2017-44TS
Published November 2017

DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

TECHNICAL SUMMARY

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PROJECT COST:
$154,854

Researchers caught Topeka shiners during the mark-and-recapture portion of the research.

Darkness in Box Culverts Not a Likely Barrier to Topeka Shiner

Field and laboratory study results showed that darkness in box culverts does not present a complete barrier for southwestern Minnesota fish species. These findings will lower the cost and reduce the delay of future box culvert replacement projects.

What Was the Need?

In 2013 the U.S. Highway 75 crossing over Poplar Creek was replaced as part of a roadway rehabilitation project that included extending the embankment slopes so that the guardrails could be removed. The installation replaced a 52-foot-long triple box culvert with a 110-foot-long double box culvert. Poplar Creek, in southwestern Minnesota, is home to the federally endangered Topeka shiner. Because the new culvert was significantly longer than the previous structure, the U.S. Fish and Wildlife Service required MnDOT to monitor the movement of the Topeka shiner through the new culvert to ensure that it did not inhibit fish passage.

Previous studies have identified culvert attributes that can impede fish swimming, such as water depth, velocity and perching. Less obvious culvert attributes such as darkness could also alter fish behavior, leading to reduced or delayed passage. Before this study, potential behavioral barriers to fish passage had not been closely investigated or quantified, especially for small warm water fish species such as the Topeka shiner. To ensure fish passage for the Poplar Creek installation and future culvert replacements, there was a need to evaluate the impact of long culverts with low light levels on the movement of the Topeka shiner and associated species.

What Was Our Goal?

Researchers developed several objectives in their efforts to assess the effect of low light levels on fish passage through replacement box culverts. As part of this effort, they wanted to determine typical light levels in the replacement culvert and other box culverts in the region. They also sought to determine if the Topeka shiner and other fish move through culverts in the same numbers they pass through control areas in the same stream, and whether light levels affect frequency of movement. Finally, if a barrier is determined, researchers sought to design or recommend a method for mitigating light in the culvert.

What Did We Do?

This study involved both a fish mark-and-recapture monitoring campaign and a set of laboratory experiments.

In the field, researchers characterized light in long box culverts (at least 8 feet by 8 feet) by collecting many light levels with a light meter at the water surface within the three culverts and at control reaches. They also measured light levels within the water column to characterize the light conditions a fish would experience.

To determine whether Topeka shiners passed through culverts in similar numbers as through control reaches of the same stream, and whether light levels affected their passage, researchers employed a mark-and-recapture process. They caught fish upstream and downstream from the culverts or control reaches, marked them with an identifier indicating where they were caught and released, and then resampled to see where fish moved. They also noted other culvert features that could affect passage, such as water depth and velocity.

continued

"This research will allow MnDOT to save both time and money when replacing other box culverts in southwestern Minnesota by eliminating the need for a fish passage study for each one."

—Scott Morgan,
Principal Hydraulics Engineer, MnDOT District 7

"Prior to this study, there had been no quantitative analysis of the impact of culvert light levels on fish passage through culverts. The field monitoring campaign and laboratory experiments in this study help to address these concerns."

—Jessica Kozarek,
Research Manager, University of Minnesota St. Anthony Falls Laboratory

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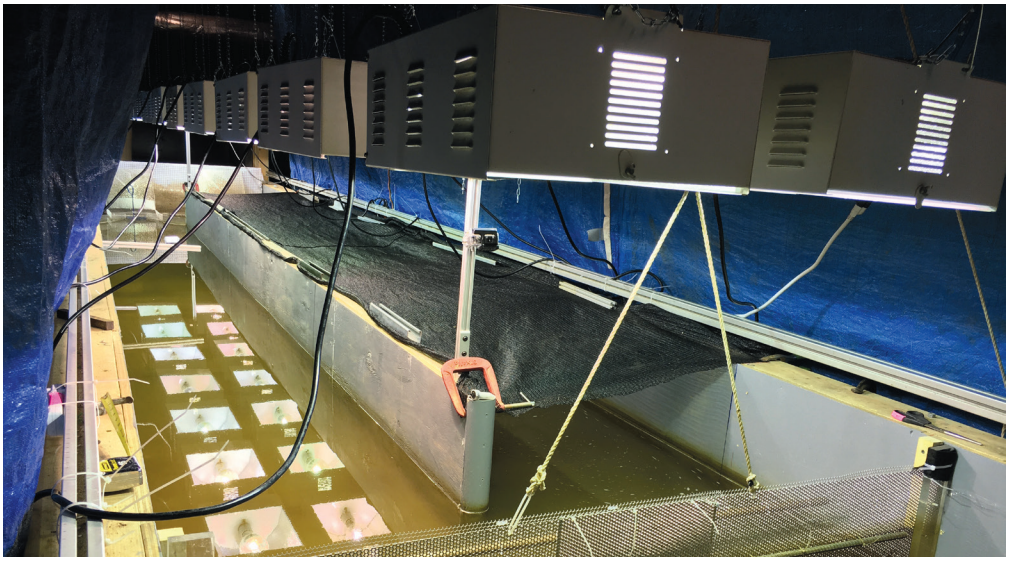

In light manipulation experiments at the St. Anthony Falls Laboratory, Topeka shiners and fathead minnows were allowed to choose channels to swim along. The degree of shade in one channel was adjusted from light to deep shade.

To control for confounding variables that could affect fish movement, a laboratory study measured Topeka shiner preference for light or dark channels. Researchers used a 25-foot-long double channel box with water diverted from the Mississippi River. Fish could choose to swim along light or shaded lanes as they preferred in this light manipulation experiment.

What Did We Learn?

Although there has been increasing concern over the potential for culverts to create behavioral barriers for fish and other organisms, this was the first study that quantified these behavioral effects for fish passage. Light levels in large box culverts were not identified as a potential barrier to the fish communities present in southwestern Minnesota. Two out of the three culverts monitored showed reduced fish passage compared to the control reaches; however, fish—including Topeka shiners—were able to pass through all three.

The longest and darkest culvert had the greatest difference in movement between the culvert and the control, but this variation could not be attributed solely to light levels. This finding was supported by experiments at the St. Anthony Falls Laboratory, where fish that could select either a shaded or lighted channel showed no avoidance of the shaded channel regardless of the shading level.

The light measurements in three culverts yielded an extensive data set that can be used to model light levels through culvert barrels. Light levels at the water surface depended on the culvert entrance, dimensions, construction material, orientation and elbows, while light levels in the water column were also affected by turbidity.

What's Next?

The conclusions of this study apply only to Topeka shiners and other small warm water fish species, and to large box culverts like those studied. Additional research is required to investigate possible barriers created by smaller, darker culverts to light-sensitive fish species and the interactions between light and other variables such as velocity.

This Technical Summary pertains to Report 2017-44, "Culvert Length and Interior Lighting Impacts to Topeka Shiner Passage," published November 2017. The full report can be accessed at mndot.gov/research/reports/2017/201744.pdf.