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# Foraging ecology of walleye and brown trout in a Great Lakes tributary

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ABSTRACT

The role of alternative prey on predator diet selection and survival of juvenile (parr) Chinook salmon (*Oncorhynchus tshawytscha*) is not well understood in the Laurentian Great Lakes. Therefore, measures of predator foraging ecology (prey species and size selection), prey densities, and functional response relationships were determined for adult walleye (*Sander vitreus*) and brown trout (*Salmo trutta*) (hatchery-reared) feeding on parr and alternate prey in the Muskegon River, a tributary of Lake Michigan, USA, from 2004 to 2007. Walleye selected for smaller than average brown trout and rainbow trout (hatchery-reared) but walleye prey size (within-prey) was independent of predator size. In general, walleye showed neutral selection for all prey species but, in some years, showed positive selection for rainbow trout and negative selection for parr. Hatchery-reared brown trout selected the smallest parr in the environment although prey size was independent of predator size. Parr were positively selected by brown trout only in April. Functional response curves were fit to describe the consumption of parr and other prey types by walleye (type II) and brown trout (type I). Interactions among rainbow trout, walleye, and brown trout favored parr survival, i.e. the presence of alternate prey (rainbow trout) significantly influenced walleye predation on parr, while brown trout appeared to become quickly limited by size or escape ability of parr. Our results should enhance understanding of food web dynamics in Great Lakes tributary habitats.



## Introduction

Foraging ecology of predatory fishes can have consequences for the distribution, abundance, and growth of prey fish populations (Lundvall et al., 1999). Predation, in general, can affect the structure of biological communities in many ways (e.g., Payne, 1969). Piscivory, more specifically, has been shown to structure fish community composition (Caley, 1993), influence short and long-term population dynamics of prey fishes (Dörner et al., 2007; Krueger et al., 2011, 2013), stabilize interactions among forage species by controlling population abundances (Pimm and Hyman, 1987), and control food webs via a top-down trophic cascade (e.g., Hairston et al., 1960). For example, Krueger and Hrabik (2005) showed that a native predator (walleye, *Sander vitreus*) was responsible for recovery of a native planktivore (lake herring, *Coregonus artedi*) through suppression of an exotic predator/competitor (rainbow smelt, *Osmerus mordax*). Observing and analyzing the foraging ecology of top predators in an ecosystem can allow for enhanced understanding of trophic structure and interspecific relations via knowledge of a predator's overall impact.

The evidence is not so strong, however, where predators actively consume multiple prey types. In [more] natural systems, multiple prey species are often present and may directly or indirectly interact with one another (Chesson, 1989; Gotceitas and Brown, 1993). Hence, alternate prey can confound and/or direct predator foraging as they tend to buffer consumption of other prey (Czesny et al., 2001; Gilinsky, 1984; Kean-Howie et al., 1988). Because prey size and species-specific vulnerability are important attributes in prey selection by predators (Bannon and Ringler, 1986; Juanes, 1994), we expect that presence of alternate prey would buffer size-structured predation mortality (e.g., Czesny et al., 2001; Hyvärinen and Huusko, 2006).

In the Muskegon River, a tributary to Lake Michigan, USA, the food web [for our purposes] is fairly simple and consists of walleye, Chinook salmon (*Oncorhynchus tshawytscha*) parr, brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*). The former species is the apex predator in the Muskegon River, while the latter three species are prey of walleyes. Foraging by trout and walleyes in rivers has been analyzed to some extent, but further investigation is critical for understanding food web dynamics and ecological ramifications. Krueger et al. (2011) found that survival of Chinook salmon parr (henceforth referred to as "parr") is heavily influenced by predation from walleyes and brown trout. Walleyes were found to consume some parr though they consumed far greater quantities of hatchery-reared brown trout and rainbow trout. Further results indicate that hatchery brown trout, despite their smaller size, consumed more parr as a group than the much larger walleyes. The authors concluded that survival of parr was

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likely controlled by parr growth, alternate prey abundance, and stocking practices for brown trout.

In the present study, we build upon those previous efforts in the Muskegon River to better understand the interactions between and among multiple predator and prey species and the associated ecological consequences. Whereas Krueger et al. (2011) focused on quantifying predation mortality by walleyes and hatchery trout on Chinook salmon parr only; in this paper we analyze prey species and size selection by walleye and brown trout relative to population biomass of all prey combined over a 3 month time period. This approach differs from many other studies of walleye and brown trout forage ecology (e.g., Elliott and Hurley, 2000; Forney, 1974; Porath and Peters, 1997; Ringler, 1979; Rudstam et al., 2015; Swenson and Smith, 1973) that were performed in controlled laboratory settings using only one prey type, or used empirical data on predator consumption of single prey species and ignored biomass and consumption of other available prey.

## Methods

### Study site

The Muskegon River extends 365 km from Houghton Lake in north-central Michigan to Muskegon, Michigan, USA, where it empties into Lake Michigan. The focus of this study was on the (ca.) 22.5 km salmonid nursery section of the Muskegon River, between Croton and Newaygo (Fig. 1; also see Godby et al., 2007). This section of river experiences mean discharge rates of approximately 85 $m^3 s^{-1}$ (range 61 – 261 $m^3 s^{-1}$) from April to June and the substrate is predominantly cobble and gravel, which provides excellent spawning habitat for Chinook salmon and other important sport fishes such as walleye and migratory rainbow trout (Auer and Auer, 1990; Merz et al., 2004; Quinn, 2005).

### Fish abundance, biomass and size

Methods to estimate the abundance and size of parr, minnows (Cyprinidae), walleyes, brown trout and rainbow trout in the Muskegon River from 2004 – 2007 were previously reported by Krueger et al. (2011). A brief description of those methods follows. In 2004, a 2.4 m diameter auger-style smolt trap was used to capture out-migrating Chinook salmon parr from May 6 to June 29. Fish were identified, counted, weighed (nearest 0.1 g) and measured (TL mm) daily. Densities of Chinook salmon parr and cyprinids were estimated for the remaining years (April 19 – June 15, 2005; April 20 – June 7, 2006; May 8 – June 6, 2007) using a barge-style electrofishing unit (3 Amps, 240 V) along daytime 100 m transects, run upstream, at five established reference sites (Carl, 1982). A pass depletion protocol (e.g. Zippin, 1958) was used to estimate parr abundance because they were generally too small (<50 mm) for effective mark and recapture estimates. We sampled each reference site twice a month and sampled most sites five times in a given field season. We weighed and measured a sub-sample of 30 Chinook salmon parr from each electrofishing transect and counted and batch weighed the remaining individuals. Abundances and biomass of Chinook salmon parr and Cyprinidae were estimated for the whole river by multiplying the mean density ($\# \cdot m^{-1}$) of fish at the five reference sites by the mean fish weight (g) on each sampling date, times the total nursery shoreline (22.5 km x 2 sides = 45 km).

Walleyes, hatchery brown trout, and hatchery rainbow trout were collected by barge electrofisher using the aforementioned methods and reference stations in addition to collections with a Smith Root boom-style AC electrofishing boat (3 Amps, 240 V). Boom-electrofishing transects were run in a downstream fashion and were always performed during the day. Upon capture, fish were placed in a 189-liter recirculating live well and counted at the end of each transect. Population abundances of these three species were estimated using data from boom electrofishing transects. Date-specific indices of abundance for brown trout and

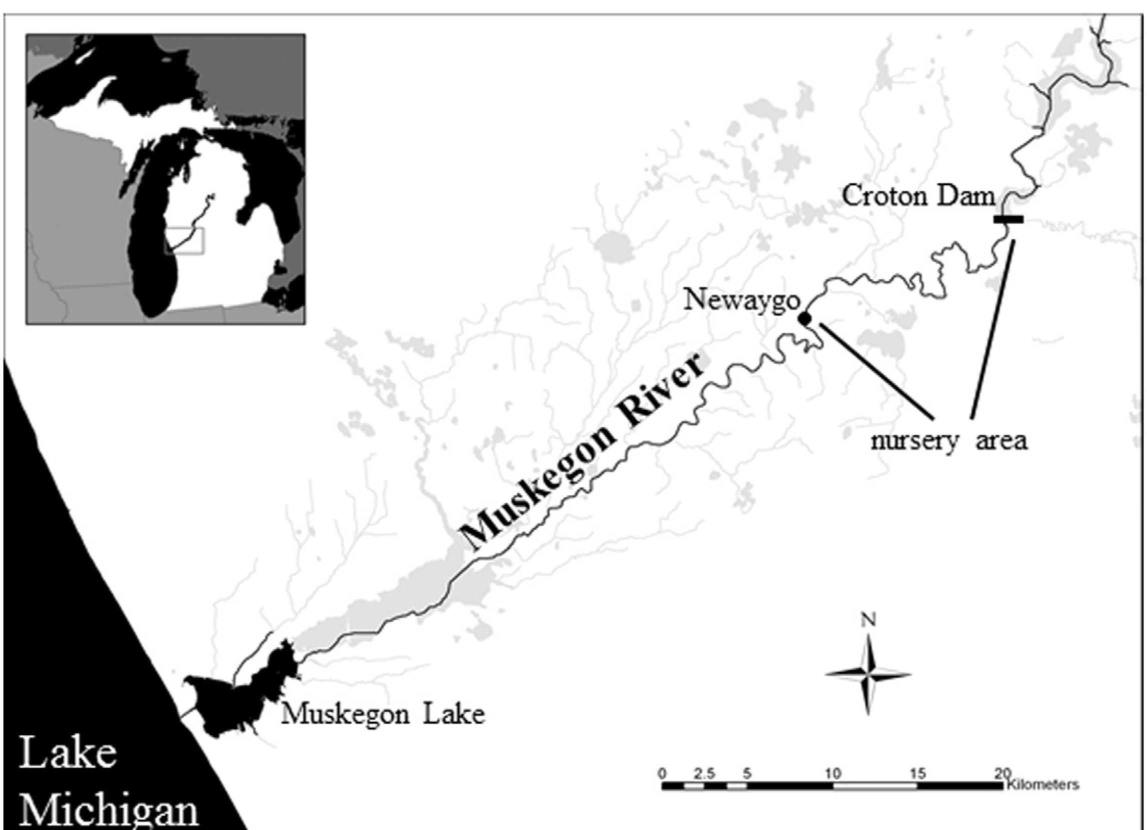


**Fig. 1.** Location of the Chinook salmon parr nursery area within the Muskegon River, Michigan, USA.