Letter

Interactions between naturalised exotic salmonids and reintroduced Atlantic salmon in a Lake Ontario tributary


Abstract – Atlantic salmon (Salmo salar) was once native to Lake Ontario, however, its numbers rapidly declined following colonisation by Europeans and the species was extirpated by 1896. Government agencies surrounding Lake Ontario are currently undertaking a variety of studies to assess the feasibility of reintroducing Atlantic salmon. We released hatchery-reared adult Atlantic salmon into a Lake Ontario tributary to examine spawning interactions between this species and fall-spawning exotic salmonids found in the same stream. Chinook salmon, coho salmon and brown trout were observed interacting with spawning Atlantic salmon in nearly one-quarter of our observation bouts, with chinook salmon interacting most frequently. Whereas a previous investigation found that chinook salmon caused elevated agonistic behaviour and general activity by spawning Atlantic salmon, the present study found that interspecific courtship was the most common form of exotic interaction with spawning Atlantic salmon. In particular, we observed precocial male Chinook salmon courting female Atlantic salmon and defending the female against approach by male Atlantic salmon. We discuss the potential implications of these interactions on the Lake Ontario Atlantic salmon reintroduction programme.

Un resumen en español se incluye detrás del texto principal de este artículo.

Introduction

Atlantic salmon (Salmo salar) was once an abundant native species in Lake Ontario (Netboy 1968; MacCrimmon 1977; Dunfield 1985; Smith 1995; Parrish et al. 1998). However, its numbers rapidly declined following colonisation of the region surrounding the lake by Europeans, and the species was extirpated from the lake by 1896. Extirpation of Atlantic salmon was likely caused by several factors, including over-exploitation, habitat destruction and erection of barriers to spawning migration (Netboy 1968; MacCrimmon 1977; Dunfield 1985; Smith 1995; Parrish et al. 1998). Sporadic attempts to reintroduce Atlantic salmon to Lake Ontario between 1880 and 1980 were unsuccessful in establishing a self-sustaining population, likely because the causes of the species decline and extirpation had not been removed.

Beginning in the 1960s and continuing to the present, government agencies bordering Lake Ontario began intensively stocking Pacific salmonids, such as chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch), and rainbow trout (O. mykiss) and a European salmonid, brown trout (S. trutta) to enhance the recreational fishery (Crossman & Cudmore 2000a,b, 2000c; Crawford 2001). Presently, roughly 3 million individuals of these species are released into Lake Ontario tributaries annually (Crawford 2001). All of these species reproduce and spend at
least a portion of their juvenile stage of development in Lake Ontario tributaries (Rand et al. 1992; Stewart et al. 1999; Hickey 2002; Stewart & Shaner 2002).

Establishment of spawning populations of exotic salmonids suggests that habitat in Lake Ontario and its tributaries are again appropriate for Atlantic salmon because their habitat requirements are similar to those of the naturalised exotics (Glova & Field-Dodgson 1995; Fausch 1998; Harwood et al. 2002; Armstrong et al. 2003). Nonetheless, recent efforts to reintroduce Atlantic salmon to Lake Ontario have yet to produce a self-sustaining population (Stewart & Shaner 2002).

Introduced species can have profound effects on native species (e.g., Tyler et al. 1998; Lawler et al. 1999; Harig et al. 2000; Levin et al. 2002). Recently, Scott et al. (2003) found experimental evidence suggesting that non-native salmonids have negative impacts on Atlantic salmon, impacts that could affect reintroduction of this species to Lake Ontario. For example, during spawning, Atlantic salmon were more active, spawned later and had higher postspawning mortality when chinook salmon were present in experimental enclosures compared with when they were absent (Scott et al. 2003). In the present study, we released hatchery-reared adult Atlantic salmon into a Lake Ontario tributary that is known to have spawning populations of exotic salmonids. Our objective was to determine the frequency and impact of the interactions observed in Scott et al. (2003) in a free ranging population.

**Methods**

We obtained 48 female (mean length = 60.7 cm; SD = 3.92) and 17 male (mean length = 54.3 cm; SD = 9.49) Atlantic salmon from the Ontario Ministry of Natural Resources Fish Culture operations (Normandale, Ontario, Canada). All fish were marked with a 95 mm long × 1.5 mm diameter orange tag that was visible to observers on the stream bank. We released the fish on 25 October 2000 at three locations within a 1.5 km section of Wilmot Creek (located c. 75 km east of Toronto, Ontario, Canada) 6.5 km upstream from the mouth at Lake Ontario (44°02’30” latitude, 78°36’56” longitude). This section of stream has a mean (SD) width of 6.32 m (1.32) and depth of 36.6 cm (18.6) making all spawning areas highly visible to observers on the stream bank. We conducted walking surveys of the 1.5 km stream section at 2 to 4-day intervals beginning on 28 October 2000. During the surveys, we recorded the location of newly constructed nests (depressions constructed in the stream bottom by females) by attaching flagging tape to vegetation on the stream bank. We returned to all new nests (those with adult salmon present in them) at the end of each survey to determine visually which species was using it. Chinook salmon, coho salmon and brown trout also nest in this section of Wilmot Creek at about the same time as Atlantic salmon and the species are easily distinguishable based on size, shape and colouration. We also made 20-min continuous observations of nesting Atlantic salmon, recording all interactions with all other non-native salmon present. In particular, we focused on aggressive interactions (chasing, biting, fighting) that interfered with Atlantic salmon spawning, behaviours that Scott et al. (2003) found impacted adult Atlantic salmon activity, spawning time and postspawning mortality. We conducted our surveys and observations until no evidence of nesting activity (females observed constructing nests or consorting with males during a survey) by Atlantic salmon had ceased. Fish in this study were not individually marked, so it is possible that individual behavioural observations do not represent different individuals.

**Results and discussion**

We identified a total of 74 Atlantic salmon nests over the duration our survey. Females initiated nest construction on 5 November 2000 and we found no evidence of new nest construction later than 8 December 2000 (Fig. 1). Spawning activity (number of females actively constructing redds or consorting with a male salmon) was highest on 14 November and we also observed a second smaller peak in activity on 29 November 2000. We conducted 20-min continuous observation bouts on 43 female Atlantic salmon (860 min of observation time), which accounted for c. 4.4% of daylight hours during the total breeding period on Wilmot Creek (assuming an average of 9.5 h of daylight per day over the 34 survey days).

![Fig. 1. Number of new Atlantic salmon nests observed during each survey of our 1500 m study section of Wilmot Creek, Ontario.](image-url)
We observed three other species of fall-spawning salmonids in the surveyed stream section: chinook salmon, coho salmon and brown trout. The other species present were observed to interact with nesting Atlantic salmon during 23% (10 of 43) of our observation bouts.

Chinook salmon spawning activity had peaked prior to release of the Atlantic salmon into the stream, but several spawning pairs and some unpaired males (sex identified by observing males perform stereotypical courtship behaviours) were present in the surveyed stream section. Although chinook salmon spawning in Wilmott Creek tend to be larger than the Atlantic salmon used in this study (Scott et al. 2003), the male chinook salmon that we observed appeared to be similar in size to the Atlantic salmon. Chinook salmon accounted for seven of the 10 observation bouts in which exotics interacted with spawning Atlantic salmon. Of those, six involved courtship of a female Atlantic salmon by a male chinook salmon. In addition to courting, the male chinook repeatedly chased away other Atlantic salmon that came close to the female. During the remaining (seventh) observation bout, a male chinook salmon behaved aggressively towards several nearby Atlantic salmon while a female Atlantic salmon was constructing a nest. However, we did not observe courtship during this bout. In all seven bouts, a male chinook salmon was aggressive towards Atlantic salmon that approached nesting female Atlantic salmon. One male brown trout was also observed to court an Atlantic salmon female from her redd. Courtship of Atlantic salmon females by exotic salmonids could have several consequences for the Atlantic salmon reintroduction programme. For example, spawning could be delayed or prevented altogether or result in hybridisation.

In the present study, the predominant form of exotic impact was interspecific mate guarding and courtship whereas in the previous study on this system (Scott et al. 2003) the predominant effect was disruption of Atlantic salmon spatial/social structure. The difference between the results of the two studies is likely a result of using pairs of chinook salmon in the enclosure study of Scott et al. (2003). In the present study there were very few breeding pairs of chinook salmon left when the Atlantic salmon were released into the Wilmott Creek site. Instead, there were several unpaired precocial males present that were highly motivated to spawn.

The results of this study provide evidence of the potential impact of introduced salmonids on the reintroduction of Atlantic salmon to Lake Ontario specifically and on the potentially devastating effect that these non-native species could have on declining and threatened native populations of Atlantic salmon on the east coast of North America. Given that there are no physical barriers to invasion of east coast Atlantic salmon rivers by chinook salmon (Hickey 2002), this study is a warning of potential negative impacts in extant wild Atlantic salmon populations.

**Resumen**

1. *Salmo salar* es nativo del Lago Ontario (Canadá). Su número decayó rápidamente después de la colonización de los Europeos hasta su extinción en 1896. Las agencias gubernamentales que rodean al Lago Ontario han desarrollado numerosos estudios para evaluar la posibilidad de re-introducirlo. 2. Con adultos de *S. salar* criados en granja repoblamos un afluente del Lago Ontario para examinar interacciones reproductivas entre esta especie y otros salmónidos exóticos de reproducción otoñal previamente introducidos en este río durante los años 60. Observamos interacciones con la puesta de *S. salar* por parte de Oncorhynchus tshawytscha, *O. kisutch* y *Salmo trutta* al menos en un cuarto del total de observaciones con *O. tshawytscha* interaccionando más frecuentemente. 3. Mientras que una investigación anterior encontró que *O. tshawytscha* causa una mayor actividad general y comportamiento agonístico en *S. salar*, este estudio encontró que el cortejo inter-específico fue la forma más común de interacción exótica durante la puesta de *S. salar*. En particular, observamos que machos precoces de *O. tshawytscha* cortejaban con hembras de *S. salar* y defendían a las hembras contra aproximaciones de machos de *S. salar*. 4. Discutimos las implicaciones de estas interacciones en el contexto del programa de re-introducción de *S. salar* en el Lago Notario.

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**References**

