J. Great Lakes Res. 31:1–10
Internat. Assoc. Great Lakes Res., 2005

Deepwater Spawning by Lake Trout (*Salvelinus namaycush*) in Keuka Lake, New York

John Fitzsimons[1,*], Georgina Fodor[1], Bill Williston[1], Henk Don[2], Bruce Gray[2], Mike Benner[2], Todd Breedon[2], and Dave Gilroy[2]

[1]*Department of Fisheries and Oceans*
867 Lakeshore Road
Burlington, Ontario L7R 4A6

[2]*Environment Canada*
867 Lakeshore Road
Burlington, Ontario L7R 4A6

ABSTRACT. *Egg deposition in deep water by a self-sustaining lake trout population is reported for Keuka Lake, one of the Finger Lakes of New York. Deep water spawning may be a critically important component to the restoration of lake trout in the Great Lakes. In 2002, spawning occurred on or about December 6 at a water temperature of 6.7°C at depths ranging from 24.6 to 27.7 m, with an average egg abundance of 1,318 eggs·m^{-2}. The population, presumably the native strain, spawned on a steep slope (30–40º) on small shale substrate with little interstitial space. Abundance of egg predators was low and limited to slimy sculpins (6.9 sculpins·m^{-2}). Early mortality syndrome (EMS), associated with an alewife diet-mediated thiamine deficiency in parents, was detected in larvae reared from the wild-caught eggs, but was of insufficient magnitude to eliminate natural reproduction in Keuka Lake.*

INDEX WORDS: *Lake trout, Keuka Lake, spawning, deepwater, sculpins, EMS.*

INTRODUCTION

Historically, native lake trout (*Salvelinus namaycush*) in the Great Lakes reportedly spawned on a greater variety of substrate types using a wider array of reproductive strategies than contemporary stocks. Diversity in spawning location and timing may have been critically important for perpetuating stocks. Specifically, spawning by historic native stocks appeared to occur on a greater variety of substrate types, over a broader time period, and over a greater range of depths than is currently observed, suggesting a broad range of reproductive strategies. Unfortunately, most of this information is circumstantial, having been inferred from collections of adults in spawning condition with little actual direct evidence of spawning; the data that are available are not quantitative (Brown *et al.* 1981, Goodier 1981, Thibodeau and Kelso 1990, Horns *et al.* 1989, Marsden and Janssen 1997). Quantitative assessment of the relative importance of spawning habitat and reproductive strategies has been seriously reduced, as lake trout were lost from all of the Great Lakes, with the exception of Lake Superior, by the 1960s due to the combined effects of overfishing and sea lamprey (*Petromyzon marinus*) (Krueger *et al.* 1995a).

Spawning substrate used by contemporary lake trout in the Great Lakes, which are mostly hatchery-reared fish, appears to differ quantitatively from substrate used by native spawning stocks, although the reasons for this are not clear. Most spawning by contemporary stocks appears to occur on cobble-rubble substrate at relatively shallow depths (< 10 m) in September–November when water temperatures are still relatively warm (Casselman 1995, Fitzsimons 1995a, Fitzsimons and Williston 2000, Perkins and Krueger 1995, unpub. data). Spawning by hatchery-reared fish at greater depths (Marsden and Janssen 1997) has been observed, but this appears to be rare.

Success in rebuilding self-sustaining populations with measurable and sustained recruitment has been limited except in Lake Superior, where lake trout

*Corresponding author. E-mail: fitzsimonsj@dfo-mpo.gc.ca

stocks differ in many respects from the other Great Lakes; these differences may be important for population restoration (Hansen *et al.* 1995, Krueger *et al.* 1995a, Selgeby 1995). In addition, lake trout stocks in Lake Superior were the least affected by the human induced changes of the last century that include habitat degradation, contaminants, and invasive species, although Lake Superior also retained several remnant stocks exhibiting a broad diversity of reproductive strategies (Hansen *et al.* 1995, Krueger *et al.* 1995a, Marsden *et al.* 1995). Accordingly, interactions between these factors and the spawning habitat and reproductive strategies used by contemporary lake trout has figured prominently in speculation about possible impediments to lake trout restoration outside of Lake Superior (Jones *et al.* 1995, Marsden *et al.* 1995, Fitzsimons 1995b, Krueger *et al.* 1995a)

Of all the spawning habitat characteristics exhibited by historic native stocks, their ability to spawn at a greater range in depths than introduced stocks may be of most significance to the current impasse in restoration of lake trout outside of Lake Superior. Spawning at deep depths may have several benefits for lake trout restoration with regards to egg survival relative to shallow reefs. Spawning at shallow depths may subject eggs to high levels of physical disturbance and probably high abundance and diversity of interstitial egg predators, both of which can increase egg mortality (Fitzsimons 1994, Eshenroder *et al.* 1995, Fitzsimons *et al.* 2002, Marsden and Janssen 1997). For example, bottom current velocity, that contributes to shear stress and physical disturbance, increased exponentially with decreasing depth at depths less than 10 m based on intensive current measurements made at a spawning reef in western Lake Ontario (M. Skafel, EC, Burlington, ON, unpub. data). Numbers of potential egg predators at shallow spawning reefs in Lake Ontario were such that at five out of eight reefs evaluated they could potentially consume from 30% to over 80% of eggs deposited in a 30-day period (Fitzsimons *et al.* 2002). Accordingly, stocking deepwater strains such as siscowets or humpers that spawn at much greater depths than shallow water strains now being stocked could reduce the problem of high egg mortality when spawning occurs at shallow depths (Burnham-Curtis *et al.* 1995, Eshenroder *et al.* 1999). However, spawning characteristics (egg density and survival, spawning period, spawning habitat, spawning depth) of deepwater strains, and the relative amount and diversity of egg and fry predators they are exposed to, have yet to be determined.

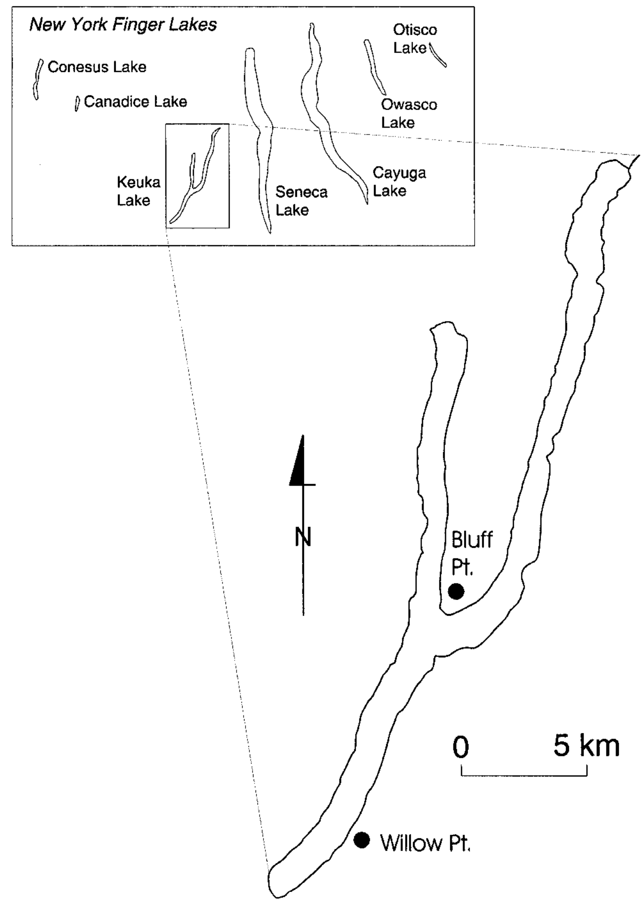

FIG. 1. Map of Keuka Lake, New York, showing study site locations.

Compared with lake trout in most of the Great Lakes and Finger Lakes, the lake trout of Keuka Lake, one of the New York Finger Lakes (Fig. 1), appear unique in that they are fully self-sustaining, apparently in spite of the presence of alewives. Lake trout stocking in Cayuga, Seneca, and Canandaigua lakes, that also have alewives, has failed to result in significant and sustained natural reproduction (D. Kosowski, NYDEC, East Avon, NY, pers. comm.). Alewives have been implicated in larval mortality, both directly through predation and indirectly through a diet-mediated thiamine deficiency causing early mortality syndrome or EMS (Krueger *et al.* 1995b, Fitzsimons and Brown 1998, Fitzsimons *et al.* 1999). Alewives contain thiaminase, a substance that breaks down their thiamine in the gut of an alewife predator (Fitzsimons *et al.* 1999). When alewives comprise a major portion of