Overpopulation and growth of yellow perch (*Perca flavescens*) and the potential effect of increased competition on brook trout (*Salvelinus fontinalis*) in Long Lake, Halifax County, Nova Scotia

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Abstract

A fisheries survey was conducted on Long Lake, Woodens River, Halifax County, Nova Scotia in May 2005. A total of 2711 yellow perch (*Perca flavescens)* were captured during a twelve day sampling period and were the most abundant fish captured. Fifty-eight yellow perch were sampled for length, weight, scales, and sex. Mean total length of yellow perch was 133mm and ranged from 81mm to 276 mm. Ages determined from scale analysis ranged from 2 – 13 years and 95% were younger than 8 years of age. Age at maturity was 2 years. The yellow perch von Bertalanffy growth curve equation, $L_t = 349(1 - e^{-0.078\ (t + 0.74)})$, defines slow growth and suggests stunting which is consistent in crowded populations. Increased abundance of yellow perch and reduced abundance of brook trout (*Salvelinus fontinalis*) has been reported by anglers in the Woodens River system. The general inability of brook trout to compete successful with yellow perch is well documented. The potential effects of this increased competition and pressure on brook trout are discussed.

Introduction and Study Area

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 empting into St. Margaret's Bay; a total area of 65 square kilometers (Figure 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 peninsula, Woodens River watershed is impacted by a number of disturbances 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 and in the tissue of resident fish captured (CCME 1994-95). This resulted in the issuance of a health advisory regarding local fish consumption. 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. Land use such as high density residential development, commercial forestry operations and, heavy traffic highway use have also impacted on water quality within the system. Seven fish species have been documented in Long Lake: American eel (*Anguilla rostrata*), banded killifish (*Fundulus diaphanus*), brook trout (*Salvelinus fontinalis*), gaspereau (*Alosa pseudoharengus*), golden shiner (*Notemigonus crysoleucas*), white sucker (*Catostomus commersonii*) and,

yellow perch (*Perca flavescens*)(Table 1)(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 in a 1984 spring creel census conducted on Big Hubley Lake. It was noted by recreational anglers to be the poorest capture season for brook trout ever seen. Anglers stated they felt impacts due to 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 likely to be a combination of factors.

Parallel to the declining brook trout numbers has been an apparent visible 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). This paper 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 to a bag at the tail end. The large fyke net had a lead (50m x 1m) and two (20m x 1m) wings that were attached to a $1m^2$ square opening that was framed with 3cm diameter hallow aluminum conduit. The net opening led to a series of framed funnels and to a bag at the tail end. Mesh size for small and large fyke nets was $1m^2$. Nets were set perpendicular to the shoreline at a depth of less than 3m and for a minimum time of 1 or 2 nights.

All fish collected were identified to species and enumerated. All fish, 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 (mm) and, total weight (g). Yellow perch weight - length relationship was described from a power function as $W = aL^b$, where W is the weight of the fish, L is the total length of the fish, and a and b are 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) and a photocopy of the magnified scale was used to age perch. Two fisheries researchers read scales and 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 described the body-scale relationship as a regression, $L_i = a+(L_c-a)(S_i-S_c)$ (Schreck and Moyle

1990). L_i, the length 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), the intercept of the body-scale regression (*a*).

Growth was described by the von Bertalanffy growth equation, $L_t = L_\infty [1 - e^{-K(t - to)}]$, where L_t the maximum fish size at time t, to the size of the fish at age 0, and K the rate of growth (Schreck and Moyle 1990, Lackey and Nielsen 1980 L_∞ is calculated by dividing the y intercept (of the regression of L_t by L_t+1) by 1 minus k (slope of the regression of L_t by L_t+1). The variables: *e* and t are known; *e* is the base of the natural logarithm equaling 2.71828 and, t is the selected age of the fish.

Results

A total of 2786 fish were captured during this field study. Species captured included brook trout (N=1); yellow perch (N=2711); white sucker (N=1); American eel (N=69) and, golden shiner (N=4). Catch-per-unit-effort (CPUE) was the highest for yellow perch at 118 fish/per net night. CPUE for brook trout and white sucker were 0.04 fish/per net night. American eel were captured at a rate of 3 fish/per net night and, golden shiner at 0.17 fish/per net night (Table 2).

Fifty-eight yellow perch were sampled from Long Lake, of which 36 were female, 19 were male and, 3 were unknown (Figure 2). Mean total length was 133mm (39,SD) and total lengths ranged from 81mm to 276mm. Mean weight was 39g (18,SD) and weights ranged from 7g to 255g. The weight- length relationship for yellow perch was $Wt = 0.0001TL^{3.03}$, $r^2 = 0.95$, (Figure 3).

The mean age of yellow perch was five years and ranged from 2 to 13 years (Figure 4). Seventy-six percent of the fish sampled were equal to or less than 5 years of age.

Mean length at age was 95mm at 2 years, 110mm for 3 years, 124mm for 4+, and 134mm for 5+ years (Table 3). The yellow perch von Bertalanffy growth curve equation, $L_t = 349(1 - e^{-0.078 (t + 0.74)})$, illustrates slow growth. Mean total length versus the von Bertalanffy growth curve is quite similar until age 6. At age 6 the mean total length makes a sharp jump upward until age 8 where length change between year intervals slows. The von Bertalanffy curve shows gradual length growth each year towards a plateau at the calculated asymptotic length of 349mm (Figure 5).

Discussion

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 length of 92mm at 2+; 108mm at 3+; 125mm at 4+. The mean lengths 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 length. The mean capture length of adult yellow perch (3+ years) found during this 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 (Flick and Webster 1992, Fraser 1978, East and Magnan 1991, and 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-per-net night of brook trout was 2.8, however, when three or more competitor species were present the mean catch of trout per net-night was found to be only 0.1 (NSDFA, unpublished data). 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 to be a significant competitor to brook trout. Yellow perch are able to adapt and utilize a wide variety of habitats. Additionally, their high reproductive potential and effective feeding capacity make them highly competitive, leading to overpopulation and stunting (Scott and Crossman 1973). Current research conducted by Browne and Rasmussen (2009) demonstrates that the intraguild predation[1] 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. This documented 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, however, Browne and Rasmussen (2009) comment that further research is required to test this theory.

Brook trout shift to a piscivorous diet at approximately 250mm (Fraser 1978; Tremblay and Magnan 1991), at which time they are no longer competing with yellow perch. However, brook trout 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

[1] "the killing and eating of species that use similar, often limiting, resources and are thus potential competitors," (Polis *et al*. 1989).

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 naturally coexist. As mentioned above yellow perch can be an important prey item for brook trout. 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 alter 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 as indicated earlier. Further research is required in order 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.

Literature Cited

Browne, D. R. and J.B. Rasmussen. 2009. Shifts in the Trophic Ecology of Brook Trout Resulting from Interactions with Yellow Perch: an Intraguild Predator–Prey Interaction. Trans. Am. Fish. Soc. Vol. 138, No. 5, pp. 1109-1122

CCME (Canadian Council of Ministers of the Environment). 1994-95. The National Containmented Sites Remediation Program. 1994-95 Annual Report. Winnipeg, Manitoba.

East, P. and P. Magnan. 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 D.W. Webster. 1992. Standing crops of brook trout in Adirondack waters before and after removal of nontrout species. N. Am. J. Fish. Manage. 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. Am. Fish. Soc. 107(4): 505-517, 1978.

Lackey, R.T., and L.A. Nielsen. 1980. Fisheries Management. Oxford: Blackwell Scientific Publication Ltd.

MacMillan, J.L., D. Caissie, T.J. Marshall, and L. Hinks. 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. 2819:41p.

NSDFA (Nova Scotia Department of Fisheries and Aquaculture). 2005. Unpublished data.

O'Brien, M. 1984. Memorandum Creel Census at Hubley Big Lake, May 10/84 to June 17/84. Nova Scotia Department of Lands and Forests.

Polis, G.A., C.A. Myers, and R.D. Holt. 1989. The ecology and evolution of intraguild predation: potential competitors that eat each other. Ann. Rev. Ecol. Syst., 20, 297-330.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 191:382 p.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. Ottawa, Ontario.

Schreck, C.B., and P.B. Moyle, Editors. 1990. Methods for fish biology. American Fisheries Society. Bethesda, Maryland.

Smith, M.W. 1938. A preliminary account of the fish population in certain Nova Scotian lakes. Trans. Amer. Fish. Soc. 67 (1937):178-183.

Quinn, N.W.S., R.M. Korver, F.J. Hicks, B.P. Monroe, R.R. Hawkins. 1994. An Empirical Model of Lentic Brook Trout. N. Am. J. Fish. Manage. Vol. 14, No. 4, pp. 692-709.

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 P. Magnan. 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/

Table 1. Fish species present in Long Lake, Woodens River system, Halifax County, Nova Scotia.

Fish Species	Scientific Name
American eel	*Anguilla rostrata*
banded killifish	*Fundulus diaphanus*
brook trout	*Salvelinus fontinalis*
gaspereau	*Alosa pseudoharengus*
golden shiner	*Notemigonus crysoleucas*
white sucker	*Catostomus commersonii*
yellow perch	*Perca flavescens*

Table 2. Fish species, number captured and catch-per-unit-effort (CPUE) in Long Lake, Woodens River system, Halifax County, Nova Scotia, during field sampling May 8th to 15th, 2005.

Fish Species	Scientific Name	Number Captured	CPUE (Catch-per-unit-effort)*
American eel	*Anguilla rostrata*	69	3
brook trout	*Salvelinus fontinalis*	1	0.04
golden shiner	*Notemigonus crysoleucas*	4	0.17
white sucker	*Catostomus commersonii*	1	0.04
yellow perch	*Perca flavescens*	2711	118

*based on 23 nights of effort

Table 3. Average lengths of yellow perch (*Perca flavescens*) captured in Lake Jesse, Nova Scotia (Smith 1939) and Long Lake, Nova Scotia, 2005.

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

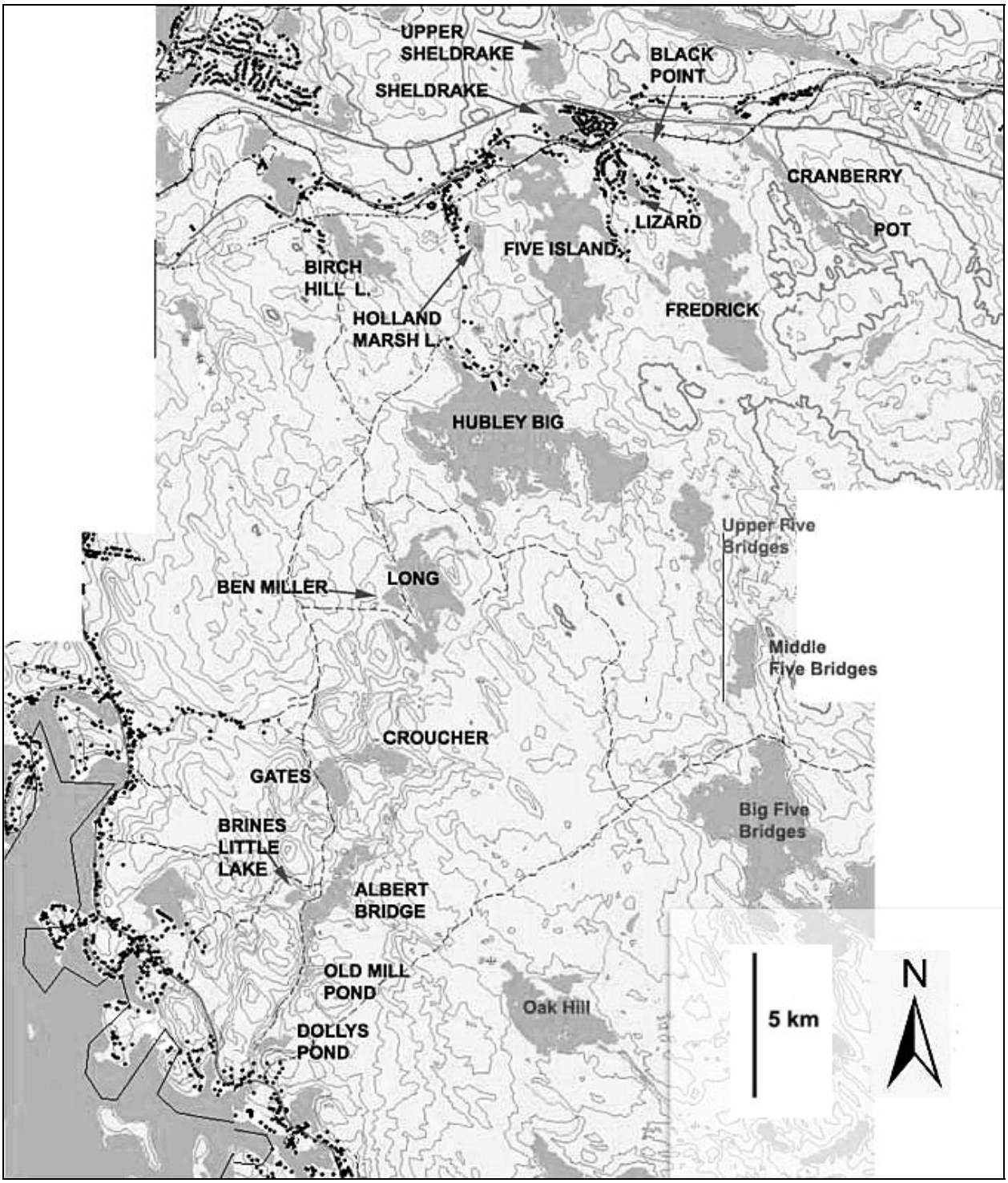


Figure 1. Map of study lake (Long Lake) and surrounding Woodens River Watershed (WRWEO 2009)

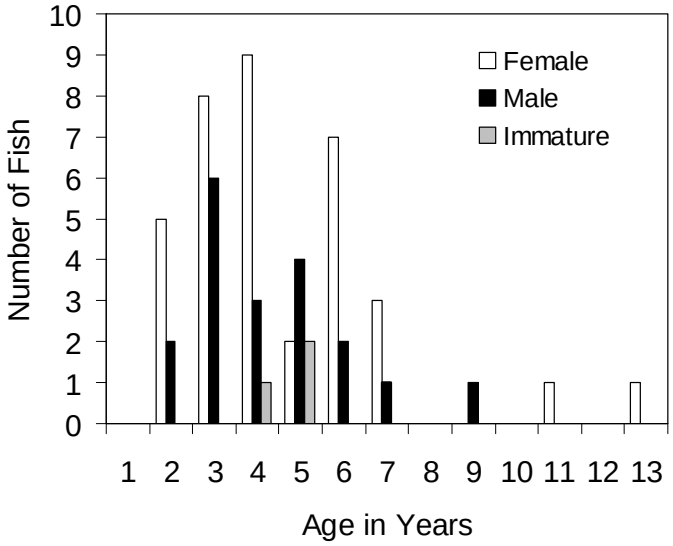


Figure 2. Age and sex structure of yellow perch (*Perca flavescens*) captured in Long Lake, Woodens River system, Halifax County, Nova Scotia, 2005.

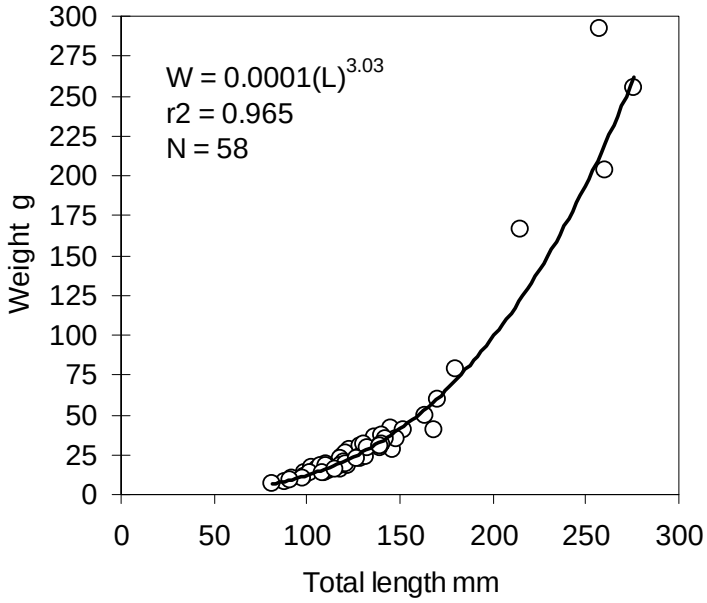


Figure 3. Length - weight relationship of yellow perch (*Perca flavescens*) captured in Long Lake, Woodens River system, Halifax County, Nova Scotia, 2005.

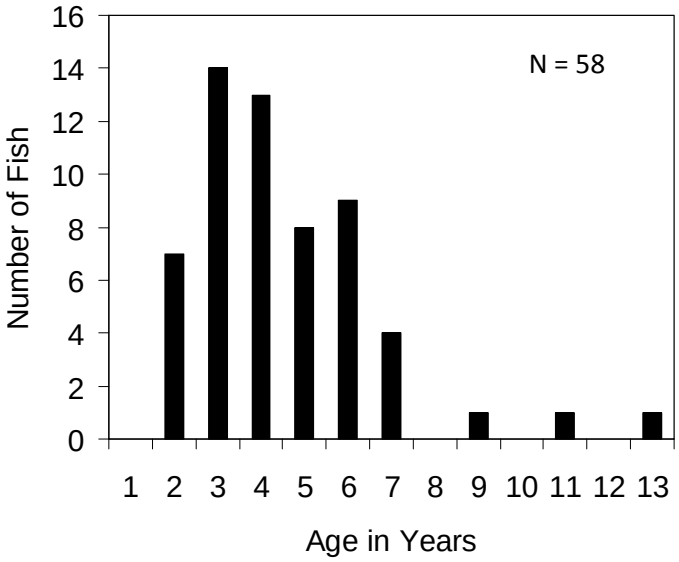
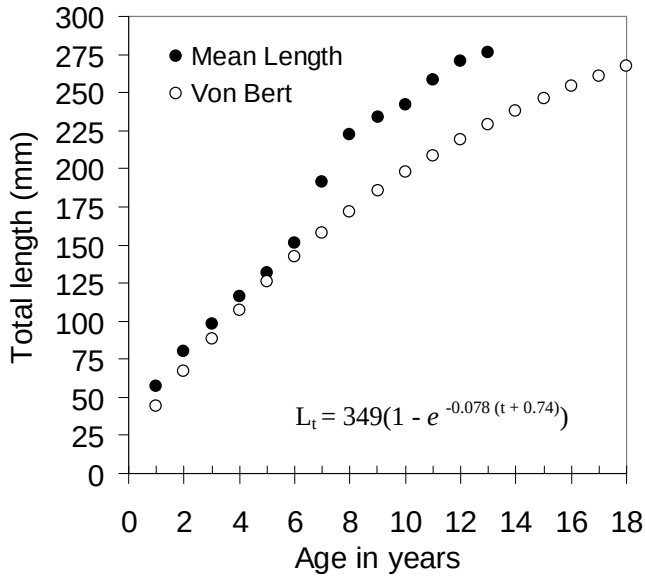


Figure 4. Age structure of yellow perch (*Perca flavescens*) captured in Long Lake, Woodens River system, Halifax County, Nova Scotia, 2005.



Fgure 5. Mean total length vs von Bertalanffy growth curve of yellow perch (*Perca flavescens*) captured in Long Lake, Woodens River system, Halifax County, Nova Scotia, 2005.