Platte River Recovery Implementation Program

Pallid Sturgeon Biology in the Platte River and its Tributaries
Annual Progress Report
(Year 2: 2023)

Prepared for: Governance Committee
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Note: this report is focused on data summarization pertaining to immigration and emigration events into and from the Platte River per guidance from the EDO.

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Definition of Acronyms and Terms

Acronyms

AICc	Akaike's Information Criteria - corrected for small sample sizes
CFS	Cubic Feet Per Second
COE	United States Corps of Engineers
EDO	Executive Director's Office
GLM	Generalized Linear Model
MDC	Missouri Department of Conservation
NGPC	Nebraska Game and Parks Commission
PRRIP	Platte River Recovery and Implementation Program
UNL	University of Nebraska-Lincoln
USGS	United States Geological Survey

Terms

Non-Reproductive	Individual in Reproductive Stage I, II, or III per USGS–-Columbia Environmental Research Center Guidelines (https://www.cerc.usgs.gov/pubs/v_clips/reproduction.pdf).
Reproductive	Individual in Reproductive Stage IV (e.g., black egg female) per USGS–-Columbia Environmental Research Center Guidelines (https://www.cerc.usgs.gov/pubs/v_clips/reproduction.pdf).
InnovaSea	Tag and receiver manufacturer.
Immigration	Individual Pallid Sturgeon from the Missouri River (tagged or recently detected) detected at the confluence and later detected upstream in the Platte River by the passive receiver array or active tracking efforts.
Emigration	Individual Pallid Sturgeon from the Platte River (tagged or recently detected) detected at the confluence and later detected in the Missouri River by passive receiver array or active.
Individual occurrence	Individual Pallid Sturgeon detected on one or both of the lower Platte River confluence receivers, then subsequently detected again in the Missouri River (i.e., no movement further into the Platte River detected).
Viewshed	Area under water that can effectively detect a transmitter by a receiver.

Executive Summary

The goal of this project is to fill gaps in understanding regarding the ecology of Pallid Sturgeon *Scaphirhynchus albus* in the lower Platte River system. Specifically, interests include quantifying time spent within the lower Platte River and its tributaries by Pallid Sturgeon, what environmental or biotic variables facilitate their movement into, out of, and within this system, and assessing habitat use. Objectives of this project are to: 1) identify 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 lower Platte River and its tributaries, and 4) provide Pallid Sturgeon genetic samples for further population and hybridization assessment. However, this report will focus largely on preliminary analyses for Objective 1 related to immigration and emigration to and from the lower Platte River at its confluence with the Missouri River per EDO instructions. Spawning has not been directly observed, nor have any confirmed Pallid Sturgeon eggs or larvae been captured to verify spawning through the first two years of this project (Objectives 2 & 3). Further, Objective 4 is a sample collection procedure as part of the fish capture effort in the lower Platte River and only the number of samples provided to Dr. Ed Heist at the University of Southern Illinois – Carbondale are reported. An initial assessment of the detection efficiency of the passive acoustic receiver array using both experimental approaches conducted seasonally and through summarizations of detections of individual Pallid Sturgeon throughout the network using the actel package (Flávio and Baktoft 2021) in Program R (R Core Team 2022) has also been provided.

Acoustic telemetry has been used to evaluate movement of Pallid Sturgeon into and out of the lower Platte River and will continue to be used to assess movements within the lower Platte River and its tributaries. Here, a series of passive receivers (N = 32) have been placed at strategic locations throughout the lower Platte River, including receivers within the Elkhorn River and Loup River, to continually monitor movements of fish as they pass the receiver locations. Active tracking, where crews cover the entirety of the study area, is also used to locate fish on a monthly basis within the study area. The active tracking data were used here to document instances when immigration or emigration occurred but was missed by the passive receiver array. Future analyses will use active detections for more fine-scale movements and habitat use. Sources of Pallid Sturgeon to populate the telemetry network come from a combination of individuals captured in the lower Platte River as part of this project and tracking individuals implanted with transmitters by concurrent work in the Missouri River when movement into the lower Platte River system occurred. Pallid Sturgeon were captured in the lower Platte River using trotlines baited with nightcrawlers *Lumbricus terrestris* following the Range-wide Pallid Sturgeon Handling Protocols and Procedures (USFWS 2019). Trotlines were deployed throughout the lower 160 km reach of the lower Platte River in locations that ideally hold pallid sturgeon (i.e., deep (>1 m) and relative swift (>0.5 m/s) velocities).

There have been 94 unique Pallid Sturgeon either tagged by UNL or moved into the lower Platte River system since March, 2022 when field work began. Fifty-four Pallid Sturgeon were captured in the lower Platte River during the 2022-2023 trotline efforts (all submitted for

genetic assessment). However, only 29 individuals were large enough to be implanted with a transmitter. An additional 65 Pallid Sturgeon from the Missouri River were detected over the two years. Key findings thus far include:

Pallid Sturgeon Movement

- Seasonality of movement into (immigration) the lower Platte River appears evident and may be greatest during spring and fall. Model results suggest discharge and temperature may also influence immigration. However, refining the scale and completeness of data is needed before clear patterns are proposed.
- Emigration out of the lower Platte River was less clear, but some increased activity did occur during the post-spawning window in May and June.
- Immigration and emigration behaviors were not entirely consistent between 2022 and 2023. Divergent hydrographs and resulting differences in temperature and other abiotic conditions between the two years may influence differences in behavior. Additional data and further analyses may clarify.
- Both reproductive and non-reproductive Pallid Sturgeon appear to regularly move into the lower Platte River and its tributaries. Stage IV reproductive female Pallid Sturgeon have been documented in the lower Platte River and tributaries. Evidence of spawning, based on departure time and no eggs present upon recapture, did occur 2023 by a single female Pallid Sturgeon.
- Movement into the lower Platte River is not limited to locations below the Elkhorn River confluence but extends the entirety of the system, albeit with lesser frequency moving upstream. Future multi-state models will be developed to try and quantify movement probabilities among mainstem and tributary locations within the lower Platte River.

Telemetry configuration

- Detection efficiency within the passive receiver network was best when multiple receivers were used to create a "gate" where a transect of receivers were placed across the river, perpendicular to flow.
- Conversely, identifying locations suitable to establish a gate at meaningful locations (e.g., transition upstream beyond the Elkhorn confluence) have been problematic under the low-water conditions experienced over the past two years.
- Passive receivers are largely influenced by line of site distance for detection.
- The composite detection range (a.k.a., viewshed) of our receivers is relatively small compared to other studies. A combination of bedform, moving sediment, wind, and water depth also impact the detection ranges.

Adjustments to field protocols and statistical analyses are planned for 2024 and include:

Field Protocols

- No captures of Pallid Sturgeon during 2 spawning seasons using ichthyoplankton nets occurred (N = 278 individual net deployments). Given the substantial time commitment required to fish these gears at a time when other activities may yield greater insight into movement and habitat use, we will cease ichthyoplankton net sampling. However, egg mat sampling will likely continue when there is a suspected spawning event or aggregations of reproductive-ready Pallid Sturgeon.
- An additional receiver will be added at the confluence of the lower Platte River with the Missouri River upstream of the current UNL maintained receiver to better detect directional movement (i.e., immigration and emigration) events.
- An additional receiver(s) will be added upstream of Arlington, NE in the Elkhorn River (e.g., Scribner, NE), pending access.
- We will also evaluate a possible reconfiguration of receivers to optimize detections. This likely will include adding additional receivers at existing stations upstream of the Elkhorn River (e.g., North Elkhorn, Fremont, North Bend, Schuyler). Suitable water depths in these reaches have largely limited where receivers can be placed, but we will seek to fill potential detection gaps where possible.

Statistical Analyses

- Preliminary analyses confirm the analytical tools we outlined in the data management plan will converge given the data we currently have in hand, yet there is need for incorporation of additional data for both the fish movements and environmental variables. We anticipate improved performance as additional data are attained. We will continue to build, refine, and seek improved avenues to analyze the data.
- Continue building GLM models with more robust data as we acquire such. Included in these analyses will be additional measures of environmental variability as outlined in the data management plan (e.g., discharge, temperature, noise levels measured by receivers, etc.).
- Evaluate other time steps: Currently, models are converging with data aggregated at the daily time step. Maintaining analyses at the daily time step will remain the priority. However, temporal spacing can be scaled up (e.g., week, month, etc.) and will be considered when reasonable to the Pallid Sturgeon life cycle.

- Explore alternative distributions during model building to include those capable of handling count data and potentially models with hierarchical structure. Cursory, zero-inflated models have been performed but further exploration of these models will occur.
- Classification and regression tree type approaches will continue to be explored to develop easily interpreted thresholds for movement events.

INTRODUCTION

Pallid Sturgeon *Scaphirhynchus albus* (Forbes and Richardson 1905) is a federally endangered fish first listed in 1990 (USFWS 1990). Pallid Sturgeon was historically 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). Rivers that historically were occupied by Pallid Sturgeon were characterized as large, swift, turbid, braided, and free flowing (Bailey and Cross 1954; Dryer and Sandvol 1993; Peters and Parham 2008). Habitat alterations 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). Of particular concern is the near or complete loss of spawning and recruitment habitat for the species.

Current recovery efforts for Pallid Sturgeon in the Missouri River basin have largely focused on the mainstem and typically included obtaining information on population dynamics assessments (e.g., population estimates, movement, survival, etc.), habitat modification (e.g., creating interception and rearing zones), and propagation (e.g., stocking hatchery reared individuals). However, 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 has been documented using tributaries across their distribution in the upper and lower Missouri River basins (Bramblett and White 2001; Hamel et al. 2016). Seasonal presence and spawning by Pallid Sturgeon within tributaries is thought to coincide with hydrologic and temperature regimes (Hamel et al. 2016). Of particular interest is the prevalence of spawning and recruitment of Pallid Sturgeon within tributaries.

Efforts reported here were part of a project initiated in July 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 was initially 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 original objectives were 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).

Focus of this report

The information contained in this report solely reflects preliminary analyses of data collected through 2023 for portions of Objective 1. Specifically, we provide initial insights into movements strictly pertaining to immigration and emigration events at the Platte River-Missouri River confluence per a directive from EDO. We also provide an initial assessment of receiver efficiency as part of an overall perspective of Objective 1 in terms of movement. Additional, supporting information for other aspects in Objective 1 (e.g., movement among river reaches within the Platte River and tributaries), summarization of work performed on the remaining objectives, and student-focused research will not be reported here.

Objective 1

This objective is aimed at identifying 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.

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. 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).

Methods

The following information outlines data sources and preliminary analyses used to investigate fish movements between the Missouri River and Platte River. These are intended more as an initial exploration and proof of concept of the types of analyses that will follow for movements within the Platte River and among its tributaries as additional data collection efforts allow. As such, all results should be viewed as preliminary.

Pallid Sturgeon Detections

- Pallid Sturgeon were caught via trotline sets in early spring and fall (2022 & 2023) in the lower Platte River (UNL crew) and Missouri River (USGS, NGPC, MDC, USFWS, COE) and surgically implanted with acoustic tags (InnovaSea V13 and V16).
- Passive acoustic receivers are located and maintained in the lower Platte River (maintained by UNL crew) and Missouri River (maintained by USGS crew) to create a system-wide array. The passive receiver array is used to detect movement between receiver locations. Each time a Pallid Sturgeon passes a receiver, a date/time stamp is recorded along with the unique identifier for the individual. The passive data we used came from two sources.
    - The UNL-led project currently maintains 32 receivers in the lower Platte River basin (Figure 1). One of those receivers is located about 1 km upstream from the Missouri River. Additional detections were also used to supplement or confirm movement status if individuals were located via active tracking.
    - The USGS maintains one receiver in the Platte River and two receivers in the Missouri River immediately upstream and downstream of the confluence.
    - These two sources were used to provide detection data for individual Pallid Sturgeon movement between the lower Platte River and Missouri River.
- The USGS receiver at the confluence of the lower Platte River with the Missouri River provides longer temporal perspective of movement dating to summer 2020. We therefore

used data that pre-date our study as a means to increase sample size for this data analysis exercise. How and when we use these "pre-project" data in the future will be clearly identified and outlined in future works if/when used. Where feasible here, we present analyses using data from all years in addition to a separate analysis using only the PRRIP supported data collection effort for illustrative purposes.

Determining Pallid Sturgeon migratory status

- A series of decisions were made to distinguish Pallid Sturgeon movements into the Platte River from the Missouri River (immigration), into the Missouri River from the Platte River (emigration), and loitering patterns at the confluence of the Platte and Missouri rivers (individual occurrence).
  - *Immigration* - Individual Pallid Sturgeon from the Missouri River (tagged or recently detected) detected at the confluence and later detected upstream in the Platte River by the passive receiver array or active tracking efforts were considered an immigrant into the Platte River.
  - *Emigration* - Individual Pallid Sturgeon from the Platte River (tagged or recently detected) detected at the confluence and later detected in the Missouri River by passive receiver array or active tracking were considered an emigrant from the Platte River.
  - *Individual occurrence* - Individual Pallid Sturgeon detected on one or both of the lower Platte River confluence receivers, then subsequently detected again in the Missouri River (i.e., no movement further into the Platte River detected).

Collection of predictor variables associated with emigration, immigration, individual occurrence

- Predictor variables used to associate immigration and emigration events into and from the Platte River included measures of central tendency and spread for Platte River discharge, Platte River temperature, and the month of year.
- Platte River raw discharge data were obtained from the USGS gage station located at Louisville, NE (approximately 24 km from the confluence of the Platte and Missouri rivers). These data were then converted to daily statistics as appropriate. The dates included spanned the time a receiver (either UNL or USGS) was installed at the confluence.
- Platte River raw water temperature data were primarily obtained from the UNL receiver located at the confluence of the Platte and Missouri rivers. These data were then converted to daily statistics as appropriate. However, there is an incomplete time series of temperature due to equipment loss in summer 2022. Therefore, we back-filled temperature data from the USGS gage station located at Louisville, NE during periods when the temperature sensor was operational. The gage does not operate its temperature sensor during winter, so we estimated seasonal means and measures of spread from existing data collected at the receiver located at the confluence of the Platte and Missouri rivers. Periods where temperature was derived included winter 2021 and winter 2022

(Figure 2). Temperature data from other receivers in the Platte River is forthcoming and will replace the derived temperatures in the future.

- Month was used as a categorical variable instead of season primarily because season was too coarse to provide separation of late winter (e.g., February and March) and late fall (e.g., November and December) periods given the abrupt start and stop of Pallid Sturgeon movement into and out of the lower Platte River during seasons.

Statistical Analysis

Pallid Sturgeon Movement

- Analyses generally followed a two-step process where we first analyzed factors that influence individual occurrence. This analysis is intended as a proxy to indicate some measure of activity in the immediate confluence area. The second step restricted data analyses focused on fish that confirmed movements between systems were noted. Here we conducted separate analyses to assess factors that influence either immigration or emigration.
- Generalized linear models (GLMs) using a binomial distribution were created to assess probability of emigration, immigration, and encounter, at the Platte River confluence with the Missouri River. Continuous variables included mean daily discharge and mean daily temperature, whereas month was treated as a categorical variable. Turbidity was not assessed due to limited data availability from the USGS gage at Louisville, NE (Figure 3). A set of GLMs were built to assess encountering a Pallid Sturgeon at the mouth of the Platte River, immigration into the Platte River, and emigration from the Platte River in R (R Core Team 2022). Model sets included a global model with all predictor variables, single predictor variable models, and a null model, then compared using AICc. All Pallid Sturgeon detections regardless of being assigned a migratory status (i.e., immigration, emigration, individual occurrence) were included when considering the probability of encounter at the mouth. However, Pallid Sturgeon that were considered an individual occurrence were not included when modeling the probability of immigration or emigration.
- Additional modeling approaches including random forest regression tree models and zero-inflated GLMs (using a Poisson distribution) were conducted. At this time, all individual encounters (i.e., counts of individual Pallid Sturgeon) within a 24 hr period were used to build count-based models. As additional counts continue to come in, emigration and immigration will be added to these models.

Acoustic receiver detection efficiency

- Detection efficiency was assessed at three passive receivers located at Louisville, NE (Right Channel; VR2Tx-489486), North Bend, NE (VR2Tx-487721), and Waterloo, NE (VR2Tx-487711) during the spring, summer, and fall using stationary range tests. Range tests were conducted at 25 m intervals up to 100 m upstream and downstream of each passive receiver using both V13 (6 second transmission rate) and V16 (7 second transmission rate) acoustic range test transmitters. Detection efficiency was calculated for each station as the number of received detections represented as a percentage of the expected detections during each 20-minute test.

- An acoustic doppler current profiler (ADCP) was used during each passive range test to measure the range of depths within the range testing area (approx. 1km). Original ADCP derived depth values were then interpolated using ordinary kriging methods to create a raster of predicted depths in ArcPro. The geodesic viewshed tool was then used to determine the area surrounding an acoustic receiver that a tag can be detected. Viewshed analyses are a form of terrain analysis that are commonly used to determine the visible area of an observer depending on their elevation and the surrounding terrain. Viewshed analyses have also been previously applied to ultrasonic frequency transmission through water and used to determine areas in which an acoustic signal can be detected by a passive receiver (Aspillaga et al. 2019). To perform the viewshed analyses, depth rasters were inverted using the Raster Calculator tool, and observer elevation was set to the inverse value of the receiver depth. Viewshed areas were then clipped within the maximum 5% detection range estimated from stationary range tests to more accurately estimate the area that transmitters can be detected from during each range test.
- Detection efficiency of each receiver placement or gate (i.e., a series of receivers in perpendicular transect across the river at a site) was calculated in the Actel package (Flávio and Baktoft 2021) using Program R (R Core Team 2022) with the number of recorded and known missed events at each passive listening station.

Results

General Telemetry 2022-2023 using only UNL data

- Crews from UNL captured 54 Pallid Sturgeon (genetic samples were taken for all fish) of which 29 were implanted with acoustic tags during 2022-2023.
- A total of 94 unique Pallid Sturgeon transmitters have been identified in the lower Platte River system by UNL from 2022 to 2023. This number accounts for 31% of all telemetry tagged Pallid Sturgeon in the Lower Missouri River as of spring 2023.
- Pallid Sturgeon were detected throughout the lower Platte River, and the Elkhorn River in 2022 and 2023. Two Pallid Sturgeon were detected in the Loup River in 2023 (Table 1; Table 2).
- Stage IV reproductive female Pallid Sturgeon have been documented in the lower Platte River and tributaries. Evidence of spawning, based on departure time and no eggs present upon recapture, did occur 2023 by a single female Pallid Sturgeon.
- The UNL passive receiver array (all 32 receivers) has a total of 13,257 detections for 2022-2023. A total of 80 unique Pallid Sturgeon individuals have been identified throughout the lower Platte River via the passive receiver array.
- Active telemetry (i.e., monthly river sweeps) has detected a total of 43 unique Pallid Sturgeon with a total of 120 active detection events.

Immigration and Emigration (Including USGS Receiver Data 2020-2023)

- A total of 1,808 Pallid Sturgeon detections occurred using both UNL and USGS receivers located at the confluence of the Platte River with the Missouri River between May 31, 2020 and October 10, 2023 (Figure 4; Figure 5).
- A total of 99 unique individual Pallid Sturgeon have been detected at the Platte River confluence with the Missouri River from 2020 to 2023.
- The number of Pallid Sturgeon detected at the Platte River confluence with the Missouri River during a 24-hr period ranged from 0 to 5.
- All predictor variables assessed (i.e., month, discharge, temperature) appear to have an influence on individual encounter, immigration, and emigration (Table 3; Table 4; Table 5).
- The model that contained the additive effects of month, mean discharge, and mean temperature was the best candidate model for the individual occurrence analysis. The model had an AICc weight of 0.73 (Table 3) to predict the probability of Pallid Sturgeon encountering the mouth. The month of October had the highest probability of an individual encounter at the mouth. In addition, lower discharges and higher temperatures increased the probability of encounter during October (Figure 6). Month itself accounted for 27% of the total model weight, whereas mean discharge and mean temperature contributed less than 0.1% to the model weight (Table 3).
- The global model was the highest-ranking model for predicting immigration with an AICc weight of 0.83 (Table 4). The month of October had the highest probability of immigration with lower discharges and higher temperatures increasing the probability of immigration during that month (Figure 7). Month accounted for 17% of the total model weight, while the weights of mean discharge and mean temperature were negligible (Table 4).
- The global model was the best candidate model for emigration out of the Platte River with an AICc weight of 0.99 (Table 5). Pallid Sturgeon had a higher probability of emigration during late spring months (i.e., May, June). Further, the probability of emigration was also high in June with low discharges and high temperatures (Figure 8).

Immigration and Emigration (Using Only UNL Receiver Data 2022-2023)

- The global model with the additive effects of mean discharge, mean temperature, and month was the highest-ranking model for predicting the probability of an individual occurrence at the mouth, with an AICc weight of 0.89. Month accounted for 11% of the total model weight, in which October had the highest probability of encounter (Table 6; Figure 9).
- The global model with the additive effects of mean discharge, mean temperature, and month was also the best candidate model for predicting the probability of Pallid Sturgeon immigration, with an AICc weight of 0.97 (Table 6). Increasing discharge and

temperature in the month of October resulted in the highest probability of immigration (Figure 10).

- The model with only month as the predictor variable for emigration was the highest ranking, with an AICc weight of 0.89 (Table 6). The month of May had the highest probability of emigration, though overlapping standard errors bars with other months suggest that the probability is not significantly different (Figure 11).

Alternative Modelling Approaches

- Daily counts of individual encounters were also assessed using zero-inflated models (with Poisson distribution) given the large number of zero values (Figure 12).
    - Model rankings were similar to those using binomial GLMs where months in spring and fall suggested greater encounters occurred at the lower Platte River confluence (Table 7). Additional model construction with more covariates as well as different structures for the binomial and count portions of the models will be assessed.
- A simple classification (Figure 13) tree using a suite of mean, daily maximum, daily minimum, and daily range for both discharge and temperature to predict individual occurrence at the confluence suggest moderate temperatures (6 – 19°C) influence Pallid Sturgeon activity. The overall classification error rate was 0.08. However, almost all of the misclassifications were individual occurrence events suggesting further refinement is needed.
- A random forest model also suggested cutoffs of mean temperature, minimum temperature, and mean discharge as potential associations with activity levels at the lower Platte River confluence (Figure 14). Prediction accuracy of model provides a starting point for future analysis (Figure 15).

Detection Efficiency

- Simple comparison of the passive vs active tracking data in the Platte River system indicated that the passive receivers detected 81% of all the fish detected within the Platte River. Conversely, active tracking detected 52% of all the fish detected within the Platte River. While this is not an assessment of efficiency per se, it highlights that the two techniques are complementary.
- Detection efficiency at each passive receiver location, measured by assessing known individuals within the listening array, was variable and ranged from 27 – 100% (mean 68%; SD 24%) detections (Figure 16). Locations that have a gate-type arrangement of receivers generally produced better detection efficiencies than locations that had a single receiver. Receivers in the Elkhorn River generally performed better than those located in the Platte River. The Loup River had two individuals that were known to be in that river and both were detected.
- Stationary range tests yielded detection efficiencies ranging from 0% to 100% between 25 and 100 meters (Figure 17). Generally, detection efficiency decreased as the distance between the transmitter and receiver increased.

- Detection efficiency was reportedly higher for V16 transmitters than V13 transmitters and was likely due to differences in transmitter signal power.
- The viewshed, or area surrounding an acoustic receiver that a tag can be detected, was largely limited by channel morphology and bedform topography, and was variable across all sites and seasons (Figure 19; Figure 20; Figure 21).

Discussion

The data have been analyzed using all the data we have in hand—including USGS detections beginning in 2020—at the Platte River-Missouri River confluence and also using solely the data gathered during the PRRIP funded project (2022-2023) for several reasons. First, the number of detections across the entire timeframe at the confluence substantially increases sample size for assessing whether or not fish were physically in the mouth of the Platte River in these preliminary analyses. Assessing occurrences at the mouth is informative for determining conditions that are conducive for fish to congregate in this area – perhaps a pre- or post-staging area for movements in either the Platte River or Missouri River. Second, the disparate timeframes highlight the potentially contradictory results and emphasize the need to be cautious in future analyses and to try to encompass as much of the variability in the system as possible. For example, the response to discharge between the entire dataset (2020-2023) is opposite the PRRIP funded project dataset (2022-2023) in some instances. Presumably, there are implications to the amount of water in the system as the recent two years have been low water years.

The amount of activity in and around the confluence area in the fall, but especially October (Figure 4; Table 7), was somewhat unexpected. Movements during this timeframe are a known phenomenon, but the potential aggregation at the confluence area and subsequent movements well into the lower Platte River we observed was unknown. Exact implications and conditions that encourage or discourage this behavior remain to be determined, but if this area is truly a staging location for further movements, there could be insights gained into water needs at that time of year.

Immigration and Emigration (Including USGS Receiver Data 2020-2023)

The negative effect that discharge had on Pallid Sturgeon probability for individual occurrence, immigration, and emigration was unexpected. Previous literature suggests that greater discharges increase the probability of Pallid Sturgeon presence in the Platte River (Hamel et al. 2016), thus increasing encounter and immigration probabilities. However, ambiguity with respect to the role elevated discharge has on individual occurrence, immigration, and emigration may stem from differences in mean discharge during 2020-2021 and during 2022-2023. If we only accounted for discharge when UNL deployed receivers, the mean discharge across the study period would go from 5,975 cfs (2020-2023) to 4,657 cfs (2022-2023). Further, the maximum discharge would decrease from 47,884 cfs (March 2021) to 20,600 cfs (March 2023). Further, detection probability may have been lower when a single USGS gauge was located at the mouth compared to following deployment of an additional receiver by UNL.

The covariate month was the greatest driver for predicting the probability of individual encounter, immigration, and emigration compared to the additive effects of discharge and temperature. Months associated with spring (i.e., March, April, May) and fall (i.e., October, November) had higher probabilities of immigration, emigration, and encounter, which is relatively consistent with when Pallid Sturgeon have been recorded migrating (Bramblett and White 2001; Wanner et al. 2007).

Increasing temperature was associated with increased probabilities of immigration for March and October but not for June. However, the probability of emigration was highest for June as temperatures increased. Downstream movements of Pallid Sturgeon have been observed in summer months, such as June, corresponding with post-spawning behavior (Delonay et al. 2014). Downstream movement may also be initiated by water temperature, as 33°C has been suggested as lethal for juvenile Pallid Sturgeon (Chipps et al. 2008). During summer, the Platte River can have temperatures exceeding 33°C (Figure 2). Therefore, Pallid Sturgeon may be initiating downstream movement for cooler water refugia. It should be noted though that our temperature data were extrapolated in some instances and therefore not as fine-scale as our other predictor variables assessed. Future analyses using temperature data from the USGS receiver located at the mouth of the Platte River instead of back-filling with the Louisville Gage will be implemented when data are available.

Immigration and Emigration (Using USGS and UNL Receiver Data 2022-2023)

Increasing discharge had a positive effect on the probability of individual occurrence and immigration when only using the timeframe UNL simultaneously had the receiver deployed in tandem with the USGS receiver. This was expected as a previous study showed the probability of Pallid Sturgeon presence increased when discharge was in the 90th percentile (Hamel et al. 2016). In addition, by only including the timeframe in which UNL also had a receiver deployed, we may have a more fine-scale perception of migration into and out of the Platte River due to the increased receiver effort.

Month was the greatest driver for predicting the probability of individual occurrence and immigration compared to the additive effects of discharge and temperature. Notably, month was the top-ranked model for emigration. The probabilities of encounter and immigration were highest in October, which would be consistent with previous observations of fall pre-spawning migration (Delonay et al. 2016). Further, May had the highest predicted probability of emigration, which could be indicative of post-spawning behavior. Pallid Sturgeon have been observed to release eggs after water temperatures reach 16-18°C (Delonay et al. 2012), which is consistent with mean water temperatures in May within the Platte River.

Increasing temperatures had a positive effect on the probability of immigration for October and March, but not for June. Again, this may be due to temperatures during June in the Platte River approaching or at the edge of Pallid Sturgeon thermal tolerances (Chipps et al. 2008). Warming water temperatures, particularly in March, would coincide with a spring migration associated with spawning (Delonay et al. 2016).

Detection Efficiency

Detection efficiency ranged from 27% to 100% (mean 68%) across the telemetry array (Figure 16). These outcomes are comparable to the telemetry array currently in place in the Red River of the North where detection efficiencies range from 25 – 100% (mean 80%; SD 20%; Pegg, unpublished data). Future analyses of fish movements will likely incorporate detection efficiency and error following methods outlined by Winton et al. (2018).

Detection range and viewscape dimensions from the Platte River are substantially lower than other reported studies (summarized in Kessel et al. 2014). Unfortunately, most of the studies reporting such information are represented by marine or large, standing water systems. Detection information for rivers is limited. However, concurrent assessments in the Red River of the North and the Missouri River-Lewis and Clark systems suggest detection ranges in the Platte River are much lower than in systems with single channels or limited braid complexity (e.g., 500-1000+ m detection range vs. < 100 m in the Platte River; Pegg, unpublished data). Undoubtedly, line of site is the predominant limiting factor in detection ranges throughout the Platte River. However, flow, wind, turbidity, and other environmental factors that influence ambient noise levels are also implicated in detection ranges.

Array locations that were composed of several receivers to form a gate were typically more efficient at detecting transmitters (Figure 16). Better efficiency at these locations is logical as many of those sites were characterized by areas of single or limited number of braided, deep channel habitats, coupled with redundant coverage from the receivers located at the gate. Deployment of multiple receivers to form a gate is not always feasible given geomorphic and hydrologic conditions. Single receiver locations like North Bend (Figure 20) were placed in the only consistent, deep water available under current conditions. However, hydropeaking changes water levels daily and also influences the overall viewshed the receiver can detect such that fish may or may not have to navigate past that location within proximity of the receiver depending on water levels. Deploying gate type listening stations in the array will be a priority when and where suitable locations are identified.

Deviations from Plan and Future Adjustments

2023 Adjustments

We added egg mat sampling (Figure 22) to our egg and larval fish sampling effort during 2023 following discussions with USGS scientists in the Upper Missouri River Basin that were using them with some success. Effectively, the mats are placed < 0.5 km downstream of known female and/or male Pallid Sturgeon that are believed to be spawning capable (e.g., stage IV black egg female). The mats are set overnight and retrieved prior to attempts to relocate the target fish the following morning.

Added receiver stations at Zwiebel, Arlington (Elkhorn River), Fremont, Schuyler, Loup (~15 km upstream of confluence).

2024 Proposed Adjustments

Egg and larval fish sampling

No captures of larval pallid sturgeon during 2 spawning seasons using ichthyoplankton nets occurred (N = 278 individual net deployments). Given the substantial time commitment required to fish these gears at a time when other activities may yield better results we will cease ichthyoplankton net sampling. However, the egg mat sampling will likely continue when there is a suspected spawning event or aggregations of reproductive-ready Pallid Sturgeon exist.

Passive receiver array

An additional receiver will be added at the confluence of the lower Platte River with the Missouri River upstream of the current UNL maintained receiver to better detect directional movement (i.e., immigration and emigration) events. An additional receiver(s) will be added upstream of Arlington, NE in the Elkhorn River (e.g., Scribner, NE), pending access. We will also evaluate a possible reconfiguration of receivers to optimize detections. This likely will include adding additional receivers at existing stations upstream of the Elkhorn River (e.g., North Elkhorn, Fremont, North Bend, Schuyler). Suitable water depths in these reaches have largely limited where receivers can be placed, but we will seek to fill potential detection gaps where possible.

Integration of telemetry data collection techniques

Future analyses will incorporate both passive and active telemetry detections in a single analysis. The first step in merging the two data streams required output information from the Actel package to summarize the passive network array. These data will then be incorporated with active telemetry detection information via an R toolkit such as RSP (Refined Shortest Paths). The RSP code was developed specifically for movement of aquatic organisms (Niella et al. 2020).

Data analyses

We are working closely with faculty in the UNL Statistics department to aid in model development. As such, we will continue to explore appropriate techniques to evaluate the data we are collecting. Further, we intend to construct a multi-state, mark-recapture model to estimate movement probabilities in/out of the Platte River, in/out the Elkhorn River, upstream of the Elkhorn River, and Loup River (if possible). Transition (movement) information are already in hand within the Platte River for the 2022-2023 sampling seasons. Developing a complete model, however, is predicated on having access to the full Lower Missouri River Pallid Sturgeon telemetry catalog so that numbers, tagging locations, etc. are known for all potential individuals in the system to build accurate capture histories for fish that could potentially engage the Platte River in some way. Discussions with USGS to acquire those data are ongoing.

References

Aspillaga, E., K. Safi, B. Hereu, and F. Bartumeus. 2019. Modeling the three-dimensional space use of aquatic animals combining topography and Eulerian telemetry data. Methods in Ecology and Evolution 10:1551-1557.

Bailey, R. M., and F. B. Cross. 1954. River sturgeons of the American genus Scaphirhynchus: Characters, distribution, and synonymy. Papers of the Michigan Academy of Science, Arts, and Letters 39:169-208.

Bramblett, R. G., and R. G. White. 2001. Habitat use and movements of Pallid and Shovelnose Sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota. Transactions of the American Fisheries Society 130:1006-1025.

Chipps, S. R., R. A. Klumb, and E. B. Wright. 2008. Development and application of juvenile Pallid Sturgeon bioenergetics model – Final Report, Study T-24-R. Study No. 2424. South Dakota State University, South Dakota.

Delonay, A. J., R. B. Jacobson, D. M. Papoulias, M. L. Wildhaber, K. A. Chojnacki, E. K. Phergio, J. D. Haas, and G. E. Mestl. 2012. Ecological requirements for Pallid Sturgeon reproduction and recruitment in the lower Missouri River – Annual Report 2010. U. S. Geological Survey File Report 2012-1009.

Delonay, A. J., K. A. Chojnacki, R B. Jacobson, J. L. Albers, P. J. Braaten, E. A. Bulliner, C. M. Elliot, S. O. Erwin, D. B. Fuller, J. D. Hass, H. L. A. Ladd, G. E. Mestl, D. M. Papoulias, and M. L. Wildhaber. 2016. Ecological requirements for Pallid Sturgeon reproduction and recruitment in the Missouri River – A Synthesis of Science, 2005-2012. Scientific Investigations Report 2015-5145.

Delonay, A. J., K. A. Chojnacki, R. B. Jacobson, P. J. Braaten K. J. Buhl, C. M. Elliot, and G. E. Mestl. 2014. Ecological requirements for Pallid Sturgeon reproduction and recruitment in the Missouri River: Annual Report 2014. U.S. Geological Survey Open File Report 2016-1013.

Dryer, M. P., and A. J. Sandvol. 1993. Pallid Sturgeon recovery plan. U.S. Fish and Wildlife Service, Bismarck, N.D.

Flávio H and Baktoft H. 2021. actel: Standardised analysis of acoustic telemetry data from animals moving through receiver arrays. *Methods in Ecology and Evolution*, **12**(1), 196-203.

Forbes, S. A., and R. E. Richardson. 1905. On a new shovelnose sturgeon from the Mississippi River. Bulletin of the Illinois State Laboratory of Natural History 7:37-44.

Hamel, M. J., JJ. J. Spurgeon, M. A. Pegg, J. J. Hammen, and M. L. Rugg. 2016. Hydrologic variability influences local probability of Pallid Sturgeon occurrence in a Missouri River tributary. River Research and Applications 32: 320-329.

Kallemeyn, L. 1983. Status of the Pallid Sturgeon: Scaphirhynchus albus. Fisheries 8:3-9.

Kessel, S. T., S.J. Cooke, M.R. Heupel, N.E. Hussey, C.A. Simpfendorfer, S. Vagle, and A.T. Fisk. 2014. A review of detection range testing in aquatic passive acoustic telemetry studies. Reviews in Fish Biology and Fisheries, 24, 199-218.

Niella Y., H. Flávio, A.F. Smoothey, K. Aarestrup, M.D. Taylor, V.M. Peddemors, and R. Harcourt. 2020. Refined Shortest Paths (RSP): Incorporation of topography in space use

estimation from node-based telemetry data. Methods in Ecology and Evolution 2020:1733–1742.
Peters, E. J., and J.E. Parham. 2008. Pallid Sturgeon Literature Review. Final Report to the Platte River Implementation Program, Kearney, NE.
R Core Team. 2022. R: a language and environment for statistical computing. R Foundation for Statistical Computing: Vienna, Australia. Available at: https://www.R-project.org/
U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants: determinations of endangered status for the pallid sturgeon. Federal Register: 55:173(6 September 1990):36641-36647.
U.S. Fish and Wildlife Service. 2019. Range-wide Pallid Sturgeon handling protocols and procedures. U.S. Fish and Wildlife Service, Denver, Colorado.
Wanner, G. A., R. A. Klumb, W. J. Stancill, and G. R. Jordan. 2007. Habitat use and movements of adult Pallid Sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota and Nebraska. Proceedings of the South Dakota Academy of Science 86: 21-33.
Winton M.V., J. Kneebone, D.R. Zemeckis and G. Fay. 2018. A spatial point process model to estimate individual centres of activity from passive acoustic telemetry data. Methods in Ecology and Evolution 9:2262–2272.

Table 1. Number of individual pallid sturgeon detected actively or passively throughout the lower Platte River system. The Platte River segments are distinguished by the Elkhorn River confluence at river kilometer (rkm) 52 (Platte Segment 1 < rkm 52; Platte Segment 2 > rkm 51).

River	Year	Transmitters
Platte Segment 1	2022	49
	2023	66
Platte Segment 2	2022	9
	2023	15
Elkhorn	2022	10
	2023	15
Loup	2022	0
	2023	2

Table 2. All individually tagged Pallid Sturgeon recorded by UNL personnel within the lower Platte River or its tributaries from 2022 to 2023. Implant date indicates when an individual Pallid Sturgeon was surgically implanted, with river mile for the Missouri River and nearest town (and state acronym) indicating where they were initially captured and implanted. Origin indicates whether an individual is hatchery produced, wild produced, or unknown. Reproductive status indicates whether an individual was reproductive (R) or non-reproductive (NR) at time of last status check (i.e., when implanted). All missing data will be updated as the Lower Missouri Telemetry Catalog is updated and shared amongst agencies.

Implant Date	Acoustic Tag	Origin	Reproductive Status	Missouri River Mile	Nearest Town
2019-09-03	A69-1602-59359	Hatchery	NR	591.8	Plattsmouth, NE
2019-09-04	A69-1602-59365	Hatchery	NR	594.8	Plattsmouth, NE
2019-10-09	A69-1602-59354	Probable wild	NR	578.4	Bartlett, IA
2019-10-24	A69-1602-19520	Hatchery	NR	733.3	Sioux City, IA
2019-10-25	A69-1602-19523	Probable wild	R	563.2	Nebraska City, NE
2020-03-25	A69-1602-59578	Hatchery	NR	195.5	Franklin Island, MO
2020-06-11	A69-1602-58917	Probable wild	NR	563.2	Nebraska City, NE
2020-06-12	A69-1602-58909	Probable wild	NR	535.0	Brownville, NE
2020-09-21	A69-1602-59046	Hatchery	NR	796.0	Yankton, SD
2020-10-08	A69-1602-59352	Hatchery	NR	592.3	Plattsmouth, NE
2020-10-14	A69-1602-59024	Hatchery	NR	607.4	Manawa, IA
2020-10-14	A69-1602-59977		NR	426.3	Atchison, KS
2020-10-22	A69-1602-59972	Hatchery	NR	447.4	French Bottoms, MO
2020-11-11	A69-1602-59988	Hatchery	NR	448.3	French Bottoms, MO
2021-03-08	A69-1602-59582	Hatchery	NR	83.0	Pinckney, MO
2021-03-10	A69-1602-55342	Hatchery	NR	598.3	Bellevue, NE
2021-03-17	A69-1602-55362		NR	628.6	Omaha, NE
2021-03-17	A69-1602-55362		NR	628.6	Omaha, NE
2021-03-25	A69-1602-55337	Hatchery	NR	591.5	Plattsmouth, NE
2021-03-25	A69-1602-55340	Hatchery	NR	563.2	Nebraska City, NE
2021-03-25	A69-1602-55344	Hatchery	NR	591.5	Plattsmouth, NE
2021-03-25	A69-1602-55335	Hatchery	NR	591.5	Plattsmouth, NE
2021-03-25	A69-1602-59980	Hatchery	NR	352.0	Labenite, MO
2021-03-30	A69-1602-55356	Hatchery	NR	680.3	Tekamah, NE
2021-04-13	A69-1602-49638	Hatchery	R	725.5	Dakota City, NE
2021-04-15	A69-1602-55355	Hatchery	NR	705.4	Sloan, IA
2021-04-16	A69-1602-19542		R	797.6	James River, SD
2021-06-05	A69-1602-49643	Hatchery	R	799.6	St. Helena, NE
2021-06-19	A69-1602-54451	Hatchery	NR	596.6	Bellevue, NE
2021-10-20	A69-1602-49253	Hatchery	NR	591.9	Bellevue, NE
2021-10-20	A69-1602-49254	Hatchery	NR	591.9	Plattsmouth, NE
2022-03-17	A69-9001-58904	Hatchery	NR		South Bend, NE

Implant Date	Acoustic Tag	Origin	Reproductive Status	Missouri River Mile	Nearest Town
2022-03-17	A69-1602-62089	Hatchery	NR		South Bend, NE
2022-03-17	A69-1602-63212		NR	596.7	Bellevue, NE
2022-03-19	A69-9001-58907	Hatchery	NR		South Bend, NE
2022-03-29	A69-1602-62101	Wild	R		La Platte, NE
2022-03-29	A69-1602-63223	Hatchery	NR	584.8	Bartlett, IA
2022-04-07	A69-1602-54445		NR	591.5	Plattsmouth, NE
2022-04-07	A69-1602-63086		NR	591.5	Plattsmouth, NE
2022-04-09	A69-1602-59042	Hatchery	NR		La Platte, NE
2022-04-10	A69-9001-58908	Hatchery	R		La Platte, NE
2022-04-16	A69-9001-58906	Hatchery	R		Ashland, NE
2022-04-16	A69-1602-62091	Hatchery	NR		Ashland, NE
2022-04-16	A69-1602-62092	Hatchery	NR		Ashland, NE
2022-09-14	A69-1602-63209	Hatchery	NR	594.3	Plattsmouth, NE
2022-09-14	A69-1604-30383	Hatchery	R	594.3	Plattsmouth, NE
2022-09-14	A69-1604-30391	Hatchery	NR	594.3	Plattsmouth, NE
2022-09-14	A69-1604-30380	Hatchery	NR	594.3	Plattsmouth, NE
2022-09-14	A69-1604-30381	Hatchery	NR	594.3	Plattsmouth, NE
2022-09-29	A69-1604-30384	Hatchery	NR	594.3	Plattsmouth, NE
2022-10-25	A69-1602-62090	Hatchery	NR		Louisville, NE
2022-10-27	A69-1602-62095	Hatchery	NR		South Bend, NE
2022-10-27	A69-1602-62094	Hatchery	NR		Louisville, NE
2022-11-01	A69-1602-62097	Hatchery	NR		Louisville, NE
2022-11-01	A69-1602-62099	Hatchery	NR		Louisville, NE
2023-03-15	A69-1602-49647	Hatchery	R	805.7	
2023-03-21	A69-1602-62088		NR		South Bend, NE
2023-03-21	A69-1604-30389	Probable Wild	R		Plattsmouth, NE
2023-03-22	A69-1602-62096		NR		Louisville, NE
2023-03-22	A69-1602-62098		R		Louisville, NE
2023-03-23	A69-1604-30387		NR	599.1	Plattsmouth, NE
2023-03-24	A69-9001-54335	Hatchery	R		Ashland, NE
2023-04-09	A69-9001-54336		R		North Bend, NE
2023-04-11	A69-9001-54334		R		North Bend, NE
2023-04-11	A69-1604-13377		NR		North Bend, NE
2023-04-18	A69-9001-54330		R		South Bend, NE
2023-04-18	A69-9001-54337		R		South Bend, NE
2023-04-25	A69-1604-22492		R	698.5	Plattsmouth, NE
2023-10-11	A69-1602-62093	Hatchery	NR		Louisville, NE
2023-10-17	A69-1604-13378	Hatchery	NR		Ashland, NE
2023-10-18	A69-9001-54329	Hatchery	NR		Louisville, NE
2023-10-19	A69-9001-54333	Hatchery	NR		La Platte, NE

Implant Date	Acoustic Tag	Origin	Reproductive Status	Missouri River Mile	Nearest Town
2023-10-19	A69-9001-54331	Hatchery	NR		La Platte, NE
	A69-1602-55347	Hatchery	NR	699.9	Sloan, IA
	A69-1604-20593	Unknown			
	A69-1604-20594	Hatchery			
	A69-9001-58905	Hatchery	NR		South Bend, NE
	A69-1602-62100	Hatchery	NR		Plattsmouth, NE
	A69-1602-62330	TBD			
	A69-1604-22499	TBD			
	A69-1604-20601	TBD			
	A69-1604-24615	TBD			
	A69-1604-20595	Hatchery			
	A69-1604-22191	Hatchery			
	A69-1604-22190	TBD			
	A69-1604-24613	TBD			
	A69-1604-20596	Hatchery			
	A69-1602-63085	TBD			
	A69-1602-63083	TBD			
	A69-1604-22188	Hatchery	R		
	A69-1604-22194	Hatchery			
	A69-1604-22502	TBD			
	A69-1604-65040	TBD			

Table 3. Candidate models, number of parameters (K), Akaike's information criterion (AICc), increase over the lowest AICc (Delta_AICc), model likelihood (ModelLik), AICc weight (AICcWt), log-likelihood of each model (LL), and the cumulative Akaike model weight (cw) for generalized linear models used to predict the probability of Pallid Sturgeon individual occurrence at the mouth of the Platte River.

Candidate Models	K	AICc	ΔAICc	ModelLik	AICcWt	LL	cw
Detection ~ mean_discharge + mean_temp + month	14	819.45	0.00	1.00	0.73	-395.55	0.73
Detection ~ month	12	821.39	1.94	0.38	0.27	-398.57	1.00
Detection ~ mean_temp	2	936.11	116.66	0.00	0.00	-466.05	1.00
Detection ~ mean_discharge	2	948.62	129.17	0.00	0.00	-472.31	1.00
Detection ~ 1	1	951.57	132.12	0.00	0.00	-474.78	1.00

Table 4. Candidate models, number of parameters (K), Akaike's information criterion (AICc), increase over the lowest AICc (Delta_AICc), model likelihood (ModelLik), AICc weight (AICcWt), log-likelihood of each model (LL), and the cumulative Akaike model weight (cw) for generalized linear models used to predict the probability of Pallid Sturgeon immigration into the Platte River.

Candidate Models	K	AICc	Delta_AICc	ModelLik	AICcWt	LL	cw
Immigration_Event ~ mean_discharge + mean_temp + month	14	479.76	0	1	0.83	-225.71	0.83
Immigration_Event ~ month	12	482.97	3.21	0.2	0.17	-229.36	1
Immigration_Event ~ mean_discharge	2	545.55	65.79	0	0	-270.77	1
Immigration_Event ~ mean_temp	2	551.34	71.57	0	0	-273.66	1
Immigration_Event ~ 1	1	551.47	71.71	0	0	-274.73	1

Table 5. Candidate models, number of parameters (K), Akaike's information criterion (AICc), increase over the lowest AICc (Delta_AICc), model likelihood (ModelLik), AICc weight (AICcWt), log-likelihood of each model (LL), and the cumulative Akaike model weight (cw) for generalized linear models used to predict the probability of Pallid Sturgeon emigration from the Platte River.

Candidate Models	K	AICc	Delta_AICc	ModelLik	AICcWt	LL	cw
Emigration_Event ~ mean_discharge + mean_temp + month	14	372.05	0	1	0.99	-171.85	0.99
Emigration_Event ~ month	12	381.75	9.70	0.01	0.01	-178.75	1
Emigration_Event ~ mean_discharge	2	401.09	29.04	0	0	-198.54	1
Emigration_Event ~ mean_temp	2	405.18	33.13	0	0	-200.59	1
Emigration_Event ~ 1	1	408.20	36.15	0	0	-203.1	1

Table 6. Comparing candidate models, model rankings, increase over the lowest AICc (Delta_AICc), and AICc weight (AICcWt), for generalized linear models used to predict the probability of Pallid Sturgeon encounter, immigration, and emigration into the Platte River for models developed using data from 2020-2023 (green-shaded) and models developed using data from 2022-2023 (i.e., following UNL receiver addition to confluence of lower Platte River; unshaded).

	Model Ranking	Model Name	Delta_AICc	AICcWt.	Model Name	Delta_AICc	AICcWt.
Individual Occurrence	Top	Detection ~ mean_discharge + mean_temp + month	0	0.73	Detection ~ mean_discharge + mean_temp + month	0	0.89
	Second	Detection ~ month	1.94	0.27	Detection ~ month	4.17	0.11
Immigration	Top	Immigration_Event ~ mean_discharge + mean_temp + month	0	0.83	Immigration ~ mean_discharge + mean_temp + month	0	0.97
	Second	Immigration_Event ~ month	3.21	0.17	Immigration ~ month	6.81	0.03
Emigration	Top	Emigration_Event ~ mean_discharge + mean_temp + month	0	0.99	Emigration ~ month	0	0.89
	Second	Emigration_Event ~ month	9.7	0.01	Emigration ~ mean_discharge + mean_temp + month	4.12	0.11

Table 7. Model rankings for zero-inflated (using Poisson distribution) models for individual occurrences at the Platte River-Missouri River confluence. The number of parameters in each model (K), Akaike's information criterion corrected for small sample size (AICc), the difference in AICc from the top ranked model (Δ AICc), the model weight (AICcWt), and the log likelihood (LL) for each model is given.

Model Name	K	AICc	Δ AICc	AICcWt	LL
Month	13	1083	0	1	-528.80
Mean Discharge	3	1204	120	0	-599.11
Mean Temp	3	1207	123	0	-600.52
Null (~1)	2	1216	132	0	-606.25

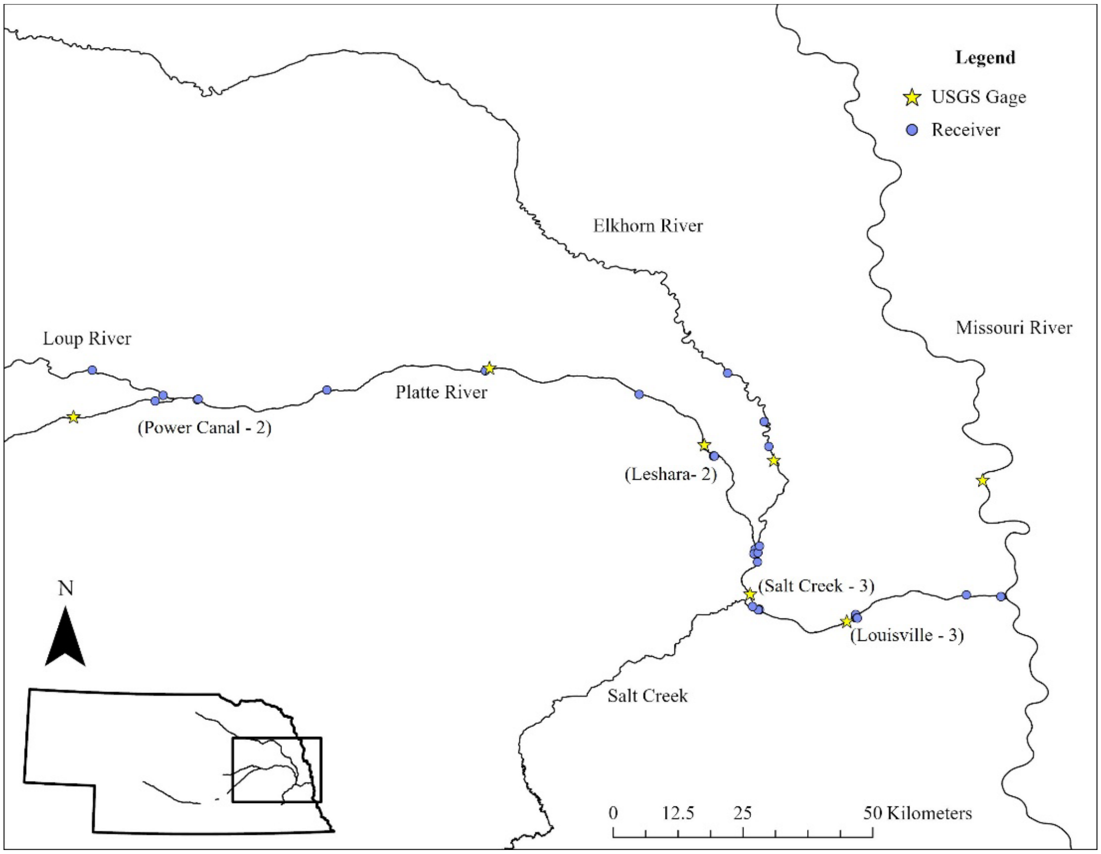


Figure 1. Map of study area with locations of U.S. Geological Survey (USGS) gages (yellow stars) and acoustic telemetry receiver locations (blue circles). Overlapping receiver locations have been labeled with the number of receivers per gate throughout the lower Platte River system.

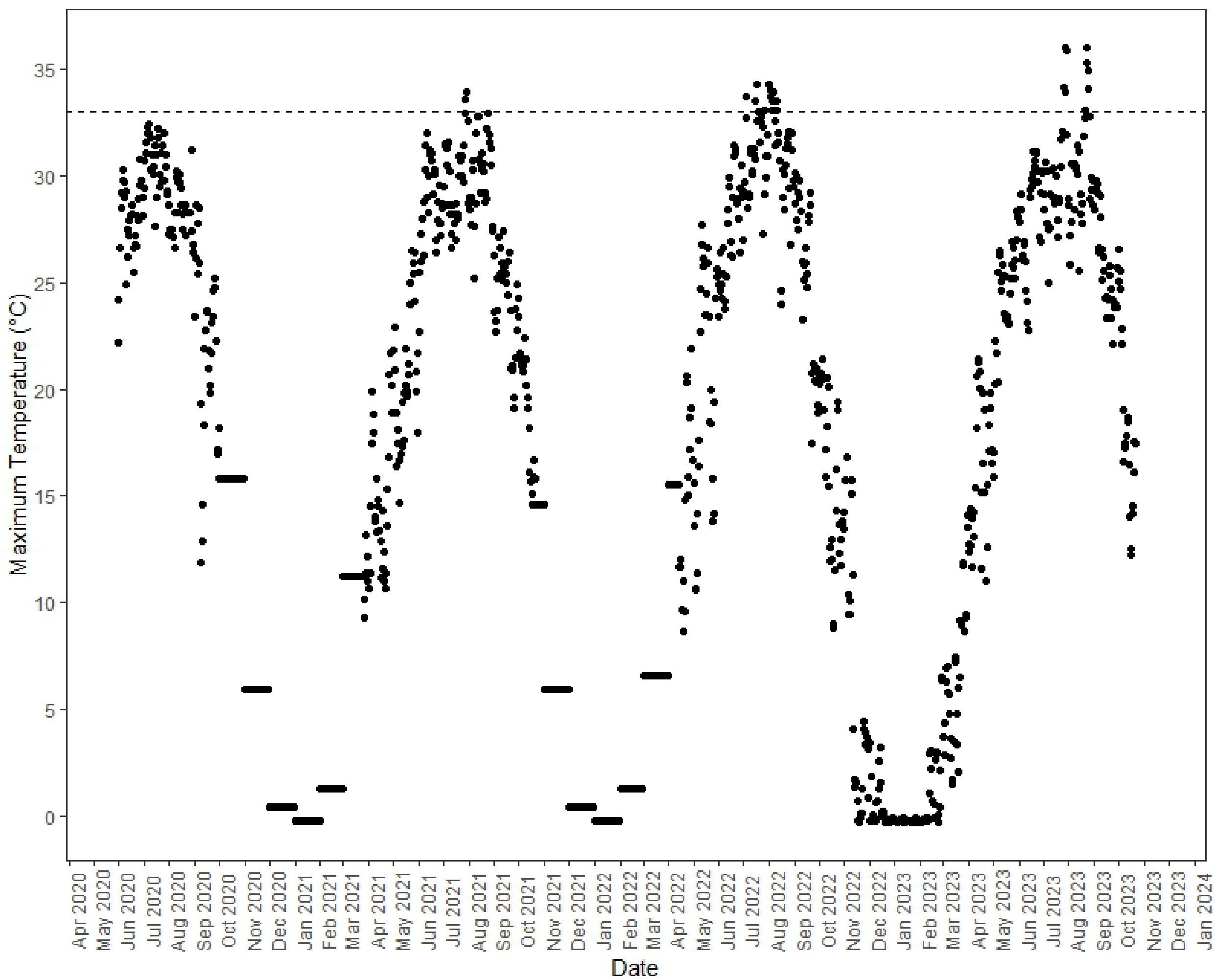


Figure 2. Maximum water temperature (°C) per day in the Platte River. Temperature was derived from the UNL Plattsmouth Receiver and Louisville Gage as described in the *Methods*. From May 2020 to November 2023, there were 26 days in which the Platte River exceeded 33°C (above dashed line).

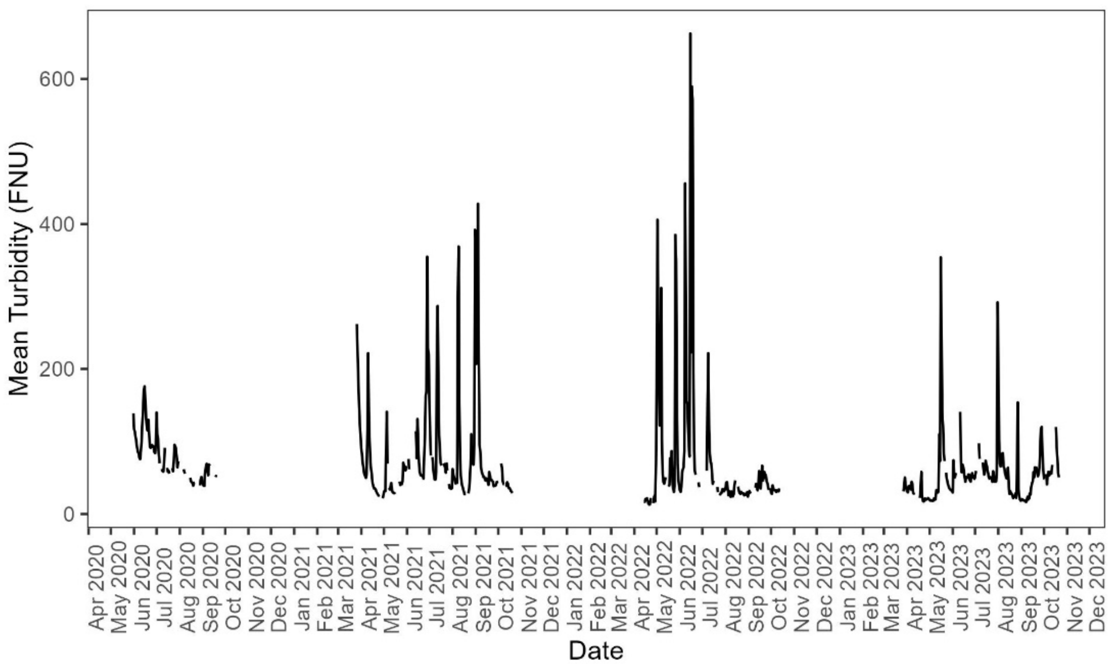


Figure 3. Mean turbidity determined from the Louisville, NE U.S. Geological Survey gage showcasing turbidity is not measured year-round, hence why we have not included turbidity in our models yet.

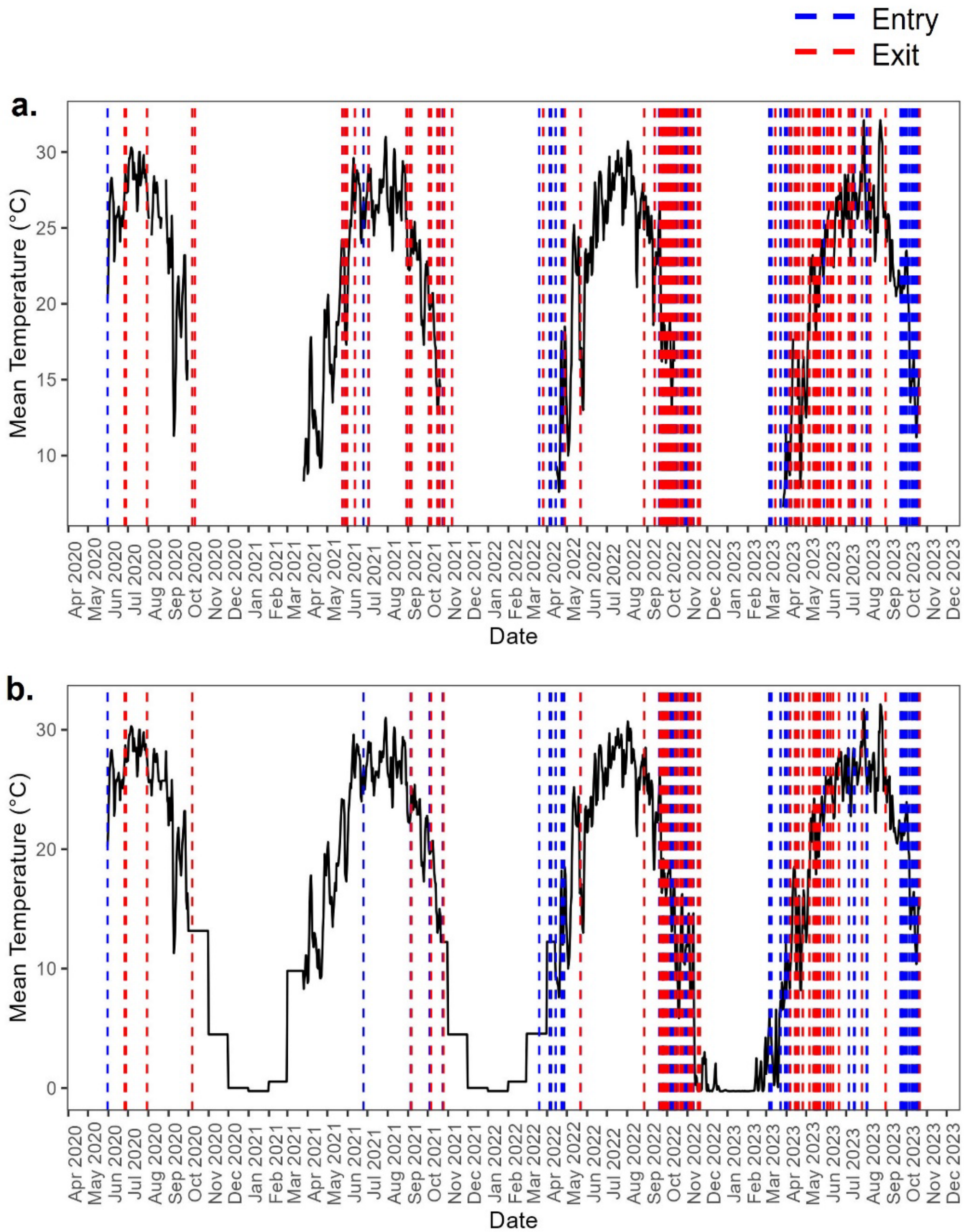


Figure 4. Immigration (blue) and emigration (red) for Pallid Sturgeon coinciding with mean temperature, derived from (a) the Louisville, NE U.S. Geological Survey Gage and (b) the Louisville U.S. Geological Survey gage (May 2020-August 2022) and UNL Plattsmouth Receiver (August 2022-October 2023). Further, (a) represents all immigrants (entries), emigrants (exits), and individual occurrences and (b) represents only immigrants (entries) and emigrants (exits).

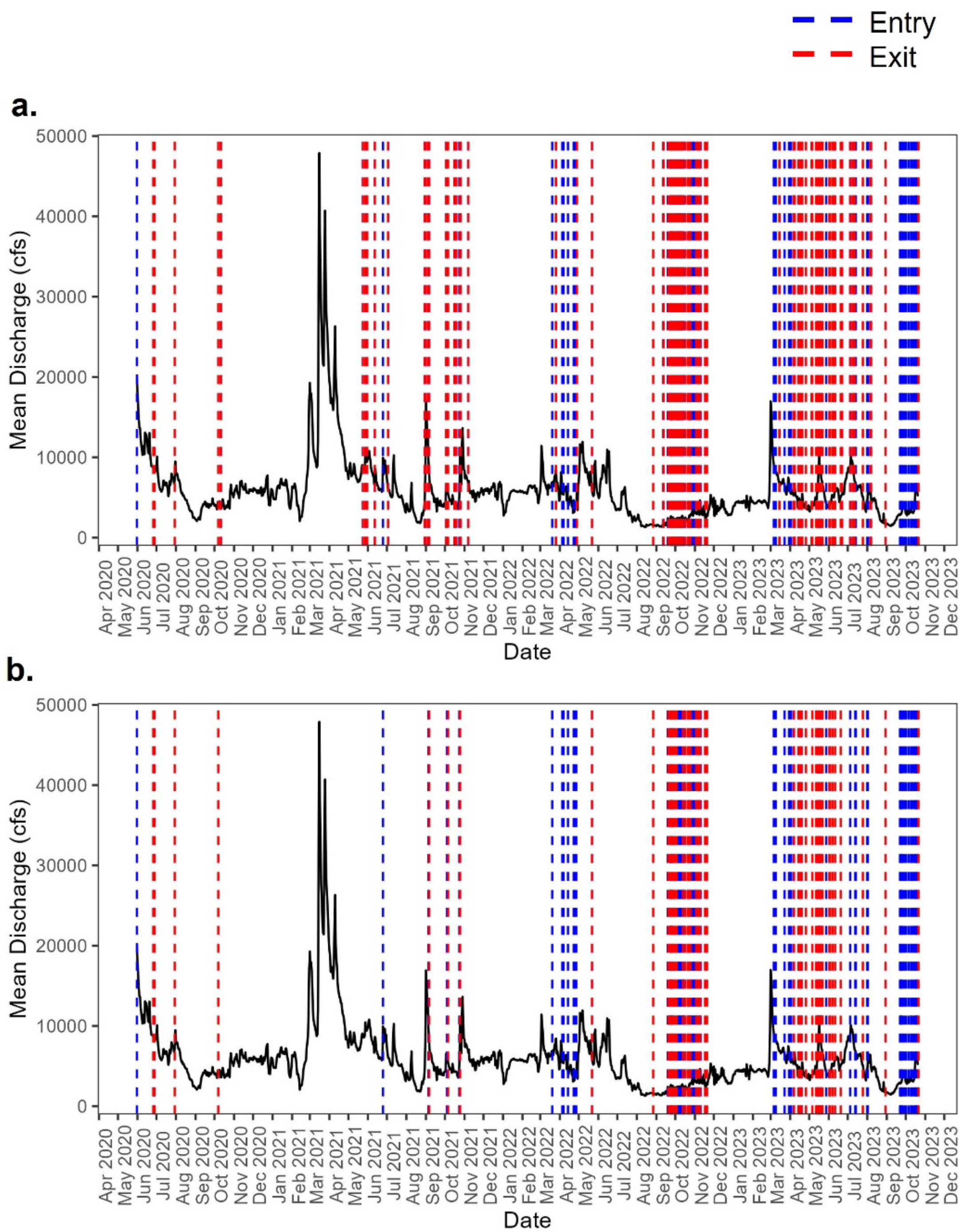


Figure 5. Immigration (blue) and Emigration (red) for Pallid Sturgeon coinciding with mean discharge derived from the Louisville, NE U.S. Geological Survey gage where (a) represents all immigrants (entries), emigrants (exits), and individual occurrences and (b) represents only immigrants (entries) and emigrants (exits).

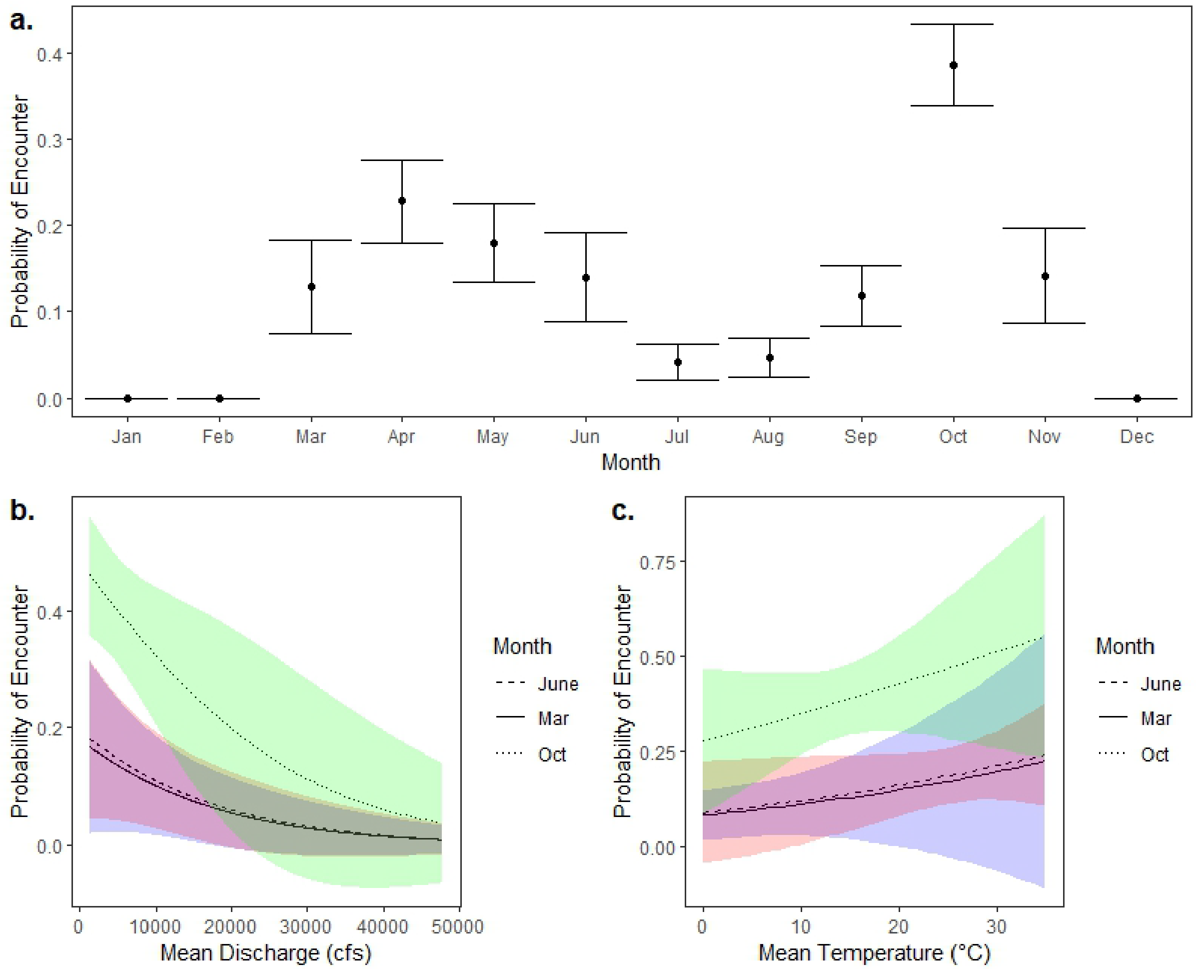


Figure 6. Generalized linear model predictive curves for the probability of Pallid Sturgeon encountering the mouth of the Platte River 2020-2023. (a) The predictive curve for the predictor variable of month with standard error with temperature held constant at the mean of 14.6 °C and discharge held constant at the mean of 5,975 cfs across all months. (b) The predictive curve for the predictor variable mean discharge for the months of March, June, and October with temperature held constant for each month at the mean of 14.6°C with 95% confidence intervals (March – blue, June – red, October – green). (c) The predictive curve for the predictor variable mean temperature for the months of March, June, and October with discharge held constant per month at the mean of 5,975 cfs with 95% confidence intervals (March – blue, June – red, October – green).

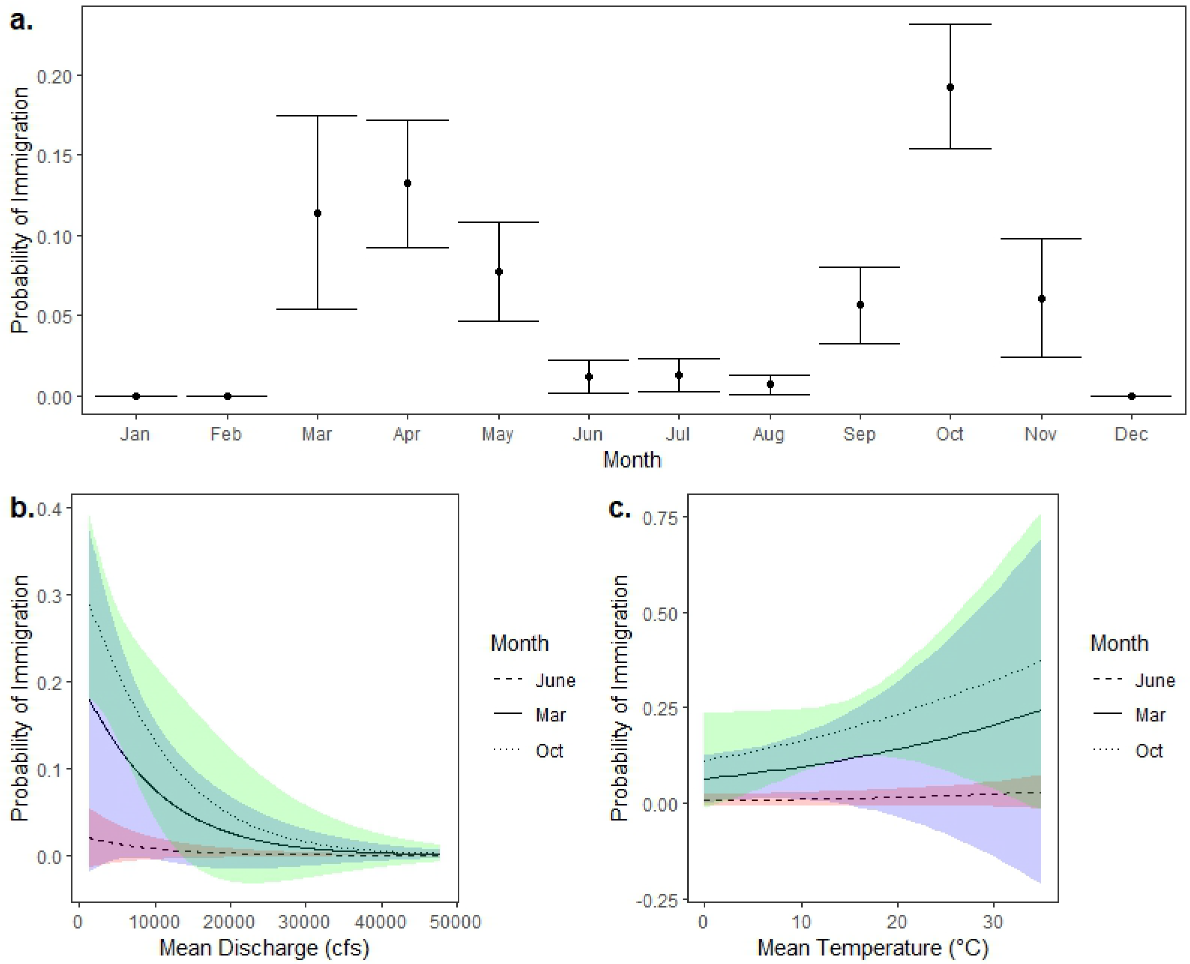


Figure 7. Generalized linear model predictive curves for the probability of Pallid Sturgeon immigrating into the Platte River 2020-2023. (a) The predictive curve for the predictor variable of month with standard error with temperature held constant at the mean of 14.6 °C and discharge held constant at the mean of 5,975 cfs across all months. (b) The predictive curve for the predictor variable mean discharge for the months of March, June, and October with temperature held constant for each month at the mean of 14.6°C with 95% confidence intervals (March – blue, June – red, October – green). (c) The predictive curve for the predictor variable mean temperature for the months of March, June, and October with discharge held constant per month at the mean of 5,975 cfs with 95% confidence intervals (March – blue, June – red, October – green).

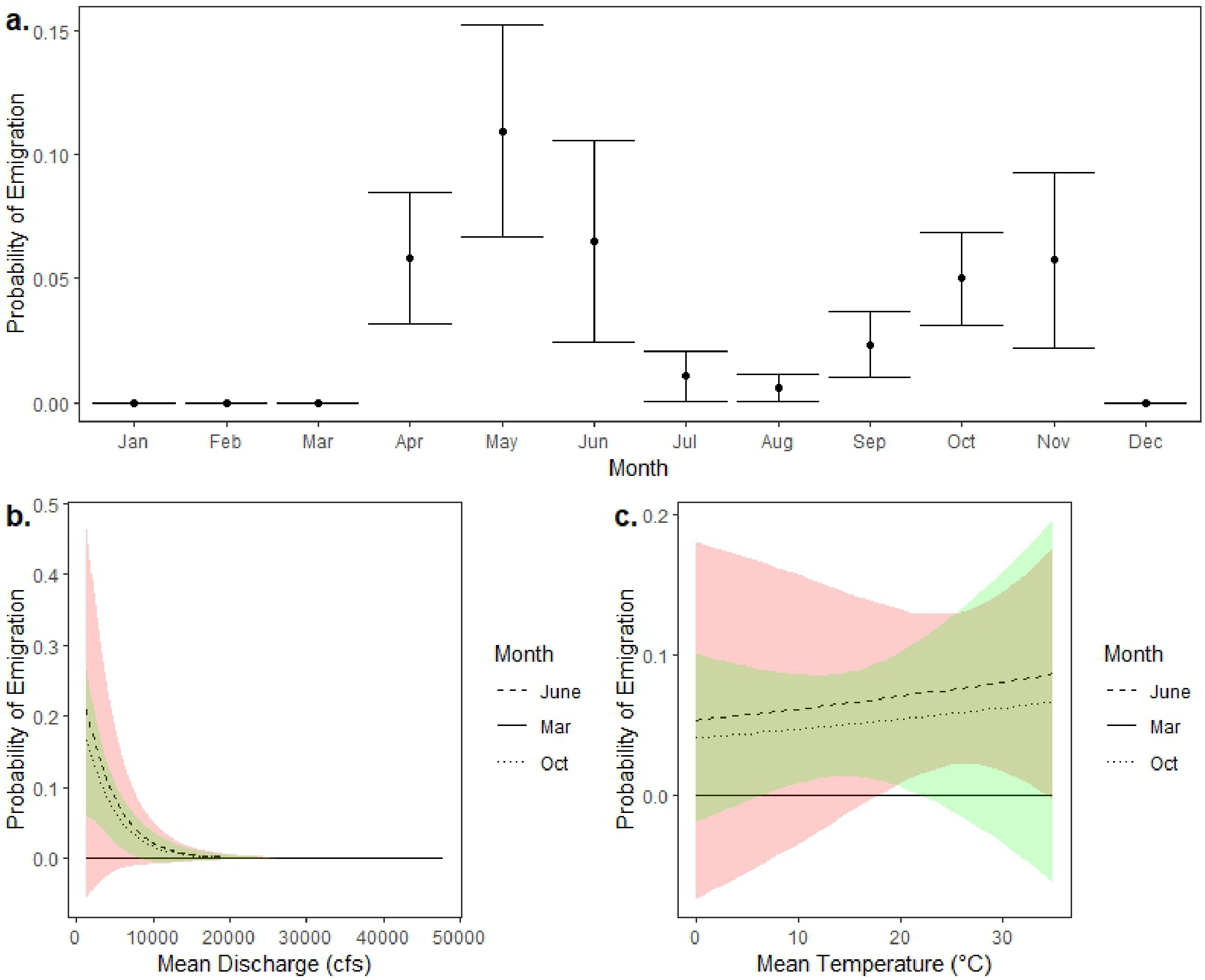


Figure 8. Generalized linear model predictive curves for the probability of Pallid Sturgeon emigrating from the Platte River 2020-2023. (a) The predictive curve for the predictor variable of month with standard error with temperature held constant at the mean of 14.6 °C and discharge held constant at the mean of 5,975 cfs across all months. (b) The predictive curve for the predictor variable mean discharge for the months of March, June, and October with temperature held constant for each month at the mean of 14.6°C with 95% confidence intervals (March – blue, June – red, October – green). (c) The predictive curve for the predictor variable mean temperature for the months of March, June, and October with discharge held constant per month at the mean of 5,975 cfs with 95% confidence intervals (March – blue, June – red, October – green).

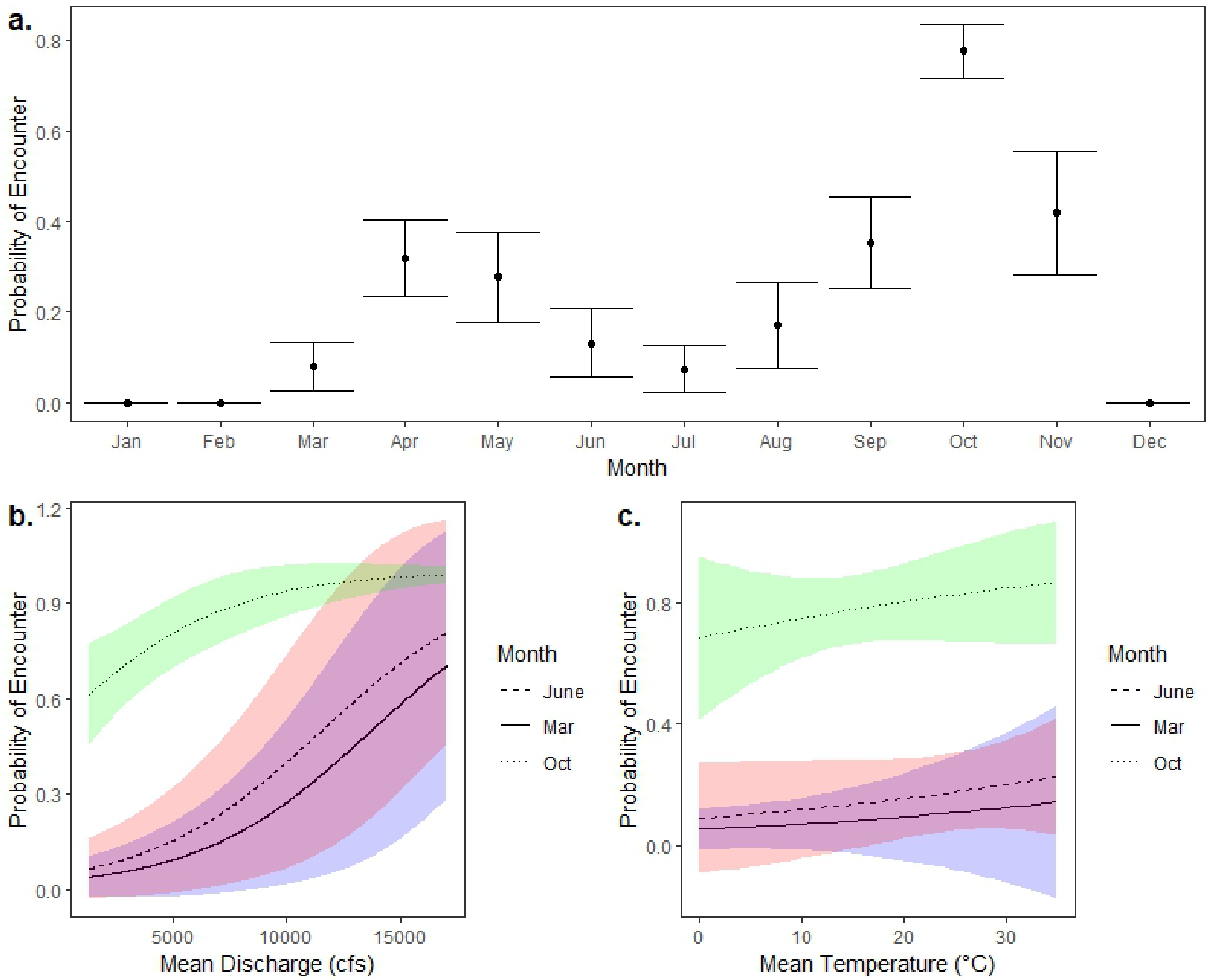


Figure 9. Generalized linear model predictive curves for the probability of Pallid Sturgeon encountering the Platte River 2022-2023. (a) The predictive curve for the predictor variable of month with standard error with temperature held constant at the mean of 14.12°C and discharge held constant at the mean of 4,338 cfs across all months. (b) The predictive curve for the predictor variable mean discharge for the months of March, June, and October with temperature held constant for each month at the mean of 14.12°C with 95% confidence intervals (March – blue, June – red, October – green). (c) The predictive curve for the predictor variable mean temperature for the months of March, June, and October with discharge held constant per month at the mean of 4,338 cfs with 95% confidence intervals (March – blue, June – red, October – green).

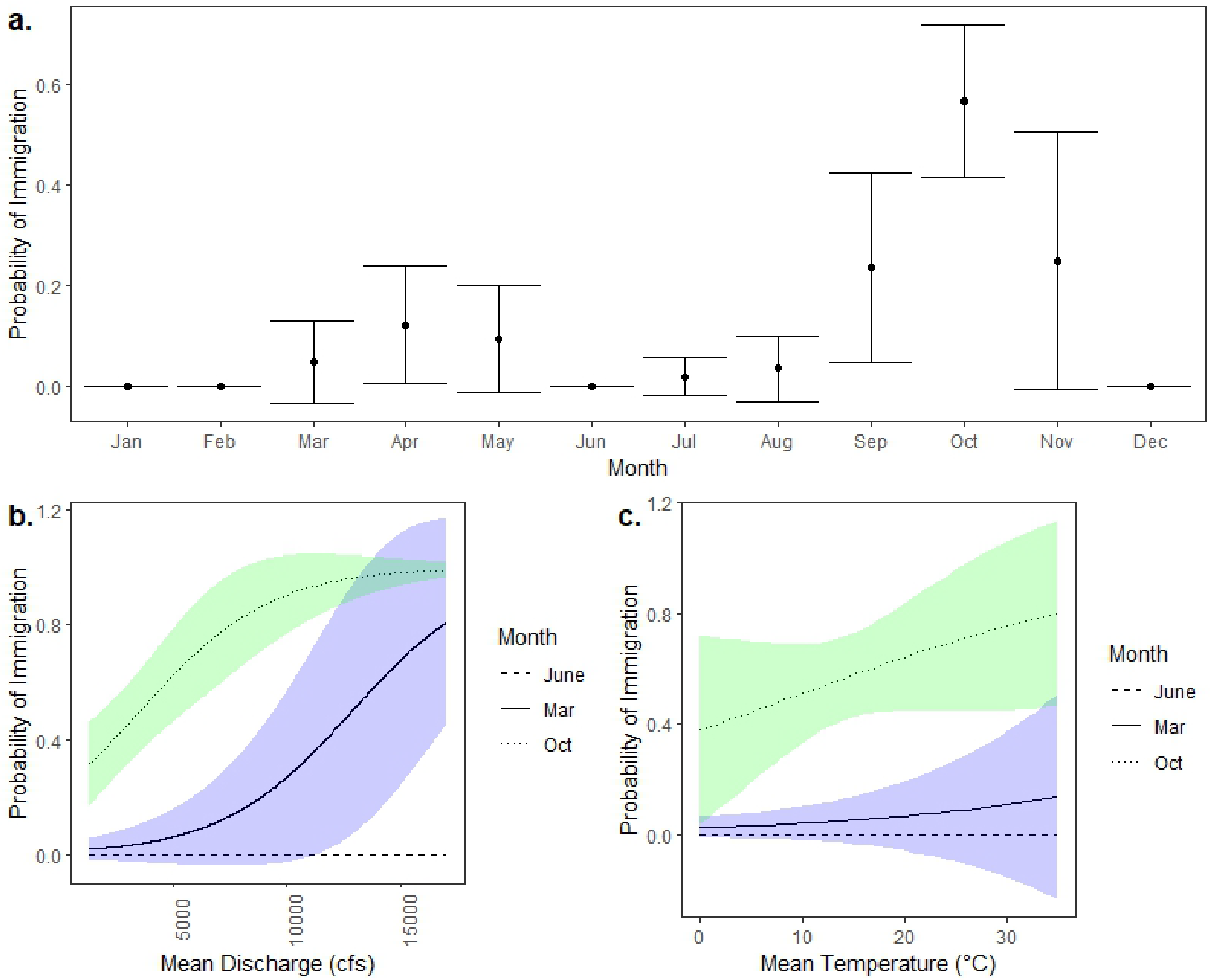


Figure 10. Generalized linear model predictive curves for the probability of Pallid Sturgeon immigrating into the Platte River 2022-2023. (a) The predictive curve for the predictor variable of month with standard error with temperature held constant at the mean of 14.12°C and discharge held constant at the mean of 4,338 cfs across all months. (b) The predictive curve for the predictor variable mean discharge for the months of March, June, and October with temperature held constant for each month at the mean of 14.12°C with 95% confidence intervals (March – blue, June – red, October – green). (c) The predictive curve for the predictor variable mean temperature for the months of March, June, and October with discharge held constant per month at the mean of 4,338 cfs with 95% confidence intervals (March – blue, June – red, October – green).

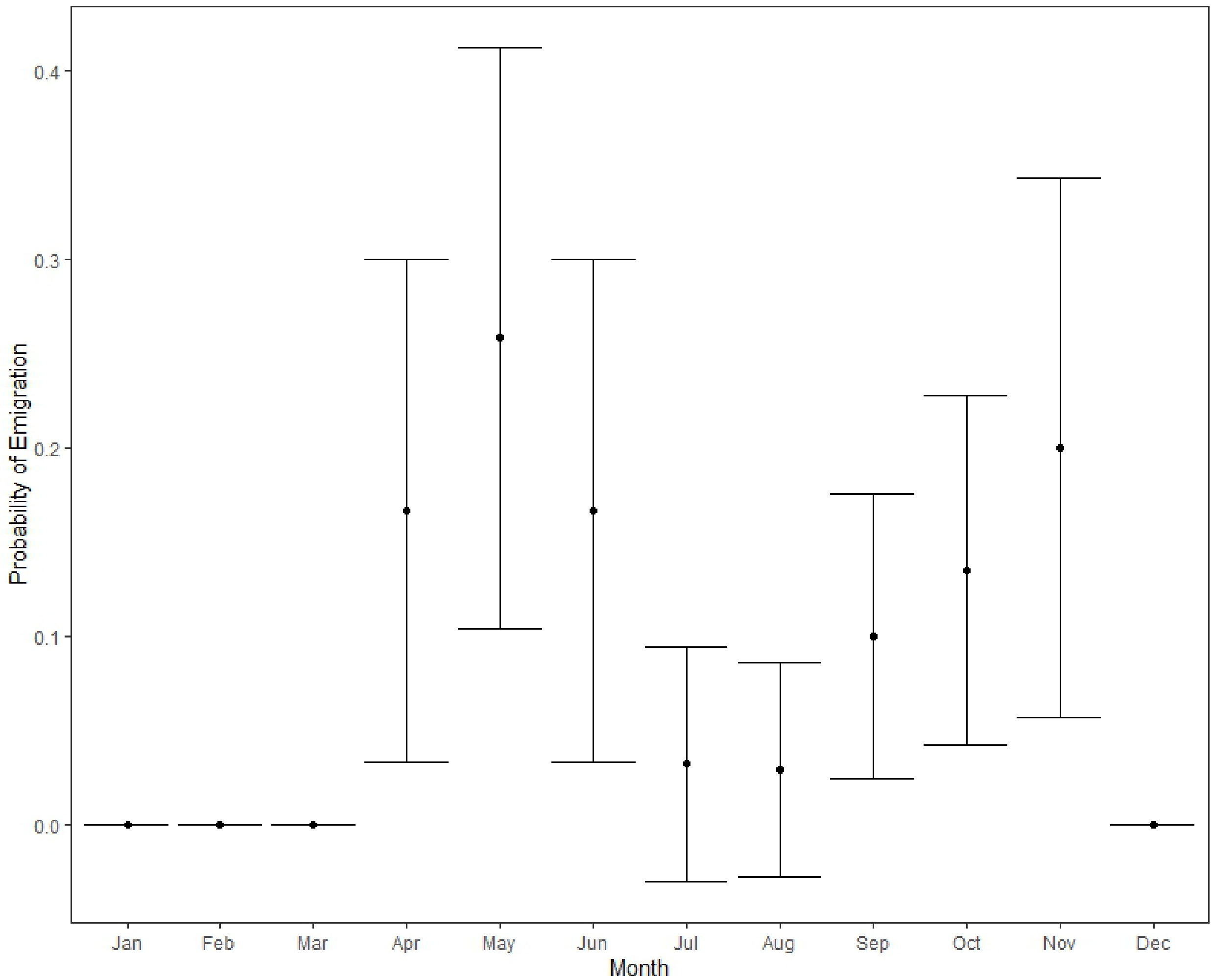


Figure 11. Generalized linear model for the predictor variable month with standard error bars for the probability of Pallid Sturgeon emigrating into the Platte River 2022-2023.

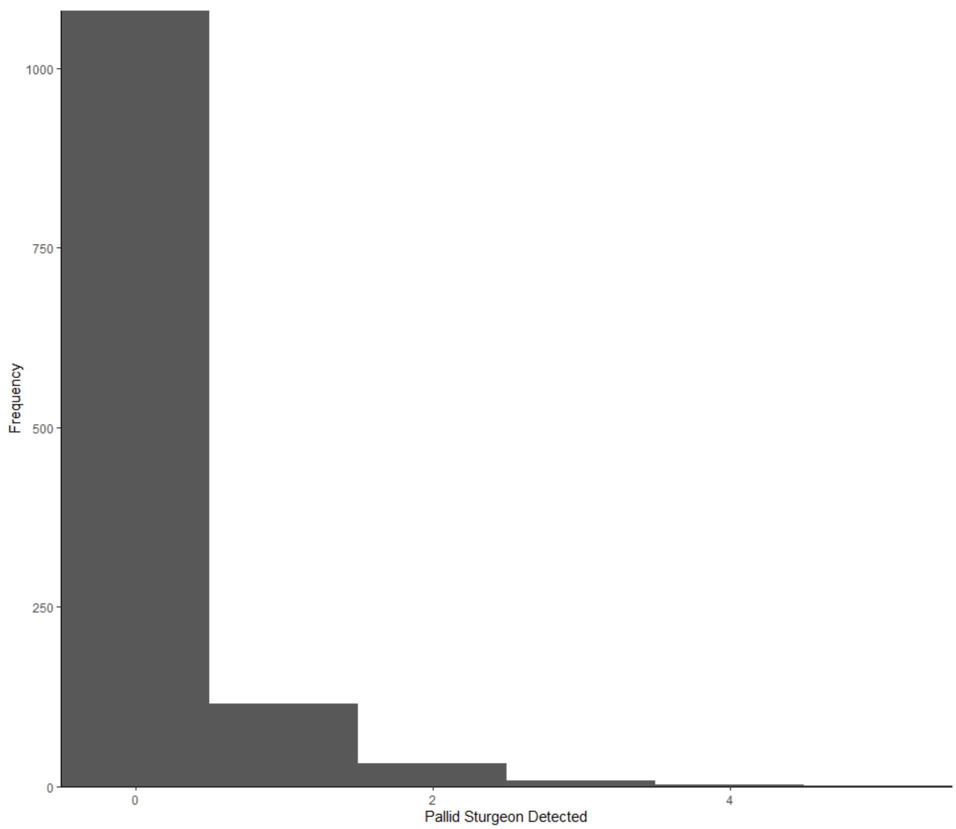


Figure 12. Frequency of counts of individual Pallid Sturgeon that met the individual occurrence criteria at the lower Platte River confluence with the Missouri River from 2020 to 2023 using both USGS and UNL receiver stations. A 0 indicates no individual occurrence; whereas, numbers > 0 indicate the number of unique individual occurrences on a given day.

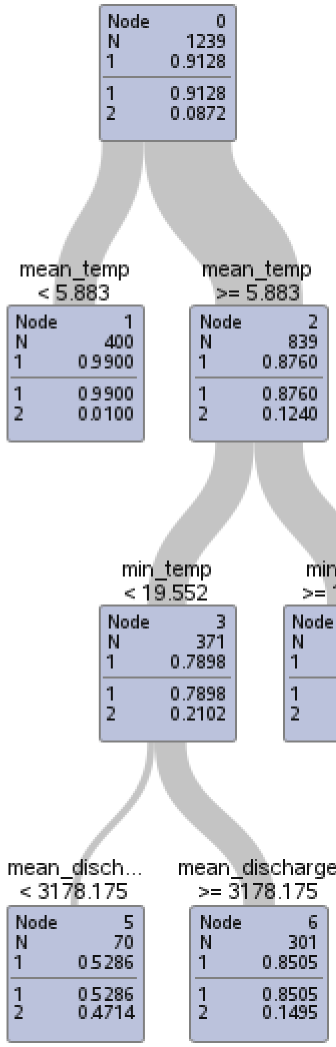


Figure 13. Example classification tree analysis using individual encounters as the response variable. No encounter was classified as a "1" and an encounter at the confluence was classified as a "2" in the bottom half of each node box. The model used variables associated with discharge (mean daily discharge, maximum daily discharge, minimum daily discharge, daily range in discharge) and temperature (mean daily temperature, maximum daily temperature, minimum daily temperature, daily range in temperature) in the Platte River to classify conditions that may be conducive to an encounter. The overall misclassification rate was 0.08. However, when evaluating the models ability to classify an actual encounter the error rate increases to 0.81.

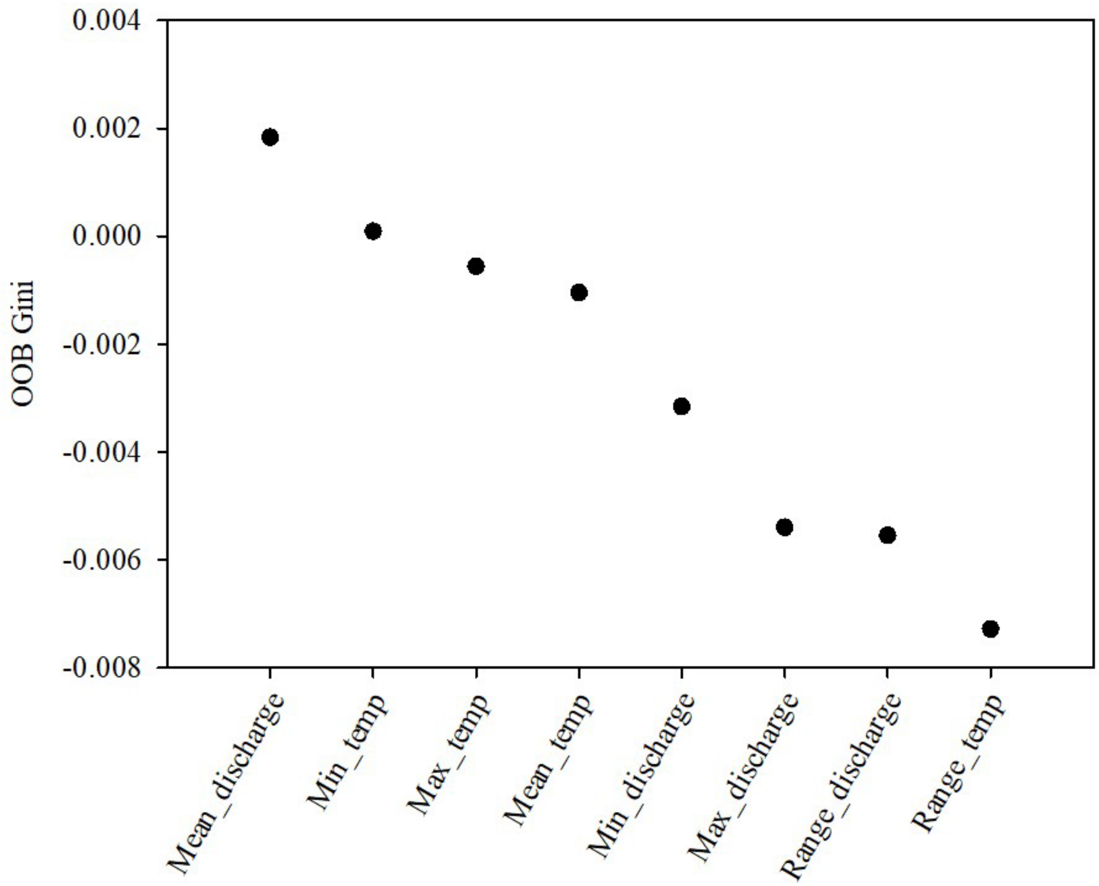


Figure 14. Random Forest estimation of variable importance. Out-of-Bag (OOB) Gini is used as a relative measure of variability in this instance. Variables with greater values indicate more importance.

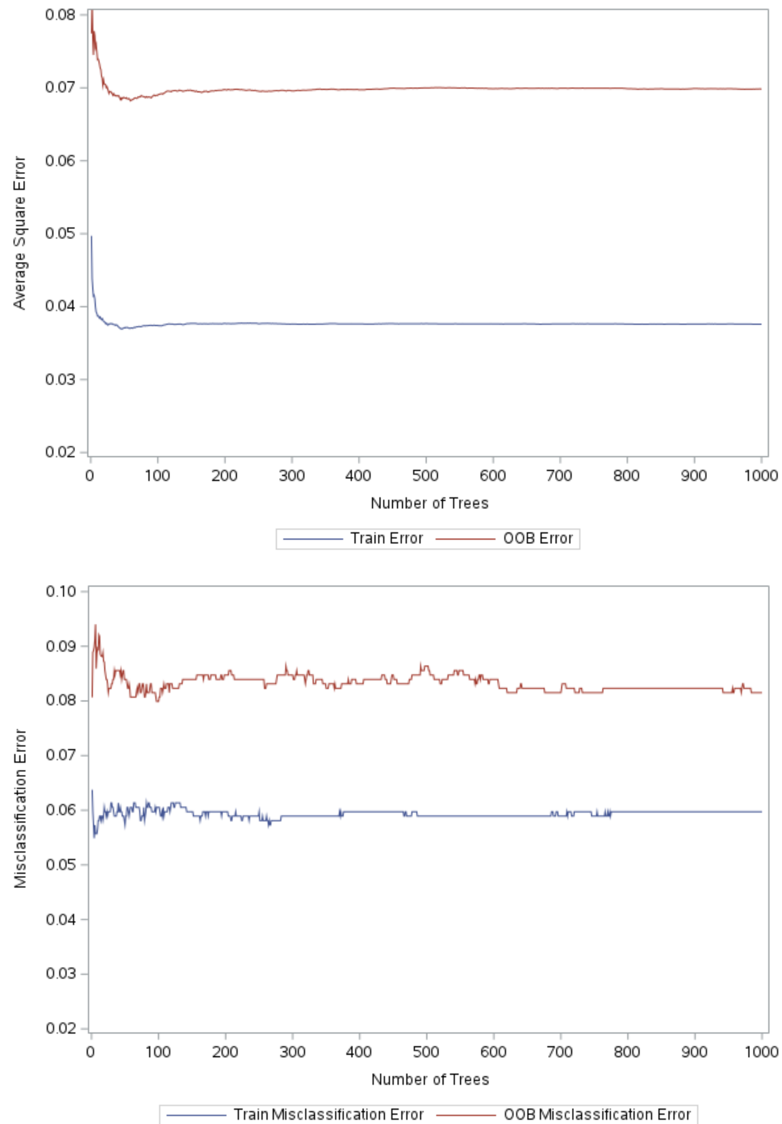


Figure 15. Example random forest model results with average square error (top) and misclassification error (bottom) using Individual Encounters as the response variable. The model used variables associated with discharge (mean daily discharge, maximum daily discharge, minimum daily discharge, daily range in discharge) and temperature (mean daily temperature, maximum daily temperature, minimum daily temperature, daily range in temperature) in the Platte River to classify conditions that may be conducive to an encounter. Train Misclassification errors (blue lines) are the error resulting from the training dataset and the Out-of-Bag (OOB) errors (red lines) measures prediction error from the trained models. See Figure 15 for variables importance.

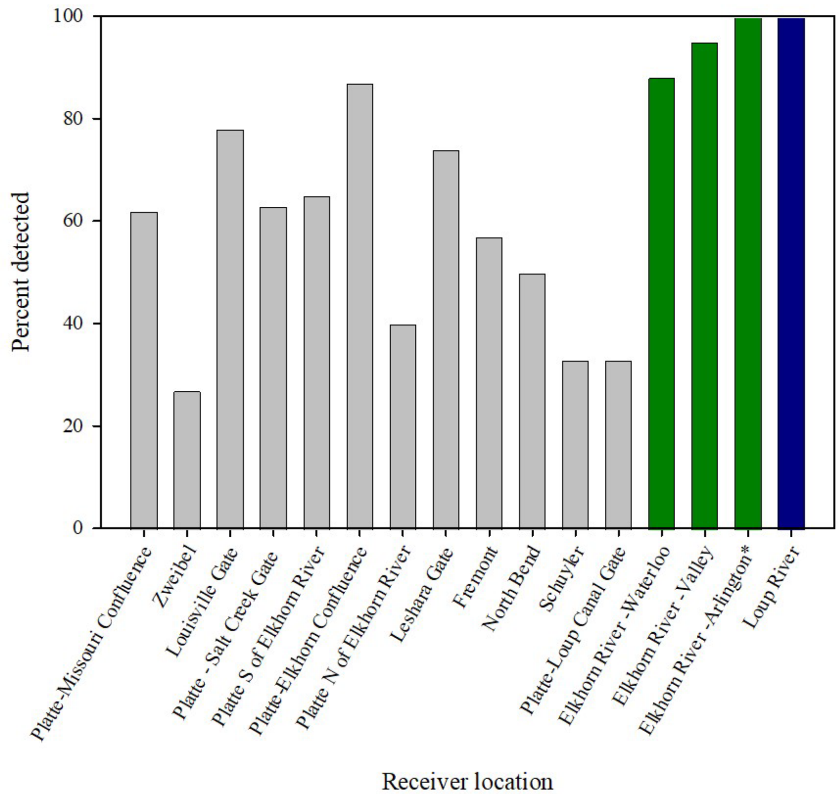


Figure 16. Detection percentages (efficiency) from known movements within the passive receiver network. Percentages were derived by dividing the number of detections at a site by the total known individuals that should have been detected based on movement within the network. The Platte River stations (gray) are presented from downstream (left) to upstream (right), Elkhorn River stations in green (*note: Arlington had no known missed detections but is at the upstream extent of the network so may not actually be 100%), and Loup River station in blue. Two individuals were known to enter the Loup River.

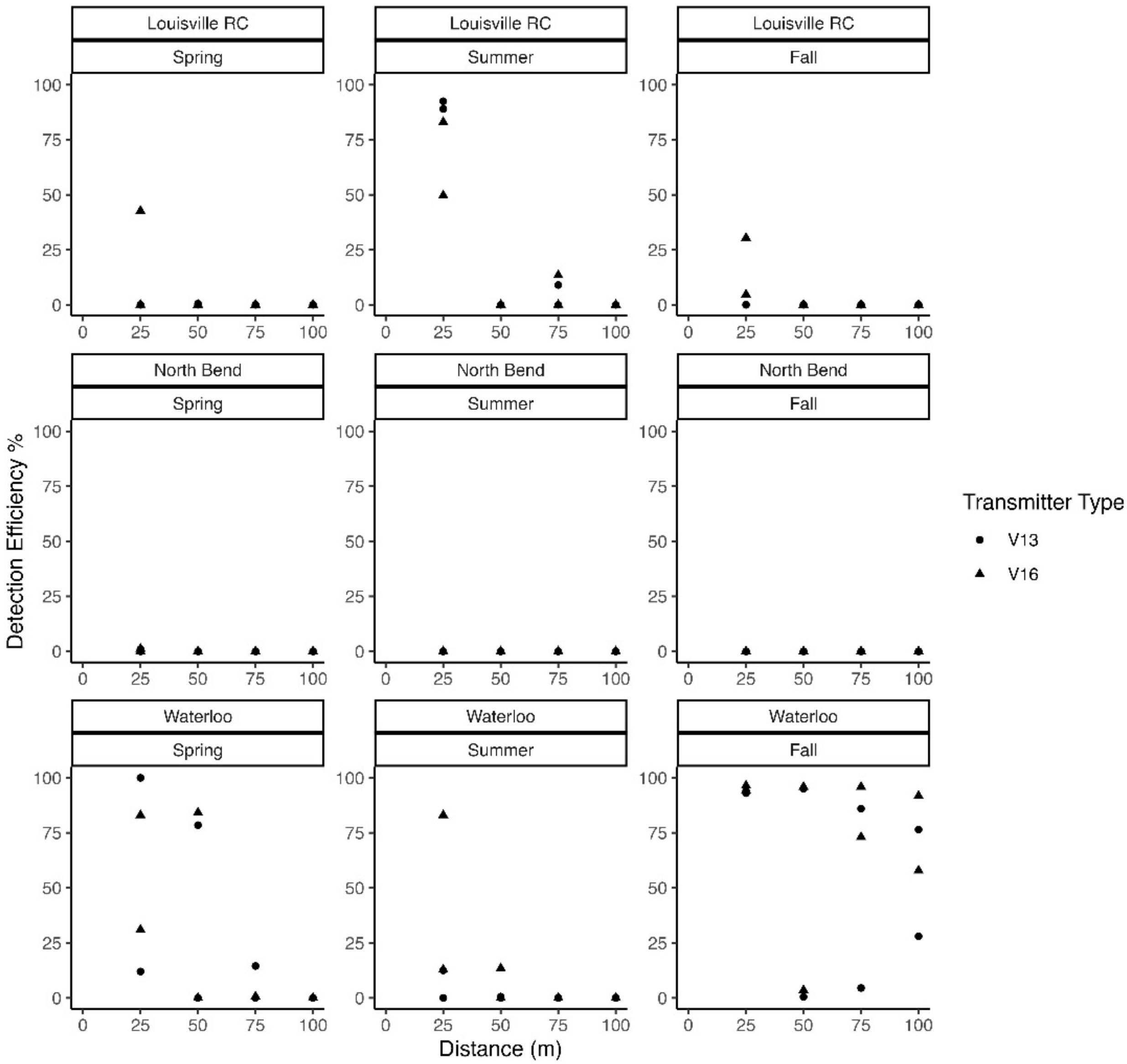


Figure 17. Detection efficiency estimates between 25 and 100 meters for V13 (circle) and V16 (triangle) range test transmitters at Louisville, North Bend, and Waterloo during Spring (May - June), Summer (September), and Fall (November) of 2023.

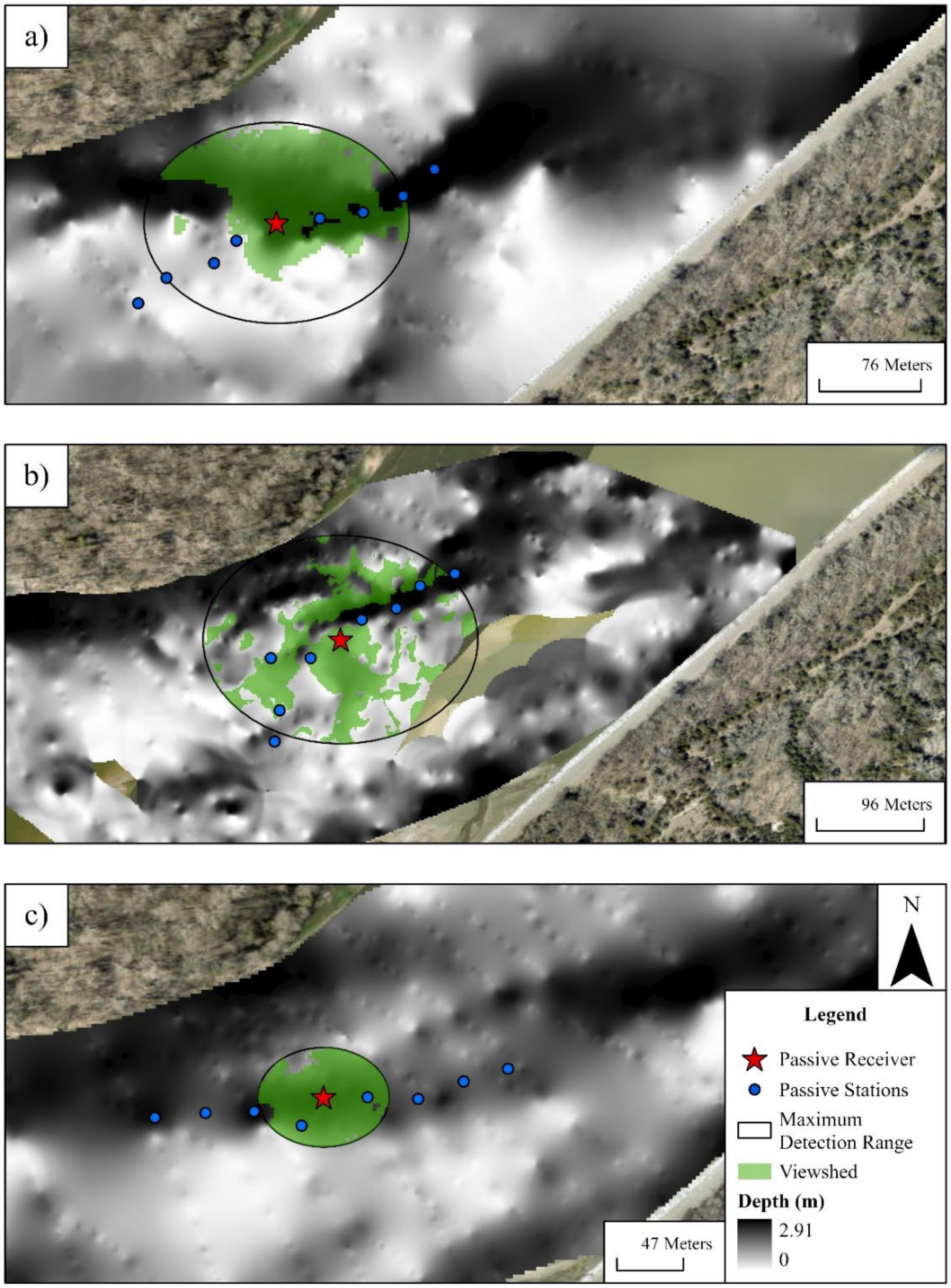


Figure 19. Estimated areas of passive detectability at Louisville (VR2Tx-489486) during a) Spring, b) Summer, and c) Fall passive range tests. Detection efficiency at each passive station (blue circles) was used to estimate the maximum detection range (black circle) around each passive receiver (red star). Depth (greyscale) values were collected using an acoustic Doppler current profiler (ADCP) and interpolated in ArcPro. Viewshed analyses (green) were used to determine the area surrounding a passive acoustic receiver that a transmitter can be detected based on the depth of the receiver and surrounding bathymetry.

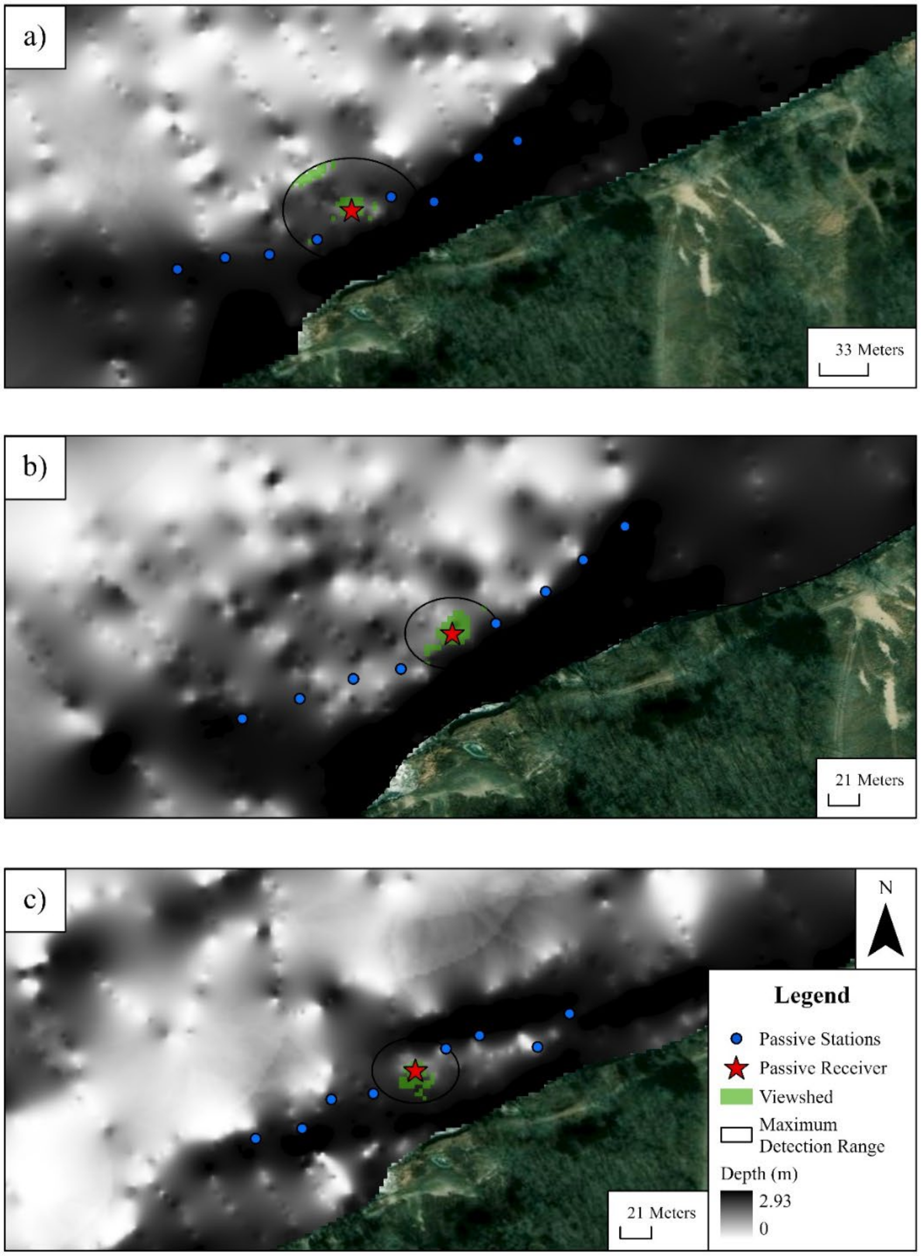


Figure 20. Estimated areas of passive detectability at North Bend (VR2Tx-487721) during a) Spring, b) Summer, and c) Fall passive range tests. Detection efficiency at each passive station (blue circles) was used to estimate the maximum detection range (black circle) around each passive receiver (red star). Depth (greyscale) values were collected using an acoustic Doppler current profiler (ADCP) and interpolated in ArcPro. Viewshed analyses (green) were used to determine the area surrounding a passive acoustic receiver that a transmitter can be detected based on the depth of the receiver and surrounding bathymetry.

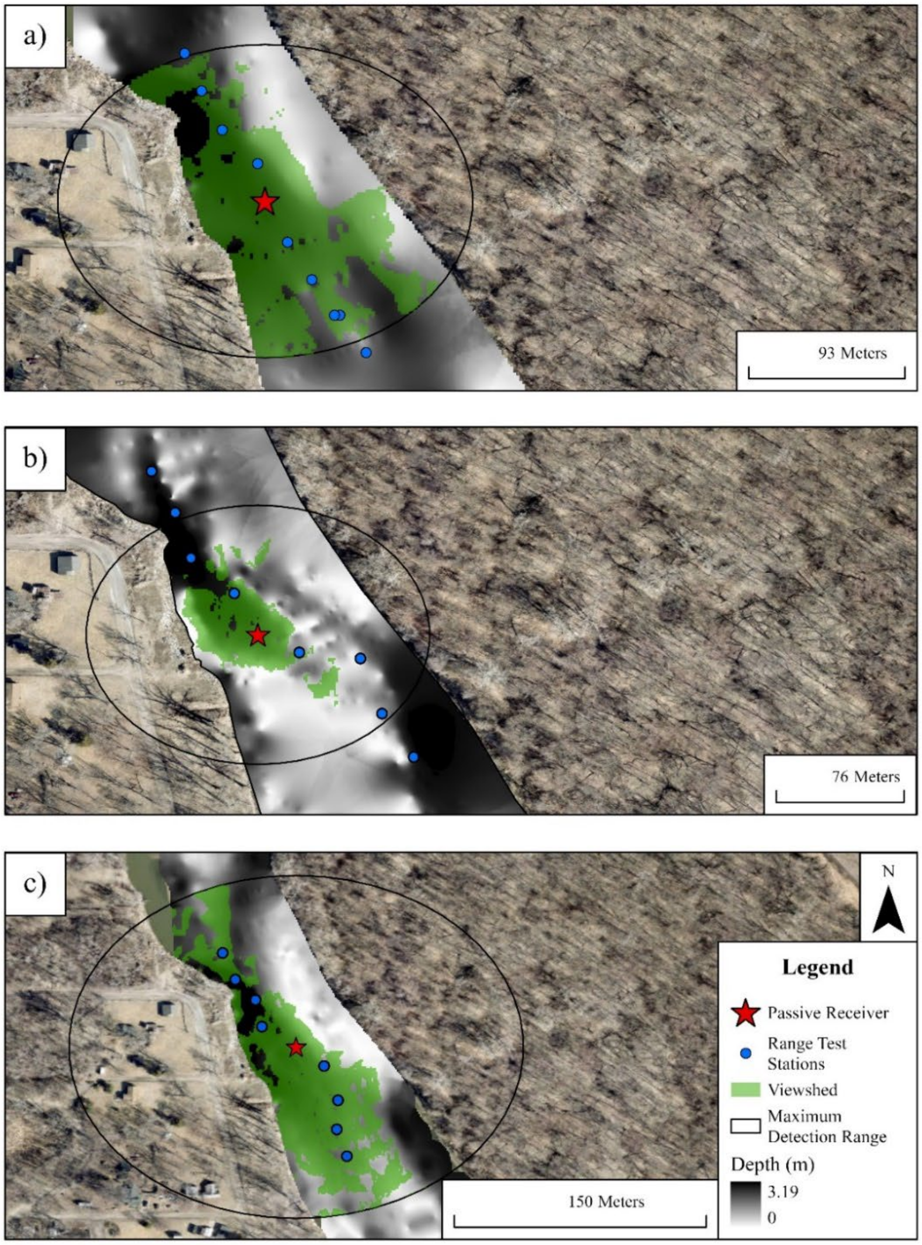


Figure 21. Estimated areas of passive detectability at Waterloo (VR2Tx-487711) during a) Spring, b) Summer, and c) Fall passive range tests. Detection efficiency at each passive station (blue circles) was used to estimate maximum detection range (black circle) around each passive receiver (red star). Depth (greyscale) values were collected using an acoustic Doppler current profiler (ADCP) and interpolated in ArcPro. Viewshed analyses (green) were used to determine the area surrounding a passive acoustic receiver that a transmitter can be detected from based on the depth of the receiver and surrounding bathymetry.

Figure 22. Egg mats pulled after an overnight set at the Loup Confluence.

Appendix I

Summary of passive receiver network detections collected during 2022-2023. The following tables and figures are the raw outputs from the Actel package and provide a general summarization of individual movements within the Platte River and its tributaries as determined by the passive receivers.

Acoustic telemetry residency analysis

Actel R package (1.3.0)

Summary

Target folder: C:/Users/cpullano2/OneDrive - University of Nebraska-Lincoln/Documents/actel2023

Timestamp: **2023-11-25 13:10:12**

Number of target tags: **98**

Number of listed receivers: **32** (of which **5** had no detections)

Data time range: 2022-03-26 19:46:20 to 2023-11-12 23:38:25 (US/Central).

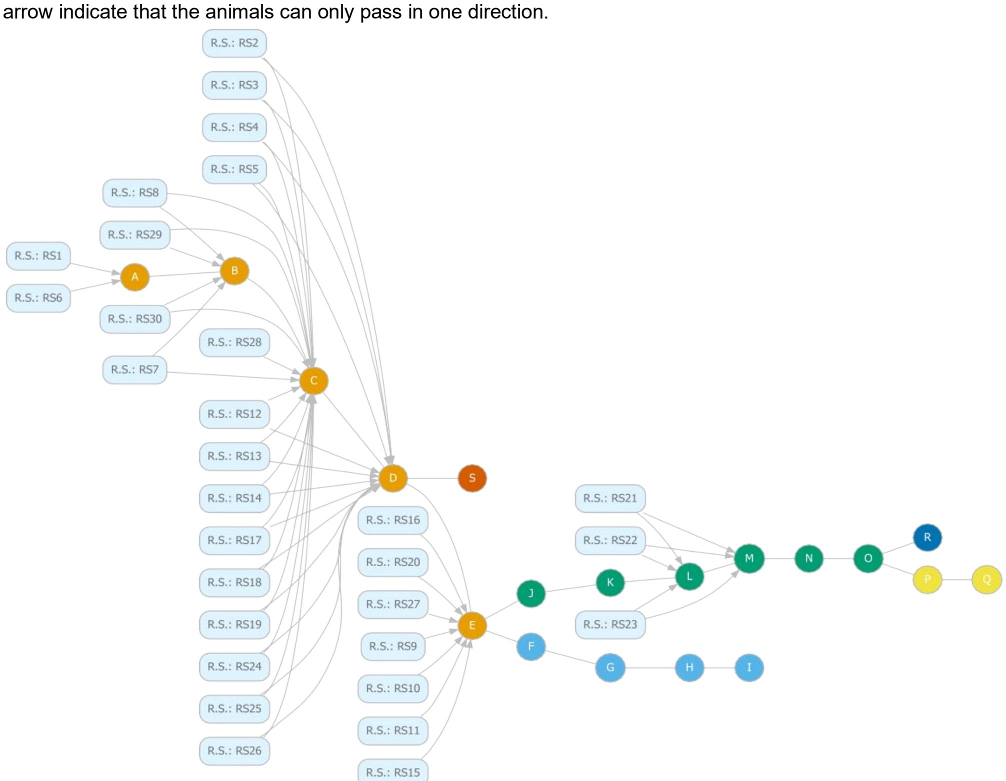
Percentage of post-release valid detections: 100%

Found a bug? **Report it here.** (https://github.com/hugomflavio/actel/issues) Want to

cite actel in a publication? Run `citation('actel')`

Study area

Arrays with the same background belong to the same section. Release sites are marked with “R.S.”. Arrays connected with an arrow indicate that the animals can only pass in one direction.



Index:

Receiver stations

Station.name	Latitude	Longitude	Easting	Northing	Section	Array	Standard.name
0.001 Plattsmouth 2 ST - VR2Tx-487720	41.05740	-95.89047	761307.1	4549789	Platte1	A	St.1
Plattsmouth (buried)	41.05765	-95.89079	761279.2	4549816	Platte1	A	St.2
0.005 Zwiebel - VR2Tx-489483	41.06022	-95.95046	756254.2	4549924	Platte1	B	St.3
0.024 Louisville RR - VR2Tx-487705	41.02095	-96.14279	740233.6	4545016	Platte1	C	St.4
Louisville RL (buried)	41.02132	-96.14163	740329.8	4545060	Platte1	C	St.5
0.024 Louisville RC - VR2Tx-489486	41.02062	-96.14201	740300.4	4544981	Platte1	C	St.6
0.024 Louisville RC - VR2Tx-487712	41.02105	-96.13993	740473.7	4545035	Platte1	C	St.7
0.024 Louisville RL - VR2Tx-487730	41.02058	-96.13924	740533.5	4544985	Platte1	C	St.8
0.041 Salt Creek RL - VR2Tx-487709	41.03555	-96.30903	726204.7	4546192	Platte1	D	St.9
0.041 Salt Creek RC- VR2Tx-487706	41.03442	-96.30873	726233.8	4546068	Platte1	D	St.10
0.041 Salt Creek RR - VR2Tx-487707	41.03444	-96.31081	726058.8	4546064	Platte1	D	St.11
0.052 Platte S. Elkhorn - VR2Tx-487708	41.11702	-96.31201	725675.1	4555230	Platte1	E	St.12
2.001 Elkhorn Mouth - VR2Tx-487728	41.13337	-96.31172	725643.4	4557046	ElkhornRiver	F	St.13
2.002 Elkhorn - VR2Tx-487714	41.14473	-96.30857	725868.8	4558316	ElkhornRiver	F	St.14
2.024 Waterloo_W.MapleRd - VR2Tx-487711	41.31677	-96.29226	726642.3	4577460	ElkhornRiver	G	St.15
2.032 Elkhorn (Valley) - VR2Tx-487710	41.35990	-96.30061	725794.2	4582227	ElkhornRiver	H	St.16
2.046 Arlington - VR2Tx-489484	41.44349	-96.36383	720223.0	4591345	ElkhornRiver	I	St.17
0.054 Platte N. Elkhorn - VR2Tx-487724	41.13897	-96.31637	725233.9	4557656	Platte2	J	St.18
Platte N Elk (buried)	41.13157	-96.31850	725080.4	4556829	Platte2	J	St.19
0.075 Leshara RR - VR2Tx-487719	41.30080	-96.38786	718693.1	4575441	Platte2	K	St.20
0.075 Leshara RC - VR2Tx-487729	41.30037	-96.38860	718632.6	4575391	Platte2	K	St.21
0.075 Leshara RC - VR2Tx-487703	41.30005	-96.38683	718781.8	4575360	Platte2	K	St.22
0.100 Fremont - VR2Tx-489485	41.40686	-96.51655	707580.6	4586900	Platte2	L	St.23
0.117 North Bend - VR2Tx-487717	41.44807	-96.78230	685249.0	4590873	Platte2	M	St.24
0.117 North Bend 2 - VRTx-487721	41.44779	-96.78272	685214.7	4590841	Platte2	M	St.25
0.140 Schulyer - VR2Tx-487723	41.41414	-97.05725	662365.2	4586553	Platte2	N	St.26
0.163 Loup Canal RR - VR2Tx-487715	41.39758	-97.28127	643678.5	4584319	Platte2	O	St.27
0.163 Loup Canal RL - VR2Tx-487716	41.39859	-97.27973	643805.0	4584434	Platte2	O	St.28
3.002 Loup - VR2Tx-487718	41.40526	-97.34039	638719.8	4585075	LoupRiver	P	St.29
Upper Loup	41.44882	-97.46295	628389.3	4589722	LoupRiver	Q	St.30
Duncan	41.39567	-97.35388	637612.4	4583989	Platte3	R	St.31
1.001 Salt Creek - Willow - VRTx-487722	41.04025	-96.32092	725189.1	4546683	SaltCreek	S	St.32

Deployments

Receiver	Array	Station.name	Standard.name	Start	Stop
487702	C	Louisville RL (buried)	St.5	2022-03-19	2023-12-31
487703	K	0.075 Leshara RC - VR2Tx-487703	St.22	2022-04-18	2023-12-31
487704	J	Platte N Elk (buried)	St.19	2022-03-25	2023-12-31
487705	C	0.024 Louisville RR - VR2Tx-487705	St.4	2022-03-19	2023-12-31
487706	D	0.041 Salt Creek RC- VR2Tx-487706	St.10	2022-03-19	2023-12-31
487707	D	0.041 Salt Creek RR - VR2Tx-487707	St.11	2022-03-19	2023-12-31
487708	E	0.052 Platte S. Elkhorn - VR2Tx-487708	St.12	2022-04-15	2023-12-31
487709	D	0.041 Salt Creek RL - VR2Tx-487709	St.9	2022-03-19	2023-12-31
487710	H	2.032 Elkhorn (Valley) - VR2Tx-487710	St.16	2022-05-25	2023-12-31
487711	G	2.024 Waterloo_W.MapleRd - VR2Tx-487711	St.15	2022-05-06	2023-12-31
487712	C	0.024 Louisville RC - VR2Tx-487712	St.7	2022-03-19	2023-12-31
487713	A	Plattsmouth (buried)	St.2	2022-03-19	2023-12-31
487714	F	2.002 Elkhorn - VR2Tx-487714	St.14	2022-03-25	2023-12-31
487715	O	0.163 Loup Canal RR - VR2Tx-487715	St.27	2022-05-15	2023-12-31
487716	O	0.163 Loup Canal RL - VR2Tx-487716	St.28	2022-05-15	2023-12-31
487717	M	0.117 North Bend - VR2Tx-487717	St.24	2022-05-25	2023-12-31
487718	P	3.002 Loup - VR2Tx-487718	St.29	2022-05-26	2023-12-31
487719	K	0.075 Leshara RR - VR2Tx-487719	St.20	2022-04-18	2023-12-31
487720	A	0.001 Plattsmouth 2 ST - VR2Tx-487720	St.1	2022-08-29	2023-12-31
487721	M	0.117 North Bend 2 - VRTx-487721	St.25	2022-07-01	2023-12-31
487722	S	1.001 Salt Creek - Willow - VRTx-487722	St.32	2022-09-22	2023-12-31
487723	N	0.140 Schulyer - VR2Tx-487723	St.26	2023-03-06	2023-12-31
487724	J	0.054 Platte N. Elkhorn - VR2Tx-487724	St.18	2023-03-10	2023-12-31
487728	F	2.001 Elkhorn Mouth - VR2Tx-487728	St.13	2023-03-10	2023-12-31
487729	K	0.075 Leshara RC - VR2Tx-487729	St.21	2023-03-07	2023-12-31
487730	C	0.024 Louisville RL - VR2Tx-487730	St.8	2022-03-19	2023-12-31
487731	R	Duncan	St.31	2023-03-06	2023-12-31
489483	B	0.005 Zwiebel - VR2Tx-489483	St.3	2023-03-20	2023-12-31
489484	I	2.046 Arlington - VR2Tx-489484	St.17	2023-05-18	2023-12-31
489485	L	0.100 Fremont - VR2Tx-489485	St.23	2023-03-07	2023-12-31
489486	C	0.024 Louisville RC - VR2Tx-489486	St.6	2022-03-19	2023-12-31
489487	Q	Upper Loup	St.30	2023-05-09	2023-12-31

Release sites

Station.name	Latitude	Longitude	Easting	Northing	Array	Type	Standard.name	n.Adult	n.Sub-adult
RS1	41.05243	-95.88158	762074.0	4549264	A	Release	RS1	78	1
RS6	41.05767	-95.89387	761020.2	4549809	A	Release	RS6	0	0
RS7	41.05260	-95.97863	753916.1	4548995	C|B	Release	RS7	1	0

Station.name	Latitude	Longitude	Easting	Northing	Array	Type	Standard.name	n.Adult	n.Sub-adult
RS8	41.05284	-95.98598	753297.4	4549001	C|B	Release	RS8	1	0
RS28	41.02124	-96.13919	740535.3	4545058	C	Release	RS28	1	0
RS29	41.05257	-95.97867	753912.9	4548992	C|B	Release	RS29	0	0
RS30	41.05690	-95.97205	754452.6	4549492	C|B	Release	RS30	0	0
RS2	40.99323	-96.21815	733994.8	4541733	D|C	Release	RS2	0	0
RS3	40.99326	-96.21308	734421.2	4541750	D|C	Release	RS3	1	0
RS4	40.99520	-96.20174	735368.2	4541996	D|C	Release	RS4	1	0
RS5	40.99593	-96.21891	733921.3	4542031	D|C	Release	RS5	1	0
RS12	40.99366	-96.21165	734540.1	4541799	D|C	Release	RS12	0	0
RS13	41.01058	-96.17239	737781.9	4543783	D|C	Release	RS13	1	0
RS14	40.99461	-96.20367	735208.0	4541925	D|C	Release	RS14	0	0
RS17	40.99489	-96.21705	734081.4	4541921	D|C	Release	RS17	0	1
RS18	41.00713	-96.18175	737007.1	4543375	D|C	Release	RS18	1	0
RS19	41.01051	-96.16758	738186.7	4543789	D|C	Release	RS19	0	1
RS24	40.99589	-96.22531	733383.1	4542010	D|C	Release	RS24	0	0
RS25	41.00304	-96.19062	736275.6	4542897	D|C	Release	RS25	1	0
RS26	40.99702	-96.20019	735492.1	4542202	D|C	Release	RS26	0	1
RS9	41.11643	-96.31208	725671.3	4555164	E	Release	RS9	1	0
RS10	41.11930	-96.31125	725731.1	4555485	E	Release	RS10	0	1
RS11	41.11930	-96.31125	725731.1	4555485	E	Release	RS11	0	0
RS15	41.11818	-96.31107	725750.1	4555361	E	Release	RS15	0	1
RS16	41.11737	-96.31113	725747.8	4555271	E	Release	RS16	1	0
RS20	41.11058	-96.31358	725565.4	4554511	E	Release	RS20	1	0
RS27	41.11581	-96.31219	725664.2	4555095	E	Release	RS27	0	0
RS21	41.44839	-96.73993	688787.5	4591000	M|L	Release	RS21	1	0
RS22	41.44383	-96.72500	690048.1	4590526	M|L	Release	RS22	1	0
RS23	41.44739	-96.73075	689557.3	4590909	M|L	Release	RS23	0	0

Array efficiency

Note:
More information on the differences between “Known missed events” and “Potentially missed events” can be found in the package vignettes.
The data used in this table is stored in the `efficiency` object.
These efficiency values are estimated using a simple step-by-step method (described in the package vignettes). In some situations, more advanced efficiency estimation methods may be required.
You can try running `advEfficiency(results$efficiency)` to obtain beta-drawn efficiency distributions (replace `results` with the name of the object where you saved the analysis).

Events recorded and missed

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Recorded events	54	29	94	75	66	35	29	21	10	17	20	8	3	1	1	2	0	0	0

Known missed events	33	77	26	43	36	5	4	1	-	26	7	6	3	2	2	0	-	-	-
Potentially missed events	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	-	-	-

Array efficiency

Note: These values already include any intra-array efficiency estimates that have been requested.

Index:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Maximum efficiency	62.1%	27.4%	78.3%	63.6%	64.7%	87.5%	87.9%	95.5%	-	39.5%	74.1%	57.1%	50%	33.3%	33.3%	100%	-
Minimum efficiency	62.1%	27.4%	78.3%	63.6%	64.7%	87.5%	87.9%	95.5%	-	39.5%	74.1%	57.1%	50%	33.3%	33.3%	100%	-

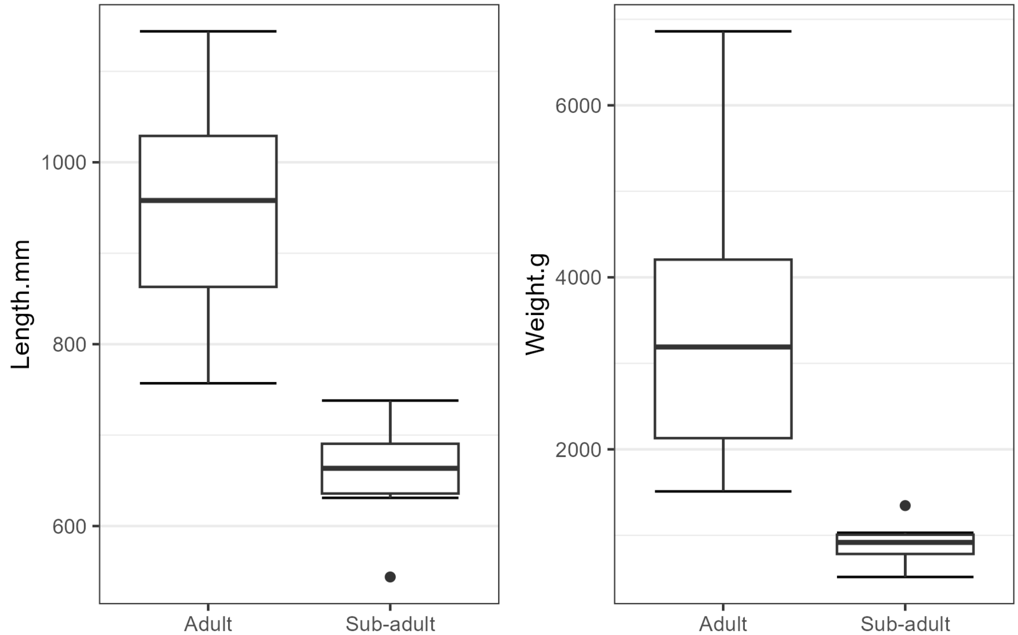
Warning messages

User comments

```
No comments were included during the analysis.
```

Biometric graphics

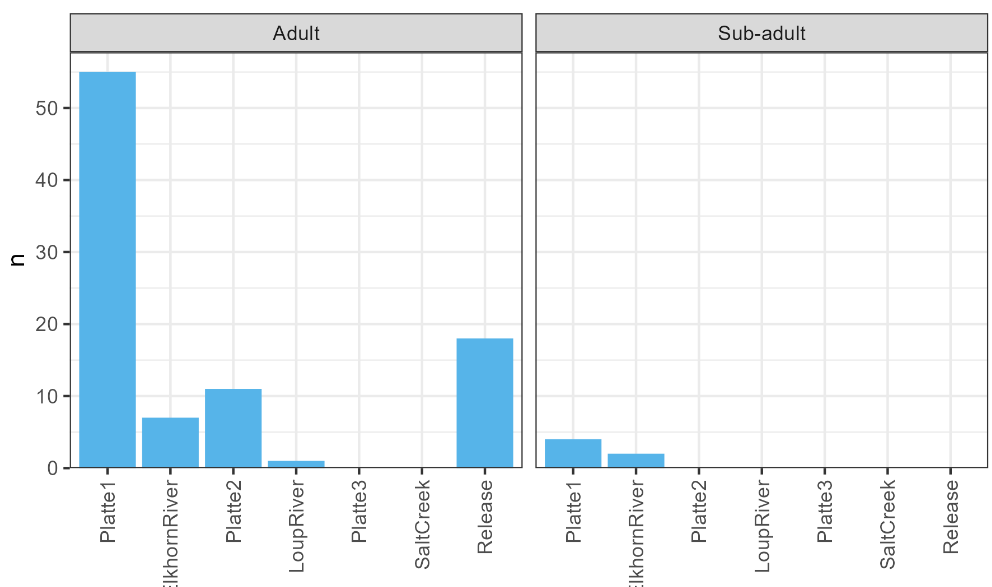
Note:
The data used in this graphic is the data present in the biometrics.csv file.



Last seen

Note:
The data used in this table and graphic is stored in the `last.seen` object.

	Disap. in Platte1	Disap. in ElkhornRiver	Disap. in Platte2	Disap. in LoupRiver	Disap. in Platte3	Disap. in SaltCreek	Disap. at Release
Adult	55	7	11	1	0	0	18
Sub-adult	4	2	0	0	0	0	0



Index:

Average time of arrival at each Array

Note:
Coloured lines on the outer circle indicate the mean value for each group and the respective ranges show the standard error of the mean. Each group's bars sum to 100%. The number of data points in each group is presented between brackets in the legend of each pannel.
You can replicate these graphics and edit them as needed using the `plotTimes()` function.
The data used in these graphics is stored in the `array.times` object.
To obtain reports with the legacy linear circular scale, run `options(actel.circular.scale = "linear")` before running your analyses.

Index:

Summary

Study area

Stations

Deployments

Release sites

Array efficiency

Warnings

Comments

Biometrics

Last seen

Array times

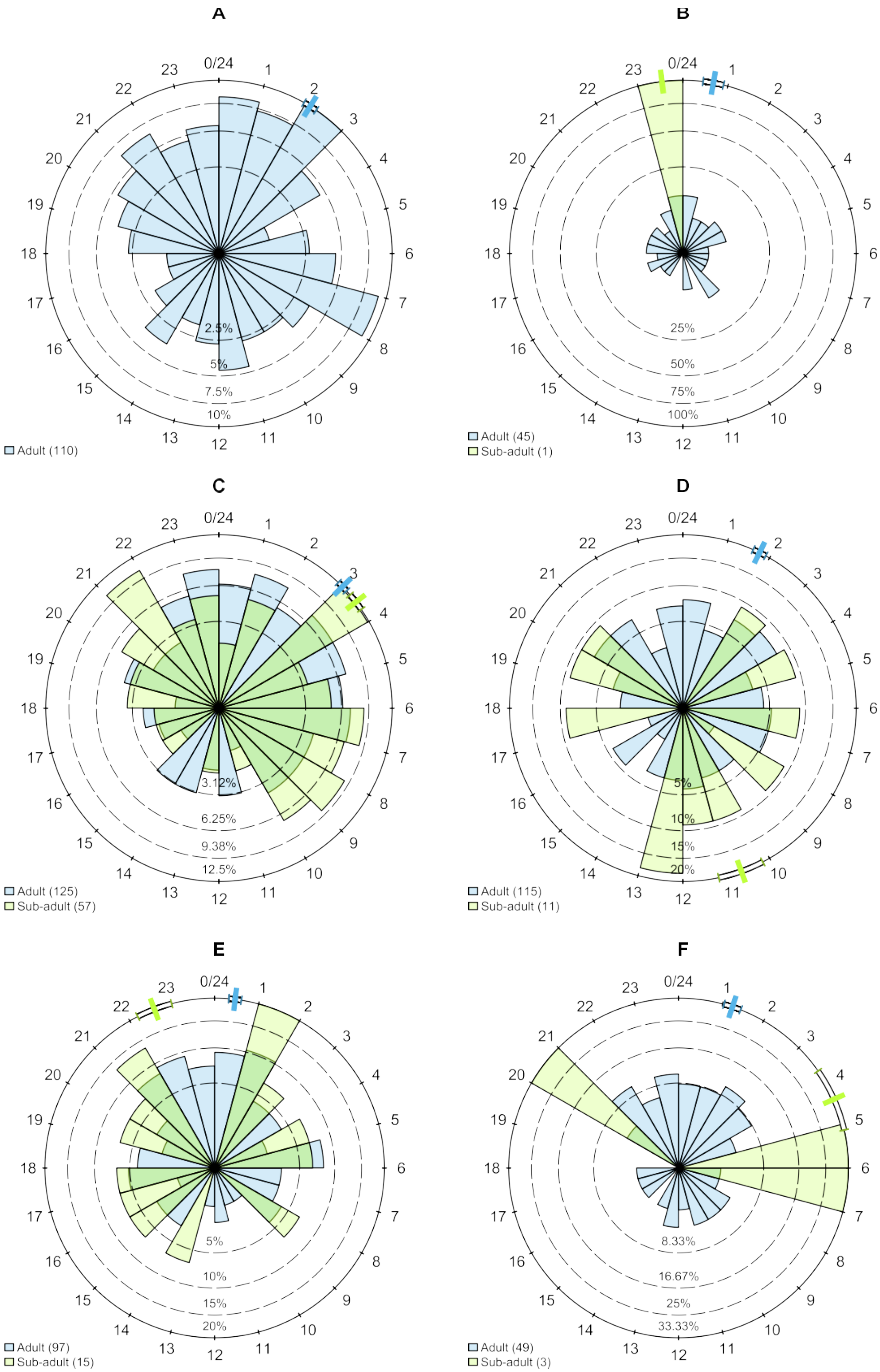
Section times

Global residency

Individual residency

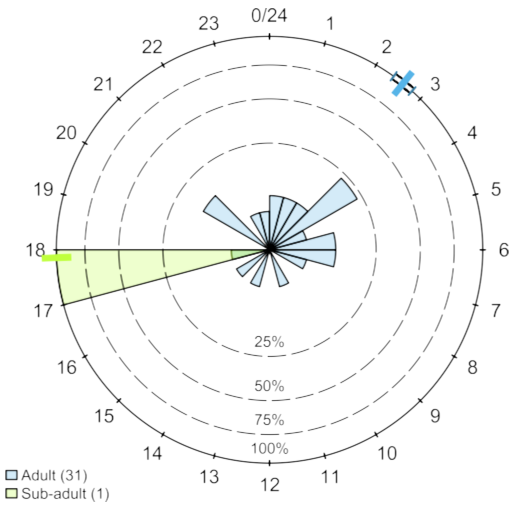
Individual detections

Full log

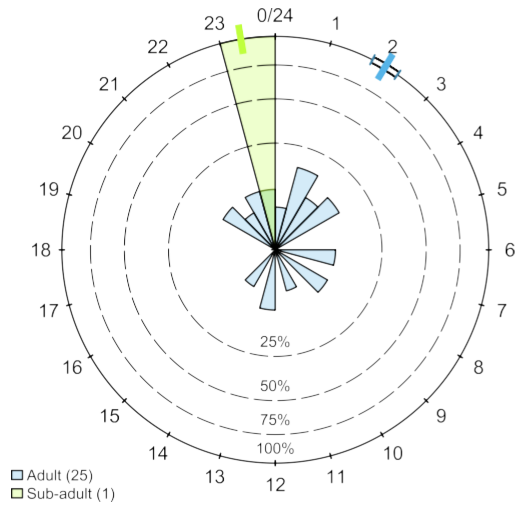


Index:

G



H



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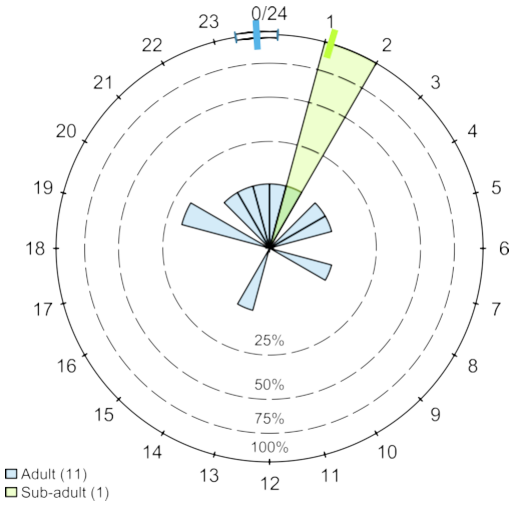

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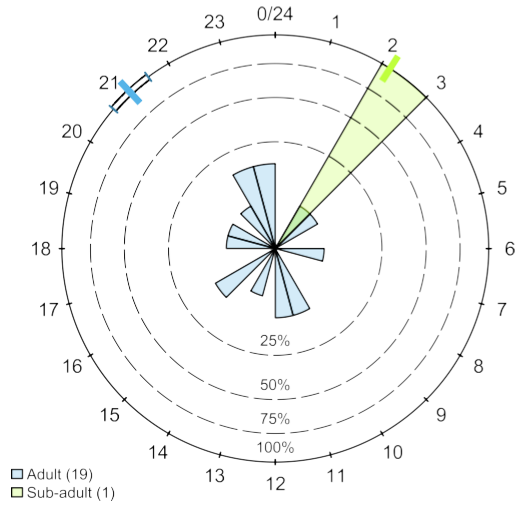
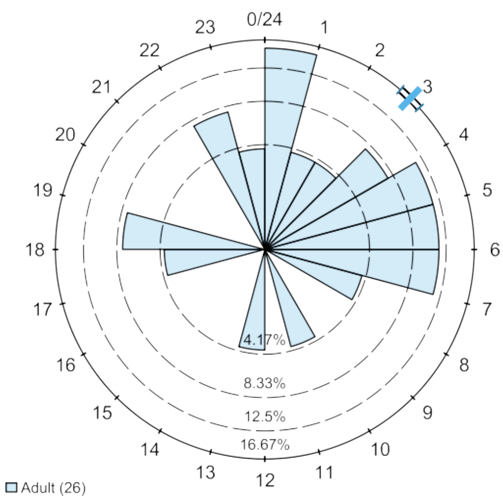
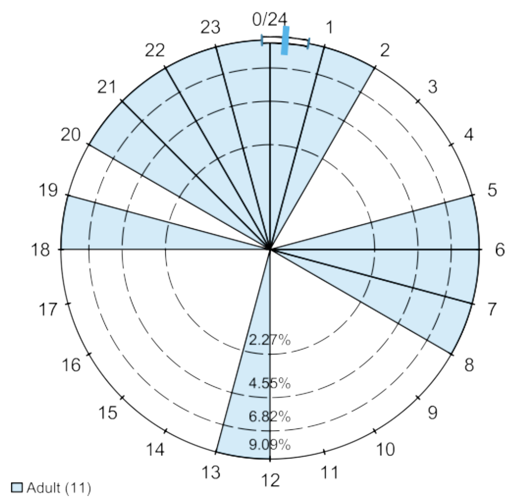
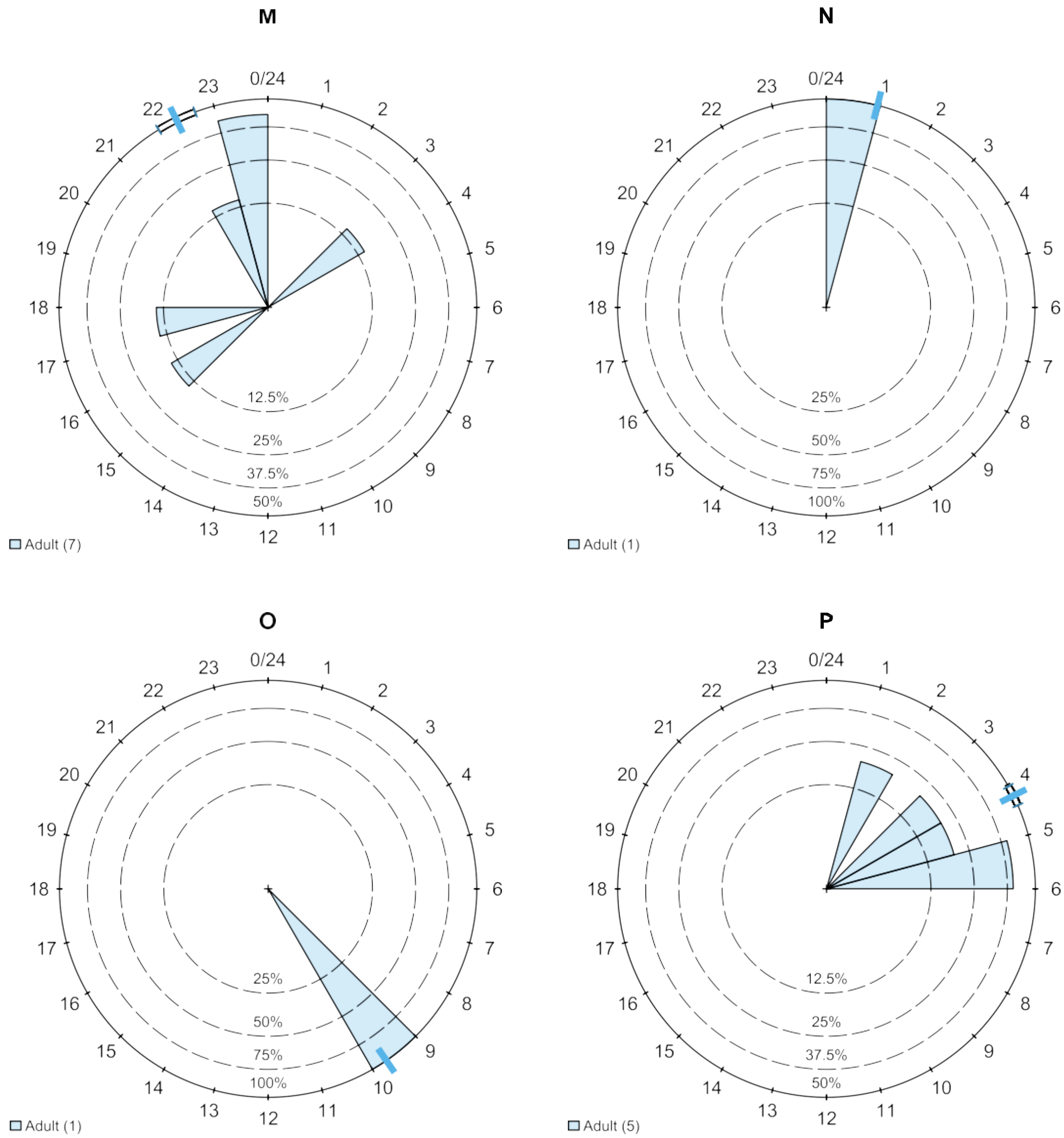


K



L





Time details for each section

Arrival days at each section

Note:

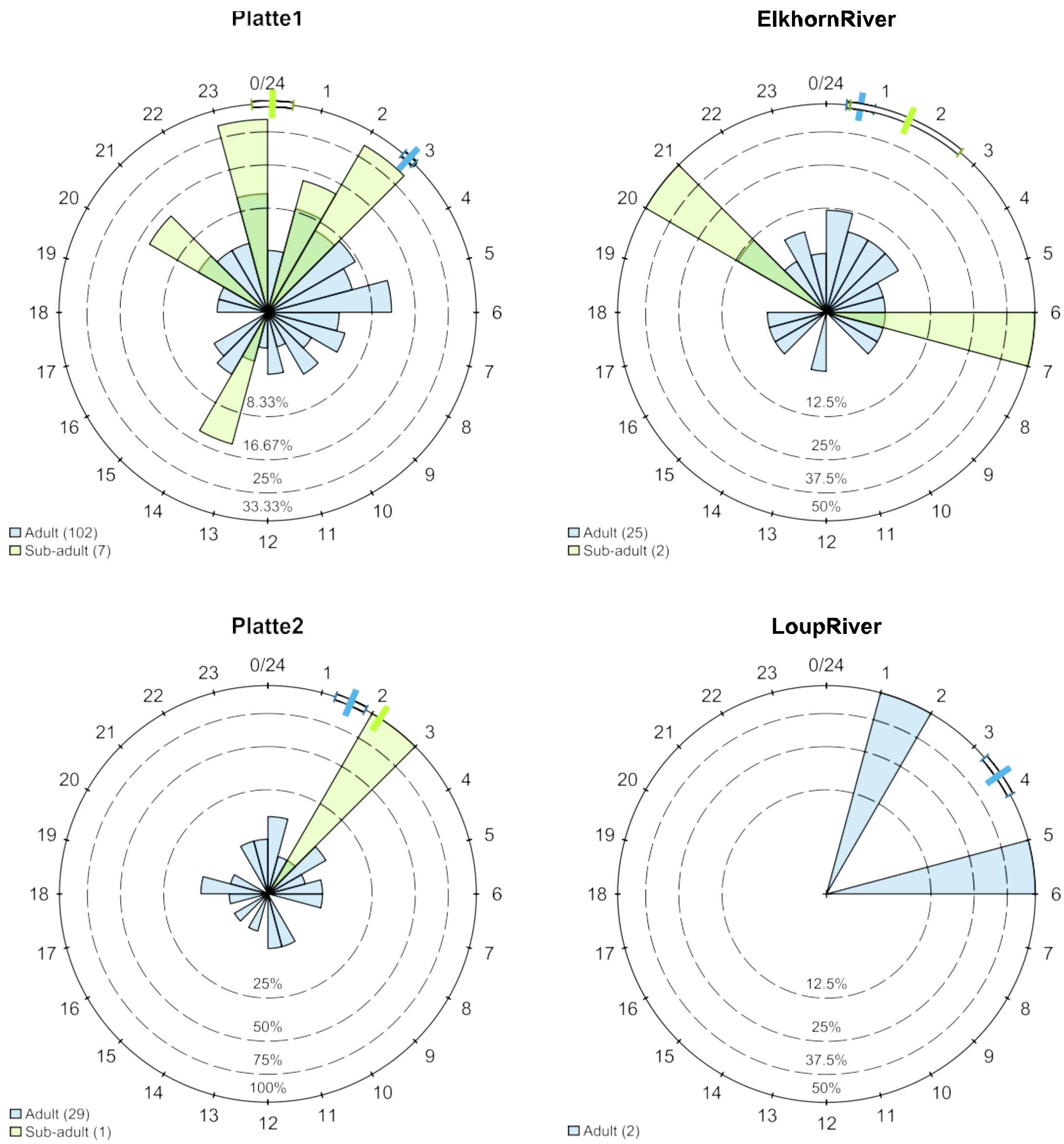
The data used in these graphics is stored in the `section.times$arrival` object.

Arrival times at each section

Note:
Coloured lines on the outer circle indicate the mean value for each group and the respective ranges show the standard error of the mean. Each group's bars sum to 100%. The number of data points in each group is presented between brackets in the legend of each pannel.

You can replicate these graphics and edit them as needed using the `plotTimes()` function. The data used in these graphics is stored in the `section.times$arrival` object.

To obtain reports with the legacy linear circular scale, run `options(actel.circular.scale = "linear")` before running your analyses.



Departure days at each section

Note:

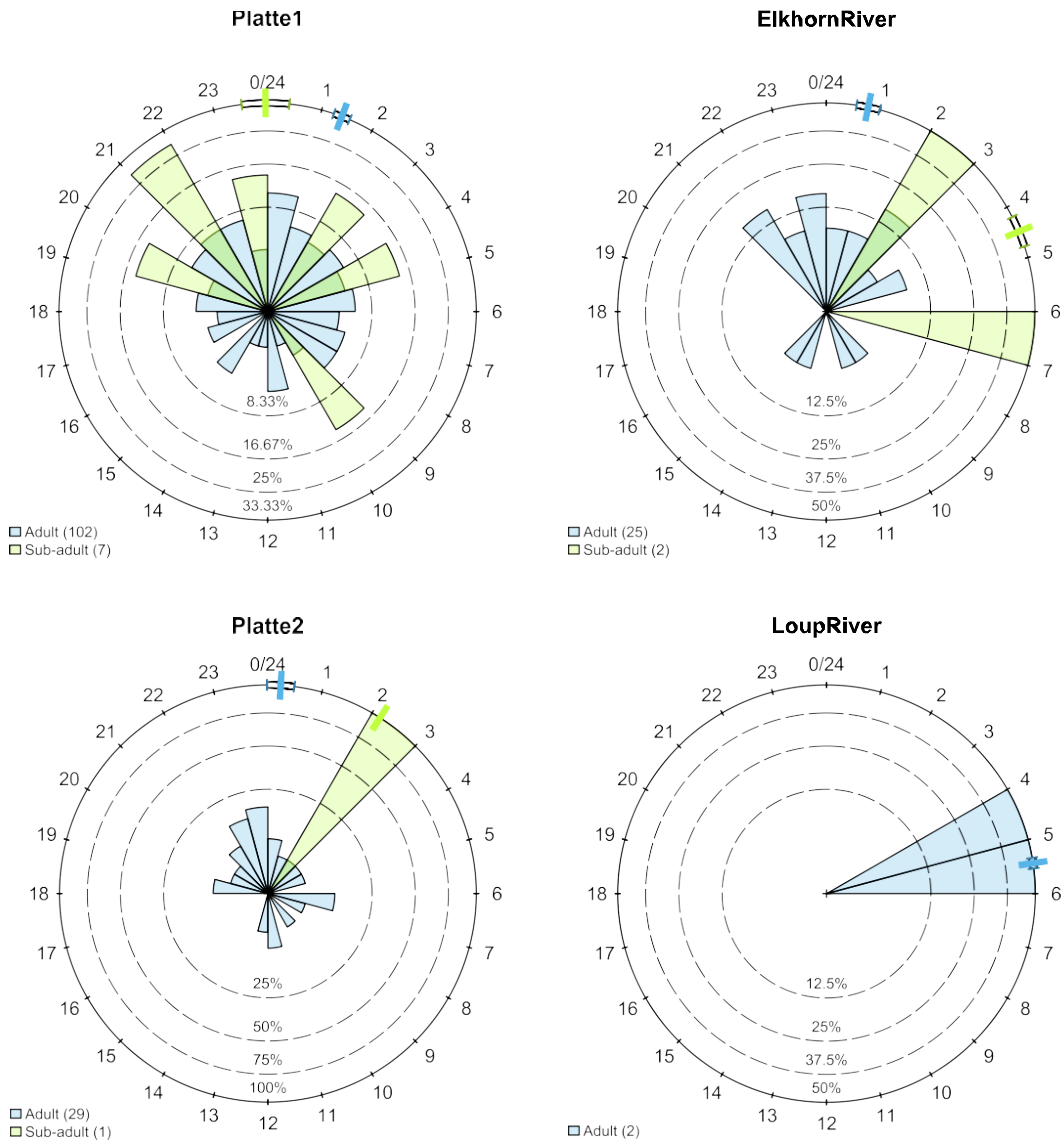
The data used in these graphics is stored in the `section.times$departure` object.

Departure times at each section

Note:
Coloured lines on the outer circle indicate the mean value for each group and the respective ranges show the standard error of the mean. Each group's bars sum to 100%. The number of data points in each group is presented between brackets in the legend of each pannel.

You can replicate these graphics and edit them as needed using the `plotTimes()` function. The data used in these graphics is stored in the `section.times$departure` object.

To obtain reports with the legacy linear circular scale, run `options(actel.circular.scale = "linear")` before running your analyses.



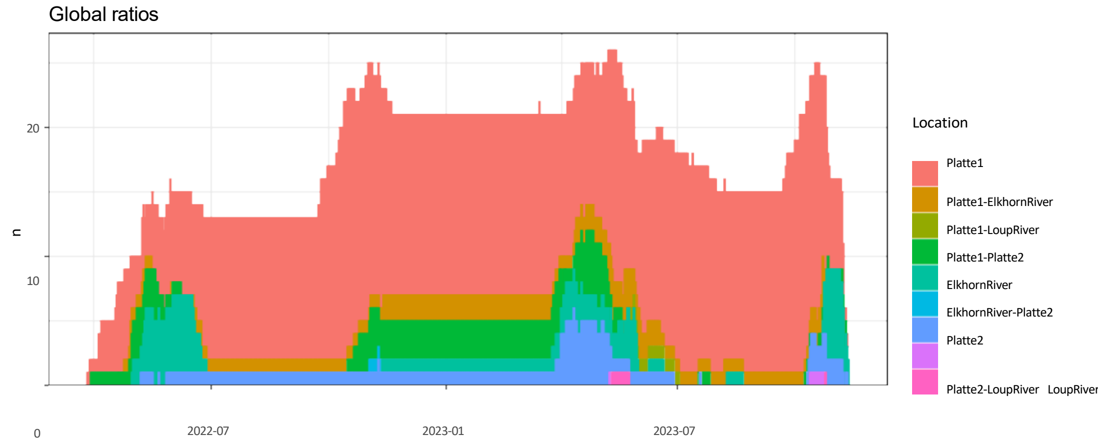
Global residency

Note:

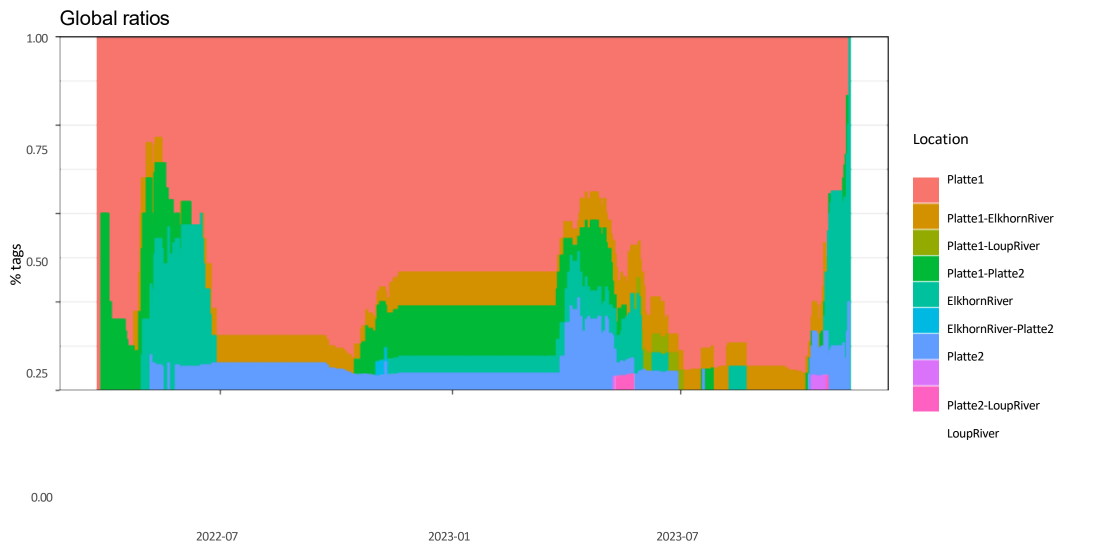
The data used in these graphics is stored in the `global.ratios` and `time.positions` objects. You can replicate these graphics and edit them as needed using the `plotRatios()` function. This data is also available split by group in the `group.ratios` object.

You can plot these results by group using the 'group' argument in `plotRatios()`.

Absolutes



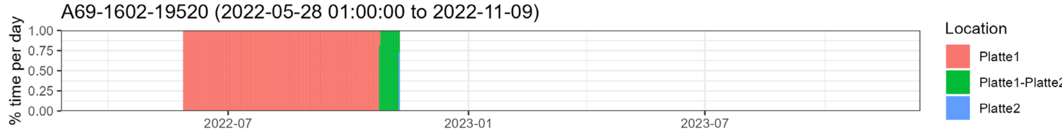
Percentages



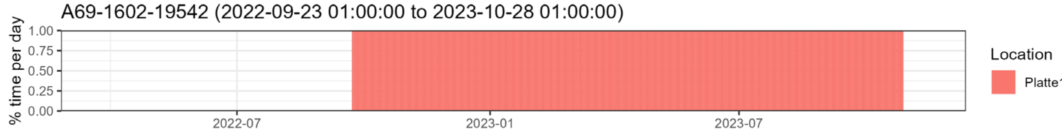
Individual residency plots

Note:
The data used in these graphics is stored in the `time.ratios` object (one table per tag). More condensed information can be found in the `section.movements` object.
You can replicate these graphics and edit them as needed using the `plotResidency()` function.

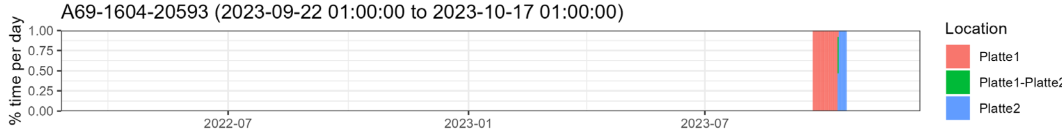
A69-1602-19520 (2022-05-28 01:00:00 to 2022-11-09)



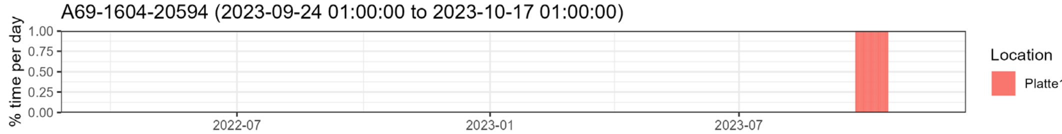
A69-1602-19542 (2022-09-23 01:00:00 to 2023-10-28 01:00:00)



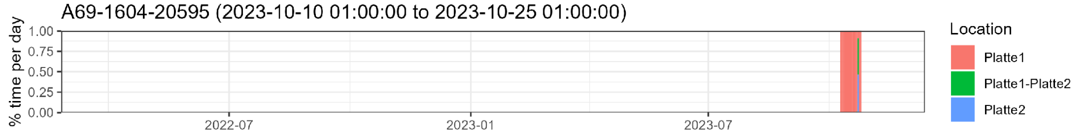
A69-1604-20593 (2023-09-22 01:00:00 to 2023-10-17 01:00:00)



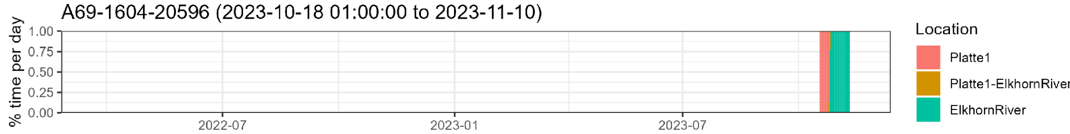
A69-1604-20594 (2023-09-24 01:00:00 to 2023-10-17 01:00:00)



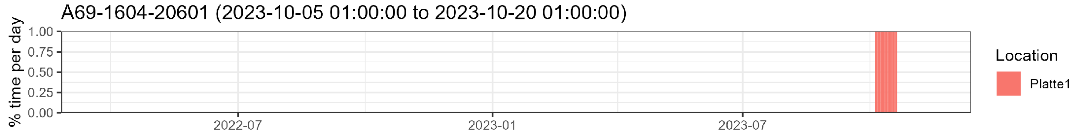
A69-1604-20595 (2023-10-10 01:00:00 to 2023-10-25 01:00:00)



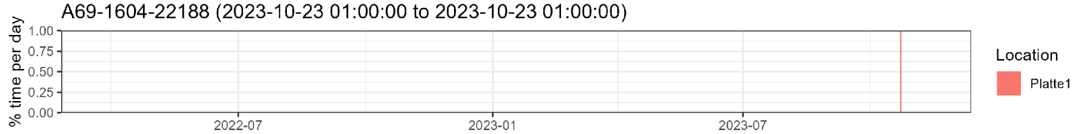
A69-1604-20596 (2023-10-18 01:00:00 to 2023-11-10)



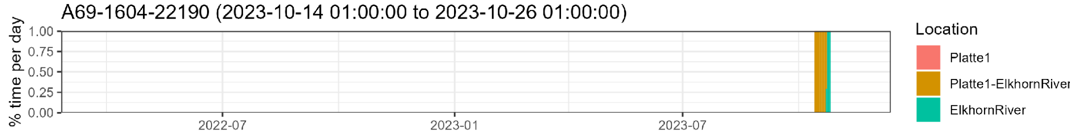
A69-1604-20601 (2023-10-05 01:00:00 to 2023-10-20 01:00:00)



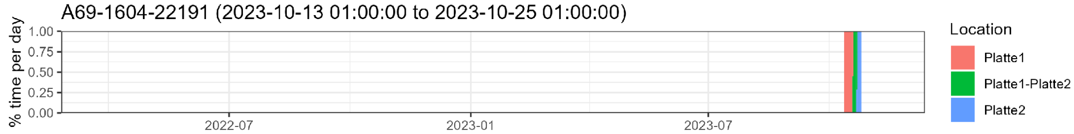
A69-1604-22188 (2023-10-23 01:00:00 to 2023-10-23 01:00:00)



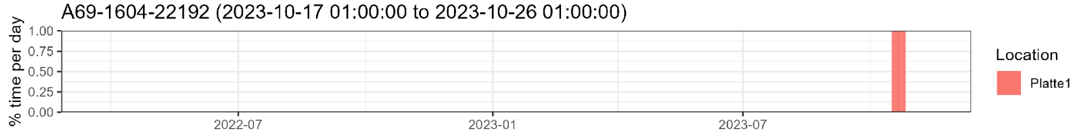
A69-1604-22190 (2023-10-14 01:00:00 to 2023-10-26 01:00:00)



A69-1604-22191 (2023-10-13 01:00:00 to 2023-10-25 01:00:00)



A69-1604-22192 (2023-10-17 01:00:00 to 2023-10-26 01:00:00)



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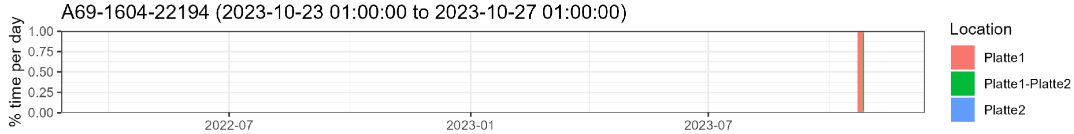
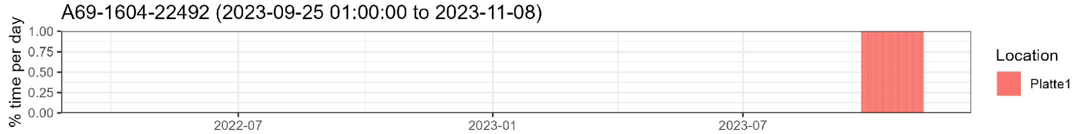
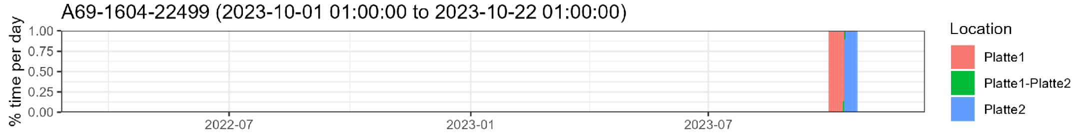


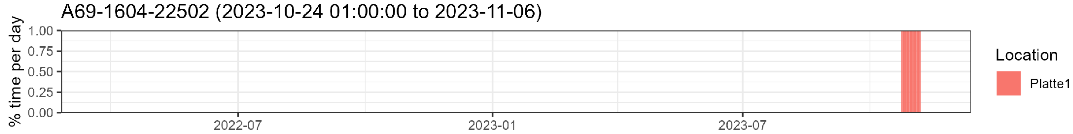
A69-1604-22492 (2023-09-25 01:00:00 to 2023-11-08)



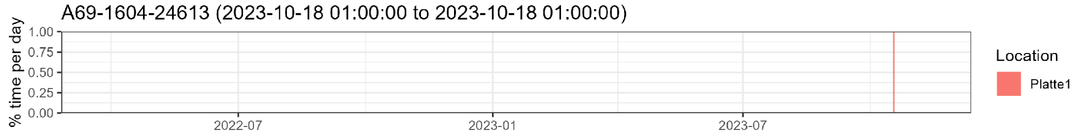
A69-1604-22499 (2023-10-01 01:00:00 to 2023-10-22 01:00:00)



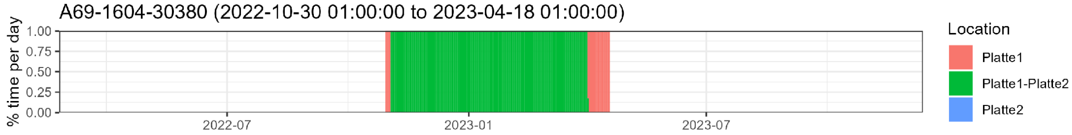
A69-1604-22502 (2023-10-24 01:00:00 to 2023-11-06)



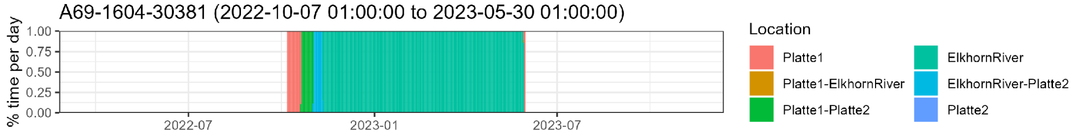
A69-1604-24613 (2023-10-18 01:00:00 to 2023-10-18 01:00:00)



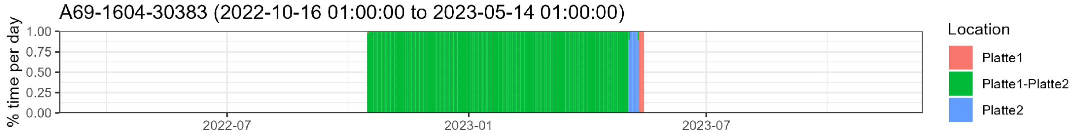
A69-1604-30380 (2022-10-30 01:00:00 to 2023-04-18 01:00:00)



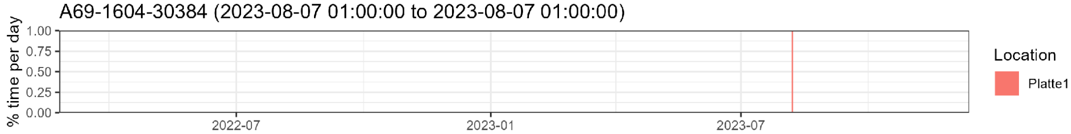
A69-1604-30381 (2022-10-07 01:00:00 to 2023-05-30 01:00:00)



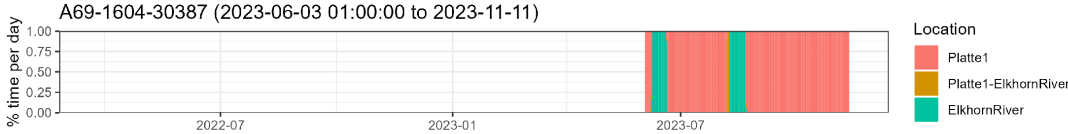
A69-1604-30383 (2022-10-16 01:00:00 to 2023-05-14 01:00:00)



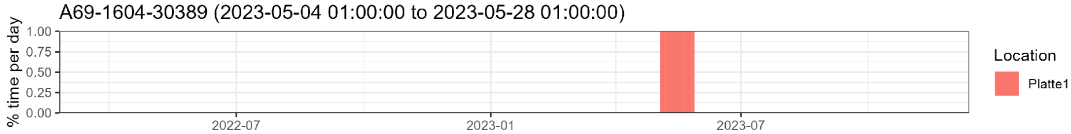
A69-1604-30384 (2023-08-07 01:00:00 to 2023-08-07 01:00:00)



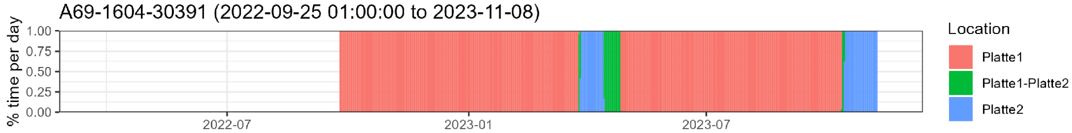
A69-1604-30387 (2023-06-03 01:00:00 to 2023-11-11)



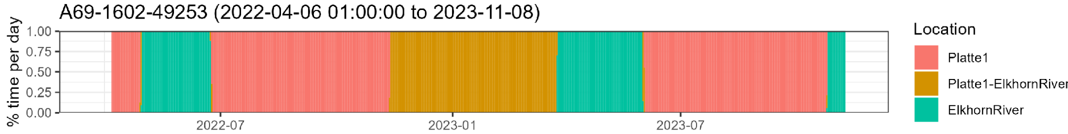
A69-1604-30389 (2023-05-04 01:00:00 to 2023-05-28 01:00:00)



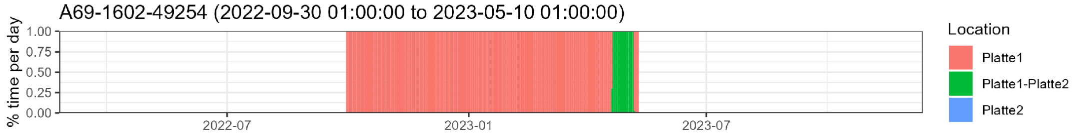
A69-1604-30391 (2022-09-25 01:00:00 to 2023-11-08)



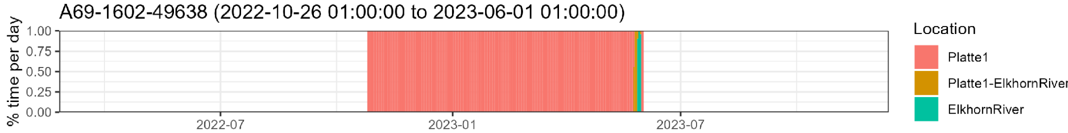
A69-1602-49253 (2022-04-06 01:00:00 to 2023-11-08)



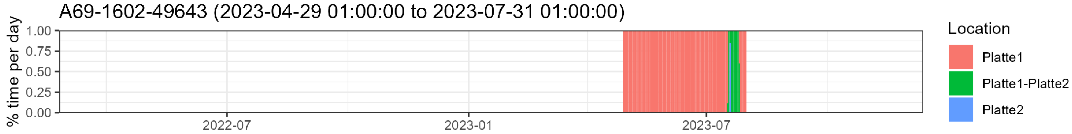
A69-1602-49254 (2022-09-30 01:00:00 to 2023-05-10 01:00:00)



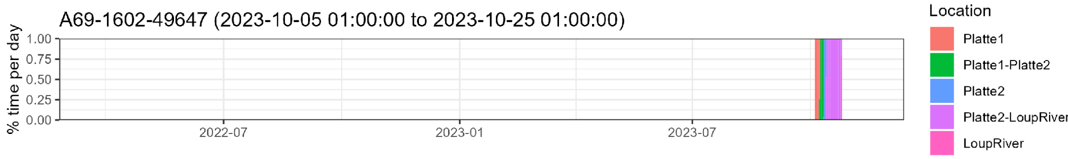
A69-1602-49638 (2022-10-26 01:00:00 to 2023-06-01 01:00:00)

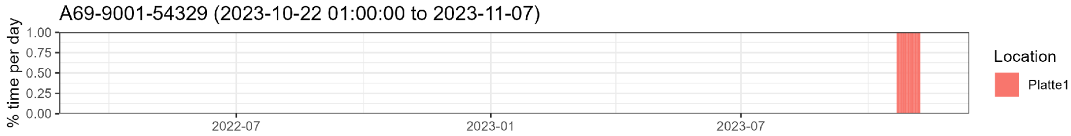


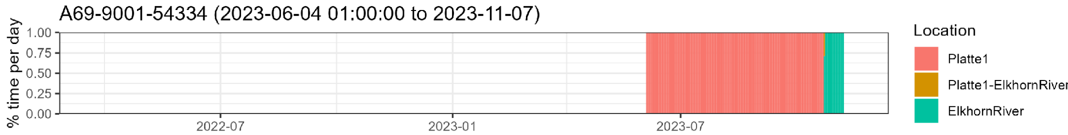
A69-1602-49643 (2023-04-29 01:00:00 to 2023-07-31 01:00:00)

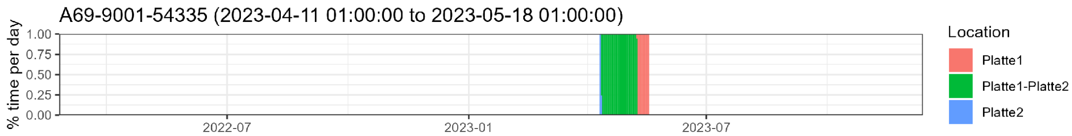


A69-1602-49647 (2023-10-05 01:00:00 to 2023-10-25 01:00:00)




A69-9001-54329 (2023-10-22 01:00:00 to 2023-11-07)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1


A69-9001-54334 (2023-06-04 01:00:00 to 2023-11-07)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1
Platte1-ElkhornRiver
ElkhornRiver


A69-9001-54335 (2023-04-11 01:00:00 to 2023-05-18 01:00:00)
% time per day
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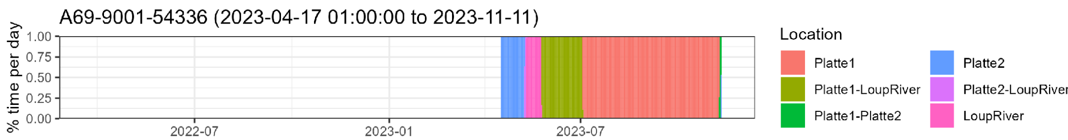
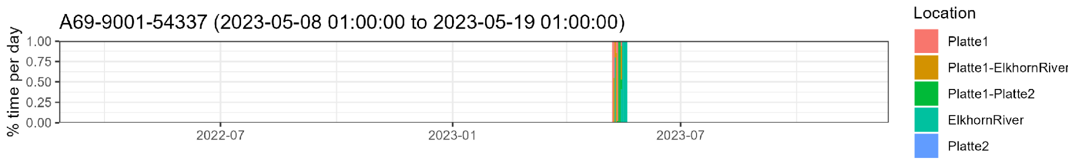
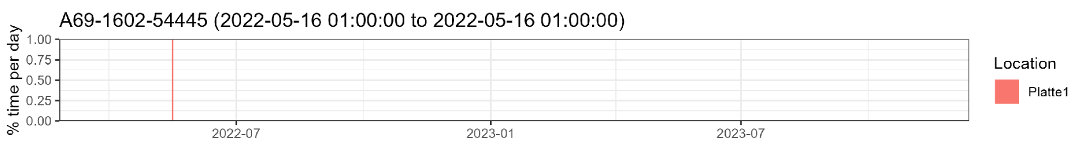
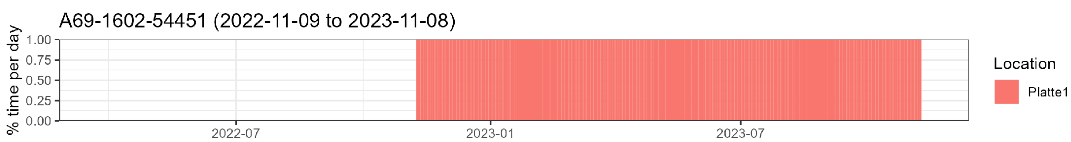
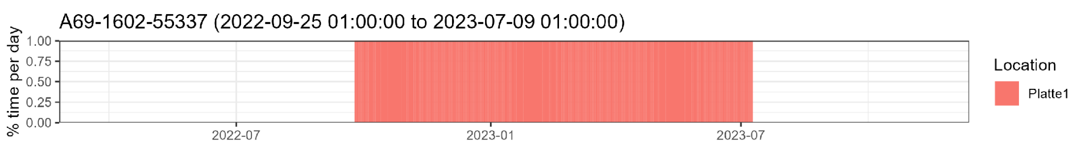
2022-07 2023-01 2023-07
Location
Platte1
Platte1-Platte2
Platte2

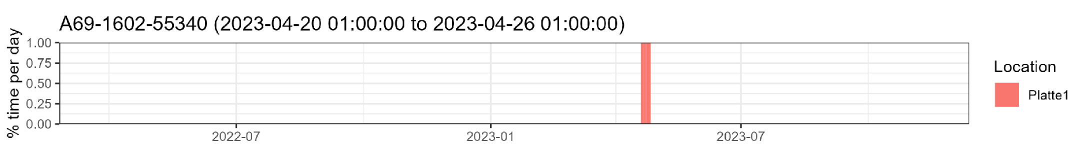

A69-9001-54336 (2023-04-17 01:00:00 to 2023-11-11)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1
Platte1-LoupRiver
Platte1-Platte2
Platte2
Platte2-LoupRiver
LoupRiver

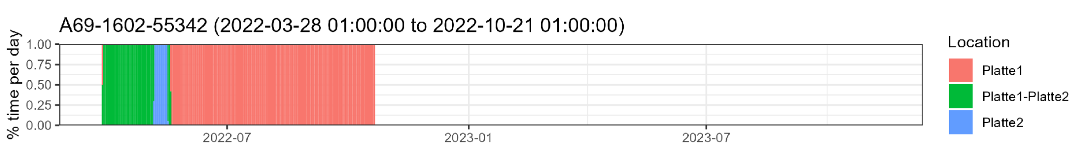

A69-9001-54337 (2023-05-08 01:00:00 to 2023-05-19 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1
Platte1-ElkhornRiver
Platte1-Platte2
ElkhornRiver
Platte2

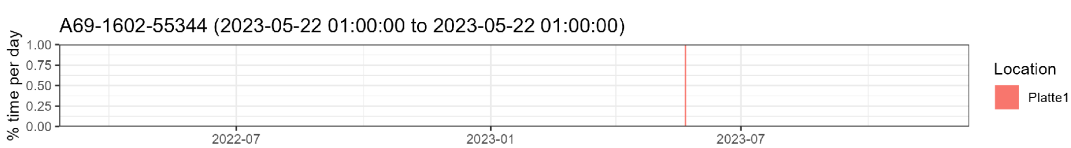

A69-1602-54445 (2022-05-16 01:00:00 to 2022-05-16 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1

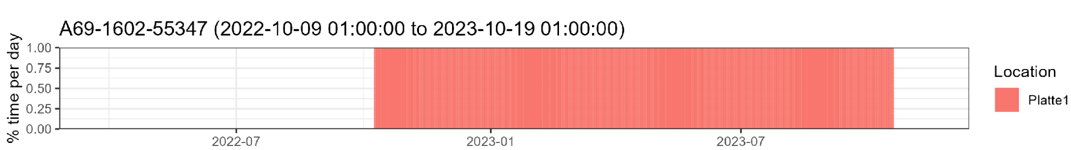

A69-1602-54451 (2022-11-09 to 2023-11-08)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1


A69-1602-55337 (2022-09-25 01:00:00 to 2023-07-09 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1

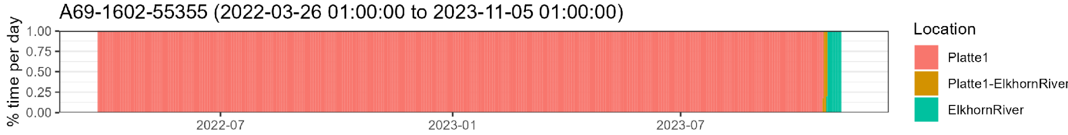

A69-1602-55340 (2023-04-20 01:00:00 to 2023-04-26 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1


A69-1602-55342 (2022-03-28 01:00:00 to 2022-10-21 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1
Platte1-Platte2
Platte2

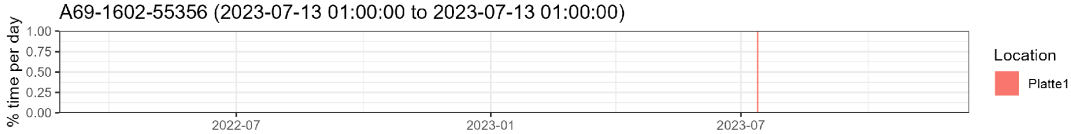

A69-1602-55344 (2023-05-22 01:00:00 to 2023-05-22 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1


A69-1602-55347 (2022-10-09 01:00:00 to 2023-10-19 01:00:00)
% time per day
1.00 0.75 0.50 0.25 0.00
2022-07 2023-01 2023-07
Location
Platte1

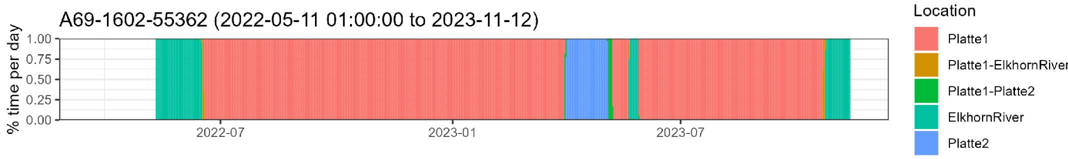
A69-1602-55355 (2022-03-26 01:00:00 to 2023-11-05 01:00:00)



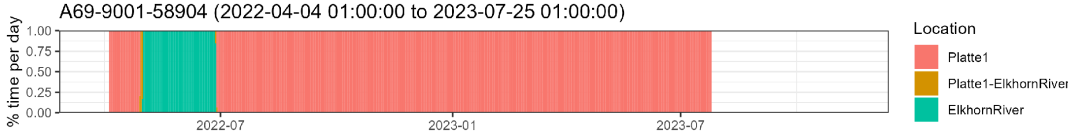
A69-1602-55356 (2023-07-13 01:00:00 to 2023-07-13 01:00:00)



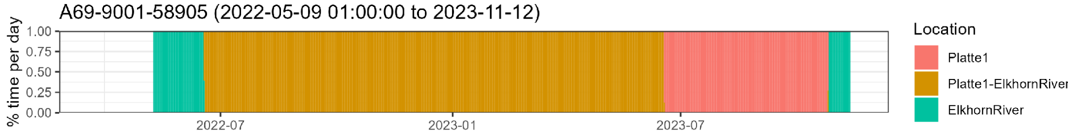
A69-1602-55362 (2022-05-11 01:00:00 to 2023-11-12)



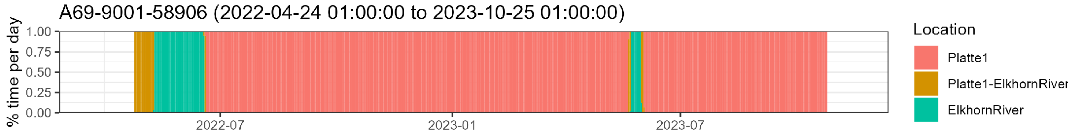
A69-9001-58904 (2022-04-04 01:00:00 to 2023-07-25 01:00:00)



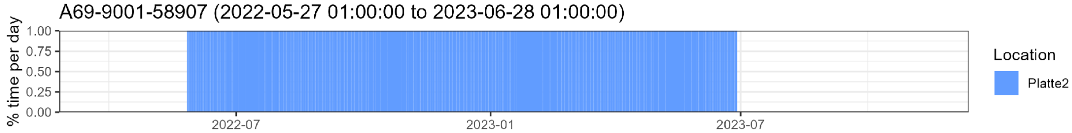
A69-9001-58905 (2022-05-09 01:00:00 to 2023-11-12)



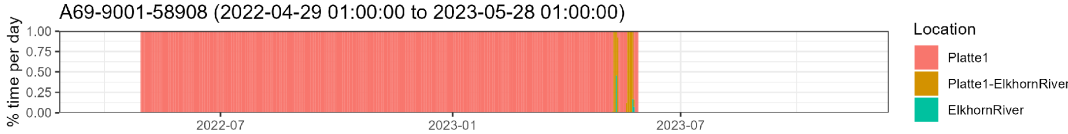
A69-9001-58906 (2022-04-24 01:00:00 to 2023-10-25 01:00:00)



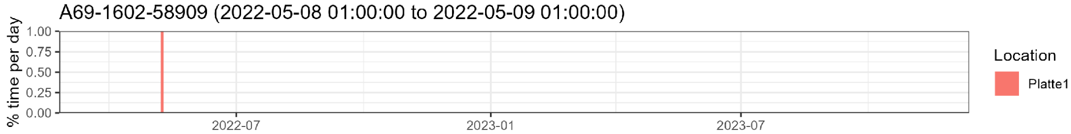
A69-9001-58907 (2022-05-27 01:00:00 to 2023-06-28 01:00:00)



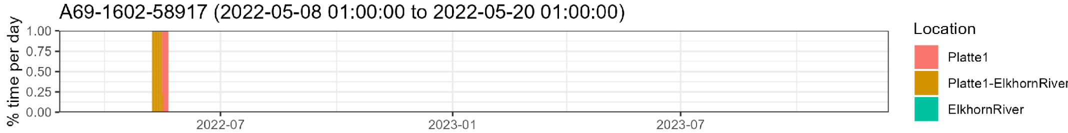
A69-9001-58908 (2022-04-29 01:00:00 to 2023-05-28 01:00:00)



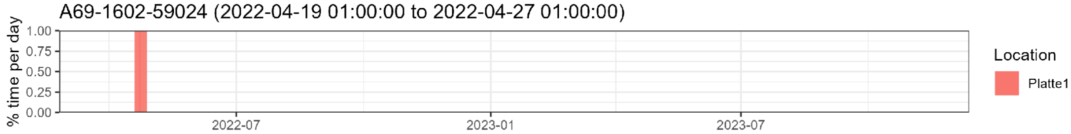
A69-1602-58909 (2022-05-08 01:00:00 to 2022-05-09 01:00:00)



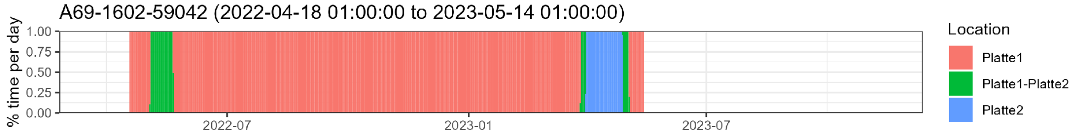
A69-1602-58917 (2022-05-08 01:00:00 to 2022-05-20 01:00:00)



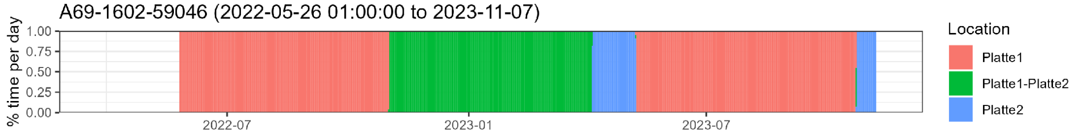
A69-1602-59024 (2022-04-19 01:00:00 to 2022-04-27 01:00:00)



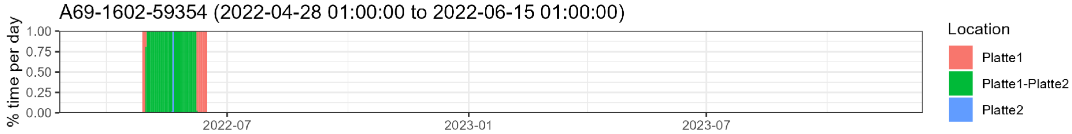
A69-1602-59042 (2022-04-18 01:00:00 to 2023-05-14 01:00:00)



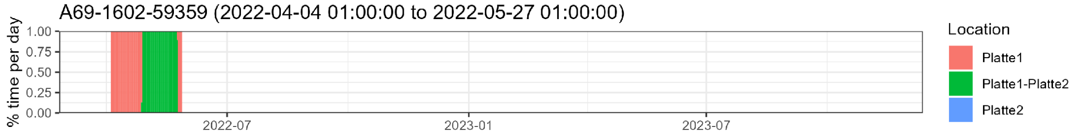
A69-1602-59046 (2022-05-26 01:00:00 to 2023-11-07)



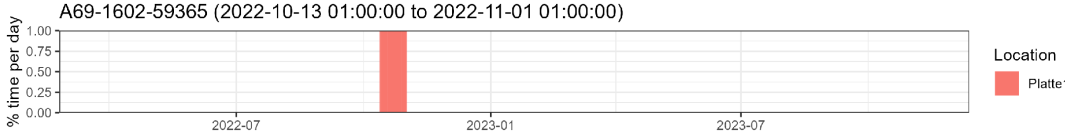
A69-1602-59354 (2022-04-28 01:00:00 to 2022-06-15 01:00:00)



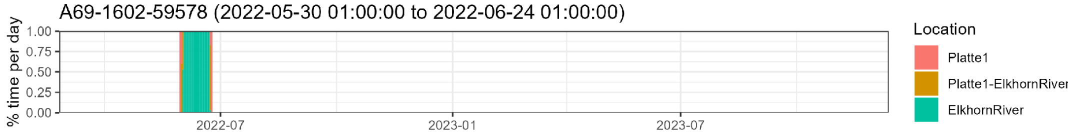
A69-1602-59359 (2022-04-04 01:00:00 to 2022-05-27 01:00:00)



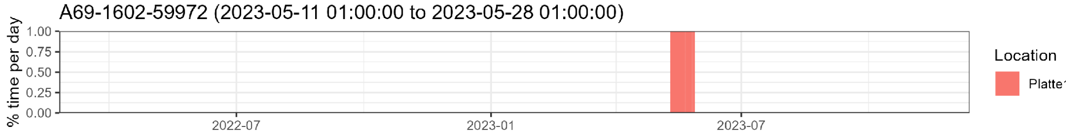
A69-1602-59365 (2022-10-13 01:00:00 to 2022-11-01 01:00:00)



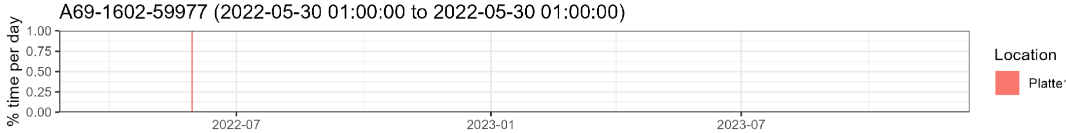
A69-1602-59578 (2022-05-30 01:00:00 to 2022-06-24 01:00:00)



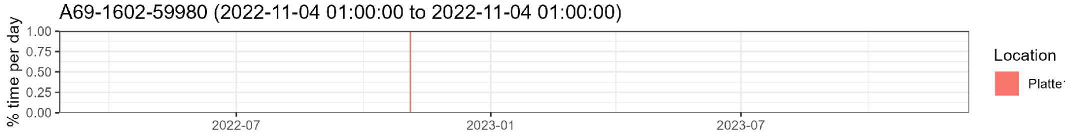
A69-1602-59972 (2023-05-11 01:00:00 to 2023-05-28 01:00:00)



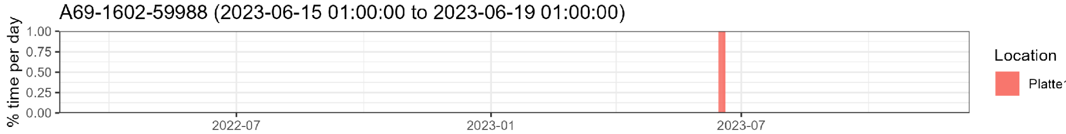
A69-1602-59977 (2022-05-30 01:00:00 to 2022-05-30 01:00:00)



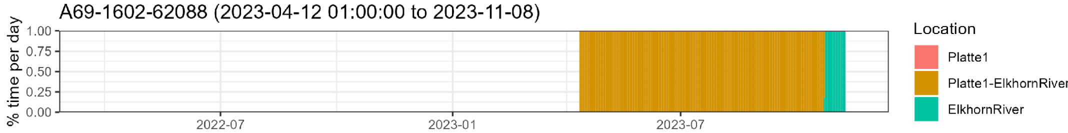
A69-1602-59980 (2022-11-04 01:00:00 to 2022-11-04 01:00:00)



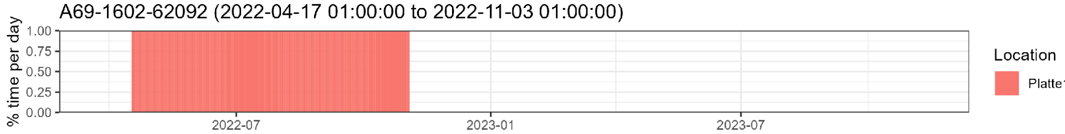
A69-1602-59988 (2023-06-15 01:00:00 to 2023-06-19 01:00:00)



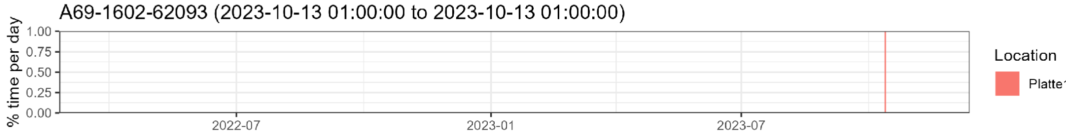
A69-1602-62088 (2023-04-12 01:00:00 to 2023-11-08)

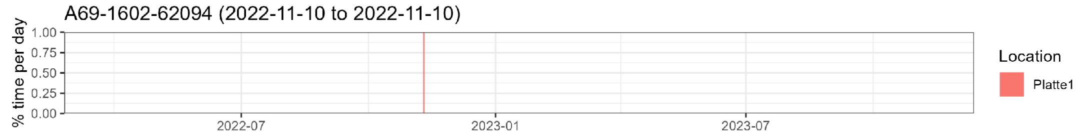


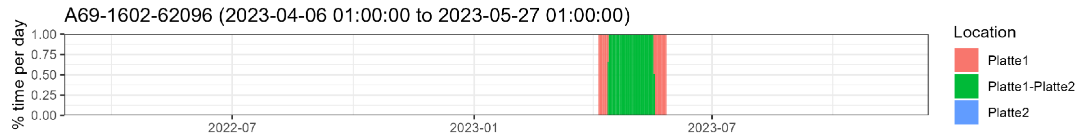
A69-1602-62092 (2022-04-17 01:00:00 to 2022-11-03 01:00:00)

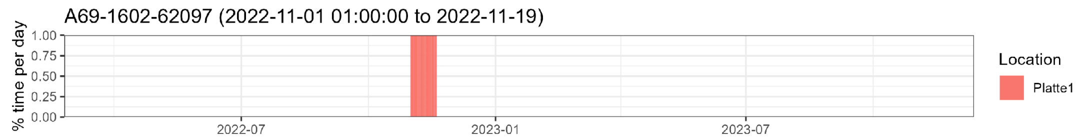


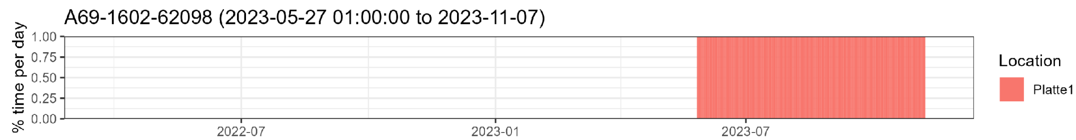
A69-1602-62093 (2023-10-13 01:00:00 to 2023-10-13 01:00:00)

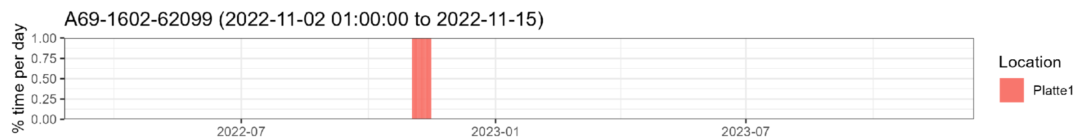


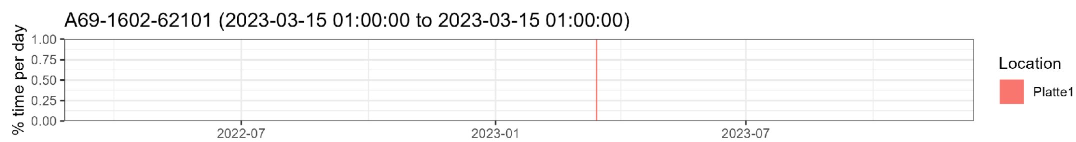

A69-1602-62094 (2022-11-10 to 2022-11-10)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

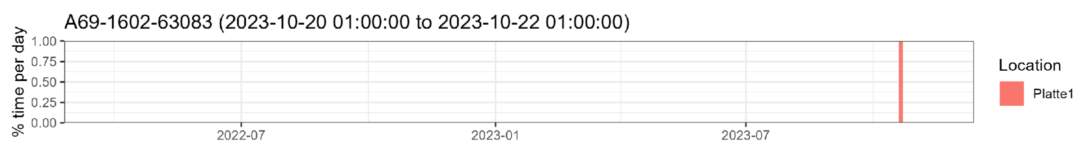

A69-1602-62096 (2023-04-06 01:00:00 to 2023-05-27 01:00:00)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1
Platte1-Platte2
Platte2

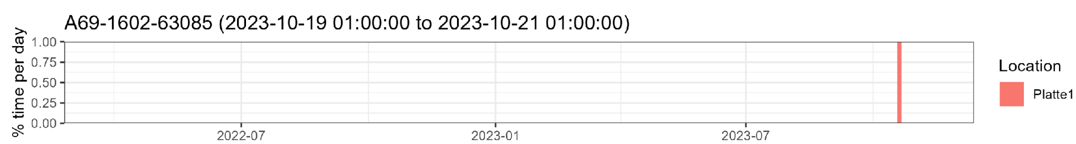

A69-1602-62097 (2022-11-01 01:00:00 to 2022-11-19)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

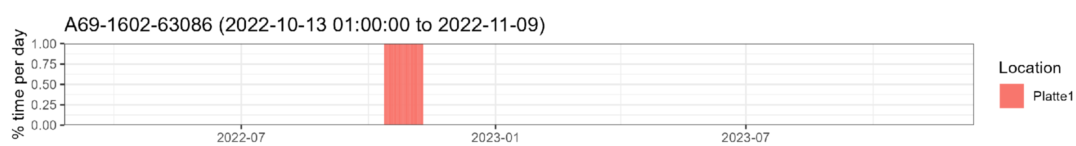

A69-1602-62098 (2023-05-27 01:00:00 to 2023-11-07)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

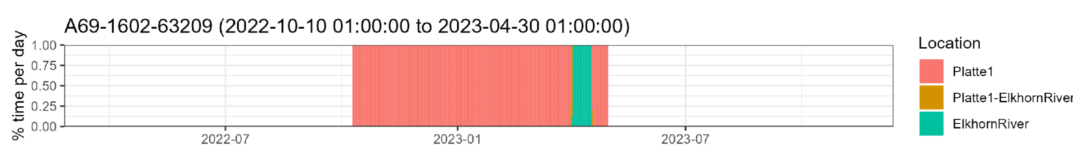

A69-1602-62099 (2022-11-02 01:00:00 to 2022-11-15)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

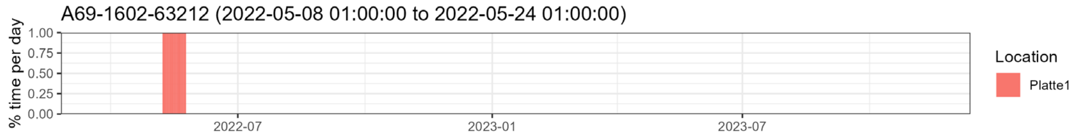

A69-1602-62101 (2023-03-15 01:00:00 to 2023-03-15 01:00:00)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

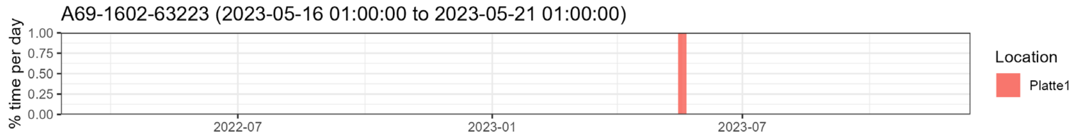

A69-1602-63083 (2023-10-20 01:00:00 to 2023-10-22 01:00:00)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1

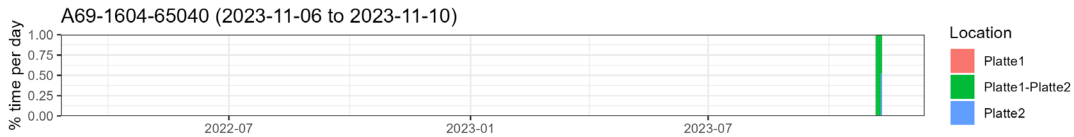

A69-1602-63085 (2023-10-19 01:00:00 to 2023-10-21 01:00:00)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1


A69-1602-63086 (2022-10-13 01:00:00 to 2022-11-09)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1


A69-1602-63209 (2022-10-10 01:00:00 to 2023-04-30 01:00:00)
% time per day
1.00
0.75
0.50
0.25
0.00
2022-07
2023-01
2023-07
Location
Platte1
Platte1-ElkhornRiver
ElkhornRiver



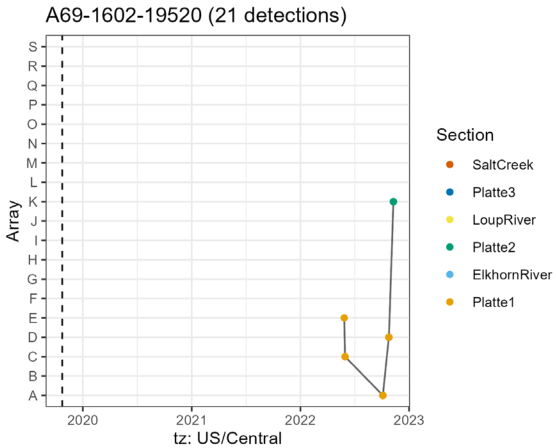


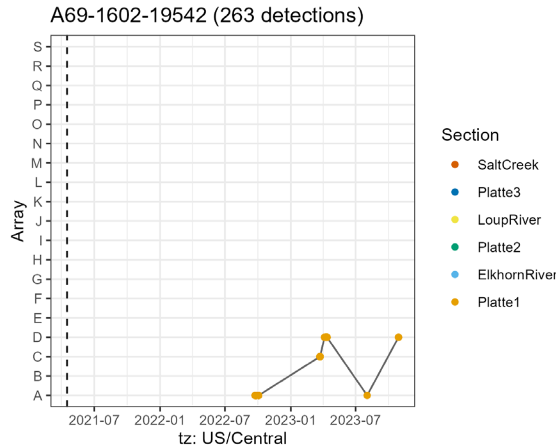


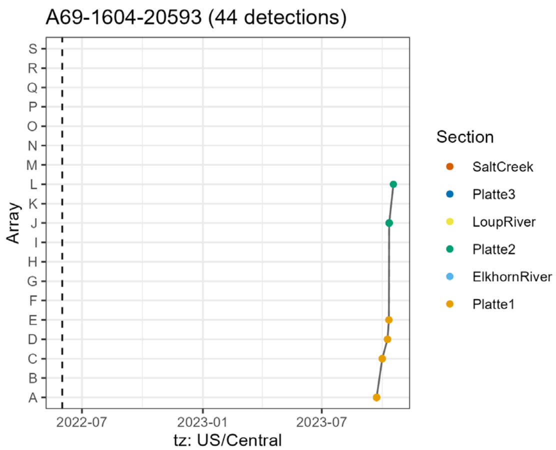
Individual detection plots

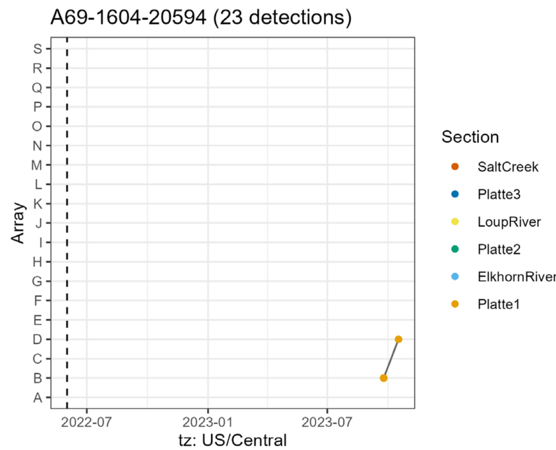
Note:
You can choose to plot detections by station or by array using the `detections.y.axis` argument.
The detections are coloured by section. The vertical black dashed line shows the release time. The full dark-grey line shows the movement events considered valid, while the dashed dark-grey line shows the movement events considered invalid. Manually **edited** tags are highlighted with **yellow** graphic borders. Manually **overridden** tags are highlighted with **red** graphic borders.

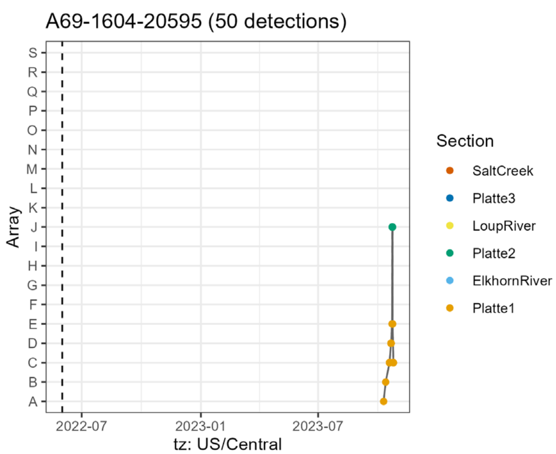
The arrays have been aligned by section, following the order provided either in the spatial input or the `section.order` argument.
You can replicate these graphics and edit them as needed using the `plotDetections()` function.
You can also see the movement events of multiple tags simultaneously using the `plotMoves()` function.
The data used in these graphics is stored in the `detections` and `movements` objects (and respective valid counterparts).

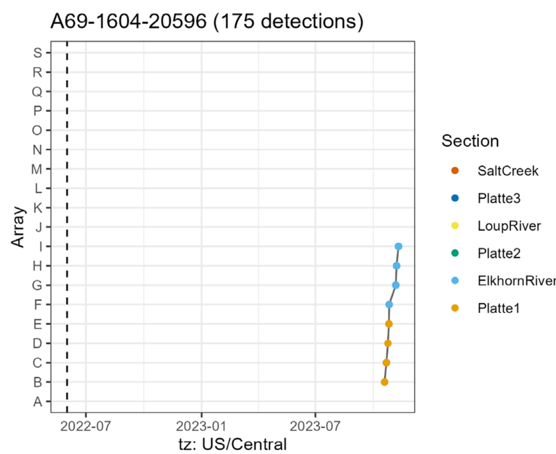

A69-1602-19520 (21 detections)
Array
2020
2021
2022
2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

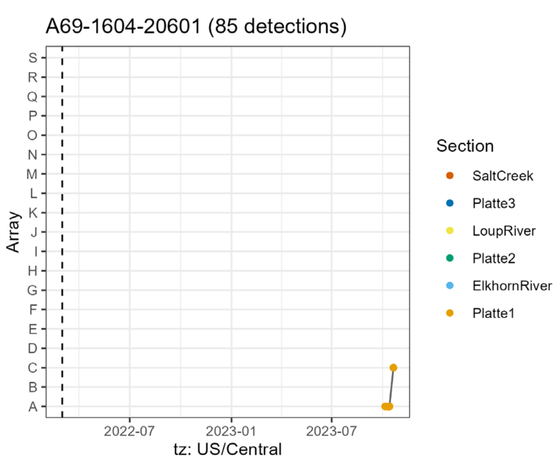

A69-1602-19542 (263 detections)
Array
2021-07
2022-01
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

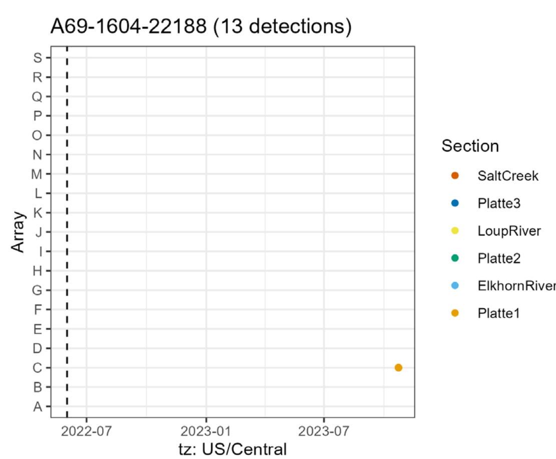

A69-1604-20593 (44 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-20594 (23 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

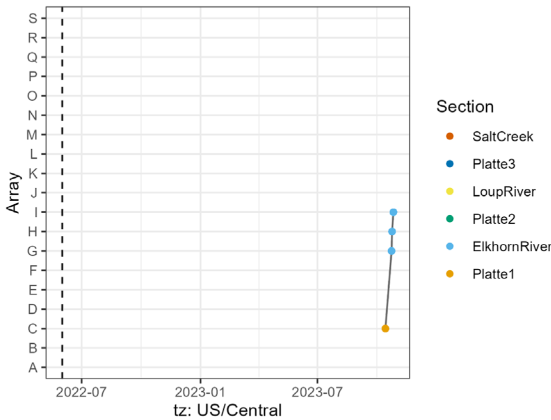

A69-1604-20595 (50 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-20596 (175 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

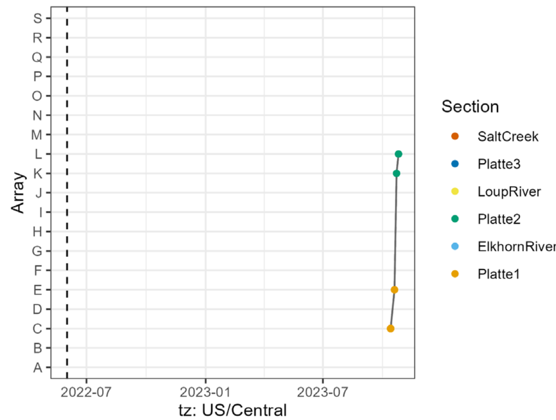

A69-1604-20601 (85 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-22188 (13 detections)
Array
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

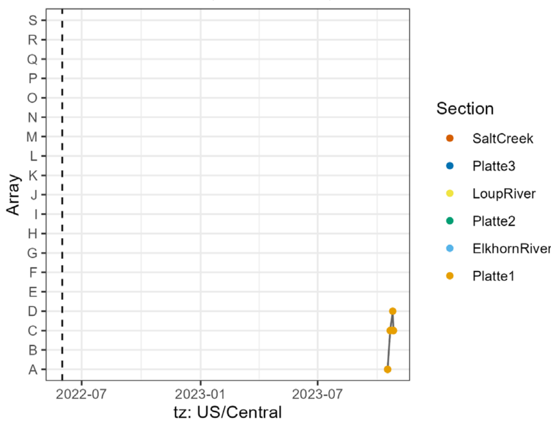
A69-1604-22190 (97 detections)



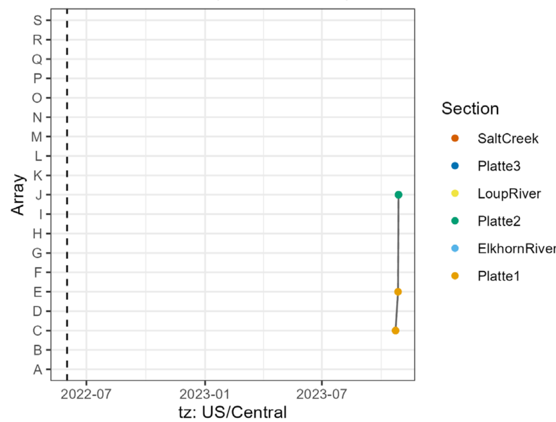
A69-1604-22191 (25 detections)



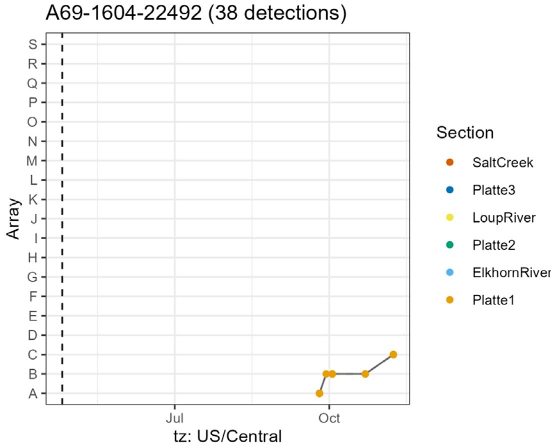
A69-1604-22192 (9 detections)



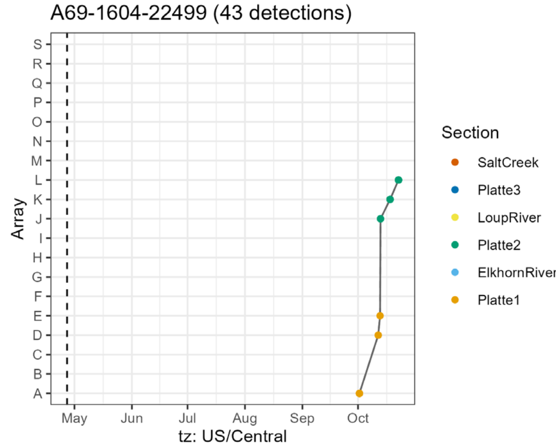
A69-1604-22194 (40 detections)



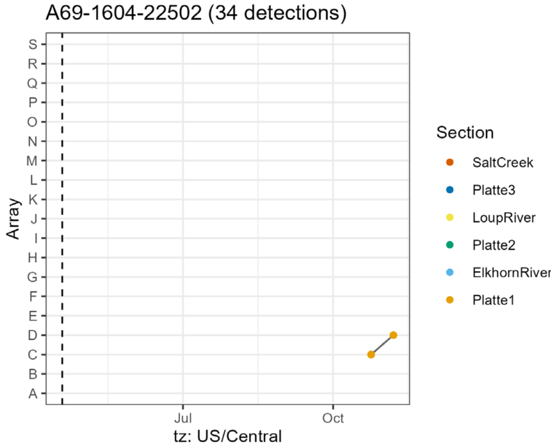
A69-1604-22492 (38 detections)



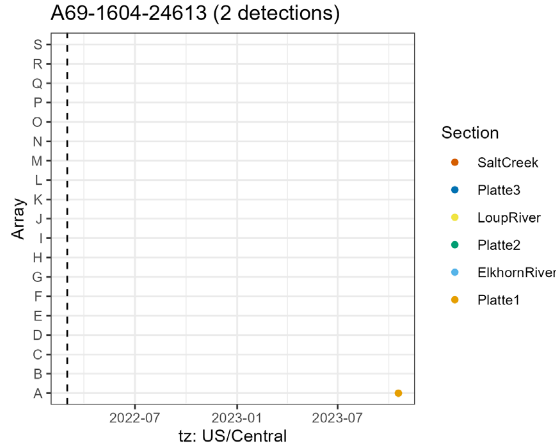
A69-1604-22499 (43 detections)

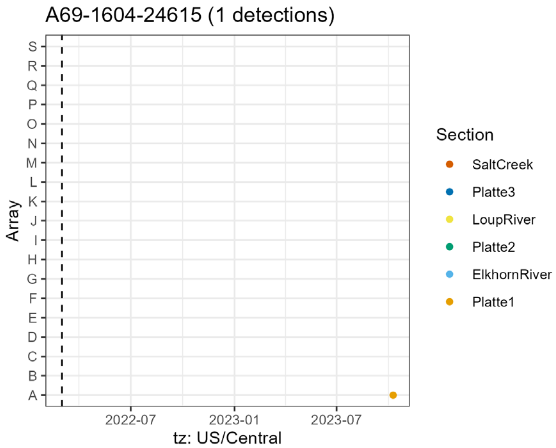


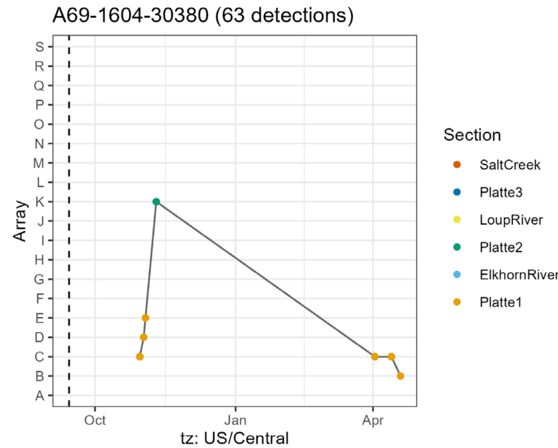
A69-1604-22502 (34 detections)

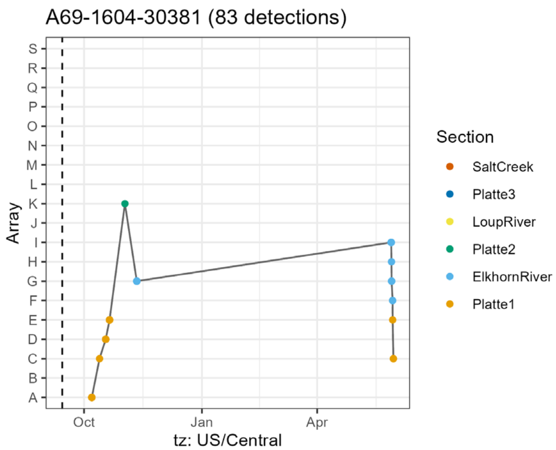


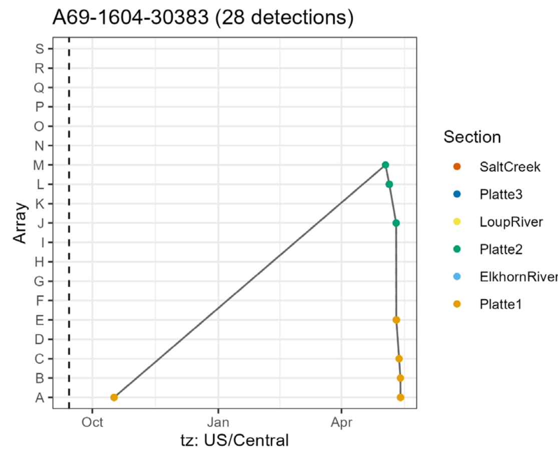
A69-1604-24613 (2 detections)

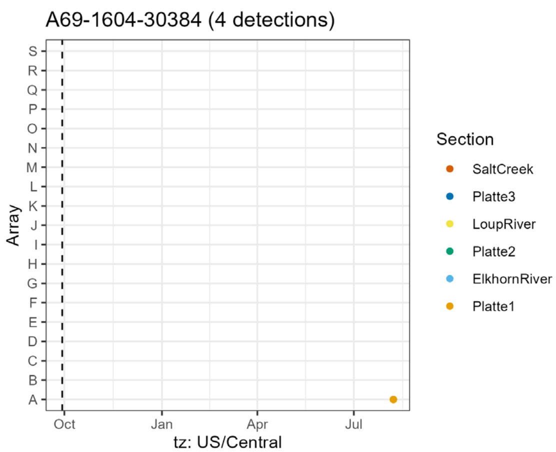


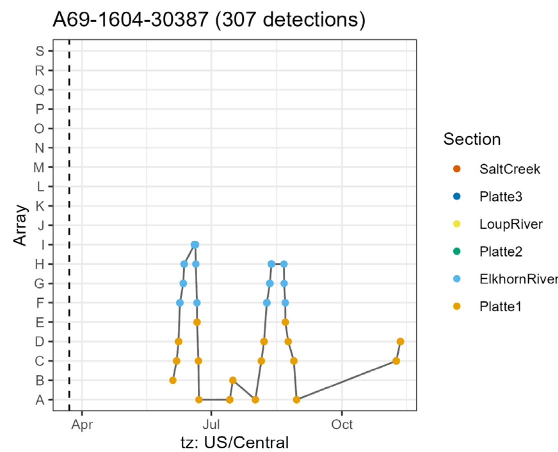

A69-1604-24615 (1 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2022-07 2023-01 2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

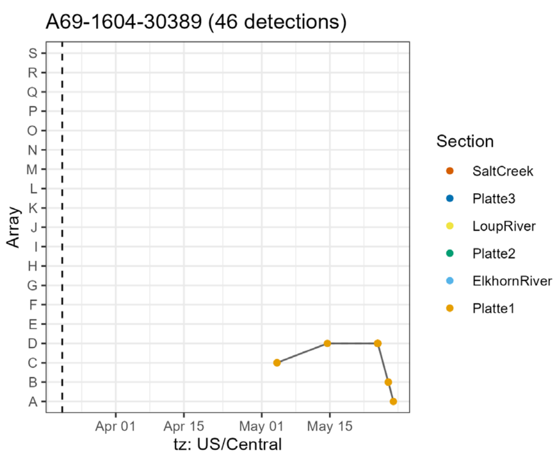

A69-1604-30380 (63 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct Jan Apr
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

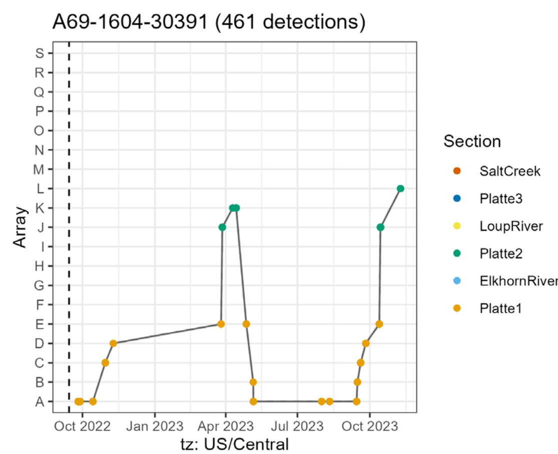

A69-1604-30381 (83 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct Jan Apr
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

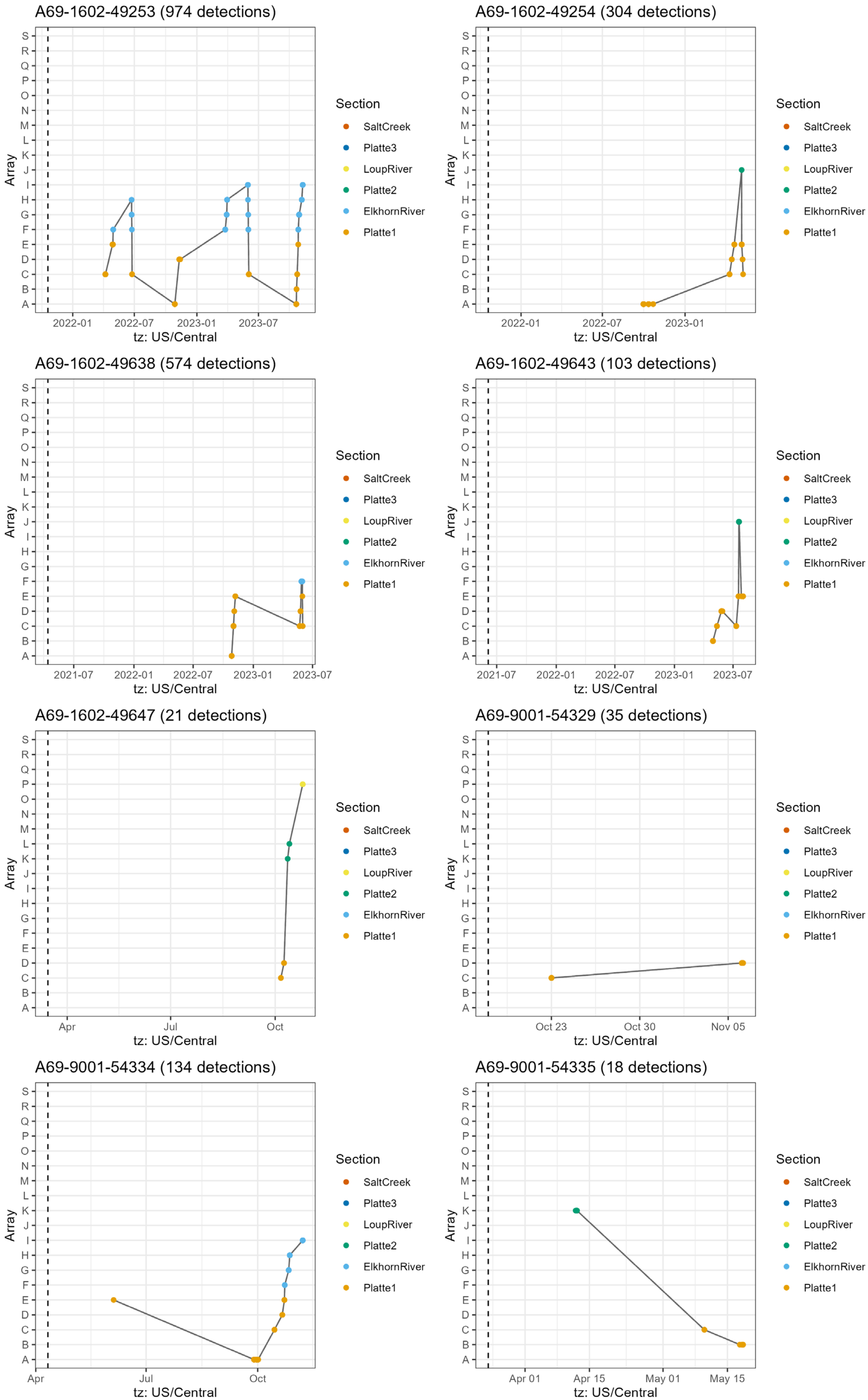

A69-1604-30383 (28 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct Jan Apr
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-30384 (4 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct Jan Apr Jul
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

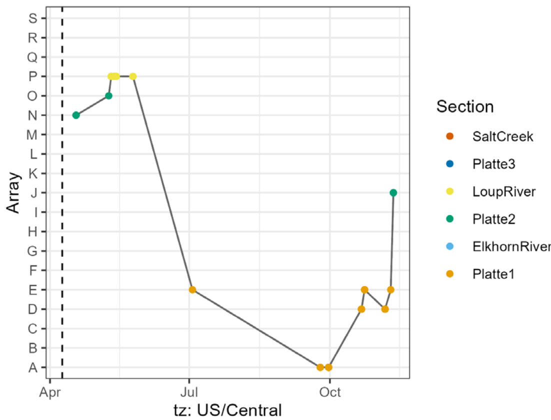

A69-1604-30387 (307 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr Jul Oct
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-30389 (46 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr 01 Apr 15 May 01 May 15
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

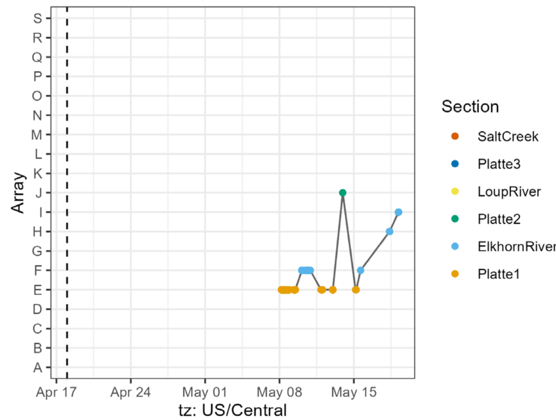

A69-1604-30391 (461 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct 2022 Jan 2023 Apr 2023 Jul 2023 Oct 2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-49253 (974 detections)
A69-1602-49254 (304 detections)
A69-1602-49638 (574 detections)
A69-1602-49643 (103 detections)
A69-1602-49647 (21 detections)
A69-9001-54329 (35 detections)
A69-9001-54334 (134 detections)
A69-9001-54335 (18 detections)
Array
S R Q P O N M L K J I H G F E D C B A
tz: US/Central
2021-07 2022-01 2022-07 2023-01 2023-07
Apr Jul Oct
Oct 23 Oct 30 Nov 05
Apr 01 Apr 15 May 01 May 15
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

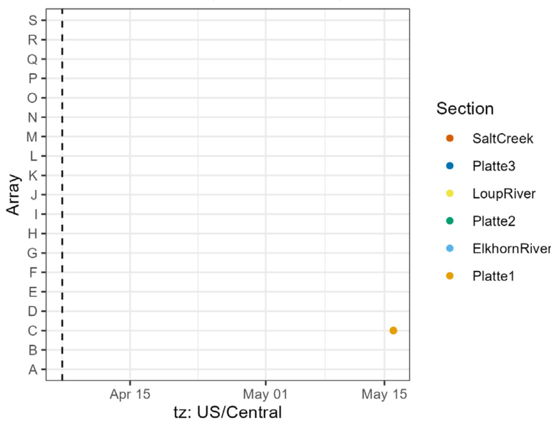
A69-9001-54336 (83 detections)



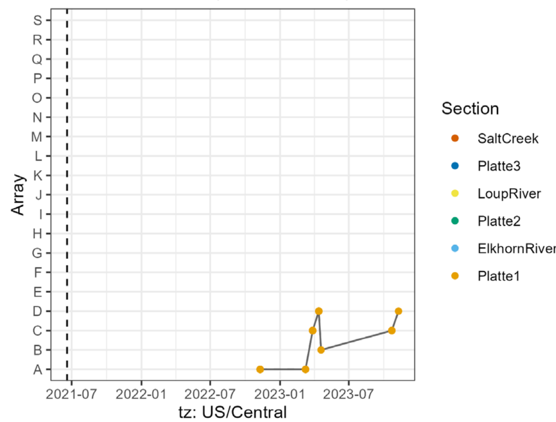
A69-9001-54337 (608 detections)



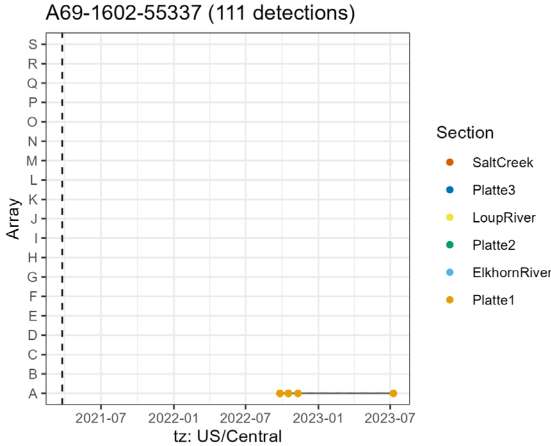
A69-1602-54445 (11 detections)



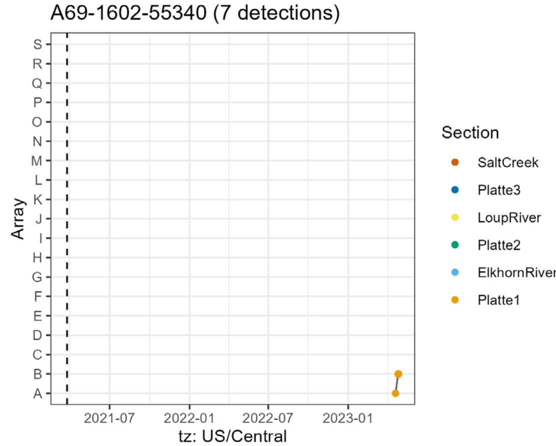
A69-1602-54451 (72 detections)



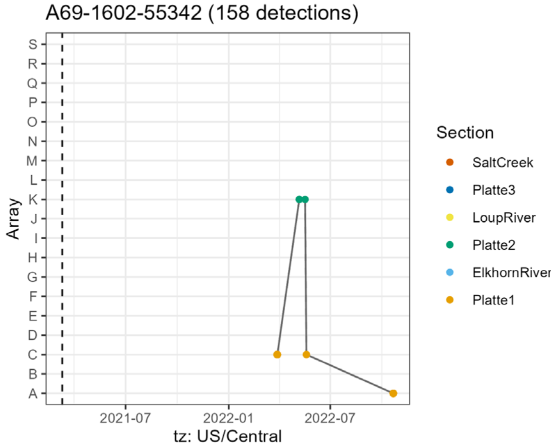
A69-1602-55337 (111 detections)



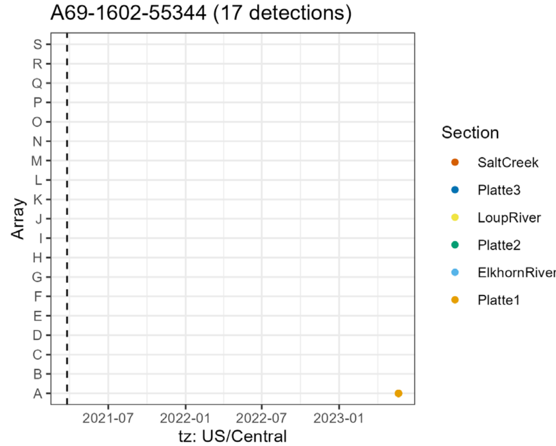
A69-1602-55340 (7 detections)



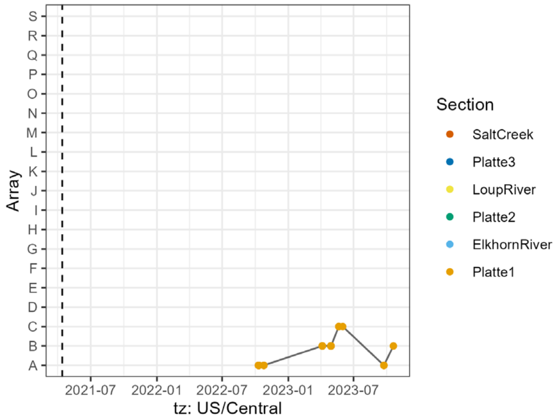
A69-1602-55342 (158 detections)



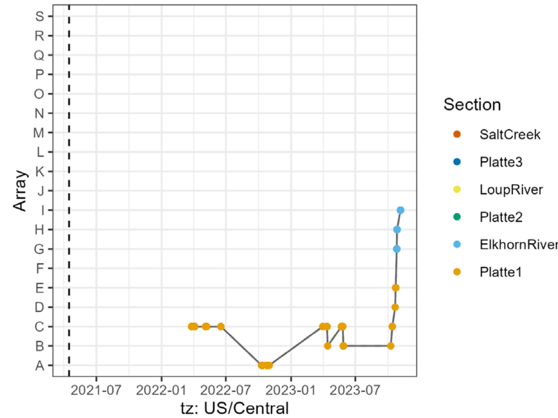
A69-1602-55344 (17 detections)



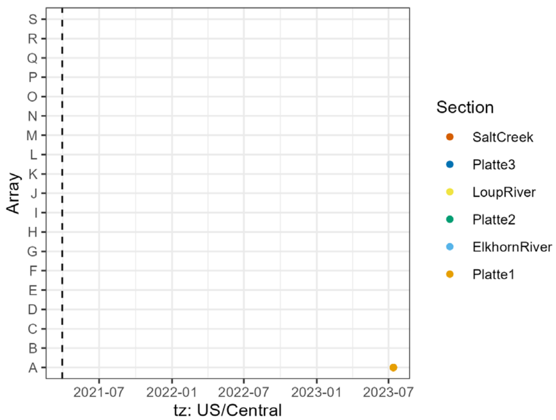
A69-1602-55347 (539 detections)



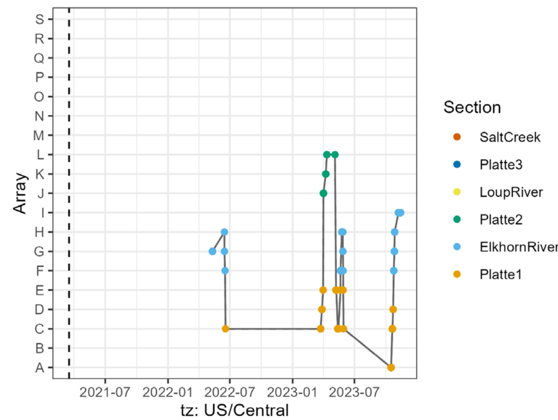
A69-1602-55355 (948 detections)



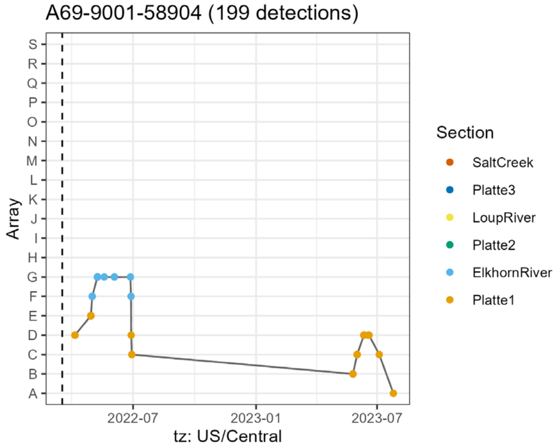
A69-1602-55356 (29 detections)



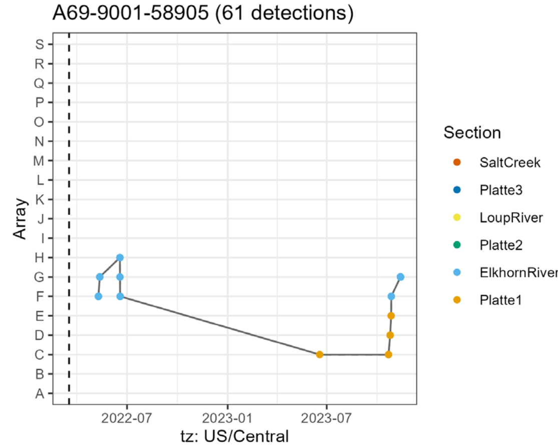
A69-1602-55362 (1066 detections)



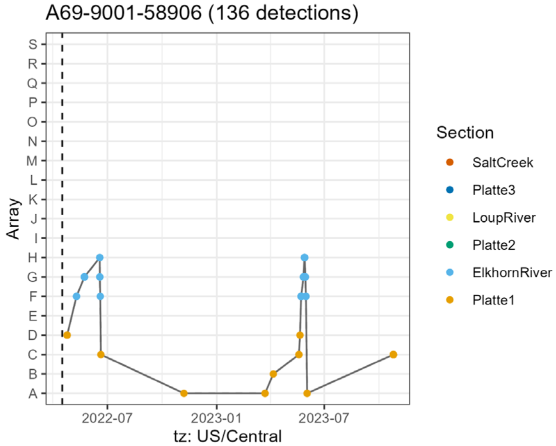
A69-9001-58904 (199 detections)



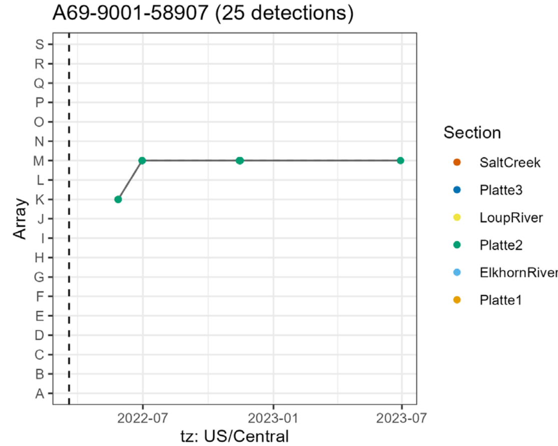
A69-9001-58905 (61 detections)

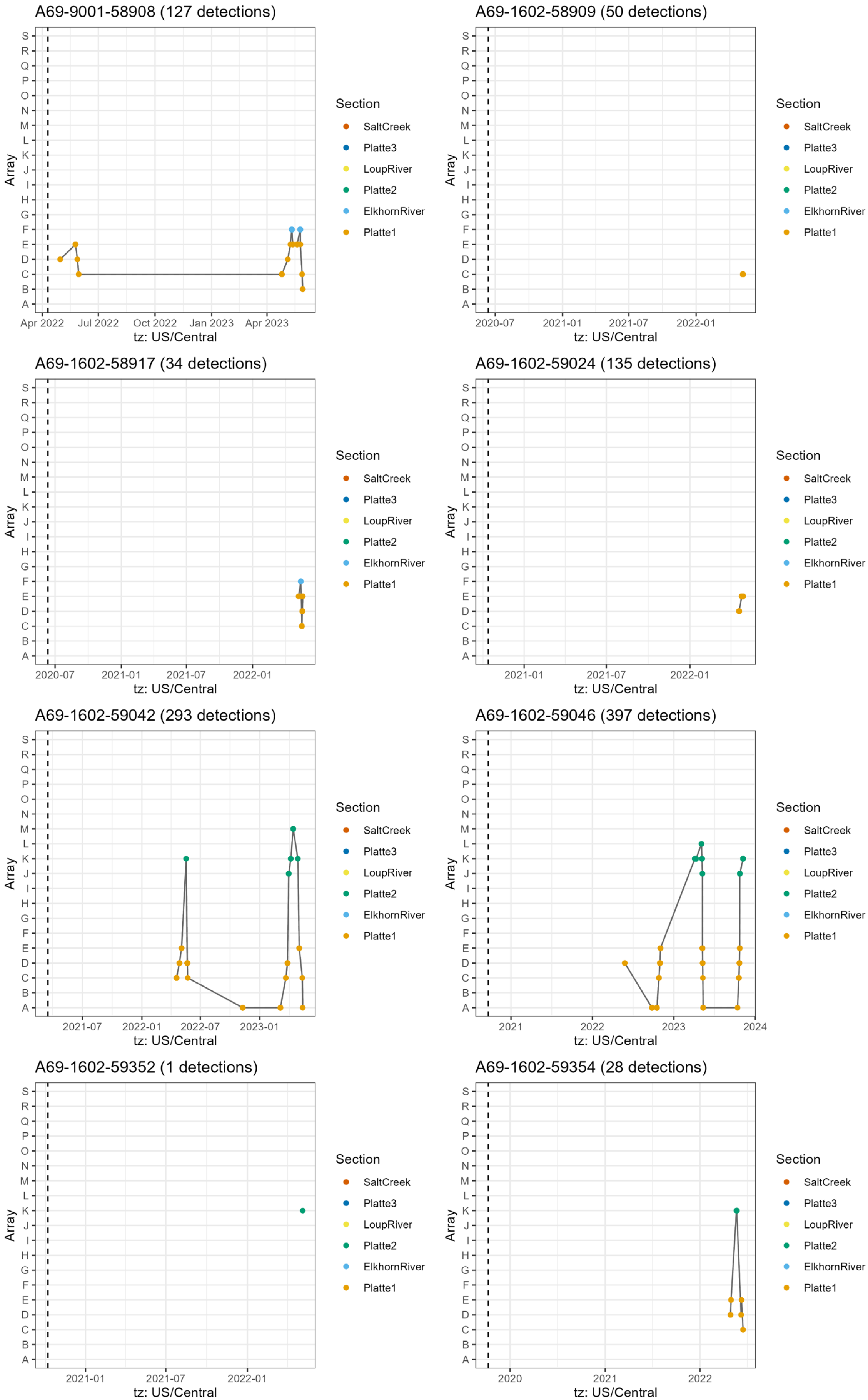


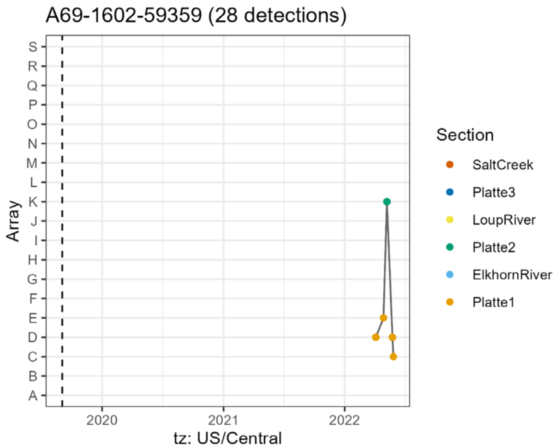
A69-9001-58906 (136 detections)

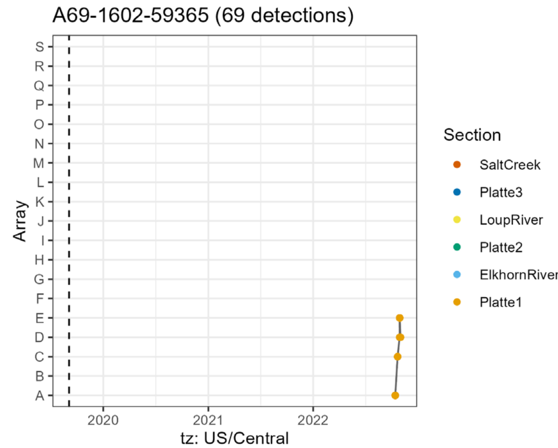


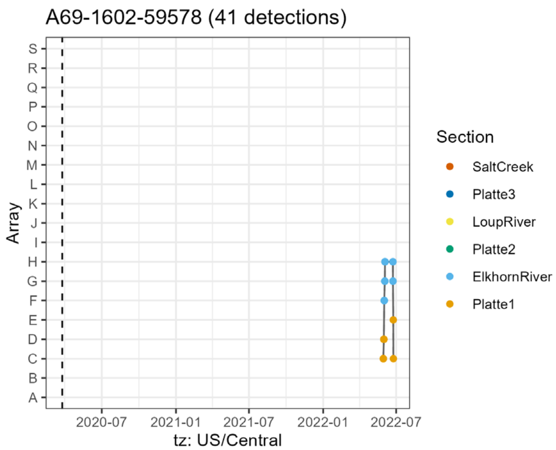
A69-9001-58907 (25 detections)

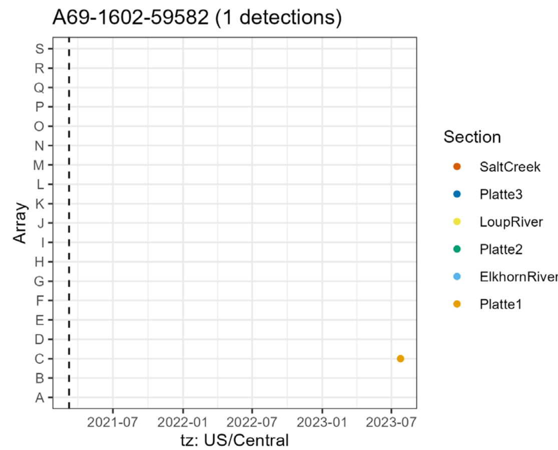


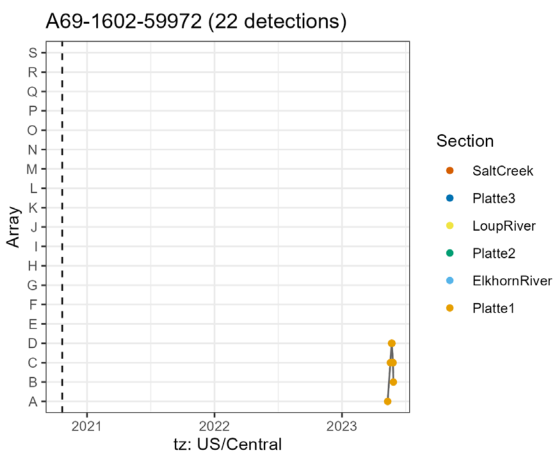

A69-9001-58908 (127 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr 2022 Jul 2022 Oct 2022 Jan 2023 Apr 2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1
A69-1602-58909 (50 detections)
2020-07 2021-01 2021-07 2022-01
tz: US/Central
A69-1602-58917 (34 detections)
2020-07 2021-01 2021-07 2022-01
tz: US/Central
A69-1602-59024 (135 detections)
2021-01 2021-07 2022-01
tz: US/Central
A69-1602-59042 (293 detections)
2021-07 2022-01 2022-07 2023-01
tz: US/Central
A69-1602-59046 (397 detections)
2021 2022 2023 2024
tz: US/Central
A69-1602-59352 (1 detections)
2021-01 2021-07 2022-01
tz: US/Central
A69-1602-59354 (28 detections)
2020 2021 2022
tz: US/Central

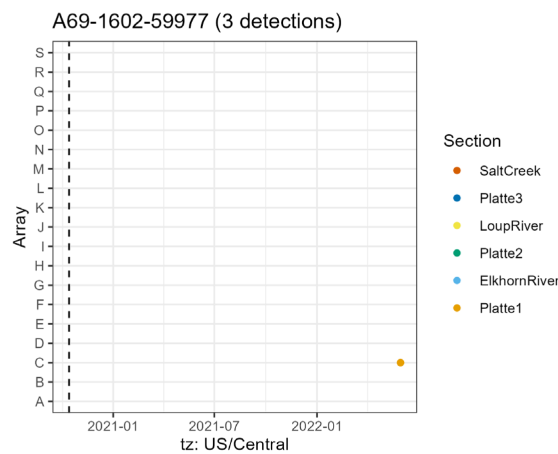

A69-1602-59359 (28 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2020
2021
2022
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

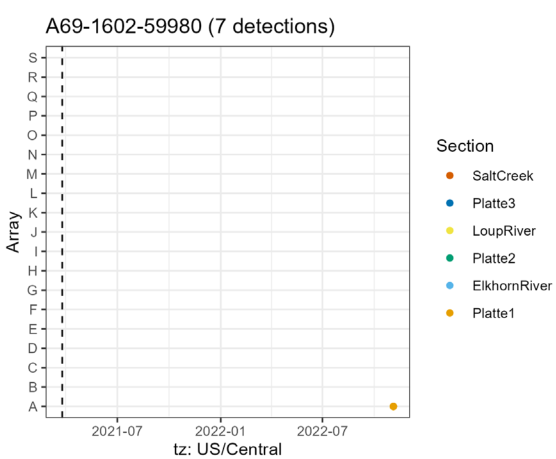

A69-1602-59365 (69 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2020
2021
2022
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-59578 (41 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2020-07
2021-01
2021-07
2022-01
2022-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-59582 (1 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2021-07
2022-01
2022-07
2023-01
2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-59972 (22 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2021
2022
2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-59977 (3 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2021-01
2021-07
2022-01
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-59980 (7 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2021-07
2022-01
2022-07
tz: US/Central
Section
SaltCreek
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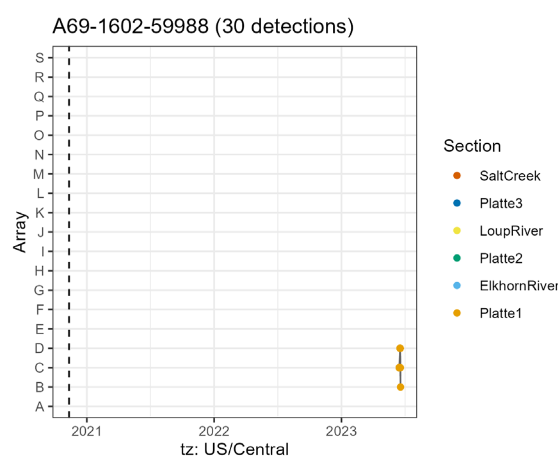
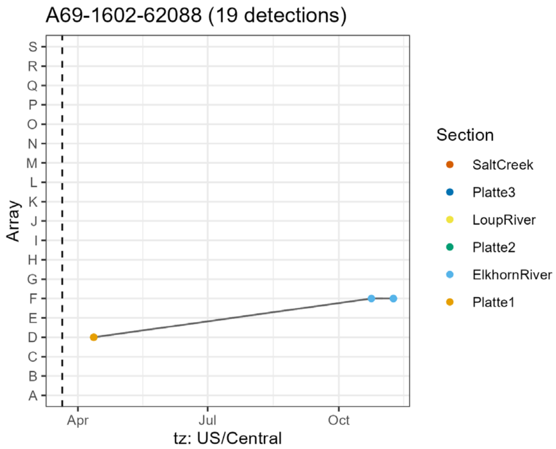
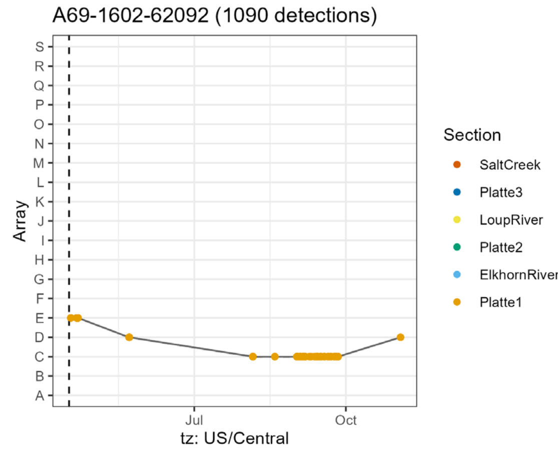
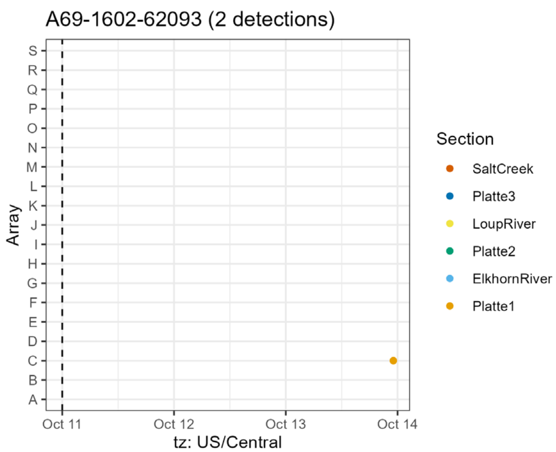
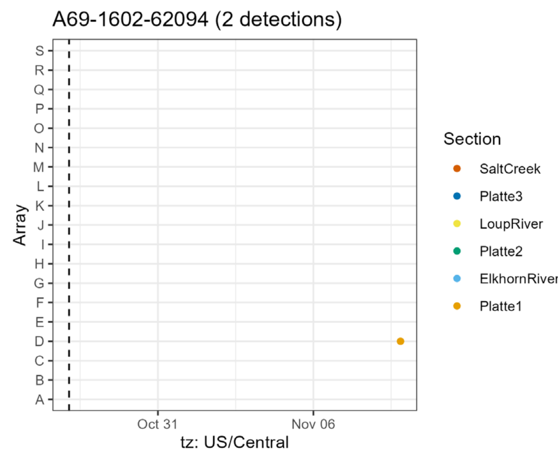
LoupRiver
Platte2
ElkhornRiver
Platte1

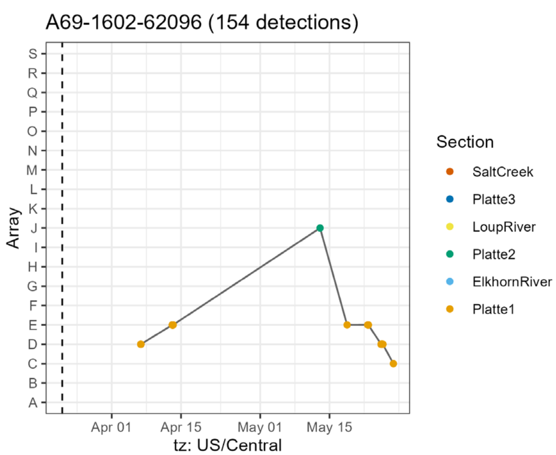

A69-1602-59988 (30 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2021
2022
2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

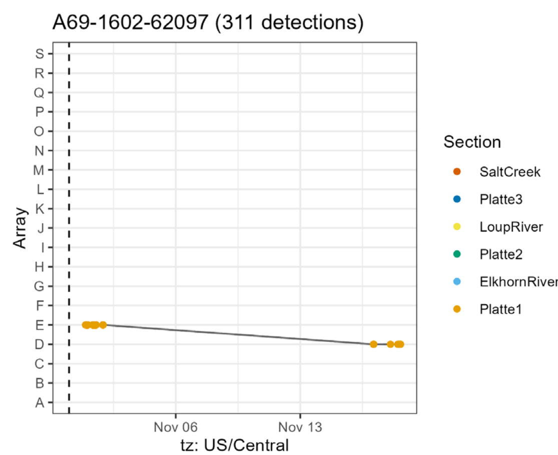

A69-1602-62088 (19 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr Jul Oct
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

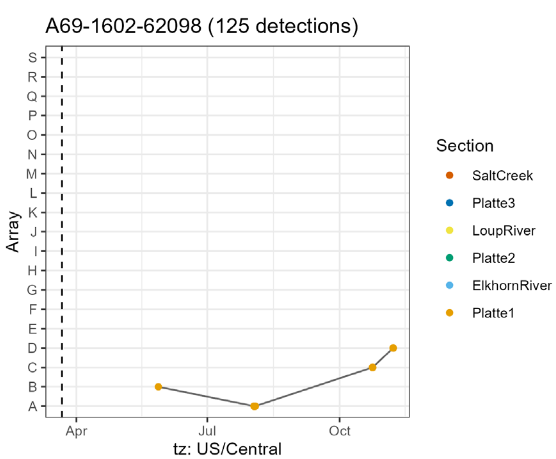

A69-1602-62092 (1090 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Jul Oct
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

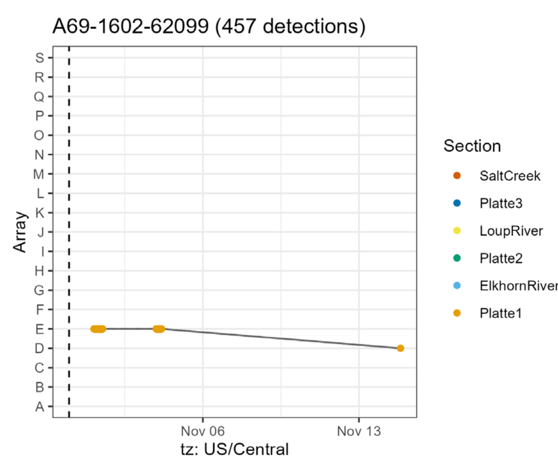

A69-1602-62093 (2 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct 11 Oct 12 Oct 13 Oct 14
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

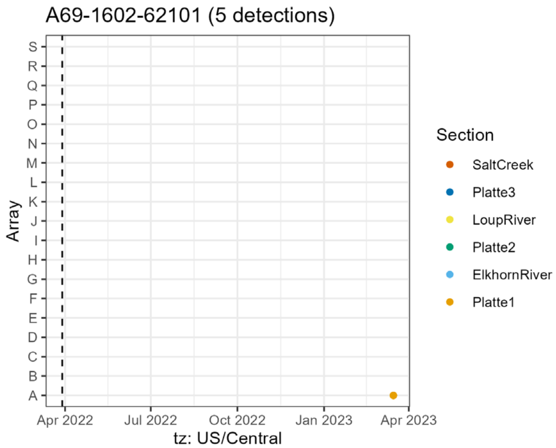

A69-1602-62094 (2 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct 31 Nov 06
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

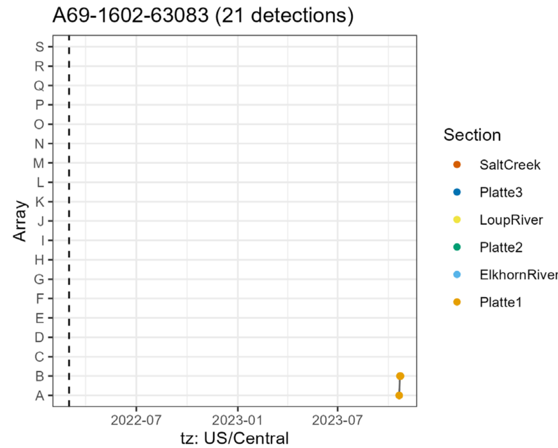

A69-1602-62096 (154 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr 01 Apr 15 May 01 May 15
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

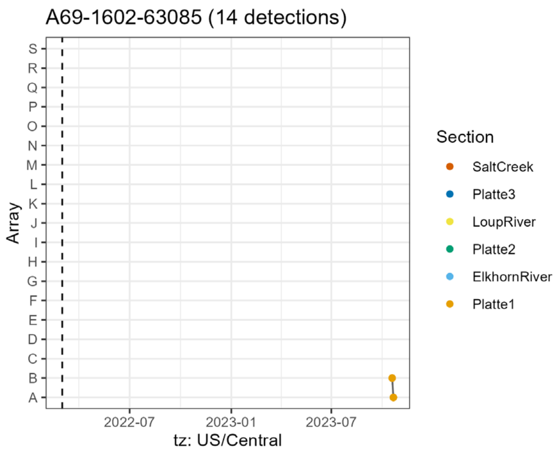

A69-1602-62097 (311 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Nov 06 Nov 13
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

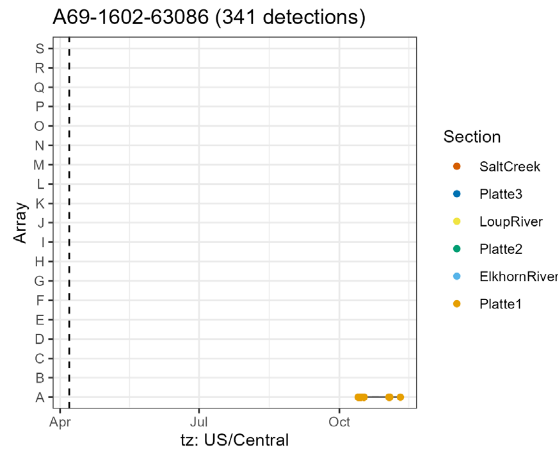

A69-1602-62098 (125 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr Jul Oct
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

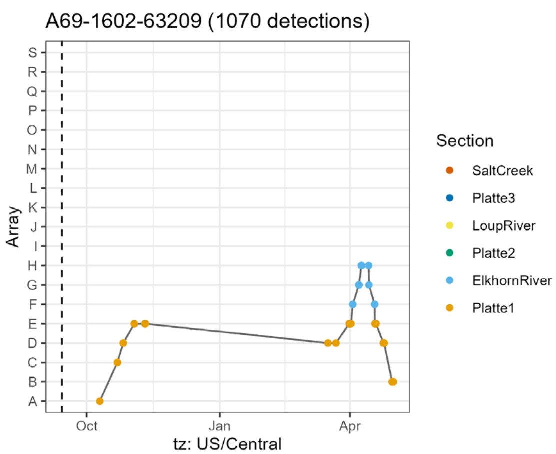

A69-1602-62099 (457 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Nov 06 Nov 13
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

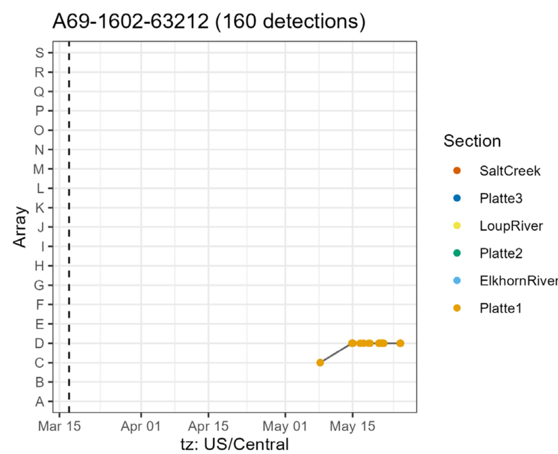

A69-1602-62101 (5 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr 2022 Jul 2022 Oct 2022 Jan 2023 Apr 2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

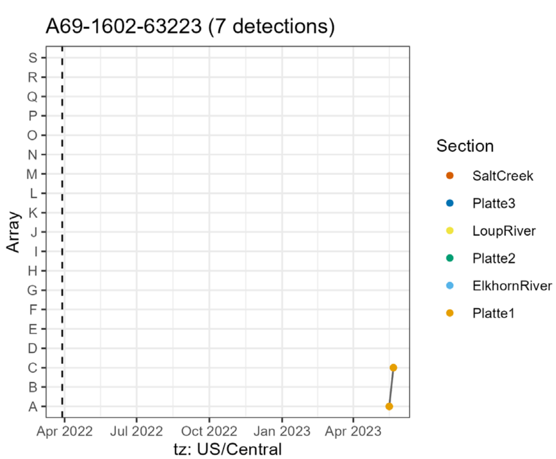

A69-1602-63083 (21 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2022-07 2023-01 2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1

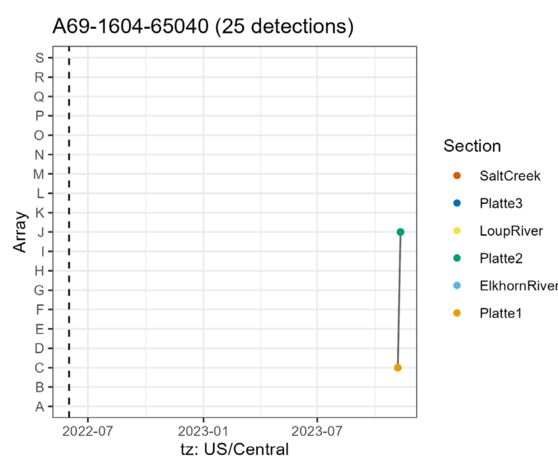

A69-1602-63085 (14 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2022-07 2023-01 2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-63086 (341 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr Jul Oct
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-63209 (1070 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Oct Jan Apr
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-63212 (160 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Mar 15 Apr 01 Apr 15 May 01 May 15
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1602-63223 (7 detections)
Array
S R Q P O N M L K J I H G F E D C B A
Apr 2022 Jul 2022 Oct 2022 Jan 2023 Apr 2023
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1


A69-1604-65040 (25 detections)
Array
S R Q P O N M L K J I H G F E D C B A
2022-07 2023-01 2023-07
tz: US/Central
Section
SaltCreek
Platte3
LoupRiver
Platte2
ElkhornRiver
Platte1