Not to be cited without
permission of the authors[1]

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 90/3

Ne pas citer sans
autorisation des auteurs[1]

Comité scientifique consultatif des
pêches canadiennes dans
l'Atlantique

CSCPCA Document de recherche 90/3

Status of Atlantic Salmon of Grand River, Richmond Co., N.S., 1988

by

P.G. Amiro and D.A. Longard
Biological Sciences Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, N.S.
B3J 2S7

ABSTRACT

A brief history of the Atlantic salmon resource of the Grand River, Richmond Co., N.S., is reviewed, physical and biological data are analyzed and an assessment of the status of the stock for 1988 is presented. Angling and fishway trap data indicate that the stock is composed of mostly July-returning 1SW and repeat-spawning grilse. Area available to juvenile production is estimated to be $5,491*10^2$ m^2 of which 16% is less than 0.12% stream gradient. Required spawning escapement is 539 fish comprised of 79% recruit grilse which contribute 70% of the $1.1*10^6$ required eggs. Data from the angling fishery, a trap in the fishway and diver estimates of redds below the fishway indicate a total return of 1,065 fish and a residual surplus of 177 fish after legal harvests. The uncertainty of proportions removed above and below the fishway, by-pass rates at the fishway for fish larger than 63cm and accuracy of estimates based on redd counts indicate a more conservative estimate of residual surplus in relation to the entire river requirement of 61 fish above the falls.

RESUME

Le présent document offre une brève rétrospective des stocks de saumon de l'Atlantique de la rivière Grand, comté de Richmond, Nouvelle-Ecosse, analyse les données physiques et biologiques relatives à ces stocks et évalue l'état de ces derniers en 1988. Les données provenant de la pêche à la ligne et des pièges de passe migratoire révèlent que le stock se compose essentiellement d'unibermarins qui remontent la rivière en juillet et de madeleinaux à pontes antérieures. On estime à $5\ 491*10^2$ m^2 la superficie disponible pour la production de juvéniles, dont 16 % de pente de rivière inférieure à 0,12 %. Les besoins de géniteurs sont de 539 poissons, dont 79 % de madeleinaux qui contribuent dans une proportion de 70 % à la ponte requise, chiffrée à $1,1*10^6$. D'après les données de pêche à la ligne, les résultats obtenus à un piège de la passe migratoire et des estimations sur les nids de frai en aval de celle-ci fournies par des plongeurs, les remontées totales s'établissent à 1 065 poissons, ce qui donne un surplus résiduel de 177 poissons après les récoltes autorisées. L'incertitude quant aux quantités de poisson retirées en amont et en aval de la passe migratorie, au taux d'évitement des poissons de plus de 63 cm et à l'exactitude des estimations fondées sur le dénombrement des nids de frai nous font pencher vers une estimation plus prudente (61 saumons en amont des chutes) du surplus résiduel par rapport au besoin total.

INTRODUCTION

The Grand River, Richmond Co., Cape Breton Island, Nova Scotia, (Fig.1) has been the subject of numerous Atlantic salmon studies and interest since at least 1893. First attempts to enhance the salmon run was by way of blasting a portion of a falls to reduce turbulence thought to impeded the passage of salmon.

A fishway was constructed at the falls in 1893, the effectiveness of which was difficult to assess due to a general increase in all fisheries in the area. When catches declined about 1915 the effectiveness and condition of the fishway came under question. Repairs and reconstruction of the fishway were completed in 1923 -1924.

Operational efficiency of the fishway again came into question in 1929 and, in an effort to assess its function, a trapping program was pursued in the fishway and above the falls. Only two fish were caught in the fishway late in the season and no fish were caught or observed above the falls.

Poor angler catches in 1936 resulted in a second attempt to assess fish passage. A fish fence with trap was installed on August 17, 1936, at the foot of Loch Lomond Lake. The installation was removed on January 11, 1937, after no salmon were caught in the trap. However, 30 salmon were angled in the lake above the fence and trap.

As a pre-requisite to improvement of fish passage, an assessment of spawning and rearing areas above and below the falls was conducted by the local fishery officer resulting in further repairs being carried out in 1947, and a new fishway constructed in 1957-1958.

A brief field program was conducted in 1976 to document the distribution of juvenile salmon and to provide quantitative estimates of densities at two sites in the main river above and below the fishway.

Catches of salmon increased during the 1980's to the point where the Grand river has consistently ranked in the top three angling rivers on Cape Breton Island. This situation has increased interest in the salmon stock by both management and users.

This document presents data requisite to the assessment of the production potential of the river and status of the stock in 1988.

Study area

The Grand River drains an area of 217 km^2 in a southerly direction for a distance of 38 km from an elevation of 108 m above sea level into the Atlantic Ocean on the east coast of Cape Breton Island. The main river begins at the outlet of Loch Lomond Lake some 15.7 km above the head of tide. A falls, a partial barrier with fishway, exists at 10.2 km from the head of tide.

Water quality is good with high pH and conductivities (MacPhail et al. 1987).

METHODS

Production area of the river was determined by remote sensing using the techniques described by Amiro et al.(1989), the detailed collection of which is explained therein. In summary the total habitat area was derived using 1:10,000 ortho-photographic maps with 5.0-m contour intervals and 1:10,000 color aerial photographs.

A counting trap was installed in the top two pools of the fishway at Grand River Falls and operated[1] daily from early June to mid-October. A barrier fence was erected at the top of the falls in September and October of 1988 such that both both upstream and downstream migrants were fished. All fish passing through the trap were measured, scale sampled and caudal fin punched.

Broodstock, seined above the fishway in mid-October, 1988 were examined for caudal fin punches. Broodstock collected above the fishway and spawned at Cobequid Fish Culture Station, 1987, were used to estimate a length-fecundity relationship from volumetric egg counts by displacement (Burrows, 1951).

Fishway by-pass rates for size classes of salmon were estimated by calculating the population of grilse (<63 cm) and salmon (=>63cm) above the falls from examination of caudal fin punches of fish collected for broodstock above the falls in mid October . The use rate (one minus the by-pass rate) for both size classes above the falls was determined by dividing the known marked releases above the falls by the population estimates above the falls from an unbiased Petersen mark-recapture method (Ricker 1975).

---

[1] This was a co-operative project between the Richmond County Development Corporation, and the Richmond County Wildlife Association funded through a job development grant by Canada Employment and Immigration Commission and under the guidence of the Dept. of Fisheries and Oceans.

Redd counts below the falls in the main river were made by two divers in mid-November. The total number of redds was estimated by increasing the total average two-diver count by a factor of 3 to account for the two-thirds of the river width un-observed by the divers. The number of spawners in the main river below the falls was estimated by dividing the total estimated redd count by 3 (i.e., an average of 3 redds female^{-1}) and the proportion females as observed during broodstock collections.

RESULTS

Sport fishery

Angling catches (Table 1) 1931-1988 show a marked increase since 1980. The 1980-1988 mean annual catch of 471 fish is more than 2.6 times the 1970-1979 average of 180 fish. This may be due in part to the catch and release regulations for fish equal to or greater than 63 cm which effectively began in 1985. However, the number of retained grilse has also increased from a mean of 172 to 373 in the same periods.

The sport fishery commences on June 15 and closes on October 15 with closures due to low water occurring frequently. The fishery is concentrated early in the season on the lower portion of the river below the falls and late in the season in the upper area and in Loch Lomond Lake. The portion of fish angled above the fishway is unknown, but a much greater portion of the catch is thought to be taken below the fishway. Local knowledgeable residents suggest that 80% of the catch is taken below the fishway.

Fishway counts

Counts at the fishway in 1988 totalled 578 fish (Table 2) and peaked in early July (Fig.2). The 50% cumulative total occurred in the first week of July (Fig.3).

Marked grilse (fish <63cm), recaptured during broodstock collections in 1988, numbered 19 of 21 grilse. There were 477 grilse marked at the fishway, indicating a population of 527 grilse above the falls and a fishway use rate of 91% for grilse.

Salmon (fish =>63cm) recaptures during broodstock collections in 1988 numbered 3 of 6 salmon. There were 101 salmon marked at the fishway indicating a population of 178 salmon above the falls and a fishway use rate of 57% for salmon.

No fish were counted moving downstream in the fall when the

fence was operative.

Redd counts

The number of redds estimated on November 15, 1988, below the fishway in the main river was 300.

Age structure

Scales aged from samples collected at the fishway in 1988 (Table 2) indicate 83% of the fish to be maiden grilse and 13% repeat-spawning grilse. Age and life history interpretations of scales indicated both consecutive- and alternate-spawning strategies for repeat-spawning grilse.

Maiden 2SW salmon comprised 3% of the count at the fishway. Age interpretation indicated the few repeat spawning salmon to be mostly consecutive spawners.

Smolt age based on ages interpreted from the 1988 fishway samples was 95% two-year and 5% three-year smolts.

Biological characteristics

Data derived from broodstock collections provide the only reliable sex composition information. Grilse recruiting to the river were composed of 74% females, consecutive repeat-spawning grilse were 100% female, alternate-spawning grilse were 66% female, and the remaining age classes had sample sizes too small to provide reliable estimates. The limited data suggest that consecutive repeats are mostly female and that males generally spawn as recruit grilse and as alternates. Alternate spawners comprised a small portion of the populations in 1988.

Fecundity of females was determined from 20 fish collected in 1987 and resulted in a significant ($p=0.000$) regression of $\log_e$ eggs on fork length. Two significant residuals were noted and removed from the final analysis. The resulting equation;

$$\mathbf{Y}_{Eggs} = 261.9*EXP(0.043*\mathbf{X}_{Length})$$

accounted for 87% of the variance (Fig.4).

Habitat area

The amount of area available for juvenile production (Table 3) was estimated at $5,491*10^2$ m^2. Habitat area above the falls was

$2,310*10^2$ m^2 and below the falls, $3,181*10^2$ m^2.

The area less than 0.12% ortho-gradient, which has a lower production rate for juvenile salmon, was estimated at $873*10^2$ m^2 or 16% of the total area. Habitat area less than 0.12% ortho-gradient above the falls was $784*10^2$ m^2 and below the falls, $89*10^2$ m^2.

The main Grand river was estimated at $3,300*10^2$ m^2 of which $1,193*10^2$ m^2 is above and $2,107*10^2$ m^2 below the falls.

Area less than 0.12% ortho-gradient in the main Grand river was estimated at $682*10^2$ m^2 of which 100% is above the falls.

Egg requirements

The number of eggs required to seed the entire Grand River and tributaries at 2.4 eggs m^{-2} (Elson, 1975) is $1.3*10^6$ eggs. Discounting the area less than 0.12% ortho-gradient reduces the requirement to $1.1*10^6$ eggs.

Egg requirement above the falls is $0.544*10^6$ eggs and with area less than 0.12% orthogradient removed, the egg requirement was $0.366*10^6$ eggs.

Required spawning escapement

The 1988 fishway data for incremental post-smolt years of both grilse and salmon and the 1987 length-fecundity relationship indicated that, for a required egg deposition of $1.1*10^6$ eggs, an escapement of 539 fish (Table 4) was required for the entire river of which 174 fish are required above the falls. The requirement for the main river below the falls is 240 fish.

Stock status

The status of the stock in 1988 was interpreted by estimating total returns and subtracting the losses due to angling, hook-and-release mortality and broodstock. The 1988 estimate is;

Source	Number of fish in 1988
Fishway count	584
+adjustment	85
Angling below @0.8 of total	253
Est. escape. below(300/3) and 70% female	143
Total River Return	1,065
Minus	
Angling total retained	316
H & R mort. @ 0.05 of total releases	6
Broodstock	27
Total Spawning Escapement	716
Requirement	539
Residual Surplus/(Deficit)	177

DISCUSSION

The estimated spawning escapement to the entire river together with the estimated fecundity and production areas indicates a surplus to spawning requirements of 177 fish. The population

estimate of salmon above the falls is 124 fish more than than the required escapement for the total river. If 20% of the catch were angled above the falls then a residual (non-harvested) surplus of 61 fish, consisting of mostly grilse (<63cm), occurred above the falls in 1988 (Table 5).

These estimates of surpluses are dependent on the accuracy of several assumptions. The estimates for escapements to the entire river are dependent on both the assumptions used to estimate escapement below the falls based on redd counts and those used to estimate the population above the falls based on mark-recapture procedures.

Accuracy of estimates of escapements based on redd counts are subject to error in the estimate of the number of redds present, and correct assumptions of the number of redds female^{-1} and the percent females in the population below the fishway is the same as those observed in broodstock collections.

Population estimates above the falls, based on recapture of marked fish at the time of broodstock collections are subject to all the assumptions of mark-recapture estimates. Grilse estimates may be suitably robust because of the numbers sampled. However, the population estimate for salmon is not nearly as robust, because large changes in the ratio of marked to unmarked fish can occur for only a small change in the numbers of either marked or unmarked fish.

This assessment is robust by nature of the dominance of maiden grilse in the population and the greater confidence in the estimate of those grilse. An estimate of an angler catch rate of 42% and an angler retained fish rate of 30%, derived from the estimates of total river returns and angler license-stub reports, is comparable to values derived in similar studies (Cutting et al. 1988) and further supports the estimate of total return.

Several research topics would improve the accuracy of Grand River assessments. These topics are: 1) An estimate of the proportion of the population angled above the falls, 2) A greater sample of the salmon population above the falls in order to improve the confidence in the estimate of fishway use by salmon and repeat-spawning grilse, and 3) A method to assess the accuracy of the estimate of escapement below the falls based on redd counts or provision of an alternative methodology.

ACKNOWLEDGEMENTS

This project would not have been possible without the co-

operation of many people in the Grand River area. The determination of Mr. R. Matheson, Chairman of the Richmond County Development Corporation, was essential in obtaining funding to initiate the project. Mr. R. Cotton and Mr. D. McNearney and the Board of Directors of the Richmond County Wildlife Association were fundamental in the project design and control. Mr. T. Wilkie managed the daily concerns of the project. Financial support was provided by way of Job Development under the direction of Mr. G. Humpheries of Canada Employment and Immigration Commission.

LITERATURE CITED

Amiro, P.G., A.J. McNeill and D.A. Longard. 1989. Results of surveys and electrofishing in the Stewiacke River, 1984 to 1988 and the St. Mary's River, 1985 and 1986. Can. Data Rep. Fish. Aquat. ci. No. 764:ix + 55 p.

Burrows, R.E. 1951. A method for enumeration of salmon and trout eggs by displacement. Prog. Fish-Cult. Vol. 13,No. 1. pp 25-30.

Cutting, R.E., E.M. Jefferson and S.F. O'Neil. 1987. Status of the Atlantic salmon of the LaHave River, Nova Scotia, in 1986 and forecast of returns in 1987. CAFASC Res. Doc. 87/106, 18 p.

MacPhail,D.K., D. Ashfield and G.J. Farmer. 1987. Chemical characteristics of selected Cape Breton rivers, 1985. Can. Data Rep. Fish. Aquat. Sci. No. 654. vii + 24 p.

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

Table 1. Recreational catch of Atlantic salmon in Grand River as reported by fishery officers 1931-1983 and through the license stub system 1984-1988.

	Grilse			Salmon			Total		
Year	Ret.1	Rel.2	Total	Ret.	Rel.	Total	Ret.	Rel.	Total
1931									5
1932									30
1933									19
1934									6
1935									13
1936									37
1937									40
1938									41
1939									45
1940									37
1941									34
1942									1
1943									2
1944									1
1945									-
1946									-
1947									2
1948									6
1949									12
1950									16
1951									43
1952									66
1953									90
1954									52
1955									65
1956									84
1957									-
1958									117
1959									162
1960									112
1961									65
1962									152
1963									94
1964									111
1965									105
1966									160
1967									53
1968									105
1969									127
1970	177	0	177	10	0	10	187	0	187
1971	85	0	85	2	0	2	87	0	87
1972	200	0	200	4	0	4	204	0	204
1973	147	0	147	0	0	0	147	0	147
1974	216	0	216	1	0	1	217	0	217
1975	53	0	53	0	0	0	53	0	53
1976	121	0	121	3	0	3	124	0	124
1977	418	0	418	14	0	14	432	0	432
1978	147	0	147	9	0	9	156	0	156
1979	163	0	163	36	0	36	199	0	199
1980	584	0	584	121	0	121	705	0	705
1981	414	0	414	91	0	91	505	0	505
1982	256	0	256	48	0	48	304	0	304
1983	138	0	138	45	0	45	183	0	183
1984	338	50	388	4	30	34	342	80	422
1985	471	71	542		133	133	471	204	675
1986	298	62	360		194	194	298	256	554
1987	308	34	342		107	107	308	141	449
1988	316	22	338		105	105	316	127	443

1 retained
2 released

Table 2. Number, length and weight statistics of Atlantic salmon by age at first maturity, post-smolt age and spawning history of fish trapped in the Grand River Falls fishway, 1988.

Post smolt (years)	Caught	Length (cm.)					Weight (kg.)				
		N	Mean	Min.	Max.	Sd	N	Mean	Min.	Max.	Sd
1	477	475	52.1	44.0	64.5	2.83	19	1.54	1.1	2.9	0.38
2 sp.1	59	58	58.5	53.0	67.5	3.19					
3 sp.1	4	4	69.9	65.0	74.0	3.75					
3 sp.1.2	7	7	64.1	63.0	65.0	0.83					
4 sp.1.2.3	1	1	64.0								
4 sp.1.3	3	3	78.3	76.0	81.0	2.05					
5 sp.1.3.4	2	2	80.0	77.5	82.5						
Total grilse	553	550	53.3	44.0	82.5	4.68	19	1.54	1.1	2.9	0.38
2SW											
2	19	19	70.0	62.0	79.0	3.91	2	3.50	2.3	4.7	1.20
3 sp.2	4	4	76.0	75.0	77.5	1.06					
4 sp.2	1	1	75.0								
4 sp.2.3	1	1	79.0								
Total salmon	25	25	71.5	62.0	79.0	4.42	2	3.50	2.3	4.7	1.20
Unknown age	1	1	82.0								
Unknown age	1	1	75.0								
Unknown age	1	1	67.5								
Unknown age	1	1	80.5								
Unknown age	1	1	54.0								
Unknown age	1	1	80.0				1	3.80			
Total caught	584										

Table 3. Area (m^2*100) by percent orthogradient and distance above the 10 m contour for the Grand River.

Dist. interval (km)	Orthogradient intervals											Row Totals	% Total Area
	0-.12	.121-.249	.25-.49	.5-.99	1-1.49	1.5-1.99	2-2.49	2.5-2.9	3-3.49	3.5-5.0	>5.0		
00.000-10	48	2,175	548	144	53	64	13	8	0	5	1	3,058	55.7
10.001-20	595	38	725	108	28	49	27	5	6	8	6	1,596	29.1
20.001-30	230	78	57	191	97	32	26	11	5	14	3	745	13.6
30.001-40	0	62	0	0	8	9	6	2	0	5	0	92	1.7
Column totals	873	2,353	1,329	443	187	154	72	27	11	32	10	5,491	100.0
Percent total area	15.9	42.8	24.2	8.1	3.4	2.8	1.3	0.5	0.2	0.6	0.2		

Table 4. Age distribution, numbers of aged fish counted at fishway trap and population above falls, mean length, mean fecundity, percent female, percent of population and percent contribution to egg deposition by post-smolt age categories of grilse and salmon at and above Grand River Falls, Richmond Co., 1988.

Post-smolt age	Spawing history 1st	2nd	3rd	Number @ age	Corrected number 1.	Mean length (cm)	Mean fecundity (eggs)	Percent 2. female @ age	Percent of pop. @ age	Percent cont. to egg depo.	Required spawners 3. Females	Males	Total
1SW													
1	0			477	524	52.1	2461	74	79.1	70	315	111	426
2	1			59	65	58.4	3227	90 a	9.8	14	47	5	53
3	1			4	7	69.9	5290	66	1.1	2	4	2	6
3	1	2		7	12	64.1	4123	90 a	1.9	3	9	1	10
4	1	2	3	1	2	64.0	4105	90 a	0.3	0	1	0	1
4	1	3		3	5	78.3	7592	90 a	0.8	3	4	0	4
5	1	3	4	2	4	80.0	8168	90 a	0.5	2	3	0	3
2SW													
2	0			19	33	69.6	5223	10	5.0	1	3	24	27
3	2			4	7	75.5	6731	90 a	1.1	3	5	1	6
4	2			1	2	75.0	6588	90 a	0.3	1	1	0	1
4	2	3		1	2	79.0	7824	90 a	0.3	1	1	0	1
Totals				578	663					100	394	145	539

1. Fishway use rates are 91% for fish <63 cm and 57% for fish >63 cm.
2. Sex composition derived from broodstock collections.
3. Required egg deposition= 1.1083E6
a. Assumed value.

Table 5. Assessment of stock status above Grand River Falls for 1988 in relation to total river requirements of 1.1*10^6 eggs.

Post smolt age	Spawing history 1st	2nd	3rd	Pot. egg deposition above falls	Surplus fish	Angled fish	Residual
1SW							
1	0			816,732	98	56	42
2	1			165,688	12	7	5
3	1			24,503	1	0	1
3	1	2		45,567	2	0	2
4	1	2	3	6,482	0	0	0
4	1	3		35,963	1	0	1
5	1	3	4	25,793	1	0	1
2SW							
2	0			17,409	6	0	6
3	2			42,511	1	0	1
4	2			10,402	0	0	0
4	2	3		12,354	0	0	0
				1,203,403	124	63	61

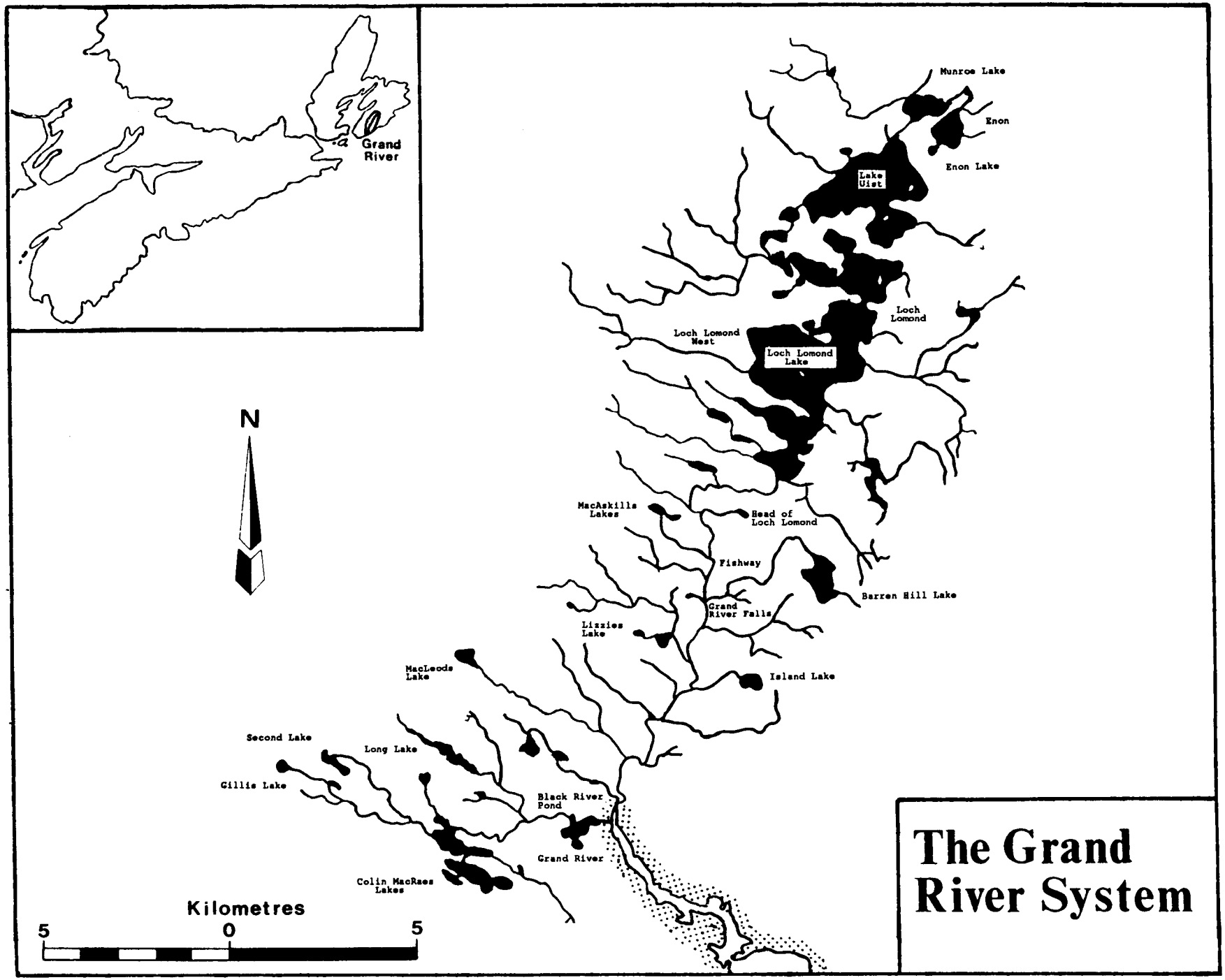

Fig. 1. Map of Grand River, Richmond County, Nova Scotia.

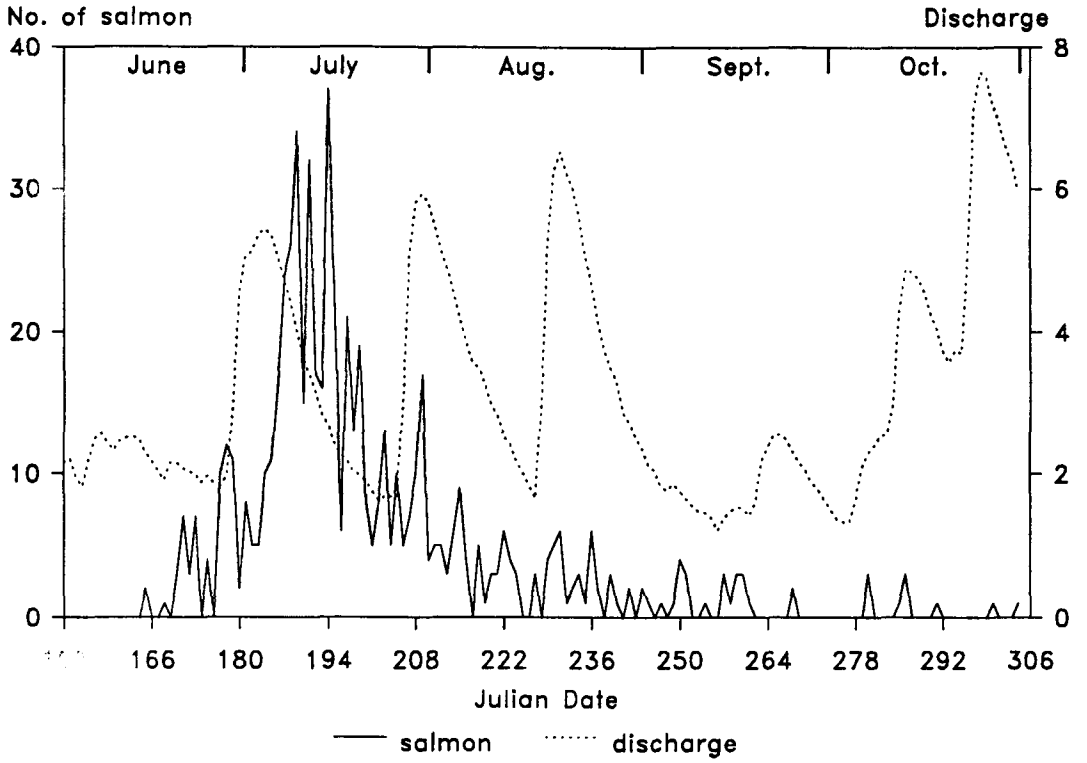

Fig. 2. Daily counts of Atlantic salmon at Grand River Falls fishway and discharge (m~3/s) at Loch Lomond guage station, 1988.

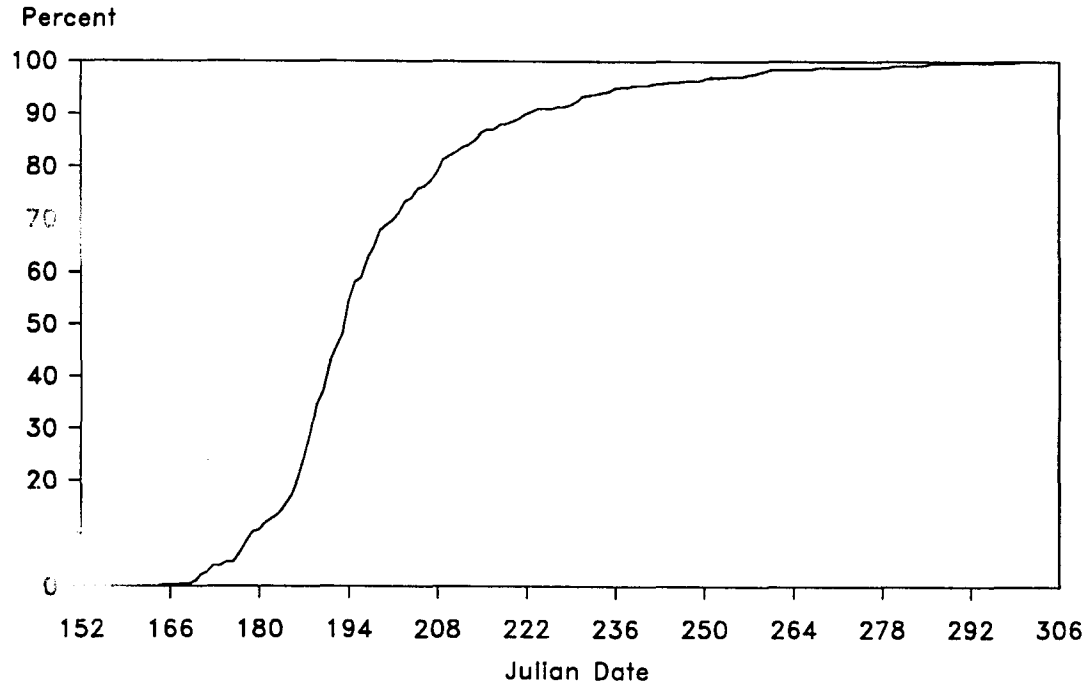

Fig. 3. Cumulative total (percent) of 584 Atlantic salmon captured at Grand River Falls fishway, 1988.

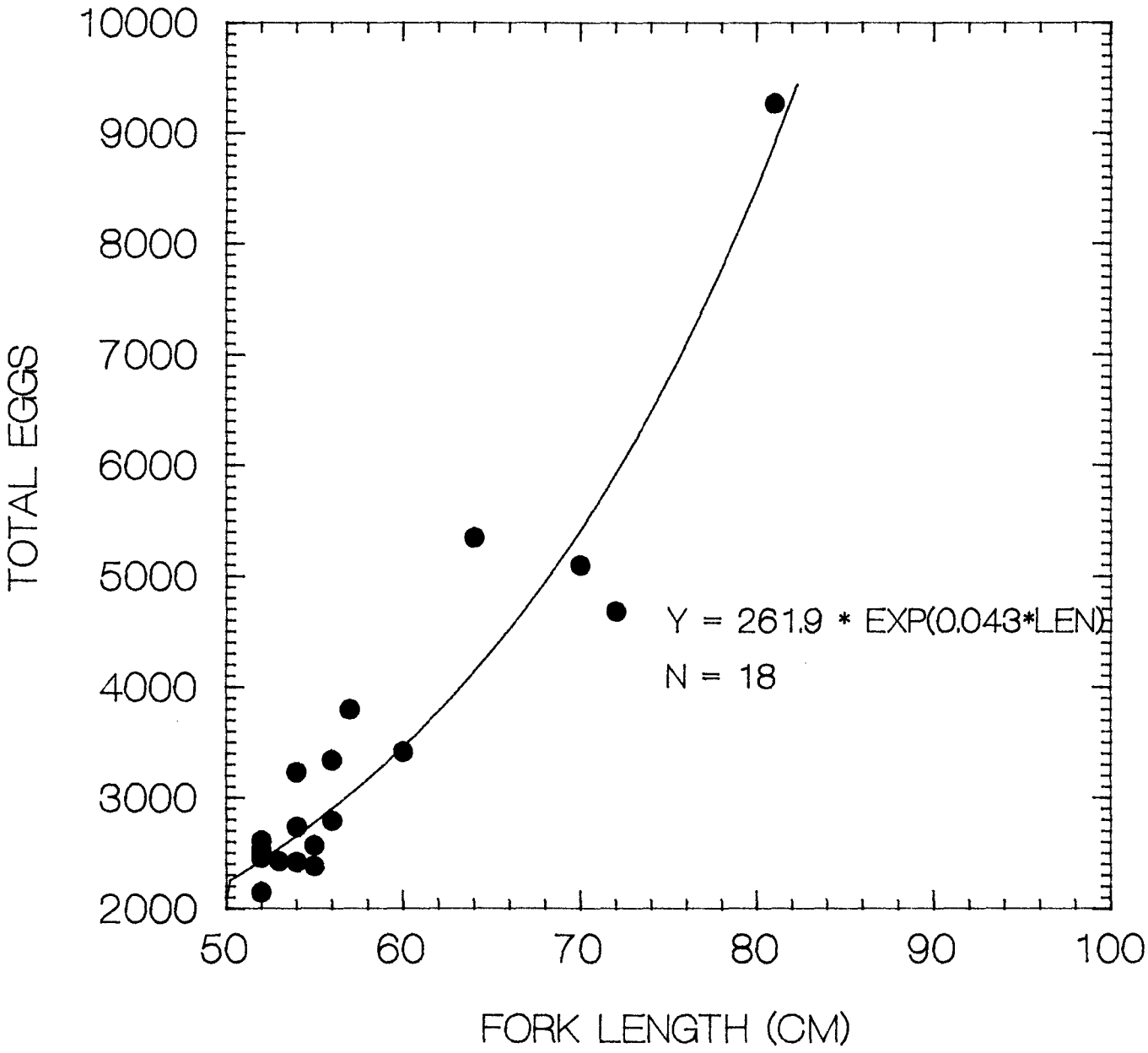

FIG. 4. Length-fecundity relationship of 18 Grand River Atlantic salmon collected in 1987.