

AN ABSTRACT OF A THESIS

ASSESSMENT OF EXHAUSTION-THRESHOLD CURVES FOR FISH VOLITIONALLY SWIMMING IN CULVERTS

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Nonnative western mosquitofish (*Gambusia affinis*) are undermining Barrens topminnow (*Fundulus julisia*) populations by means of aggression and predation towards topminnow fry and juveniles. This study investigated the predictive performance of exhaustion-threshold (ET) curves developed from fixed velocity swimming endurance tests for volitional swimming in culverts. ET curves are plots of mean flow velocity versus passage-barrier length. Flow velocity-barrier length combinations that fall above an ET curve are predicted to be impassable, while combinations that fall below an ET curve are predicted to be passable. A passage/exclusion study was carried out for both species in a laboratory flume consisting of a culvert between upstream and downstream staging ponds. Sixteen trials for each species were run and passage was monitored for 240 topminnows (29.0-89.8 mm total length) and 238 mosquitofish (31.7-56.9 mm total length). Three culvert flow regimes were considered: a pressurized pipe flow, a drawdown flow profile, and a backwater flow profile. When predicted to pass by the ET curves, 93.4% of mosquitofish did so in this study. The ET curves successfully predicted exclusion of mosquitofish 90.0% of the time. For mosquitofish in the drawdown and pressurized profile, the ET curves successfully predicted exclusion 78.3% and 91.7% of time, respectively. The backwater flow was the only flow condition that successfully predicted outright (100%) mosquitofish exclusion. The overall Cohen's kappa value for mosquitofish prediction was 0.77. For the pressurized flow and backwater flow the Cohen's kappa was 0.88 and 0.90, respectively. Flow velocity was a significant predictor of mosquitofish passage or exclusion (Logistic Regression; $P < 0.001$), as expected. Overall, 71.7% of topminnows passed when predicted to do so by the ET curves. Successful passage was predicted 65.2%, 73.2%, and 77.1% of the time for the pressurized flow, drawdown flow, and backwater flow, respectively. Total length was a significant predictor of topminnow passage or exclusion (Logistic Regression; $P < 0.001$). This study reinforces and verifies the predictive capabilities of ET curves for use in regional passage screens for culvert assessments and also shows that although outright exclusion may not be possible, a culvert designed as a selective barrier using the ET curves can be a powerful management tool for reducing the numbers of mosquitofish that infiltrate topminnow habitat.