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Habitat use by juvenile salmonids in Lake Ontario tributaries-species, age, diel and seasonal effects

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ABSTRACT

Understanding the habitat needs of fish and how these requirements may change seasonally over a 24-h period is important, especially for highly managed sport species. Consequently, we examined the diel and seasonal habitat use of four juvenile salmonid species in streams in the Lake Ontario watershed. For juvenile Atlantic salmon *Salmo salar* and juvenile rainbow trout *Oncorhynchus mykiss*, differences in day versus night habitat use were more profound than seasonal differences. Observed differences in day versus night habitat for all species and age classes were mainly due to the use of less object oriented cover at night and to a lesser extent to the use of slower velocities and smaller substrate at night. Seasonal differences in habitat use were also observed, likely due to increased fish size, and included movement to deeper and faster water and the use of larger substrate and more cover from summer to winter. Different habitat variables were important to individual species. Juvenile Atlantic salmon were associated with higher water velocities, juvenile rainbow trout with larger substrate and more cover, and subyearling Chinook salmon *O. tshawytscha* and subyearling coho salmon *O. kisutch* with small substrate and less cover. Our observations demonstrate that habitat partitioning occurs and likely reduces intraspecific and interspecific competition which may increase the potential production of all four species in sympatry. Consequently, these findings provide important information for resource managers charged with managing, protecting, and enhancing Great Lakes tributaries where all or some of these species occur.

Introduction

It has long been recognized that salmonid populations in streams are governed by available food and space (Chapman, 1966). Moreover, how these resources are partitioned, both intraspecifically and interspecifically, are important for establishing a stream's carrying capacity for salmonids (Quinn, 2005). A considerable amount of research has been directed at the habitat requirements of salmonids in streams (Nickelson et al., 1992; Rodriguez, 1995; Armstrong et al., 2003; Railsback et al., 2005), with an early emphasis on deriving habitat suitability curves (Bovee, 1986) and habitat probability indices (Guay et al., 2000). The emphasis on examining salmonid habitat in streams may be related to the limited amount of stream habitat (2–20%) that is generally usable by salmonids (Allen, 1969), or perhaps that habitat can be manipulated (improved) to correct perceived population bottlenecks (Rosenfeld, 2003). When considering food and space as regulators for stream salmonids, cf. Chapman (1966), the ability to influence space through habitat improvements is more straightforward than influencing food supply. Increasing riffle habitat has been shown to increase both aquatic insect production (Walther and Whiles, 2008) and salmonid parr densities (Cox, 2011). However, it has been pointed out by several authors that both the protection of stream habitat for salmonids (to prevent loss of economic opportunity) and the actual habitat manipulations to address perceived limiting factors, comes at a monetary cost (Armstrong et al., 2003; Rosenfeld, 2003; Reeves et al., 2010). Because of these monetary costs, it is imperative that managers have the best available information on salmonid habitat needs to increase the efficacy of management actions and reduce management costs. Consequently, all of these factors likely contribute to the plethora of habitat studies on stream salmonids as well as the models that have been developed to use these data for predictive purposes (Rosenfeld, 2003).

Several species of non-native migratory salmonids are now naturalized in many Great Lakes tributaries, including those of Lake Ontario (Johnson, 1980; Biette et al., 1981; Carl, 1982; Crawford, 2001). These species include Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and rainbow trout *O. mykiss*. Although natural reproduction of these important game species is welcome in many tributaries of the Great Lakes, naturally reproduced Pacific salmonids may pose an impediment for native Atlantic salmon *Salmo salar* restoration in Lake Ontario (Johnson and Wedge, 1999), the only Great Lake where the species was historically present (Parsons, 1973). Several studies have examined interspecific associations of naturalized Pacific

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salmonids with Atlantic salmon in Lake Ontario tributaries (Stanfield and Jones, 2003; Coghlan et al., 2007; Dietrich et al., 2008; Van Zwol et al., 2012). The general consensus of these studies is that the presence of naturalized Pacific salmonids has a negative impact on the growth and/or survival of juvenile Atlantic salmon. Current fisheries management objectives for Atlantic salmon in Lake Ontario incorporate natural reproduction as a component of the restoration effort (Stewart et al., 2013). In order for natural reproduction of Atlantic salmon to occur and contribute to the population, it is important to understand the habitat needs of the species in the remaining tributaries that support juvenile salmonid production (McKenna and Johnson, 2005). Moreover, the habitat needs of juvenile Atlantic salmon must be placed in context with the habitat needs of sympatric juvenile Pacific salmonids in Lake Ontario tributaries. The complexity of understanding recruitment and landscape effects on naturalized salmonids in the Lake Ontario watershed has led to the development of new models that predict the distribution and densities of these species (Stanfield et al., 2006).

Combining multivariate analyses and hypothesis testing methods provides an objective means to separate habitat conditions with different salmonid species (Johnson and McKenna, 2015). Moreover, the combination of these approaches allows for the identification and specification of both intraspecific and interspecific differences in the suite of habitat conditions. Furthermore, application of these techniques helps to more clearly elucidate driving factors such that a conceptual model of resource partitioning may be developed. These models can have wide application in management of stream habitats and salmonid production across a gradient of habitat conditions. Our objectives were to apply these modelling techniques to an extensive database of juvenile salmonid microhabitat use to examine intraspecific and interspecific differences in habitat use in tributaries of the Lake Ontario watershed. We also sought to identify the most important habitat variable(s) for each species.

Methods

Juvenile salmonid habitat was assessed in four high quality streams in the Lake Ontario watershed. Three streams, Little Sandy Creek, Orwell Brook, and Trout Brook, all drain the Tug Hill Plateau Region of central New York. Two of these streams, Orwell Brook and Trout Brook, discharge into the Salmon River which enters Lake Ontario at Port Ontario, NY (Fig. 1). Little Sandy Creek, discharges directly into Lake Ontario approximately 12 km north of Port Ontario. The fourth stream, Grout Brook, is a tributary of Skaneateles Lake, one of New York's Finger Lakes, within the Lake Ontario watershed. The Tug Hill streams have long been recognized for their ability to produce large numbers of naturally reproduced non-native Pacific salmonids (Johnson and Ringler, 1981; McKenna and Johnson, 2005). Grout Brook is similar in size, gradient, morphology, and habitat quality to the Tug Hill streams. The Tug Hill streams support high densities of juvenile migratory Pacific salmonids and Grout Brook has high densities of juvenile rainbow trout that are the progeny of adults migrating from Skaneateles Lake. Atlantic salmon fry were stocked in each stream during the spring at least one month prior to habitat observations. All four streams have excellent spawning gravels, an approximate 1:1 pool-to-riffle ratio, good riparian cover, and summer water temperatures < 21 °C. A 1:1 pool riffle ratio is generally thought to provide optimal food and cover conditions for juvenile salmonids (Needham, 1940). The most common non-salmonid species present in the Tug Hill streams are blacknose dace (*Rhinichthys atratulus*) and fantail darter (*Etheostoma flabellare*), and in Grout Brook, slimy sculpin (*Cottus cognatus*).

Salmonid habitat analysis was carried out in summer (June–September), fall (October, November), and winter (February) in representative 1–2 km reaches of each stream that were selected after walking about 60% of the entire length of each stream. Sampling was conducted from 2000 to 2010 within the same reach of each stream but individual

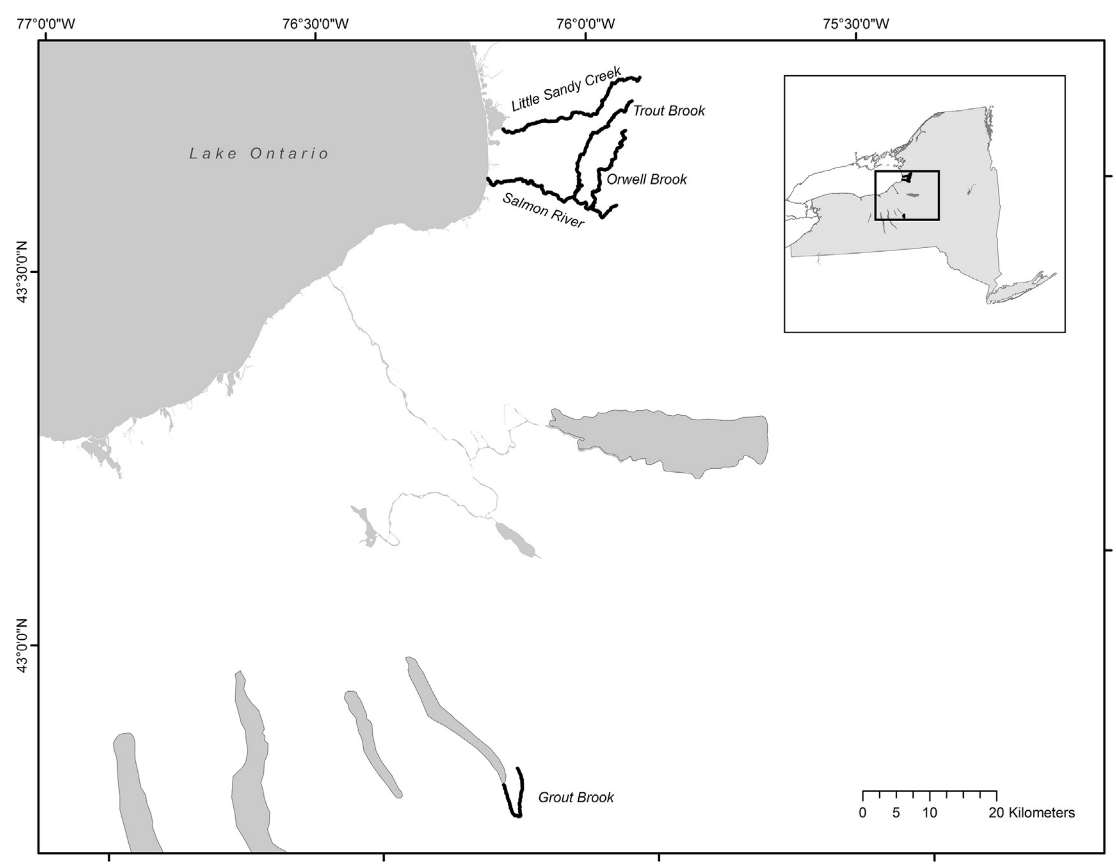

Fig. 1. Locations of study streams in the Lake Ontario watershed.

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