

GROWTH AND OVERPOPULATION OF YELLOW PERCH AND THE APPARENT EFFECT OF INCREASED COMPETITION ON BROOK TROUT IN LONG LAKE, HALIFAX COUNTY, NOVA SCOTIA

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A fish survey was conducted on Long Lake, Woodens River, Halifax County, Nova Scotia during May 2005. A total of 2711 yellow perch were captured over a twelve day period and were the most abundant fish. Fifty-eight yellow perch were sampled for length, weight, scales, and sex. Total length of yellow perch ranged from 81mm to 276 mm with a mean of 133mm. Ages determined from scale analysis ranged from 2 to 13 years but 95% were younger than 8 years of age. Age at maturity was 2 years. The Von Bertalanffy growth relationship for yellow perch described slow growth and suggested stunting which is consistent in crowded populations. Increased abundance of yellow perch and reduced abundance of brook trout has been reported by anglers in the Woodens River system and was evident from our catches. The apparent effect of increased, intraguild competition on the brook trout population is discussed.

Keywords: yellow perch, brook trout, overpopulation, stunting, intra-guild competition.

INTRODUCTION

Long Lake is located in Halifax County, Nova Scotia and is part of the Woodens River system. This watershed includes 19 connected lakes and flows southwest into Woodens River, eventually emptying into St. Margaret's Bay for a total watershed area of 65 square kilometers (Fig. 1; WRWEO 2009). The underlying geology of the Woodens River drainage is characterized by shallow soils and exposed granite bedrock with limited groundwater, productivity, and natural buffering capacity against acid precipitation.

Located approximately 20 kilometers west of the Halifax city core, Woodens River watershed is impacted by a number of disturbances

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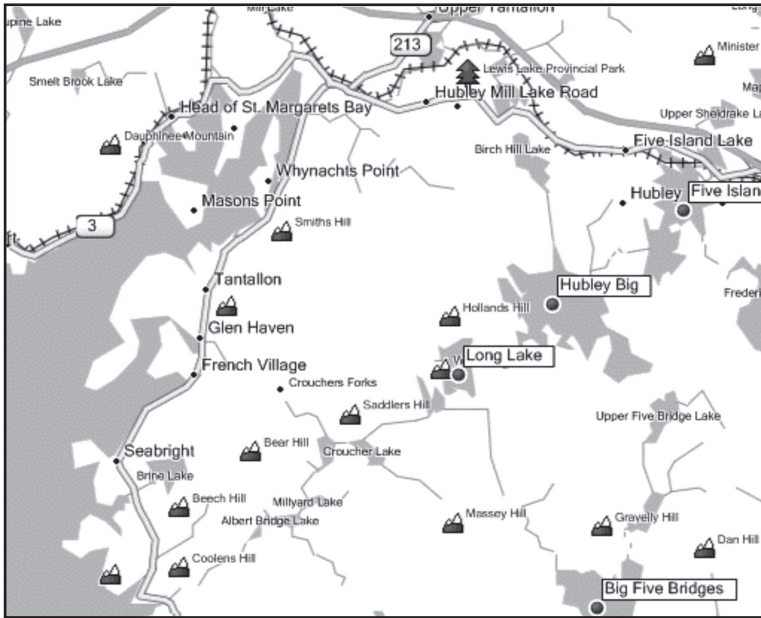


Fig 1 Map of study lake (Long Lake, 44.647233° 63.800773°) and surrounding Woodens River Watershed, Halifax County, Nova Scotia.

influencing the environment. In October of 1994 the Nova Scotia Department of Health announced that polychlorinated biphenyl (PCB) contaminants had been found in Five Island Lake in the watershed and in the tissue of resident fish captured (CCME 1994-95). This resulted in the issuance of a health advisory regarding local fish consumption. Land use such as high density residential development, commercial forestry operations and a heavy highway traffic use have also impacted water quality in the watershed.

In 2001 the Nova Scotia Department of Fisheries and Aquaculture designated the Woodens River system as a Special Management Area. The Woodens River Special Trout Management Area has been under catch-and-release only regulations. Seven fish species have been documented in Long Lake: American eel, *Anguilla rostrata* (Lesueur, 1817), banded killifish, *Fundulus diaphanous* (Lesueur, 1817), brook trout, *Salvelinus fontinalis* (Mitchill, 1815), alewife, *Alosa pseudoharengus* (Wilson, 1811), golden shiner, *Notemigonus crysoleucas* (Mitchill, 1814), white sucker, *Catostomus commersonii* (Lacépède, 1803) and yellow perch, *Perca flavescens* (Mitchill, 1814) (Stantec 2008).

Historically this system has been popular for its recreational brook trout fishing. An indication of a decline in the brook trout population of the Woodens River system was documented during the 1984 spring creel census conducted on Big Hubley Lake (O'Brien 1984). It was noted by recreational anglers to be the poorest capture season for brook trout ever. Anglers stated acid rain and extreme fishing pressure were to blame (O'Brien 1984). The specific reason for the decline in the brook trout population was not clear and was probably due to a combination of factors.

Inverse to the declining brook trout numbers has been an extreme increase in the population of yellow perch. It appears that this large population of yellow perch may have stunted growth characteristics commonly associated with overpopulation (Scott and Crossman 1973). Our work presents yellow perch sampling data that was conducted in Long Lake in 2005. These data are used to discuss the potential aquatic community shift and its impact on the brook trout population.

METHODS

Fish sampling was conducted in Long Lake between the 4th and 19th May, 2005. Ten small fyke nets and one large fyke net were used to collect fish. Each small net consisted of two hoop nets that were attached with a 0.5m x 5m lead. Each hoop net had a 0.5m circular opening that directed fish into a series of 6 circular hoops with funnels and finally to the bag end. The large fyke net had a lead (50m x 1m) and two (20m x 1m) wings that were attached to a 1m² square opening that was framed with 3cm diameter hollow aluminum conduit. The net opening led to a series of framed funnels and to a bag end. Mesh size for small and large fyke nets was 1 cm². Nets were set perpendicular to the shoreline at a depth of less than 3m and for a minimum time of 1 or 2 nights. The total effort was 23 net-nights.

All fish collected were identified to species, enumerated and with the exception of 58 yellow perch samples, were returned live to the lake. The sample of yellow perch was frozen for later analysis.

In 2006, the yellow perch were measured for total length (TL mm) and, total weight (g). The yellow perch weight - length relationship was described from a power function as:

$$W = aL^b,$$

where W is the weight of the fish in g, L is the total length of the fish in mm, and a and b are constant parameters (Ricker 1975).

Fish were dissected to determine sex. Scale samples were collected from each fish and mounted on microscope slides. Scales were magnified (40x) using an overhead projector and a photocopy of the magnified scale was used to age perch. Two fisheries researchers determined ages and annulus marks on each scale. Total scale length and distances between focus and annuli were determined for the purpose of back-calculation of length at age for individual yellow perch.

A modification of the Fraser-Lee equation was used to determine the back-calculated length at age. This modification of the Fraser-Lee equation (Schreck and Moyle 1990) described the body-scale relationship as a regression:

$$L_i = a + (L_c - a)(S_i - S_c)$$

where L_i , the length in mm at age i is determined by inputting the known measurements of: length of fish at capture (L_c), distance from scale focus to scale annulus (S_i), total scale length and (S_c), and the intercept of the body-scale regression (a).

Growth was described by the Von Bertalanffy growth equation:

$$L_t = L_{inf} [1 - e^{-K(t - t_0)}],$$

where L_t is the TL at time t , t_0 is the size of the fish at age 0, and K the rate of growth (Schreck and Moyle 1990, Lackey and Nielsen 1980). The L_{inf} is calculated by dividing the y intercept (of the regression of L_t by $L_t + 1$) by $1 - k$ (slope of the regression of L_t on $L_t + 1$).

RESULTS

A total of 2786 fish were captured from Long Lake during this field study. Species captured included brook trout, yellow perch, white sucker, American eel and golden shiner (Table 1). A total of 2711 yellow perch were captured for a catch-per-unit-effort (CPUE) of 117.09 /net night, the highest of the study. Only one brook trout and one white sucker were captured for a CPUE of 0.04 /net night. Fifty-eight yellow perch were collected for detailed analysis of which 36 were female, 19 were male and 3 were unknown (Fig 2). Mean total length and standard deviation (SD) were 133 ± 39 mm and TL ranged from 81mm to 276mm. Mean weight and SD were 39 ± 18 g

Table 1 Fish species, number captured and catch-per-unit-effort (CPUE) in Long Lake, Woodens River system, Halifax County, Nova Scotia, during field sampling 4th to 19th of May, 2005. The CPUE is based on 23 net-nights of sampling.

Fish Species	Scientific Name	Number Captured	CPUE (Catch-per-unit-effort)*
American eel	<i>Anguilla rostrata</i>	69	3.00
Brook trout	<i>Salvelinus fontinalis</i>	1	0.04
Golden shiner	<i>Notemigonus crysoleucas</i>	4	0.17
White sucker	<i>Catostomus commersonii</i>	1	0.04
Yellow perch	<i>Perca flavescens</i>	2711	117.09

and weights ranged from 7g to 255g. The weight-length relationship for yellow perch was $Wt = 0.0001TL^{3.03}$ ($r^2 = 0.965$; Fig 3).

The mean age of yellow perch was 4.53 yr and age ranged from 2 to 13 yr (Fig 4). Seventy-six percent of the fish sampled were 5 years of age or less. Mean TL at age was 95mm for 2+ years, 110mm for 3+ years, 124mm for 4+, and 134mm for 5+ years (Table 2). The yellow perch Von Bertalanffy growth equation, $L_t = 349(1 - e^{-0.078(t + 0.74)})$ with a K of 0.078, illustrates extremely slow growth. Mean TL at age versus the calculated von Bertalanffy growth relationship was similar until age 6. At age 6 the mean TL made a sharp upward jump until age 8 when length change between year intervals slowed. The von Bertalanffy curve shows gradual length growth each year towards a plateau at the calculated asymptotic TL of 349mm (Fig 5).

DISCUSSION

Sampling bias associated with method of capture and time of sampling can influence the catchability of certain fish species and the size of the fishes captured. Ricker (1975) suggests the use of fyke nets will tend to select for faster growing and larger individuals in a population. For this reason, the rate of growth and mean size of yellow perch in our study may be slightly greater than the true population characteristics. Time of year is also a consideration as water temperature and seasonal influences can impact behavior and habitat usage of fish in a lake (Hayes and Livingstone 1955). By

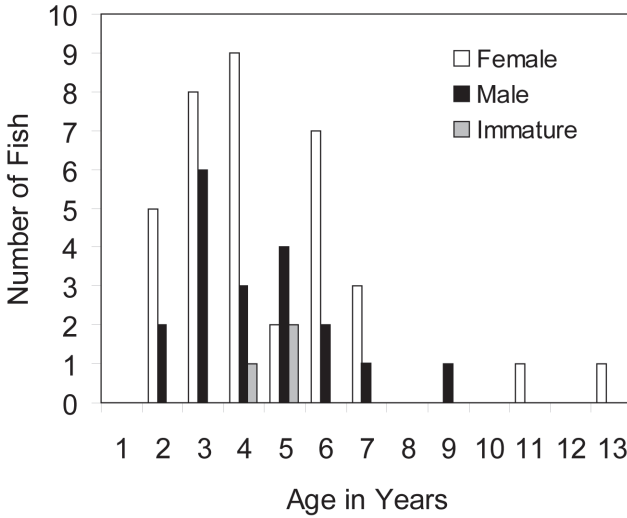


Fig 2 Age and sex structure of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

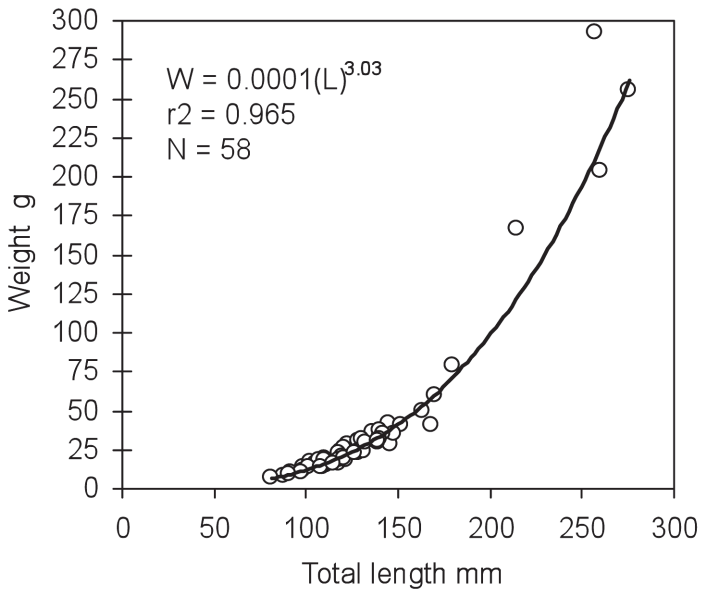


Fig 3 Weight - length relationship of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

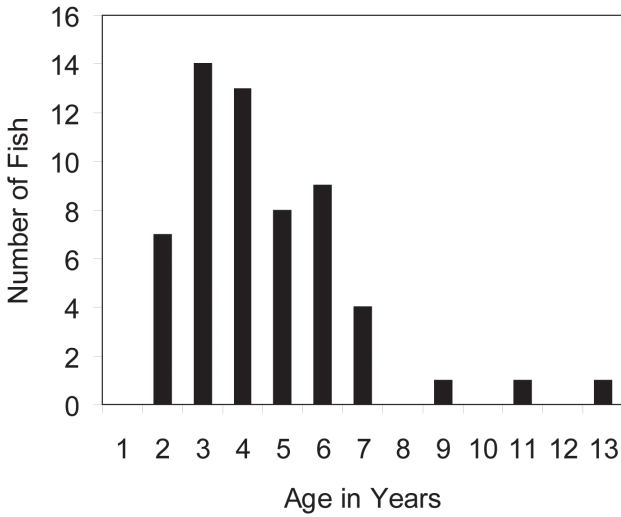


Fig 4 Age structure of yellow perch captured in Long Lake, Halifax County, Nova Scotia, 2005.

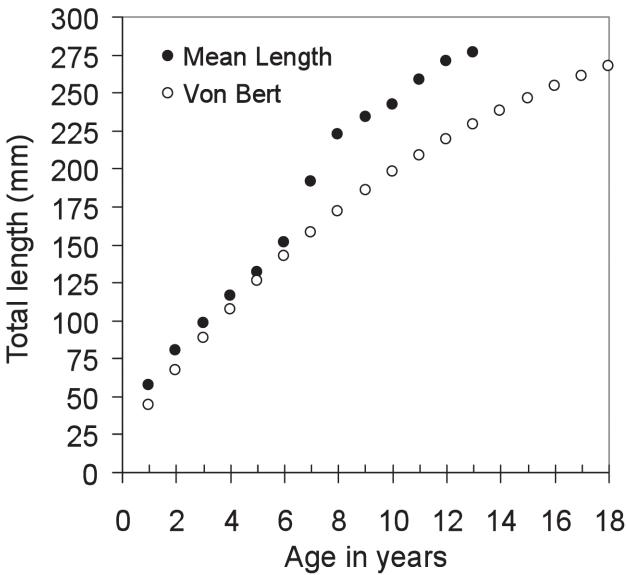


Fig 5 Mean total length vs age of yellow perch captured in Long Lake in relation to the calculated Von Bertalanffy relationship.

Table 2 Average total length in relation to year class of yellow perch captured in Lake Jesse, Nova Scotia (Smith 1939) and Long Lake, Nova Scotia, 2005.

Year class	Average Total Length (mm)	
	Lake Jesse (Smith 1939)	Long Lake (2005)
2+	92	95
3+	108	110
4+	125	124

sampling during May, sampling bias was minimized as yellow perch and brook trout are similarly active in shallow, littoral areas during this time of year and therefore the likelihood of capture was similar. During May, yellow perch are spawning and brook trout are actively feeding in the littoral zone, allowing us to interpret fyke net CPUE as an index of population density in Long Lake.

Growth of yellow perch is highly variable and limited documentation is available on the general population characteristics of stunted yellow perch in Nova Scotia. Smith (1939) described the stunted population of yellow perch in Lake Jesse, Nova Scotia as having a mean TL of 92mm at 2+; 108mm at 3+; 125mm at 4+. The mean TL at age observed by Smith (1939) in Lake Jesse were similar than those found in Long Lake in 2005. Scott and Crossman (1973) state that adult yellow perch found in crowded populations rarely exceed 152mm in TL. The mean capture TL of adult yellow perch (3+ years) found during our study was 110mm, with only 16% of the fish sampled exceeding 152mm TL.

The inability of brook trout to compete successfully with other species has been commonly noted (Fraser 1978; East and Magnan 1991; Flick and Webster 1992; Quinn *et al.* 1994). In lakes, the density of brook trout declines with an increase in competitive species. In a study of 16 Nova Scotia lakes it was found that in lakes with only one competitor species, the mean catch/net night of brook trout was 2.8, however, when three or more competitor species were present the mean catch/net-night declined to only 0.1 (NSDFA, unpublished data). Our catch of 0.4 trout/net-night in this study, suggests the population density in Long Lake may be similar to other lakes where the intraguild competition with other fish species is significant (Polis *et al.* 1989). As well, Quinn *et al.* (1994) also documented that brook trout density decreased with community complexity in Algonquin Provincial Park, Ontario.

White sucker, American eel, and yellow perch are found in Long Lake and all are considered to be direct competitors of brook trout (MacMillan *et al.* 2008). Yellow perch were found to be the most abundant fish present in Long Lake and are likely the most significant competitor with brook trout. Yellow perch are able to adapt and utilize a wide variety of habitats (Scott and Crossman 1973). Additionally, their high reproductive potential and effective feeding capacity make them highly competitive, leading to overpopulation and stunting (Scott and Crossman 1973). Recent research conducted by Browne and Rasmussen (2009) demonstrates that the intraguild predation between brook trout and yellow perch can result in a feeding niche shift which is unfavorable to brook trout abundance. In non-perch lakes juvenile brook trout were found to feed primarily in the littoral zone of lakes, however, in lakes containing yellow perch their feeding was predominately on pelagic prey, including larval perch (East and Magnan 1991; Browne and Rasmussen 2009). This documented niche shift corresponded to a decline in CPUE of brook trout (Browne and Rasmussen 2009). It is suggested that a shift to pelagic resource use at an earlier developmental stage for brook trout may result in a decrease in recruitment to larger-size classes, but Browne and Rasmussen (2009) comment that further research is required to test this hypothesis.

Brook trout shift to a piscivorous diet at approximately 250mm TL (Fraser 1978; Tremblay and Magnan 1991), at which time they are no longer competing for food with yellow perch. Brook trout, however, may experience reduced growth rates in the first two years due to competition with yellow perch and the above discussed niche shift. Browne and Rasmussen (2009) also found that the mean size of prey fish consumed by brook trout in non-perch lakes were smaller than that in perch lakes. This indicates that brook trout in perch lakes may have to grow to a larger size before shifting to a piscivorous diet due to limits on the size range of available prey.

Brook trout and yellow perch can naturally coexist. Yellow perch, especially the nektonic larvae, can be an important prey item for brook trout (East and Magnan 1991). The natural balance of these two species may be affected by numerous other factors. These include but are not limited to: habitat quality and quantity, recreational fishing pressure, competitive species, acidification, and global warming. Individual and combined effects of these factors may have altered the natural balance of yellow perch and brook trout in Long Lake.

The significance and implication of competition between yellow perch and brook trout is not clear. There are potentially additional factors impacting brook trout abundance within the Woodens River system. We suggest further research is required to quantify the factors inhibiting brook trout production. In the presence of these unknowns and to prevent further degradation of the resource, continued application of special management regulations is advisable.

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REFERENCES

- Browne, D.R. and Rasmussen, J.B.** 2009. Shifts in the trophic ecology of brook trout resulting from interactions with yellow perch: an intraguild predator-prey interaction. *Trans. Amer. Fish. Soc.* 138: 1109-1122.
- CCME (Canadian Council of Ministers of the Environment)** 1995. The national contaminated sites remediation program. 1994-95 Annual Report. Winnipeg, Manitoba.
- East, P. and Magnan, P.** 1991. Some factors regulating piscivory of brook trout in lakes of the Laurentian Shield. *Can. J. Fish. Aquat. Sci.* 48: 1735-1743.
- Flick, W.A. and Webster, W.D.** 1992. Standing crops of brook trout in Adirondack waters before and after removal of non-trout species. *N. Amer. J. Fish. Manag.* 12: 783-796.
- Fraser, J.M.** 1978. The effect of competition with yellow perch on the survival and growth of planted brook trout, splake, and rainbow trout in a small Ontario lake. *Trans. Amer. Fish. Soc.* 107: 505-517.
- Hayes, F.R. and Livingstone, D.A.** 1955. The trout population of a Nova Scotia as affected by habitable water, poisoning of the shallows and stocking. *J. Fish. Res. Board Can.* 12 : 618-635.
- Lackey, R.T. and Nielsen, L.A.** 1980. Fisheries management. Oxford: Blackwell Scientific Publication Ltd.
- MacMillan, J.L., Caissie, D., Marshall, T.J. and Hinks, L.** 2008. Population indices of brook trout (*Salvelinus fontinalis*), Atlantic salmon (*Salmo salar*), and salmonid competitors in relation to summer water temperature and habitat parameters in 100 streams in Nova Scotia. *Can. Tech. Rep. Fish. Aquat. Sci.* No. 2819: 41pp.

- MacMillan, J. and Crandlemere, T.** 2004. Brook trout populations in lakes of the mainland and Cape Breton highlands of Nova Scotia and management considerations, 2002 -2003.NSDFFA (Nova Scotia Department of Fisheries and Aquaculture) (2005) Unpublished data.
- O'Brien, M.** 1984. Memorandum on the creel census at Hubley Big Lake, May 10/84 to June 17/84. Nova Scotia Department of Lands and Forests.
- Polis, G.A., Myers, C.A., and Holt, R.D.** 1989. The ecology and evolution of intraguild predation: potential competitors that eat each other. *Ann. Rev. Ecol. Sys.* 20: 297-333.
- Quinn, N.W.S., Korver, R.M., Hicks, F.J., Monroe, P.B. and Hawkins, R.R.** 1994. An empirical model of lentic brook trout. *N. Amer. J. Fish. Manag.* 14: 692-709.
- Ricker, W.E.** 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.* No. 191: 382pp.
- Schreck, C.B. and Moyle, P.B.** 1990. *Methods for fish biology.* Amer. Fish. Soc. Bethesda, Maryland.
- Scott, W.B. and Crossman, E.J.** 1973. *Freshwater fishes of Canada.* Fish. Res. Board Can. Bulletin 184. Ottawa Ontario.
- Smith, M.W.** 1938 A preliminary account of the fish population in certain Nova Scotian lakes. *Trans. Amer. Fish. Soc.* 67: 178-183.
- Stantec.** 2010. Biological and supporting water quality studies, Woodens River Watershed, 2009. Completed for the Nova Scotia Department of Transportation and Public Works Halifax, Nova Scotia.
- Tremblay, S. and Magnan, P.** 1991. Interactions between two distantly related species, brook trout (*Salvelinus fontinalis*) and white sucker (*Catostomus commersoni*). *Can. J. Fish. Aquat. Sci.* 48: 857-867.
- WRWEO (Woodens River Watershed Environmental Organization).** 2009. Nova Scotia, Canada. World Wide Web electronic publication. Accessed: March 09, 2010. <http://www.wrweo.ca/>

