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Muskellunge egg incubation habitat in the upper Niagara River

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ABSTRACT

Identification, conservation, and restoration of spawning and nursery habitats are essential for conserving the self-sustaining population of muskellunge (*Esox masquinongy*) in the upper Niagara River. The objectives of this study were to describe muskellunge egg incubation habitat, identify the most important habitat features associated with the presence of eggs, and make comparisons between spawning habitats identified through visual observation of spawning adults and collection of eggs. We conducted surveys for muskellunge eggs at four locations from 2012 through 2014 and used logistic regression to identify habitat features related to the presence or absence of eggs. We used Bayesian information criterion to select the most likely model and area under the receiver operating characteristic curve tests to determine variable importance and evaluate the model. One-hundred-thirty-six viable muskellunge eggs and two yolk-sac larvae were collected from 30 locations. The most likely model contained parameters for the percent rank of algae or aquatic macrophyte cover of the substrate and water depth. The percent rank of algae or aquatic macrophyte cover was the most important predictor of egg occurrence, and the odds of collecting a muskellunge egg increased by 100% for every 10 percentile increase in percent rank of cover. Spawning habitat features identified in this study were similar to those identified through visual observation of spawning adults. Muskellunge egg incubation locations and habitats should be protected from development and alteration to ensure the sustainability of muskellunge in the Niagara River.

Introduction

The muskellunge (*Esox masquinongy*) is the largest piscivore in the Great Lakes and provides unique fisheries for trophy-sized fish in all Great Lakes connecting channels and several areas of the Great Lakes proper. Most populations of muskellunge in the Great Lakes are self-sustaining. Early life stages of muskellunge are sensitive to habitat perturbations. It is hypothesized that loss or depletion of many muskellunge populations is due to alteration of spawning and nursery habitats (Trautman, 1981; Hanson et al., 1986; Kapuscinski et al., 2007; Kapuscinski et al., 2014). The sensitivity of muskellunge to alteration of spawning and nursery habitats is explained by three major factors: (1) increased biological oxygen demand of spawning substrates following anthropogenic eutrophication or artificial water-level regulation (Dombeck et al., 1984; Zorn et al., 1998), (2) the muskellunge is a scatter-spawning species and provides no parental care (Scott and Crossman, 1973), and (3) the propensity for muskellunge spawning habitats to be disturbed by human encroachment on aquatic ecosystems (e.g., shoreline armoring, removal of coarse woody debris, artificial water-level regulation, dredging of coastal embayments for marinas).

The vulnerability of muskellunge to environmental disturbance has resulted in an emphasis on study of spawning and nursery habitats. Three general methods have been used to identify muskellunge spawning habitats (see Crane et al., in press, for a review of these methods): telemetry (Strand, 1986; Pierce et al., 2007; Diana et al., 2015), visual observation of spawning (Zorn et al., 1998; Rust et al., 2002; Crane et al., 2014; Nohner and Diana, 2015), and egg collection (Farrell et al., 1996; Monfette et al., 1996; Farrell, 2001). Visual observation and telemetry provide information on habitat use by spawning adults, but may not provide information on egg incubation habitat if eggs are transported away from their initial deposition point by water currents. However, habitat descriptions based on collection of eggs may be misleading if eggs are redistributed to suboptimal habitats (Kelder and Farrell, 2009). Ideally, visual observation of spawning behavior or telemetry is validated by collection of eggs at points where fish were observed or believed to have spawned. In fluvial environments, where egg transport is likely, only including points validated by collection of eggs may result in a sample size that is prohibitive of rigorous quantitative analysis (e.g., Crane et al. (2014) only collected muskellunge eggs at 5 of 15 points where muskellunge were observed spawning). If eggs are likely to be transported away from their initial deposition point, results from separate surveys of spawning adults and collection of eggs should be considered together when describing habitat features that are associated with muskellunge reproduction.

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Crane et al. (2014) presented a study of muskellunge spawning habitat in the upper Niagara River based on visual observation of spawning fish from 2011 through 2013. Fish were observed spawning in areas with moderate water currents (up to 32 cm/s) during the 2011 spawning period. It became apparent that there was potential for transport of eggs away from spawning points, and eggs were only collected at three of nine locations where muskellunge were observed spawning. Egg collection techniques were refined during the 2011 field season and a randomized survey for eggs was conducted from 2012 through 2014 (presented here) to complement the results presented by Crane et al. (2014) and provide a more holistic view of muskellunge reproductive ecology in the upper Niagara River. The objectives of this study were to describe muskellunge egg incubation habitat, identify important habitat features of locations where muskellunge eggs were collected, and make qualitative comparisons between spawning habitat documented through visual observation and egg collection.

Methods

Study area

The US waters of the upper Niagara River extend from the outlet of Lake Erie at Buffalo, New York to Niagara Falls at Niagara Falls, New York (about 32 km, as measured along the international border). The upper Niagara River supports a self-sustaining recreational fishery for muskellunge despite extensive in-water, riparian, and wetland habitat alteration (Kapuscinski et al., 2014). This investigation focused on four shallow water (≤2 m) locations that were identified by Harrison and Hadley (1978), Kapuscinski and Farrell (2014), and Crane et al. (2014) as important areas for muskellunge spawning and rearing (Fig. 1).

Habitat and egg data collection

Areas surveyed for muskellunge eggs and associated habitat features ranged in size from 8 to 42 ha and are henceforth referred to as "sites". Sites 2, 3, and 4, were nearshore locations with a gradient of increasing depth away from land; therefore, these sites were stratified into shallow (≤1 m) and deeper water zones (>1 – ≤2 m). Site 1 was a large mid-river shoal with no distinct habitat gradients, so it was not stratified. Site 1 was surveyed in 2012 and 2013, Site 2 was surveyed in 2013, and Sites 3 and 4 were surveyed in 2014. Sampling locations within each site (henceforth referred to as "points") were defined by a 1-m^2 quadrat and selected using the random point generator in ArcGIS (ArcGIS 10.1, Esri, Redlands, California). Surveys commenced when adult-sized muskellunge (about 80 cm; Harrison and Hadley, 1979) began congregating in the survey areas and finished when spawning activity was no longer observed.

The percent aerial cover of the substrate by algae or aquatic macrophytes, height of algae or aquatic macrophytes, dominant algae or

Fig. 1. Map of the upper Niagara River and four sites surveyed for muskellunge eggs and associated habitat features. Surveys were conducted from 2012–2014. Basemap from Esri Inc., 2014.