in the upper study area of the Kanawha River through late May before returning to the lower study section of the Ohio River during June and August. Fish 4681 was primarily in the lower Kanawha River section during October-November 2022, but it moved upstream to the Grimms Landing and Winfield areas during late March-May of 2023. Fish 4681 was primarily in the lower Ohio River section of R.C. Byrd Pool during June, but it spent most of its time in the lower Kanawha River section during July 2023. This fish returned to the lower Ohio River section of the pool in October 2023.

The time of residence of tagged Paddlefish differed among receiver locations (Figure 4, Table 1). Extended stays at a receiver were not the normal behavior for Paddlefish, as only 12% of stays exceeded 10 days, and 60% and 78% of stays were for <3 days or <6 days, respectively. The highest

Table 1. Residence time (days) for five Paddlefish (*Polyodon spathula*) at 12 receiver locations in the Robert C. Byrd pool of Ohio and Kanawha rivers. Residence time is defined as the consecutive number of days in the vicinity of each stationary receiver. Min and Max are the minimum and maximum number of days at a receiver location.

Site	Mean	Min	Max
Ambrosia	4.27	1	24
Arbuckle	2.83	1	8
Eightmile Island	1.62	1	3
Gallipolis Ferry	28.11	1	162
Grimms Landing	3.83	1	18
Mason Bridge	3.50	1	9
Pt. Pleasant	1.37	1	3
Raccoon Creek	2.40	1	5
Racine Dam	5.40	1	17
R.C. Byrd Dam	1.50	1	3
Tenmile Creek	10.54	1	107
Winfield	3.82	1	22

mean residence time (mean = 28 days) occurred for tagged Paddlefish in the vicinity of Gallipolis Ferry, a value influenced by three extended stays immediately following tag and release dates by fish 4672, 4678, and 4680 of 162, 145, and 158 days, respectively. However, fish 4672, 4678, 4680, and

4681 also had moderately long stays at this location of 45, 46, 36, and 28 days, respectively, during late spring and early summer. Two tagged Paddlefish (4671 and 4681) had extended stays in the vicinity of the Tenmile Creek receiver of the Kanawha River. Fish 4671 relocated to Tenmile Creek four days following its tag and release date and stayed at this site for 93 days. Fish 4671 also stayed at the Tenmile Creek location for 49 days following its arrival at this site on 11 January 2023. Fish 4681 stayed 107 days at the Tenmile Creek location following its arrival at this site on 13 December 2022.

Four of the five tagged Paddlefish approached a lock and dam on the Ohio River on 11 occasions, usually staying less than one day, and only a single instance of dam passage was observed. Fish 4671 did not approach a lock and dam during the study period. Fish 4672 was at the Racine Locks and Dam on 2 April 2023 (1 day), 30 April 2023 (7 days), and 13 May 2023 (1 day), and it approached the R.C Byrd Locks and Dam on 7 June 2023 (1 day) and 6 October 2023 (1 day). Fish 4678 arrived at the Racine Dam on 24 April 2023 and stayed for 17 days, and it returned on 14 May 2023 for one day. Subsequently,

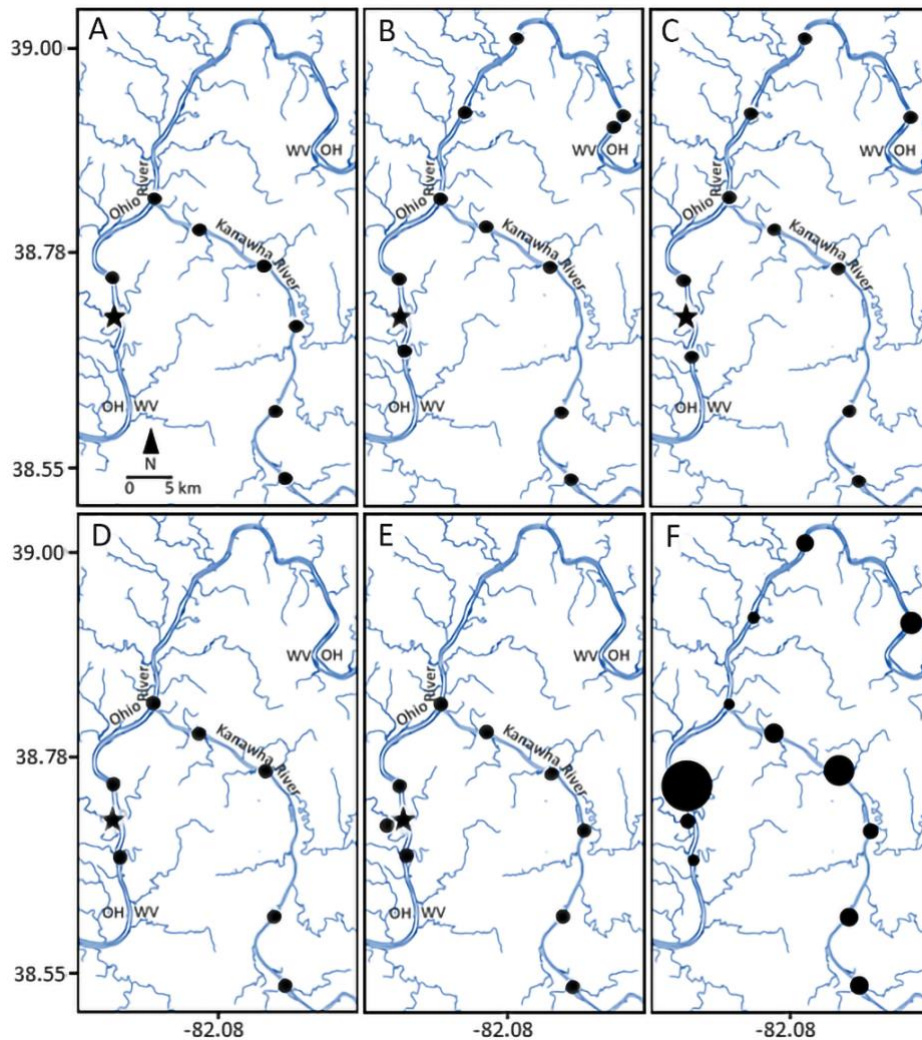


Figure 4. Stationary receiver locations with detections of Paddlefish tags 4671, 4672, 4678, 4680, and 4681 (A-E, respectively) from October 2022-August 2023. A star represents the tag and release location at the mouth of Raccoon Creek. Bubble plot (F) of residence time for five Paddlefish (i.e., mean value of the consecutive number of days in vicinity of each stationary receiver). Bubble size is proportional with the largest bubbles representing mean values of 28 and 11 days for Gallipolis Ferry and Tenmile Creek sites, respectively, and the smallest size plotted for 1 day.

this tagged Paddlefish was recorded on two receivers at the R.C. Byrd Dam, suggesting that this fish may have passed through the lock and entered the Greenup pool. The first recovery was recorded on 3 July 2023 at the upstream side of the dam, where the tag pinged a total of five times. On the same date, the tag pinged a total of 36 times on a receiver from the downstream side. Fish 4680 was recorded at the R.C. Byrd Locks and Dam on 8 June 2023 for a single day, and subsequently at the same lock on 26 August 2023. Fish 4681 pinged at the R.C. Byrd Dam on 8 October 2023.

Discussion

The five tagged Paddlefish were highly mobile within the R.C. Byrd pool of the Ohio and Kanawha rivers during the 2022-2023 study period. As expected, the highest rates of movement during this study occurred during the months of April and May, a spring period consistent with spawning-associated movements (Zigler et al. 2003, Firehammer and Scarnecchia 2006). Individual variations in movement patterns were observed, where all five fish moved upstream in the Kanawha River during the expected spawning months, but only two of the tagged Paddlefish explored the Ohio River upstream of the confluence with the Kanawha River. This study, which used an array of stationary receivers, was not designed to determine a spawning location or if spawning occurred, but the movement patterns observed during spring are consistent with migratory spawning behavior.

Evidence suggests dam passage occurred for only one of the five tagged Paddlefish, and passage was downstream at the R.C. Byrd Lock and Dam. Based on the propensity for Paddlefish to move upstream for spawning during spring, upstream passage was anticipated at the Racine and Winfield dams. Upstream passage was expected to occur during lockage of recreational or commercial vessels, as reported by Turney et al. (2022). Only two of the five Paddlefish approached the Racine Dam and no passage occurred. Receivers were not placed at the Winfield Dam on the Kanawha River, but all fish located in the Winfield area downstream of the dam were later relocated at sites further downstream, so it is likely that no tagged fish passed the Winfield Dam. In a study of 71 tagged Paddlefish in the upper Mississippi River drainage, Zigler et al. (2004)

reported 53 dam passage events (20 upstream and 33 downstream) where 71% occurred during spring and 29% occurred during summer and fall. In a study on the Alabama River, Simcox et al. (2015) reported a low rate (8%) of upstream passage through locks. Downstream passage may be an easier route as the fish does not have to navigate the timing of lock operations. It is unknown if the single downstream passage reported herein was through the lock or through the gate, but based on receiver locations, the fish was inside the lock chamber prior to passage.

Residence time of tagged individuals, as determined by the number of consecutive days in the vicinity of a receiver, was mostly less than three days in the R.C. Byrd Pool, reflecting the highly mobile nature of Paddlefish in large river systems. Long periods of residence time (93-162 days) in the vicinity of Gallipolis Ferry and Tenmile Creek were observed shortly after fish were tagged and released, likely an artifact of recovery time following surgery. Paddlefish in the areas of Gallipolis Ferry and Tenmile Creek, however, also exhibited relatively long residence times (28-107 days) during other periods of the study. Paddlefish are filter feeders (Kuhajda 2014) with embedded sensory cells in their long rostrums which aid in locating concentrations of plankton (Wilkins and Hoffman 2007). Locations where fish experienced long residence times may reflect important feeding areas or could also represent staging or overwintering areas. Low mean residence times (< 3 days) for sites at Arbuckle, Eightmile Island, Point Pleasant, Raccoon Creek, and R.C. Byrd Dam indicate lower use of these sites by Paddlefish in the R.C. Byrd Pool, which could suggest less ideal riverine conditions, or may just be an artifact of individual variation.

The low sample size of tagged Paddlefish in this study (n=5) is a recognized concern for strong inference, but it does provide a baseline of information for future studies. We also acknowledge that the addition of age and sex information for tagged Paddlefish would have contributed to our understanding and interpretation of movement data. Inference from the current assessment supports the highly mobile nature of Paddlefish, indicating that the entire R.C. Byrd Pool is utilized throughout the year. The Kanawha River section of the pool was used extensively during the spring spawning period, and further assessment of passage is warranted for

Winfield Locks and Dam. Additional recovery information from the tagged Paddlefish during 2024 and 2025 will provide further insights on movement patterns within R.C. Byrd Pool. Tagging of additional fish would be beneficial to increase sample size for future assessments, and as an additional effort toward the long-term conservation and management of Ohio River Paddlefish.

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