Platte River Recovery Implementation Program

Pallid Sturgeon Biology in the Platte River and its Tributaries
Annual Progress Report
(Year 1: 2021 – 2022)

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INTRODUCTION

Pallid Sturgeon *Scaphirhynchus albus* were first described as a distinct species by Forbes and Richardson (1905). Prior to being listed as federally endangered in 1990 (USFWS 1990), Pallid Sturgeon were already believed to be uncommon within its range of the Missouri and Mississippi rivers and other major tributaries such as the Platte, Yellowstone, and Kansas rivers (Bailey and Cross 1954; Kallemeyn 1983). These rivers were historically characterized as large, swift, turbid, braided, and free flowing (Bailey and Cross 1954; Dryer and Sandvol 1993; Peters and Parham 2008). Today, habitat alterations to these rivers such as channelization and impoundments have been suggested as major contributors to the decline of Pallid Sturgeon as contemporary conditions no longer align with the life-history needs of the species (Kallemeyn 1983; Dryer and Sandvol 1993).

Life History Overview

Pallid Sturgeon are broadcast spawners whereby eggs are deposited onto substrates where they remain in place until hatching (Chojnacki et al. 2020). Once the eggs hatch, larval sturgeon enter the water column and drift downstream with the river current up to 12-13 days (Kynard et al. 2002; Fuller et al 2008). Drift distance ranges from 245 km to 530 km and is dependent on channel configuration and river discharge (Braaten et al. 2008). Specific habitats needed for the larval stages are not entirely known. However, Phelps et al. (2010) found that 85% of age-0 Pallid Sturgeon and Shovelnose Sturgeon *S. platorynchus* were occupying island side channels and main channel dike borders that had sandy substrate, slower bottom velocities, and moderate depths ranging from 2 to 5 m in the middle Mississippi River. Larval sturgeon primarily prey upon macroinvertebrates such as ephemeropterans and chironomids (Braaten et al. 2007; Sechler et al. 2012; Gosh et al. 2019). Similarly, Harrison et al. (2014) noted that prey items consisted of burrowers found in sandy substrates, suggesting this may be an important prey source for sturgeons to seek once feeding exogenously.

Pallid Sturgeon transition to the juvenile life-stage at about 200-mm fork length (Peters and Parham 2008). Juvenile Pallid Sturgeon initially prey upon benthic macroinvertebrates (Wanner et al. 2007) but shift to a piscivorous diet at a length of about 500-mm fork length (French et al. 2013). The predominant fish species consumed by Pallid Sturgeon include native cyprinids such as Sturgeon Chub *Macrhybopsis gelida* and Sicklefin Chub *M. meeki* (Gerrity et al. 2006).

Female Pallid Sturgeon reach sexual maturity at ages ranging from 9-12 years; whereas males reach maturity at 5-7 years (Keelyne and Jenkins 1993). Pallid Sturgeon generally spawn once every two to four years upon reaching sexual maturity (Bramblett and White 2001; Tripp et al. 2009). Spawning behavior may include individual Pallid Sturgeon moving in excess of 100 km during early spring (Fuller et al. 2008; DeLonay et al. 2009). Daily movements can be greater than 20 km/d (Bramblett and White 2001). Fuller et al. (2008) observed that Pallid Sturgeon movement may be associated with river discharge events in the spring. The current state of knowledge regarding Pallid Sturgeon spawning site selection indicates they use hard substrates, such as bank revetment or bedrock rather than softer substrates like sand (Delonay et al. 2015; Elliot et al. 2020). However, much of this information is limited to large, mainstem rivers.

Current recovery efforts for Pallid Sturgeon in the Missouri River basin have largely focused on the mainstem and typically included population dynamics assessment (e.g., population estimates, movement, survival, etc.), habitat modification (e.g., creating interception and rearing zones), and propagation (e.g., stocking hatchery reared individuals). There are substantial gaps in knowledge regarding Pallid Sturgeon use of tributaries to the mainstem Missouri River including how and when Pallid Sturgeon use these tributaries, what initiates their use (e.g., environmental cues), and is successful spawning occurring. These knowledge gaps are the impetus for this project.

Pallid Sturgeon Biology in the Platte River and Its Tributaries Project

The Pallid Sturgeon Biology in the Platte River and its Tributaries project was initiated on July 1, 2021 as part of the Platte River Recovery Implementation Program's (PRRIP) ESA compliance contributions related to the federally endangered Pallid Sturgeon in the lower portion of the Platte River, Nebraska. This 5-year study is intended to provide information pertaining to known knowledge gaps about environmental correlates of Pallid Sturgeon use, spawning habitat, and reproduction and recruitment in the lower Platte River and its tributaries. The specific objectives are to:

1. Identify relations among environmental conditions (i.e., river discharge and temperature) with the timing and extent of Pallid Sturgeon movement into and within the lower Platte River and its tributaries.

2. Identify Pallid Sturgeon spawning habitat in the lower Platte River and its tributaries.

3. Verify successful spawning by Pallid Sturgeon in the Platte River and/or its tributaries.

4. Provide Pallid Sturgeon genetic samples for further population and hybridization assessment (in collaboration with Southern Illinois University's parallel project).

The information provided and data summarized in this report details work accomplished during the first year of the study, establishes baseline details for future years, and addresses adjustments to sampling protocols that occurred as we were met with logistical challenges in 2022 and also adjustments in future years. This report also summarizes methods and results for each objective to document progress on specific items.

STUDY AREA

The lower Platte River is a 160-km reach, starting at the confluence of the Loup River and the Platte River near Columbus, Nebraska. The Elkhorn River and Salt Creek are major tributaries of the lower Platte River before it flows into the Missouri River near Plattsmouth, Nebraska. This study aims to gather information on Pallid Sturgeon in the lower Platte River and its tributaries. The focal locations for collecting Pallid Sturgeon and habitat data include the lower Platte River from the Loup River confluence to the Platte River terminus with the Missouri River, the Elkhorn River, the Loup River, and Salt Creek (Figure 1).

GENERAL METHODS OVERVIEW

During the 2022 field season, Pallid Sturgeon collection focused on capturing adult and juvenile individuals for telemetry as well as sampling free embryos, larvae, and exogenous feeding age-0 Pallid Sturgeon to document spawning and recruitment. Telemetry data, including active and passive detections, as well as *in situ* and remote habitat data collection are aimed at informing Objective 1 and Objective 2. Ichthyoplankton net sets at the Platte River terminus as well as opportunistic surveys immediately downstream of suspected spawning adults are targeted to address Objective 3 and document presence of egg, larval, and/or juvenile Pallid Sturgeon. Tissue samples collected while completing Objectives 1 – 3 guide decisions regarding priority fish to actively track and to complete Objective 4 in coordination with Southern Illinois University at Carbondale. Additional procedural details are outlined in the Objective-Specific Methods and Results sections.

Cursory descriptions of water quality parameters where Pallid Sturgeon were collected versus locations where they were not collected were conducted for the first field season. Substantially more in-depth statistical analyses are ongoing and will be presented as additional data are collected and analyzed.

OBJECTIVE-SPECIFIC METHODS AND RESULTS

Objective 1: Identify relations among environmental conditions (i.e., river discharge and temperature) with the timing and extent of Pallid Sturgeon movement into and within the lower Platte River and its tributaries.

Methods

Pallid Sturgeon Collection for Telemetry: Collection of Pallid Sturgeon for telemetry tag implantation occurred during March – April and October – November, 2022. Collection efforts occurred from the Elkhorn River confluence with the Platte River downstream to the Missouri River (Figure 1). This reach historically produced the majority of Pallid Sturgeon catches in the Platte River (Hamel and Pegg, 2014). The intent was to maximize the number of Pallid Sturgeon captured during the narrow water temperature window that allows collection and handling of Pallid Sturgeon (< 18.3 °C for 24 hr set times; U.S. Fish and Wildlife Service 2019) during this first year of collection.

Fish collection methods followed established collection techniques used in the Platte River and the approved Pallid Sturgeon Handling Protocol (U.S. Fish and Wildlife Service 2019). Baited trotlines were used as the sole gear to collect individuals suitable for transmitter implantation as they have produced the greatest number of Pallid Sturgeon during previous sampling efforts in the Platte River (Peters and Parham 2008; Hamel and Pegg 2019). Trotlines were 32 m long with a 6 mm diameter nylon main line. Hooks were attached to the main line using a 30 cm line at 1.5 m intervals (N = 20 hooks/line). Circle hooks (Gamakatsu; size = 5/0) were used and baited with nightcrawlers *Lumbricus terrestris* for all trotline sets. The sets were allowed to fish overnight with a maximum set time of 24 hours when water temperatures remained below 18°C. Start and stop times, georeferenced location (e.g., latitude and longitude coordinates), and habitat variables for each trotline set were recorded at the time trotlines were set. Specific habitat measures are described below.

Relative abundance is often used as an index of true abundance. This index is typically reported as catch per unit effort (CPUE) and defined as:

$$\text{CPUE} = qN,$$

where CPUE is the number of fish caught per unit effort, q is the catchability coefficient (i.e., probability of catching an individual fish in one unit of effort), and N is true abundance of a fish stock or population (Hubert and Fabrizio 2007). The principle assumption with using relative abundance is that the number of fish caught is proportional to effort used to capture the fish and is directly tied to specific requirements related to fish density, constant fish catchability, gear independence (e.g., one sample does not interfere with captures of another sample), etc. The intent of this study was to specifically target locations likely to capture Pallid Sturgeon based on previous knowledge of captures in the Platte River. This means many of the assumptions that are compulsory in using relative abundance as an index have not been met, nor were they intended to be as the intent was to capture as many Pallid Sturgeon as possible. Here, we report CPUE as the number of Pallid Sturgeon captured per trotline ***only*** as a means to represent effort and captures within the Platte River to implant transmitters.

Captured fish were temporarily placed in a holding tank before processing. All fish except sturgeon species were identified, measured for total length (mm) and weight (g), then released near the capture location. All sturgeon were identified, then measured for fork length (mm) and weight (g). Shovelnose Sturgeon were released near the capture location. Pallid Sturgeon that exceeded the minimum weight requirement received a telemetry tag (See *Implanting transmitters into Pallid Sturgeon* below). All Pallid Sturgeon were checked for presence of marks (e.g., scute(s) removed, elastomer marks, etc.) indicating a hatchery fish and Passive Integrated Transponder (PIT; 125.0 or 134.2 kHz; Biomark unencrypted) tag implanted during previous studies. If a PIT tag was present, the unique identification number was recorded and matched to the study and location where initially tagged. A new PIT tag was inserted into the dorsal musculature immediately below the dorsal fin if one was not present.

Implanting transmitters into Pallid Sturgeon: Two sizes of uniquely coded acoustic transmitters were used. Tag size depended on the weight of the individual Pallid Sturgeon to ensure the transmitter did not exceed 2% of the fish's body weight to reduce potential impacts of the transmitter on fish behavior (Cooke et al. 2012). A V-16 (16 mm X 71 mm; 24 g) transmitter was used for fish > 870 g and a V-13 (13 mm X 39 mm; 9.2 g) transmitter was used for fish 370 – 870 g. Both transmitters operate with a 40-80 second delay that allows the V-13 to function for a minimum of 342 days and the V-16 tags to function for a minimum of 1415 days.

Acoustic detection within the Platte River requires line-of-sight or an unobstructed path to the receiver to be detected. The braided nature of the Platte River may impede longer range detections. Therefore, an Advanced Telemetry Systems (ATS) radio transmitter was implanted in addition to the V-16 or V-13 transmitter on a select few individuals that were large enough to hold both transmitters. Each radio transmitter (28 g weight) was set up with a unique frequency ranging from 48-49 MHz to facilitate locating the fish and had an estimated battery life of 629 days. Reproductively mature sturgeon that met the weight requirements to support both transmitters, in which the combined weight of the tag was less than 2% of the fish's body weight, were double implanted.

As required under our Federal Endangered Species Collectors Permit and the revised Pallid Sturgeon Handling Protocols, all personnel responsible for surgery completed training for proper handling and surgical methods (see Appendix B for training completion dates). Surgery procedures generally followed guidelines developed for proper care and handling of Pallid Sturgeon (USFWS 2012, Kroboth et al. 2020). Transmitters were inserted into the body cavity of the Pallid Sturgeon via an incision cut in the abdomen near, but not along, the ventral line. The incision was closed using non-absorbable, monofilament suture material with independent sutures to ensure proper closure. Sex identification was performed using visual examination, where possible, during surgical implantation as outlined in Wildhaber et al. (2007). All procedures followed field sterilization procedures for instruments, transmitters, and suture materials and did not occur when air temperatures were below 2^{o}C. A post-operative injection of antibiotics (Liquamycin Vaccination at 1 mL/kg) was administered to reduce the risk of infection. Pallid Sturgeon were released near the point of capture once transmitter signal was verified as functional and the fish could swim freely.

Additional sources of transmitter-implanted Pallid Sturgeon: Pallid Sturgeon have been implanted with similar tags in the Missouri River as part of long-term monitoring efforts by U.S. Army Corps of Engineers, U.S. Geological Survey, and multiple state resource management agencies. Individual Pallid Sturgeon previously implanted with transmitters on the Missouri River mainstem were incorporated into our tracking efforts when initially detected or we were notified when an individual entered the Platte River by Nebraska Game and Parks Commission (NGPC) staff conducting Pallid Sturgeon telemetry research on the Missouri River. Further, when a previously tagged Pallid Sturgeon was encountered while performing standard telemetry surveys, that fish was added to our survey list. Detailed information for fish moving into or out of the Platte River system was communicated to the NGPC staff and they, in turn, reciprocated with details including—but not limited to—sex, reproductive status, and initial stocking location.

Habitat measures at Pallid Sturgeon capture locations: Physical and chemical conditions were assessed at the beginning of each trotline set and included water temperature, conductivity, dissolved oxygen, pH, depth, and bottom water velocity. Habitat measurements were recorded at the start of each trotline set as trotlines typically capture a majority of fish within the first four hours of deployment (Steffensen et al. 2013). Precise depths in areas > 1.5 m exceeded the logistical capacity of the depth sampling equipment used during the 2022 trotline effort. This situation has been remedied and will be more precisely measured starting in 2023. Turbidity values at USGS gage stations were noted to indicate general river water clarity conditions during overnight sets. Sampling habitat locations were classified as primary channel, secondary channel, or braided. Sandbar complexes surrounding each sample location were described as dry, partial, overflowing, or braided. Assessing habitat conditions at capture locations is largely intended to aid in focusing future trotline placement and, given the targeted sampling scheme, is not intended to assess habitat use or selection.

Passive Tracking: Passive telemetry stations (VR2Tx receivers) were deployed in the Platte River, Elkhorn River, Loup River, and Salt Creek at strategic locations to document fish movements (Table 1; Figure 2). A receiver was placed in each channel in river segments where multiple channels existed. However, in areas with one channel, common in the Elkhorn River, only one receiver was deployed. The network ranged from inside the Loup River (2.75 km upstream of the confluence with the Platte River) to the confluence of the Platte River with the Missouri River. No receiver was placed in the Platte River upstream of the confluence with the Loup River in 2022 due to extremely low water levels (Figure 3). In addition, the network extended into the Elkhorn River (35.2 km upstream of the confluence with the Platte River) and Salt Creek (1 km upstream of the confluence with the Platte River). The passive tracking network was an integral component of the entire telemetry portfolio to document the extent of Pallid Sturgeon movements in the Platte River and its tributaries.

Acoustic Range Testing: We conducted 8 stationary range tests and 2 drift range tests near Louisville State Recreation Area on the Platte River in 2021. The discharge during testing was approximately 7,000 cfs (USGS 06805500). We deployed an acoustic receiver (VRTx485656) in deep (> 1m) water near riprap and attached it to the anchor with the receiver sensor pointing towards the water surface. Then, we deployed another acoustic receiver (VRTx481015) in shallower water (~1m) in the center of the river and attached it to the anchor with the sensor pointed towards the river bottom, but suspended such that the receiver would be in the water column. After deploying the receivers, we used the V16 test tag to do six stationary range tests which lasted five to ten minutes each. We then conducted two more stationary tests using the V13 test tag for ten minutes at each station. Prior to starting the stationary tests for each tag, we confirmed that the receiver was making positive detections by doing in-air tests. Once stationary tests were completed, we did two drift tests (Drift Test 1 = 350 m river center; Drift Test 2 = 310 m river right) using the V13 test tag. To ensure we would be able to get accurate distances of detections, waypoints were recorded using a Garmin GPS at receiver locations, stationary test locations, and drift start and end points. The GPS unit was programmed to draw a track and collect points on a 1-second interval to compare our location time with positive detection times by the receivers. We then used ArcGIS to determine which stations resulted in positive identifications and our detection distances from the stationary and drift tests.

Active Tracking: Active tracking included *extensive* tracking to locate all fish and *intensive* tracking to follow reproductively ready adults during the spawning season. Both tracking events used an InnovaSea VR100-300 mobile tracking receiver with an omnidirectional VHTx-69k transponding hydrophone to locate fish.

Extensive tracking was conducted monthly from April – November as river conditions (flow, weather, ice, etc.) permitted. The search process was a systematic sweep sample where the field crew(s) searched for fish in the Platte River between Columbus - Plattsmouth and radiated into the tributaries as the passive tracking network indicated movement into each tributary. We calculated an index of detections during each tracking event as number of detections per hour (DPH). We also calculated DPH for each the area downstream of the Elkhorn River and the area upstream of the Elkhorn River and by season. Intensive tracking is outlined in Objective 2.

Habitat measures at Pallid Sturgeon detection locations: Habitat use for relocated Pallid Sturgeon has been and will continue to be assessed at multiple spatial scales. Micro-scale and meso-scale habitat information was collected when Pallid Sturgeon were located at sub-meter spatial scales. Micro-scale habitat variables used to describe habitat at the location of capture included water velocity, water depth, water temperature, turbidity, and conductivity. Precise depths in areas > 1.5 m exceeded the logistical capacity of the depth sampling equipment used during the 2022. This situation has been remedied and will be more precisely measured starting in 2023. Mesoscale habitat variables used to describe the area surrounding the location of capture included primary-channel, secondary-channel, or braided. Sandbar complexes were also categorized as dry, partial, overflowing, or braided. These data are consistent with previous habitat measures from the Platte River (Peters and Parham 2008; Hammen et al. 2018; Hamel and Pegg 2019; Platte River Recovery Stage-Change Study 2009). We used the nearest USGS hydrologic stream gage to assess river discharge where Pallid Sturgeon were located. The combination of physical habitat measurements with hydrologic patterns will be further assessed to provide insight into the dynamic nature of habitat use within the Platte River.

Results

A total of 52 confirmed Pallid Sturgeon and one F1-hybrid were detected through capture, active, and/or passive tracking on the lower Platte River and its tributaries in 2022 (Figure 4; Tables 2-4).

Platte River Captures and Transmitter Implantation. We targeted the deepest water available at time of trotline deployment, but actual depths varied. A total of 164 trotlines were set throughout the lower Platte River at depths ranging from < 0.5 m to ≥ 1.5 m. Overall, 26 Pallid Sturgeon (Figure 5) and one F1-hybrid (Figure 6) were collected with a mean CPUE of 0.159 Pallid Sturgeon per trotline (Table 2). Most Pallid Sturgeon were captured between river kilometers 30 and 50 (Figure 5). We also delineated season of capture following solstice and equinox criteria where winter was trotline captures up to March, 19, 2022 (N = 20 trotlines), spring captures began March 20, 2022 (N = 94 trotlines), and fall captures began September, 22, 2022 (N = 50 trotlines). Captures were comparable across seasons. Other fish species captured included Shovelnose Sturgeon, Common Carp *Cyprinus carpio*, Channel Catfish *Ictalurus punctatus*, Flathead Catfish *Pylodictis olivaris*, and Shorthead Redhorse *Moxostoma macrolepidotum* (Table 5).

A total of 16 acoustic transmitters were implanted into Pallid Sturgeon during 2022 (Table 4). However, one of the Pallid Sturgeon (A69-1602-62088; not listed in Table 4) was found deceased about 2 weeks following initial implantation and was not included in further analyses. The mortality was reported to U.S. Fish and Wildlife Service and a necropsy was conducted by Nebraska Game and Parks Commission staff who verified that the mortality was not a direct result of the surgery (i.e., no internal organs were damaged by scalpel or suture). Additionally, a radio transmitter was implanted into a Pallid Sturgeon previously tagged by U.S. Fish Wildlife Service (Acoustic ID A69-1602-59042). The remaining 10 Pallid Sturgeon collected in 2022 did not meet the weight requirement for an acoustic tag (Table 3).

Habitat measures at capture locations. These habitat results are indicative of where Pallid Sturgeon were captured and does not imply any comparison of overall habitat availability or selection. Consistent depth across the length of a given trotline was not always possible. However, Pallid Sturgeon were not caught when trotlines were set in water that was consistently < 0.5 m. Mean pH, temperature, dissolved oxygen, bottom velocity, and conductivity between trotline sets where Pallid Sturgeon were captured compared to where not captured were similar (Table 6).

Acoustic Range Testing: We were able to get positive detections at Station 2 and Station 3 with the VRTx 485656 receiver, as well as positive detections at Station 5 with the Tx481015 receiver. Station 2 was directly 46.4 m upstream of the receiver, while Station 3 was slightly upstream and to river left of the receiver by 39.8 m (Figure 7). Further, Station 5 was 19.4 m upstream of the VRTx481015 receiver. While we were not able to get detections during Drift 1 (river center), we were able to get detections by VRTx485656 receiver during Drift 2 (river right). Our detection range for the drift was 54.1 m (Figure 7), in which we received detections both upstream and downstream of the receiver. Additional evaluation of detection efficiency and probabilities will continue in 2023.

Passive and Active Tracking. A total of 37 unique Pallid Sturgeon were detected either passively or actively between March - November 2022. Specifically, nine Pallid Sturgeon tagged with acoustic transmitters by UNL were detected following implantation and 28 Pallid Sturgeon were previously tagged by other agencies (Table 4). The remaining six individuals tagged by UNL have not been detected following implantation to date. Graphical and straight-line movements for fish that had multiple detections are provided in Appendix A.

Standardizing detections among the passive receivers is ongoing as temporal disparities are being addressed. The transmitters can potentially be detected every 2-3 minutes that may lead to many detections of a single individual at one receiver. For example, a single fish may remain within detectable range of a receiver for hours or days that results in multiple detections. How to deal with those detections varies depending on circumstances, objectives of the study, etc. For now, we report the number of detections gathered at the stations and by unique fish identification code. Detections were also combined for sets of receivers that were deployed in one area to increase detection probability in portions of the river that are wide and have multiple, deep channels (e.g., receiver numbers 1-3 at Louisville are considered one station).

The passive detection network detected Pallid Sturgeon from the mouth of the Platte River upstream to North Bend (Figures 8-9; Figure A-4). Pallid Sturgeon were not detected on the Loup Power Canal receivers, nor the Loup River receiver, the upstream most receiver (Figure 8). However, locating water deep enough to place receivers in some reaches of the Platte River above the Elkhorn River – Platte River confluence created delays in deployment of receivers in this area and may have limited the number of passive detections. Deployment timing will be ameliorated in future years.

Pallid Sturgeon moved downstream towards the Missouri River during late spring and summer when discharges in the Platte River ranged from 3500 cfs to 10,600 cfs (Figure 10) and temperatures were approximately 17°C to 29°C at the Louisville gage (Figure 11; Table 7). Discharge in the Missouri River ranged from about 27,500 cfs to 31,300 cfs (Figure 11) and temperatures ranged from 17°C to 27°C at the Omaha gage corresponding to downstream movements of individuals transitioning from the Platte River to the Missouri River (Figure12; Table 7). Conversely, Pallid Sturgeon entered the Platte River in the fall when discharge ranged from approximately 1,900 cfs to 2,300 cfs and water temperatures ranged from approximately 15°C to 19°C (Figures 10-12; Table 7). During fall Pallid Sturgeon movement into the Platte River, the Missouri River had discharges ranging from 32,000 to 33,200 cfs (Figure 11; Table 7), but fall temperatures were not available for the Missouri River gage. Turbidity was greater in the spring when Pallid Sturgeon were moving downstream, compared to when Pallid Sturgeon were entering the Platte River during the fall (Figure 13).

The passive detection network was also used to monitor movement between the Elkhorn River and the Platte River. Eight Pallid Sturgeon entered the Elkhorn River between April and early June. Discharge for entry in the Elkhorn River ranged from approximately 1,090 cfs to 2,230 cfs, while the Platte River had discharges ranging from 3,160 cfs to 5,930 cfs. In addition, the water temperature in the Elkhorn River when Pallid Sturgeon were entering ranged from 13°C to 23°C, while in the Platte River temperatures at that time were similarly 12°C to 23°C (Table 8). Pallid Sturgeon moving downstream in the Elkhorn River presumably into the Platte River also occurred from late April to late June. Discharge for downstream movement ranged in the Elkhorn River from approximately 980 cfs to 1,385 cfs, while the Platte River had discharges ranging from 2,260 cfs to 4,970 cfs. Temperature during downstream movement in the Elkhorn River ranged from 18°C to 29°C and 19°C to 29°C in the Platte River (Table 8).

A total of 40 unique fish detections were identified during active tracking efforts. Crews spent a total of 329.5 hrs active tracking during the 2022 field season (Table 9). There were 33 active tracking detections below the Elkhorn River – Platte River confluence area during 140.8 hrs of effort. Only one detection was identified upstream of the Elkhorn River – Platte River confluence in the Platte River with 138.4 hours of effort. A total of 6 detections were made while active tracking the Elkhorn River during the 50.3 hours of effort (Table 9). There were 130.8 hrs spent tracking during the spring (33 detections), 138.2 hrs in the summer (1 detection), and 60.5 hours in the fall (6 detections) (Table 10). Active tracking detections of Pallid Sturgeon indicated these individuals were in depths ranging from 0.5 m to ≥ 1.5 m (Table 11). Water quality conditions were generally similar to those measured during the capture portion of this study, except for temperature which had a larger variance across seasons (Table 11). The farthest upstream active detection was upstream of North Bend, Nebraska between river kilometers 120 and 130, and the most downstream active detections were at the mouth of the Platte River with the Missouri River (Figure 14). Pallid Sturgeon locations in the Elkhorn River extended upstream to about the Highway 36 bridge (Figure 14; see Appendix A for specific fish movements into the Elkhorn River).

Objective 2: Identify Pallid Sturgeon spawning habitat in the lower Platte River and its tributaries.

Methods

Intensive Tracking: The *extensive* telemetry methods described in Objective 1 were coupled with the passive receiver network to locate and identify Pallid Sturgeon in the system that were suspected to be reproductively ready. Upon detection of these priority sturgeon, crews would immediately start intensively tracking them. Intensive tracking consisted of attempting to relocate the fish every day during the potential spawning season. Repeated location information (i.e., multiple locations per day) was gathered once the fish arrived at its apex location to monitor for spawning behavior. Sampling for Objective 3 was initiated upon locating individuals exhibiting spawning behavior (i.e., repeated short upstream and downstream movements in the same general area). Attempts were made to maintain contact with these fish following any post-spawn movements.

Habitat measures at Pallid Sturgeon potential spawning locations: Physical and chemical conditions were assessed at each location where spawning was thought to occur and included water temperature, conductivity, dissolved oxygen, pH, depth, turbidity, and bottom water velocity. Sampling locations were classified as main-channel, secondary-channel, or braided. Sandbar complexes surrounding each sample location were described as dry, partial, overflowing, or braided. These were taken as single measurements once a fish was detected.

Results

Spawning was not confirmed with capture of known Pallid Sturgeon eggs or larvae (see Objective 3) during the 2022 field season. However, potential spawning behavior was observed at two locations within the Platte River. The first occurred just downstream of the confluence with the Elkhorn River. Specifically, a NGPC tagged (A69-1602-58917) mature female Pallid Sturgeon exhibited a repeated pattern of up and downstream movement within the same general area on May 8, 2022 (Figure 15). The female was first detected in the Elkhorn River, approximately 50 meters from the mouth. After the initial detection, it did not appear in that area for approximately five minutes but was relocated after drifting approximately 100 meters downstream from the Elkhorn River mouth into the Platte River. This female then repeatedly moved away from and toward the second location about every 2 minutes. This behavior is consistent with female spawning behavior observed in the Missouri River and suggested potential spawning.

The second instance of suspected spawning behavior occurred approximately 8 km upstream from the confluence of the Platte River with the Missouri River. A male Pallid Sturgeon (A69-1602-62101) captured by our crews on March 29, 2022 was determined to be reproductively mature and made small (< 1 km) upstream and downstream movements until its last known detection at that location on May 13, 2022 (Figure 16). This behavior is also consistent with male spawning behavior.

Objective 3: Verify successful spawning by Pallid Sturgeon in the Platte River and/or its tributaries.

Methods

Documenting Pallid Sturgeon Spawning Success: Sampling used to attempt to identify spawning success in the lower Platte River followed a two-part process. First, ichthyoplankton nets were used to target early life-stage Pallid Sturgeon at the confluence of the Platte River with the Missouri River as well as above and below the confluence of the Elkhorn River with the Platte River (Figure 17). Sampling was conducted weekly when temperatures exceeded 15^{o} C through June 30, 2022. We sampled the Platte River along a transect (perpendicular to flow) approximately 1-km upstream from the confluence. Habitat diversity is greater in the Platte River compared to available sample locations on the Missouri River. Therefore, three locations along the transect – about 50-m away from each bank and a mid-river location were used in the Platte River. Exact sample locations were dictated by water conditions and presence of sandbars, but we targeted the deepest water available in the Platte River. DeLonay et al. (2016) reported the majority of Pallid Sturgeon were collected in outside bend habitats on the Missouri River. Hence, outside bend habitats about 1-km upstream and 1-km downstream of the Platte River confluence were targeted. All nets were set at the river-substrate interface on the riverbed.

Second, site(s) where behavior by individuals implanted with transmitters suggested spawning occurred were sampled (per Objective 2). Here, ichthyoplankton nets were deployed immediately downstream of the suspected spawning location to target collection of free embryos and/or larval Pallid Sturgeon to document successful spawning. The amount of water filtered was dependent on debris load. Sampling sites were selected based on channel configuration to maximize capture probability. Sampling began immediately after spawning behavior was observed (Objective 2) and continued daily for 7 days. Field samples were sorted in the field and preserved in alcohol.

Sample Collection: Ichthyoplankton nets were used to collect free embryos, larvae, and early life-stages of exogenous feeding individuals. We subsampled each area a minimum of three times on the day of sampling, where nets were deployed along a transect perpendicular to the flow at left, middle, and right bank of the river as conditions allowed in the Platte River and its tributaries. We also collected three replicate samples in a similar manner at the Platte River confluence as well as in the Missouri River immediately upstream and downstream of where the Platte River empties into the Missouri River as described above.

The 750-micron mesh nets were conical in shape, with either 0.5-m or 0.75-m diameter openings that extend 4-m to a cod end to hold captured material. The nets were set from an anchored boat to ensure stationary deployment and consistent gear operation. The goal was to use the 0.75-m diameter net throughout the sampling period, but low water levels exposed the net at times requiring the smaller diameter net to be used. Nets were deployed in tandem (i.e., one net starboard/one net port) at each deployment (Figure 18). Both nets were placed at or near the bottom of the water column at the water-substrate interface to target Acipenseridae (sturgeon and paddlefish) species using a 15-25 kg weight (DeLonay et al. 2016). Drift net deployment times varied depending on quantities of organic flotsam in the water column but were a maximum of 5-minute sets in all locations. Effort targeted at potential spawning sites varied due to the size of the suspected spawning site area, but nets were deployed to ensure at least three (3) samples per day were collected at each site.

Net deployment times varied, but sampling effort was standardized according to the amount of water sampled in each net as follows. Relative density of fish captured (e.g., number of individuals per cubic meter; $\#/m^3$) in the nets reported as number of fish per unit volume of water sampled (V) was calculated as:

$$V = \pi * R^2 * H$$

where R is the net radius, and H is the distance of water sampled. The variable H was determined using a General Oceanics (Miami, FL) flow meter positioned at the mouth of the net during deployment. This flow meter counts propeller revolutions in the instrument that can then be multiplied by a manufacturer-provided constant to convert flow into distance of water sampled.

Processing Suspected Sturgeon Species: All samples were initially screened immediately following net retrieval for individuals from the Order Acipenseriformes (i.e., sturgeon and paddlefish) in consultation with Nebraska Game and Parks staff with egg and larval fish identification expertise. Individuals identified as being from Acipenseriformes were preserved in 70% ethanol and sent for genetic identification per Objective 4. Remaining fish in the sample were preserved in either a 10% buffered formalin or 70% ethanol solution to be processed at a later date. The remaining preserved specimens were identified to Family.

Habitat Measures Taken at Suspected Spawning Sites: Habitat information from the suspected spawn site(s) was recorded to quantify abiotic conditions during the spawning season. Micro-scale habitat variables used to describe habitat at the location of potential spawning included water velocity, water depth, water temperature, turbidity, conductivity, and pH. Mesoscale habitat variables used to describe the area surrounding the location of capture included primary-channel, secondary-channel, overflowing bar, or back-water. These data are consistent with previous habitat measures from the Platte River (Peters and Parham 2008; Hammen et al. 2018; Hamel and Pegg 2019; Platte River Recovery Stage-Change Study 2009).

Results

A total of 178 nets were deployed in May and June during 39 days of sampling (Table 12). Mean water temperature was 21.8°C (Table 13) and average volume of water sampled per net was 3401 m^3 (S.E. = 948). Overall, we collected 454 eggs and 84 larval fish (Table 14). Average larval density was 4.1 X $10^{-4}/m^3$ (S.E. 0.65 X 10^{-4}) and egg density was 4.1 X $10^{-4}/m^3$ (S.E. 0.95 X 10^{-4}).

A total of three potential Pallid Sturgeon eggs/larvae were collected during 2022. Two eggs were collected during May. One egg was collected at the mouth of the Elkhorn River (May 12, 2022) and the other within the Elkhorn River (May 23, 2022). Genetic tests were unable to discriminate between Shovelnose Sturgeon and Pallid Sturgeon. Interestingly, the egg collected at the mouth of the Elkhorn River was in close proximity to where the active tracking location identified potential Pallid Sturgeon spawning to have occurred on or around May 8, 2022. Sampling at the second identified potential spawning location yielded no sturgeon species in daily ichthyoplankton net sets in the area between May 12-20, 2022.

A third possible early life-stage Pallid Sturgeon was captured at the confluence of Platte River – Missouri River confluence on August 22, 2022 during larval fish sampling for a concurrent invasive carp project. This ~10-mm individual was confirmed a Shovelnose Sturgeon following genetic analysis.

Objective 4: Annual sampling of fish and free embryo/larvae/young-of-year from the Lower Platte to provide samples for Dr. Ed Heist's genetic study.

Methods

A fin clip for all individuals identified as a Pallid Sturgeon or suspected Pallid Sturgeon x Shovelnose Sturgeon hybrid during sampling (discussed in Objective 1) was collected and preserved in 70% ethanol for genetic identification. Tissue samples from all Pallid Sturgeon captured as part of this project were provided to Southern Illinois University for genetic analyses to assess species identification, demographics, and the potential degree of hybridization with Shovelnose Sturgeon (See companion project from Dr. Heist for specific details). Juvenile and adult Pallid Sturgeon (and potential hybrids that are phenotypically identified in the field) collected under Objective 1 will provide insights into the sturgeon populations (i.e., ratio of wild to hatchery-origin, natural recruitment via juvenile wild-origin fish collected, occurrence/rate of hybridization). Age-0 (embryos, larval, and exogenous feeding) individuals collected under Objective 3 were also sent to Southern Illinois University to confirm reproductive success in the lower Platte River, purity of these reproductive events, and contribution of the Platte River to the lower Missouri River sturgeon populations. All samples (e.g., fin clips or whole specimens depending on life stage) were preserved, documented, and shipped to the laboratory for further processing following protocols provided by Southern Illinois University.

Results

A total of 27 fin clips, two eggs, and one larval fish were evaluated during the 2022 field season. Genetic confirmation of both wild (n = 1) and hatchery (n = 24) Pallid Sturgeon were documented from the Platte River (Tables 3-4). Further, an additional fish that was a suspected hybrid based on field meristic assessment was confirmed an F1 Pallid Sturgeon x Shovelnose Sturgeon hybrid (Figure 6).

DEVIATIONS FROM PLAN AND FUTURE ADJUSTMENTS

Adjustments during 2022 field season

The below information highlights substantive adjustments made during the 2022 field season. Most of these changes were a result of unanticipated, logistical challenges related to the telemetry effort.

Transmitters – The aim is to maintain connection to the larger acoustic telemetry array in the Missouri River system, but we also recognize there are limitations to the acoustic technology in the Platte River. Specifically, the braided nature of the channel and undulating bottom contours may hinder the "line of site" requirement for acoustic telemetry. Previous fish telemetry work in the Platte River has used radio telemetry. Radio telemetry worked well in the Platte River because the river is shallow thus allowing the signal to travel through air more than water in most situations. However, the radio tags become unreliable if the fish moves into the Missouri River due to depth and specific conductivity issues. Therefore, we used this sample year as a pilot to evaluate if using both acoustic and radio tags would increase detections by incorporating radio transmitter use into fish large enough to hold both an acoustic tag and the radio tag as means to increase detections in the Platte River. Our anecdotal observations indicate that there is a small, incremental gain to detection distance with the radio tags, but none of the fish that had both transmitters were missed by the active tracking portion of the acoustic telemetry effort. Further, the additional mass and volume the radio tag took in the body cavity of the individuals that received both tags may have incorporated additional and unanticipated stress. We had one documented mortality (mortality was reported to USFWS) following surgical procedures and that fish received both tags. It is unclear whether adding two transmitters increased stress and led to the fish's death. Therefore, we intend to be cautious and will only use a single acoustic transmitter per fish in the future.

Receiver Placement – Receiver locations and timing of deployment differed from the proposed plan in some instances. Specifically, fewer receivers were placed above the Elkhorn River confluence than originally anticipated and those that were deployed were put into operation later than originally anticipated. This change was largely driven by water levels. For example, water deep enough to accommodate one or more receivers upstream within a reasonable distance (i.e., 5 km) of the Loup River-Platte River confluence did not exist (Figure 14). Shallow water conditions were prevalent throughout many of the reaches of the Platte River upstream of the Elkhorn River confluence, but we placed receivers as conditions allowed.

Larval Samples – We extended the period for sampling behind suspected spawning aggregations from 3 to 7 days.

Adjustments for 2023 field season

Receiver Placement/Removal – We intend to deploy receivers in the originally proposed locations upstream of the Elkhorn River if conditions will allow and in advance of the initial trotline sampling if at all possible to detect potential movement of Pallid Sturgeon with acoustic tags upstream of the Elkhorn during the more active spawning period. Further, our observations this fall suggest that most of the receivers will need to be retrieved before the river is fully iced-over during winter to prevent loss of substantial amounts of equipment. We expected this scenario might happen and are adjusting accordingly.

Fish Collection Locations – Fish collection locations during year 1 were intended to optimize collection of fish suitable for implanting a transmitter. We intend to broaden our collection effort further upstream in 2023 to incorporate better coverage of the entirety of the lower Platte River data collection. Specifically, we will deploy one crew to attempt to collect Pallid Sturgeon upstream of the Elkhorn River – Platte River confluence during the winter-spring collection effort in 2023, while the second crew maintains collection and tracking attention in downstream locations.

Range Tests – Additional stationary range tests and blind tracking will be conducted to determine efficiency and performance of acoustic telemetry technology in the Lower Platte River (see student-directed research). The results of this work will enable a better understanding regarding detection probability and range as well as inform passive receiver placement and active tracking methods in the future.

Telemetry effort calculation standardization – Specific estimates of how and what the passive receiver network detects provide some unique spatial and temporal challenges in presenting specific data (Kraus et al. 2018). One logistical issue is the amount of data gathered by each receiver and how to parse observed detections to meaningful units. We intend to standardize future detections on each passive receiver such that unique fish detections will be identified on a per 24-hr period to filter detections across the passive detection network and provide a means to effectively summarize detections. That is, any passive receiver, or set of receivers, that has multiple detections of a unique individual during a set, daily period (i.e., midnight to midnight) will be identified as being at/near the receiver once per day. More specific information like exact date, time, and temperature on directed movements or other unique behaviors (e.g., spawning, entry/departure from the Platte River, etc.) by individuals can and will be used when appropriate and available.

Remotely-sensed habitat data – In addition to *in situ* habitat variables collected, we intend to leverage LIDAR data obtained by PRRIP throughout the study area as a means to assess potential habitat selection and build habitat use functions. Further, we will use an acoustic doppler current profiler (ADCP) to map river locations where spawning is thought to occur. Test runs of the ADCP were conducted near Louisville, NE on the Platte River in early Fall 2022 (Figure 19) in collaboration with Dr. Aaron Mittelstet at the University of Nebraska-Lincoln.

We are currently working on how best to integrate these data into a cohesive analysis on habitat use by Pallid Sturgeon.

Additional data coordination

Efforts to integrate portions of the data from this project with concurrent data being collected in the lower Missouri River was initiated in 2022 through discussions to establish a data sharing agreement with all collaborating partners involved (i.e., EDO, UNL, NGPC, USFWS, USGS, USCOE, other state agencies involved, etc.). We will continue to work on a formal agreement to ensure data integrity and utility across the greater Missouri River basin. This agreement will outline the exact data needs for all parties involved but will generally include basic information such as Pallid Sturgeon morphometric details, transmitter codes, tagging date, tagging location, and detection history when pertinent to a specific research question or objective.

STUDENT-DRIVEN RESEARCH UPDATE

The below synopses highlight the current line of questions being developed by the graduate students involved with this project at the time of this report's submission. The ideas and topics are not yet complete so should be viewed as works in progress. Therefore, the questions and objectives provided herein are subject to change until approved by the students' respective advisory committee (anticipated to occur in early 2023).

Chris Pullano – MS

The Platte River is a relatively shallow and braided system with complex, shifting sandbar dynamics. Acoustic telemetry is an essential component of this study to maintain continuity with ongoing Pallid Sturgeon telemetry studies on the mainstem of the Missouri River despite the associated challenges. We know that the bathymetric nature of the river may impede our ability to make longer range acoustic detections while monitoring tagged Pallid Sturgeon. The performance of acoustic telemetry is also impacted by the amount of acoustic noise in the system that suppresses transmissions. Ambient acoustic noise in a river is influenced by turbulence, depth, flotsam, and other biological disturbance. To better understand how we can maximize performance of acoustic technology in the Platte River, my first objective is to determine the environmental variables that influence detection distance and efficiency using seasonal range tests. These results can be used to better understand detection probability as Pallid Sturgeon are monitored with both active and passive tracking techniques.

Previous investigations have documented the presence of Pallid Sturgeon throughout the Lower Platte River between March – December with the highest probability of occurrence during high discharge periods of the spring and fall (Hamel et al. 2014; Hamel et al. 2016). Other studies on the Missouri and Platte rivers have informed managers of general basin-wide movement patterns, but little is known about the differences in movement patterns among size or demographic groups. Therefore, my second objective is to determine the difference in seasonal displacement among demographic groups of Pallid Sturgeon within the lower Platte River, NE.

Jenna Ruoss – Ph.D.

The lower Platte River has likely been influenced by various anthropogenic uses over the past two centuries (McKinley 1935; Carlson 1963), but it has retained much of its braided, turbid characteristics similar to conditions that existed pre-European settlement (Peters and Schainost 2005). There is much debate in the literature regarding the implications of water management, especially when dealing with recovery of rare or threatened species. However, few studies have empirically evaluated whether contemporary environmental conditions can or cannot continue to meet life-history needs of a given fish community or species compared to historical conditions. The flow regime of a river drives ecological processes such as the creation of habitat, maintaining diversity, and recruitment of organisms. Flow regimes are usually characterized by the magnitude, frequency, duration, timing, and rate of change of hydrological conditions. My overall goal is to determine how current hydrological conditions are structuring fish communities in large, braided rivers. More specifically, I want to know how compatible life-history strategies are for fish currently found in these types of rivers to current conditions as it relates to timing of flows, access to habitat, etc. across space and time. I intend to begin to achieve this goal by using data collected from the Platte River to answer three specific questions. My first question is, has the general behavior of basic flow variables changed over time? It is important to understand if and how variables like timing of flows have changed over time. Specifically, I will estimate flow conditions in the lower Platte River using a Soil and Water Assessment Tool (SWAT) model to evaluate if the annual water cycle has substantially changed over the period of available climate and flow data (~ 1800- present).

My second question is, what habitat patches are available under varying flow conditions? Differing flows affect habitat creation, availability, and accessibility for organisms that may need them. I will use current data collection from fish location habitat assessments, LIDAR, and ADCP in the lower Platte River to determine the interconnectedness of habitats along the lower Platte River. Further, I will use a combination of LIDAR and ADCP to relate geomorphological features to flow.

My third question is, how compatible are the life history strategies of fish currently observed in the lower Platte River to the current hydrological conditions? There is a growing body of literature suggesting that the phenologic aspects of when and where species should be located in time and space is changing for some organisms. This change in timing can lead to biotic (e.g., food availability) and abiotic (habitat availability) mismatches that can change conditions suitable for long term sustainability of a given population. I will focus on evaluating information gathered from my first two questions to better understand the relationship between the flow regime and life history composition of fish assemblages in the lower Platte River. I intend to use discharge records, fish surveys, and fish life history classifications to determine how suitable the lower Platte River is for its current fish assemblages.

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Table 1. Location of 21 passive receivers deployed in the lower Platte River basin and their initial deployment date and removal date during 2022. Some receivers were removed to prevent ice damage during winter months but will be repositions following ice-out. Locations mapped in Figure 2, with *Receiver Number* corresponding to those listed here.

Receiver number	Receiver ID	Deployment date	Removal date	Latitude	Longitude	Reference location
1	487705	3/19/2022	11/28/2022	41.03451	-96.31075	Louisville River Right
2	487712	3/19/2022		41.02105	-96.13993	Louisville River Center
3	487702	3/19/2022		41.03509	-96.13889	Louisville River Left
4	487706	3/19/2022	11/28/2022	41.03471	-96.30986	Salt Creek River Center
5	487707	3/19/2022	11/28/2022	41.03451	-96.31075	Salt Creek River Right
6	487709	3/19/2022	11/28/2022	41.03509	-96.30889	Salt Creek River Left
7	487713	3/19/2022		41.05765	-95.89079	Plattsmouth
8	487714	3/25/2022		41.14473	-96.30857	Elkhorn Mouth
9	487704	3/25/2022		41.13157	-96.31850	Platte River Upstream of Elkhorn River
10	487708	4/15/2022	11/28/2022	41.11714	-96.31154	Platte River Downstream of Elkhorn River
11	487703	4/18/2022	11/28/2022	41.30115	-96.38870	Leshara
12	487711	5/6/2022	11/22/2022	41.31646	-96.29228	Elkhorn River - Waterloo
13	487716	5/15/2022	11/28/2022	41.39806	-97.27900	Loup Power Return River Left
14	487715	5/15/2022	11/28/2022	41.39818	-97.28303	Loup Power Return River Right
15	487710	5/25/2022	11/28/2022	41.35996	-96.30054	Elkhorn River - Valley
16	487717	5/25/2022		41.44807	-96.78230	North Bend
17	487718	5/26/2022	11/28/2022	41.40609	-97.34114	Loup River
18	487719	6/16/2022		41.30063	-96.38927	Leshara
19	487720	8/29/2022		41.05740	-95.89047	Plattsmouth (replacement)
20	487722	9/22/2022		41.04025	-96.32092	Salt Creek - Willow Point
21	487721	9/19/2022	11/28/2022	41.44794	-96.78311	North Bend 2 (replacement)

Table 2. Number of trotlines set in the lower Platte River in 2022 and the number of Pallid Sturgeon caught each season. Mean catch per unit effort (CPUE) is the mean number of Pallid Sturgeon captured per trotline (95% confidence interval).

Season	Trotlines set	Pallid Sturgeon caught	Mean CPUE (CI)
Winter (till 3/19/22)	20	6	0.300 (0.05 - 0.55)
Spring (start 3/20/22)	94	10	0.106 (0.04 - 0.18)
Fall (start 9/22/22)	50	10	0.200 (0.06 - 0.34)
All	164	26	0.159 (0.09 - 0.22)

Table 3. Capture date, location (river kilometer; RKM), fork length, weight, and origin of Pallid Sturgeon that did not meet the requirement to receive an acoustic transmitter. Fish origin was defined at hatchery (H) or wild (W). Hatchery fish were further identified to year-class by the two-digit code (e.g., H07 = 2007 year-class). Asterisk (*) denotes Pallid Sturgeon x Shovelnose Sturgeon hybrid. Corresponding pluses (+) denotes recapture of same fish.

Capture date	RKM	Fork length (mm)	Weight (g)	Genetic results
3/17/2022	30	492	362	H17
4/2/2022	39	492	344	H19+
4/10/2022	12	526	416	H18
4/16/2022	48	497	358	H18
10/25/2022	30	500	386	H19+
10/27/2022	32	535	468	H18
11/1/2022	49	516	448	H18
11/1/2022	49	581	534	H18
11/1/2022	49	663	1156	W- F1*
11/1/2022	49	514	424	H18

Table 4. Summary information for acoustic tagged Pallid Sturgeon encountered during 2022 field season in the Platte River. Capture, Active, and Passive columns indicate the number of encounters for each method. First encounter date and River kilometer (RKM) indicate the date and location of first contact. Reproductive Status indicates Non-Reproductive (NR), Reproductive (R), or Unknown (U). Fish origin Wild (W), Unknown (U), or Hatchery (H) with hatchery fish identified to year-class by a two-digit code (e.g., 07 = 2007 year-class); Tagging Agency is University of Nebraska-Lincoln (UNL), Nebraska Game and Parks Commission (NGPC), Missouri Department of Conservation (MDC), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), or U.S. Army Corps of Engineers (USACE).

Acoustic ID	**Capture**	**Active**	**Passive**	**First Encounter Date**	**RKM**	**Fork Length (mm)**	**Weight (g)**	**Sex**	**Reproductive Status**	**Origin**	**Genetic ID**	**Tagging Agency**
A69-1602-62089	1	1	0	3/17/2022	31	524	468	U	NR	H17	16267	UNL
A69-9001-58904	1	3	135	3/17/2022	31	885	1926	U	NR	H08	16280	UNL
A69-9001-58905	1	5	15	3/17/2022	30	796	1750	U	NR	H08	16281	UNL
A69-9001-58907	1	2	13	3/19/2022	31	809	2106	U	NR	H13	16298	UNL
A69-1602-55355	0	2	644	3/19/2022	31	1071	4880	F	NR	H02		NGPC
A69-1602-62100	1	0	0	3/25/2022	2	607	748	U	NR	H15	16299	UNL
A69-1602-55342	0	1	100	3/28/2022	24	1072		U	NR	H02		NGPC
A69-1602-62101	1	4	0	3/29/2022	9	889	2268	M	R	W	16279	UNL
A69-1602-59359	0	0	28	4/5/2022	40	870	2676	F	NR	H06		NGPC
A69-1602-49253	0	2	154	4/7/2022	24	832	2097	U	NR	H01		NGPC
A69-1602-59042	1	0	215	4/9/2022	9	947	2736	F	NR	H01	16303	USFWS/UNL
A69-9001-58908	1	0	21	4/10/2022	10	980	3308	M	R	H05	16298	UNL
A69-1602-62091	1	2	0	4/16/2022	49	635	726	U	NR	H13	16301	UNL
A69-1602-62092	1	1	1084	4/16/2022	49	677	940	U	NR	H15	16300	UNL

Acoustic ID	Capture	Active	Passive	First Encounter Date	RKM	Fork Length (mm)	Weight (g)	Sex	Reproductive Status	Origin	Genetic ID	Tagging Agency
A69-9001-58906	1	3	41	4/16/2022	49	1080	4688	M	R	H02	16304	UNL
A69-1602-59024	0	1	135	4/19/2022	40	818	2010	F	NR	H09		NGPC
A69-1602-54445	0	1	11	4/25/2022	3	937	3190	F	NR	U		NGPC
A69-1602-59354	0	0	28	4/28/2022	40	920	3046	F	NR	U		NGPC
A69-1602-55362	0	1	17	4/29/2022	11	787	1638	U	NR	U		NGPC
A69-1602-63212	0	2	160	4/29/2022	16	880	2435	M	NR	U		NGPC
A69-1602-59352	0	0	1	5/5/2022	67	1022	4496	M	NR	H02		NGPC
A69-1602-58909	0	0	50	5/8/2022	24	1094	6800	F	NR	U		USGS
A69-1602-58917	0	2	34	5/8/2022	50	1082	6860	F	NR	U		NGPC
A69-1602-59977	0	1	3	5/8/2022	50	851	2240	F	NR	U		MDC
A69-1602-19523	0	3	0	5/9/2022	5	1040	5780	F	R	U		USGS
A69-1602-55335	0	1	0	5/11/2022	11	1071	4880	F	NR	H02		NGPC
A69-1602-59046	0	0	55	5/26/2022	40	757	1540	F	NR	H06		USFWS
A69-1602-19520	0	0	15	5/28/2022	49	900	2680	F	NR	H03		USGS
A69-1602-59578	0	0	34	5/30/2022	24	792	2040	U	U	H10		USACE
A69-1602-19542	0	0	17	9/23/2022	2	960	3195	M	R	U		USFWS
A69-1602-55337	0	0	13	9/25/2022	2	1061	5280	M	NR	H01		NGPC
A69-1604-30391	0	1	265	9/25/2022	2			F	NR	U		NGPC
A69-1602-49254	0	1	49	9/30/2022	2	953	3078	U	NR	H04		NGPC

Acoustic ID	Capture	Active	Passive	First Encounter Date	RKM	Fork Length (mm)	Weight (g)	Sex	Reproductive Status	Origin	Genetic ID	Tagging Agency
A69-1604-30381	0	0	47	10/7/2022	2			F	NR	U		NGPC
A69-1602-55347	0	0	98	10/10/202	2	845	2200	F	NR	H07		USGS
A69-1602-63209	0	2	37	10/10/202	2			M	NR	U		NGPC
A69-1602-63086	0	1	272	10/13/202	2	1034	5020	F	NR	U		NGPC
A69-1602-59365	0	1	63	10/14/202	2	971	3846	F	NR	H02		NGPC
A69-1602-62090	1	0	0	10/25/202	31	571	552	U	NR	H18	16294	UNL
A69-1602-62094	1	0	0	10/27/202	27	1100	5042	U	NR	H02	16291	UNL
A69-1602-62095	1	0	0	10/27/202	30	832	1792	U	NR	H08	16282	UNL
A69-1602-62097	1	0	0	11/1/2022	49	995	3520	U	NR	H01	19277	UNL
A69-1602-62099	1	0	0	11/1/2022	49	650	896	U	NR	H09	16297	UNL

Table 5. Total catch for trotlines set (n = 164 sets) during spring and fall 2022.

Common name	**Scientific name**	**Total**
Blue Sucker	*Cycleptus elongatus*	1
Common Carp	*Cyprinus carpio*	6
Channel Catfish	*Ictalurus punctatus*	35
Shorthead Redhorse	*Moxostoma macrolepidotum*	1
Flathead Catfish	*Pylodictis olivaris*	3
Sturgeon F1 Hybrid	*S. albus* x *platorhynchus*	1
Pallid Sturgeon	*Scaphirhynchus albus*	26
Shovelnose Sturgeon	*Scaphirhynchus platorhynchus*	242

Table 6. Mean pH, temperature, dissolved oxygen (DO), bottom velocity (Velocity), and conductivity with 95% confidence intervals (CI) where Pallid Sturgeon were captured and not captured for trotlines set in the lower Platte River. Velocity is bottom velocity. Captured indicates that ≥ 1 Pallid Sturgeon was captured on each trotline.

Variable	**Captured (CI)**	**Not Captured (CI)**
pH	8.0 (7.9–8.1)	8.2 (8.1–8.2)
Temperature (°C)	10.1 (8.1–12.1)	9.5 (8.8–10.2)
DO (mg/L)	14.0 (13.1–14.9)	13.8 (13.3–14.3)
Velocity (m/s)	1.6 (1.1–2.1)	1.6 (1.4–1.7)
Conductivity (µS/cm)	462 (293–631)	557 (500–614)
Depth ≤ 1.5 m	1.23 (1.05–1.41)	1.11 (1.04–1.18)
# Depth > 1.5 m	4	28

Table 7. Pallid Sturgeon entry and exit of the Platte River and Missouri River in 2022. Red shade denotes fall movement patterns of Pallid Sturgeon entering the Platte River. Asterisk (*) denotes last detection in the spring or summer on a Louisville receiver, indicating downstream movement [possibly] into the Missouri River.

	Platte River (Louisville Gauge)								Missouri River (Omaha Gauge)			
Acoustic ID	Date tagged or initially encountered	Date in	Date out	Total days	Temp in (◦C)	Temp out (◦C)	Mean Discharge in (cfs)	Mean Discharge out (cfs)	Temp in (◦C)	Temp out (◦C)	Discharge in (cfs)	Discharge out (cfs)
A69-1602-19520	5/28/22	10/5/22			18.9		2210				33100	
A69-1602-19542	9/23/22	9/23/22			16.2		2260				32100	
A69-1602-49254	9/30/22	9/30/22			16.5		2290				32000	
A69-1604-30381	10/7/22	10/7/22			14.9		2120				33500	
A69-1604-30391	9/25/22	9/25/22			18.9		2130				32100	
A69-1602-55355	3/19/22	10/10/22			15.9		2170				33200	
A69-1602-59046	5/26/22	9/24/22			18.1		2520				32100	
A69-1602-59365	10/14/22	10/14/22					1990				33100	
A69-1602-63209	10/10/22	10/10/22			15.9		2170				33200	
A69-9001-58906	4/16/22		6/20/22*			28.7		5680		26.7		28500
A69-1602-49253	4/7/22		6/24/22			26.6		4440		26.6		27700
A69-1602-54445	4/25/22	4/25/22			12		3840		12.5		28900	

	Platte River (Louisville Gauge)								Missouri River (Omaha Gauge)			
Acoustic ID	Date tagged or initially encountered	Date in	Date out	Total days	Temp in (◦C)	Temp out (◦C)	Mean Discharge in (cfs)	Mean Discharge out (cfs)	Temp in (◦C)	Temp out (◦C)	Discharge in (cfs)	Discharge out (cfs)
A69-1602-55342	3/28/22		5/19/22*			24.4		7880				
A69-1602-55362	4/29/22	4/29/22	6/18/22*	50	17.9	25.9	3700	9110	13	25.7	29000	30700
A69-1602-59042	4/9/22	4/9/22	5/23/22*	44	x	17.1	6250	5290	6.4	17.2	24900	27900
A69-1602-59354	4/28/22		6/15/22*			23.7		10600		25		31300
A69-1602-59359	4/5/22		5/28/22*			20.8		7150		17.1		28400
A69-1602-59578	5/30/22		6/24/22*			26.6		4440		26.6		27700
A69-1602-59977	5/8/22		5/30/22*			23.6		5450		21		28000
A69-1602-62101	3/29/22	3/29/22	5/13/22	45	x	24.1	6620	8850	6.3	20.1	25700	27500
A69-9001-58904	3/17/22		6/29/22*			26.8		3440			x	27900
A69-9001-58908	4/10/22	4/10/22	5/30/22*	50	x	23.6	6680	5450	6.8	21	24800	28000

Table 8. Pallid Sturgeon entry and exit to/from the Elkhorn River and Platte River in 2022.

	Elkhorn River (Waterloo Gauge)								Platte River (Leshara Gauge)			
Acoustic ID	Date tagged or initially encountered	Date in	Date out	Total days	Temp in (◦C)	Temp out (◦C)	Discharge in (cfs)	Discharge out (cfs)	Temp in (◦C)	Temp out (◦C)	Discharge in (cfs)	Discharge out (cfs)
A69-1602-49253	4/7/2022	4/27/2022	6/3/2022	37	14.9	21.9	1089	1662	15	23	4410	4020
A69-1602-55362	4/29/2022	5/11/2022	6/15/2022	35	22.9	25.8	2233	1694	23	25	5200	4970
A69-9001-58904	3/17/2022	5/1/2022	6/27/2022	46	13.3	24.9	1463	986	12	25	5400	2260
A69-9001-58905	3/17/2022	5/9/2022	6/18/2022	40	19.9	28.7	2069	1385	21	29	5930	4400
A69-9001-58906	4/16/2022	5/9/2022	6/19/2022	41	19.9	28.9	2069	1305	21	28	5930	3870
A69-1602-58917	5/8/2022	5/8/2022	5/16/2022	8	16.6	21.4	2134	1991	17	22	5670	4970
A69-1602-59024	4/19/2022	4/26/2022	4/28/2022	2	13	18.1	1166	1122	13	19	3160	2560
A69-1602-59578	5/30/2022	6/3/2022	6/24/2022	21	21.9	27.3	1662	1086	23	27	4020	3110

Table 9. Number of hours spent active tracking, number of detections collected, and mean detections per hour (DPH) in each segment of the Lower Platte River during 2022.

Segment	Hours Tracked	Number of Detections	Mean DPH (CI)
Downstream of Elkhorn River	140.8	35	0.323 (0.219 - 0.426)
Upstream of Elkhorn River	138.4	1	0.006 (0 - 0.042)
Elkhorn River	50.3	8	0.147 (0.093 - 0.201)
All	329.5	44	0.172 (0.069 - 0.275)

Table 10. Number of hours spent active tracking, number of detections collected, and mean detections per hour (DPH) in the Lower Platte River during each season 2022.

Season	Hours tracked	Number of detections	Mean DPH (CI)
Spring (through 3/20/22)	130.8	37	0.323 (0.124 - 0.522)
Summer (start 6/21/22)	138.2	1	0.008 (0 - 0.023)
Fall (start 9/22/22)	60.5	6	0.081 (0 - 0.214)
All	329.5	44	0.172 (0.069 - 0.275)

Table 11. Mean pH, temperature, dissolved oxygen, turbidity, bottom velocity (Velocity), and conductivity with 95% confidence intervals (CI) where Pallid Sturgeon were actively detected in the lower Platte River basin.

Variable	**Mean at Detection (CI)**
pH	8.41 (8.13 – 8.69)
Temperature (°C)	16.5 (14.9 – 18.1)
DO (mg/L)	12.7 (10.4 – 15.0)
Turbidity (NTU)	103 (68 – 138)
Velocity (m/s)	0.52 (0.38 – 0.66)
Conductivity (µS/cm)	520 (435 – 605)
Mean ≤ 1.5 m	0.92 (0.83 – 1.00)
# > 1.5	12

Table 12. Larval fish sampling locations, effort, and volume of water sampled May – June, 2022. Specific locations are shown in Figure 17. Sites are identified as general locations for both routine, weekly sampling and targeted sampling at suspected spawning locations as determined by telemetry.

General sample area	Weekly/Target	Number days sampled	Total number nets	Volume sampled (m^3)
Platte River confluence	Weekly	14	77	92,360.5
Lower Platte River	Target	5	19	9,765.7
Elkhorn River and confluence area	Both	19	74	412,089.3
Loup River confluence	Target	1	8	27,150.9
Total		39	178	541,366.4

Table 13. Mean pH, temperature, dissolved oxygen (DO), turbidity, bottom velocity (Velocity), and conductivity with 95% confidence intervals (CI) of larval net deployments (n = 178).

Variable	**Mean at deployment (CI)**
pH	8.63 (8.77 – 8.68)
Temperature (°C)	21.8 (21.1 – 22.5)
DO (mg/L)	11.3 (10.7 – 11.9)
Turbidity (NTU)	178 (148 - 208)
velocity (m/s)	0.68 (0.67 – 0.75)
Conductivity (µS/cm)	580 (521 - 629)
Mean ≤ 1.5 m	1.15 (1.08 – 1.22)
# > 1.5 m	84

Table 14. The total catch of larval fish collected in the lower Platte River and Elkhorn River. Individuals were identified to Family where possible (n = 88). Unknown individuals are listed as UNK.

	Acipenseridae	**Cyprinidae**	**Catostomidae**	**Clupeidae**	**Ictaluridae**	**UNK**
Platte River	0	41	8	1	1	32
Elkhorn River	0	3	1	0	0	1
Total	0	44	9	1	1	33

*Note: One egg was collected in the Elkhorn River and one in the Platte River. A larval sturgeon was also captured at the Platte River – Missouri River confluence area during sampling for a concurrent project.

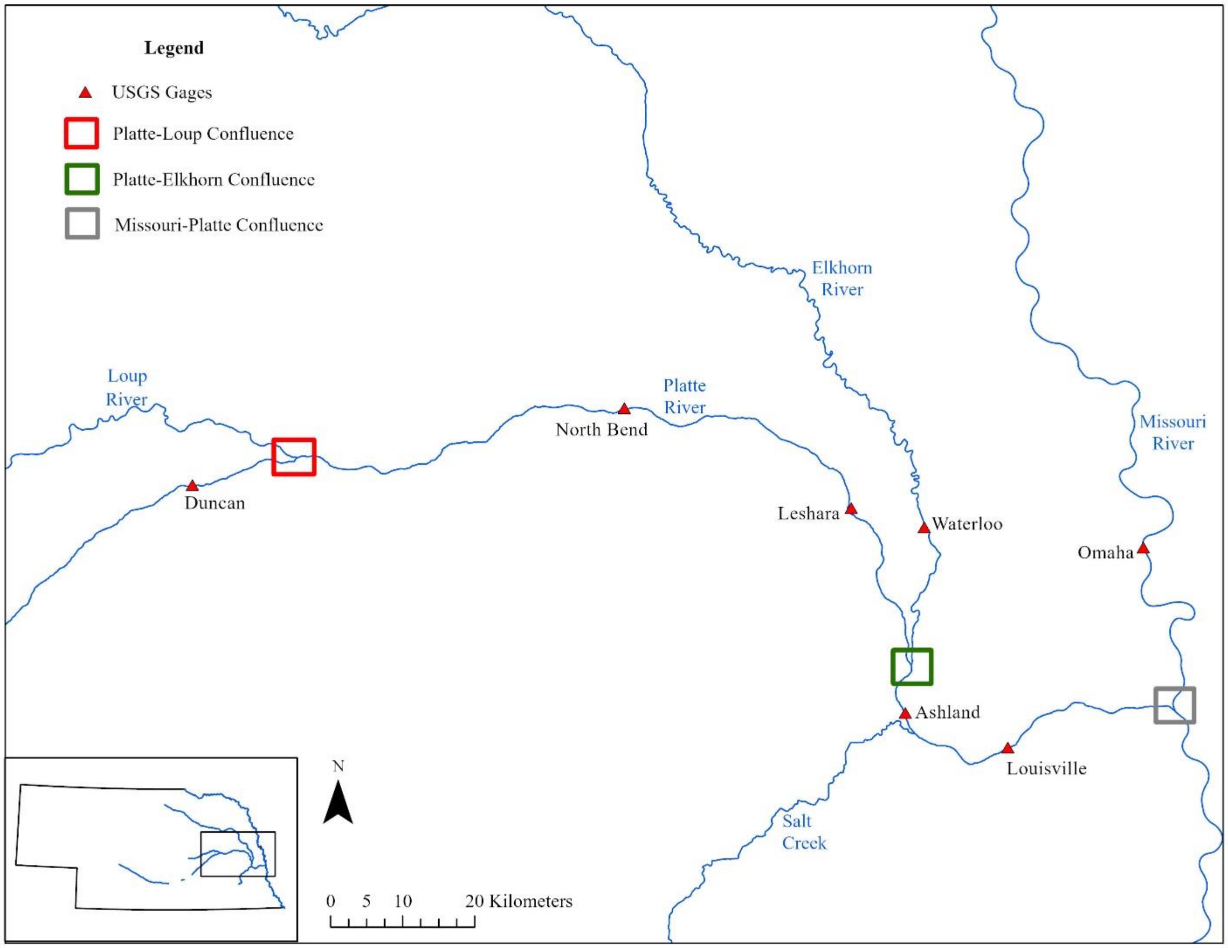


Figure 1. Map of the lower Platte River and its tributaries. Boxed areas indicate locations where two rivers converge.

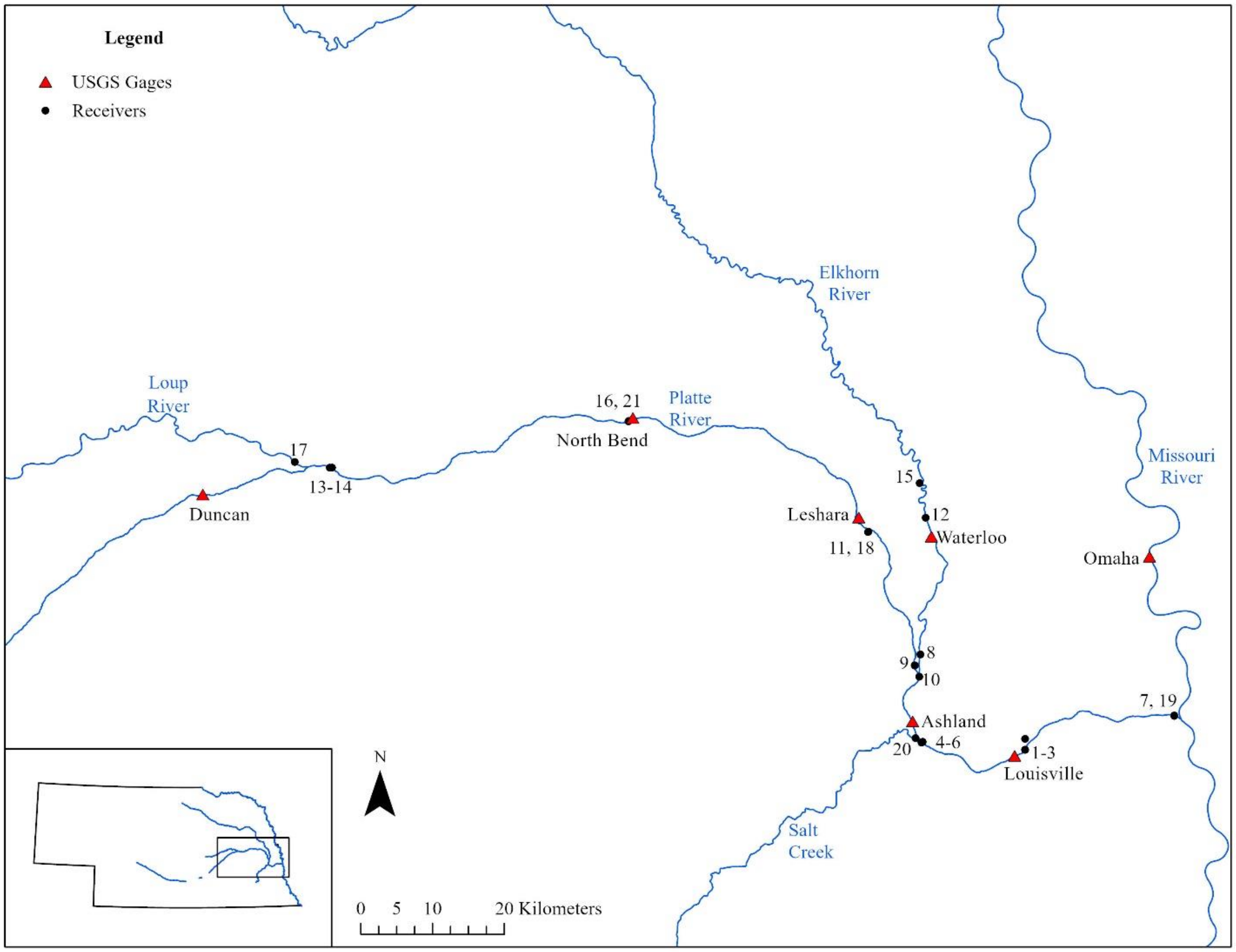


Figure 2. Locations of receivers and USGS gages used throughout the lower Platte River and its tributaries during 2022. The numbers on the map are referenced to receiver numbers identified in Table 1. Receiver gates (a series of 2 or more receivers) are indicated with a range of numbers (e.g., receivers 1-3 near the Louisville gage indicates 3 receivers are placed across the river to optimize detection coverage).

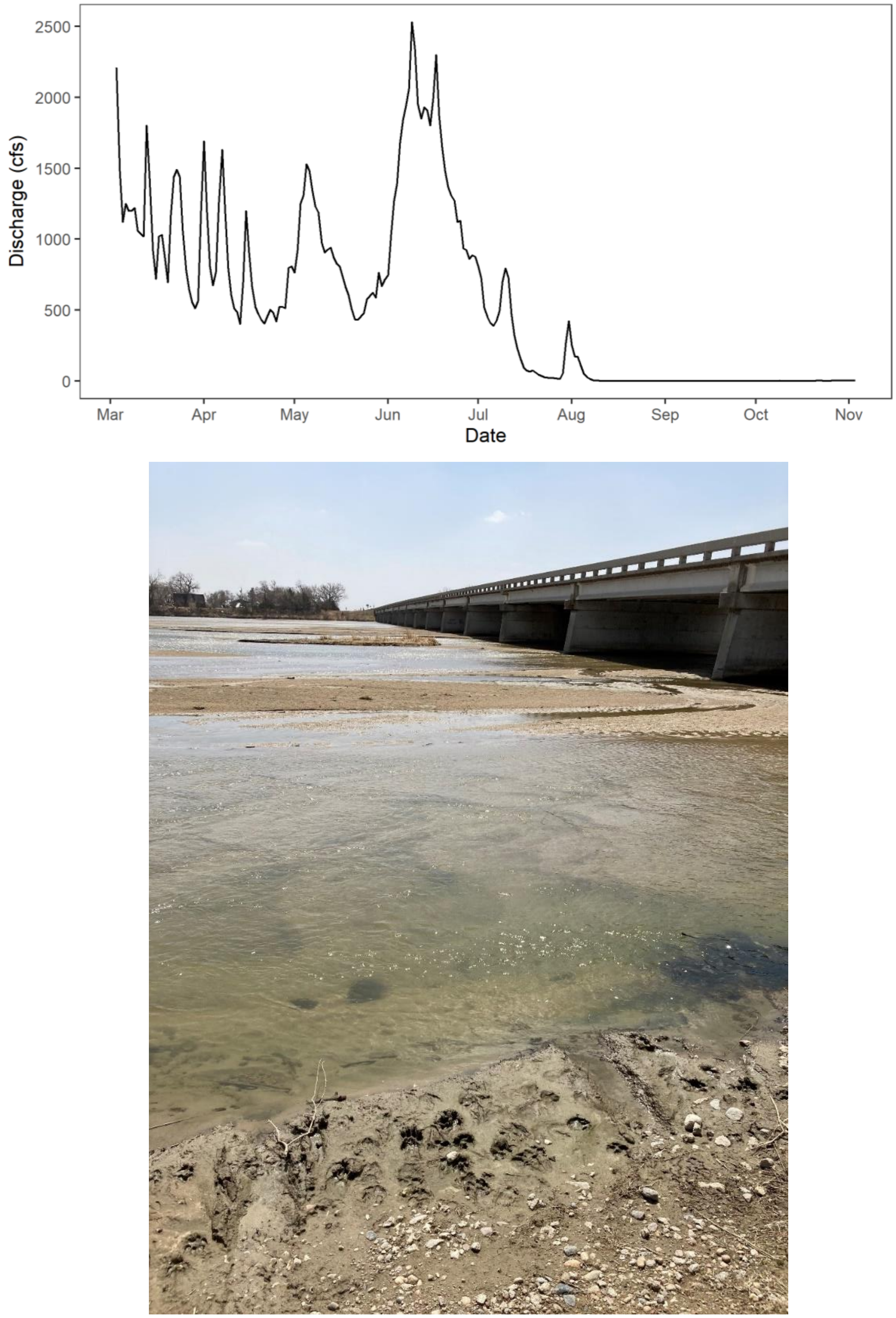


Figure 3. Mean daily discharge in cubic feet per second (cfs) at Duncan (USGS gage 06774000) during Pallid Sturgeon sampling in 2022 (top) and photo of Platte River at Columbus, Nebraska (U.S. Highway 81) on April 22, 2022 (bottom). The Duncan gage is the nearest upstream gage to Columbus, Nebraska.

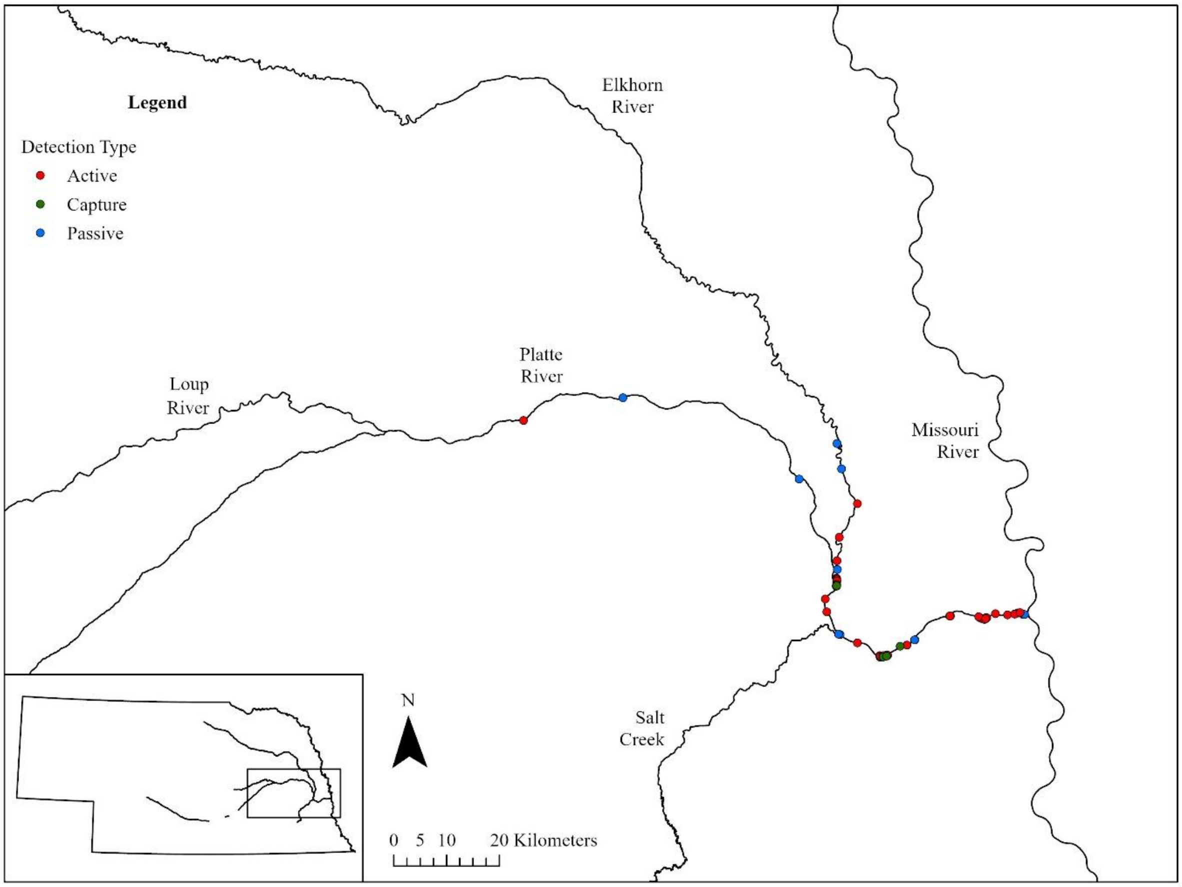


Figure 4. Map indicating locations of Pallid Sturgeon captures (green circles), active detections (red circles), or passive detections (blue circles) throughout the lower Platte River system during 2022.

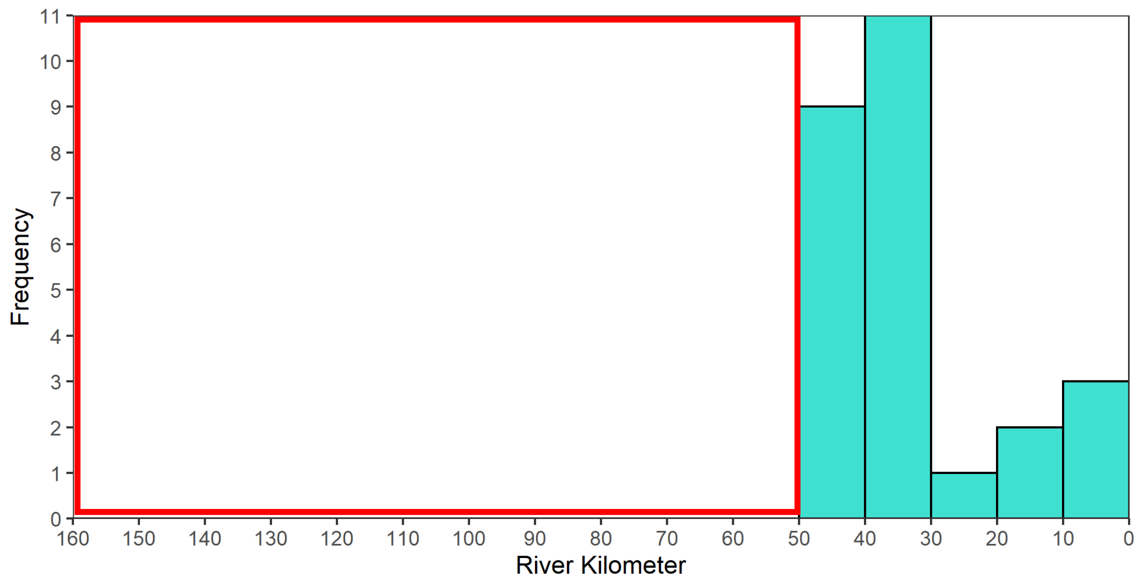


Figure 5. Pallid Sturgeon capture frequency in the lower Platte River from March 3, 2022 to November 3, 2022. Blue bars indicate number of Pallid Sturgeon captured in each 10-km reach sampled. Note that trotlines were fished solely in the lower 50 km of the Platte River in 2022. The red box indicates where fishing efforts did not take place, but will in the future.

Figure 6. Ventral (left) and lateral (right) view of the F1 hybrid sturgeon captured in 2022. Barbels are relatively straight across and equal size characteristic of a Shovelnose Sturgeon. Belly scutes were absent, characteristic of a Pallid Sturgeon.

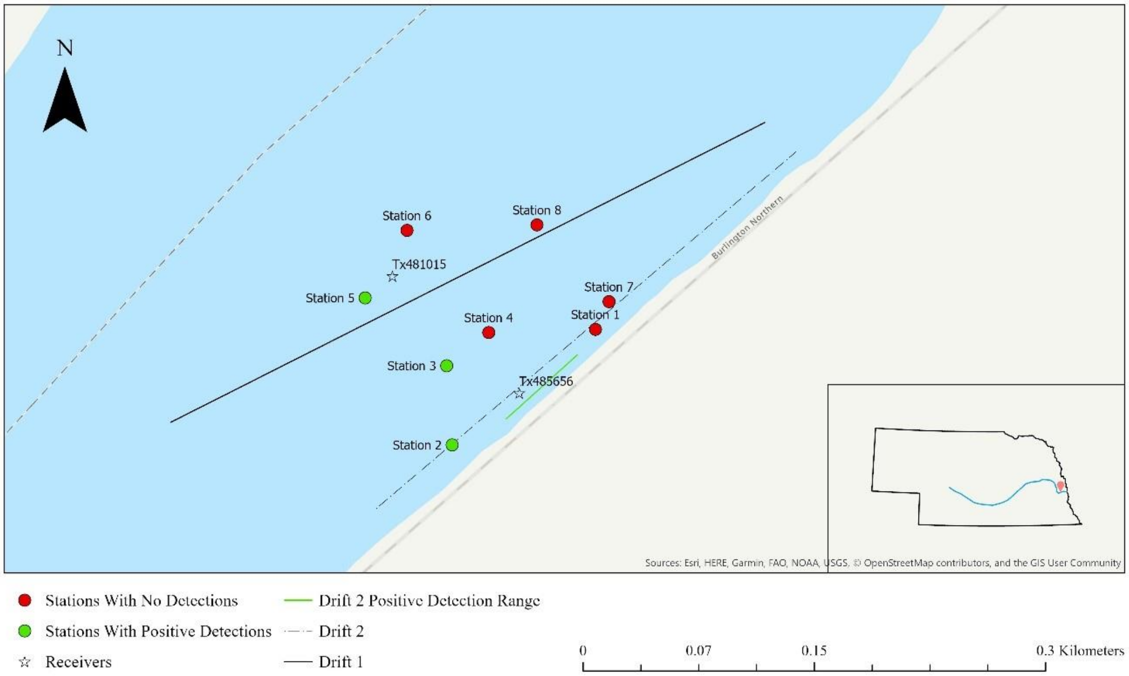


Figure 7. Range test results from December 14, 2021 on the Platte River near Louisville, Nebraska in which stations (red circles = stations with no detections, green circles = stations with positive detections), receiver locations (stars), and drifts (solid line = drift 1, dashed line = drift 2, green line = positive detections during drift) are shown.

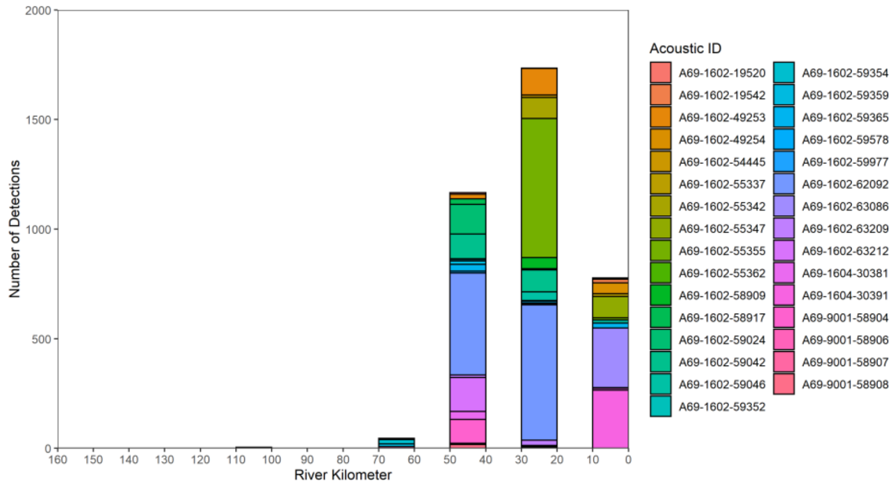


Figure 8. Passive tracking detection frequency in the lower Platte River from March 3, 2022 to November 3, 2022. Distance on the x-axis is in river kilometers (rkm) upstream from the mouth of the Platte River (rkm 0).

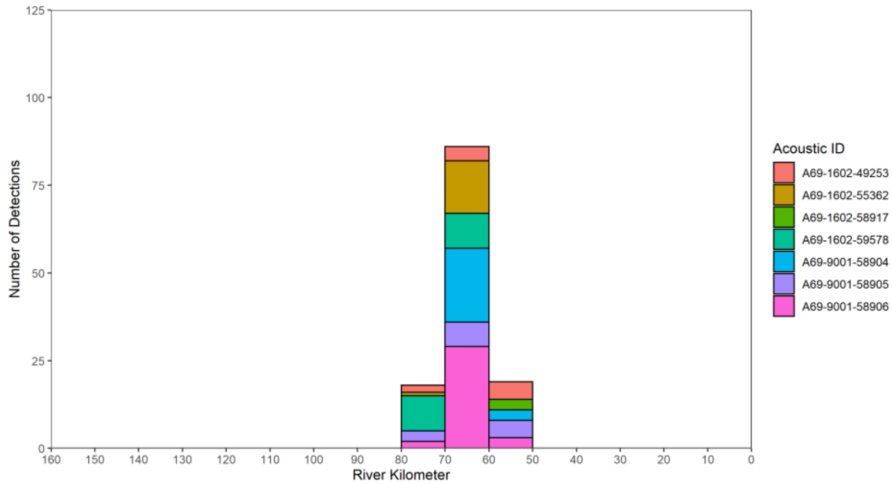


Figure 9. Passive tracking detection frequency in the Elkhorn River from March 3, 2022 to November 3, 2022. Distance on the x-axis is in river kilometers (rkm) upstream from the mouth of the Platte River (rkm 0). Note that the mouth of the Elkhorn River is located the rkm 50-60 cell where it empties into the Platte River. All other locations shown are in the Elkhorn River.

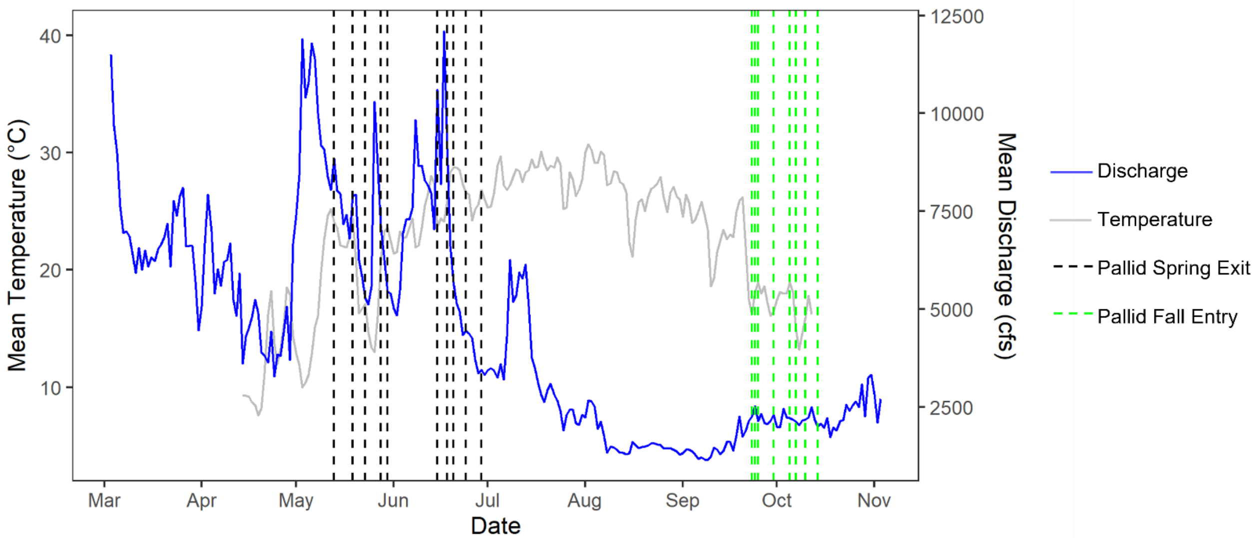


Figure 10. Suspected Platte River exit or marked downstream movement (dashed, black line) and entry (dashed, green line) by Pallid Sturgeon during 2022. Mean daily discharge (blue line; cubic feet per second; cfs) and temperature (gray line) from the Louisville USGS gage (06805500) are represented. A detection indicating entry or downstream movement does not necessarily specify a Pallid Sturgeon entered or left the Platte River system on that specific date.

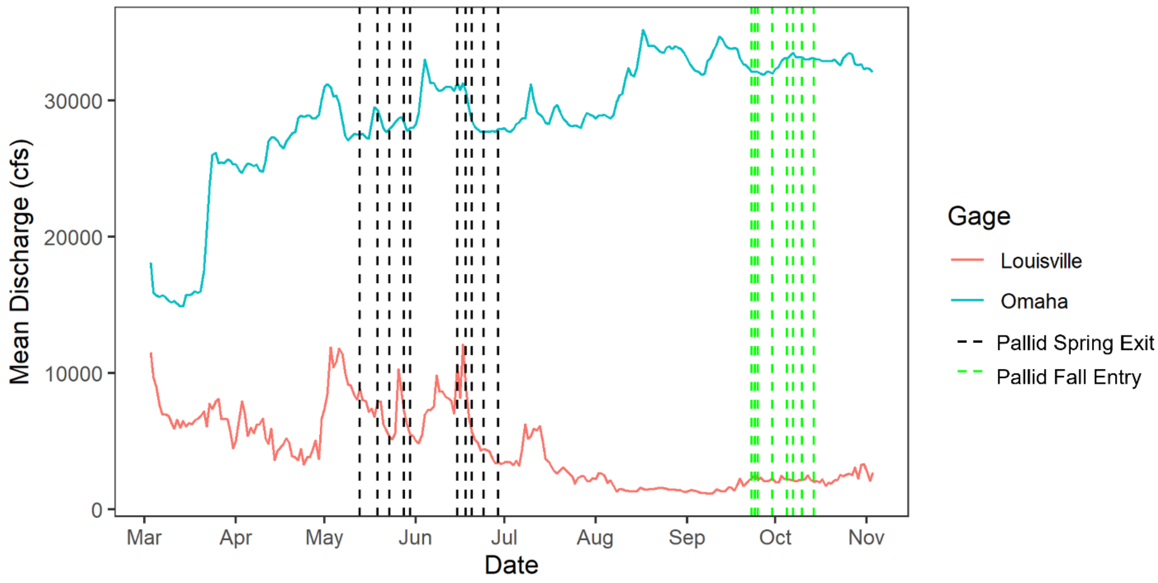


Figure 11. Suspected Platte River exit (dashed, black line) and entry (dashed, green line) by Pallid Sturgeon during 2022. Mean daily discharge (cubic feet per second; cfs) of the Platte River (red) at the Louisville (06805500) and Missouri River (blue) at the Omaha (06610000) USGS gages are provided for general reference of conditions in each river at time of entry/exit. A detection indicating entry or downstream movement does not necessarily specify a Pallid Sturgeon entered or left the Platte River system on that specific date.

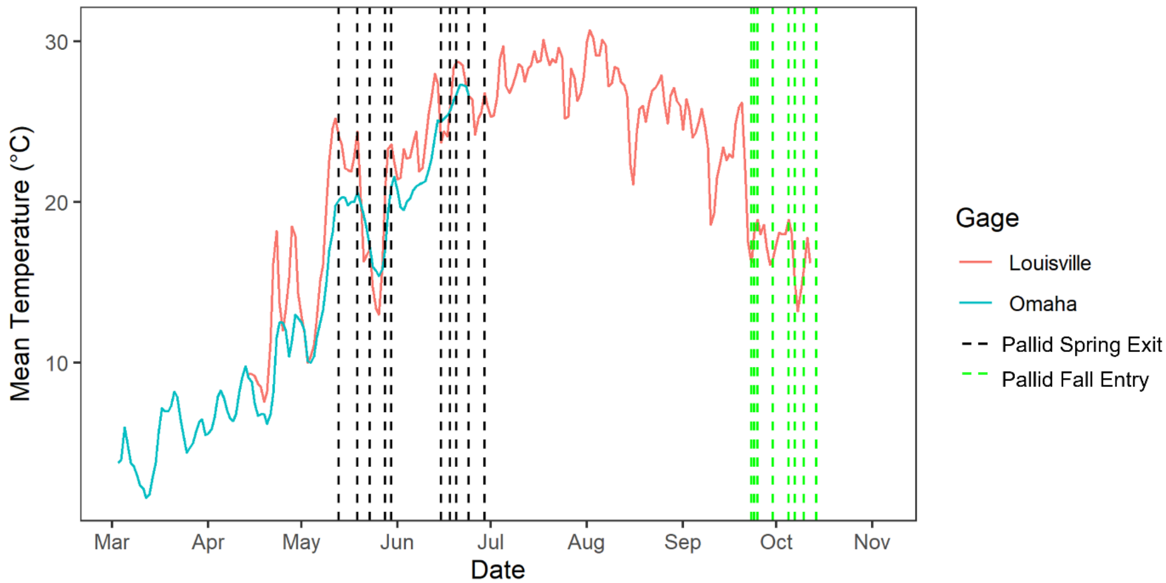
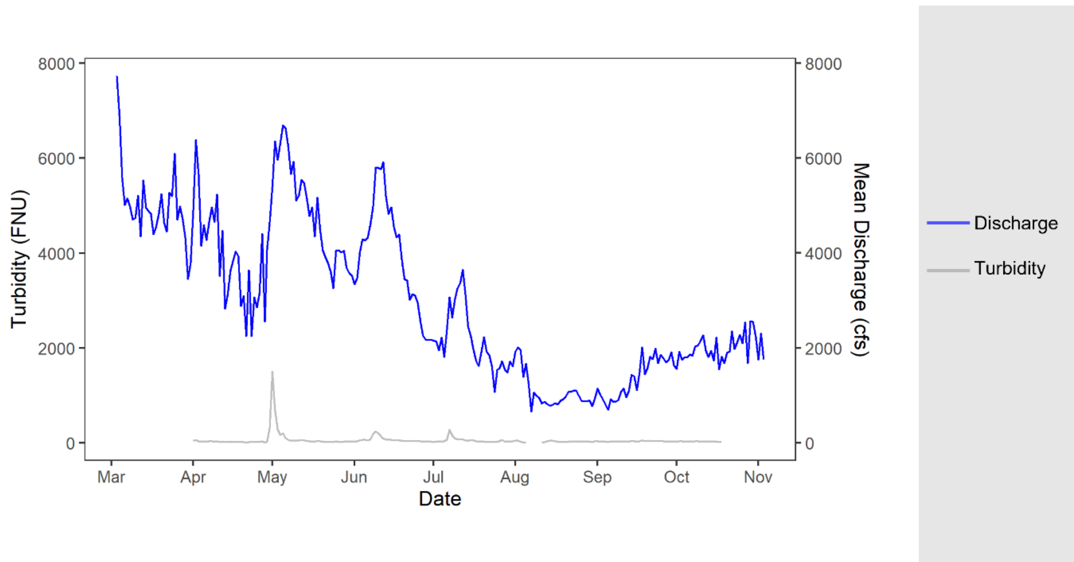


Figure 12. Platte River exit (dashed, black line) and entry (dashed, green line) by Pallid Sturgeon during 2022. Mean daily temperature (°C) of the Platte River (red) at the Louisville (06805500) and Missouri River (blue) at the Omaha (06610000) USGS gages are provided for general reference of conditions in each river at time of entry/exit. A detection indicating entry or downstream movement does not necessarily specify a Pallid Sturgeon entered or left the Platte River system on that specific date.



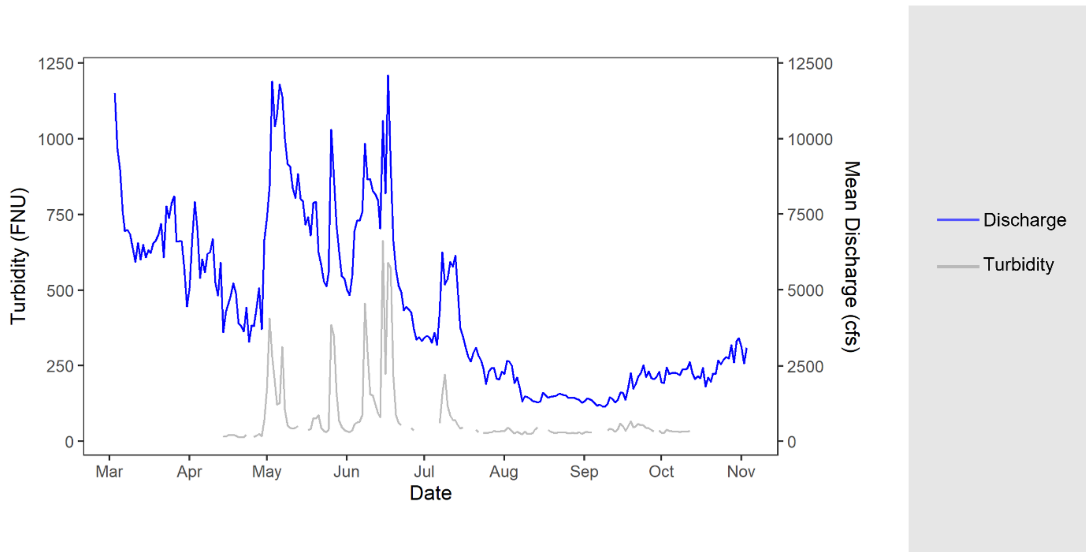


Figure 13. Mean daily discharge (blue; cubic feet per second; cfs) and turbidity (gray; Formazin Nephelometric Unit; FNU) in 2022 determined by the USGS gage at Leshara (06796500) (top) and USGS gage at Louisville (06805500) (bottom).

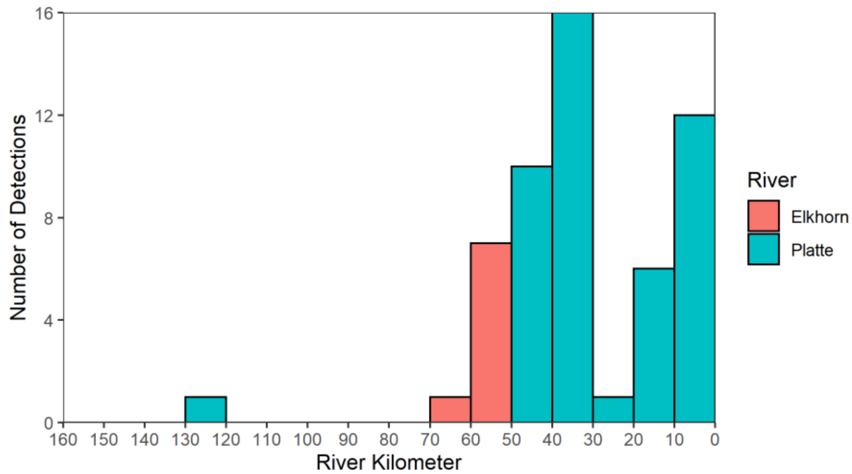


Figure 14. Total number of detections from active tracking river sweeps in the lower Platte River (blue) and Elkhorn River (pink) from March 3, 2022 to November 3, 2022.

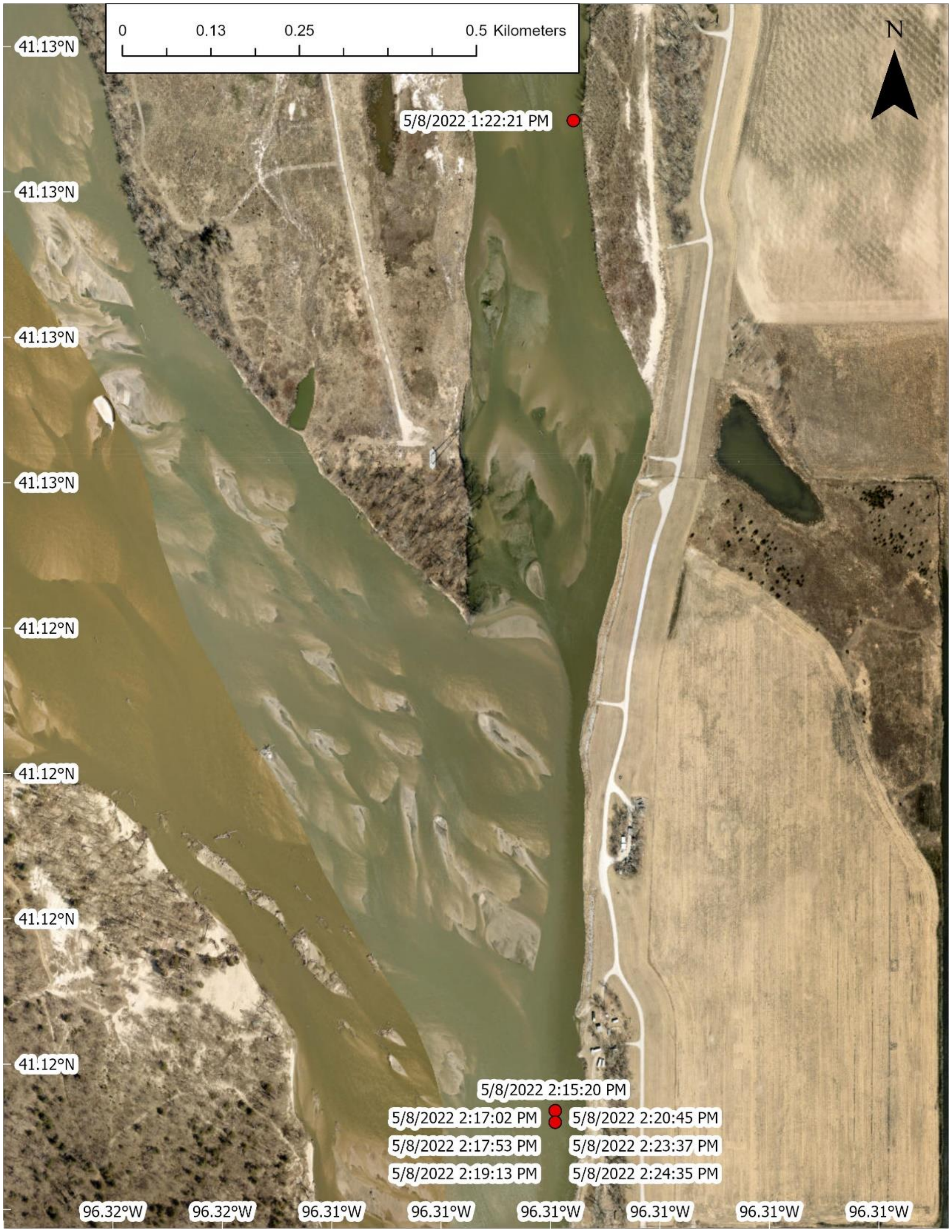


Figure 15. Suspected spawning movement behavior exhibited by Pallid Sturgeon A69-1602-58917 at the mouth of the Elkhorn River, flowing into the lower Platte River during a monthly active tracking sweep. Timestamps (date-central time zone) denote when the fish was detected multiple times downstream in the Platte River of the initial upstream detection within the Elkhorn River.

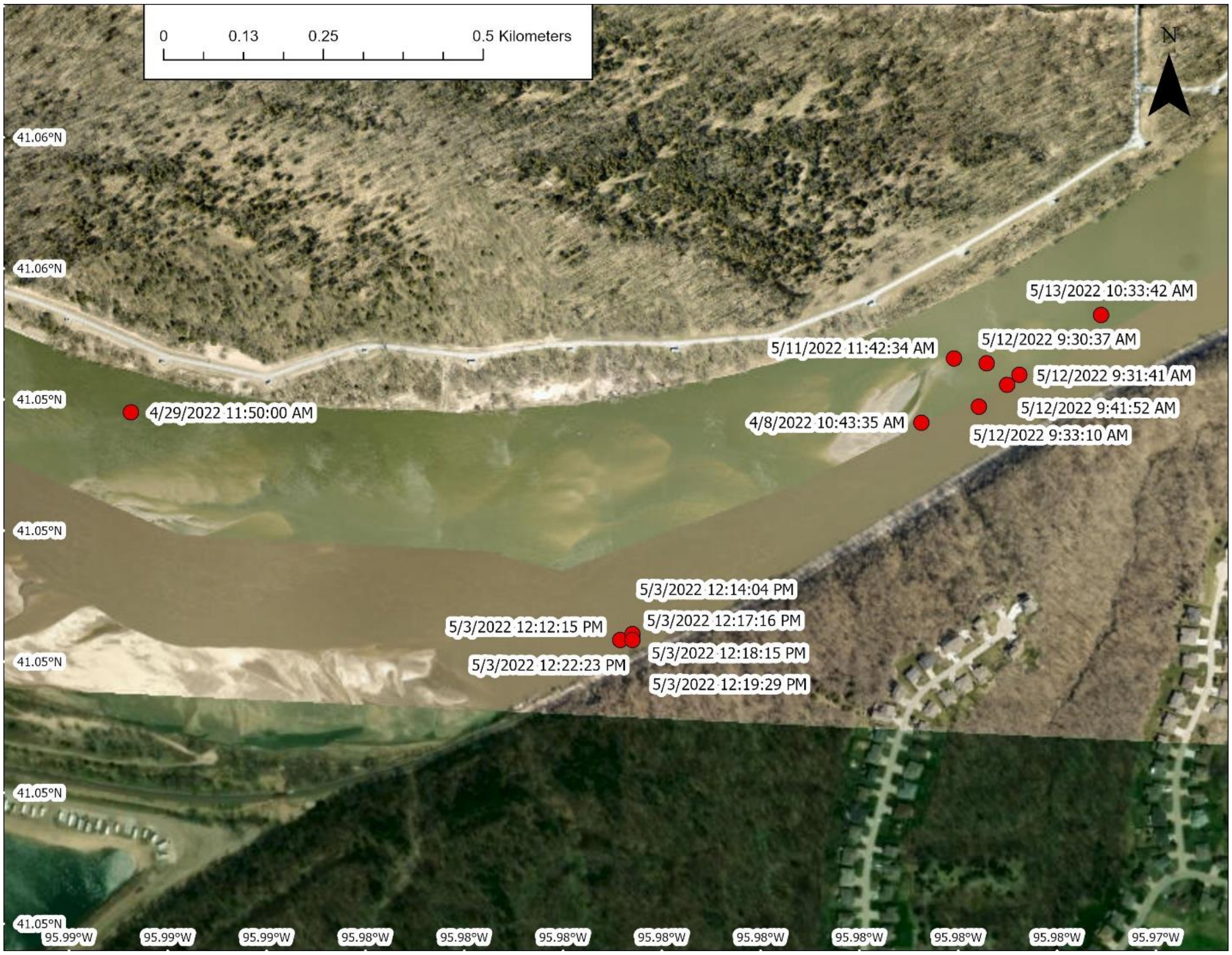


Figure 16. Suspected spawning movement behavior exhibited by Pallid Sturgeon A69-1602-62101 at the mouth of the Elkhorn River, flowing into the lower Platte River following intensive tracking efforts. Timestamps (date-central time zone) denote when the fish was detected multiple times downstream in the Platte River of the initial upstream detection within the Elkhorn River.

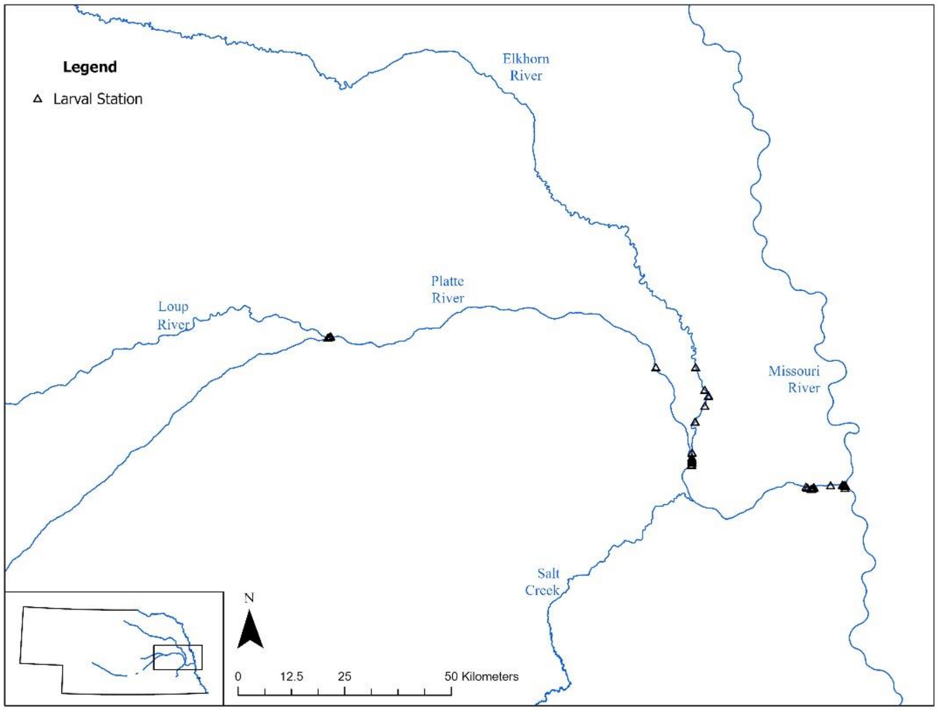


Figure 17. Locations of larval stations sampled throughout the lower Platte River and its tributaries in 2022.

Figure 18. Image of ichthyoplankton net deployment on the Platte River in 2022.

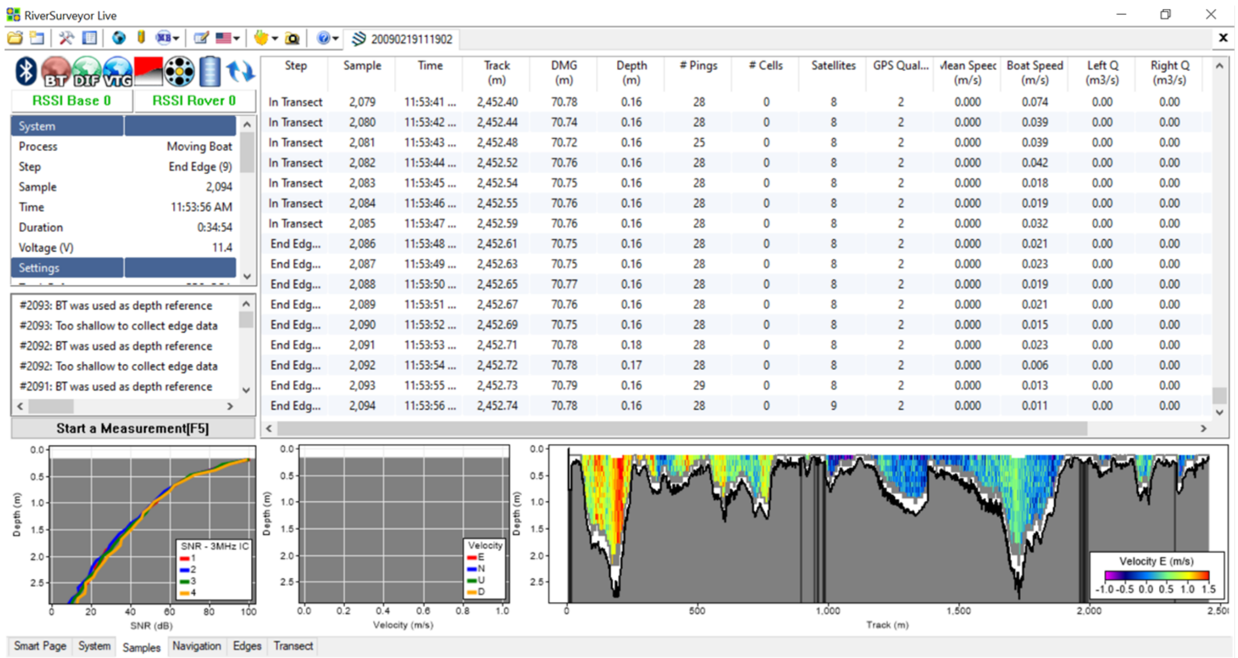
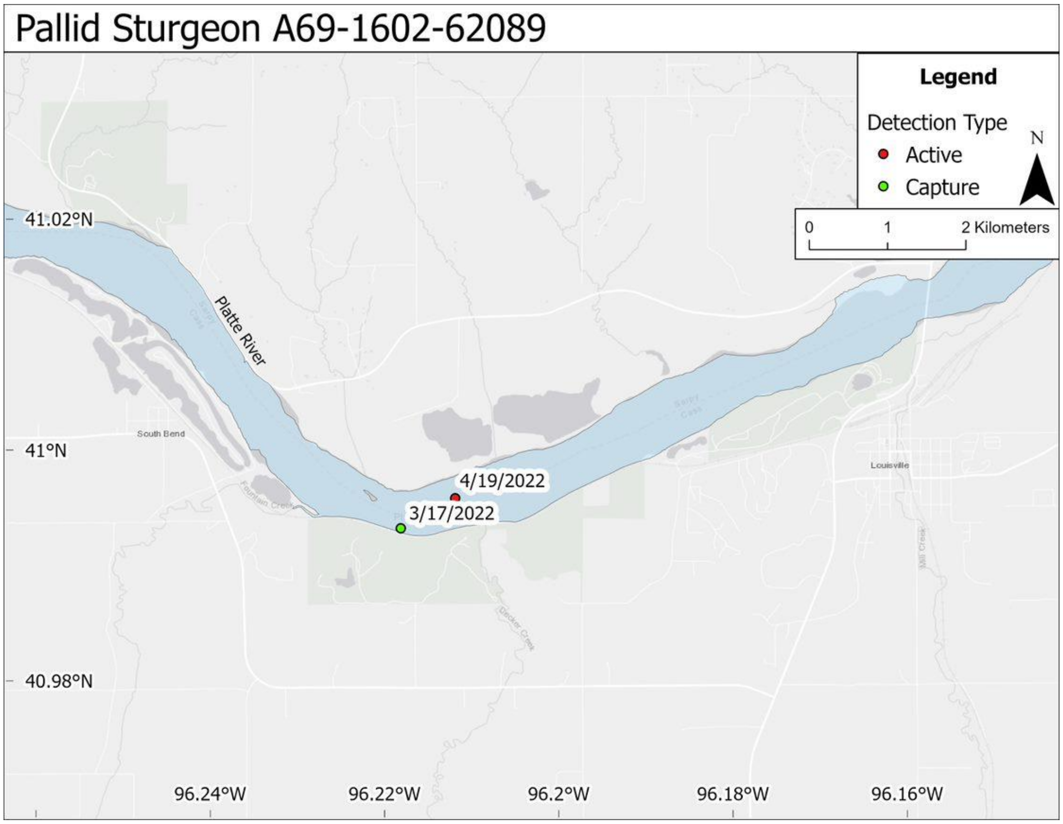


Figure 19. Pilot habitat data collected on October 5th, 2022 using an acoustic doppler current profiler (ADCP) on the Platte River near Louisville, Nebraska. The ADCP generates a depth profile and water velocity profile (lower right figure).

Appendix A: Individual fish movement summary information

The figures in this appendix highlight individual movement history information for each fish having an acoustic transmitter that was encountered in the Platte River during 2022. Table A-1 summarizes those fish having only one detection. The figures are designed to show locations of each individual on an overlay of the lower Platte River Basin (top) as well as straight line movements (bottom) with associated hydrologic information relative to their specific location(s) using the USGS Louisville Gage (06805500) for the Platte River and the USGS Waterloo Gage (06800500) for the Elkhorn River. Capture location is indicated as a green dot, active tracking detection location is indicated as a red dot, and passive tracking detections are indicated as a blue dot on both the map and the inset portions of the figures. Several individuals moved into the Elkhorn River for varying periods of time over the course of 2022. Gray boxes on the inset indicate the general timeframe those individuals were in the Elkhorn River. Specific details are given for each individual in their respective captions.

Our passive and tracking efforts also detected one Blue Sucker *Cycleptus elongatus*, originally tagged in a South Dakota tributary to the Missouri River, seven Silver Carp *Hypophthalmichthys molitrix* initially tagged in the Missouri River near Gavins Point Dam, and one Silver Carp tagged in the Little Sioux River, a tributary to the Missouri River in Iowa. Location data for these fish have been provided to their respective project leads for further analyses.



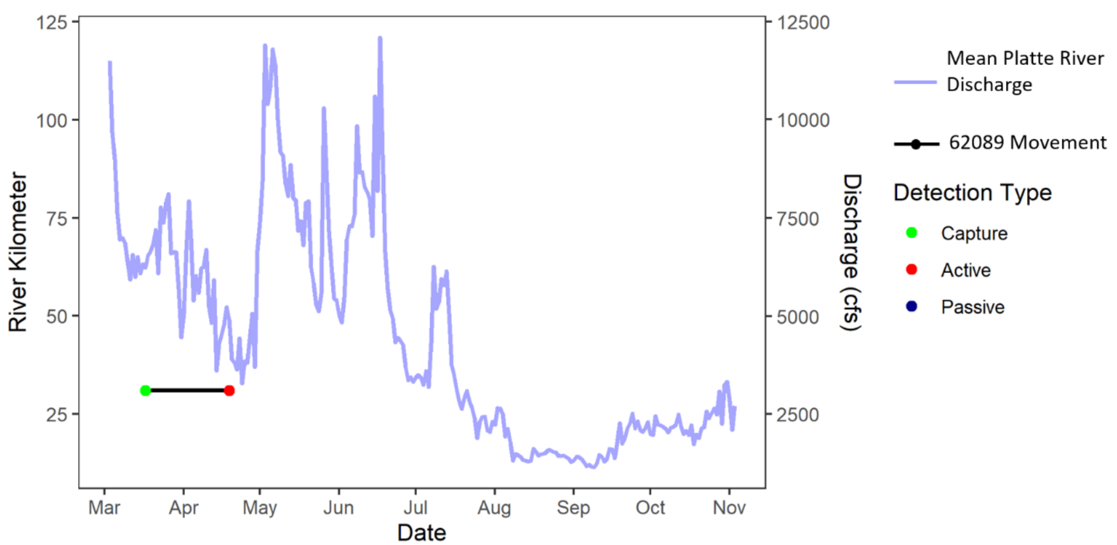


Figure A-1. Capture location and relocations of Pallid Sturgeon A69-1602-62089 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

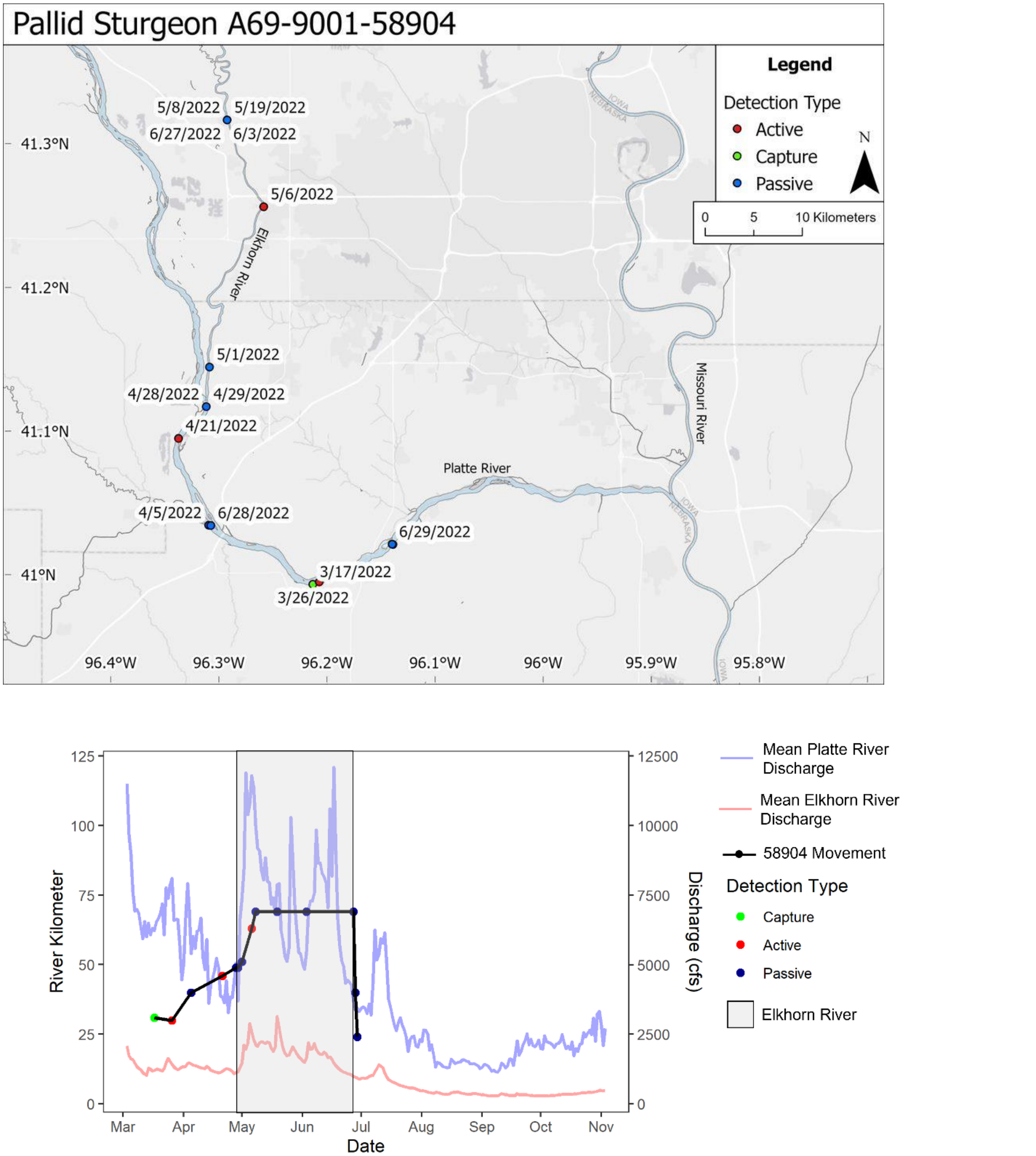


Figure A-2. Capture location and relocations of Pallid Sturgeon A69-9001-58904 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

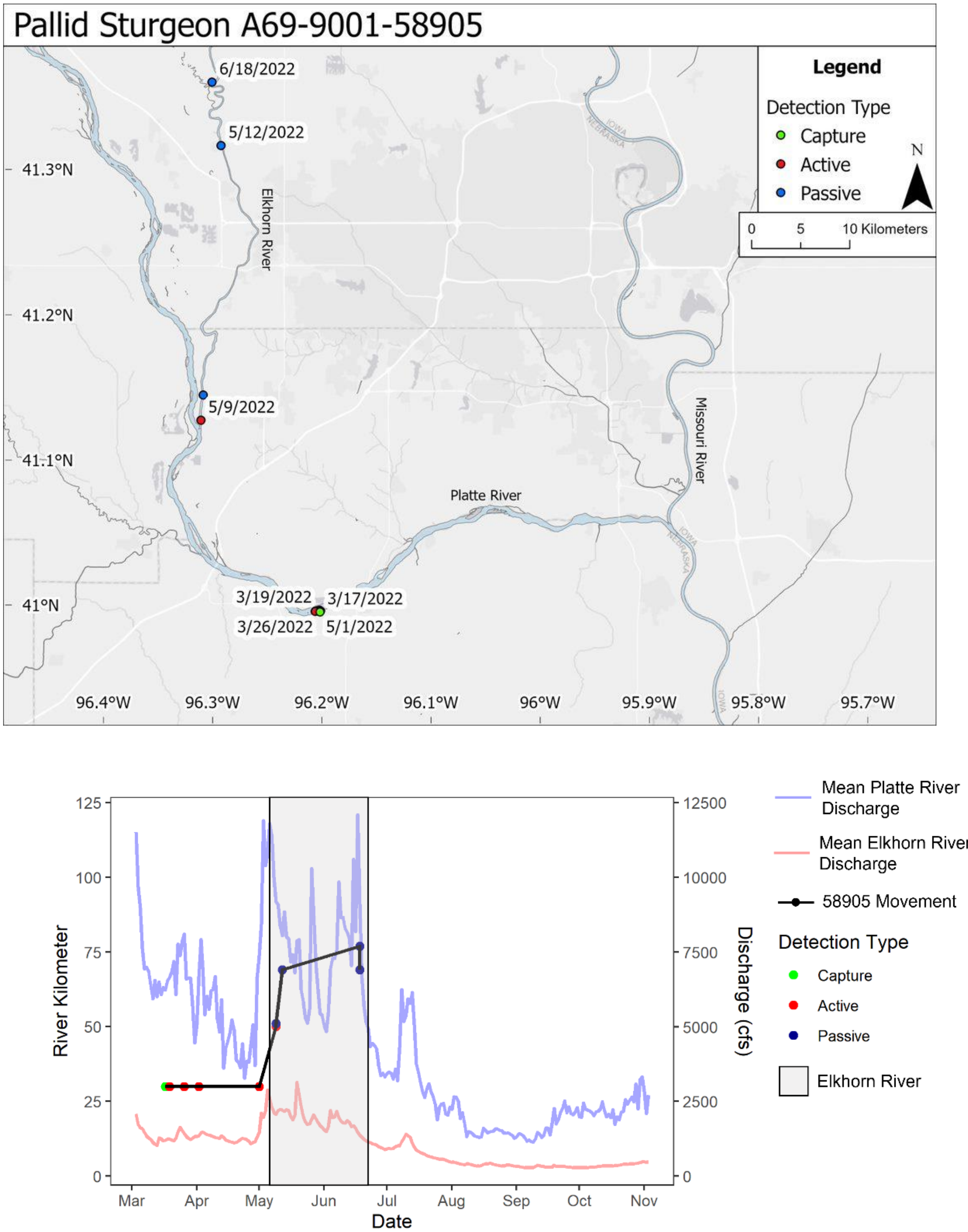
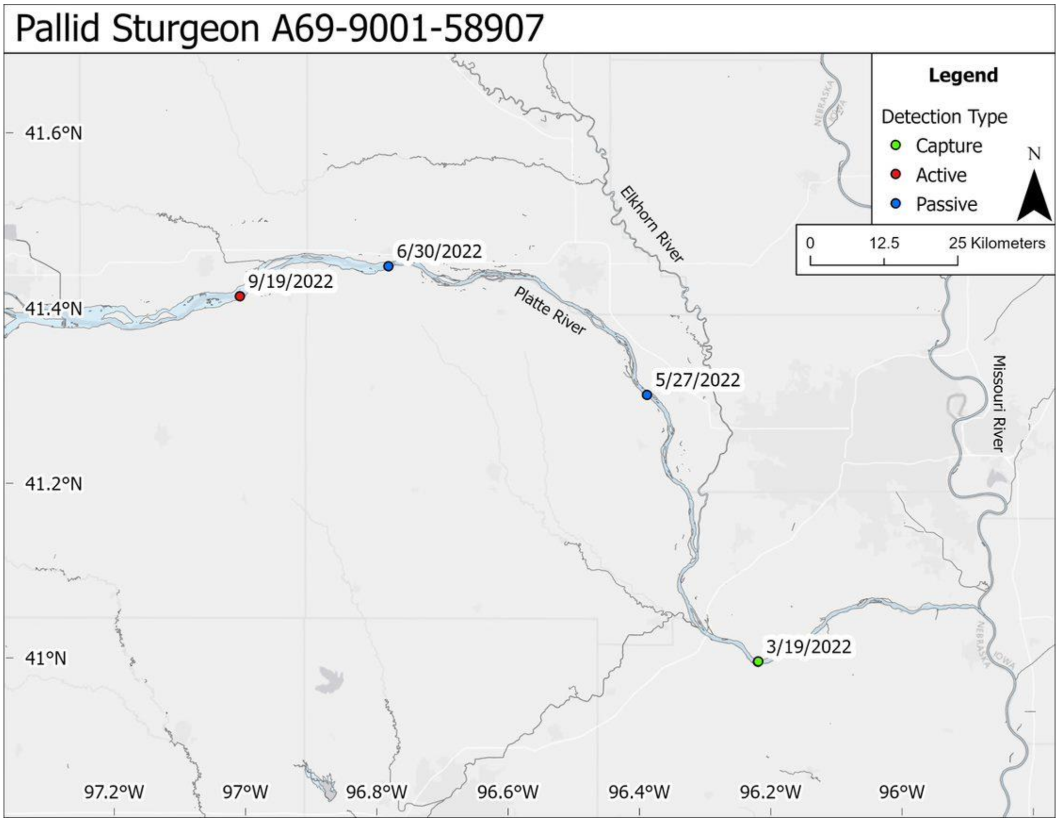


Figure A-3. Capture location and relocations of Pallid Sturgeon A69-9001-58905 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).



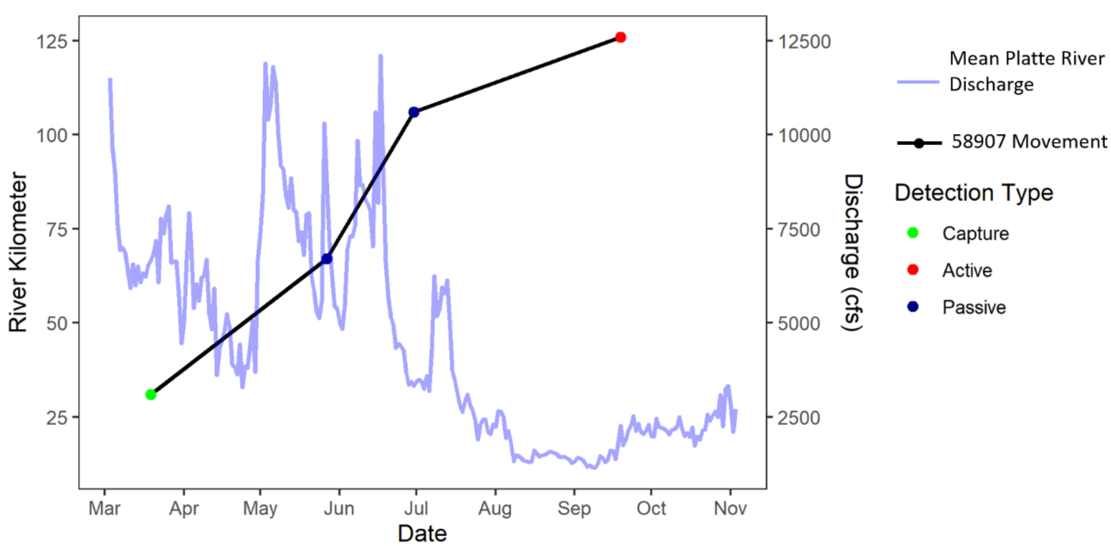
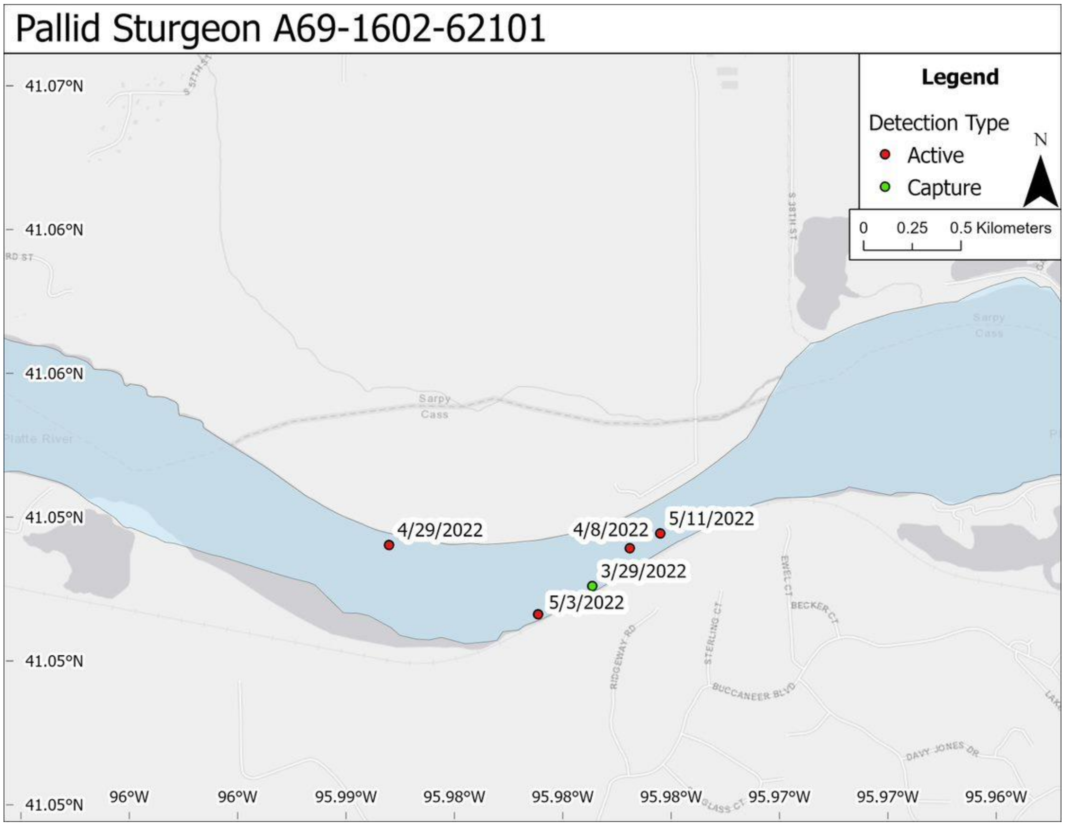


Figure A-4. Capture location and relocations of Pallid Sturgeon A69-9001-58907 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



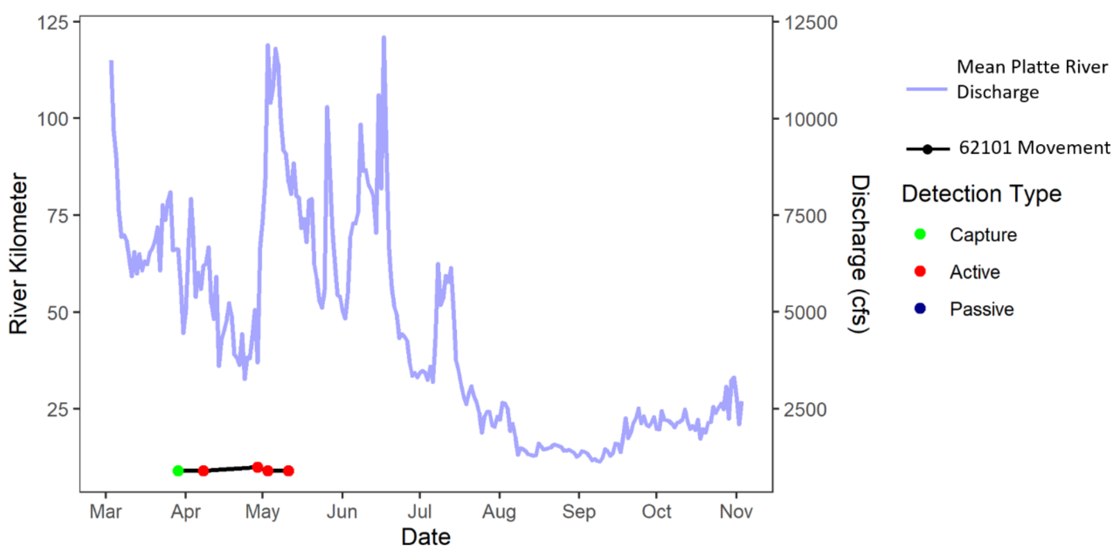


Figure A-5. Capture location and relocations of Pallid Sturgeon A69-1602-62101 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs). See Figure 16 for potential spawning related movements.

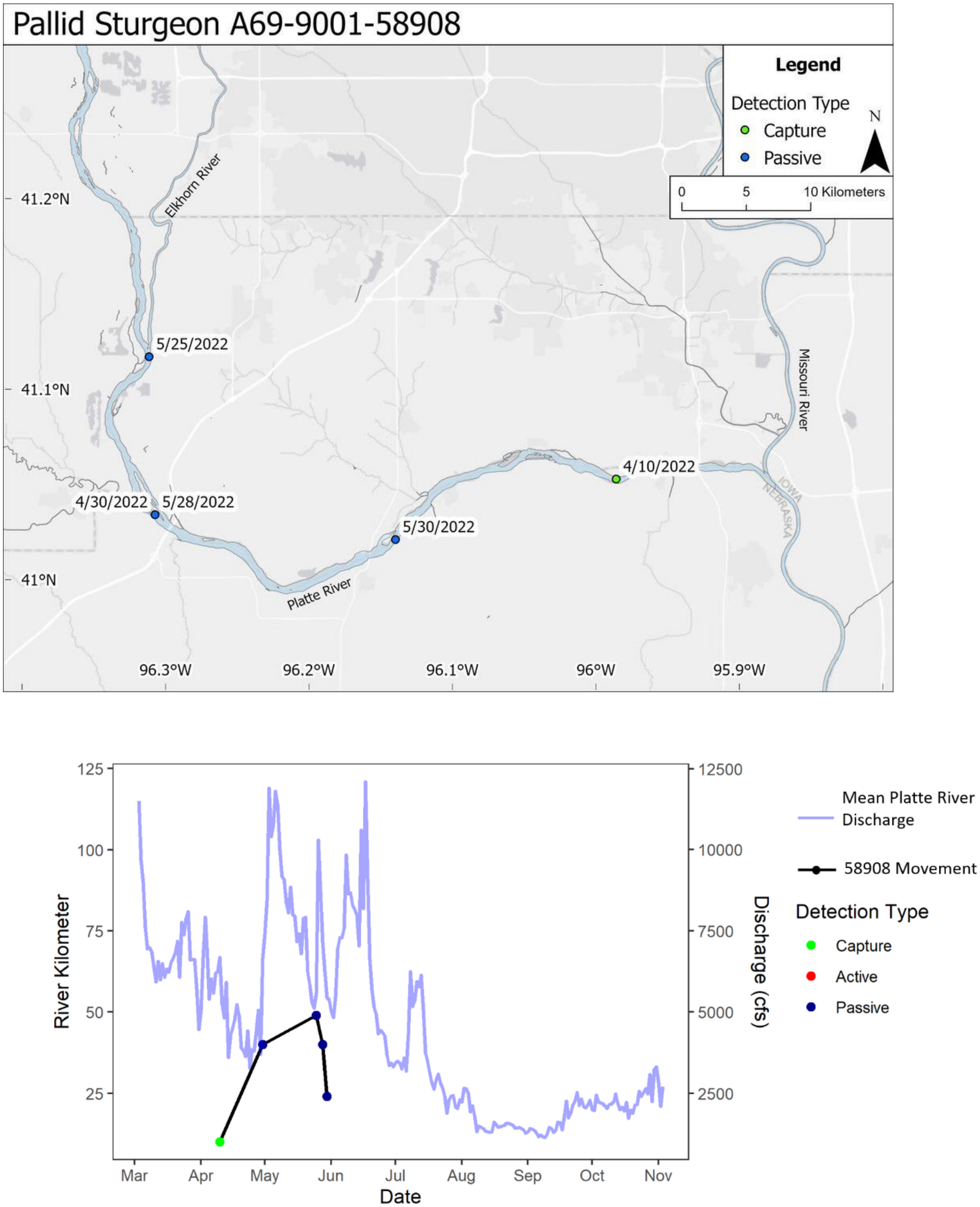
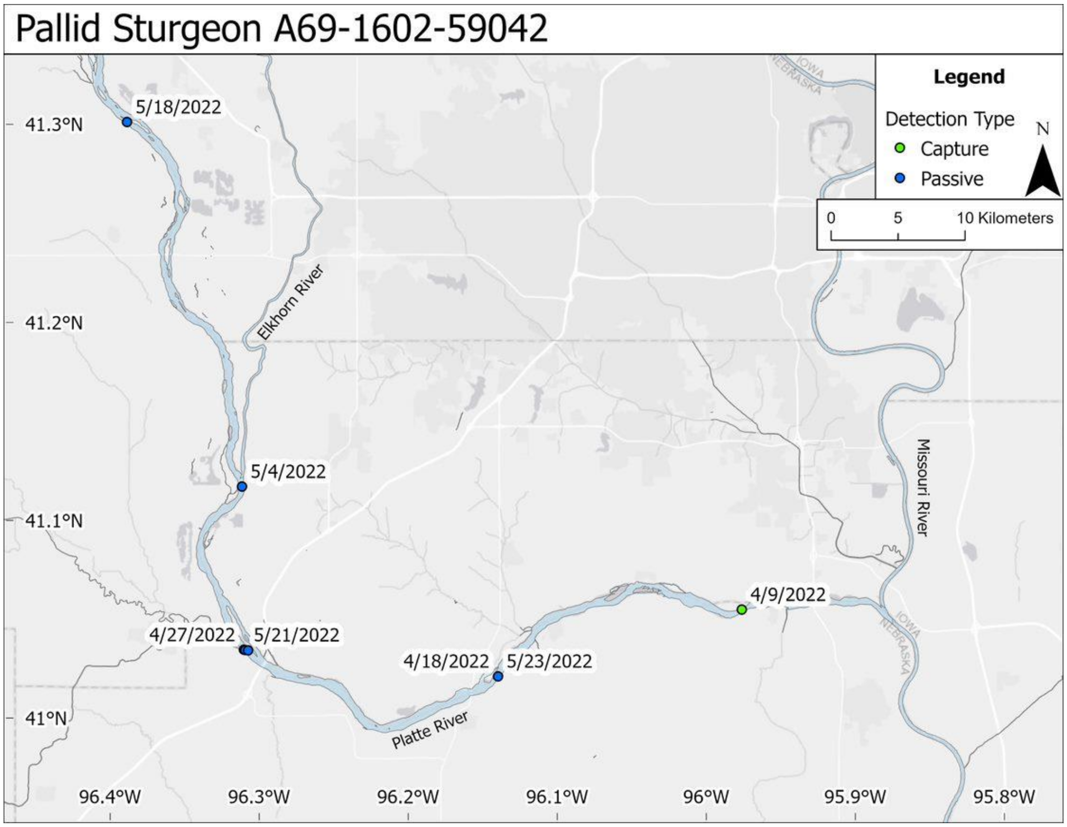


Figure A-6. Capture location and relocations of Pallid Sturgeon A69-9001-58908 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



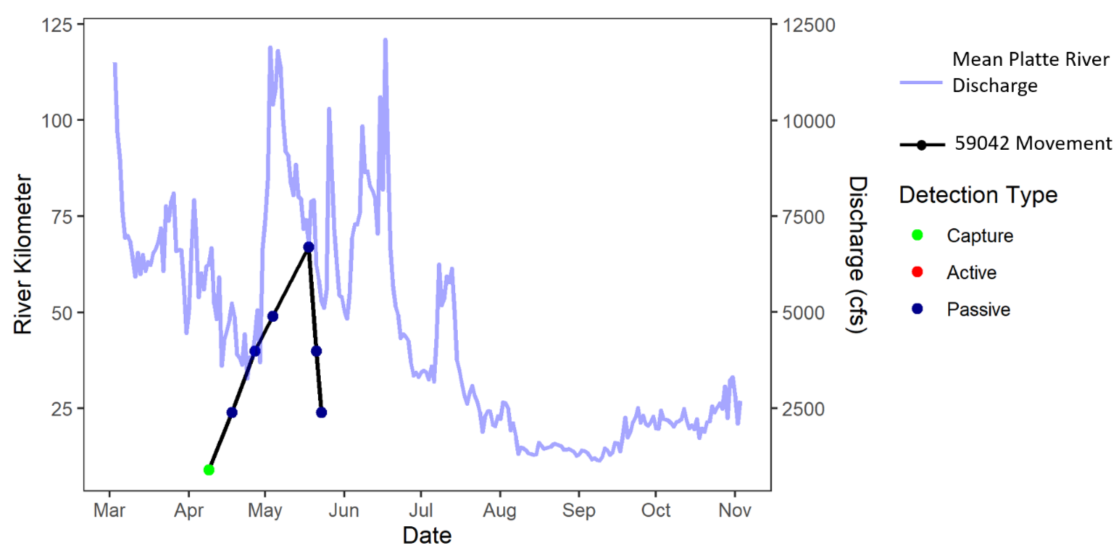
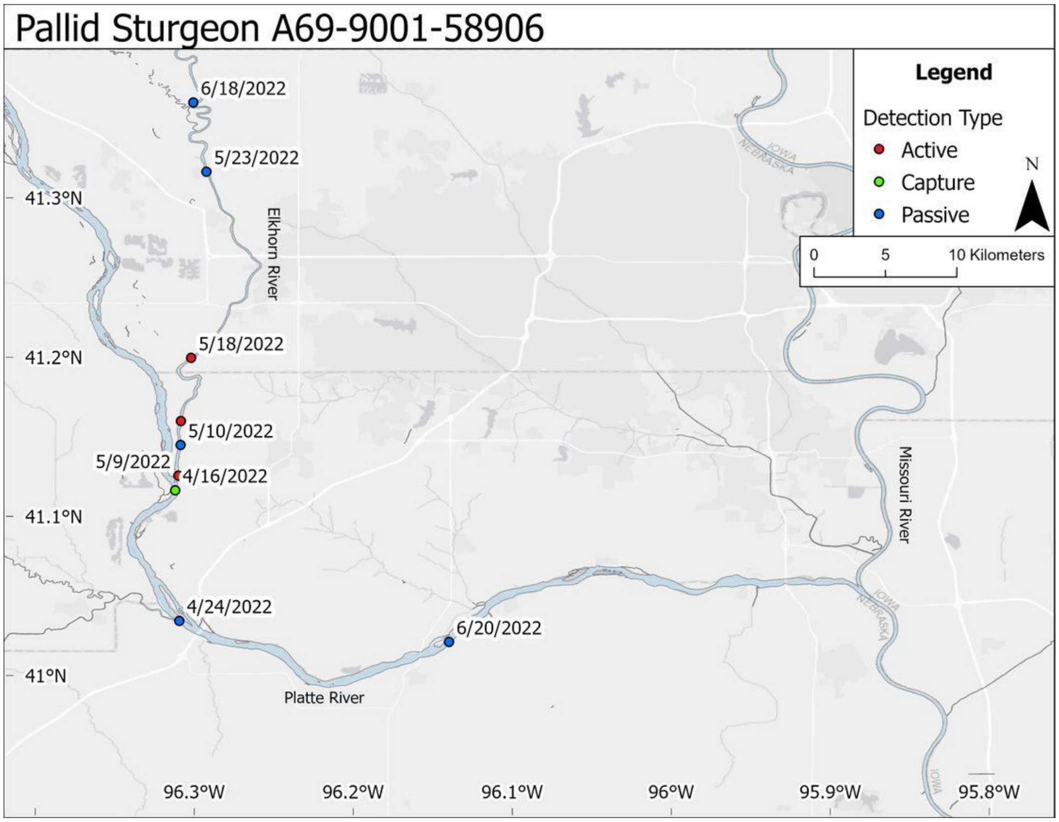


Figure A-7. Capture location and relocations of Pallid Sturgeon A69-1602-59042 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



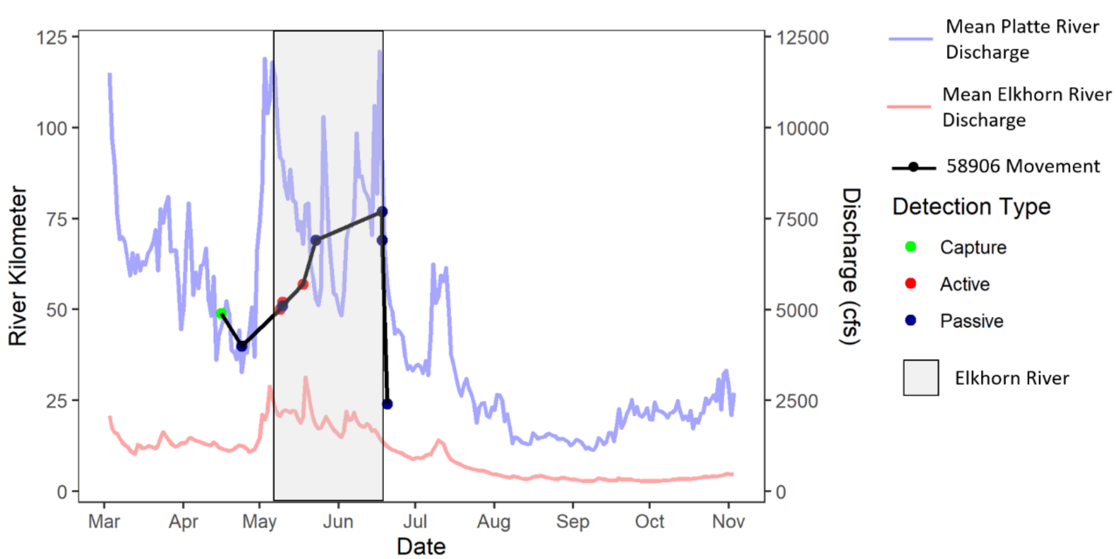
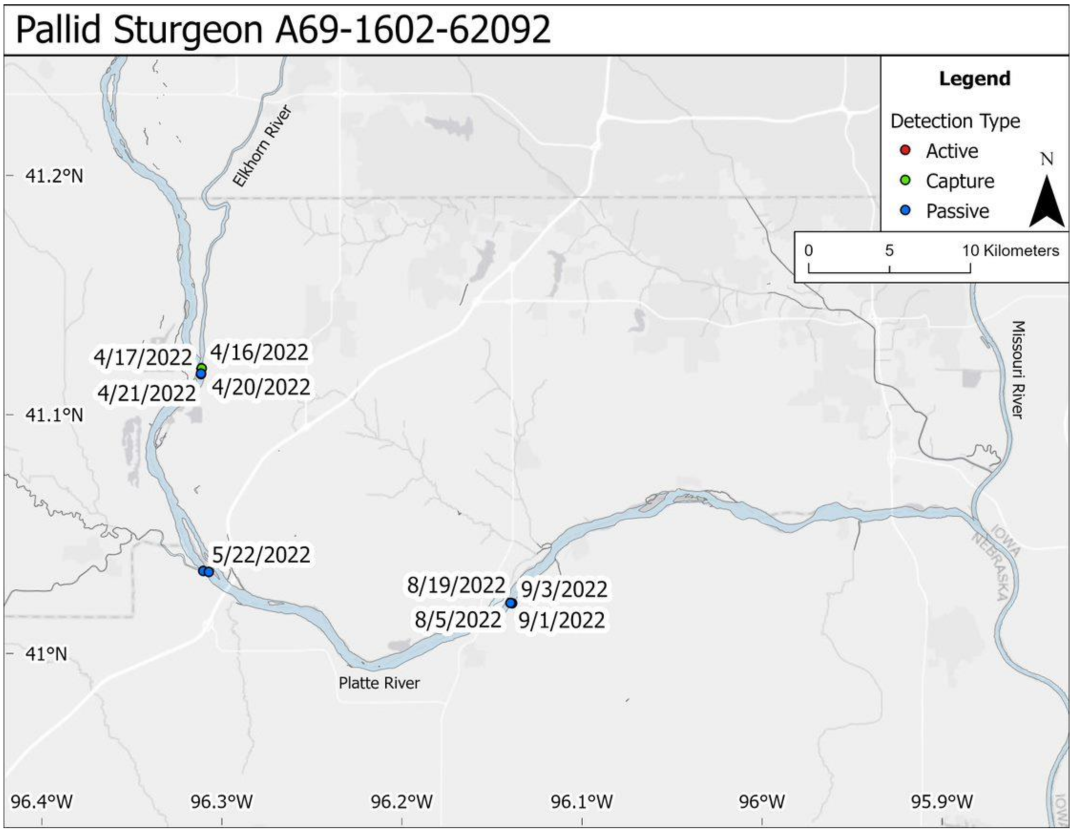


Figure A-8. Capture location and relocations of Pallid Sturgeon A69-9001-58906 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).



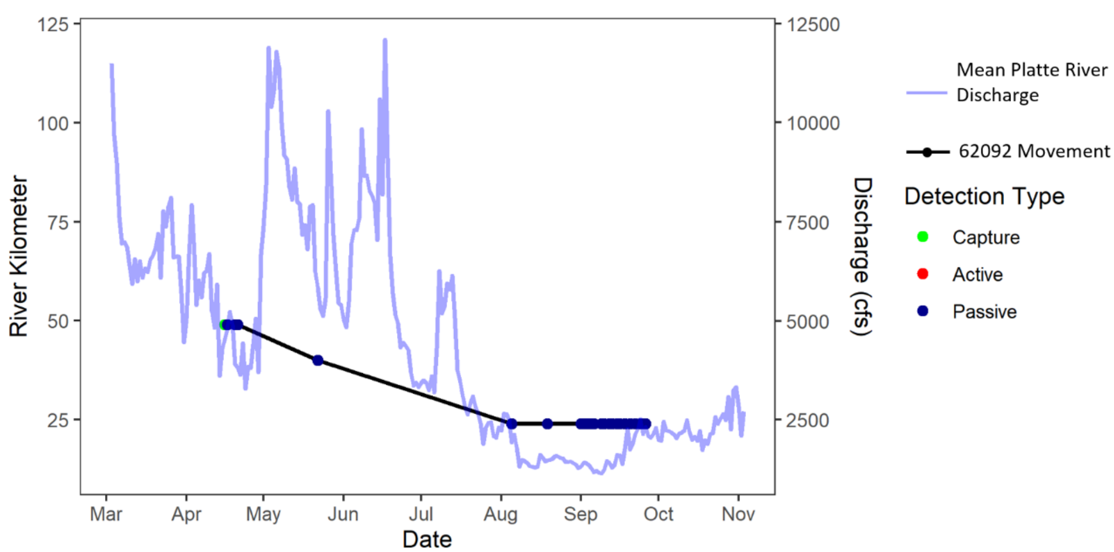
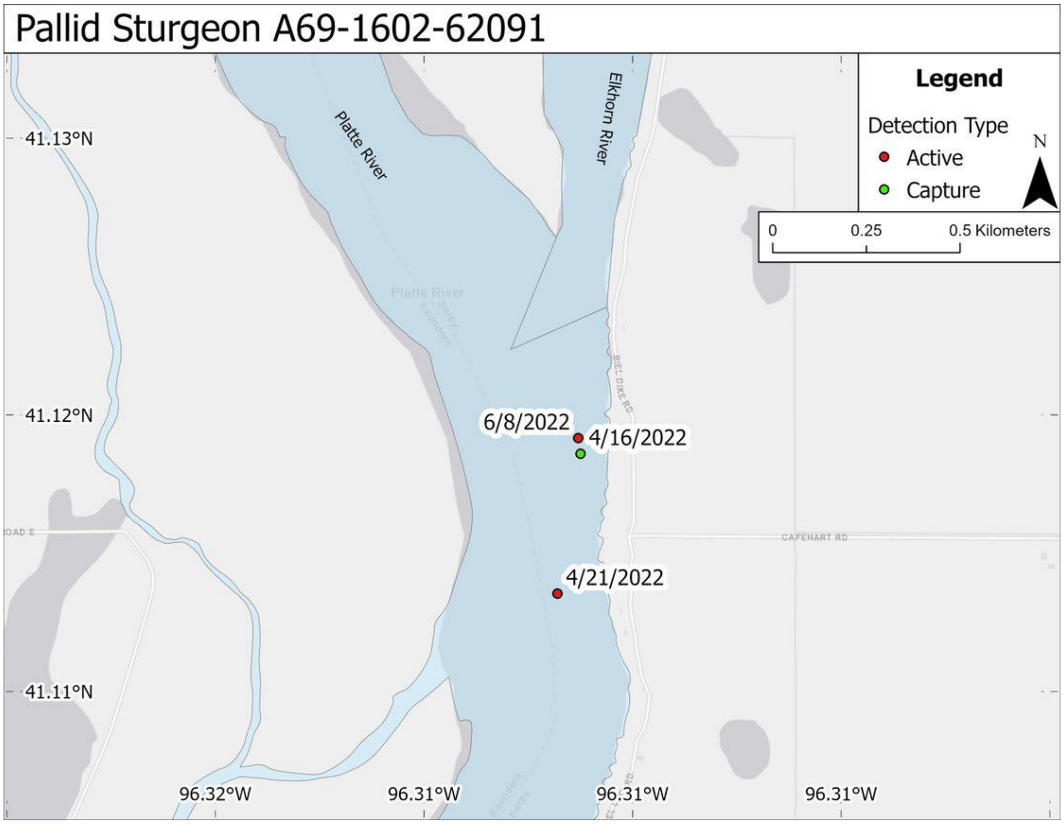


Figure A-9. Capture location and relocations of Pallid Sturgeon A69-1602-62092 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



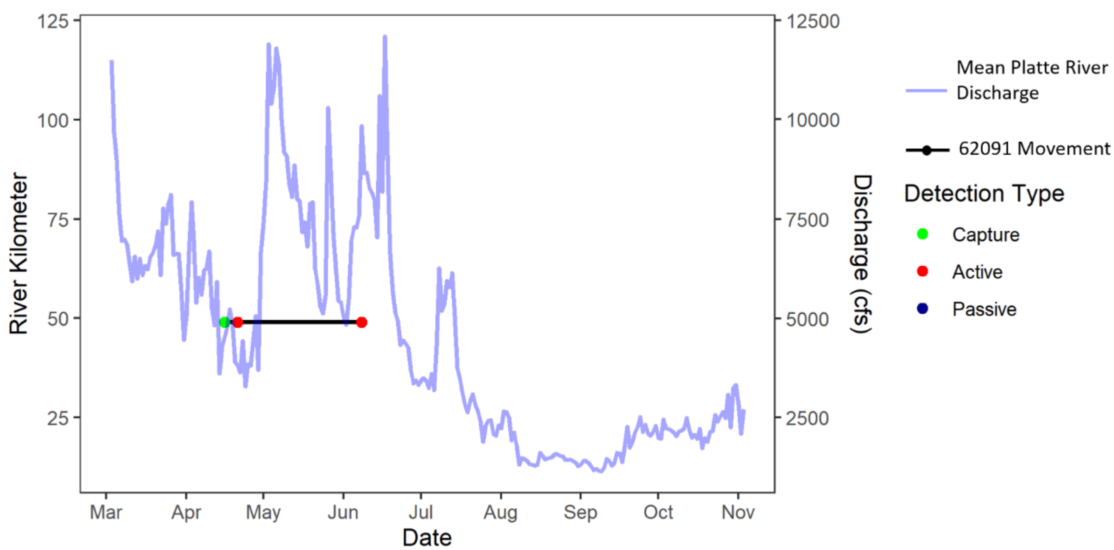
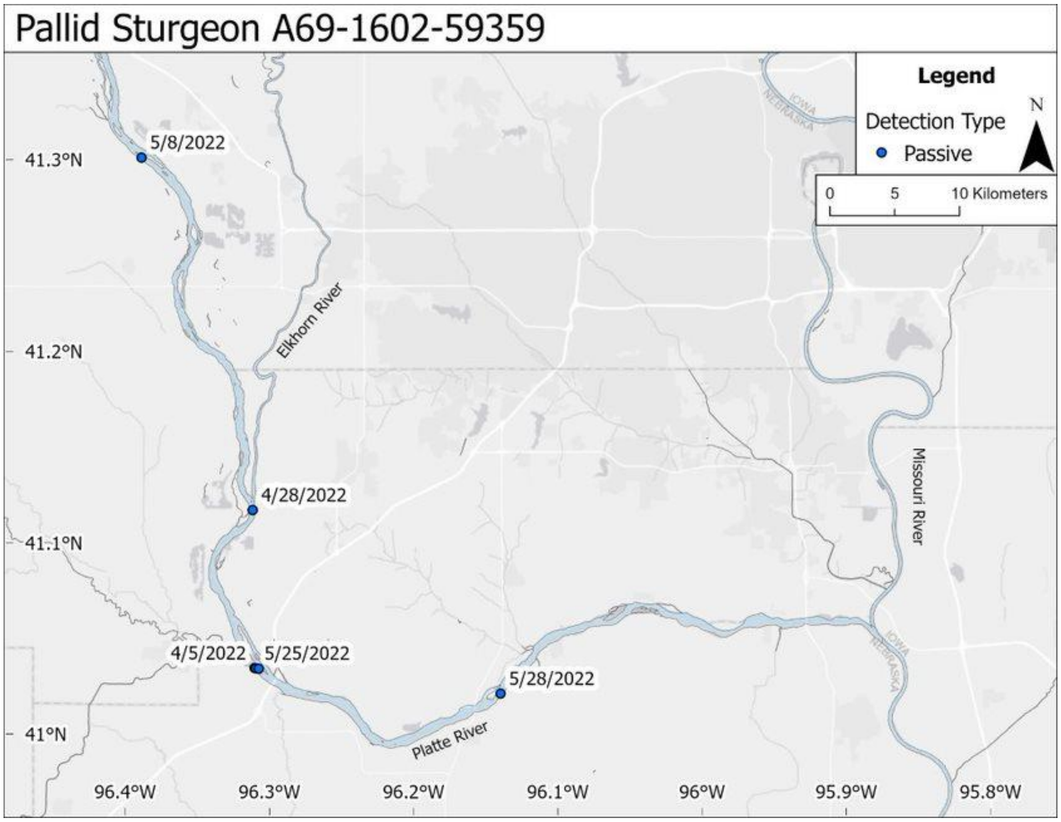


Figure A-10. Capture location and relocations of Pallid Sturgeon A69-1602-62091 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



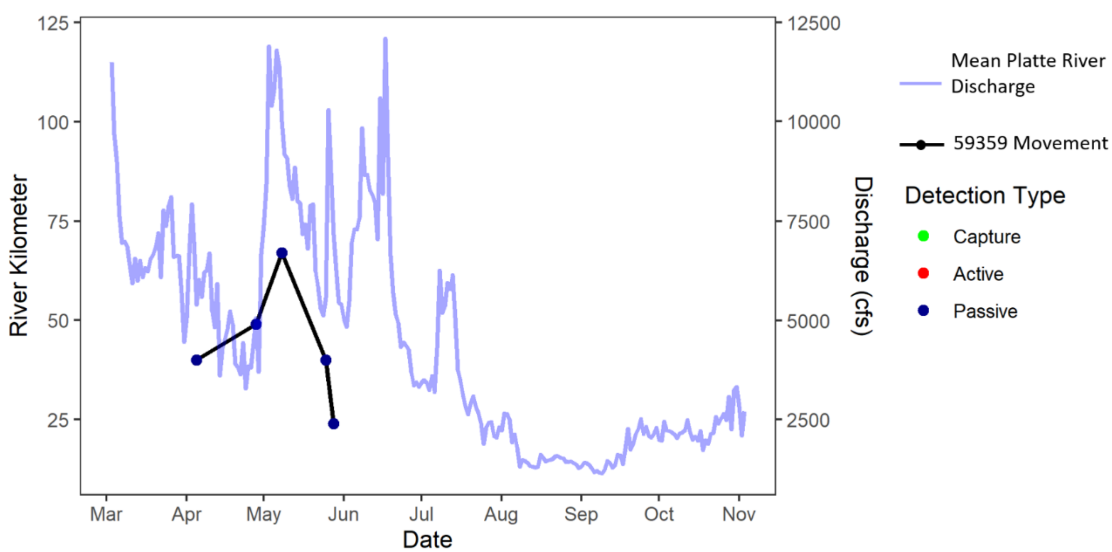
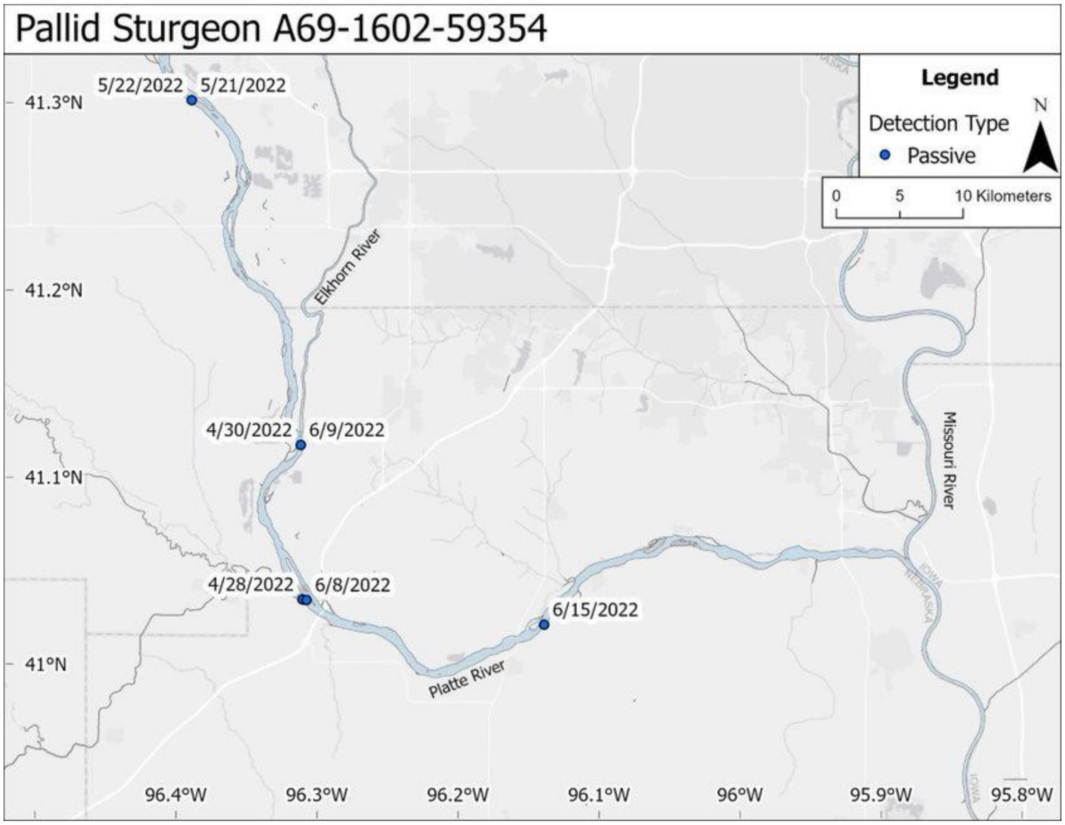


Figure A-11. Capture location and relocations of Pallid Sturgeon A69-1602-59359 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



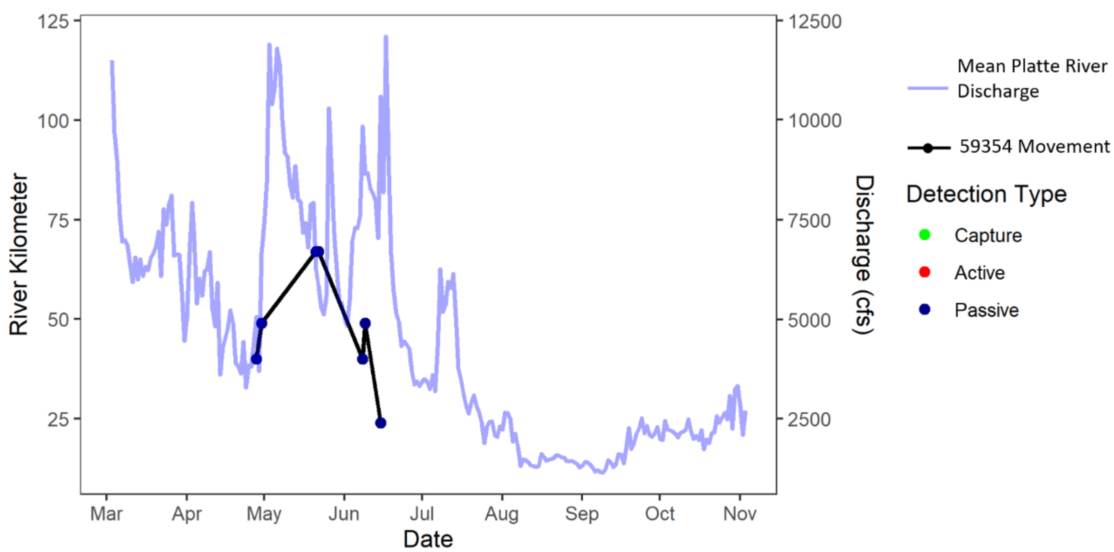
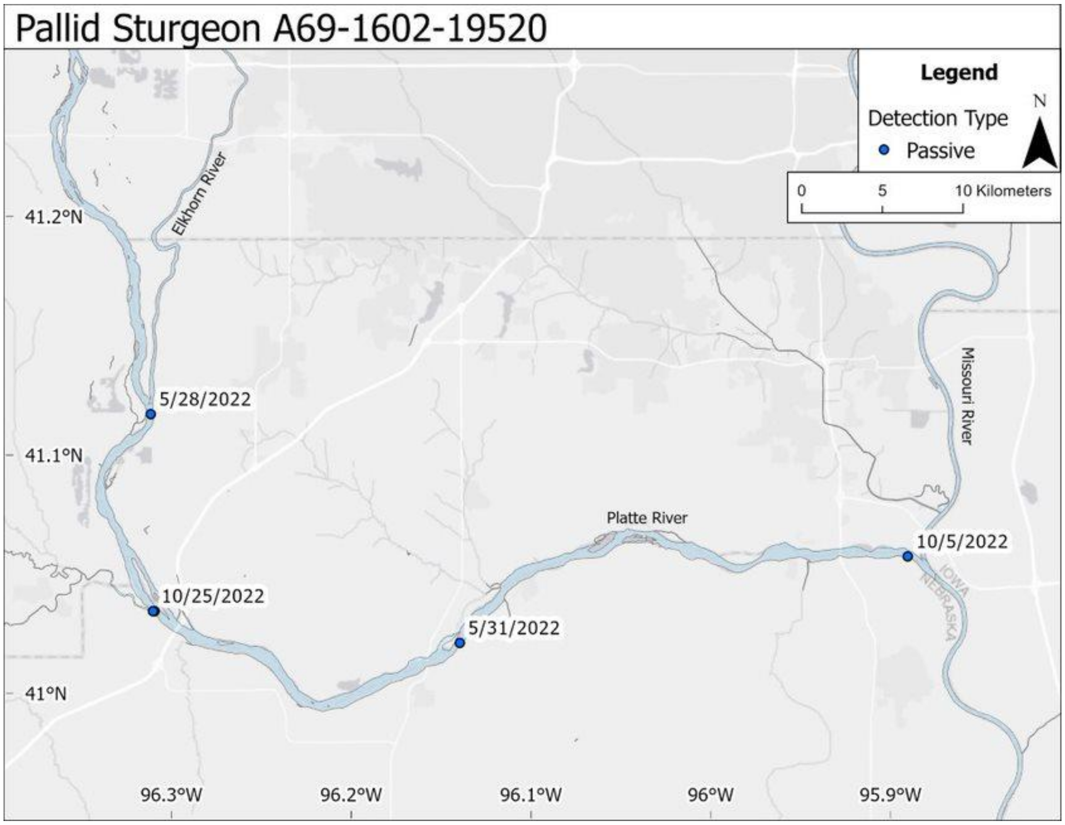


Figure A-12. Capture location and relocations of Pallid Sturgeon A69-1602-59354 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



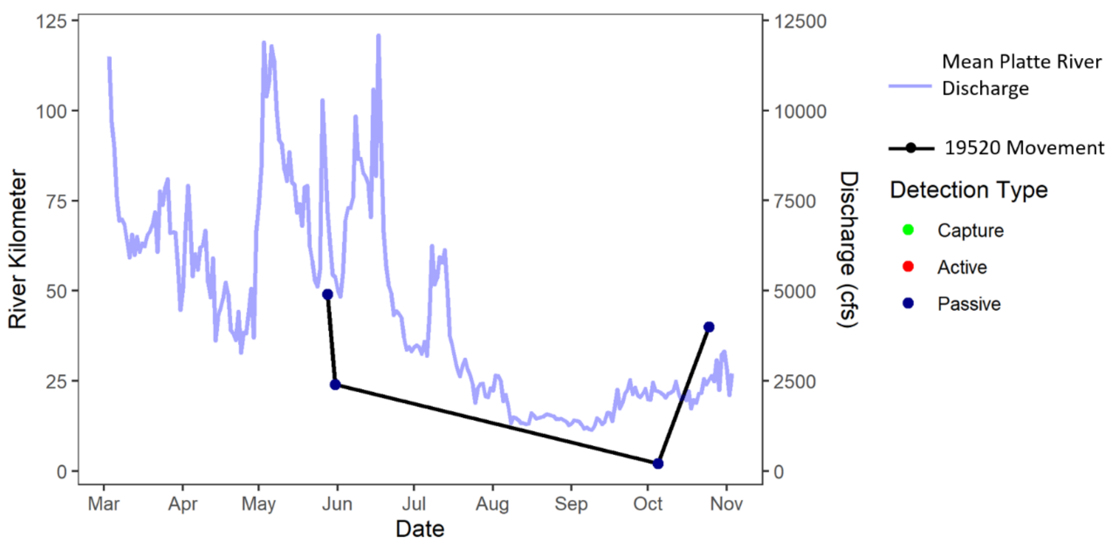


Figure A-13. Capture location and relocations of Pallid Sturgeon A69-1602-19520 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

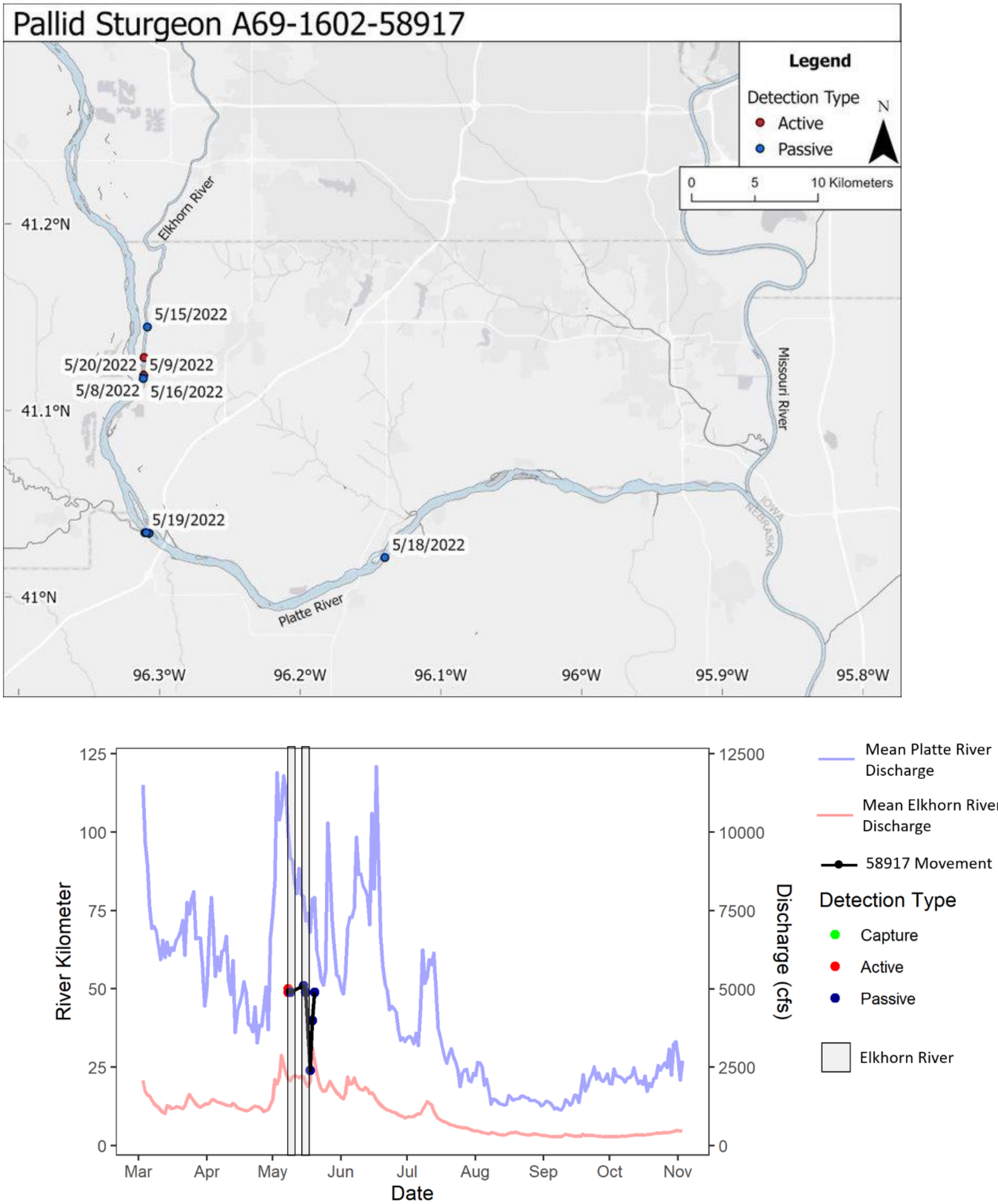
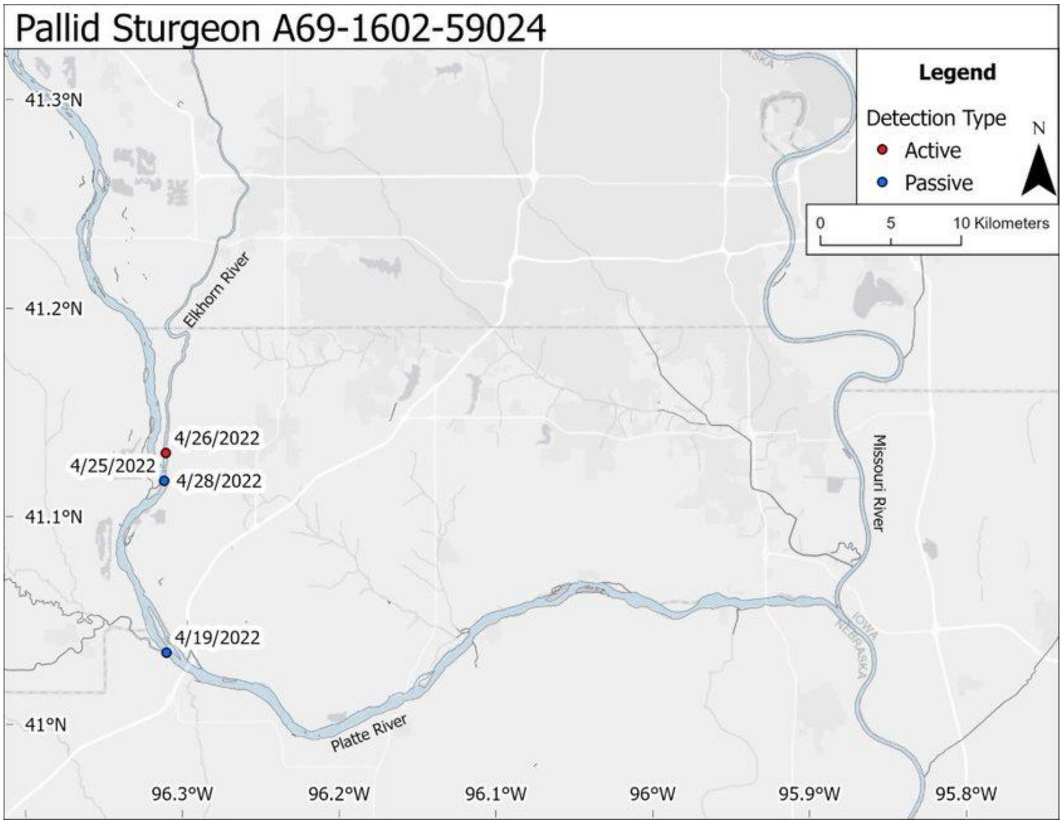


Figure A-14. Capture location and relocations of Pallid Sturgeon A69-1602-58917 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs). See Figure 15 for potential spawning related movements.



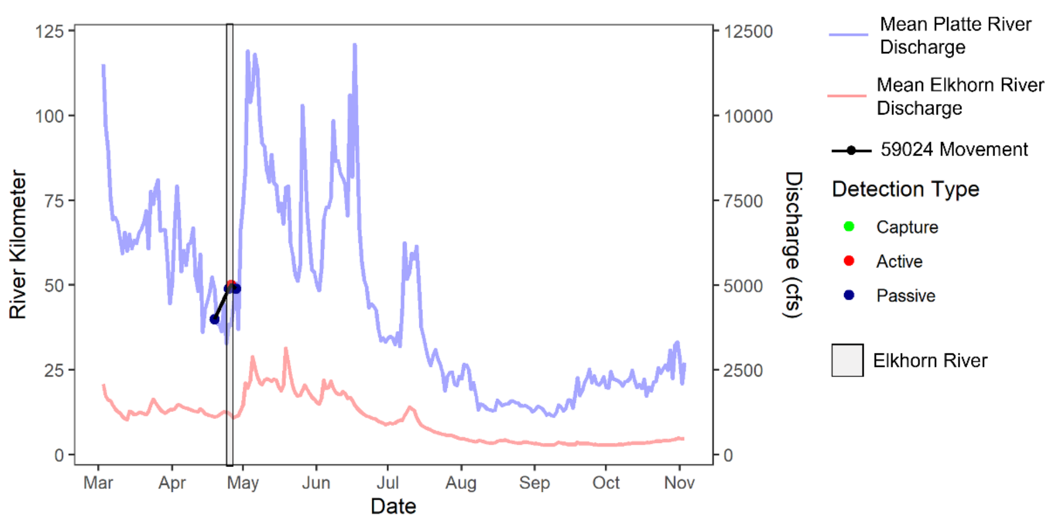
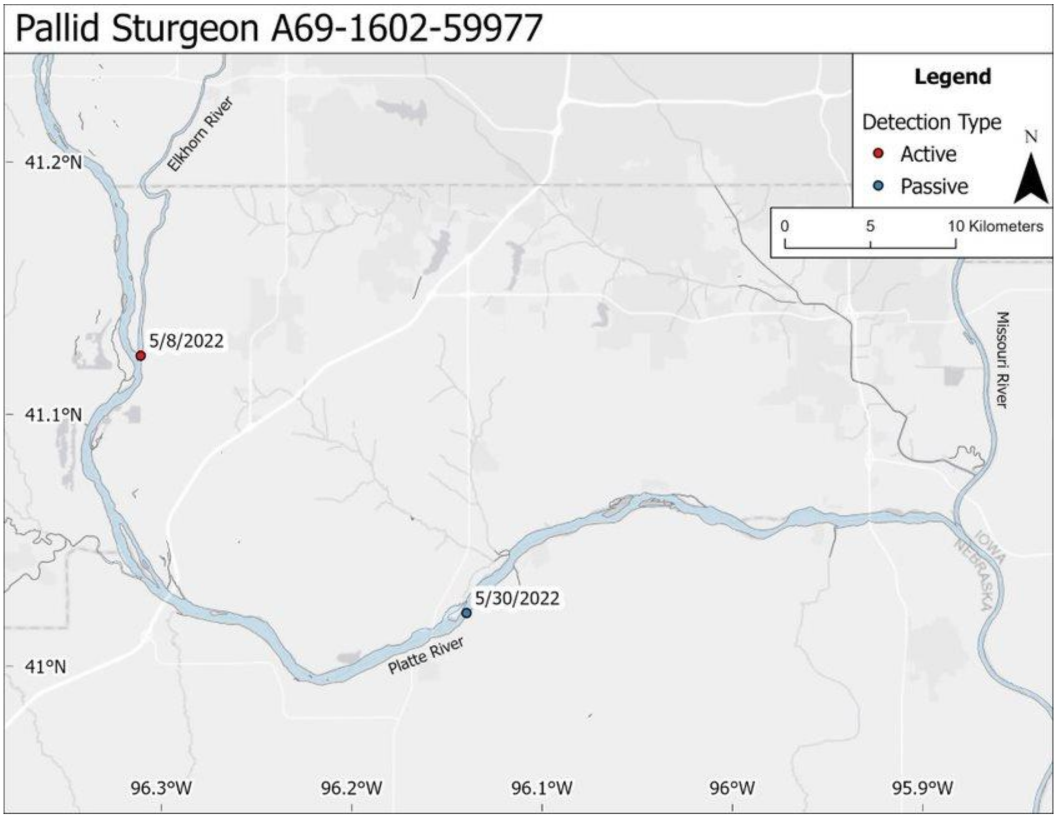


Figure A-15. Capture location and relocations of Pallid Sturgeon A69-1602-59024 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).



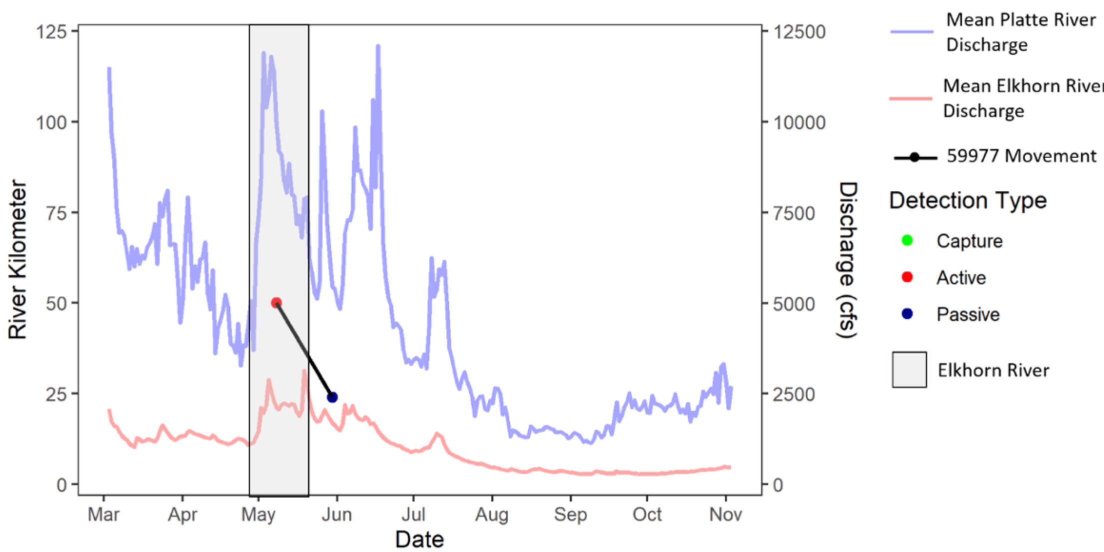


Figure A-16. Capture location and relocations of Pallid Sturgeon A69-1602-59578 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).

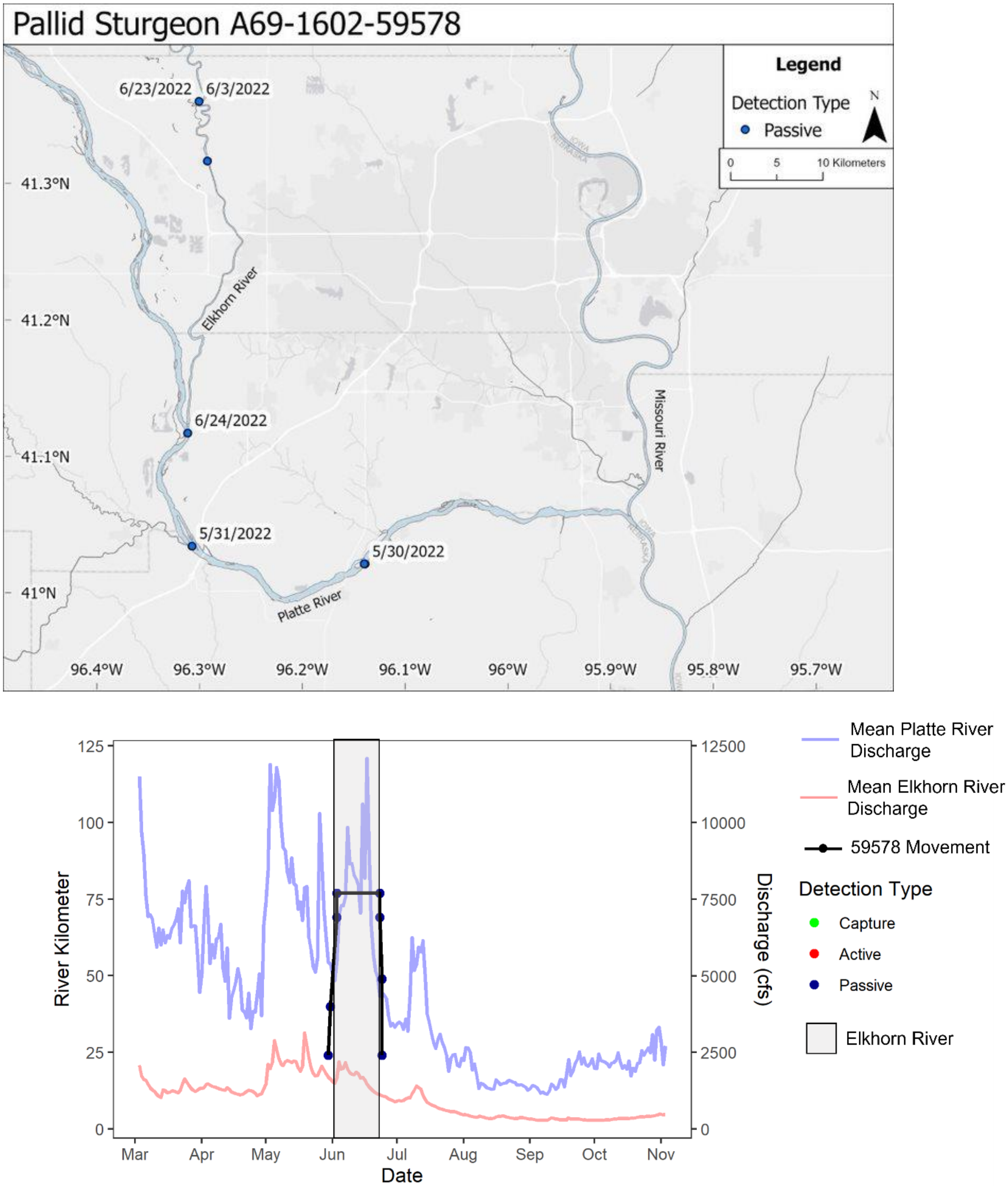


Figure A-17. Capture location and relocations of Pallid Sturgeon A69-1602-59578 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).

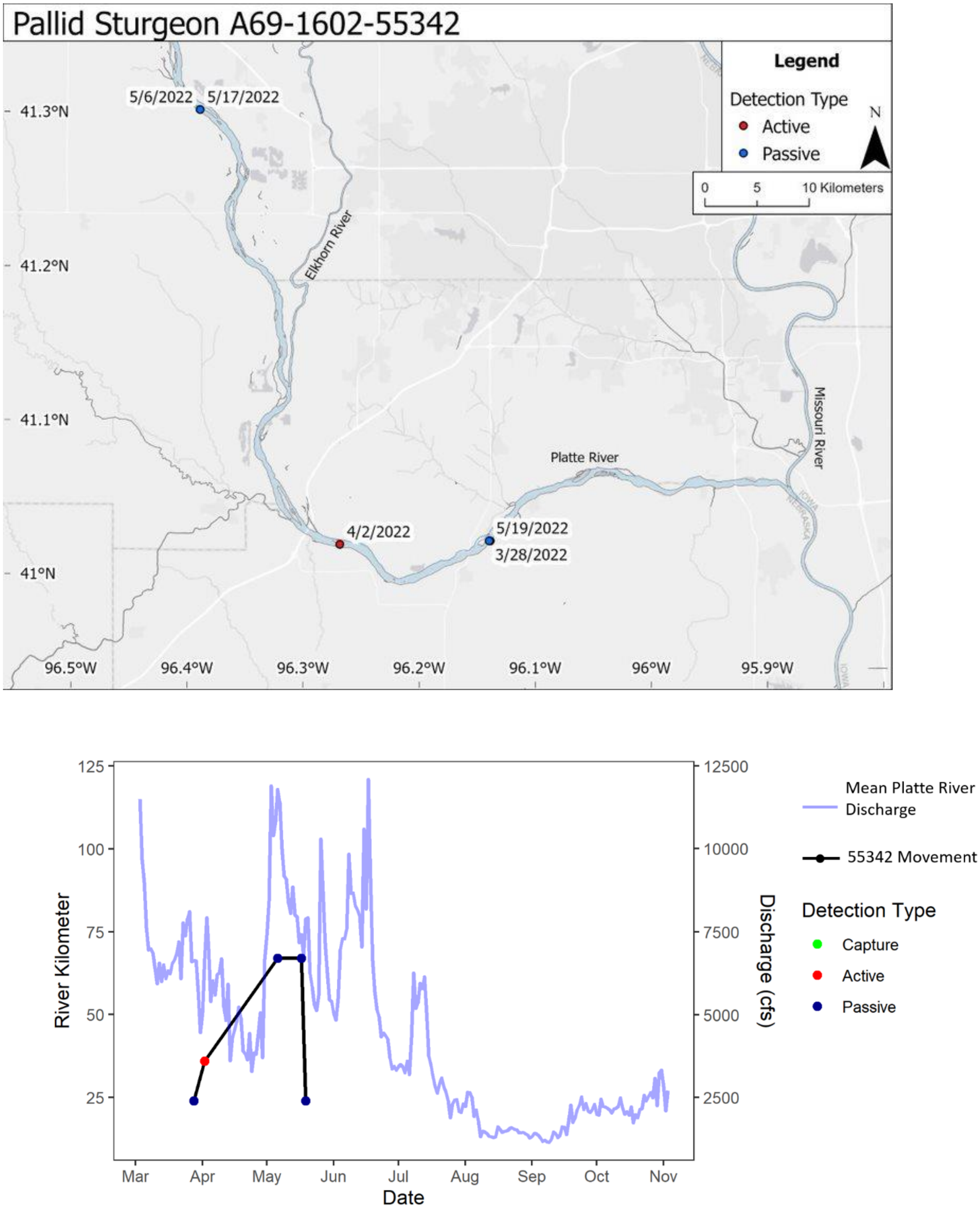


Figure A-18. Capture location and relocations of Pallid Sturgeon A69-1602-55342 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

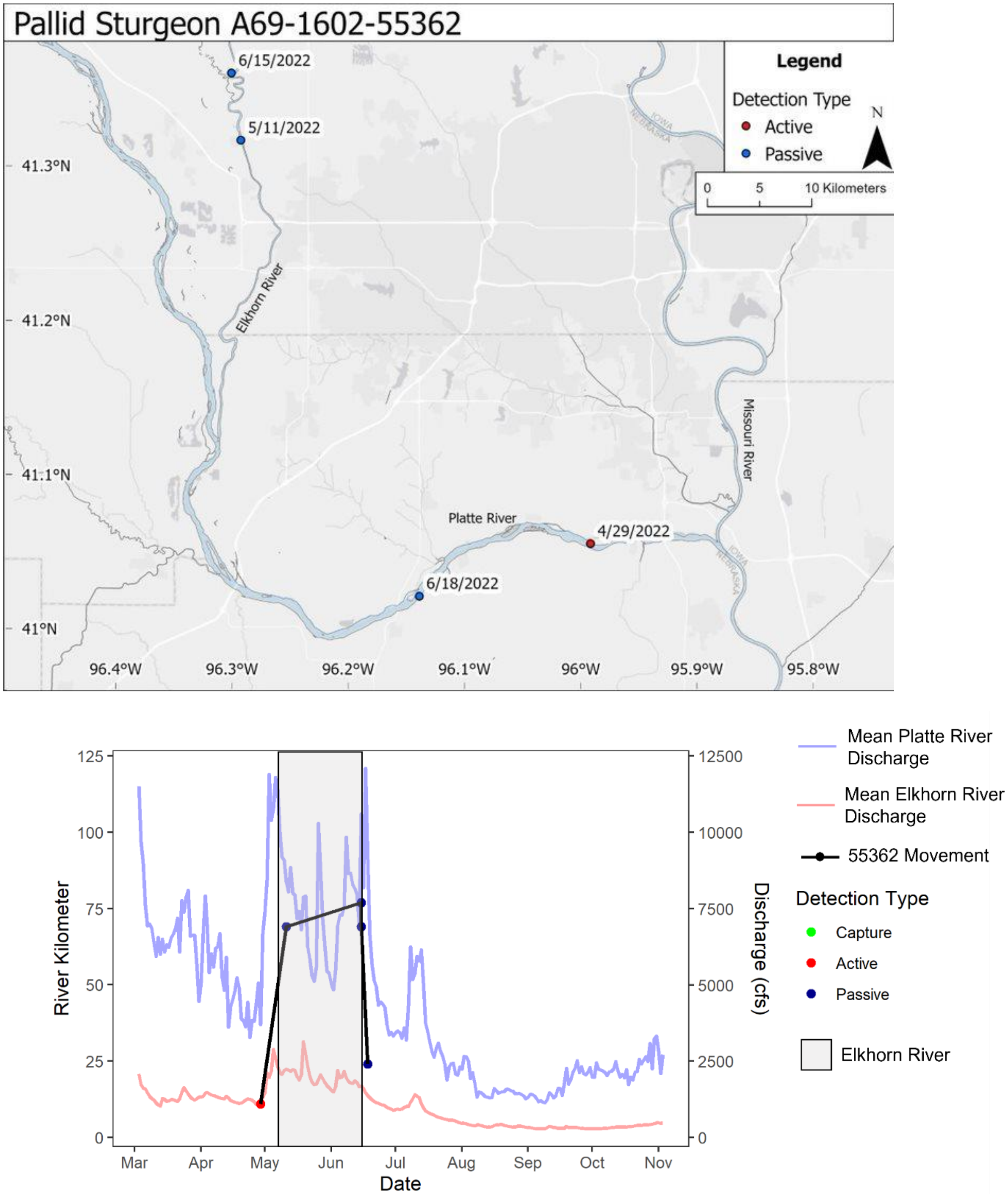


Figure A-19. Capture location and relocations of Pallid Sturgeon A69-1602-55362 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).

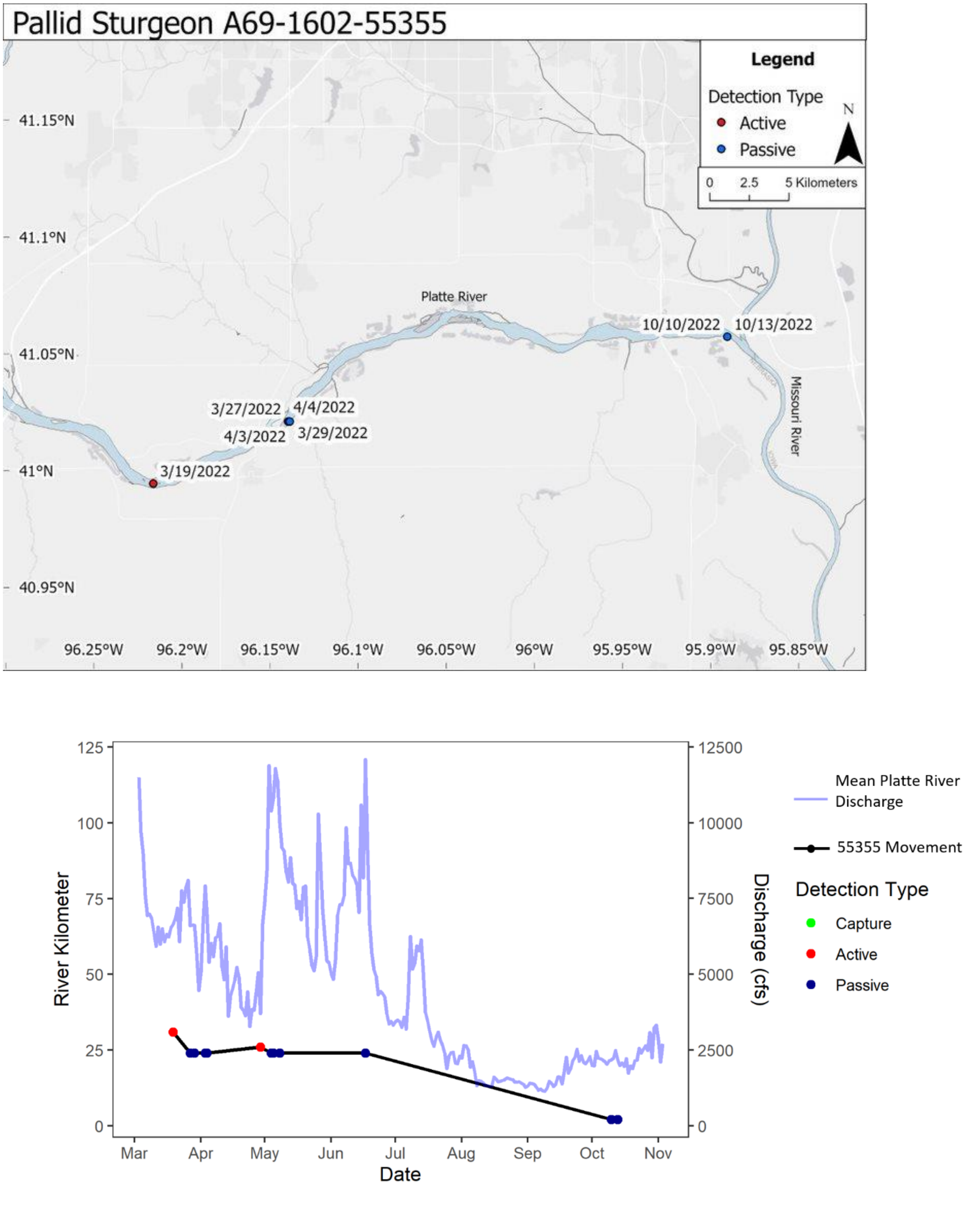


Figure A-20. Capture location and relocations of Pallid Sturgeon A69-1602-55355 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

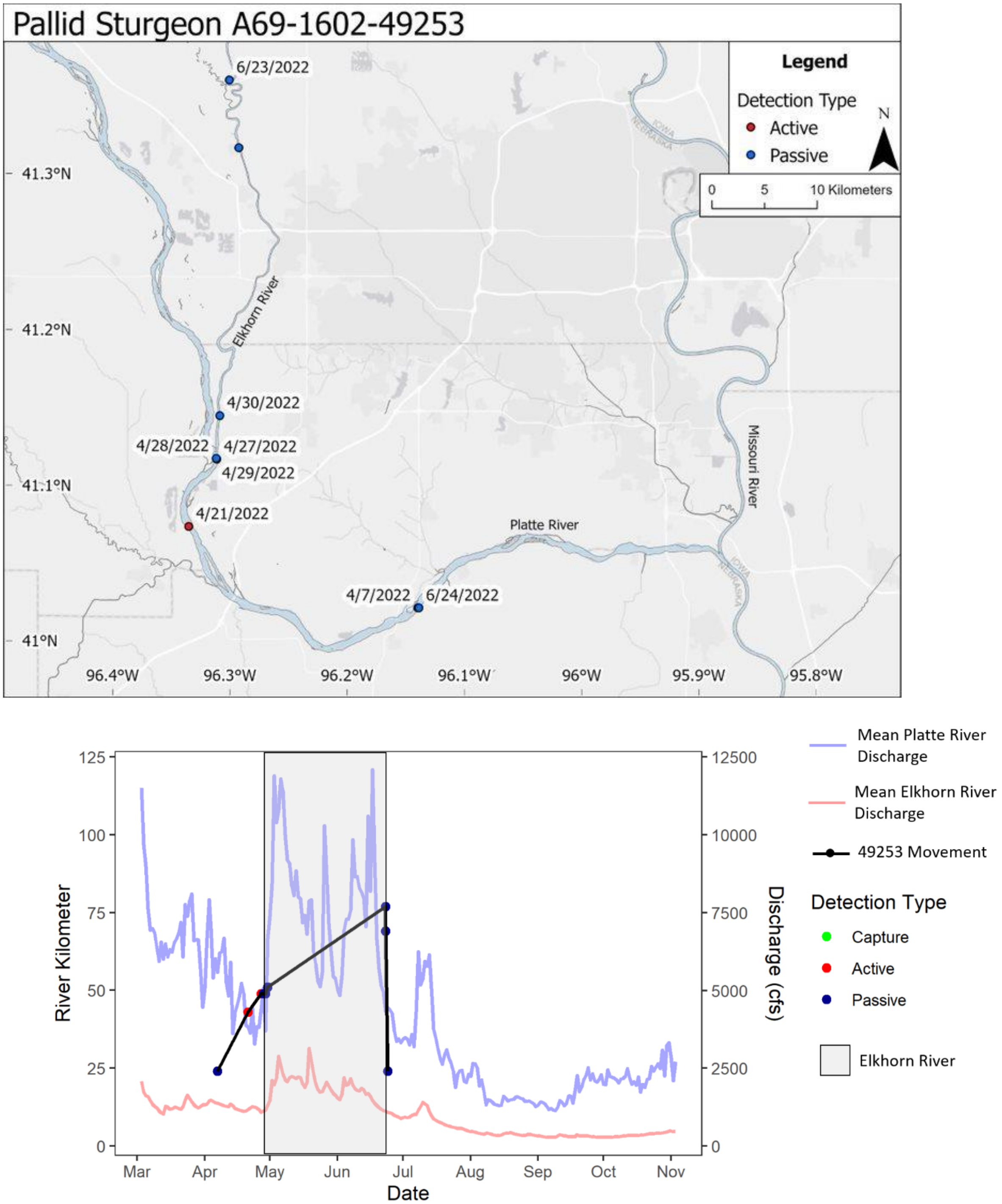
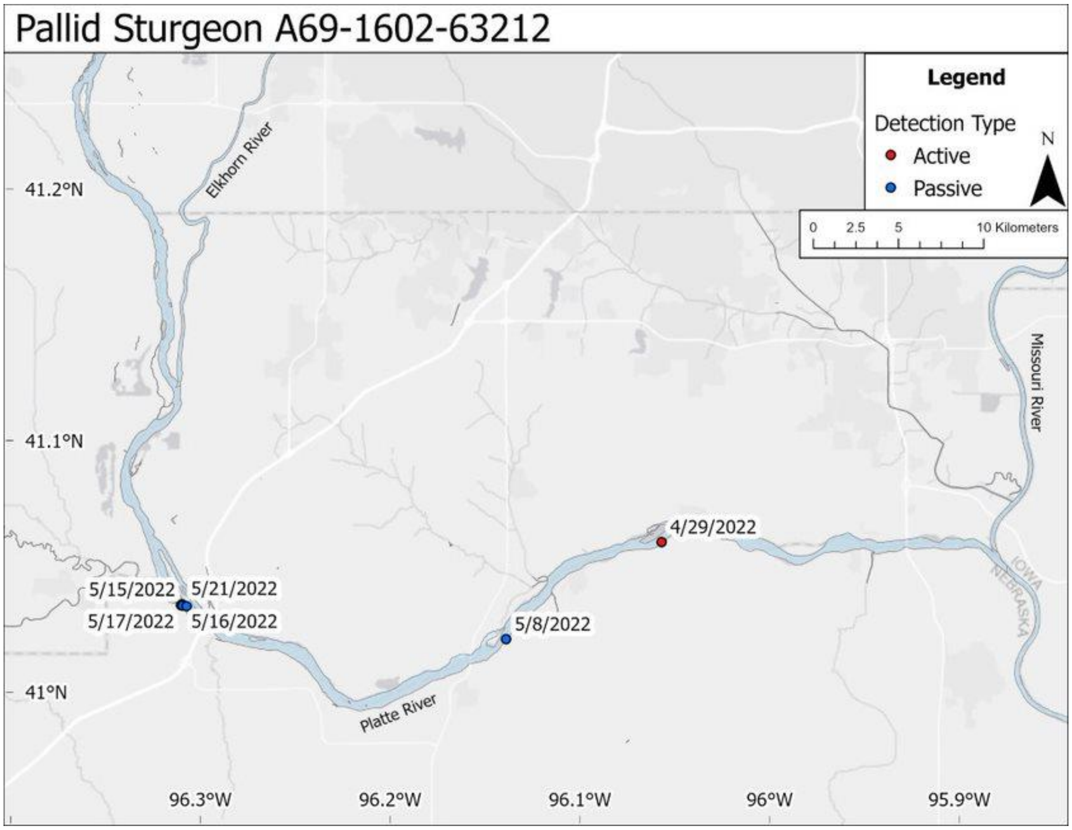


Figure A-21. Capture location and relocations of Pallid Sturgeon A69-1602-49253 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. The grey box indicates the general period of time the fish was located within the Elkhorn River. Mean daily discharge is in cubic feet per second (cfs).



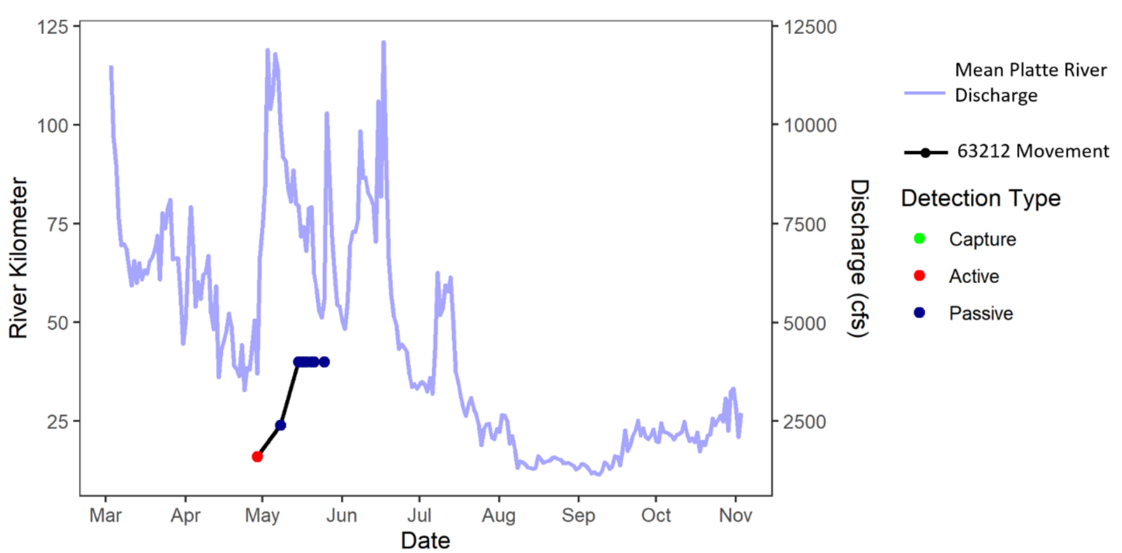
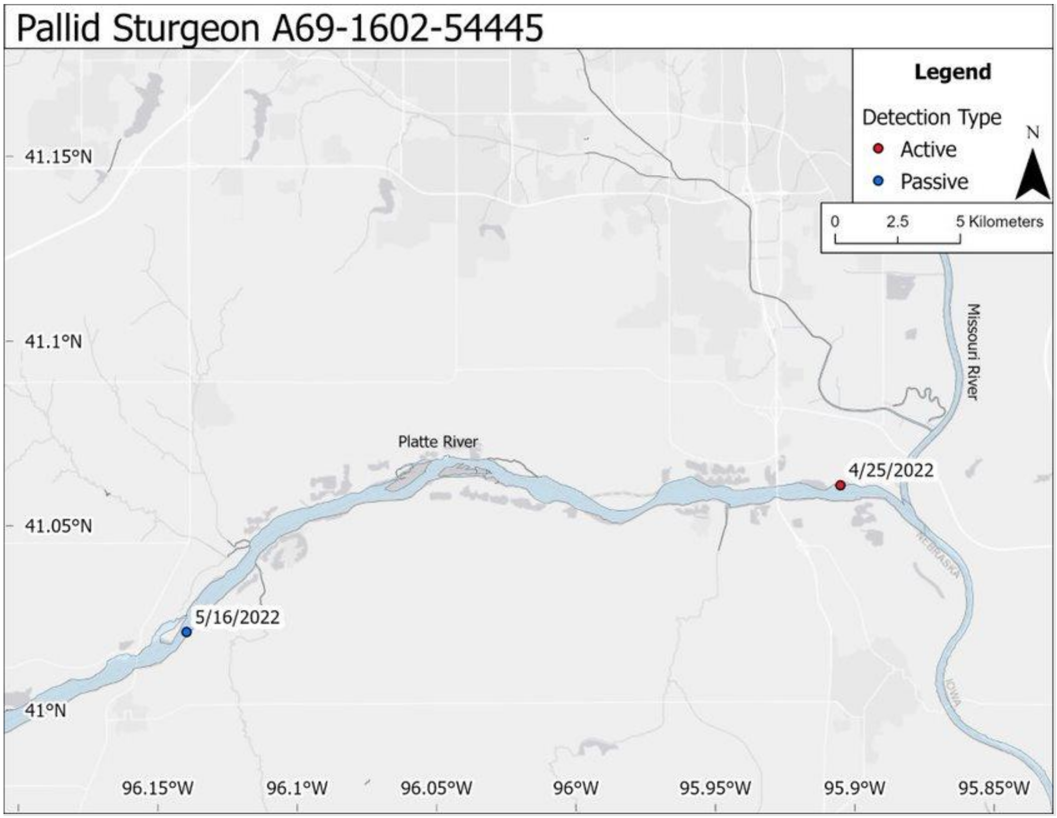


Figure A-22. Capture location and relocations of Pallid Sturgeon A69-1602-63212 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



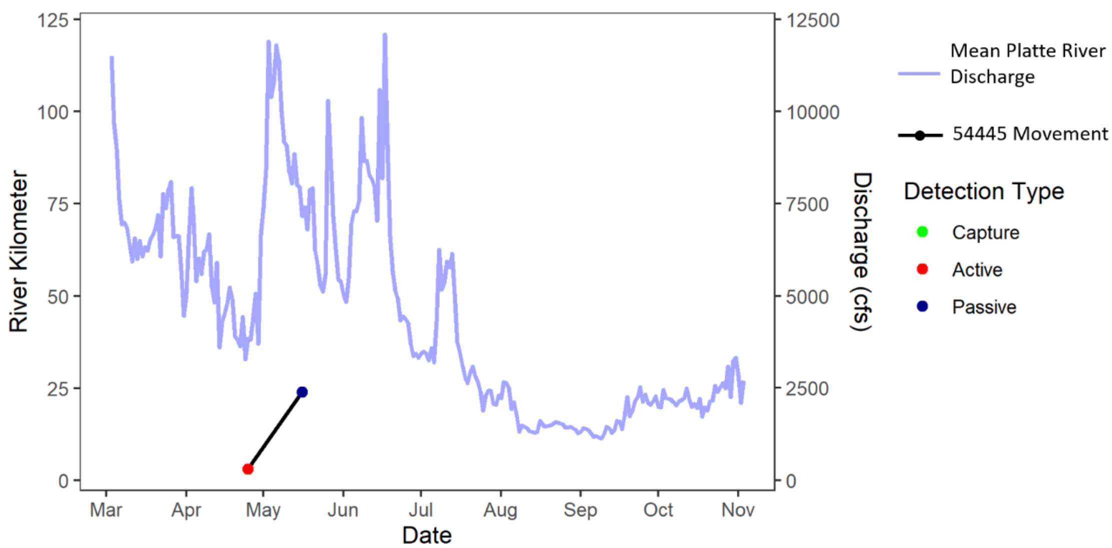
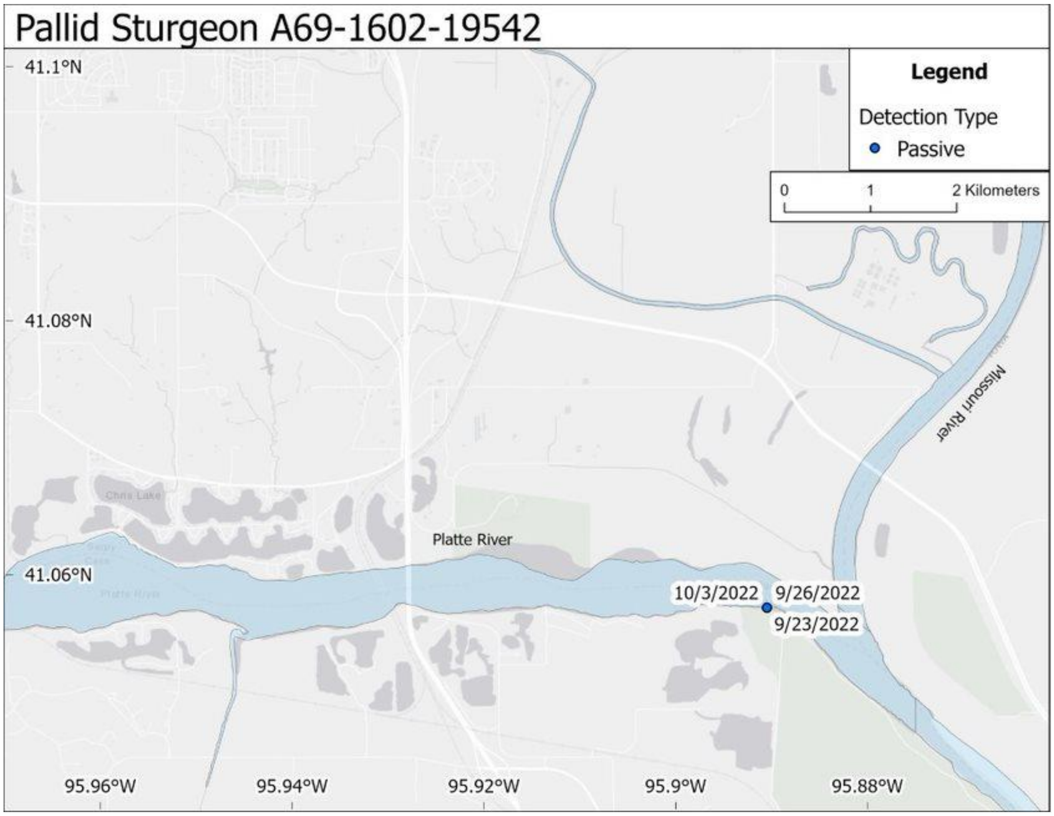


Figure A-23. Capture location and relocations of Pallid Sturgeon A69-1602-54445 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



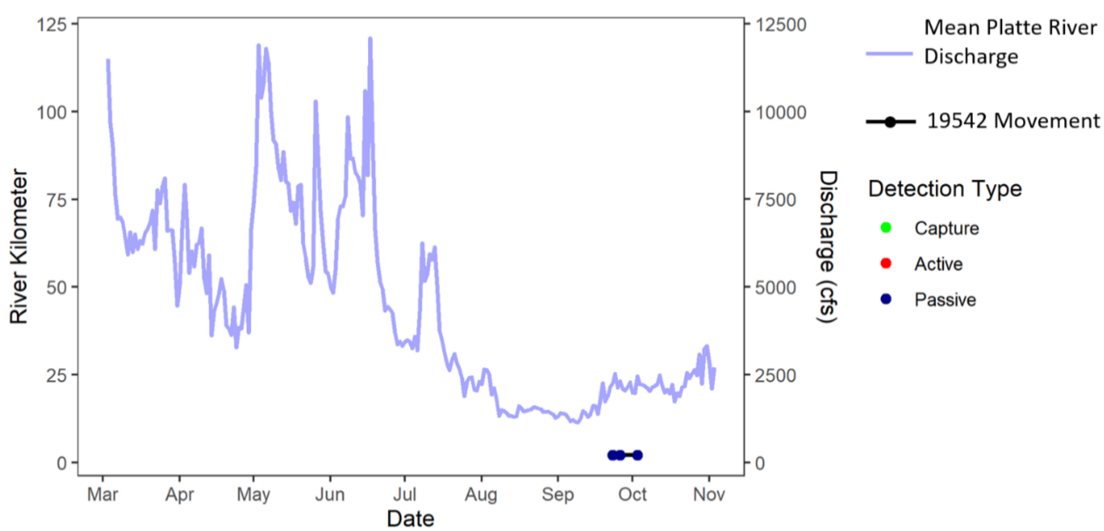
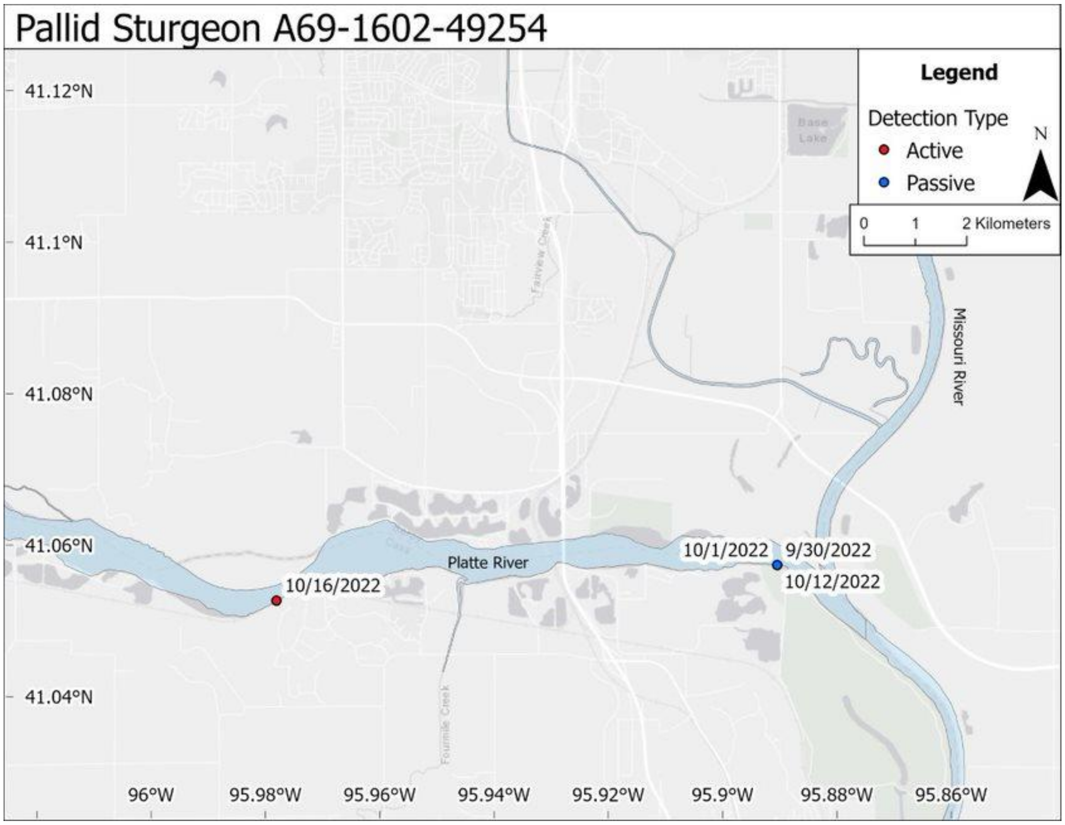


Figure A-24. Capture location and relocations of Pallid Sturgeon A69-1602-19542 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



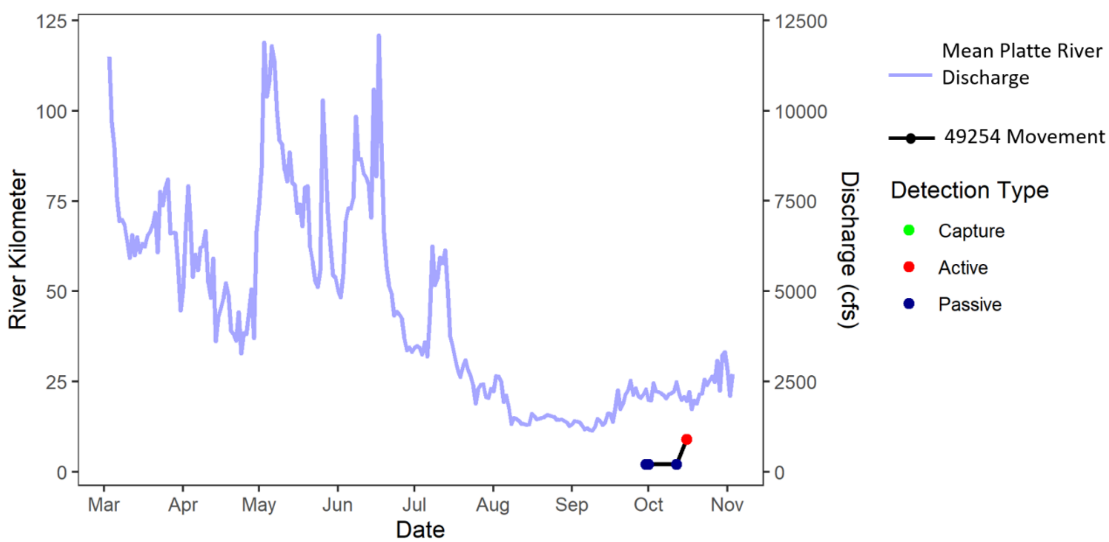
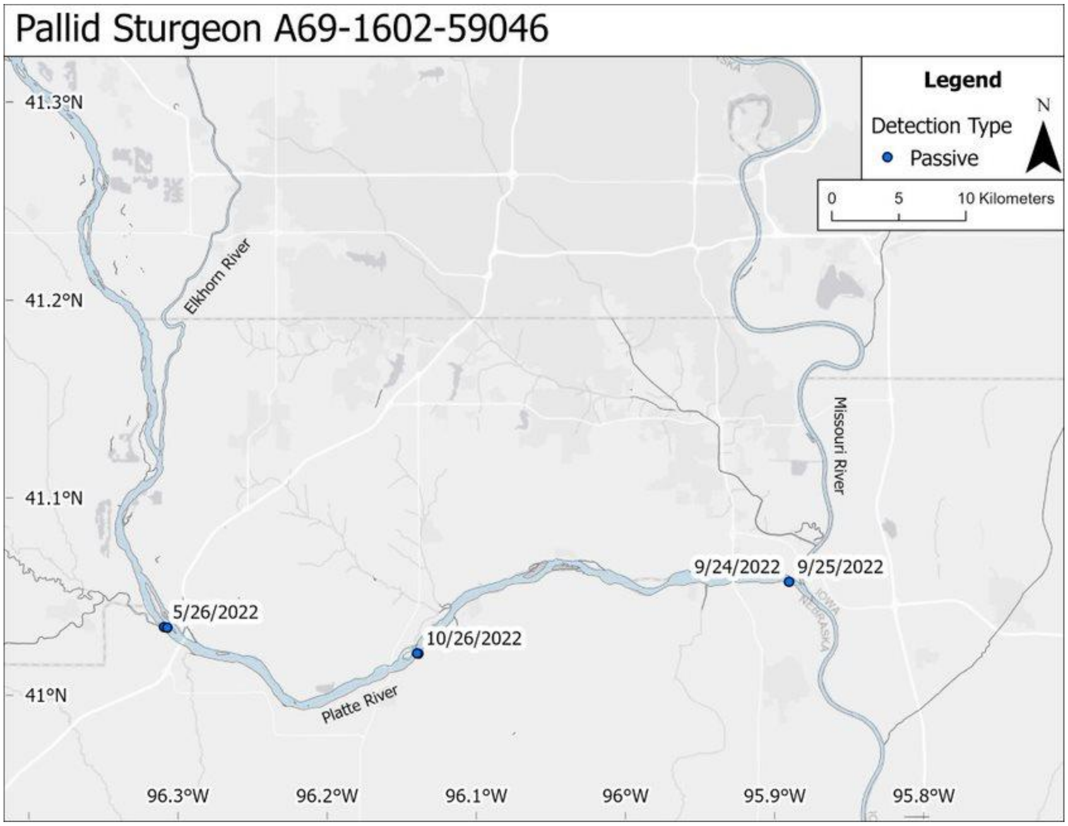


Figure A-25. Capture location and relocations of Pallid Sturgeon A69-1602-49254 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



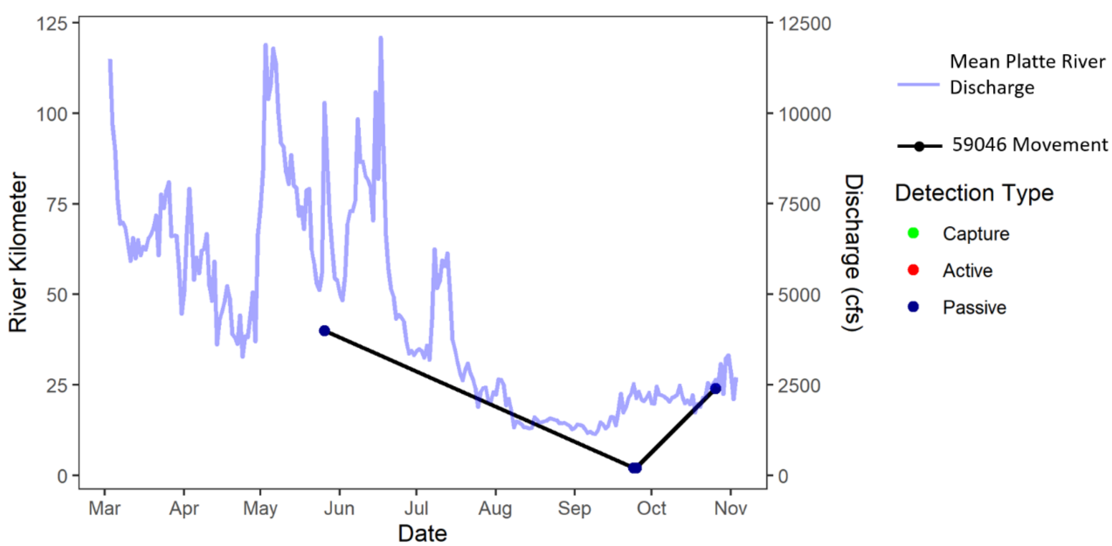


Figure A-26. Capture location and relocations of Pallid Sturgeon A69-1602-59046 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

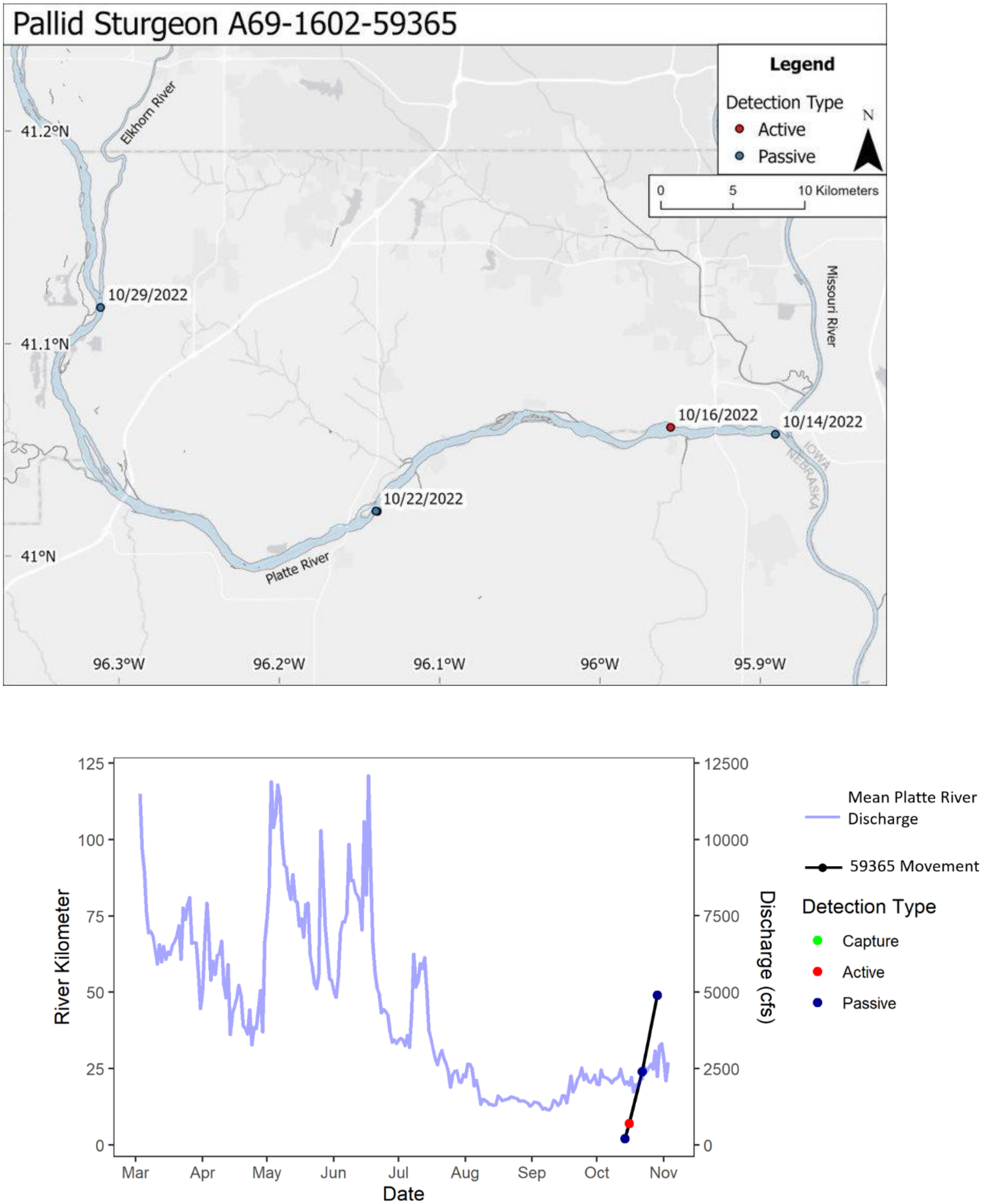
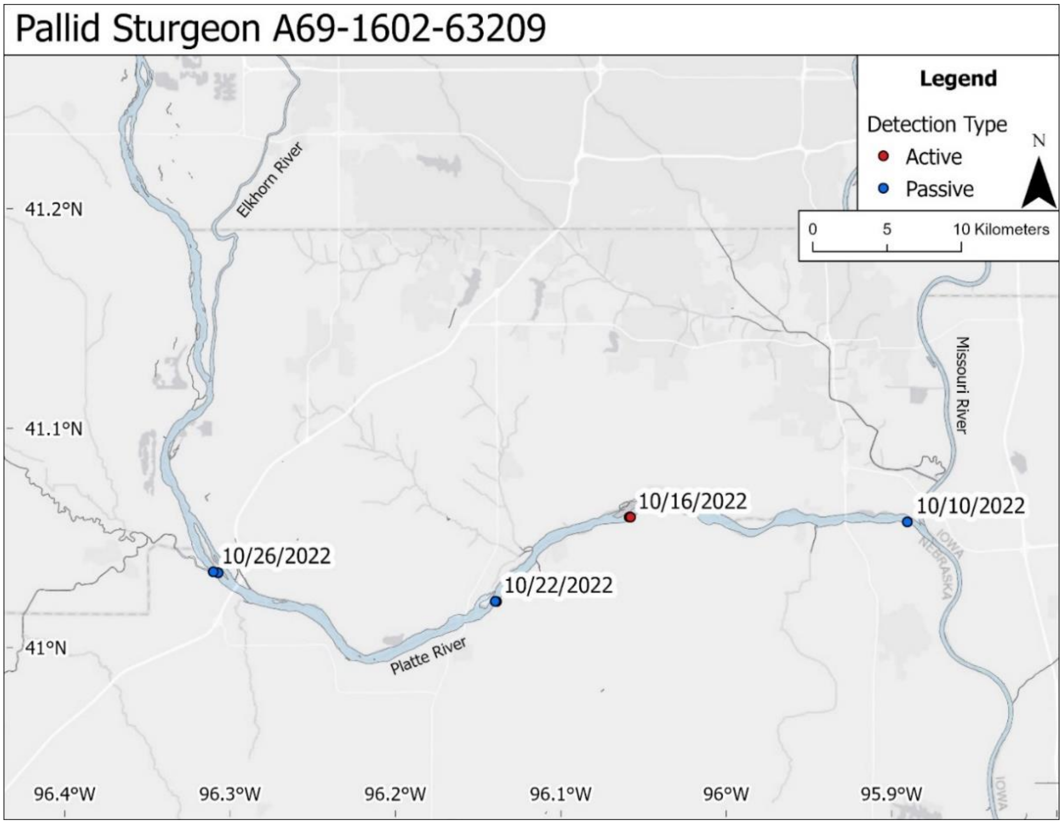


Figure A-27. Capture location and relocations of Pallid Sturgeon A69-1602-59365 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



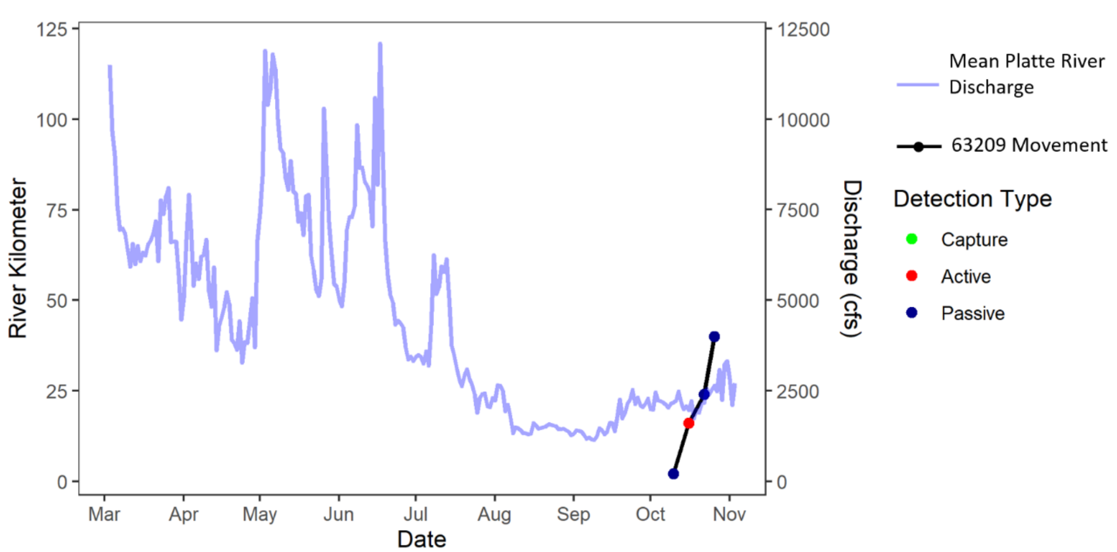
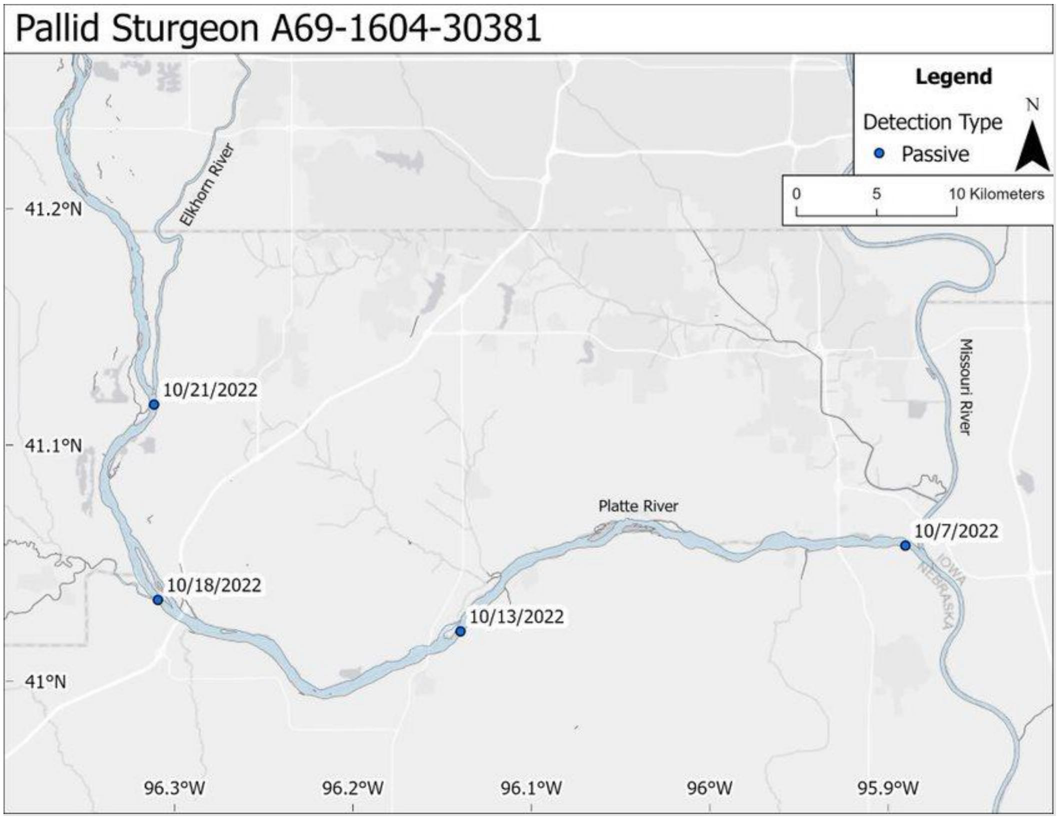


Figure A-28. Capture location and relocations of Pallid Sturgeon A69-1602-63209 in the lower Platte River during 2022. Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The inset shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



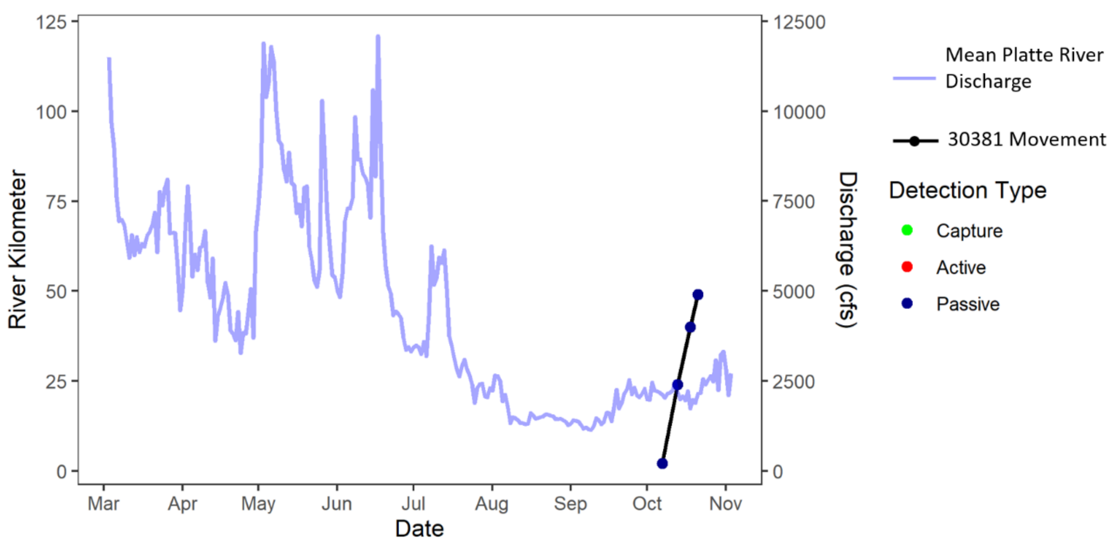
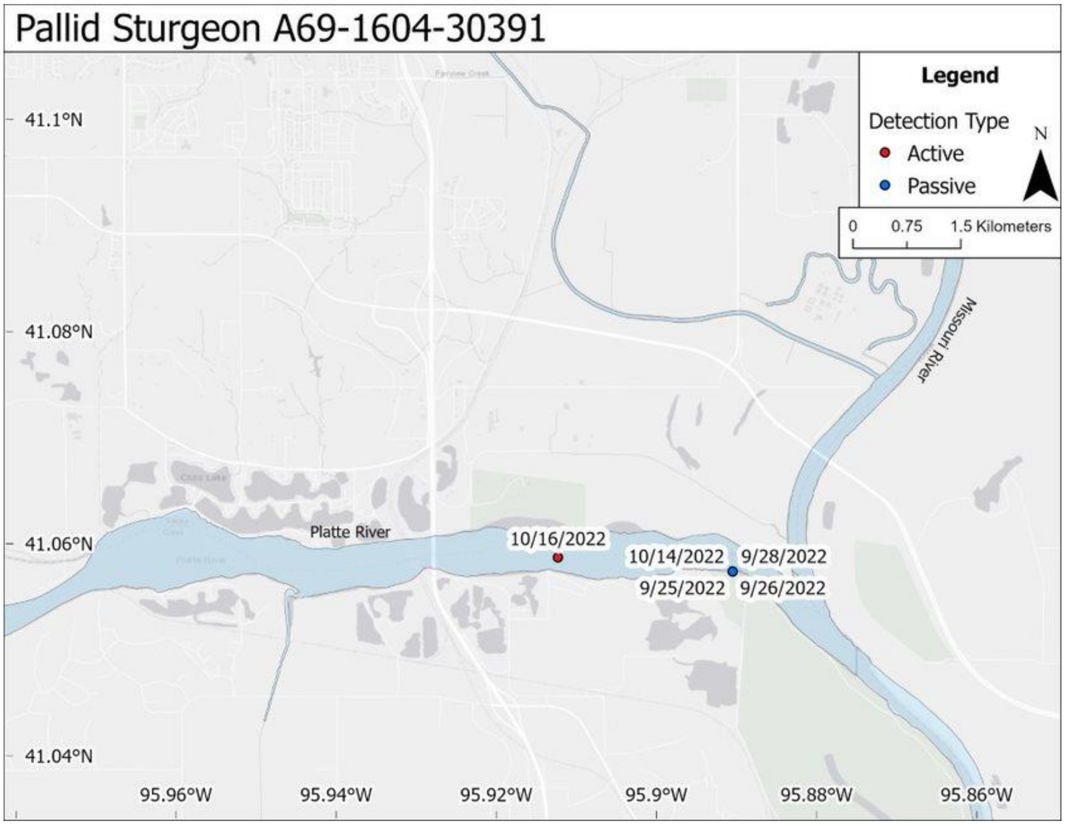


Figure A-29. Capture location and relocations of Pallid Sturgeon A69-1604-30381 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).



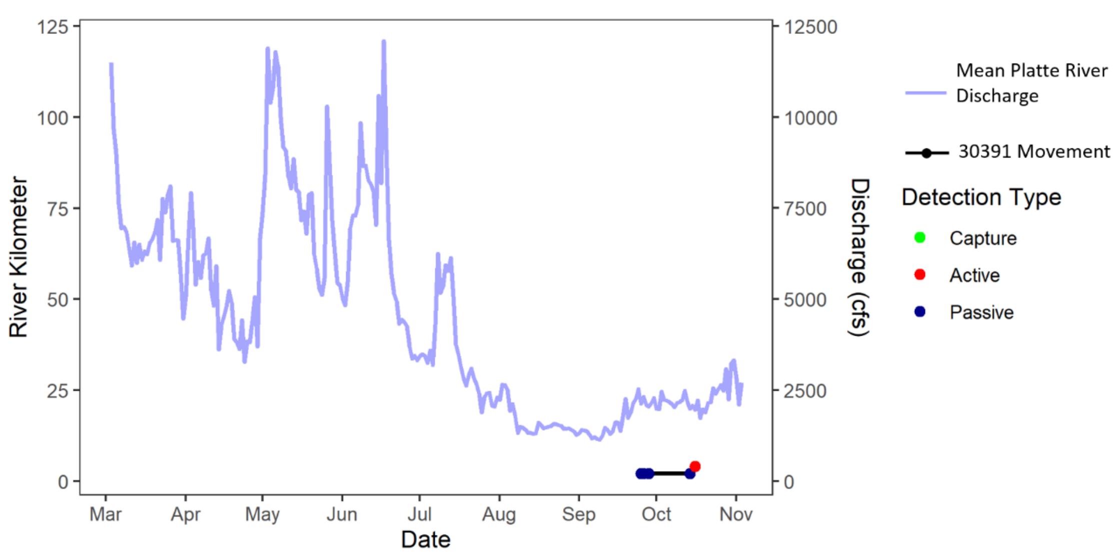


Figure A-30. Capture location and relocations of Pallid Sturgeon A69-1604-30391 in the lower Platte River during 2022 (top). Green dot indicates location and date of capture, red dots indicate locations made during active tracking, and blue dots indicate detections at passive receivers. The bottom graph shows linear movement of the fish through time. Mean daily discharge is in cubic feet per second (cfs).

Appendix B: Completed training for key personnel

The following table documents project-specific training completed by key personnel. Training programs are noted as U.S. Department of Interior (DOI) or University of Nebraska-Lincoln (UNL) followed by course training course title, date completed, and valid through.

Name	Position	Training course completed	Date completed	Valid through
Christopher Pullano	M.S.	DOI – Motorboat Operator Certification Course (MOCC)	6/25/2018	6/25/2023
Christopher Pullano	M.S.	UNL IACUC - General Regulation Training	12/17/2021	12/17/2026
Christopher Pullano	M.S.	UNL Surgery procedure training	2/17/2022	2/16/2027
Christopher Pullano	M.S.	DOI Airboat training	3/3/2022	3/2/2027
Christopher Pullano	M.S.	DOI – Over the Water	3/15/2022	3/15/2025
Jenna Ruoss	Ph.D.	DOI – Over the Water	11/4/21	11/4/2025
Jenna Ruoss	Ph.D.	DOI – Motorboat Operator Certification Course (MOCC)	11/8/21	11/8/2026
Jenna Ruoss	Ph.D.	UNL IACUC - General Regulation Training	12/17/2021	12/17/2026
Jenna Ruoss	Ph.D.	UNL Surgery procedure training	2/17/2022	2/16/2027
Jenna Ruoss	Ph.D.	DOI Airboat training	3/3/2022	3/2/2027