# Impacts of low light levels in culverts on Topeka shiner and other prairie stream fish movement

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## INTRODUCTION

The Topeka shiner *Notropis topeka* is a federally endangered fish species inhabiting the rapidly declining headwater prairie streams of the central US (Hatch 2001). Once abundant throughout portions of Iowa, Kansas, Minnesota, Nebraska, and South Dakota, the species' range has decreased by 80%, with 50% occurring within the past 25 years (Tabor 1998). A variety of factors could have contributed to their decline including accessibility to prime habitat. When streams intersect roadways, culverts span the area and create potential barriers to fish movement (Bouska 2010). Understanding Topeka shiner behavior and potential avoidance of culverts could be vital to the survival of the species.

Culverts create potential barriers to off-channel habitat by physically impeding swimming abilities because of insufficient depth, excess stream velocity, perched culverts and blockages from debris or sediment (Blank et al. 2011). Culverts can also deter movement behaviorally through reduction of light levels and lack of substrate (Woltz et al. 2008). In either case, culverts may isolate small populations of fish causing reduced species abundance and diversity, loss of genetic diversity, and local species extinction, further endangering the long-term survival (Bouska 2010).

The current study focuses on the potential for low light levels in long culverts to act as barriers to fish movement. The study was required by the United States Fish and Wildlife Service (USFWS) as part of the authorization to build Culvert 59X09, which allows US Highway 75 to cross Poplar Creek in Pipestone County, Minnesota. The crossing was replaced in 2013 as part of a roadway rehabilitation project that included extension of the embankment slopes so that the guardrails could be removed and resulted in lengthening of the culvert. The study is specifically designed to determine how much light exists seasonally in Culvert 59X09, and whether or not those light levels act as a barrier to movements by Topeka shiners and other associated species. As such, the study determines if the same number of Topeka shiners and its common associates move through Culvert 59X09 and other selected culverts as through nearby control reaches of the same streams. An additional objective is to determine if pond-reared Topeka shiners and surrogate species will travel through varying light levels with equal frequency (or without preference) while holding other natural field variables constant .

The outcomes of this study influence the replacement of other long culverts in critical Topeka shiner habitat and determine if mitigating factors, such as skylights, are necessary.

Is the objective to just go light vs dark or is it to determine what level if any will be dark enough to dissuade movement?

## RESEARCH SITES

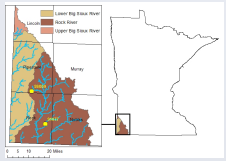



Figure 1. Culvert Study Sites in Southwestern Minnesota

### Culvert 59X09

Culvert 59X09 crosses Poplar Creek 23.8 km north of Luverne, MN under US Highway 75. Its current measurements are two 4.9 m wide x 3.7 m high x 33.5 m long box culverts with aprons and extensions of the embankment slopes (Figure 2). Two tributaries feed into the main pool in the upstream section of the culvert, and flows into a longer pool at the downstream edge of the culvert.

### Culvert 91077

Culvert 91077 crosses Elk Creek 9.7 km east of Luverne, MN under Interstate 90. It has three box culverts with aprons and guardrails instead of embankments but is still longer than Culvert 59X09 (47.5 m) (Figure 3). Culvert 91077 has one channel that feeds the upstream and flows through the culvert to a shallow, rip rap area downstream followed by a deeper pool.

Figure 2. Culvert 59X09

Figure 3. Culvert 91077

## METHODS

**Physical measurements - Velocity, depth, light**

Length, width, and height were measured at both culverts. Light measurements were conducted throughout the day using a handheld photometer. Readings were taken in broad daylight, at upstream and downstream entrances to the culverts, and at the midpoint within each barrel.

Stream velocity was measured at Culvert 59X09 using an Acoustic Doppler Velocimetry (ADV). Measurements were taken at both entrances of the culvert and at the midpoint within the culvert for each barrel. The stream was too shallow to use an ADV at Culvert 91077. Instead, stream velocity was calculated using multiple, neutrally buoyant orange peels released at the start of each box and timed until they reached the end of the culvert.

**Fish mark and recapture**

Culvert 59X09

A trawl net was used for most fish collecting upstream and downstream due to the depth of the water. Kick nets were used in the upstream tributaries and seine nets for collecting fish along the shallow stream sides and within the culvert. All fish collected within the culvert were incorporated in the upstream analysis.

All fish within 3-15 mm were used in the tagging process (length similar to Topeka shiner). Fish were anaesthetized using a 2:1 ratio tricaine methanesulfonate (MS-222), and baking soda. Once a fish was fit for tagging (loss of equilibrium), their total length (tip of snout to tip of caudal fin), was recorded and the fish was tagged using a visible implant elastomer (VIE) kit. On day one, all fish were tagged in the left, dorsal region of their body and anterior to the dorsal fin (Figure 4). Four specific colors were used to indicate if a fish was collected upstream or downstream of the culvert and if they were released upstream or downstream (Figure 5). After all portions of the culvert were sampled, tagged fish were released into their respective areas.

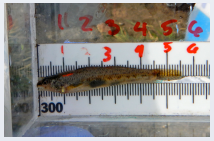


Figure 4. Fish with red tag on left, dorsal side of the body anterior to dorsal fin

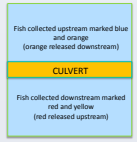



Figure 5. Diagram of experimental site with road crossing for evaluated culverts

A second day of collecting and tagging was conducted 24 hours later. All fish were checked for a tag using a UV light. Then the fish were tagged in the left, dorsal region of the body and just below the dorsal fin (Figure 6). Any recaptured, tagged fish were noted and marked again with a release color that corresponded to the area the fish was recaptured in. After all portions of the culvert were sampled, tagged fish were released into their respective areas.

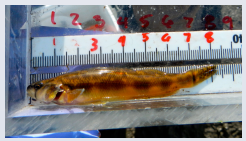


Figure 6. Fish with orange tag on left, dorsal side of the body below dorsal fin

The final recapture procedure was conducted five days later. All fish were checked for a tag. If a fish did not have a tag, their species was recorded for population analysis. If a fish did have a tag, the species, color of the tag, location of the tag, and length of the fish were noted. All fish were released after the area had been thoroughly sampled.

Culvert 91077

On day one, fish collecting was done via seine net due to the shallow depth of the stream. Fish were tagged in a similar fashion to Culvert 59X09. The color scheme and tag position on the fish were the same. Fish were only tagged in the left, dorsal region of the body and anterior to the dorsal fin. After all portions of the culvert were sampled, tagged fish were released into their respective areas.

The final recapture was conducted five days later. Similar to Culvert 59X09, all fish within size were checked for a tag and noted for their species, color of tag, and body length (Figure 7). All fish were released after the area had been thoroughly sampled.

Figure 7. Recaptured Topeka shiner with red tag at Culvert 91077

## RESULTS

**Light**

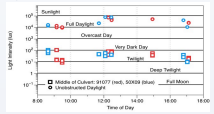


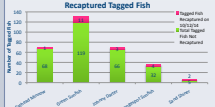

Figure 8. Light intensities recorded in full sunlight and mid-culvert at Culvert 59X09 and 91077 compared to light intensities experienced naturally.

**Culvert 59X09-Day 1 (10/11/14)**

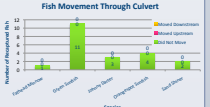

•Total Tagged Fish: 443
•Total Tagged Topeka shiner: 8

**Culvert 59X09-Day 2 (10/12/14)**


•Total Tagged Fish: 430
•Total Tagged Topeka shiner: 4



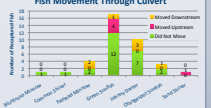

•Total Recaptured Fish: 21
•Total Recaptured Topeka shiners: 0
•Total Recapture Rate: 4.7%




•Total Fish Moved Through Culvert: 0

**Culvert 59X09-Final Day (10/18/14)**


•Total Recaptured Fish: 37
•Total Recaptured Topeka shiners: 0
•Total Recapture Rate: 4.2%

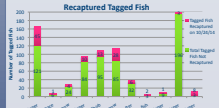



•Total Fish Moved Through Culvert: 12

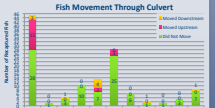
**Culvert 91077-Day 1 (10/19/14)**


•Total Tagged Fish: 816
•Total Tagged Topeka shiners: 11

**Culvert 91077-Final Day (10/24/14)**




•Total Recaptured Fish: 121
•Total Recaptured Topeka shiners: 11
•Total Recapture Rate: 14.8%
•Topeka shiner Recapture Rate: 72.7%




•Total Fish Moved Through Culvert: 29
•Total Topeka shiners Moved Through Culvert: 1

## CONCLUSIONS

In conclusion, fish passed through Culvert 59X09. The culvert did not act as a complete barrier, but it is unknown if it is as a partial barrier at this time. It is also unknown if Topeka shiners moved through the culvert due to their low capture numbers and nonexistent recaptures. Overall, total fish collected, recapture rates, and number of fish moving through the culvert were lower at Culvert 59X09 than the other culvert sampled. A number of variables could have contributed to this. Water temperatures are colder in the fall, and subsequently fish tend to move less. Another contributing factor to lack of movement may have been caused by the larger predatory fish found within the culvert (2 Northern Pikes). The lack of light within the culvert may have also affected the rate at which fish moved through the culvert. Light levels taken at noon within the culvert had readings similar to light levels expected at twilight in open conditions. The stream was also very deep in areas, which made collecting very challenging and many tagged fish may have been missed.

Fish also passed through Culvert 91077, including one Topeka shiner. The culvert did not act as a complete barrier even with the shallow water depth. It is unknown if the culvert is a partial barrier. More fish were tagged at this culvert because it was shallower and easier to collect. The higher collection numbers and colder water temperatures encouraging fish not to move may have contributed to the higher recapture rates. The shallow depth of the water within the culvert, however, may have deterred many fish from moving through the culvert. The lack of light within the culvert may have also affected fish movement through the culvert. Light levels taken at noon within the culvert had readings similar to light levels expected at twilight in open conditions.

Research will continue at Culvert 59X09 and 91077 to increase the overall tag and recapture rates, especially those of Topeka shiners. Control experiments at each culvert site will be performed to determine if fish are more likely to swim through natural stream reaches in comparison to those with dark culverts impeding the waterway. The two culverts will be periodically monitored throughout the spring, summer, and fall months to account for different spawning events and subsequent flooding seasons promoting fish movement. Other culverts in the area with a history of Topeka shiner will also be monitored to encompass a variety of light levels into the study.

In addition, future plans include a laboratory study using surrogate species and pond-reared Topeka shiner to evaluate fish response to varying light levels in a controlled environment. Our research will determine if low light levels pose a barrier to fish movement and if light mitigation needs to be considered in long culverts.

## REFERENCES

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