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Habitat use by subyearling Chinook and coho salmon in Lake Ontario tributaries

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ABSTRACT

The habitat use of subyearling Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) was examined in three tributaries of Lake Ontario. A total of 1781 habitat observations were made on Chinook salmon (698) and coho salmon (1083). During both spring and fall, subyearling coho salmon used pool habitat with abundant cover. During spring, principal component analysis revealed that water depth was the most important variable governing subyearling Chinook salmon habitat use. Substrate materials used by Chinook salmon in the spring and coho salmon in the fall were significantly smaller than were present on average within the study reaches. When the two species occurred sympatrically during spring they exhibited similar habitat selection. Although the habitat used by coho salmon in Lake Ontario tributaries was consistent with observations of habitat use in their native range, higher water velocities were less important to Chinook salmon than has previously been reported.

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Introduction

Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) are non-native Pacific salmonids that are stocked annually in Lake Ontario for sport fishing purposes. Although Chinook salmon were first introduced in 1873, annual releases of the two species have only occurred since 1968 (coho salmon) and 1969 (Chinook salmon) with eggs from salmon originating from the Columbia River (Parsons, 1973). Both of these species have established naturalized populations in the Lake Ontario watershed (Johnson, 1980; McKenna and Johnson, 2005). Although aspects of the feeding ecology of juvenile Pacific salmon have been examined in Lake Ontario tributaries (Johnson and Ringler, 1980; Johnson, 2007; Johnson, 2008), little information is known on the habitat use of these species in the Lake Ontario basin. This is surprising because, within their native range, the quality and quantity of stream habitat have been shown to govern smolt production (Chapman and Bjornn, 1969; Nickelson et al., 1992). Moreover, hydrologic regimes differ between streams in the Pacific Northwest and the Great Lakes, and how this variation may affect habitat use is unknown. Within the Great Lakes basin, the most extensive studies have been directed at winter habitat of juvenile coho salmon in Lake Superior tributaries (Ford and Lonzarich, 2000; Healy and Lonzarich, 2000).

One major difference in the early life history of Chinook salmon and coho salmon in Lake Ontario tributaries is stream residency. Both species spawn during the fall with peak spawning of Chinook salmon occurring mid-October, whereas peak spawning of coho salmon occurs in late October and early November. Chinook salmon fry generally begin emerging from the gravel early in May and coho salmon fry begin emerging about one week later. Most subyearling Chinook salmon enter Lake Ontario by late June (i.e., <60 d stream residency), whereas coho salmon remain in natal streams for almost one year. Consequently, there is only about a 30-d period (mid May–mid June) where subyearling Chinook salmon numbers are sufficient to describe accurately habitat use and compare it to subyearling coho salmon. Stream residency time for Chinook salmon and coho salmon in Lake Ontario tributaries is similar to that reported for the species elsewhere in the Great Lakes (Carl, 1982; Ford and Lonzarich, 2000).

The Tug Hill region of New York, which drains into eastern Lake Ontario, has some of the highest quality juvenile salmonid nursery streams in the Great Lakes basin (Wildridge, 1990; McKenna and Johnson, 2005). In terms of juvenile migratory salmonid production, the top producers are Orwell Brook, Trout Brook, and Little Sandy Creek (McKenna and Johnson, 2005). The purpose of this study was to examine the habitat use of naturalized subyearling Chinook salmon and coho salmon in these three Lake Ontario tributaries.

Methods

Subyearling Chinook salmon and coho salmon habitat use was examined during late spring and fall in representative 1.0 km reaches of Little Sandy Creek, Orwell Brook, and Trout Brook in central New York. Orwell Brook and Trout Brook are third-order tributaries of the Salmon River that discharges directly into Lake Ontario at Port Ontario. Little Sandy Creek, also a third order stream, discharges directly into Lake Ontario about 12 km north of the Salmon River. All three of these streams have excellent spawning gravels, good pool-to riffle ratio, good riparian cover, and summer water temperature less than

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Table 1
Number of subyearling Chinook salmon and coho salmon habitat observations, and available habitat observations, by season, in Orwell Brook, Trout Brook, and Little Sandy Creek, New York.

	Chinook	Coho		Available	
	Spring	Spring	Fall	Spring	Fall
Stream					
Orwell Brook	324	234	78	683	626
Trout Brook	217	390	161	445	396
Little Sandy Creek	157	168	62	603	523

21 °C. Chinook salmon habitat was quantified during spring (June), whereas the stream habitat use of subyearling coho salmon was examined during both spring and fall (October).

The spot-electrofishing method was used to capture salmon for habitat analysis. This method, when used while working upstream, is effective in small shallow streams (<12 cm mean depth), where water depth is insufficient for snorkeling (Heggenes et al., 1990; Johnson and Douglass, 2009). At the site of each fish collection, a numbered buoy was placed and the number and species of salmon were recorded. Water depth, water velocity, cover (percent and type), and substrate size were recorded at the site of each buoy. Depth was measured with a calibrated wading rod, and water velocity with a Marsh-McBirney model 201d digital flow meter. The amount of cover and substrate size were both visually estimated. Cover was quantified at 5% increments as total available cover within four fish lengths of the location of the buoy, and recorded as substrate cover, surface turbulence cover, and vegetative cover. Substrate size was determined using a modified Wentworth particle-size scale with values of 1 (detritus), 2 (mud), 3 (silt), 4 (sand), 5 (gravel), 6 (rubble), 7 (boulder) and 8 (bedrock) (Orth et al., 1981). Available habitat within each stream reach was quantified from 25 transects across the stream about 40 m apart. Water depth, water velocity, amount of cover, and substrate size were recorded at stations spaced 0.25 m apart along each transect.

Variables for salmonid habitat use and available habitat were not normally distributed. A Kruskal–Wallis one-way non-parametric analysis of variance (ANOVA) was used to test for differences in habitat variables between the species and available habitat, and to compare differences in the types of cover used based on ranked groups. Dunn's pair-wise comparison tests which corrects for multiple comparisons were used to determine which ranked groups were different (Zar, 2010). Principal component analysis (PCA) was used to determine the ordination of salmonid habitat and available habitat (ter Braak and Smilauer, 2002). A significance level of $\alpha = 0.05$ was used for all comparisons.

Results

A total of 698 habitat observations were made on subyearling Chinook salmon with 46% being made in Orwell Brook, 31% in Trout Brook, and 23% in Little Sandy Creek (Table 1). Most (72%) of the observations on subyearling coho salmon habitat occurred during spring. Available habitat in each stream was quantified from 1309 observations in Orwell Brook, 1126 observations in Little Sandy Creek, and 841 observations in Trout Brook (Table 1).

Subyearling Chinook salmon occupied areas that were significantly deeper with smaller size substrate materials than were available, on average, within the study reach of each of the three streams during spring (Table 2, Fig. 1). Associations between the other two habitat variables examined, velocity and cover, were low or inconsistent among the streams for Chinook. Subyearling Chinook salmon used areas that had faster velocities compared to available velocities in Orwell Brook, but were found to use slower velocities compared to available velocities in Trout Brook. Only in Trout Brook were subyearling Chinook salmon found to use more cover than was available on average within the study reach (Table 2).

During spring, subyearling coho salmon always occupied areas that were significantly deeper and slower, with more cover and smaller size substrate materials than were available in the study

Table 2
Statistical analysis of seasonal (S = Spring, F = Fall) habitat use including cover type (%) for coho and Chinook salmon and available habitat (A) for Little Sandy Creek (df = 4,2028), Orwell Brook (df = 4,1281), and Trout Brook (df = 4,1404). Analysis done on ranked groups but group means are shown for comparative purposes. The sample size for each group is stated in Table 1. Values followed by an asterisk (*) significantly differ ($p < 0.05$).

	Depth (cm)	Velocity (cm/s)	Substrate	Total cover (%)	Submergent cover	Overhanging cover
Little Sandy Creek						
Coho-S vs. A	31.0 v 14.2*	0.12 v 0.21*	5.6 v 6.2*	18.9 v 9.2*	9.7 v 9.2	9.3 v 0.27*
Chn-S vs. A	27.2 v 14.2*	0.15 v 0.21	5.8 v 6.2*	9.3 v 9.2	4.6 v 9.2*	4.3 v 0.27*
Coho-S vs. Chn-S	31.0 v 27.2*	0.12 v 0.15	5.6 v 5.8*	18.9 v 9.3*	9.7 v 4.6*	9.3 v 4.3*
Coho-F vs. A	28.6 v 22.8*	0.1 1 0.34*	5.9 v 6.1*	13.3 v 9.8*	8.2 v 6.2*	4.8 v 0.52*
Coho S vs. F	31.0 v 28.6	0.12 v 0.11	5.6 v 5.9*	18.9 v 13.3*	9.7 v 8.2*	9.3 v 4.8*
A-S vs. A-F	14.2 v 22.8*	0.21 v 0.34*	6.2 v 6.1*	9.2 v 9.8*	9.2 v 6.2*	0.27 v 0.52
p	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F stat	210	14.2	67.5	45.2	29.8	58.7
Orwell Brook						
Coho-S vs. A	30.9 v 12.4*	0.15 v 0.19*	5.9 v 6.2*	14.9 v 8.5*	4.3 v 4.9	6.3 v 1.1*
Chn-S vs. A	18.0 v 12.4*	0.23 v 0.19*	5.8 v 6.2*	7.6 v 8.5	4.2 v 4.9	3.3 v 1.1*
Coho-S vs. Chn-S	30.9 v 18.0*	0.15 v 0.23*	5.9 v 5.8	14.9 v 7.6*	4.3 v 4.2	6.3 v 3.3*
Coho-F vs. A	41.8 v 16.2*	0.16 v 0.29*	6.1 v 6.1	23.9 v 10.2*	12.2 v 6.6*	9.7 v 0.98*
Coho S vs. F	30.9 v 41.8*	0.15 v 0.16	5.9 v 6.1*	14.9 v 23.9*	4.3 v 12.2*	6.3 v 9.7*
A-S vs. A-F	12.4 v 16.2*	0.19 v 0.29*	6.2 v 6.1	8.5 v 10.2*	4.9 v 6.6*	1.1 v 0.98
p	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F stat	194	17.9	51.8	47.9	37.8	56.9
Trout Brook						
Coho-S vs. A	22.9 v 12.4*	0.14 v 0.19*	5.7 v 6.1*	11.5 v 6.3*	5.1 v 3.8*	5.2 v 0.82*
Chn-S vs. A	19.5 v 12.4*	0.12 v 0.19*	5.7 v 6.1*	8.2 v 6.3*	5.4 v 3.8*	2.6 v 0.82*
Coho-S vs. Chn-S	22.9 v 19.5*	0.14 v 0.12	5.7 v 5.7	11.5 v 8.2*	5.1 v 5.4	5.2 v 2.6*
Coho-F vs. A	35.3 v 18.9*	0.14 v 0.31*	6.0 v 6.1	19.1 v 6.9*	10.0 v 3.8*	6.9 v 1.2*
Coho S vs. F	22.9 v 35.3*	0.14 v 0.14	5.7 v 6.0*	11.5 v 19.1*	5.1 v 10.0*	5.2 v 6.9
A-S vs. A-F	12.4 v 18.9*	0.19 v 0.31*	6.1 v 6.1	6.3 v 6.9*	3.8 v 3.8	0.82 v 1.2
p	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F stat	95.7	19.1	50	29.3	24.9	38.6