Age, Growth, Maturity and Food Habits of Landlocked Salmon (Salmo salar) in Soldiers Pond, a Newfoundland Lake

by W. J. Bruce

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Age, Growth, Maturity and Food Habits of Landlocked Salmon (*Salmo salar*) in Soldiers Pond, a Newfoundland Lake

by W. J. BRUCE

This is the forty-third Technical Report from the Research and Development Directorate Newfoundland Biological Station St. John's, Newfoundland

Ceci est le quarante-troisième Rapport Technique de la Direction du Recherche et Développement Station biologique de Terre-Neuve Saint-Jean, Terre-Neuve

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ABSTRACT

Bruce, W. J. 1976. Age, Growth, Maturity and Food Habits of Landlocked Salmon (*Salmo salar*) in Soldiers Pond, a Newfoundland Lake. Fish. Mar. Serv. Res. Dev. Tech. Rep. 668: 16 p.

The ouananiche in Soldiers Pond, Newfoundland are very slow-growing and short-lived. The 2+ and 3+ age-groups constituted 85.2% of the sample and only 1.2% of the sample lived beyond 4+ years. The maximum fork length recorded was of a 14.5 cm 6+ male. There was considerable overlap of age-groups with respect to length and weight distributions for both sexes. The greatest increment in length occurred during the first year of life, while the largest weight increments occurred in the later years. The weight increased as the 2.6741 power of the length. The overall sex ratio was very close to 1:1, with males maturing one year earlier (2+) than the females (3+). Ovaries from fish 11.0-14.9 cm in length contained an average of 49 eggs (range of 27-92). Benthic fauna, particularly immature insects, constituted the bulk of the diet. The cladoceran, *Holopedium gibberum*, occurred in a large number of the stomachs.

RÉSUMÉ

Bruce, W. J. 1976. Age, Growth, Maturity and Food Habits of Landlocked Salmon (*Salmo salar*) in Soldiers Pond, a Newfoundland Lake. Fish. Mar. Serv. Res. Dev. Tech. Rep. 668: 16 p.

Dans l'étang Soldiers, à Terre-Neuve, les ouananiches ont une croissance très lente et vivent très peu longtemps. Les groupes des 2 et des 3 ans constituaient 85,2% de l'échantillon, et seulement 1,2% des poissons échantillonnés avaient dépassé les quatre ans. La longueur maximale observée à la fourche était de 14,5 cm chez un mâle de six ans. Les groupes d'âges se chevauchaient considérablement en ce qui a trait à la répartition de la longueur et du poids chez les deux sexes. La plus forte augmentation de la taille s'est produite pendant la première année de vie, tandis que pour le poids, elle avait lieu plus tard. Le poids augmentait proportionnellement à la puissance 2,6741 de la longueur. Le rapport des sexes était d'environ 1:1, les mâles devenant adultes à 2 ans, un an avant les femelles. Chez les poissons de 11,0 à 14,9 cm de longueur, les ovaires contenaient en moyenne 49 oeufs (27 à 92). Les ouananiches se nourrissaient surtout au dépens de la faune benthique, plus particulièrement d'insectes non adultes. On a trouvé un grand nombre du cladocère *Holopedium gibberum* dans leur estomac.

INTRODUCTION

The ouananiche (landlocked Atlantic salmon), *Salmo salar*, is generally distributed throughout Newfoundland except for the Great Northern Peninsula (Scott and Crossman 1964). It is also present in western Labrador (Backus 1957; Bruce 1974, 1975). Despite its wide distribution, very few studies have been conducted on ouananiche populations in Newfoundland. Two papers have been published describing ouananiche on the Island of Newfoundland (Andrews 1966; Leggett and Power 1969). Apart from these, there are a number of unpublished reports on government files with respect to age and growth of ouananiche and one masters thesis describing the fecundity of landlocked salmon from two Avalon Peninsula lakes (Lee 1971).

From earlier studies (Wiseman 1971, 1972, 1973; Wiseman and Whelan 1974), it was discovered that ouananiche populations of Avalon Peninsula lakes exhibited very slow growth compared to other Newfoundland populations (Andrews 1966; Leggett and Power 1969), and particularly with those in Maine (Everhart 1950; Havey and Warner 1970). The primary purpose of this paper is to document the growth, maturity, and food habits of this very slow-growing population before any forage species are introduced into the lake. It also attempts to explain some reasons for this apparent dwarfism or stunted growth in Soldiers Pond.

Soldiers Pond (Fig. 1) is a relatively shallow (maximum depth 7 m), soft water lake situated at 47°25' North Latitude and 52°59' West Longitude. It has an area of 144 ha and a mean depth of 2.7 m. It lies at an altitude of 161 m and drains into Conception Bay. The water is slightly acidic with a pH of 6.9 and a total hardness of 4.3 ppm. Physical, chemical, and other biological factors of the lake have been previously described by Wiseman (1973). Two other native fish species are present in the lake, the eastern brook trout, *Salvelinus fontinalis*, and the American eel, *Anguilla rostrata*. The American smelt, *Osmerus mordax*, and the three-spine stickleback, *Gasterosteus aculeatus*, have been introduced into the lake.

METHODS

All fish used in this study were collected between September 23 and October 8, 1975, using lake trap nets. Each net consisted of a 30.5 m leader, two 9.1 m wings, a body of one 1.2 m square frame and four 0.6 m frames with a trailing codend. They were fished overnight in water 1.2-3 m deep. Fish were frozen shortly after capture and upon thawing were measured

(fork length) to the nearest millimeter and weighed to the nearest gram using a triple beam Dial-O-Gram balance. Scales were removed from the left side of each fish between the lateral line and dorsal fin and placed in scale envelopes. They were later aged using a Bausch and Lomb microprojector with a magnification 43X. The ovaries from 39 fish were preserved in 5% formalin and total counts were later made on both ovaries. Stomach samples, taken from the lower esophagus to the pyloric sphincter, were placed in individual vials containing 10% formalin and later analyzed in the laboratory.

RESULTS

AGE COMPOSITION

The ouananiche at Soldiers Pond have a relatively short life span (Table 1). A 5+ female and a 6+ male were the oldest fish captured. Approximately 85% of the sample comprised the age 2+ and 3+ age-groups, with the males dominant in the first group and the females in the latter.

LENGTH AND WEIGHT DISTRIBUTION OF THE AGE-GROUPS

There was considerable overlap of the different age-groups with respect to length, with only 7.0 cm separating the five age-groups (Table 2). The females were significantly larger in the 4+ and 3+ age-groups ($P < 0.05$ and $P < 0.01$ respectively). There was no significant difference ($P > 0.05$) in length between the males and females for the 2+ age-group. Results of t-tests between the males and females for the different age-groups showed an identical pattern with respect to weight differences (Table 3).

AGE AND GROWTH

The mean scale length/fish length plot yielded a straight line relationship described by the equation:

$$L_f = 2.96\, L_s + 2.53 \qquad (r = 0.99)$$

where L_f = fish length, L_s = scale length. Substituting the average annular scale lengths into the equation, back-calculated lengths were computed for ages 1 to 6 (Table 4, Fig. 2).

The greatest increment in length occurred during the first year with decreasing growth increments during subsequent years.

The age-weight relationship, calculated from placing back-calculated lengths into the general length-weight equation is presented in Table 5 and Fig. 3.

The mean length of females (11.86 cm) was significantly larger ($P < 0.01$) than the mean length of males (10.96 cm). There was also a significant difference ($P < 0.01$) between the mean weight of females and males (15.1 and 13.6 g respectively).

Unlike the length increments which are greatest during the earlier years, the largest increments in weight occur during the later years.

LENGTH-WEIGHT RELATIONSHIP

The relationship between length and weight is expressed by the equation:

$$\text{Log } W = 2.6741 \text{ Log } L - 1.6631 \qquad (r = 0.96)$$

Separate length-weight relationships were calculated for each sex, but a t-test used to check for significance between the slopes showed there was no significant difference between the sexes ($P > 0.05$). The mean calculated weights (using the computed length-weight equation) for the mean lengths of fish in each length group are presented in Fig. 4.

SEX RATIO, MATURITY AND FECUNDITY

The sex ratio (male:female) for the total sample was about 1:1. There was a significantly larger number of males than females in the 2+ age-group ($\chi^2 = 6.22$, $P < 0.05$). However, there was no significant difference in the sex ratios for the two older age-groups on the sample overall (Table 6). There were twice as many 4+ females as males among the 4+ fish, implying a higher mortality rate for males among older fish.

Age at maturity data (Table 7) indicated that males generally mature one year earlier (2+) than the females. At age 3+ 97.3% of the males, and 65.9% of the females were mature.

Direct egg counts were made of 39 pairs of ovaries in the fecundity study. The mean lengths and weights by age-group of these fish are presented in Table 8.

The 39 fish were grouped into 1.0 cm length classes and the mean number of eggs was computed for each length class (Table 9). The egg counts ranged from 27 to 92, with a mean of 49. A logarithmic transformation was applied to the mean lengths and computed egg counts giving the equation:

$$\text{Log } F = 2.6458 \text{ Log } L - 1.2259 \quad \text{or} \quad F = 0.0059L^{2.6458}$$

where F = fecundity and L = length (cm) (N = 39, r = 0.95). The calculated egg counts from the above equation in relation to total lengths are shown in Fig. 5.

The relationship between ouananiche egg production and weight is shown in Table 10. As was the case with length, there is a direct relationship between weight and total fecundity (Log F -1.1350 Log W -0.2049, r = 0.98).

FOOD

Analysis of the contents of 175 stomachs (Table 11) indicated that insects and cladocerans were the predominant food of the ouananiche. Trichopterans were the most important benthic food and the cladoceran, *Holopedium gibberum*, was the predominant plankter. Forty-five of the stomachs were empty.

DISCUSSION

Unlike many of the other ouananiche populations studied in Newfoundland, the landlocks at Soldiers Pond have a relatively short life span with less than 2.0% of the population living beyond 5 years, and with a maximum recorded age of 6+ years. Wiseman and Whelan (1974) reported that 24 out of 29 Avalon Peninsula lakes studied contained ouananiche older than 6 years, with a maximum age of 11 years. Lee (1971), working on two additional Avalon Peninsula lakes, found the 3+ to 6+ age-category was the most abundant and the oldest fish was 8 years from Ocean Pond. Leggett and Power (1969), comparing ouananiche populations from two Newfoundland lakes, discovered the two populations differed greatly in many respects including age. In Flatwater Pond only 3.2% of the sample surpassed 4 years, while in Gambo Pond 39.6% lived beyond this age. The maximum ages recorded at both lakes were 10+ and 9+ respectively. Andrews (1966) reported ouananiche 9 years old in the Terra Nova system, eastern Newfoundland. Scott and Crossman (1964) gave 5 years as the maximum age for ouananiche sampled from five lakes on the Avalon Peninsula. Backus (1957) gave the

age-length relationship for 10 ouananiche from Flour Lake, Hamilton River, Labrador. There were two 7+ fish with a mean standard length of 38.5 cm. Bruce (1974) found one fish 12+ years old in a sample of 41 from the Unknown River, western Labrador. Bruce (1975) reports 10+ ouananiche (57.0 cm) at Sandgirt Lake, Smallwood Reservoir, western Labrador. Ouananiche in Maine generally live longer than 6 years (Everhart 1950; Havey and Warner 1970) and the oldest fish reported from there was 13+ years (Warner 1961).

The growth rate of the Soldiers Pond population is the slowest reported to date, with a maximum length of 14.5 cm at age 6+ years. The mean length for age 6 fish from 29 Avalon Peninsula lakes was 24.5 cm and the largest fish was 54.5 cm (Wiseman and Whelan 1974). Populations in other areas of the Island of Newfoundland show a faster growth rate (Leggett and Power 1969; Andrews 1966) but they are still somewhat slower growing than the ouananiche in Maine (Everhart 1950; Havey and Warner 1970). The growth rate of ouananiche from western Labrador (Bruce 1974) is much faster than any of those on the Island but still slower than the fish from Maine. From our own studies here on the Island (Wiseman 1971, 1972, 1973) and from those in Maine as reported by Havey and Warner in 1970, it is apparent that ouananiche attain their largest sizes and reach maximum ages where forage fish species are present, particularly smelt. This lack of forage species, the great numbers of ouananiche in a particular lake, together with the general unproductive nature of Avalon Peninsula lakes (Wiseman 1971, 1972) are believed to be the causative factors for this slow growth. Genetic factors may also be important here but they were not studied here.

The sex ratio in this sample was very close to 1:1 but the females outnumbered the males in the 3+ and 4+ categories, implying a higher mortality rate for males. Similar results have been reported for two other Avalon Peninsula lakes (Lee 1971). On the other hand, the males matured one year earlier (2+) than the females, as was also observed by Lee (1971), Leggett and Power (1969), and Warner (1961). In Maine, male ouananiche generally mature at age 3+ and females a year later (Everhart 1950; Havey and Warner 1970). Generally, early maturity is associated with good growth (Alm 1959) but this is not the case for dwarfed whitefish populations in Maine (Fenderson 1964). Fenderson states that in cases of extremely slow growth, early maturity is accelerated by unknown physiological factors.

The mean number of eggs per fish (49) is the lowest ever recorded for ouananiche. Fecundity studies on ouananiche are few, but Lee (1971) reported a linear relationship between fecundity and fish length where fish with a mean length of 23 cm had 279 eggs in Forest Pond and those with a mean length of 27.4 cm had 346 eggs in Ocean Pond. Wiseman (1971) found the relationship between fecundity and fish length to be curvilinear with the number of mature eggs approximately proportional to the cube of the length (range 147-1211). Incerpi and Warner (1969), studying fecundity of ouananiche in 15 Maine lakes, found the mean number per female was 1779, with a range of 632-4578 for fish between 33.0 and 73.4 cm.

Benthic invertebrates, particularly immature insects, formed the bulk of the ouananiche diet; one plankter, *Holopedium gibberum*, occurred in 44.6% of the stomachs. Apart from the occurrence of plankton, these organisms together with terrestrial insects generally constitute the ouananiche diet when forage species are absent (Wiseman 1971, 1972; Leggett and Power 1969; Lackey 1969; Havey and Warner 1970; Speirs 1974). The absence of food in approximately 1/4 of the sample may indicate that ouananiche have an insufficient supply of food. The bottom fauna of Avalon Peninsula lakes is sparse both qualitatively and quantitatively by North American standards (Wiseman 1971) and is not available to the ouananiche during the entire growing season as they seek out the deeper, cooler waters during the summer months (Leggett and Power 1969). The presence of plankton in 44.6% of the stomachs might also be suggestive of an insufficient benthic food supply. This, along with intraspecific competition resulting from the high standing crop of ouananiche at Soldiers Pond (Wiseman, personal communication), help limit the growth of ouananiche.

From the findings in this study it is suggested that a poor physiochemical environment, which in turn determines the bottom fauna of a lake, has resulted in a very slow-growing ouananiche population with an extremely low fecundity. This is compensated for by an early age at maturity and the very large population which has a high potential for egg production.

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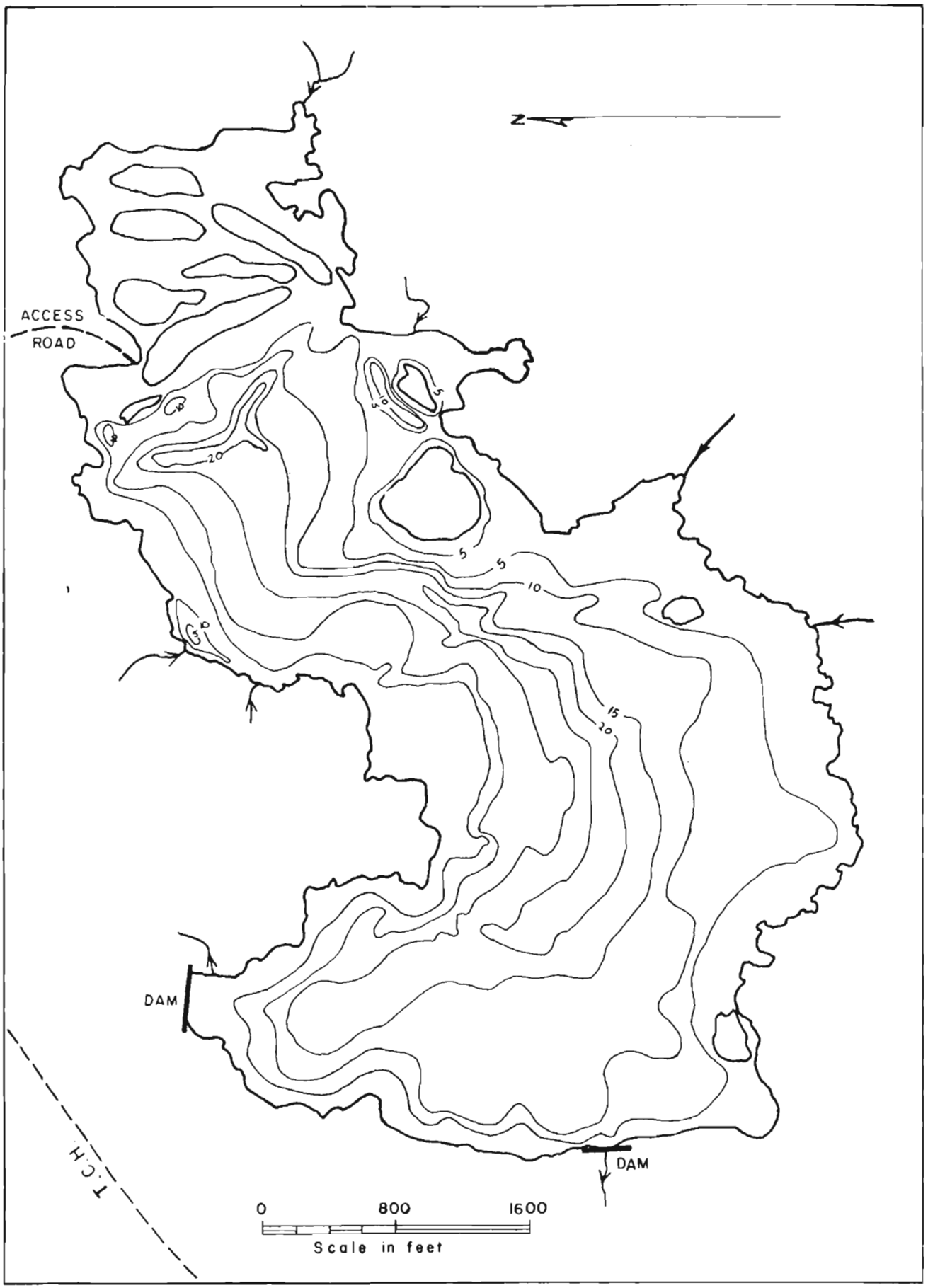

Fig. 1. BATHYMETRIC MAP OF SOLDIERS POND.

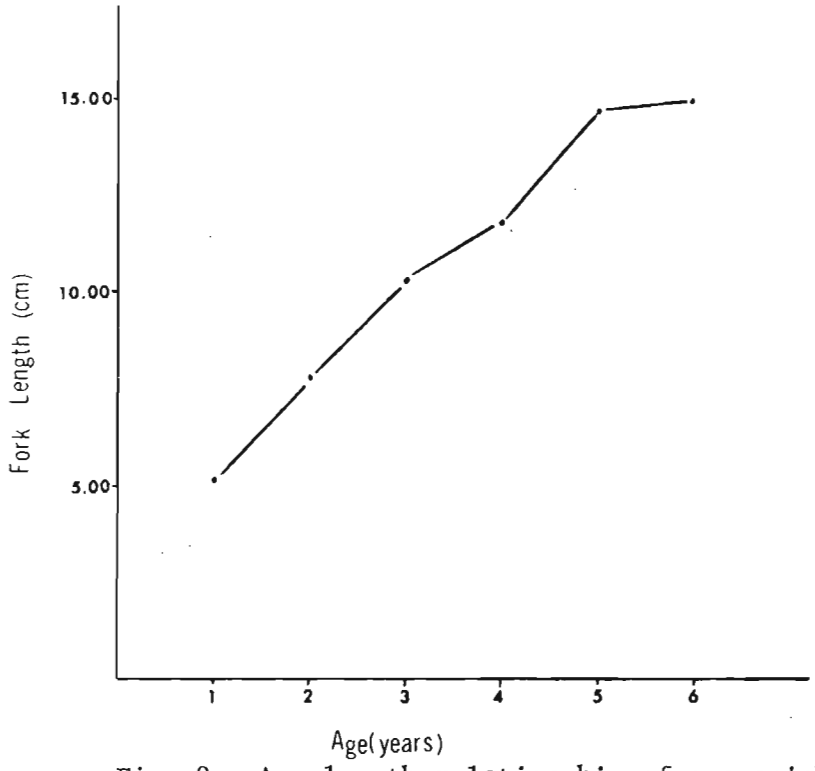

Fig. 2. Age-length relationship of ouananiche from Soldiers Pond.

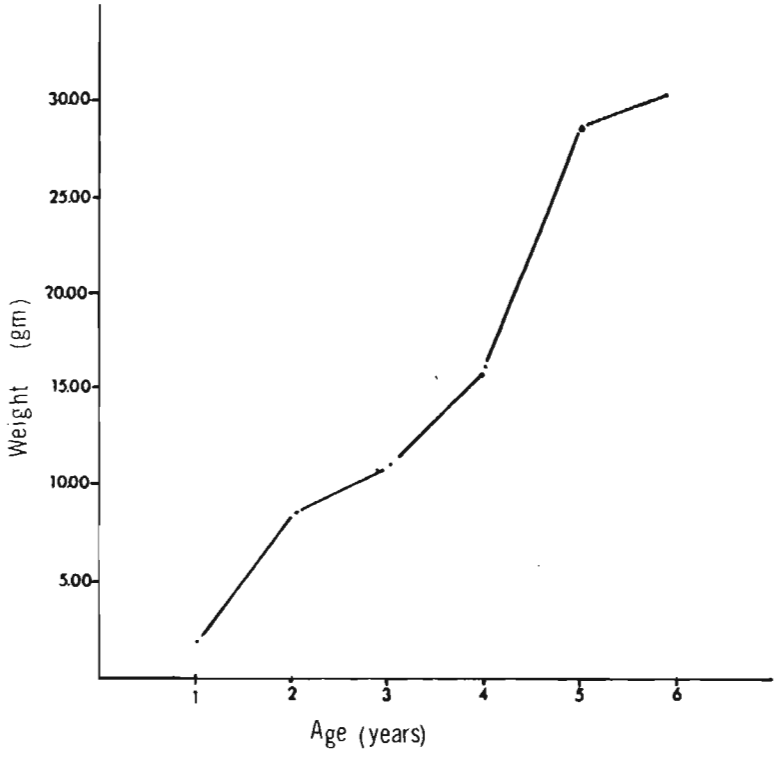

Fig. 3. Age-weight relationship of ouananiche from Soldiers Pond.

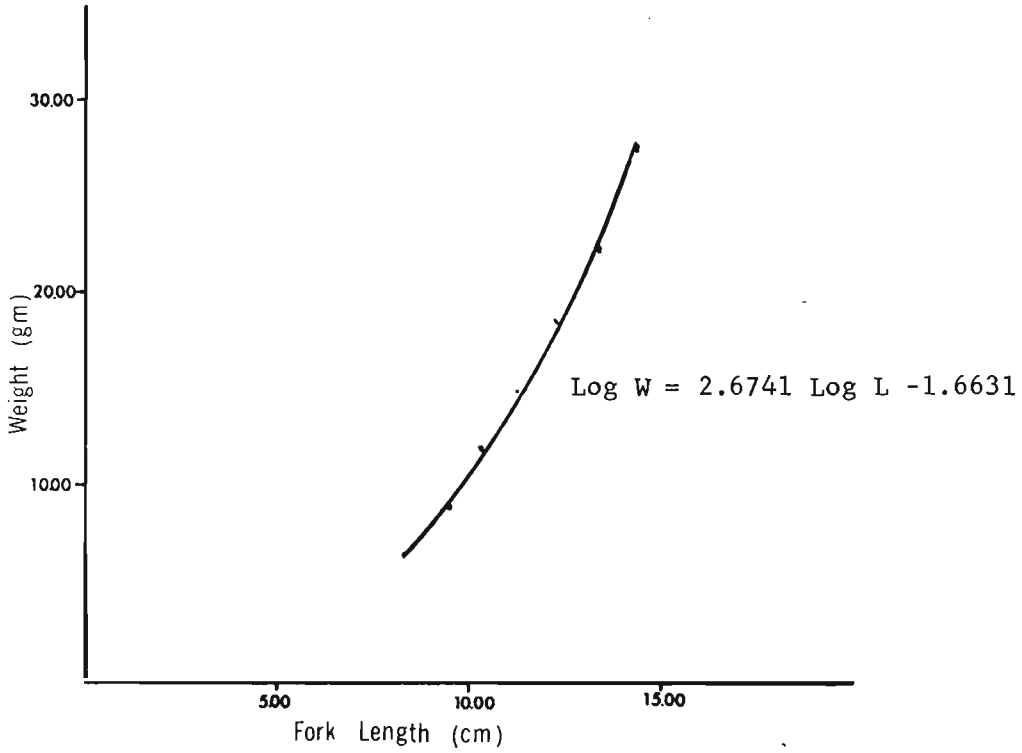

Fig. 4. Length-weight relationship of ouananiche from Soldiers Pond.

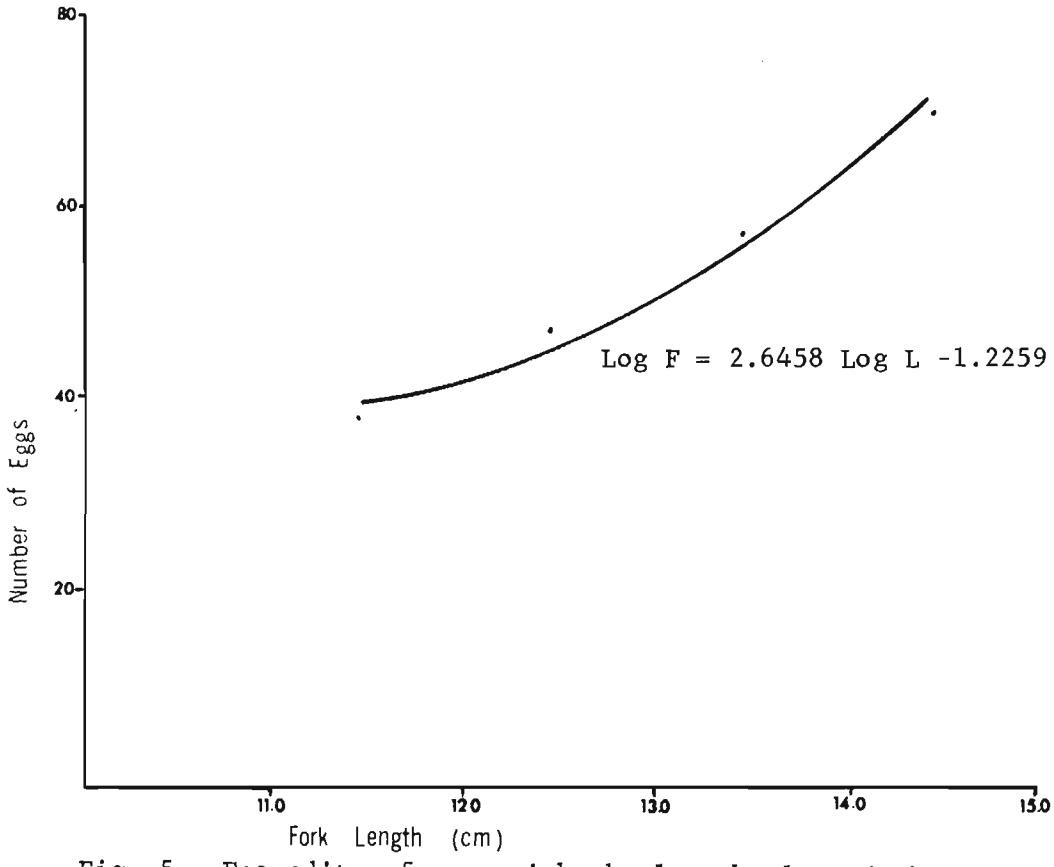

Fig. 5. Fecundity of ouananiche by length class (cm).

Table 1. Age composition (sexes combined and separated) of ouananiche from Soldiers Pond, 1975.

		2+	3+	4+	5+	6+	Total
Males & Females	(No.)	71	78	24	1	1	175
	(%)	(40.6)	(44.6)	(13.6)	(0.6)	(0.6)	(100.0)
Males		46	37	8	-	1	92
		(50.0)	(40.2)	(8.7)	-	(1.1)	(100.0)
Females		25	41	16	1	-	83
		(30.1)	(49.4)	(19.3)	(1.2)	-	(100.0)

Table 2. Length distribution (percentage) of the age-groups of ouananiche from Soldiers Pond, 1975.

Length interval (cm)	Age-group and sex											
	2+		3+		4+		5+		6+	
	M	F	M	F	M	F	M	F	M	F
8.0 - 8.9	-	(4.0) 1	-	-	-	-	-	-	-	-
9.0 - 9.9	(30.4) 14	(16.0) 4	(8.2) 3	(4.9) 2	-	-	-	-	-	-
10.0-10.9	(52.2) 24	(60.0) 15	(16.2) 6	(9.8) 4	(25.0) 2	-	-	-	-	-
11.0-11.9	(17.4) 8	(20.0) 5	(37.8) 14	(31.7) 13	(75.0) 6	(18.8) 3	-	-	-	-
12.0-12.9	-	-	(27.0) 10	(24.4) 10	-	(12.5) 2	-	-	-	-
13.0-13.9	-	-	(10.8) 4	(22.0) 9	-	(68.7) 11	-	(100) 1	-	-
14.0-14.9	-	-	-	(7.2) 3	-	-	-	-	(100) 1	-
Totals	(100) 46	(100) 25	(100) 37	(100) 41	(100) 8	(100) 16		(100) 1	(100) 1	

Table 3. Weight distribution (percentage) of the age-groups of ouananiche from Soldiers Pond, 1975.

Weight interval (g)	Age-group and sex													
	2+				3+				4+				5+				6+			
	M		F		M		F		M		F		M		F		M		F	
6.0 - 9.9	(21.7)	10	(20.0)	5	(8.2)	3	(2.4)	1	-		-		-		-		-		-	
10.0-13.9	(67.4)	31	(72.0)	18	(21.6)	8	(19.5)	8	(50.0)	4	(6.2)	1	-		-		-		-	
14.0-17.9	(8.7)	4	(8.0)	2	(45.9)	17	(29.3)	12	(50.0)	4	(25.0)	4	-		-		-		-	
18.0-21.9	(2.2)	1	-		(16.2)	6	(22.0)	9	-		(43.8)	7	-		(100)	1	-		-	
22.0-25.9	-		-		(5.4)	2	(22.0)	9	-		(18.8)	3	-		-		-		-	
26.0-29.9	-		-		(2.7)	1	(2.4)	1	-		(6.2)	1	-		-		(100)	1	-	
30.0-33.9	-		-		-		(2.4)	1	-		-		-		(100)	1	(100)	1	-	
Totals	(100)	46	(100)	25	(100)	37	(100)	41	(100)	8	(100)	16			(100)	1	(100)	1		

Table 4. Back-calculated fork lengths (cm) at annulus formation of ouananiche from Soldiers Pond.

Annulus	1	2	3	4	5	6
Fork length (cm)	5.1	7.9	10.2	11.7	14.7	15.0

Table 5. Age-weight (back-calculated) relationship of ouananiche from Soldiers Pond.

Annulus	1	2	3	4	5	6
Weight (g)	1.7	5.4	10.9	15.6	28.6	30.2

Table 6. Sex ratios of ouananiche, by age-group, from Soldiers Pond.

Age										
2+		3+		4+		5+		6+	
M	F	M	F	M	F	M	F	M	F
46	25	37	41	8	16	-	1	1	-
1.84:1		0.90:1		0.50:1		-		-	

Table 7. Percentage of mature ouananiche by age-class (sexes separated).

Sex	Age-class					
	2+	3+	4+	5+	6+	N
Male	93.5	97.3	100.0	-	100.0	92
Female	4.0	65.9	75.0	100.0	-	83

Table 8. Mean fork length (cm) and weight (g) by age-class of ouananiche studied for fecundity at Soldiers Pond.

	Age			
	2+	3+	4+	5+
Mean total length (cm)	11.3	12.7	13.1	13.0
Mean weight (g)	15.1	20.3	21.7	20.0
Number of fish	1	26	11	1

Table 9. Fecundity (actual count) of ouananiche by length class (cm).

Length (cm)	No. of fish	No. of eggs/fish	
		Mean	Range
11.0-11.9	10	41.0	33-49
12.0-12.9	9	42.0	27-65
13.0-13.9	18	53.0	34-74
14.0-14.9	2	73.0	54-92

Table 10. Fecundity (actual count) of ouananiche by weight class (g).

Weight (g)	No. of fish	No. of eggs/fish	
		Mean	Range
14.0-16.9	10	39.0	28-45
17.0-19.9	9	41.0	34-50
20.0-22.9	8	50.0	37-73
23.0-25.9	10	59.0	39-74
26.0-28.9	1	66.0	-
29.0-31.9	0	-	-
32.0-34.9	1	92.0	-

Table 11. The food of 175 ouananiche from Soldiers Pond, expressed as percentage of occurrence.

Food item	Frequency	Percent
Insecta		
Odonate (nymph)	3	2.3
Ephemerophtera (nymph)	15	11.5
Trichoptera (larva)	60	46.2
Diptera (larva)	5	3.8
(adult)	2	1.5
Coleoptera (adult)	1	0.8
Mollusca		
Lymnaea sp.	5	3.8
Cladocera		
Holopedium gibberum	58	44.6
Bomina sp.	2	1.5
Amphipoda	12	9.2
Unidentifiable insect remains	43	33.1
Detritus	8	6.2
Empty	45	25.7