Journal of Great Lakes Research xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Evidence of lake trout (*Salvelinus namaycush*) spawning and spawning habitat use in the Dog River, Lake Superior

Nicholas E. Jones [a,*], Michael Parna [a], Sarah Parna [b], Steve Chong [c]

[a] River and Stream Ecology Lab, Aquatic Research and Monitoring Section, Ontario Ministry of Natural Resources and Forestry, Trent University, DNA Building 2140 East Bank Drive, Peterborough, ON K9J 7B8, Canada
[b] Species Conservation Policy Branch, Ontario Ministry of Natural Resources and Forestry, 300 Water Street, Peterborough, ON K9J 3C7, Canada
[c] Upper Great Lakes Management Unit, Ministry of Natural Resources and Forestry, 1235 Queen Street East, Sault Ste. Marie P6A 2E5, Canada

ARTICLE INFO

Article history:
Received 12 March 2018
Accepted 20 July 2018
Available online xxxx

Communicated by Nicholas Johnson

Keywords:
Adfluvial
Lake trout
Dog River
Spawning
Habitat

ABSTRACT

Lake trout spawn primarily in lakes, and the few river-spawning populations that were known in Lake Superior were believed to be extirpated. We confirmed spawning by lake trout in the Dog River, Ontario, during 2013–2016 by the collection of and genetic identification of eggs, and we describe spawning meso- and micro-habitat use by spawning fish. Between 2013 and 2016, a total of 277 lake trout eggs were collected from 39 of 137 sampling locations in the river. The majority of eggs (220) were collected at the transition between the estuary and the river channel crossing the beach. Lake trout eggs were most often located near the downstream end of pools in areas characterized by rapid changes in depth or slope, coarse substrates, and increased water velocities, where interstitial flows may occur. Depths in wadeable areas where eggs were found averaged 0.9 m (range: 0.4 to 1.3 m) and substrate sizes consisted of large gravel, cobble, and boulder; comparable to spawning characteristics noted in lakes. Water velocities averaged 0.66 $m \cdot s^{-1}$ (range: 0.33 to 1.7 $m^3 \cdot s^{-1}$) at mid-depth. This information on spawning habitat could be used to help locate other remnant river-spawning populations and to restore river-spawning lake trout and their habitat in rivers that previously supported lake trout in Lake Superior. The Dog River population offers a unique opportunity to understand the ecology of a river spawning lake trout population.

Introduction

Lake trout are one of the most diverse vertebrate species in Canada (Muir et al., 2015). In Lake Superior alone, at least four different lake trout morphotypes have been described including leans, siscowets, redfins and humpers, which spawn at over 250 different locations in the lake (Goodier, 1981). Each morph has unique adaptations such as eye position, gape size, and gillraker length and spacing to exploit different niches including inshore, offshore, benthic, and pelagic habitats, as well as both piscivorous and planktivorous feeding behaviours (Muir et al., 2015). Leans were prized by fishermen whom recognized thirty-six types related to colouration (e.g., yellowfins, salmon trout, grays), body shape and size, and behavioral differences including seasonal movements and spawning habits (Goodier, 1981; Muir et al., 2015). While lake trout are traditionally thought of as a lake-spawning species (Gunn, 1995; Sly and Evans, 1996), they have historically been documented to spawn in several tributaries of Lake Superior. According to Loftus (1958), notable river-spawning populations of lake trout occurred in the Pukaskwa, Eagle, Dog (University), Bear (Makua), Gravel (Sand), and Montreal rivers. Goodier (1981) noted additional rivers including Little Pic and Steel rivers. Goodier (1982b) further indicated populations in the Black Sturgeon, Aquasoban, Steel, Little Pic, Pic, White Gravel, Swallow, Falls, Pipe, Ghost, Michipicoten, Old Woman, Baldhead, Agawa, and Chippewa. In northern Canada (e.g., Northwest Territories), there are likely many other populations of river-spawning lake trout (P. Vecsei, Department of Fisheries and Oceans, personal communication).

Commercial fishing, including for lake trout, expanded rapidly in the 19th and 20th centuries. From 1920 to 1950, lake trout supported the commercial harvest of 2 million $kg \cdot yr^{-2}$ in Lake Superior. River-spawning populations once supported substantial fisheries, for example, a six-day one-man catch of 4500 kg was reported from the Dog River (Goodier, 1982a). Commercial harvest declined sharply in the 1950s as lake trout stocks collapsed primarily as a result of overfishing and sea lamprey (*Petromyzon marinus*) predation (Wilberg et al., 2003). River-spawning populations of lake trout were lost from many Lake Superior tributaries where they formerly occurred and spawning populations in the Dog and Montreal rivers declined from over 2000 fish in 1952 to only a few fish in 1955 (Loftus, 1958).

Acknowledging the uniqueness of river-spawning lake trout, the Ontario government made an effort to establish a refuge and captive

* Corresponding author.
E-mail address: Nicholas.Jones@ontario.ca (N.E. Jones).

https://doi.org/10.1016/j.jglr.2018.07.017
0380-1330/

breeding program that could be used as a source for stocking into the Great Lakes. In 1955 eggs were collected from lake trout captured in the Dog River; two and one-half years later 5000 lake trout were stocked at the mouth of the Dog River and 4000 were stocked into the Mishibishu Lake chain at the headwaters of the Dog River (Loftus, 1958; Kerr, 1977). From 1956 to 1973, roughly 400,000 Mishibishu strain lake trout (originating from the eggs collected in the Dog River and fish stocked into the Mishibishu lakes) were planted at the mouth of the Dog River (Kerr, 1977). By 1977, ripe lake trout, all of which were stocked fish based on fin clips, were confirmed in the Dog River. The Mishibishu strain of lake trout was subsequently stocked in Lake Ontario from 1996 to 2006, totalling 700,000 fish (Great Lakes Fish Stocking Database). The propensity of this strain to ascend rivers in the fall was noted when the stocked fish returned in large numbers to tributaries around Lake Ontario, especially the Ganaraska River (J. Bowlby, retired, Ontario Ministry of Natural Resources and Forestry, personal communication).

Much of what is known about lake trout spawning habitat is focused on lakes. Marsden et al. (1995) reviewed current knowledge on lake trout spawning habitat, they noted that lake trout spawn in shallow water (>2 m) near shorelines and in deeper water (80 m) offshore. One explanation for the wide range of depths at which lake trout spawn is that lake trout evolved as a shallow water or even riverine spawning species with high site fidelity and the depth variability now observed is a product of changes in water levels at historic spawning sites in the Great Lakes (Marsden et al., 1995). Substrate sizes used by spawning lake trout vary from 8 cm to 300 cm in diameter with large interstitial spaces that can hold eggs (Marsden et al., 1995). In smaller lakes, the preferred substrate sizes are smaller as is the fetch across lakes and the magnitude of waves. Wind driven water movement at spawning areas is important for maintaining interstitial spaces and the movement of high water quality within substrate; however, too much wind energy can also lead increased egg mortality. Recent research suggests that glacial structures such as drumlins, eskers, and moraines provide suitable conditions for lake trout spawning and egg incubation, especially where lake currents can remove fine sediments from these landforms (Riley et al., 2014). Unlike lake trout, most other species of salmonines require high flows in streams and rivers to periodically sort and clean sediments. In lakes, lake trout must use substrates that were deposited by other forces (e.g., glaciers, waves, lake ice) and rely on currents in the lake to maintain and clean substrates (Riley et al., 2014). While there are a multitude of possible factors related to lake trout spawning habitat quality reviewed by Marsden et al. (1995), substrate characteristics and the cleanliness of interstitial spaces are key for protecting eggs from physical forces and predators, and to maintain water quality.

The Dog River population offers a unique opportunity to understand the ecology of a river-spawning population and to contrast this information with what is known for lake populations. Our study objectives include confirming spawning in the Dog River through the collection of lake trout eggs and genetic analyses and describing the meso- and microhabitat used by lake trout for spawning. Information on spawning habitat could be used to guide future search efforts for remnant river-spawning populations and to aid in restoring river-spawning lake trout and their habitat in rivers that previously supported lake trout.

Methods

The Dog River is a remote wilderness river located 30 km west of the town of Wawa, Ontario (Fig. 1). The Dog River was selected as a study site due to anecdotal reports of the presence of lake trout during the fall spawning period. The river is accessible by boat via Lake Superior or by helicopter when the river is not navigable by boat due to low flows. Field crews visited the Dog River in the fall each year from 2012 through 2016. Large-scale habitat features (e.g., riffles, pools, mesohabitat) were identified by staff walking the length of the river

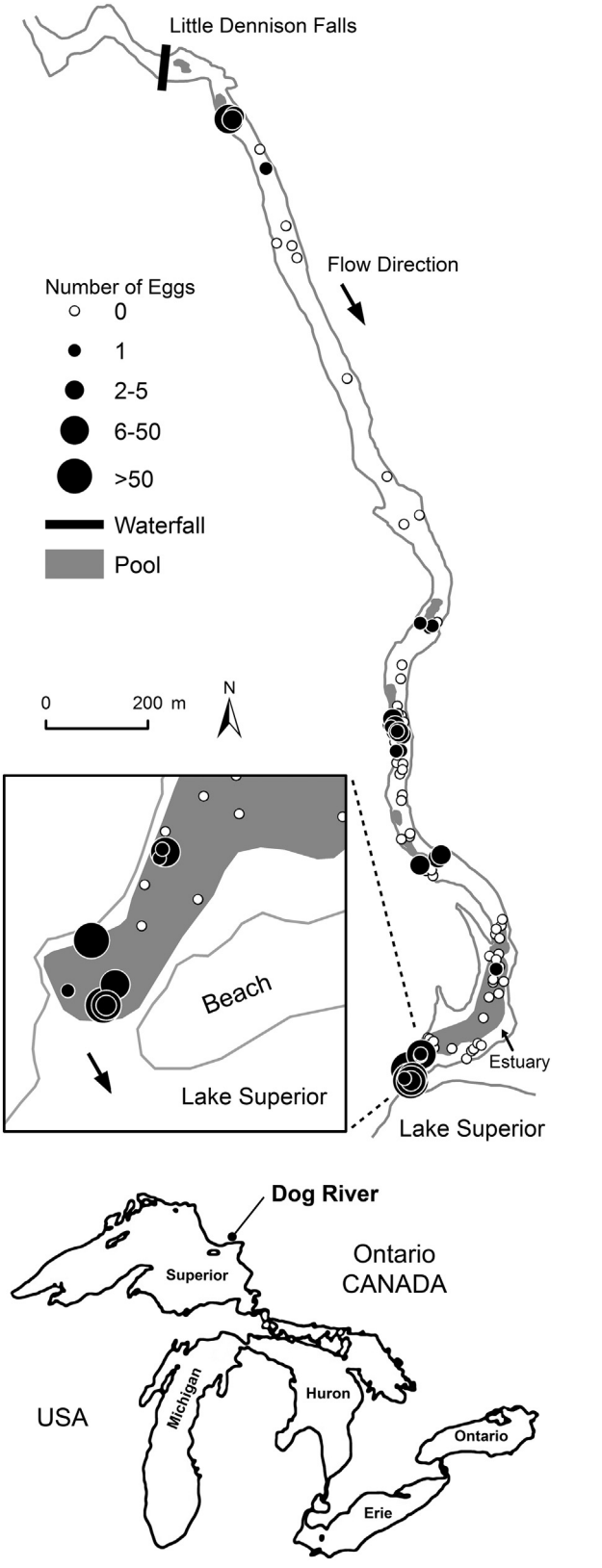

Fig. 1. The Dog River is a remote wilderness river located (N47.962°, W85.195°) 30 km west of the town of Wawa, Ontario. Sampling occurred in fall of 2012 through 2016. Shown are locations where lake trout eggs were detected (black circles) and not detected (open circles). Numbers of eggs are indicated by the size of the circles. Pools are shaded in grey, whereas, riffles and runs are not shaded and makeup the remaining area.

Please cite this article as: Jones, N.E., et al., Evidence of lake trout (*Salvelinus namaycush*) spawning and spawning habitat use in the Dog River, Lake Superior, J. Great Lakes Res. (2018), https://doi.org/10.1016/j.jglr.2018.07.017