Michigan Department of Natural Resources
Fisheries Research Report 2068, 2004

A Long-term Field Test of Habitat Change Predicted by PHABSIM in Relation to Brook Trout Population Dynamics during Controlled Flow Reduction Experiments

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Abstract.–We assessed the utility of the Physical Habitat Simulation system (PHABSIM) in a Michigan trout stream by testing the assumption of a positive linear relation between modeled habitat (weighted usable area, WUA) and brook trout *Salvelinus fontinalis* population levels. We also determined the effects of water withdrawal on brook trout survival, growth, and movement. We simulated irrigation withdrawals by diverting water from a 0.6-km reach of Hunt Creek from 1 June through 31 August each year during 1991-98. We withdrew about 50% of normal summer discharge in 1991-94, 75% in 1995-96, and 90% in 1997-98. We compared abundance, survival, and growth of brook trout between each dewatering period and to pretreatment levels during 1984-90. Ratios of brook trout population parameters in the treatment zone to those in upstream and downstream reference zones were used to help identify temporal influences unrelated to dewatering treatments.

Overall, we found poor correlation between WUA predictions at different flows and brook trout abundance or survival rates. Fall abundance of yearling-and-older (YAO) brook trout and survival of YAO fish from spring to fall was positively related to nocturnal (resting) WUA but not with diurnal (foraging) WUA. Fall abundance of young-of-the-year (YOY) brook trout was not significantly correlated with either diurnal or nocturnal WUA. Predicted changes in WUA at reduced discharge levels, compared to normal flow, were generally small relative to natural between-year variation in trout abundance and survival, suggesting that low summer flows had less influence on the population than other factors.

Spring-to-fall survival of YAO brook trout in the dewatered zone, relative to reference zones, was significantly higher when flow was reduced by 75% than at normal flow, or when discharge was reduced by 90%. Fall abundance of YOY brook trout in the treatment section, relative to reference zones was usually highest when 75% of flow was diverted. Fall condition of brook trout in the dewatered zone was significantly lower when 50% or 90% of water was diverted, as compared to condition in reference zones. Mean fall length at age did not change in response to

reductions in summer baseflow. Fewer brook trout emigrated when 75% or 90% of water was diverted than when flow was reduced by 50%.

Water warming rate increased when ≥75% of flow was diverted. Mean summer water temperatures increased 1.6 °C/km when 75% of water was diverted and 2.4 °C/km when 90% was diverted. In contrast, mean summer water temperature cooled by an average of 0.2 °C/km during two summers when flow was normal. Our analysis of warming relative to percentage of water withdrawn showed that the risk of trout habitat loss from dewatering is very large and proportional to the magnitude of withdrawal.

Our findings of generally insignificant, or inconsistent relationships between WUA and population parameters such as abundance, survival, and growth, suggest that PHABSIM was poorly suited for predicting biological impacts of water diversions from low gradient brook trout streams draining glacial outwash sand and gravel. Increases in water warming resulting from water diversion probably pose the greatest threat to coldwater fish communities.