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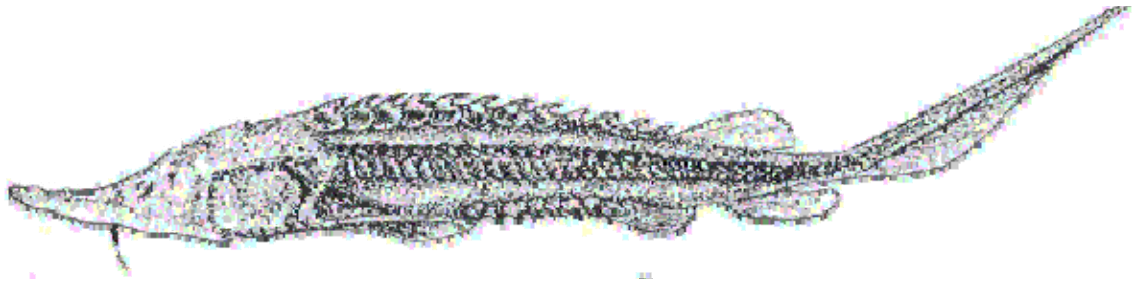
Update on Sturgeon Research



U.S. Department of the Interior
U.S. Geological Survey

Columbia Environmental Research Center
4200 New Haven Road
Columbia, Missouri 65201

September 14, 2005

The U.S. Geological Survey, Columbia Environmental Research Center (CERC) is conducting multidisciplinary research on spawning behavior, physiology, and habitat use of sturgeon on the Missouri River. Beginning in March, 2005, CERC scientists captured 50 female shovelnose sturgeon in each of two hydrologically distinct segments of the Missouri River (Figure 1). Each river segment was expected to exhibit differences in availability of habitat and environmental variables prior to and throughout the sturgeon spawning season. The lower segment is located on the lower Missouri River between the Osage River and Grand River (river miles 110-192). The upper segment is located between the Platte River in Nebraska and the Big Sioux River in Iowa (river miles 605-670).

Only female sturgeon determined to be at a reproductive stage of IV or greater were selected for inclusion in this study. Stage IV females have dark pigmented eggs, and are expected to spawn within the year. Sturgeon were captured using entanglement gear, including drifted and stationary gill and trammel nets. Most fish were collected using gill nets in overnight and short-term sets. Capture locations were recorded with a GPS and as fish were removed from the nets they were kept in separate tanks. Fish were weighed, measured, and uniquely tagged with a temporary floy tag to identify the fish's capture location. Individuals that were > 0.95 kg and thought to be females were examined using a portable ultrasound and endoscope to accurately assess reproductive readiness. The ultrasonic images will be processed to estimate the fecundity of each tagged female.

Females visually assessed to be at Stage IV or greater were surgically implanted with an acoustic transmitter and an archival data storage tag (DST). Acoustic transmitters used were manufactured by Lotek Wireless, Inc. and operate at 77 kHz. Transmitters are uniquely coded for individual fish using the Lotek MAP proprietary digital coding system. A subset of the transmitters used (20%) are also equipped with sensors that report temperature and pressure data, in addition to fish identification as the fish is tracked. Transmitter life-expectancy is approximately 291 days. Implanted archival tags will continuously record time, temperature, and pressure data at a maximum interval of 15 minutes.

During the implantation procedure tissue samples were collected to determine the stage of maturation of the eggs and readiness to ovulate and spawn. A 3-5 mL blood sample was drawn from the caudal peduncle and a small sample of oocytes (> 20) was collected through the abdominal incision. Following implantation each fish was externally marked with a permanent floy tag and released as close as practical to their site of capture. The uniquely numbered floy tags are placed at the base of the pectoral fin and include agency identification and contact information.

Tracking of fish began immediately after implantation and continued through mid-August. Multiple crews tracked these fish to document movement and habitat use prior to, during and after spawning. Measurements of water conditions (e.g.,temperature, conductivity, turbidity) and habitat characteristics (e.g., depth, substrate) were recorded concomitant with sturgeon locations. A customized ArcPad application was used to interactively collect, validate, and store data in the field. All location and environmental measurements are being consolidated into databases compatible with GIS software. Daily reports are generated to provide summaries of fish locations and movements, and efforts of the tracking crews.

In the lower segment, 47 of 50 individuals have been relocated (1 to 10 locations, mean = 4.9) since implantation (Figure 2). Tracking effort in the lower segment has involved 2 boats each with a 2-person crew tracking on a near daily basis with the goal of locating each fish at least once per week. As of September 1, the effort has required 653 boat hours covering 500 miles of river between the mouth of the Missouri River at Saint Louis to St. Joseph, Missouri. In the upper segment, 42 of 50 individuals have been relocated (1 to 17 locations, mean = 8.1) since implantation (Figure 3). One fish was captured by a recreational angler as it moved upstream

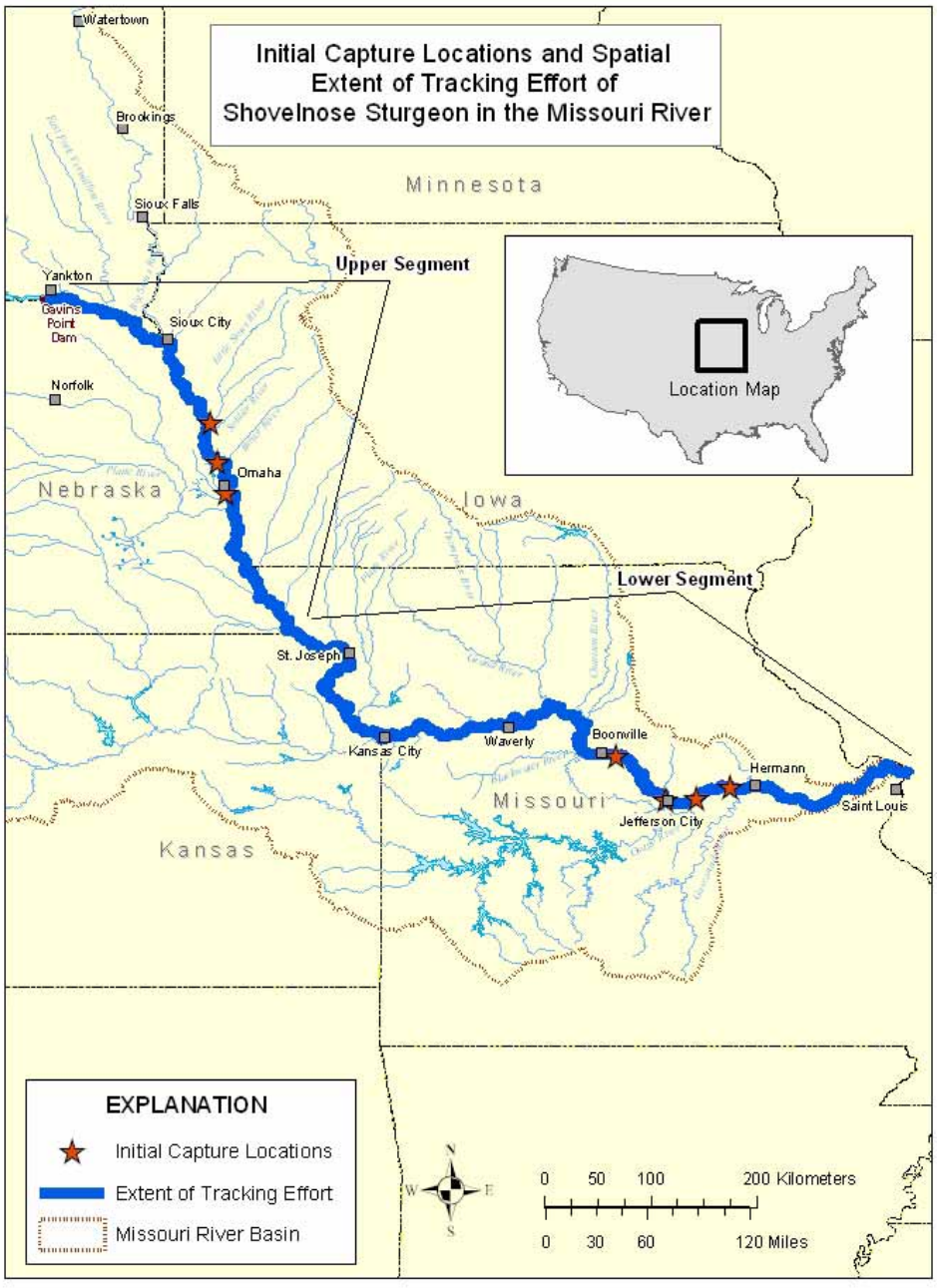


Figure 1. Initial capture locations and spatial extent of tracking effort of shovelnose sturgeon in the lower Missouri River.

Figure 2. Sturgeon locations from April 6 to September 1, 2005 in the lower segment.

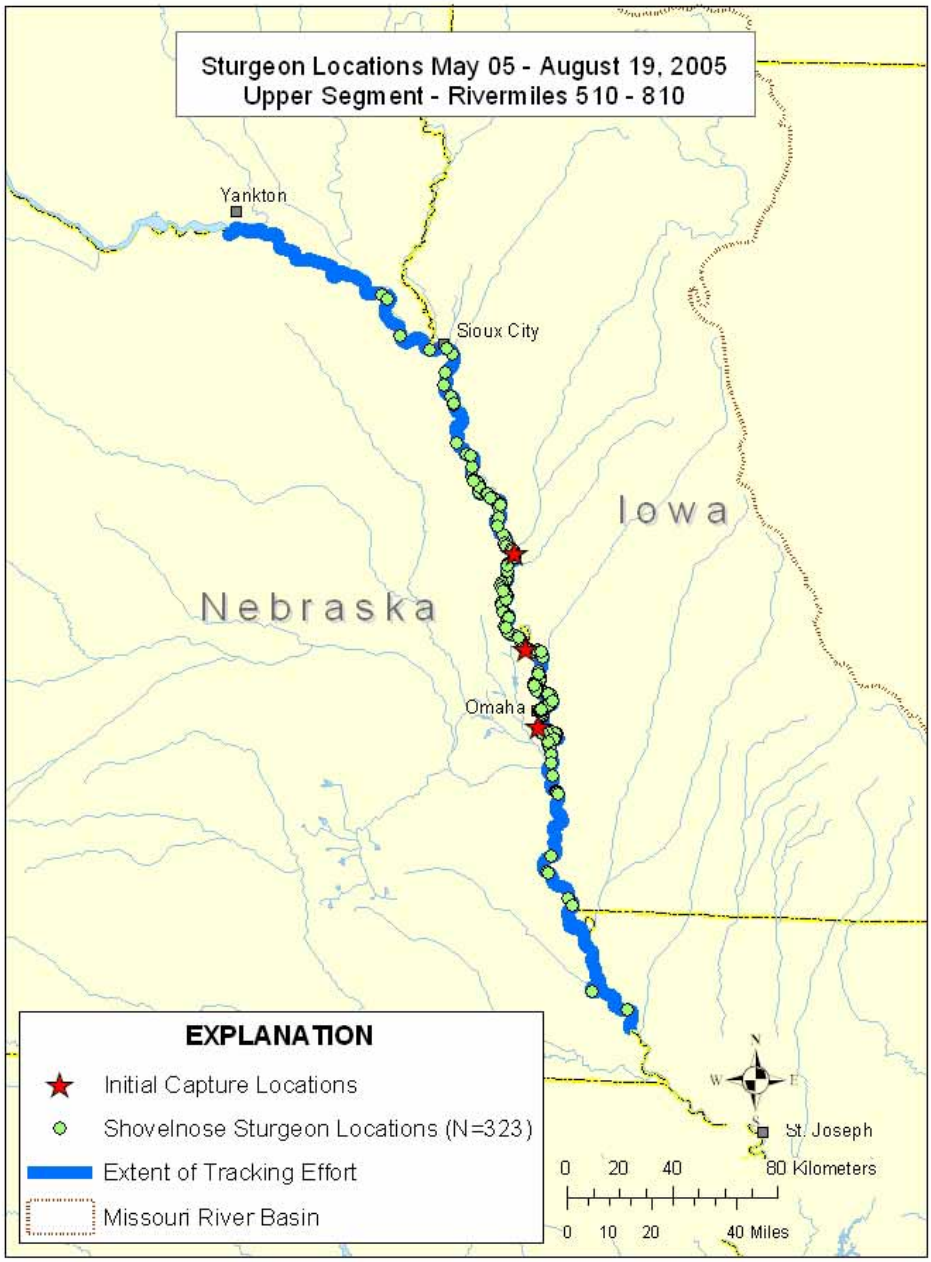


Figure 3. Sturgeon locations from April 6 to September 1, 2005 in the upper segment.

prior to spawning. Tracking effort in the upper segment has involved 1 or 2 boats with 2-person crews tracking on a near daily basis with the goal of locating each fish at least once per week. As of September 1, 2005 the effort has required 323 boat hours covering 300 miles of river from below Brownville, Nebraska to Yankton, South Dakota. Beginning in Mid-August crews began to recover tagged fish. Tagged fish are recovered by drifting trammel nets over the fish's location. Recapture success is highly dependent upon flow conditions and fish location . Upon recovery, the reproductive status of each fish is re-assessed and the archival tags recovered. Recaptured sturgeon are photographed, and a blood sample is taken. Fish are then euthanized and a necropsy is performed to visually assess spawning success and to obtain samples of gonad tissue for histological examination. Pectoral spines are removed for age determination. Tracking and recovery efforts will continue through December, or until 50% of all implanted fish have been recaptured. After all fish are collected and data from loggers recovered, data analysis and interpretation will commence.

Blood plasma collected from the 100 fish at the time of implantation has been analyzed for testosterone, 11-ketotestosterone, estradiol, and cortisol. Ovarian biopsies from the tagged fish were also collected to determine readiness to spawn using the germinal vesicle breakdown (GVBD) assay, by measuring polarization index, and through histological observation. Immediately after receipt, ovarian tissue was subjected to the GVBD assay. The polarization index was calculated from measurements of a subsample of eggs from the GVBD assay and another 5 eggs that were not assayed (a total of 1,000 eggs). Tissue histology is pending. Additional tissues were collected from shovelnose sturgeon captured in close proximity to the fish being tracked and from other opportunistic catches of shovelnose sturgeon as the reproductive season has progressed to more closely assess physiological changes associated with the final maturation phase of the oocyte. Laboratory work has also involved measurement of To, or the time required for one mitotic cleavage, at four different temperatures. This unit of measure will be used to standardize the timing of events during the final maturation period leading up to spawning. Currently, lab personnel are receiving and processing tissue samples of recollected tagged fish. Subsequent laboratory activities will involve hormone analyses and tissue histology. Data analysis and interpretation will commence once data are collected.

Twelve of the sturgeon evaluated for reproductive readiness and implanted with transmitters in spring of 2005 have been recaptured to date. Of those recovered, 75% (9 of 12) have spawned successfully. For the purposes of this interim progress report sturgeon #131 has been selected as an example to illustrate the type of data collected and results. Sturgeon #131 was collected from the Missouri River on April 21, 2005 near the Little Sioux River at rivermile 668.5. A reproductive assessment was performed and the fish was surgically implanted with a tranmistter and DST tag. Physiological measurements indicated that sturgeon# 131 was developing normally for a spawn in the spring of 2005. The polarization index of the eggs upon initial capture and tagging was 0.17 and did not change significantly after eggs were exposed to progesterone in the GVBD activation assay. It is generally accepted in sturgeon culture that fish with a PI of .07 will likely respond to a forced hormonal induction of maturation and are therefore approaching a state of spawning readiness. A PI of 0.17 and a lack of response in the assay indicates that at capture, sturgeon #131 was not very close to spawning. An Estrogen/Testosterone ratio of 1.0 was measured from blood plasma, and is well within the expected hormone range for females at this stage. Androgens (e.g., testosterone) are typically as high or higher than estrogens for both males and females during spawning migrations. A cortisol level of 26.5 ng/mL indicates the fish was not severely stressed at the time of implantation and release. Telemetry tracking data shows that sturgeon #131 moved little after implantation (Figure 4). In mid-May it began moving upstream, passing the Big Sioux River and entering the Recreational River Reach. The farthest upstream location observed by the tracking vessels was at rivermile 759.8 on June 14, 2005. Fish #131 moved little until after mid-July when it began rapidly moving downstream. It was

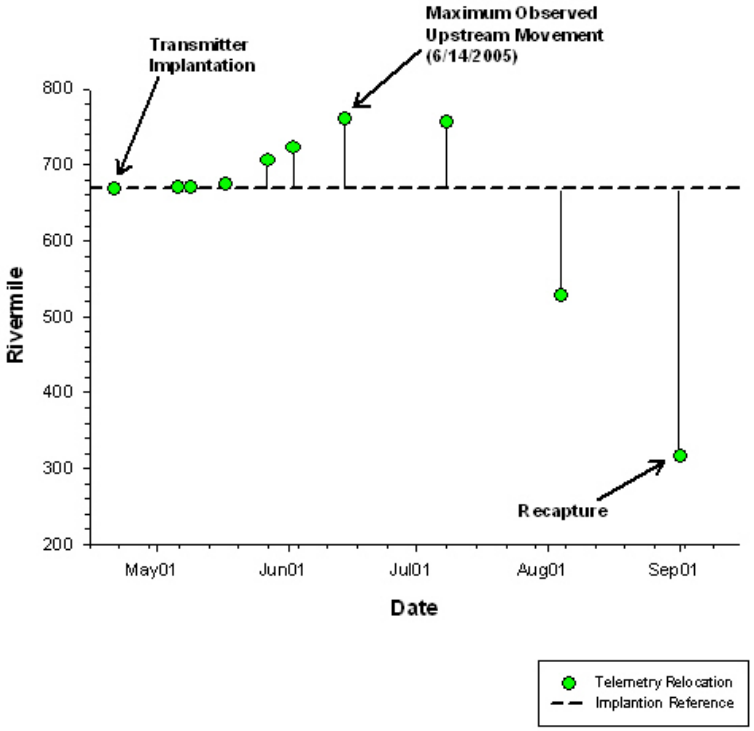


Figure 4. Locations of fish 131 by rivermile from implantation through recapture. For reference purposes the horizontal dashed line indicates the rivermile at which the fish #131 was fish captured, implanted with a transmitter and archival tag, and released.

recaptured September 1, 2005 at rivermile 315.7, nearly 445 miles downstream from its most upstream location. Steroid measurements and histology on tissues from the fish upon recapture are pending. However, gross observations indicated that fish #131 spawned completely. Gonads had very few atretic eggs and those that remained were in the area proximal to the surgical incision. Ovaries already showed very well-developed lamellar structure with fat deposits and early vitellogenic eggs indicating that preparation for the fish's next spawning event was progressing normally. The pattern of activity evidenced in the DST depth data recovered from sturgeon #131 is similar to that of other fish that have successfully spawned in the 2004 pilot study (Figure 5). Rapid upstream movement is indicated by high amplitude variation of depths used, followed by a dramatic behavioral change when the fish reaches the apex of its spawning migration. The DST data for sturgeon #131 correlates well with the telemetry location data and suggests that spawning occurred in mid-June, in the Recreational River Reach, in close proximity to its furthest upstream location on June 14, 2005. Examination of the temperature data stored in the DST device, suggests that spawning occurred between 20-22° C (Figure 6).

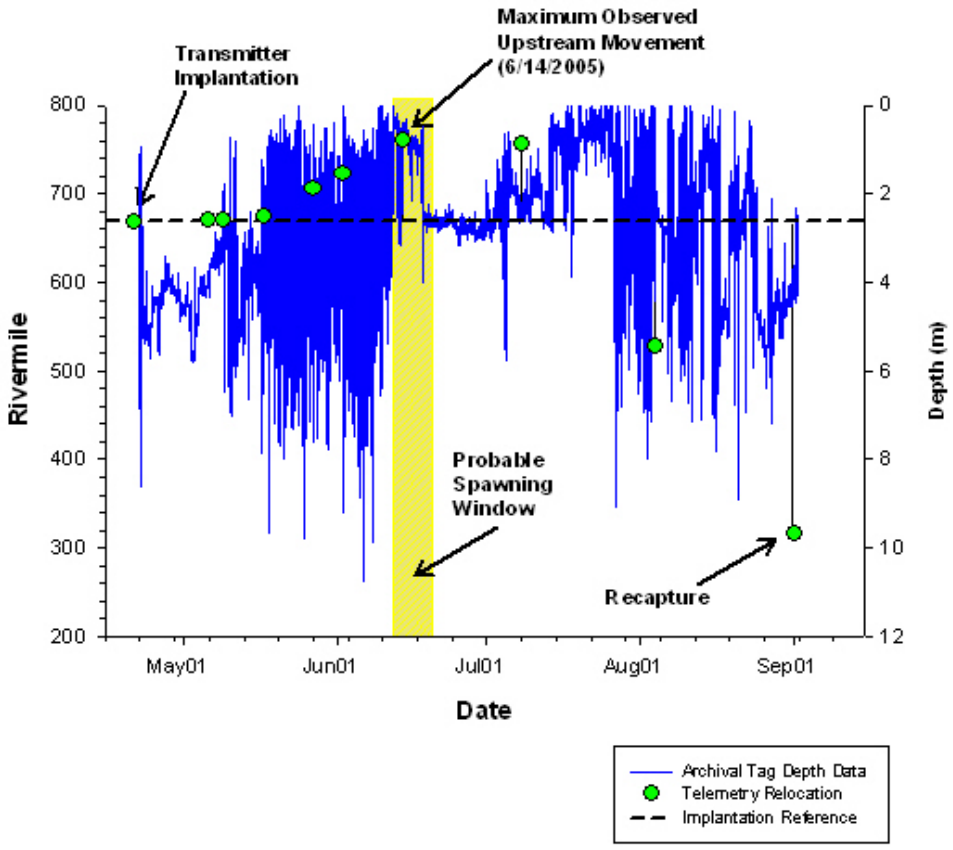


Figure 5. Locations of fish 131 by rivermile from implantation through recapture. For reference purposes the horizontal dashed line indicates the rivermile at which the fish #131 was fish captured, implanted with a transmitter and archival tag, and released.

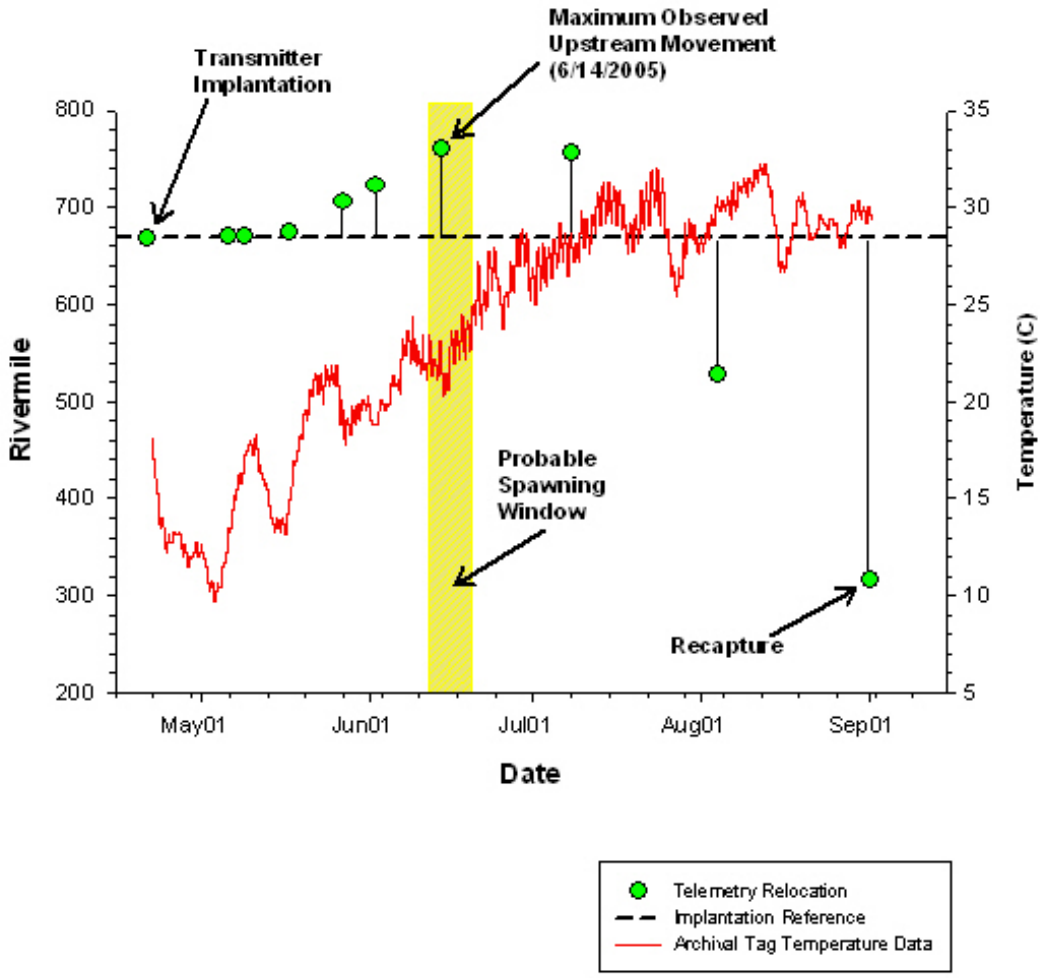


Figure 6. Locations of fish 131 by rivermile from implantation through recapture. For reference purposes the horizontal dashed line indicates the rivermile at which the fish #131 was fish captured, implanted with a transmitter and archival tag, and released.

Environmental Conditions

The original study design was based on the assumption that the upper study segment was unlikely to have a substantive spring rise, and would therefore provide a control for comparison of sturgeon behavior in the lower study segment where a spring rise was very likely. In reality, the spring and summer of 2005 was characterized by substantive spring rise events in both segments (Figure 7). Although violating the premise of the experiment, this situation provided an experimental opportunity that is highly relevant to the research design. Results from 2005 will be particularly useful for comparison with subsequent years with or without spring rises. Discharge and temperature records are

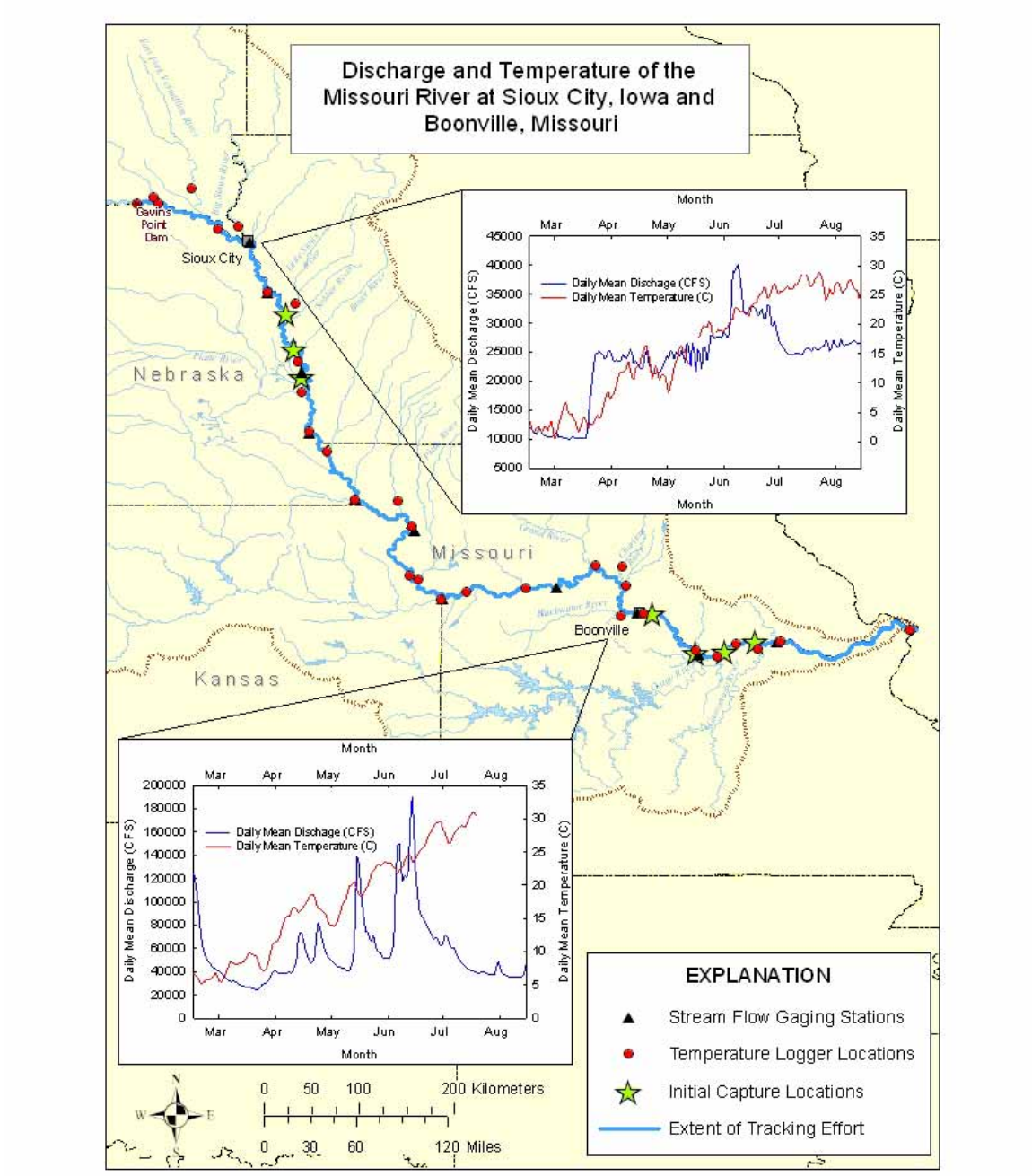


Figure 7. Locations of study segments, US Geological Survey streamflow gaging stations, and temperature loggers installed as part of this study. Hydrographs and thermographs shows the environmental context of spring-summer 2005.

being compiled and archived for comparison with location, habitat, and physiology data. In addition to existing US Geological Survey gage records and temperature data provided by other agencies at Gavins Point dam, Sioux City, and Decatur, we collected high-frequency temperature data at 31 sites in major tributaries and the mainstem.

Physical

Two hydroacoustic habitat assessment boats have been operating in support of this project. As of August 31, 94 sturgeon locations have been mapped for physical habitat -- 37 in the lower segment and 57 in the upper segment (Figures 8 and 9). Mapping reaches are randomly selected from the previous day's fish locations, subject to the constraint that discharge may not vary more than 15% from when the fish was located. Maps consist of complete river reaches, surveyed bank to bank at the prevailing discharge, and extending upstream and downstream of the fish location to encompass a cross-over to cross-over or bend to bend reach. This design allows for assessment of all macrohabitats available to the fish. The reaches typically cover 2.5-3.0 km of the channel. In the lower segment, cross sections are spaced at 40 m for most of the reach to quantify habitat availability. Cross section spacing was 20 m for 100 m upstream and 100 m downstream of the fish location to provide a higher resolution for quantifying habitat use. Cross section spacing in the upper segment is 30 m, with 15 m spacing 75 m upstream and 75 m downstream of the fish.

Figure 8. Locations of habitat assessment reaches, lower segment .

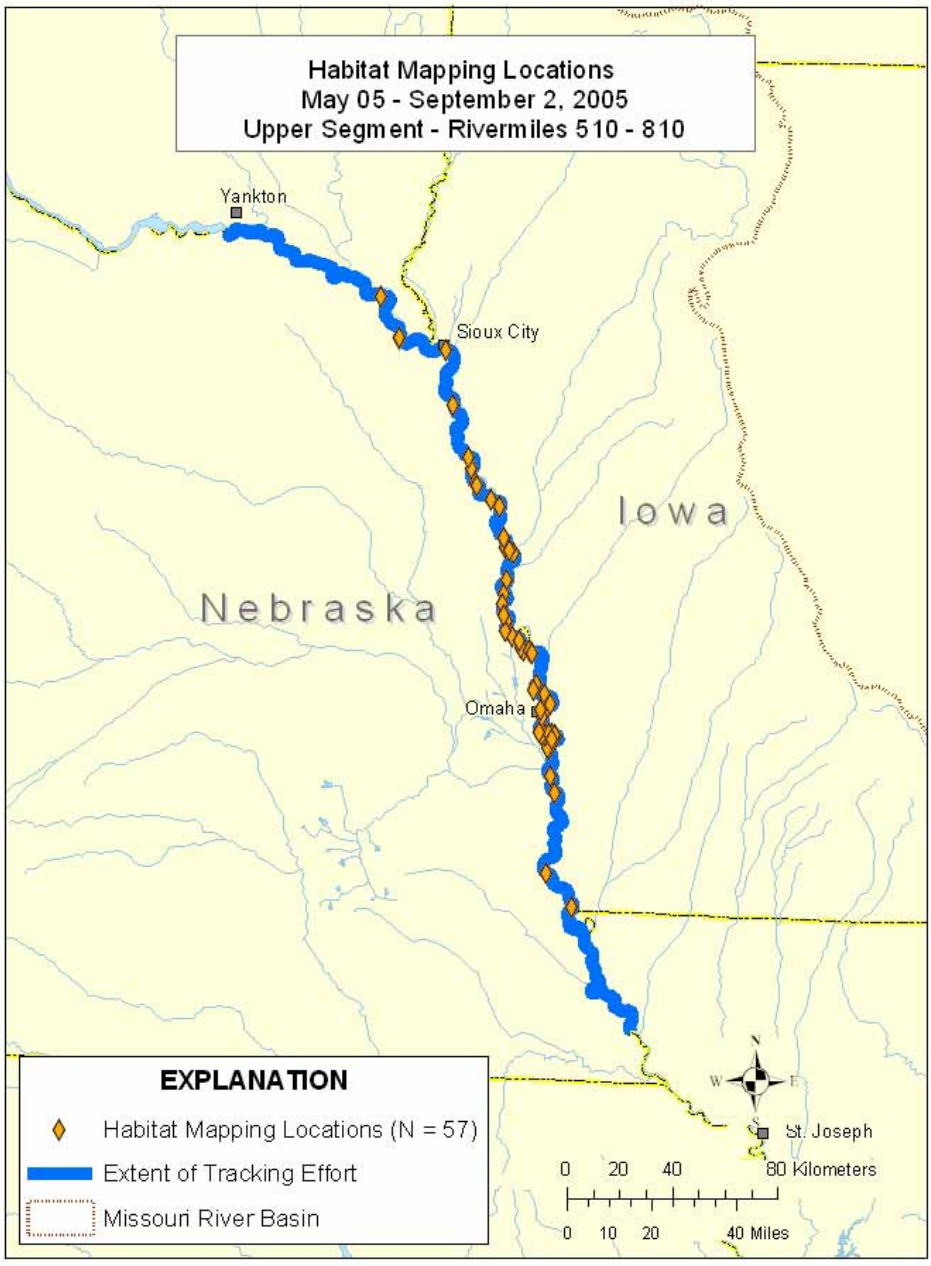


Figure 9. Locations of habitat assessment reaches, upper segment.

Hydroacoustic data have been archived for processing and map compilation at the end of the tracking season. Examples of habitat maps for one fish location in the Gavins Point Reach are shown in Figures 10-13.

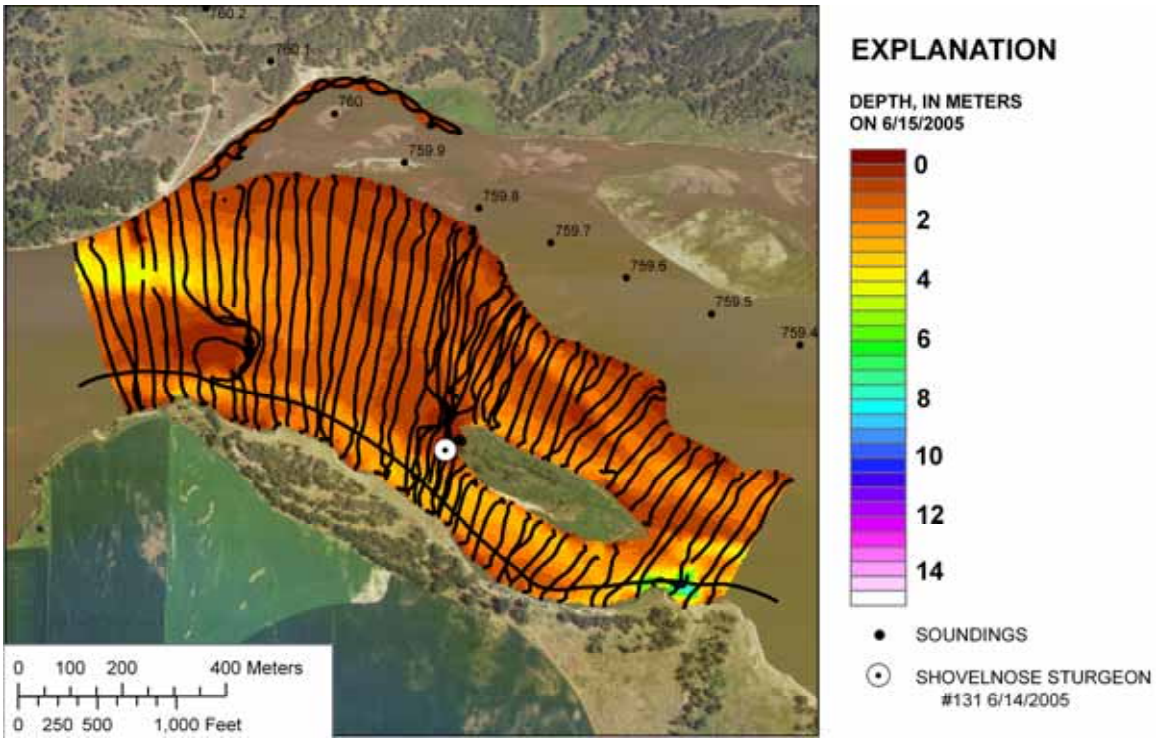


Figure 10. Map of fish 131 position near RM 760; located 6/14/2005, mapped 6/15/2005, showing depths and data collection density. Areas outside of mapped boundary were too shallow to map at the time of assessment.

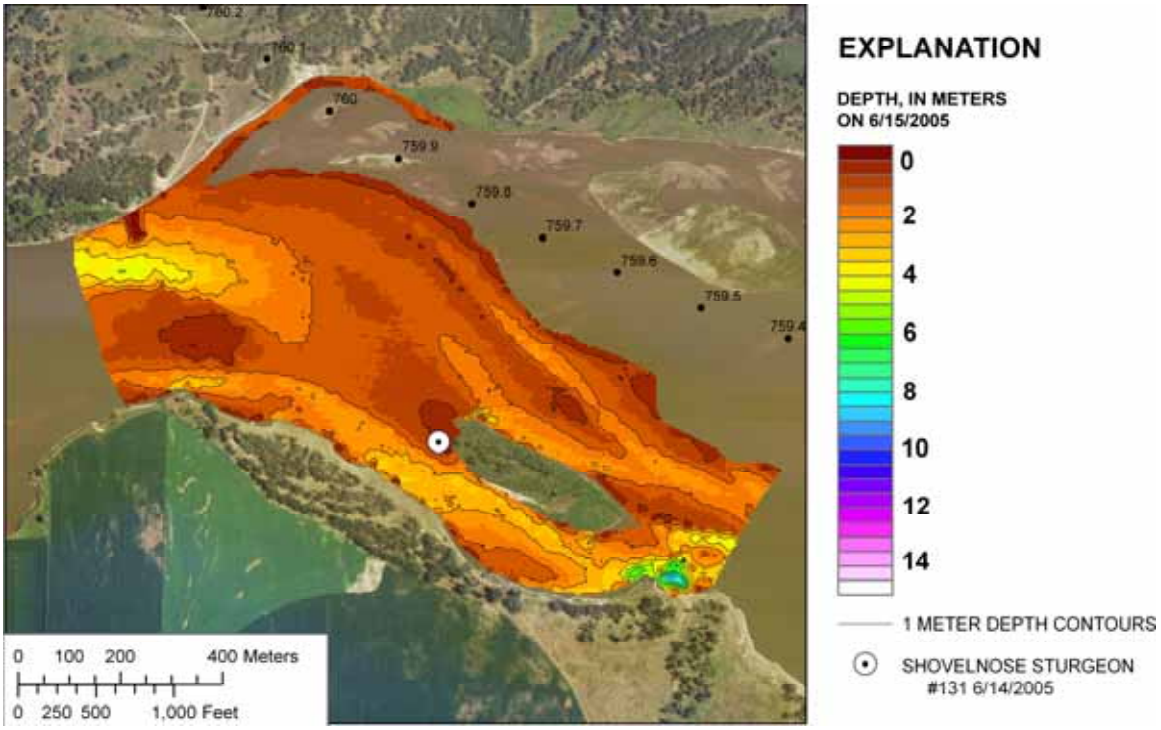


Figure 11. Map of fish 131 position, 6/15/2005 showing depth contours.

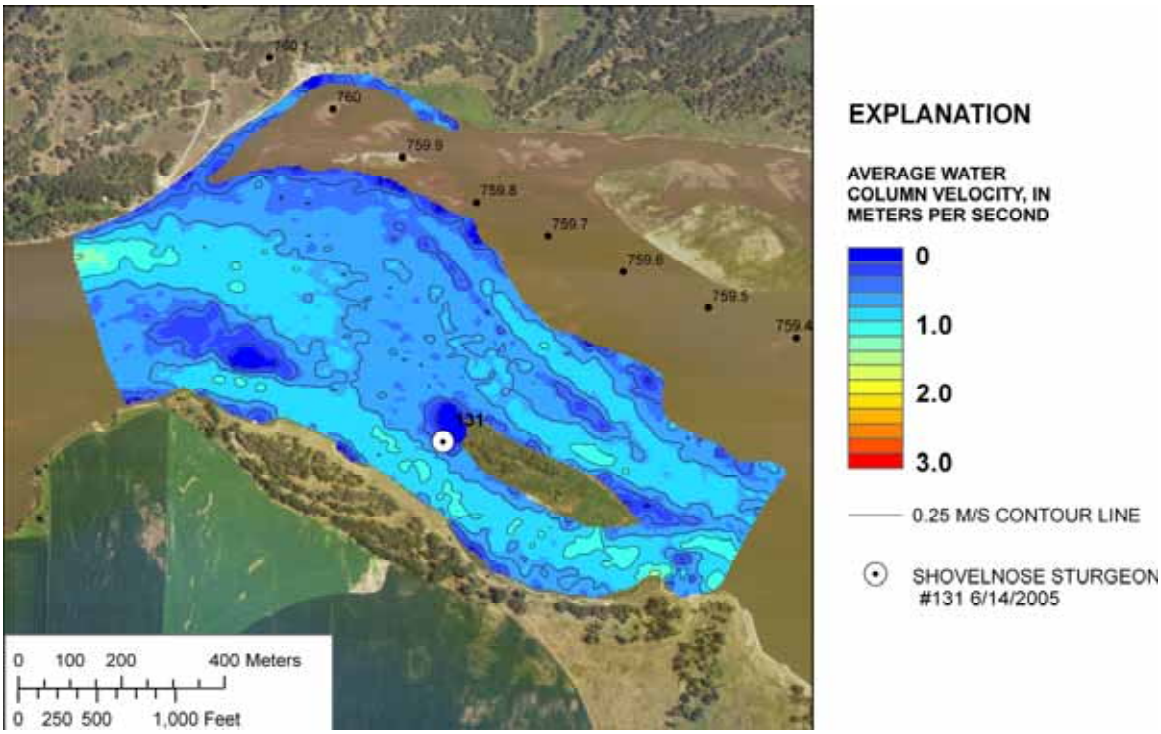


Figure 12. Map of fish 131 position 6/15/2005, showing velocity contours

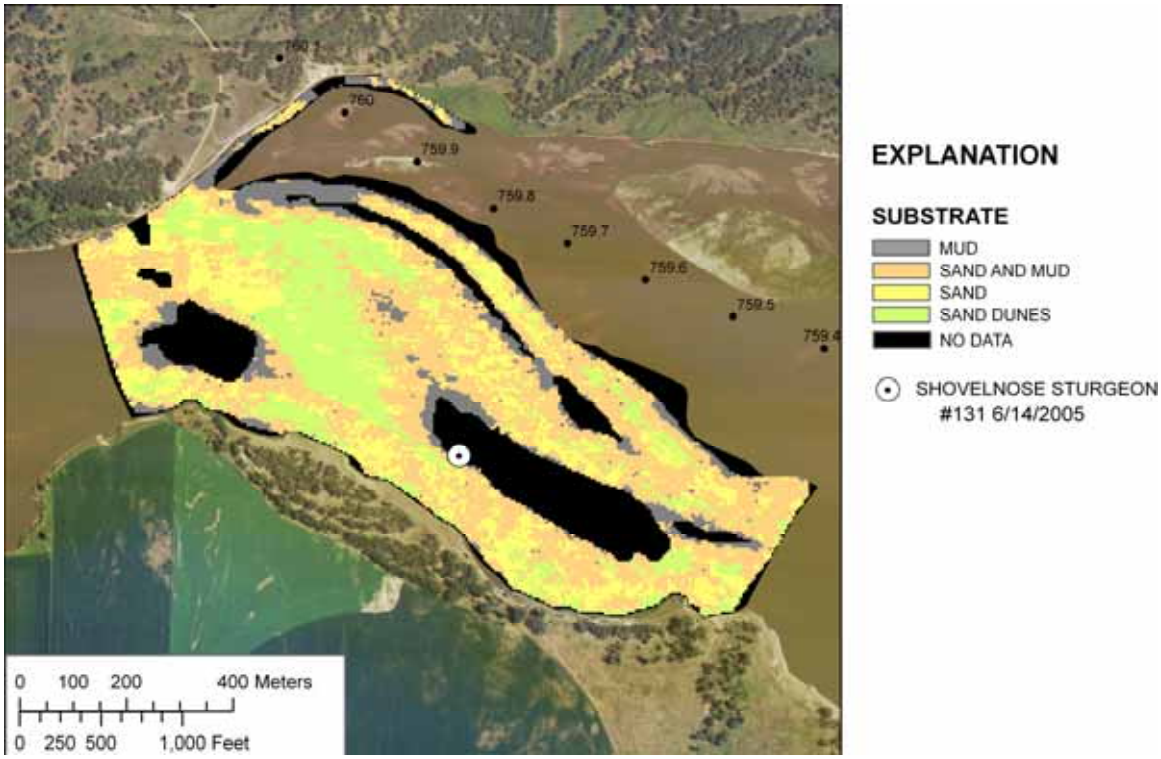


Figure 13. Map of fish 131 position 6/15/2005 showing substrate classes

Potential Spawning Substrates

Field work was initiated to locate gravel and rock deposits within the channel of the Missouri River from the mouth at St. Louis to Gavins Point Dam. All work was carried out at discharges representing 90-percent exceedance or less in order to maximize the potential for locating potential spawning sites. Once a deposit was located, measurements were taken on the size and type of deposit.. To date (September, 2005) 70-percent of the lower Missouri River between Gavins Point Dam and the mouth, north of St. Louis, Missouri has been surveyed for hard substrate deposits. The inventory includes 274 hard substrate deposits and 34 bedrock exposures (Figure 14). In addition to the ubiquitous rip-rap and wing dikes lining the banks below Sioux City, Iowa, potential spawning substrates are derived from two additional sources; local bedrock and till-derived deposits. Local bedrock sources can exist *in situ* where the river has impinged on a bedrock exposure or the local bedrock clastics can be delivered via tributary rivers and streams, where fans often develop at the tributary mouths. Glacial till and till-derived deposits have different histories, depending on geography. In the state of Missouri, some of the till-derived deposits are suspected to owe their genesis to erosion of the river bed and subsequent exposure and mobilization associated with the high energy flooding events of the early 1990s. Immediately below Gavins Point Dam in South Dakota, *in situ* glacial till can be viewed along the banks of the river. This difference is directly related to the age of the respective deposits.

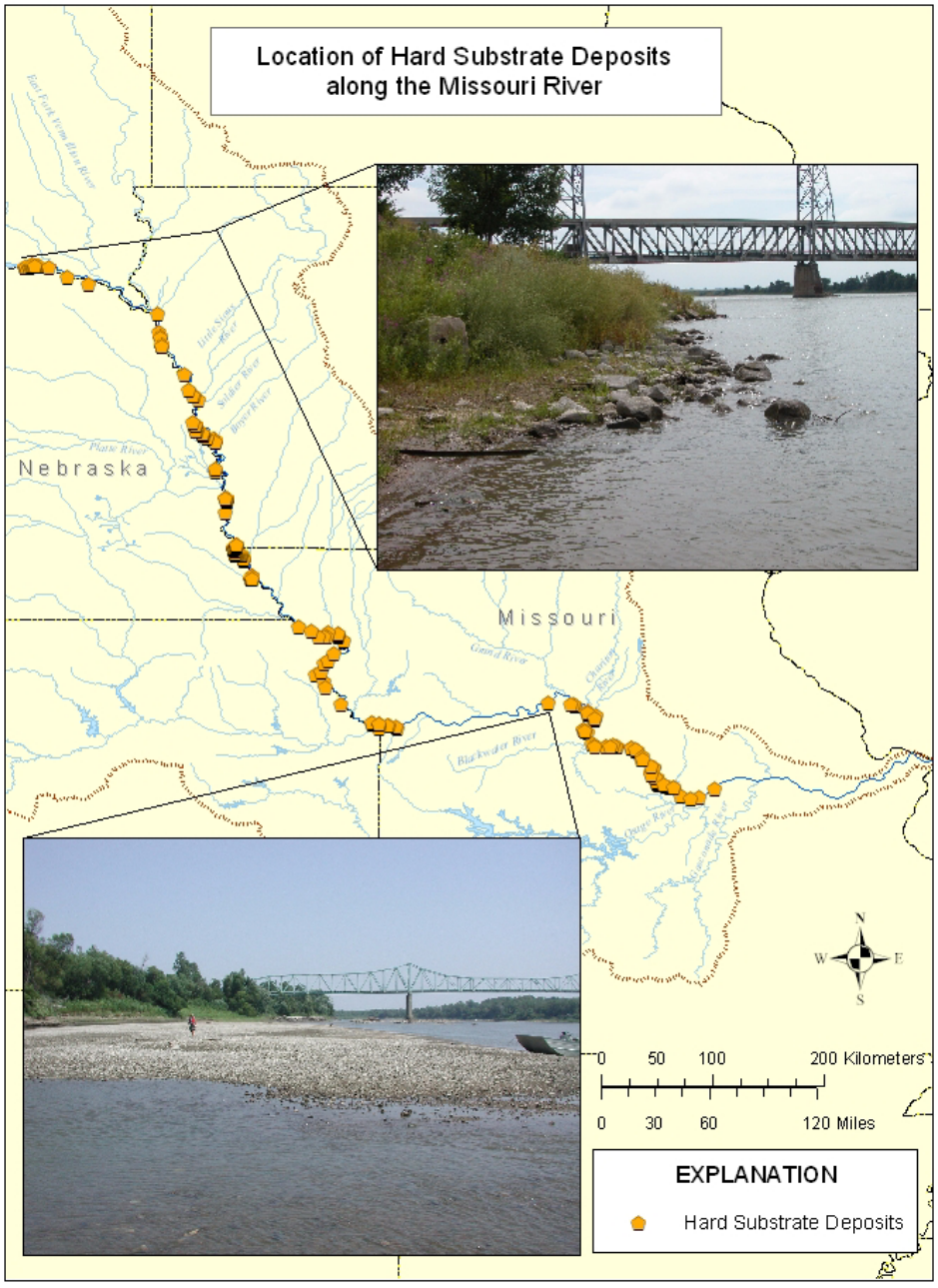


Figure 10. Location of hard substrate deposits along the Missouri River.