Using Mussel Spat Rope to Facilitate Small Fish Passage in Culverts

What Was the Need?
Roadway culverts for rivers and streams can create barriers for fish passage through insufficient water depth, excessive current, perched outlets and other behavioral barriers. Maintaining free fish passage for Minnesota’s high-quality fish population is a concern for fish and wildlife organizations and for MnDOT, which must maintain culverts and construct new channels that do not create fish barriers. While much fish passage research has been done on the coasts and has focused on large migratory species such as salmon, few studies have addressed the passage of smaller fish. Recent research in New Zealand demonstrated the effectiveness of mussel spat rope—rope with long, dense fibers used in mussel aquaculture—to assist small species fish passing through steep, perched or high-velocity culverts. The successful results from this research led MnDOT to investigate mussel spat rope as a possible low-cost, low-maintenance method to facilitate fish passage in Minnesota’s culverts.

What Was Our Goal?
The objective of this project was to determine whether mussel spat rope was an appropriate and effective tool in helping small fish species pass through Minnesota culverts.

What Did We Do?
Investigators conducted a literature review to evaluate previous studies. Then researchers from St. Anthony Falls Laboratory conducted experiments in the laboratory and in the field to investigate the use of mussel spat rope as a fish passage aid.

Hydrodynamic performance. Hydrodynamic performance tests were performed in a 20-inch-wide by 30-foot-long flume fed by water diverted from the Mississippi River into the laboratory. Researchers measured velocity, depth and water surface slope, and sediment accumulation around arrays of ropes. They installed single- and multi-rope configurations and examined many variations of flume flow and depth, recording the rope’s effects on water velocity and turbulence.

In a second experiment, researchers released fine sand into the flume containing two- and four-rope configurations to investigate the rope’s effect on sediment transport. Because the ropes slowed local water velocity, deposits were observed on, between and under the ropes in two different depth tests after one and two hours of sediment feed.

Rope durability, performance and use by fish. Researchers installed mussel spat rope in two Minnesota box culverts: one in the northeast serving a fast current trout stream and one in the southwest serving a slow current prairie stream in critical fish habitat. Double strands of mussel spat rope were installed near a wall in each culvert and examined many times for approximately two years. Each observation included photographic and video recordings of the installations.

Small fish species’ interaction with the rope. Laboratory investigations of fish behavior with the rope were conducted in a 5-foot-wide by 32-foot-long flume with a raised section representing a box culvert. Two Plexiglas windows allowed viewing.

Researchers showed how low-cost mussel spat rope commonly used in mussel aquaculture can help small fish species navigate through culverts by reducing current velocity and providing protected areas for fish to shelter and rest.

Technical Summary

Technical Liaison:
Petra DeWall, MnDOT
Petra.DeWall@state.mn.us

Project Coordinator:
Mitchell Bartelt, MnDOT
Mitchell.Bartelt@state.mn.us

Principal Investigator:
Jessica Kozarek, University of Minnesota

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Researchers installed two sets of double-strand ropes along a wall, similar to those in the field sites. Four video cameras tracked motion, recorded overhead views of the flume and captured fish behaviors at the midpoint and ends. Researchers used three species of small fish common to Minnesota: fathead minnow, white sucker and johnny darter. Five fish were released into the test area at a time and allowed to swim for an hour. Their progress and behavior were filmed and analyzed.

What Did We Learn?

Key observations from these investigations follow:

- Mussel spat rope created small corridors (about 6 inches) of reduced velocity and turbulence along its length, which was sufficient to aid the passage of small fish. Sediment collected in, between and beneath the ropes. The presence of culvert floor sedimentation may assist fish passage.

- The rope displayed wear over two years in the field, raising a concern about plastic microparticle release into streams. Sediment covered some ropes over time, suggesting a need for maintenance in some culverts. Only a few fish were observed at the field installations.

- In the laboratory flume, test fish swam near and between doubled rope lengths, apparently taking advantage of the reduced current near and beneath the ropes. While there was variation among species, most fish that swam upstream through the simulated box culvert ended their passage on the rope side, evidence that the rope provided cover and refuge from the current.

What’s Next?

Mussel spat rope will be a low-cost, low-maintenance tool to help small fish pass through culverts. The final report for this study includes guidance for installing the rope. The low-cost method will also be included in an upcoming guide for designing culverts that allow aquatic organism passage.