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Strain-specific survival and growth of juvenile Atlantic salmon in Central New York tributaries

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ABSTRACT

Reintroduction of Atlantic salmon *Salmo salar* in the Lake Ontario watershed represents a historical challenge for fisheries managers dating to the late 1800s. To assess the feasibility for reintroduction, strain-specific differences in survival and growth was evaluated in central New York tributaries in 2014 and 2015. Fry of Lake Memphremagog and Sebago Lake strains were stocked at target densities of 100 fry/100 m^2 in tributaries within the Ontario Drumlins and Fish Creek regions. Salmon abundance, density, and survival was estimated at each stocking location. Standardized mass-specific growth rate (G_s) and absolute growth in length (G_L) of age-0 parr and age-1 pre-smolts was evaluated with two-way analysis of variance. For both strains, survival was largely site-dependent in the Drumlins region and stream-dependent in the Fish Creek region. The Lake Memphremagog strain exhibited faster growth, suggesting that physiological adaptations of this strain make it a more suitable candidate for reintroduction in the region when the source is available. However, limited availability of the Lake Memphremagog strain may direct future efforts to employ the more widely-evaluated and available Sebago Lake strain.

Introduction

Atlantic salmon *Salmo salar* is a native member of the fish communities in New York and Lake Ontario, the latter of which once supported the world's largest indigenous freshwater population (Webster, 1982). However, following European settlement, the construction of dams, pollution, overexploitation, deforestation, and habitat degradation in tributaries (Huntsman, 1944; Parsons, 1973; MacCrimmon, 1977; Webster, 1982; Coghlan, 2004), in addition to thiamine deficiency related to predation on invasive Alewife *Alosa pseudoharengus* (Smith, 1970; Ketola et al., 2000; Madenjian et al., 2008), contributed to significant declines in the Atlantic salmon population. Despite propagation efforts, these impediments resulted in extirpation of Atlantic salmon from Lake Ontario by the 1890s (Parsons, 1973; Webster, 1982; Dunfield, 1985) with the last wild individual taken from New York waters in 1898 (Smith, 1985). A self-sustaining population has not since been documented.

The potential for reestablishing a native predatory fish and enhancing recreational opportunities in Lake Ontario and New York has grown in recent years, sparking the interest of angler groups (Murphy, 2003), as well as academic, state, and federal agencies (McKenna and Johnson, 2005). This objective has led to the consideration of many factors that may improve reintroduction potential, with the genetic strain of origin emerging as a leading characteristic of interest (Murphy, 2003; Dimond and Smitka, 2005; Millard, 2005). Individuals of the original Lake Ontario strain no longer exist (COSSARO, 2011), and recent assessments have included the stocking and evaluation of other strains to identify a potential candidate for reintroduction into Lake Ontario and its tributaries (reviewed in Dimond and Smitka, 2005). The extent of strain characteristics often considered and evaluated represents a variety of morphological, physiological, and behavioral traits. Strains that exhibit potamodromy, or permanent freshwater residency (Blair, 1938; Parsons, 1973; Webster, 1982), inlet-spawning tendencies (Greig et al., 2003; Nemeth et al., 2003), and originate from watersheds of relatively similar habitat (Armstrong et al., 2003) have gained particular interest as potential candidates. A highly-competitive strain of Atlantic salmon is required for stocking and reintroduction to tributaries of Lake Ontario which are now plentiful with introduced salmonids, particularly Rainbow Trout (*Oncorhynchus mykiss*), which may compete for space and resources (Riley and Power, 1987; Hearn and Kynard, 1986; Johnson and McKenna, 2015), and may influence fitness (Houde et al., 2015a), growth (Coghlan et al., 2007; Van Zwol et al., 2012a, 2012b), and behavior (Scott et al., 2005). While estimates of survival and growth of stocked salmonids across southern Lake Ontario tributaries are relatively sparse (Coghlan et al., 2007), significant differences among Atlantic salmon strains have been reported within the region (Murphy, 2003; Dimond and Smitka, 2005; Millard, 2005; Van Zwol et al., 2012a; Houde et al., 2015a).

Life history variability among strains offers a unique opportunity to assess salmon success in Lake Ontario tributaries to select the most

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suitable candidate for reintroduction. The objective of this study was to evaluate survival and growth rates of two strains of Atlantic salmon in central New York tributaries. In a region abundant with biotic and abiotic obstacles, successful reintroduction may rely on strain-specific differences in survival and growth (Murphy, 2003). By selecting comparable tributary conditions for both strains, we assumed the strains would exhibit similar survival and growth tendencies following stocking.

Methods

Study sites

Field studies were conducted in tributaries of Lake Ontario and Oneida Lake, NY in 2014 and 2015. Lake Ontario tributaries, including Eightmile Creek, Rice Creek, and Little Creek, were located in the Ontario Drumlins region (Drumlins) along the southeastern lakeshore west of Oswego, NY (Wildridge, 1990; Fig. 1). The Drumlins region which contains direct tributaries to Lake Ontario has deep, calcareous, well-drained soils, with extensive agricultural development and relatively sparse forests (Coghlan et al., 2007). Tributaries to Oneida Lake were located in the Fish Creek watershed, a major source to Oneida Lake, which ultimately discharges into Lake Ontario via the Oswego River. Study tributaries included Furnace Creek, Mad River, and Point Rock Creek. The watershed is located within the Tug Hill Uplands region of New York, a heavily forested area with localized agriculture and minimal urbanization (Murphy, 2003; Coghlan et al., 2007). Regional tributaries historically provided migration routes and spawning habitat for Atlantic salmon (Dunfield, 1985), while Oneida Lake may have supported a small population or provided summer refuge for salmon migrating from Lake Ontario (Webster, 1982).

Stocking and sampling

Fry were stocked at a target density of 100 fish/100 m^2 at four or six sites in each tributary in June of both years. Sites were 100 m in length and adjacent sites were separated by ≥200 m. Two strains of Atlantic salmon were evaluated, the Lake Memphremagog (Magog) and Sebago Lake strains. Prior to stocking, resource constraints directed the Magog strain to be reared at the Morrisville State College Aquaculture Facility, Morrisville, NY while the Sebago strain was reared at the Fish Creek Atlantic Salmon Club Hatchery, McConnellsville, NY. Study sites were paired to reduce habitat variability between strains and each site was

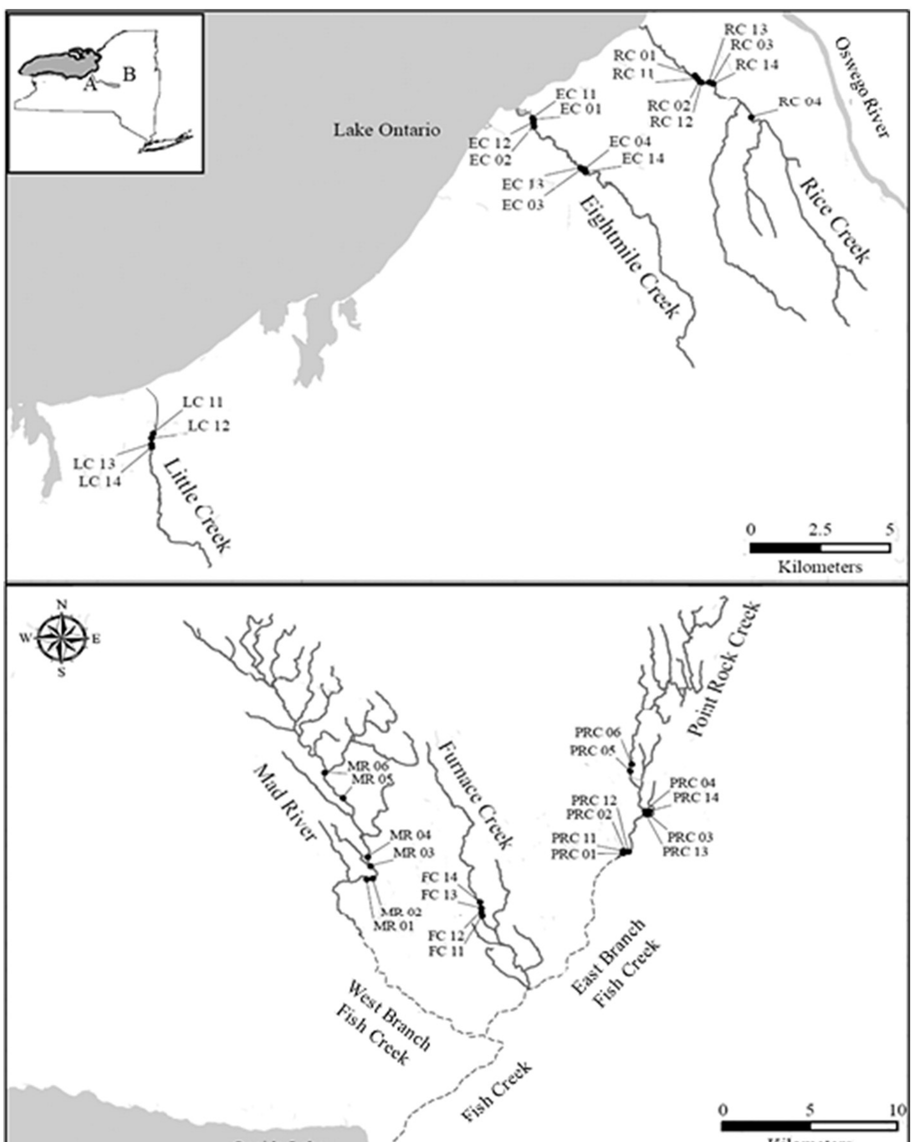

Fig. 1. Atlantic salmon survival and growth study sites in Ontario Drumlins (A; Lake Ontario) and Fish Creek (B; Oneida Lake) region, NY tributaries. Sites identifications beginning with "0" were evaluated in 2014; identifications beginning with "1" were evaluated in 2015.

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