Experimental mixing of a north-temperate lake: testing the thermal limits of non-native rainbow smelt, a cold-water fish

Background

This project involved designing and implementing an innovative device that initiates whole-lake mixing of the water column for invasive fish control. Researchers aimed to determine how rainbow smelt populations would respond to the loss of cold-water habitat after thermal mixing.

Rainbow Smelt

Rainbow smelt (*Osmerus mordax*) are non-native to Wisconsin, and there is anecdotal evidence that anglers have intentionally introduced these fish into some northern Wisconsin lakes. Rainbow smelt can negatively impact native species of fish like walleye and cisco, and favor cold-water habitats of deeper lakes. This species is currently listed as restricted under ch. NR 40.

Figure 1. GELI device in Crystal Lake, Vilas County.

Research Methods

- A **Gradual Entrainment Lake Inverter (GELI)** device was used to initiate whole-lake mixing of the water column in Crystal Lake, Vilas County.
- Sparkling Lake in Vilas County was also monitored during the study and used as an unmanaged control.

Summary of Results

- The GELI technology was effective for fully mixing the water column, thereby eliminating the coldwater refuge for rainbow smelt in Crystal Lake.
- Significant changes in smelt behavior occurred after mixing, including unusual jumping and changes in movement patterns.
- A significant reduction in the rainbow smelt population was observed in Crystal Lake, with a more than two-fold increase in mortality rates. However, some adults survived, and this approach did not result in complete eradication of the species from the lake.
- Results suggest that within the adult population, mixing eliminated larger rainbow smelt from the lake, but smaller individuals tended to survive.
- There were some short-term impacts to water quality observed during the experiment, but water clarity later returned to pre-treatment values.

Potential applications:

This experimental technique sharply reduced smelt populations, but based on results this method is unlikely to be a good option for complete eradication of rainbow smelt populations on its own. Smelt were found to be more capable of surviving high water temperatures than previously believed, highlighting the resilience of invasive species. However, the researchers suggest the potential for this kind of approach to be used in combination with other control techniques. Even if not currently feasible for widespread use in Wisconsin, this research improved our knowledge of how this invasive species responds to changes in its habitat and provided an opportunity to test information derived from laboratory experiments and models in the field. These results and similar studies can help us better understand how to approach innovative AIS control techniques in the future, particularly those that consider the thermal limits of invasive species.

Related Publications and Resources

Gaeta J.W., R.S. Read, J.F. Kitchell, and S.R. Carpenter. 2012. Eradication via destratification: Whole-lake mixing to selectively remove rainbow smelt, a cold-water invasive species. Ecological Applications 22(3): 817-827.

Lawson Z.J., M.J. Vander Zanden, C.A. Smith, E. Heald, T.R. Hrabik, and S.R. Carpenter. 2015. Experimental mixing of a north-temperate lake: Testing the thermal limits of a cold-water invasive fish. Canadian Journal of Fisheries and Aquatic Sciences 72: 926-937.

Heald E, T.R. Hrabik, Y. Li, Z. Lawson, S.R. Carpenter, and M.J. Vander Zanden. 2017. The effects of experimental whole-lake mixing on horizontal spatial patterns of fish and zooplankton. Aquatic Sciences 79(3): 543-556.

Smith C.A., J.S. Read, M.J. Vander Zanden. 2018. Evaluating the "Gradual Entrainment Lake Inverter" (GELI) artificial mixing technology for lake and reservoir management. Lake and Reservoir Management 34(3): 232-243.

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