Adjusting Temperature of Lake Water as a Method To Control Zebra Mussels

Source: http://www.hudsonriver.org/ls/reports/Polgar_Gephart_TP_04_12_final.pdf

ABSTRACT

The introduction of zebra mussels to the Hudson River in 1991 caused strong impacts throughout the ecosystem. Since 2005, these ecosystem impacts have changed, likely as a result of a shift toward smaller-bodied mussels. Since this shift in size structure has had a dramatic influence on the ecosystem, the cause of the size-structure is of interest in this project. Specifically, the role of temperature as a driver of the size structure shift was studied using a combination of parameter estimations for a stage structured matrix model based on long-term data, respiration differences among size classes at different temperatures (acute thermal effect), and the effect of increasing temperature on mortality (chronic thermal effect). The goal of this study was to test the following alternative hypotheses related to temperature: i) mortality increased in large mussels, favoring small-bodied mussels; ii) mortality increased in all size classes such that few mussels survive to a large size class; iii) high temperatures reduced growth rates, leading to smaller mussels. While the results from the analyses of the mechanism by which temperature affects size structure are not conclusive, they suggest that, based on the matrix model results and the acute thermal tolerance results, large mussels are not less thermally tolerant. Further, the experiments on chronic exposure to high temperatures indicated that there is a strong temperature effect on mussel survival, beginning at temperatures that frequently occur in the Hudson River during the summer. This means that high temperatures could be a significant source of mortality for zebra mussels in the Hudson River.

RESULTS

The parameter estimations based on long-term zebra mussel size data showed a decrease in survival and growth parameters for medium- and large-bodied mussels (Table 1). Medium mussels went from an estimate of 74% surviving without growing into the next size class, to 0%, and large mussels went from 51% surviving to 30% surviving. Growth from the medium size class to the large size class also decreased from 6% to 0%. The results also showed a decrease in net fecundity for medium mussels by 0.13 veligers/mussel, but an increase for large mussels by 10.44 veligers/mussel. For small bodied mussels, net fecundity plus survival, and growth parameters both increased. Related to the hypotheses, these results show a decrease in growth and survival for medium and large mussels, but an increase in both for small mussels.

The acute thermal tolerance results suggest that small mussels are less thermally tolerant than large mussels, but since the experiment only focused on respiration, conclusions are limited because there are other physiological parameters relevant to thermal stress. These results do motivate further experiments using a scope for growth (SFG) approach. SFG provides a measure of an organism's stress by measuring the energy acquisition (feeding and digestion) against energy expenditure (metabolism and excretion) (Widdows et al. 1995). Further work using this approach would be valuable. The experiments on chronic exposure to high temperatures indicated that there is a strong temperature effect on mussel survival, beginning at temperatures much lower than expected. The effect of temperature on mortality became clear between 23 and 25°C, temperatures that the Hudson River frequently reaches during the summer. Even mussels at depth are exposed to these temperatures because the Hudson River is wellmixed with uniform temperatures over depth. Therefore, high temperatures could be a significant source of mortality for zebra mussels in the Hudson River.

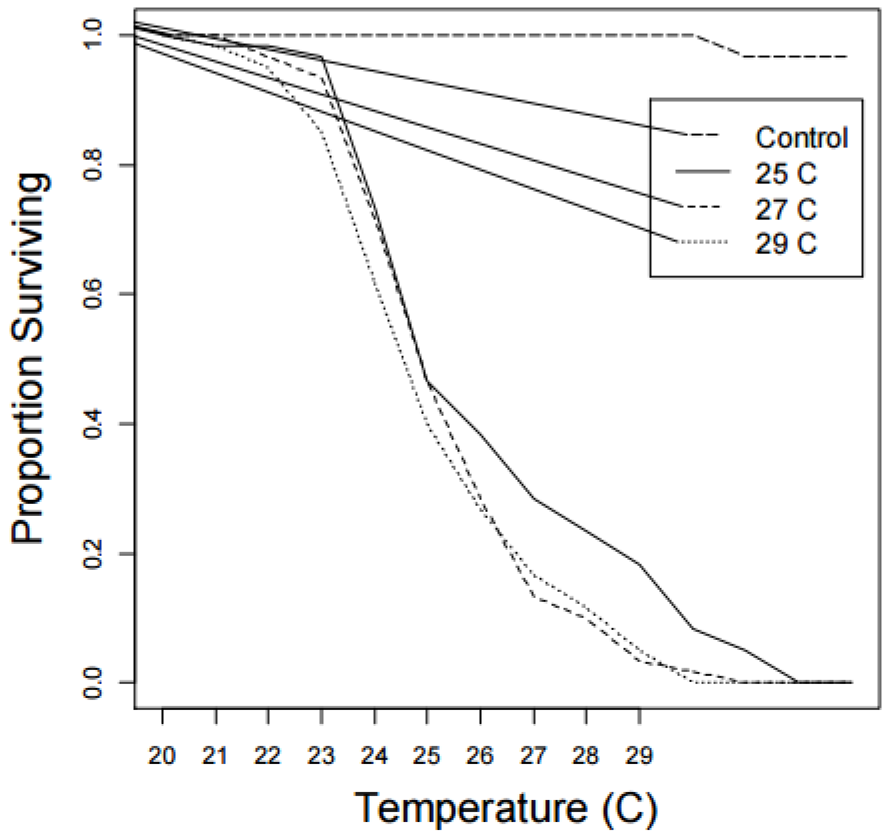

Figure 5: A plot of the proportion of mussels surviving as the temperature was raised 1°C per day to the experimental temperature. After the experimental temperature was reached, the tank was kept at that temperature for each day as the other tanks continued to be raised to their experimental temperatures. The control tanks were kept at 18°C on all days.