Study Objectives:

The Pallid Sturgeon Biology in the Platte River and its Tributaries project is intended to provide information pertaining to known knowledge gaps about environmental correlates of Pallid Sturgeon use, spawning habitat, and reproduction in the lower Platte River and its tributaries. The specific objectives are to:

1) Identify relations among environmental conditions (i.e., river discharge and temperature) with the timing and extent of Pallid Sturgeon movement into and within the lower Platte River and its tributaries,
2) Identify Pallid Sturgeon spawning habitat in the lower Platte River and its tributaries,
3) Verify successful spawning by Pallid Sturgeon in the Platte River and/or its tributaries, and
4) Provide Pallid Sturgeon genetic samples for further population and hybridization assessment (in collaboration with Southern Illinois University's parallel project).

The purpose of this document is to outline data needs for each of the above-listed objectives as well as provide an outline of considered statistical and non-statistical approaches to assess the obtained data*. Statistical analyses may change as more data are acquired and assumptions of different statistical tests are evaluated.

<u>*NOTE:</u> The information contained herein is not intended to be a compendium of all possible analyses or questions that may be addressed. Rather this document provides a guide for how the analyses are currently, and will be in the future, handled. A guiding reference for analyzing telemetry data is provided by Whoriskey et al. (2019) and references therein.

Data Sources and Analyses:

<u>Pallid Sturgeon Encounter Data Sources:</u> Data used to summarize and analyze movement (i.e., into, out of, and within the Platte River system) and potential spawning habitat use of Pallid Sturgeon in the Platte River system will come from two primary sources of acoustic telemetry: 1) a passive receiver array within the lower Platte River basin and 2) active (extensive and intensive) tracking within the lower Platte River and its largest two tributaries including the Loup River and Elkhorn River. The two primary sources of detecting Pallid Sturgeon will be used in isolation or combined depending on the question being addressed and the spatial and temporal resolution of predictor variables accessible. Common data types gathered for all tracking activities include date an individual was detected, time of day detected, and georeferenced location (GPS coordinates for active tracking or receiver location if detected on passive array).

Passive tracking (acoustic receiver network)
The passive receiver array within the lower Platte River basin currently includes 30+ InnovaSea VR2Tx receivers including locations within the Loup River and Elkhorn River. Date, time, and water temperature information are all recorded when a Pallid Sturgeon implanted with a transmitter is detected. Water temperature is also continuously recorded by each receiver at 15-minute intervals.

Active tracking

Extensive tracking occurs monthly from March to November and covers the entire lower Platte River from the confluence of the Loup River to the Missouri River including the lower Elkhorn River (Arlington, NE to confluence), and lower Loup River (Columbus, NE to confluence). Extensive tracking efforts are typically completed within one week of initiation.

Intensive tracking includes daily—to the extent possible—relocations of reproductively ready Pallid Sturgeon during the spawning season (when water temperatures are between 15 C and 24 C). Reproductively ready Pallid Sturgeon are identified either through *in situ* collections (trot lining by UNL crews) within the lower Platte River or through detection within the passive receiver array (the last known reproductive assessment by Missouri River Pallid Sturgeon Assessment crews are used to determine reproductive status). Attempts to locate and follow reproductively ready Pallid Sturgeon generally occur daily during the spawning season to assess behaviors that will hopefully lead to identification of spawning sites if spawning occurs.

Habitat use for relocated, reproductively ready Pallid Sturgeon has been and will continue to be assessed at multiple spatial scales. Micro-scale habitat variables used to describe habitat at the location of capture include water velocity (Hach water velocity meter), water depth (depth stick or sonar), water temperature (YSI meter), and turbidity (YSI meter). Mesoscale habitat variables used to describe the area surrounding the location of capture include primary-channel, secondary-channel, or braided. Sandbar complexes were also categorized as dry, partial, overflowing, or braided. Macroscale habitat measures will include the river reach where detection occurred (see Question 2 below). These data are consistent with previous habitat measures from the Platte River (Peters and Parham 2008; Hammen et al. 2018; Hamel and Pegg 2019; HDR 2009). We will use the nearest USGS hydrologic stream gage to assess river discharge where reproductively ready Pallid Sturgeon were located. Additional, date-specific habitat measures are collected from other sources (e.g., USGS, NWS, USFWS, USCOE, etc.) and will be used to explore correlates of fish movement patterns using the analysis framework in Figure 1.

Objective 1

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

Question 1. What river conditions (e.g., water temperature, river discharge, turbidity), season, and fish characteristics (reproductive, non-reproductive, stocking origin) are related to movement by Pallid Sturgeon into and out of the Platte River basin?

Experimental Units: The experimental unit will be a set time interval. Initially, we will set the time interval at one day. The time interval can be further reduced or expanded depending on the level of variation in river discharge or water temperatures (substantial sub-daily hydropeaking) as well as the intensity of movements by Pallid Sturgeon. The Innovasea receivers record the exact date and time an individual is detected which provides great flexibility in setting time intervals for assessments. For instance, time intervals could be expanded to incorporate greater than a week and could include season (based on calendar dates). An alternative approach may be using individual fish as the experimental unit and developing encounter histories of individual fish for use in a mark-recapture analysis.

Response Variables: The response variable will be the count of individual Pallid Sturgeon detected at the lowermost receivers upstream of the mouth of the Platte River during the predetermined time interval (Table 1). Detection data for this question will come from only passive receivers located at the Platte River confluence. Based on the previous detections of individual Pallid Sturgeon, we will know the direction of movement as either upstream or downstream. For instance, we will know from monthly extensive tracking and receiver downloads when and where individual Pallid Sturgeon were in the Platte River. We will also know what Pallid Sturgeon were in the Missouri River by referencing the Missouri River Pallid Sturgeon Tag Catalogue in coordination with Nebraska Game and Parks Commission and other state and federal partners. If individual fish are used as the experimental unit, the response variable will be a detection of an individual fish and we will assign each fish to a geographic state being either the Platte River or the Missouri River. In the case of multiple detections at a receiver in a day, detection data will be condensed based on a 24-hour period.

Predictor Variables: The predictor variables will include means and measures of variation of river discharge, water temperature, and turbidity in the lower Platte River and the differences in water temperature and river discharge between the lower Platte River and the Missouri River within a defined period of interest (e.g., daily, weekly, monthly, seasonally). River discharge and water temperature data may also be summarized using a lagging period prior to detection of a Pallid Sturgeon entering or exiting the Platte River (e.g., 7-day mean river discharge). An additional variable accounting for season (categorical) or day of year will also be considered. The source of temperature and discharge data for the lower Platte River will be the USGS gaging station at Louisville, NE (Gage ID: 06805500) that will provide sub-daily (e.g., every 15 minutes) discharge, temperature, and turbidity conditions for areas below the Elkhorn River and Salt Creek confluences to give a sense of conditions as individuals move into or out of the Platte River. Few tributaries enter the Platte River below Salt Creek and, as such, the conditions at Louisville, NE are appropriate for assessing the hydrologic conditions and temperature of that river reach. The source of discharge data for the Missouri River near the Platte River confluence will be the USGS gaging station at Nebraska City (Gage ID: 06807000). There are no active temperature gages on the Missouri River near the Platte River confluence (above or below). However, we will request temperature data from USGS cooperators maintaining passive receivers (that record temperature data) on the Missouri River near the Platte River confluence. Specific components of the flow regime including measures of magnitude, duration, timing, rate of change, and frequency of flows will be explored as potential predictor variables (Richter et al. 1996; Olden and Poff 2003). Measures of variation (e.g., daily coefficient of variation) and extreme values (e.g., maximums and minimums) like those used in the Index of Hydrologic Alteration (IHA; Table 2) for both river discharge and water temperature will be a focus given prior research has suggested variation in river conditions is an important driver of Pallid Sturgeon occurrence in the Platte River. Each hydrologic and temperature variable can be scaled similarly as the response variable (daily, weekly, monthly, seasonally). Development of statistics for river discharge, temperature, and turbidity will follow Olden and Poff (2003) and Spurgeon et al. (2016). Additional variables may include year, day of year, season, reproductive status of individuals, sex and age of fish, and origin of fish (hatchery or wild). See <u>*Potential Analysis*</u> section for how predictor variables will be incorporated into models.

<u>Hypotheses (models to assess given data)</u>:

Null: No association exists between Pallid Sturgeon movement into or from the Platte River and river conditions (discharge, water temperature, or turbidity), season, or fish characteristics (reproduction, origin). (Testable Hypothesis #1)

Factors associated with <u>entrance</u> into lower Platte River:

1) River conditions:
    a. Temperature:
        i. Pallid Sturgeon are more likely to enter the lower Platte River from the Missouri River as temperatures in the lower Platte River are within suitable spawning temperature of approximately 16 degrees C to 24 degrees C. (Testable hypothesis #2)
        ii. Pallid Sturgeon are more likely to enter the lower Platte River from the Missouri River when temperatures in the lower Platte River are greater than they are in the Missouri River up to thermal tolerance levels (> 30 degrees C). (Testable hypothesis #3)
        iii. Pallid Sturgeon will be less likely to enter the lower Platte River when water temperatures in the lower Platte River are greater than 30 degrees C. (Testable hypothesis #4)
    b. Discharge:
        i. Pallid Sturgeon are more likely to enter the lower Platte River when mean daily discharge in the lower Platte River is in the upper 75% of mean annual flow. (Testable hypothesis #5)
        ii. Pallid Sturgeon are more likely to enter the lower Platte River when the coefficient of variation in daily discharge is in the lower 25% of annual coefficent of variation in river discharge. (Testable hypothesis #6)
        iii. Pallid Sturgeon are more likely to enter the lower Platte River when the mean 30-, 60-, or 90-day river discharge is in the upper 75% of long-term river discharge in the lower Platte River. (Testable hypothesis #7)

c. Turbidity:
    i. Pallid Sturgeon are more likely to enter the lower Platte River when turbidity in the lower Platte River greater than the annual mean turbidity levels in the lower Platte River. (Testable hypothesis #8)

2) Seasonality:
    a. Spring
        i. Pallid Sturgeon movement into the Platte River will occur early in the year during late winter/early spring regardless of discharge or temperature. (Testable hypothesis #9)
    b. Summer
        i. Pallid Sturgeon movement into the Platte River during summer will be minimal when compared to spring and fall movements. (Testable hypothesis #10)
    c. Fall
        i. Pallid Sturgeon movement into the Platte River will occur late in the year during late fall/early winter regardless of discharge or temperature. (Testable hypothesis #11)
    d. Spring and Fall
        i. Pallid Sturgeon movement into the Platte River will occur at two separate pulses with one occurring early in the year and the other occurring during late fall. (Testable hypothesis #12)

3) Fish characteristics:
    a. Reproductively mature individuals
        i. Reproductively ready Pallid Sturgeon will move into the Platte River immediately before or during the spawning season. (Testable hypothesis #13)
    b. Non-reproductive individuals
        i. Non-reproductive individuals will enter the Platte River at a consistent rate throughout the year. (Testable hypothesis #14)
    c. Source of individuals
        i. Pallid Sturgeon stocked closer to the Platte River and/or from brood stock collected near the Platte River will have a greater probability of movement into the Platte River compared to those stocked further from the Platte River and those from brood stock not associated with prior use of the Platte River. (Testable hypothesis #15)

Interactions among river conditions, seasonality, and fish characteristics may also occur and may be included in model structures and represent more realistic testable hypotheses than single variable models. For instance, a model with all three variable types including river condition (e.g., a variable describing the flow regime and/or temperature regime), seasonality (e.g., day of year), and reproductive status (e.g., non-reproductive Pallid Sturgeon) may possess a greater amount of support (delta AICc or model weight) in a candidate model set compared to river condition alone. If over-dispersion is prevalent then alternatives to AICc may be considered (e.g., QAIC).

Factors associated with <u>exit</u> out of the Lower Platte River:

1) River conditions:
    a) Temperature:

i) Pallid Sturgeon will exit the Platte River basin as water temperatures warm above 30 degrees C. (Testable hypothesis #1)

b) Discharge:

i) Pallid Sturgeon will exit the Platte River basin as mean daily river discharge falls below the 25% annual river discharge. (Testable hypothesis #2)

c) Turbidity:

i) Pallid Sturgeon will exit the Platte River basin as mean turbidity falls below the 25% annual river turbidity. (Testable hypothesis #3)

2) Seasonality:

a) Summer

i) Pallid Sturgeon movement out the Platte River will occur during summer following reproduction season. (Testable hypothesis #4)

b) Winter

i) Pallid Sturgeon movement out of the Platte River will occur during late fall/early winter. (Testable hypothesis #5)

3) Fish characteristics:

a) Reproductively mature Individuals

i) Reproductively ready Pallid Sturgeon will leave the Platte River immediately following the reproductive season. (Testable hypothesis #6)

b) Non-reproductive individuals

i) Non-reproductive individuals will leave the Platte River at a consistent rate throughout the year. (Testable hypothesis #7)

Interactions among river conditions, seasonality, and fish traits may also occur and may be included in model structures and represent more realistic testable hypotheses than single variable models. For instance, a model with all three variable types including river condition (e.g., a variable describing the flow regime and/or temperature regime), seasonality (e.g., day of year), and reproductive status (e.g., non-reproductive Pallid Sturgeon) may possess a greater amount of support (delta AICc or model weight) in a candidate model set compared to river condition alone. If over-dispersion is prevalent then alternatives to AICc may be considered (e.g., QAIC).

Potential Analyses: We anticipate counts of Pallid Sturgeon movement into and out of the Platte River will be greatly skewed and exhibit numerous zeros. For instance, we anticipate fluxes of individuals into the Platte River will occur early in the year as water temperatures reach levels associated with spawning. Further, we anticipate fluxes of individuals out of the Platte River during summer as water temperatures reach levels associated thermal tolerance limits (i.e., mortality). However, days of zero entry and exit will occur. Given the anticipated number of zero counts, generalized modelling approaches to account for non-normality and excessive zeros will likely be considered (see Whoriskey et al. 2019). As such, we may employ generalized linear models using a Poisson distribution or a zero-inflated negative binomial model to model counts of Pallid Sturgeon entering or exiting the Platte River based on the aforementioned predictor variables. We also anticipate the predictor variables will be highly correlated. For instance, mean water temperature and mean discharge will likely be correlated and would not be considered together in a single model. However, mean water temperature and the coefficient of variation in sub-daily discharge may not be correlated and could be considered together in a single model. Fish characteristics including reproductive status and source location are individual-level covariates and difficult to use with raw count data. We may subdivide the data into counts of different groups (e.g., reproductive or non-reproductive individuals) and assess the two stages separately. Alternatively, we may include a categorical dummy variable where characteristics of the group moving into or out of the system are labelled as—for example— reproductive, non-reproductive, or both reproductive and non-reproductive. An information theoretic approach will be used initially where competing models will be assessed (e.g., AICc). Alternative approaches may include forms of variable selection procedures (backward or forward variable selection) or potential boosted regression tree approaches. If individual fish are used as the experimental unit, the encounter histories will be used in a multi-state mark-recapture framework to assess the probability of movement into or out of the Platte River. Such mark-recapture models are extremely data intensive and linking the probability of transitioning from the Missouri River to the Platte River (or vice-versa) with individual covariates or environmental covariates may be limited.

Question 2. What river conditions (water temperature, river discharge, turbidity), spatial arrangement of reaches, season, and fish characteristics (reproductive, non-reproductive, stocking origin) are related to movement by Pallid Sturgeon and subsequent connectivity within and among lower Platte River reaches and tributaries?

Experimental Units: Individual Pallid Sturgeon.

Response Variables: There will be a hierarchical structure used to assess movements within the Platte River basin that will capitalize on integrating multiple data sources including extensive and intensive tracking as well as the passive receiver network similar to Moore et al. (2021). The Platte River basin will be subdivided into reaches that will include 1) the Platte River above the Loup River confluence, 2) the Loup River, 3) the Platte River between the Loup River confluence and the Elkhorn River confluence, 3) the Elkhorn River, and 4) the Platte River below the Elkhorn River confluence. Each reach contains multiple passive receivers which will be used to infer presence of a Pallid Sturgeon within a reach. Passive receiver arrays provide sub-daily scale detection data and can assess potential movements between reaches if such movements occur within days. Response variables will include Pallid Sturgeon detections, the direction and magnitude of movement of individual Pallid Sturgeon (determined from previous detection locations), and maximum upstream river kilometer occupied. The initial focus will be to assess movement probabilities among reaches (Inter-reach connectivity). Movement information from intensive (daily), extensive (monthly), and passive (acoustic receivers) tracking will be used. Given constraints that daily encounters may not occur as a result of non-perfect detection or limited movement among reaches, scaling of time periods may be necessary (e.g., use of weekly or monthly movements in place of daily). Such scaling of the response variable will automatically necessitate a change in the temporal scale of predictor variables used to assess correlation with inter-reach connectivity. Additional response variables will include the number of detections between successive river reaches as well as the number of detections at individual receivers within the Platte River basin.

Predictor Variables: Potential predictor variables include reproductive status of individual Pallid Sturgeon, origin (i.e., hatchery-origin versus wild-origin), day-of-year, and the suite of variables characterizing the flow regime, temperature regime, and turbidity of the Platte River reach or tributary where movement was detected. The source of temperature and discharge data will be the USGS gaging stations located throughout the lower Platte River and the lower extents of major tributaries. Specific gages will include 06793000 (Loup River near Genoa, NE), 06800500 (Elkhorn River near Waterloo, NE), 06794700 (Platte River near Schuyler, NE), 06796000 (Platte River near North Bend, NE), 06796500 (Platte River near Leshara, NE), 06801000 (Platte River near Ashland, NE), and 06805500 (Platte River near Louisville, NE). Few tributaries enter the Platte River between these gaging stations and the information gleaned at each gage will be appropriate for assessing the hydrologic conditions and temperature of that river reach. Reproductive season will be delineated based on water temperature where spawning season will include the period in late winter and early spring when water temperatures are between 14 and 24 C. If water temperature is not available from USGS gages, we will use the temperature data from individual receivers within each river reach.

Hypotheses:

Hypotheses associated with inter-reach connectivity

1) River Conditions
    a) River discharge
        i) Transition probabilities from downriver to upriver reaches will be greater during or immediately following periods of elevated discharges. (Testable hypothesis #1)
    b) Water temperature
        i) Transition probabilities from downriver to upriver reaches will be greater during periods when water temperature is within spawning range. (Testable hypothesis #2)
2) Spatial arrangement of reaches
    a) Distance between reaches
        i) Transition probabilities between the Platte River below the Elkhorn River and the Elkhorn River will be greater than transition probabilities between the Platte River below the Elkhorn River and reaches above the confluence with the Ekhorn River. (Testable hypothesis #3)
3) Fish Characteristics
    a) Reproductive state
        i) Transition probabilities among reaches will be greater for reproductively-ready Pallid Sturgeon compared to non-reproductively ready Pallid Sturgeon. (Testable hypothesis #4)

Hypotheses associated with space use and residency

1) Fish Characteristics
    a) Reproductive state
        i) Pallid Sturgeon will exhibit three unique movement patterns including a migratory pattern, a sedentary pattern, and a roaming pattern that will be dependent on reproductive status and/or season. (Testable hypotheses #1)

Potential Analyses: A multistate movement model may be used to quantify the probability of movement among river reaches (Inter-reach connectivity). Multistate models will be constructed using Program

MARK or the RMark package in Program R. We also may use a mix of analytical approaches that include Generalized Linear Models, Generalized Linear Mixed Models, and Generalized Additive Models to test for differences in movement related to the suite of predictor variables. For instance, a generalized linear mixed model may be used to assess differences in total documented distance moved (or additional response variables such as transition from downstream to upstream reaches) where individual Pallid Sturgeon would be considered a random effect and sex and reproductive status would be considered fixed effects. Further analyses may include multi-distance spatial clustering where we will evaluate aggregation and dispersion relative to time and environmental variables in a similar fashion as Holmquist et al. (2019). Kernel distance sampling may be used to evaluate space use between sexes and reproductive classes. Space use assessments may be expanded depending on data availability from outside the Platte River basin. Network analysis may be used to assess connectivity among river reaches where the number of times individuals are detected at different receiver locations or river reaches could be used to evaluate movement propensity within the river network. Any inference to origin will be dependent on the number of wild fish tagged in the Platte River system. See Figure 1 for a decision tool to help support decisions regarding statistical approaches to analyze movement data obtained through telemetry studies.

Objective 2

<u>Objective 2.</u> Identify Pallid Sturgeon spawning habitat in the lower Platte River and its tributaries.

<u>Question 1.</u> What physical and chemical variables at relocation points are associated with reproductively-ready Pallid Sturgeon use in the lower Platte River basin including tributaries?

<u>Experimental Units:</u> Individual reproductively ready male and female Pallid Sturgeon.

<u>Response Variables:</u> Repeated presence points from reproductively ready female and male Pallid Sturgeon obtained from intensive and extensive tracking efforts.

<u>Predictor Variables:</u> Predictor variables will include individual-level covariates including sex and age (if known) as well as reach-specific assessments of the full range of discharge, temperature, turbidity, depth and velocity at an approximately 1Km river reach scale. Characterization of depth and velocity will follow closely those methods used in the Missouri River from Acoustic Doppler Current Profiler (ADCP) and side-scan technology (Elliot et al. 2020). The synthesis of ADCP data will enable estimation of meso-habitat availability within the river reach as well as channel complexity that can be used to assess use and availability of habitats. A measure of distance to nearest sandbar complex will also be assessed. The development of a 2-D hydraulic model (pending completion by EDO) may enhance the type and breadth of predictor variables available for analyses including providing estimates of sheer stress near relocation points as well as an assessment of the dynamic nature of areas where Pallid Sturgeon reside and move (e.g., potential avoidance of areas that exhibit greater sheer stress during hydropeaking).

<u>Hypotheses:</u> Pallid Sturgeon in the Platte River will use deeper depths and moderate velocities than what is available when spawning is present. (Testable hypothesis #1).

<u>Potential Analyses:</u> Generalized linear models and generalized linear mixed models—with logit links—may be used to evaluate habitat use of reproductively ready Pallid Sturgeon in the lower Platte River. Presence points as well as the summary of availability from the ADCP data (and potential 2-D hydrologic model) will be used to infer habitat selection. Further, a full suite of selectivity indices exists to assess habitat selection. For instance, Ivlev's Selectivity Coefficient has been used to assess Pallid Sturgeon habitat selection in the Missouri River mainstem (Elliot et al. 2020) and may be used to assess Pallid Sturgeon habitat selection in reaches of the Platte River. Additional analyses may include regression tree methods (e.g., random forests or boosted regression tree) to evaluate habitat suitability within the lower Platte River provided the results of the 2-D hydrologic model. Such an approach may allow assessment of the contiguousness of habitat patches within the Platte River under varying flow conditions.

Objective 3

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

Question 1. Is there evidence of spawning defined as the release of gametes in the Platte River or its tributaries?

Experimental Units: The experimental units will include individual Pallid Sturgeon, icthyoplankton tows, or egg mat deployments.

Response Variables: Recapture of individual Pallid Sturgeon following spawning behaviors that exhibit weight loss, capture of eggs, or capture of larvae.

Predictor Variables: Not applicable.

Hypotheses: Not applicable.

Potential Analyses: Not applicable. Gametes will be verified as Pallid Sturgeon pending results from objective 4 (see below).

Question 2. Do reproductively ready Pallid Sturgeon exhibit similar spawning behaviors as those found in the Missouri River mainstem and the Yellowstone River?

Experimental Units: Individual Pallid Sturgeon.

Response Variables: Movement of individual Pallid Sturgeon (See objective 1).

Predictor Variables: Sex and reproductive status of Pallid Sturgeon (See objective 1).

Hypotheses: Pallid Sturgeon in the Platte River will exhibit upstream movements with staging occurring prior to initiation of short bursts of movement that indicate spawning (Testable hypothesis #1).

Potential Analyses: Analyses will largely consist of non-statistical descriptions of behavior.

Objective 4

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

We are providing samples to Dr. Ed Heist at Southern Illinois University and do not anticipate analysis of raw genetic data. Results of genetic analyses are of primary importance to habitat research to ensure that habitat metrics are indeed collected for genetically verified pallid sturgeon, not hybrids or shovelnose sturgeon and that intensive tracking efforts are dedicated to pallid sturgeon. Results of genetic analysis indicating individual Pallid Sturgeon as hatchery-origin or wild origin may be incorporated into movement models or habitat use models as categorical predictor variables when available.

Data Preparation, Storage, and Sharing:

Standardized telemetry data analyses developed by Flavio and Baktoft (2021) named "Actel" will be followed as a general data pipeline to facilitate initial, basic data analyses from listening arrays in the Platte River and tributaries (Figure 2). Preliminary QA/QC will be used to identify possible data anomalies including the presence of undocumented tag numbers or tags from other studies and species. Telemetry data for assessment of movement through the passive receiver array will be formatted into four tables that will include the tag data, the receiver locations and release sites, the receivers deployed at each site, and a detection file. These tables can then be used to create summaries of:

a. Residence times, and
b. Movement events.

Data from active tracking will be stored as a .csv file with all identifying information for each fish including tag ID, initial tagging date, agency that originally tagged the individual, the last known reproductive status of the fish, and the last known location of the fish. All data will be stored using a OneDrive account and backups will be created on an external hard drive.

References

Elliot, C. M., DeLonay, A. J., Chojnacki, K. A., & Jacobson, R. B. (2020). Characterization of Pallid Sturgeon (Scaphirhynchus albus) spawning habitat in the lower Missouri River. *Journal of Applied Ichthyology* 36:25-38.

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

Hamel, M. J., and M. A. Pegg. 2019. Riverine Sportfish Ecology and Management. Final report to Nebraska Game and Parks Commission.

HDR. 2009. Lower Platte River Stage Change Study Final Protocol Implementation Report. Final report to Platte River Recovery Implementation Program.

Hammen, J. J., M. J. Hamel, M. L. Rugg, and M. A. Pegg. 2018. Habitat associations of shovelnose sturgeon Scaphirhynchus platorynchus (Rafinesque, 1820) in the lower Platte River, Nebraska. Journal of Applied Ichthyology 34:12-20.

Holmquist, L. M., Guy, C. S., Tews, A., Trimpe, D. J., & Webb, M. A. (2019). Reproductive ecology and movement of pallid sturgeon in the upper Missouri River, Montana. *Journal of Applied Ichthyology*, 35:1069-1083.

Moore, M.J., C.P. Paukert, B.L. Brooke, and T. R. Moore. 2021. Lake Sturgeon seasonal movements in regulated and uregulated Missouri River trbutaries. *Ecohydrology* 15:e2256.

Olden, J.D., and N.L. Poff. 2003. Redundancy and the choice of hydrological indices for characterizing streamflow regimes. *River Research and Applications* 19:101-121.

Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Technical Series No. 18, Nebraska Game and Parks Commission, Lincoln, Nebraska. 232pp.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10: 1163-1174.

Spurgeon, J.J., M.A. Pegg, and M.J. Hamel. 2016. Multiscale approach to hydrological classification provides insight to flow structure in altered river system. *River Research and Application* 32: 1841-1852.

The Nature Conservancy. 2009. Indicators of Hydrologic Alteration Version 7.1. User's Manual.

Whoriskey, K., Martins, E. G., Auger-Méthé, M., Gutowsky, L. F., Lennox, R. J., Cooke, S. J., ... & Mills Flemming, J. (2019). Current and emerging statistical techniques for aquatic telemetry data: A guide to analysing spatially discrete animal detections. *Methods in Ecology and Evolution* 10:935-948.

Table 1. Sources of data for potential variables describing river conditions derived for use in analyses for Question 1 and Question 2 assessing correlates with Pallid Sturgeon movement into, out of, and within the Platte River. This list is not exhaustive and some sources may be added or removed depending on data availability.

Variable Type	**Variable**	**Unit of measure**	**Minimum Scale**	**Source**	**Description**
Response	Pallid Sturgeon entering/exiting Platte River	Count	Daily	Passive Receiver	Daily counts from the passive receiver at the confluence of the Platte River with the Missouri River. Additional detections from the USGS receiver will be added when data becomes available.
Response	Pallid Sturgeon location within/among Platte River basin reaches	Detection (Yes/No)	Daily	Passive Receiver/Active Tracking	The river reach a Pallid Sturgeon is detected in will be documented and used to assess transition probabilities among river reaches
Predictor	Water temperature	°C	15 minutes	USGS Gages	Water temperature will be obtained from the USGS gage located in Louisville, NE on the Platte River.
Predictor	Water temperature	°C	15 minutes	VR2Tx (Receivers)	Water temperatures will be obtained when receivers are recovered. Continuity of data dependent on recovering receivers (USGS receivers will be primary source).
Predictor	River Discharge	m^3/s	15 minutes	USGS Gages	River discharge will be obtained from the USGS gage located in Louisville, NE on the Platte River.
Predictor	Turbidity	NFU or NTU	15 minutes	USGS Gages	Turbidity will be obtained from the USGS gage located in Louisville, NE on the Platte River.

Table 2. Parameters generated from flow data using the Index of Hydrologic Alteration (IHA; Richter et al. 1996). Table modified from The Nature Conservancy (2009). Similar parameters can be developed for water temperature.

IHA Parameter Group	Hydrologic Parameters	Ecosystem Influence
Magnitude of monthly water conditions (12 parameters)	Mean or median flow for each month	• Habitat availability for aquatic organisms • Soil moisture for plants • Availability of water for terrestrial animals • Influences water temperature, oxygen levels, photosynthesis in water column
Magnitude and duration of annual extreme water conditions (12 parameters)	Annual minimum, 1-day mean Annual minimum, 3-day mean Annual minimum, 7-day mean Annual minimum, 30-day mean Annual minimum, 90-day mean Annual maximum, 1-day mean Annual maximum, 3-day mean Annual maximum, 7-day mean Annual maximum, 30-day mean Annual maximum, 90-day mean Number of zero-flow days Base flow index: 7-day minimum flow/mean flow for year	• Balance of competitive, ruderal, and stress-tolerant organisms • Creation of sites for plant colonization • Structuring aquatic ecosystems by abiotic vs. Biotic factors • Structuring of river channel morphology and physical habitat conditions • Duration of stressful conditions such as low oxygen in aquatic environments • Duration of high flows for aeration of spawning beds in channel sediments
Timing of annual extreme water conditions (2 parameters)	Julian date of each annual 1-day maximum Julian date of each 1-day minimum	• Compatibility with life cycles of organisms • Predictability/avoidability of stress for organisms • Access to special habitats during reproduction to avoid predation • Spawning cues for fish • Evolution of life-history strategies
Frequency and duration of high and low pulses (4 parameters)	Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days)	• Availability of floodplain habitat for aquatic organisms • Nutrient and organic matter exchange between river and floodplain • Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses)

IHA Parameter Group	Hydrologic Parameters	Ecosystem Influence
Rate and frequency of water condition changes (3 parameters)	Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals	• Drought stress • Entrapment of organisms on islands, floodplains (rising levels) • Desiccation stress on low0mobility organisms

Figure 1. Potential analytical approaches based on goals and data constraints for assessing acoustic telemetry data. Diagram from Whoriskey at al. (2019)

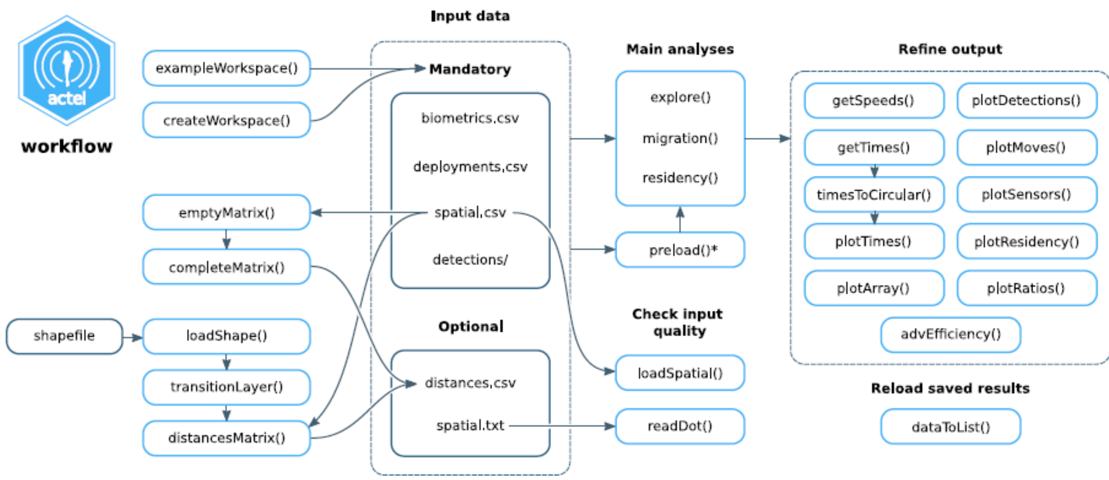

Figure 2. The actel workflow with associated packages as described in Flávio and Baktoft (2021). The approach to processing and analyzing telemetry data from passive receivers as well as active tracking for Pallid Sturgeon in the Platte River basin will follow a similar process. Figure from Flávio and Baktoft (2021).