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Effect of stocking sub-yearling Atlantic salmon on the habitat use of sub-yearling rainbow trout☆

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ABSTRACT

Atlantic salmon (*Salmo salar*) restoration in the Lake Ontario watershed may depend on the species' ability to compete with naturalized non-native salmonids, including rainbow trout (*Oncorhynchus mykiss*) in Lake Ontario tributaries. This study examined interspecific habitat associations between sub-yearling Atlantic salmon and rainbow trout as well as the effect of salmon stocking on trout habitat in two streams in the Lake Ontario watershed. In sympatry, Atlantic salmon occupied significantly faster velocities and deeper areas than rainbow trout. However, when examining the habitat use of rainbow trout at all allopatric and sympatric sites in both streams, trout habitat use was more diverse at the sympatric sites with an orientation for increased cover and larger substrate. In Grout Brook, where available habitat remained constant, there was evidence suggesting that trout may have shifted to slower and shallower water in the presence of salmon. The ability of sub-yearling Atlantic salmon to affect a habitat shift in rainbow trout may be due to their larger body size and/or larger pectoral fin size. Future studies examining competitive interactions between these species during their first year of stream residence should consider the size advantage that earlier emerging Atlantic salmon will have over rainbow trout.

Introduction

Prior to 1900 Atlantic salmon (*Salmo salar*) was the dominant migratory salmonid species in Lake Ontario (Webster, 1982). The decline of Atlantic salmon in the Lake Ontario basin coincided with increased European settlement (Huntsman, 1944). Several causal factors have been implicated in the decline, and eventual extirpation of salmon by the turn of the century. Those factors that have been cited most often include severing access to natal streams (mill dams), overfishing, and deforestation (Parsons, 1973). Even before Atlantic salmon became extirpated, management agencies began experimenting with introduction of Pacific salmonids into Lake Ontario with the first release of rainbow trout (*Oncorhynchus mykiss*) occurring about 1878 (MacCrimmon and Gots, 1972). Continued release of rainbow trout (steelhead) established naturalized populations of the species in several tributaries of Lake Ontario (MacCrimmon and Gots, 1972). By the 1970s juvenile rainbow trout (steelhead) were the numerically dominant salmonid in most of New York's higher quality tributaries that entered Lake Ontario (Johnson and Ringler, 1981).

Expanding populations of sea lamprey (*Petromyzon marinus*) in the Great Lakes beginning in the 1930s led to the decimation of large fish species including lake trout (*Salvelinus namaycush*) (Christie and Goddard, 2003). It was not until sea lamprey control was achieved in Lake Ontario in the 1960s that management agencies began restoration efforts for native species such as lake trout as well as a new round of Pacific salmonid introductions (Parsons, 1973). However, it was not until 1987 that efforts were initiated to reestablish Atlantic salmon in Lake Ontario (Stanfield and Jones, 2003). The delay in attempting to restore Atlantic salmon in Lake Ontario was likely due to the overwhelming success of the Pacific salmon introduction program and recognition that wild salmon populations were declining globally in spite of ongoing restoration efforts (Parrish et al., 1998).

Renewed binational interest in restoring Atlantic salmon in Lake Ontario led to several studies that addressed anticipated biological impediments that could impact successful reintroduction. One of the major biological impediments identified was the high densities of naturalized Pacific salmonid juveniles that were present in historic Atlantic salmon nursery streams (Jones and Stanfield, 1993). Because of similar juvenile life history, habitat requirements, and current levels of juvenile densities in Lake Ontario tributaries, the non-native species of most concern was rainbow trout (Johnson and Wedge, 1999). Stanfield and Jones (2003) found that habitat conditions greatly influenced competitive interactions between juvenile Atlantic salmon and rainbow trout in tributaries along the northern shoreline of Lake Ontario. Dietrich et al. (2008) examined the effects of stocking high and low densities of Atlantic salmon on abundance and growth of sub-yearling rainbow trout in two Lake Ontario tributaries and concluded that salmon stocking may impact trout. In work done in a Finger Lake tributary in New York that is within the Lake Ontario watershed, Coghlan and Ringler (2005) found that, as stream temperatures increase, Atlantic salmon became increasingly

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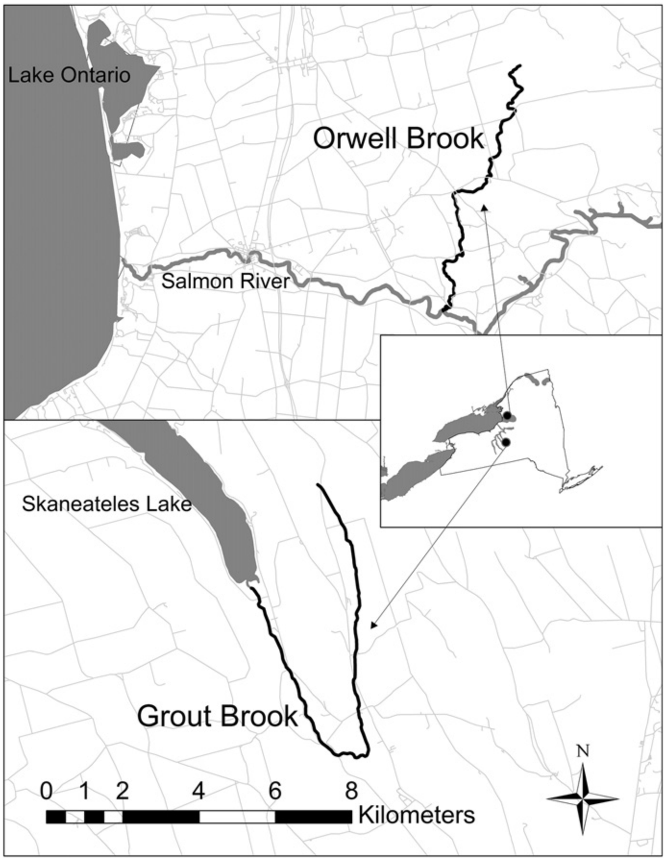

Fig. 1. Location of allopatric and sympatric sites in Grout Brook and Orwell Brook in Central New York.

favored over rainbow trout in terms of competitive interactions. Trophic interactions between the two species in Lake Ontario tributaries are less well known. However, Johnson and Waldt (2014) provided evidence that juvenile rainbow trout may subtly shift to a more drift feeding strategy in sympatry with juvenile Atlantic salmon.

Habitat studies on juvenile Atlantic salmon and rainbow trout in sympatry are rare. Hearn and Kynard (1986) observed that although yearling Atlantic salmon and rainbow trout used similar habitat in tributaries of the White River, Vermont, sub-yearling salmon occupied deeper and swifter water than sub-yearling trout. Stanfield and Jones (2003) found that densities of sub-yearling Atlantic salmon were generally higher at sites with greater abundance of rock cover and lower

Table 3
Mean depth, velocity, substrate size, and percent total cover (± standard error) of sub-yearling rainbow trout (RBT), sub-yearling Atlantic salmon (ATS), and available habitat (AH) during pre-stocking, 2-week post stocking, and 9-week post stocking periods in Orwell Brook and Grout Brook. Orwell Brook-Tubbs, Grout Brook-Lower, and Grout Brook-Mill were sympatric sites and Orwell Brook-Orwell and Grout Brook-Scott were allopatric sites.

	Depth (cm)	Velocity (cm/s)	Substrate	Total Cover (%)
Orwell Brook-Tubbs				
RBT pre-stocking	15.7 ± 0.5	29.6 ± 1.1	6.1 ± 0.01	9.3 ± 0.5
RBT week 2 post	17.1 ± 0.5	13.2 ± 0.5	6.1 ± 0.02	11.1 ± 0.4
RBT week 9 post	25 ± 1.4	41.4 ± 2.7	6.1 ± 0.03	11.1 ± 0.9
ATS pre-stocking	–	–	–	–
ATS week 2 post	16 ± 0.7	18.6 ± 1.1	6.2 ± 0.02	11.9 ± 0.6
ATS week 9 post	22.4 ± 1.2	68.9 ± 3.7	6.2 ± 0.02	10.9 ± 0.8
AH pre-stocking	15.6 ± 0.9	16.8 ± 1.1	6 ± 0.03	5.4 ± 0.6
AH week 2 post	11.5 ± 0.7	12.8 ± 0.9	6.2 ± 0.02	4.3 ± 0.5
AH week 9 post	19.2 ± 0.8	44.5 ± 2.2	6.1 ± 0.02	4.9 ± 0.5
Orwell Brook-Orwell				
RBT pre-stocking	14 ± 0.4	25 ± 1.2	6.1 ± 0.02	11 ± 0.6
RBT week 2 post	10.5 ± 0.4	11.5 ± 0.7	6.1 ± 0.02	8.8 ± 0.4
RBT week 9 post	20.7 ± 0.6	40.2 ± 2.7	6.1 ± 0.02	12.9 ± 0.7
AH pre-stocking	10.9 ± 0.5	21.9 ± 1.4	6.1 ± 0.03	6.7 ± 0.7
AH week 2 post	9.1 ± 0.8	7.5 ± 0.7	6.2 ± 0.03	4.3 ± 0.5
AH week 9 post	21.7 ± 0.6	55.9 ± 2.9	6.1 ± 0.02	8.1 ± 0.5
Grout Brook-Lower				
RBT pre-stocking	18.8 ± 0.5	34.9 ± 1.2	5.7 ± 0.03	7.4 ± 0.5
RBT week 2 post	19 ± 0.6	36.5 ± 1.2	5.7 ± 0.03	8.7 ± 0.4
RBT week 9 post	21.4 ± 0.7	31.0 ± 1.3	5.9 ± 0.03	8.5 ± 0.4
ATS pre-stocking	–	–	–	–
ATS week 2 post	18.9 ± 0.9	45.8 ± 2.5	5.9 ± 0.03	8.8 ± 0.7
ATS week 9 post	19.7 ± 1.5	52.9 ± 3.1	6 ± 0.03	7.3 ± 0.8
AH pre-stocking	20.4 ± 1.3	24.4 ± 1.7	5.7 ± 0.05	4.4 ± 0.6
AH week 2 post	17.9 ± 1	26.4 ± 1.9	5.6 ± 0.05	4.1 ± 0.5
AH week 9 post	17.9 ± 0.9	26.9 ± 2	5.7 ± 0.05	3.5 ± 0.4
Grout Brook-Mill				
RBT pre-stocking	15.2 ± 0.5	35.1 ± 1.9	6.2 ± 0.02	10.2 ± 0.8
RBT week 2 post	17.1 ± 0.5	36.6 ± 1.3	6.1 ± 0.02	11.9 ± 0.6
RBT week 9 post	19.6 ± 0.7	30.3 ± 1.8	6.2 ± 0.03	13 ± 0.8
ATS pre-stocking	–	–	–	–
ATS week 2 post	16.9 ± 0.4	42.5 ± 1.2	6.2 ± 0.01	14.2 ± 0.6
ATS week 9 post	16.8 ± 0.6	47.9 ± 3.7	6.2 ± 0.02	13.9 ± 1.3
AH pre-stocking	14.4 ± 0.6	28 ± 1.7	6.2 ± 0.02	7.4 ± 0.8
AH week 2 post	13.3 ± 0.6	26.1 ± 1.8	6.1 ± 0.02	7.3 ± 0.9
AH week 9 post	13.4 ± 0.6	30.2 ± 2.2	6.1 ± 0.03	7.3 ± 0.8
Grout Brook-Scott				
RBT pre-stocking	12.9 ± 0.3	21.6 ± 1	6.1 ± 0.02	9.1 ± 0.6
RBT week 2 post	12.6 ± 0.6	24.7 ± 1.3	6.2 ± 0.04	10.1 ± 0.5
RBT week 9 post	15.3 ± 0.7	36.3 ± 2	5.9 ± 0.03	15.9 ± 1.3
AH pre-stocking	11.3 ± 0.7	16.1 ± 1.1	5.9 ± 0.04	6.5 ± 0.6
AH week 2 post	10.5 ± 0.6	12.1 ± 0.9	5.9 ± 0.04	6.5 ± 0.7
AH week 9 post	13.9 ± 0.8	19.9 ± 1.9	5.9 ± 0.04	5.5 ± 0.7

Table 1
Number of habitat observations on sub-yearling Atlantic salmon and sub-yearling rainbow trout in allopatric and sympatric sites in Orwell Brook, New York.

Orwell Brook						
	Sympatric sites			Allopatric sites		
	1 week pre-salmon stocking	2 weeks post salmon stocking	9 weeks post salmon stocking	1 week pre-salmon stocking	2 weeks post salmon stocking	9 weeks post salmon stocking
Atlantic salmon 0+	–	209	150	–	–	–
Rainbow trout 0+	327	313	145	243	310	97

Table 2
Number of habitat observations on sub-yearling Atlantic salmon and sub-yearling rainbow trout in allopatric and sympatric sites in Grout Brook, NY.

Grout Brook									
	Sympatric sites						Allopatric sites		
	Lower	Mill	Lower	Mill	Lower	Mill	1 week pre-salmon stocking	2 weeks post salmon stocking	9 weeks post salmon stocking
Atlantic salmon 0+	–	–	202	128	143	68	–	–	–
Rainbow trout 0+	166	348	220	363	152	254	225	215	133