DFO Atlantic Fisheries
Research Document 94/89

MPO Pêches de l'Atlantique
Document de recherche 94/89

Status of Atlantic Salmon (Salmo salar L.) in the Highlands River, St. George's Bay (SFA 13), Newfoundland, 1993

by

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Abstract

A counting fence was installed in the Highlands River, located in the southwestern part of insular Newfoundland (SFA 13), and was operated from May 18 to September 28, 1993. Previous fence counts had been made in 1980, 1981 and 1982. Population estimates of juvenile salmon were made at the same sites that were used in 1980 and 1981. The number of migrating smolt (9984) was less than in the earlier counts (12,373 to 15,839), although the number of kelt (90), grilse (137) and large salmon (88) was greater than in the previous study (kelts 58-73; grilse 82-127; salmon 29-56). The river has been closed to angling since 1978. Spawning escapement provided only about 57% of target egg requirements. Underyearling salmon densities at most stations were higher than when sampled a decade earlier, suggesting that spawning escapement in 1992 (the first year of the moratorium on the commercial salmon fishery) was higher than in the previous study. Smolt ages are predominantly 2+ and 3+ (23.8% and 66.7% in 1993), so that higher grilse returns resulting from increased egg depositions can first be expected in 1996, with a greater increase in 1997. Maximum production of juvenile salmon, and subsequently optimum yields of smolts and adult salmon, therefore may not occur until after this time. In addition to natural waterfalls in the system, obstructions to adult salmon migration on some other tributaries occur due to a collapsed bridge, beaver dams and improperly constructed culverts.

Résumé

Une barrière de dénombrement installée dans la rivière Highlands, dans le sud-ouest de l'île de Terre-Neuve (ZPS 13), a été mise en service du 18 mai au 28 septembre 1993. Les dénombrements préalables remontaient aux années 1980, 1981 et 1982. Des estimations de la population de saumons juvéniles ont été réalisées aux mêmes endroits qu'en 1980 et 1981. Il s'est avéré que le nombre de saumoneaux migrateurs (9 984) était inférieur à celui des recensements antérieurs (de 12 373 à 15 839), quoique le nombre de saumon noir (90), de madeleineaux (137) et de grands saumons (88) était supérieur aux résultats précédents (saumon noir : 58-73); madeleineaux : 82-127; saumons : 29-56). La pêche à la ligne est interdite dans la rivière depuis 1978. L'échappée de reproducteurs n'a fourni qu'environ 57 % de la ponte-cible. La densité des fingerlings à la plupart des stations était supérieure à celle d'il y a dix ans, ce qui donne à croire que l'échappée de reproducteurs de 1992 (première année du moratoire sur la pêche commerciale du saumon) était supérieure à celle du dénombrement précédent. Les saumoneaux sont en prédominance d'âge 2+ et 3 + (23,8 % et 66,7 % respectivement en 1993); on peut donc s'attendre à une hausse des montaisons de madeleineaux résultant d'une plus grande ponte en 1996, hausse qui sera encore plus marquée en 1997. Ce n'est sans doute qu'après cette période que l'on assistera à une production maximale de saumons juvéniles et, partant, à un rendement optimal des saumoneaux et des saumons adultes. En plus des chutes naturelles de la rivière, un pont effondré, des digues de castor et des ouvrages de drainage mal construits font obstacle à la migration du saumon adulte dans certains affluents.

Introduction

The Highlands River is a fourth order system, located on the south west coast of Newfoundland (48° 11' 38"), in Salmon Fishing Area (SFA) 13, flowing westerly from the southern part of the Long Range Mountains, and draining into St. George's Bay (Fig. 1). Porter et al. (1974) give a general description of the river and estimated the drainage basin to be 183.1 km^2.

In 1980, 1981, and 1982, Fisheries and Oceans estimated adult salmon spawning escapement and smolt yields of the Highlands River, with population studies of juvenile salmon conducted in 1980 and 1981 (Gibson et al. 1987). Highlands R. was selected at that time because: it was believed to be similar to other rivers in St. George's Bay with a population of multi-sea-winter salmon; the salmon population had declined; the river had been closed to angling since 1978; the river was reasonably small, enabling a fish counting fence to be installed at its mouth, and fish could be easily sampled throughout the system.

Based on angling statistics available for the Highlands R. up to 1977 (Table 1), Chadwick et al. (1978) reported that two trends were apparent: the amount of fishing effort required to catch fish had doubled, and the proportion of large salmon had declined (Figs. 2 and 3). In response to a general decline of the salmon stocks of insular Newfoundland in more recent years a five-year moratorium on the commercial fishery was imposed in 1992. This included early retirement of commercial fishermen as well as the introduction of quotas for angling in each SFA. The angling quotas were assigned for each SFA as a whole, but not on the individual rivers within each SFA. The Highlands R. remained closed to angling.

In 1993, a counting fence was installed on the Highlands R. to examine the effects of the commercial fishing moratorium, by comparing counts of adult salmon and smolts with those made a decade earlier. Estimates also were made of juvenile salmonid densities at the same sites as in the previous study. In this paper, we look at the counts observed on the Highlands R. made in 1993, calculate the spawning escapement and determine the status of the stock by comparison with target spawning escapement (derived from the fluvial and lacustrine habitat of the system), and compare juvenile salmon densities with those found in previous years.

Methods

BIOLOGICAL CHARACTERISTIC DATA

In 1993, adult salmon passing through the fence were not sampled. Biological characteristics of adult Atlantic salmon in Highlands R. were therefore obtained from kelts sampled from the fence in the early 1980s as well as angling catches prior to 1978 (Table 1). For this paper, the biological characteristics of bright salmon and kelts were combined for both size groups.

Information on weight was not recorded in past years. Therefore, fecundity had to be expressed as a function of combined (bright and kelt) mean length. Calculations for grilse and large salmon were performed separately. The total potential egg deposition for the system was obtained by summing the potential egg depositions by grilse and large salmon. Potential egg deposition and required number of spawners are presented using fecundity estimates from grilse of Biscay Bay River (O'Connell unpublished data). However, relative fecundity of large salmon is higher than that of grilse, so potential egg deposition as related to the proportion of the target egg requirement is derived from the fecundity of New Brunswick salmon (Randall 1989).

Spawning Escapement

The Highlands R. has been closed to angling since 1978, and since losses due to poaching and natural mortality are unknown, the spawning escapement (SE) was assumed equal to all adult salmon released upstream from the counting fence.

Egg Deposition

Egg deposition (ED) was calculated as:

$$\mathbf{ED = SE \times PF \times ML \times RF}$$

where,

SE = number of spawners
PF = percent females
ML = mean length of females
RF = relative fecundity (No. of eggs/cm)

TARGET SPAWNING REQUIREMENT

Target egg deposition is related to a reference figure of 240 eggs/100 m^2 for fluvial habitat, and 368 eggs/ha for lacustrine habitat (CAFSAC 1992), derived from

recommendations by Elson (1975) and O'Connell et al. (1991). Target spawning deposition, and total required spawners, are calculated in Table 2.

Densities of juvenile salmon

The same stations that were sampled in previous years (Fig.1) were sampled in August of 1993. As in the previous study (Gibson et al. 1987), population estimates were made by: (1) the Zippin depletion method, using an electrofisher, with four sweeps per station in riffles and flats, and (2) by the Petersen mark and recapture method, using a beach seine, supplemented with an electrofisher, in pools. Both methods were used at most sites as part of another study to test relative efficiencies of the two methods in various types of habitat, and habitat variables were measured as part of a study of productive capacity of habitat types, but these data will be presented elsewhere.

Results

COUNTING FENCE TOTALS

The number of migrating smolt in 1993 was less than that in the previous study, however the number of kelt, grilse, and large salmon was greater. Comparing the four years, the counting fence totals were as follows:

Year	Smolt	Small salmon (< 63 cm)	Large Salmon (≥ 63cm)	Kelt
1980	15,130	82	55	73
1981	15,839	127	29	63
1982	12,373	100	56	58
1993	9,984	137	88	90

In 1993, the 9984 smolt, plus 877 parr, emigrated downstream between May 18 to June 16, (Fig. 4). The first kelt was enumerated emigrating downstream on May 21, and the last was released September 12. On June 18 an adult trap was installed in place of one of the smolt traps. At the time the fence was removed, September 28, the counts had dwindled to almost nil (Figs. 5 and 6).

Other counts include upstream migration of 63 trout, and downstream migration of 731 trout, 163 eels, 43 smelt, and 13 sticklebacks. A summary of downstream and upstream counts for 1993 are listed in Tables 3 and 4 respectively.

In 1980, the smolt counting fence was in operation from May 7 until June 30 and the adult fence was in operation from May 7 until October 13. The fence operation dates for 1982 were from May 23 until September 29. These dates are comparable to fence operation dates in 1993, however the fence operation dates for 1981 were from April 27 until September 9, a shorter period then that of 1993. Therefore, in 1981, some adult counts may have been missed (Figs. 5 and 6).

TOTAL RIVER RETURNS AND SPAWNING ESCAPEMENT

The spawning escapement and potential egg deposition for small salmon (SS) and large salmon (LS) for Highlands R. in the early 1980s and 1993 were as follows:

Year	Spawning escapement		Egg deposition (No. × 10^5)		Percent Target egg deposition
	SS	LS	SS	LS	
1980	82	55	1.576	2.213	25
1981	127	29	2.442	1.167	24
1982	100	56	1.922	2.254	28
1993	137	88	2.634	3.541	41
			2.237[1]	6.273[1]	57[1]

[1](Randall 1989; other fecundity estimates from O'Connell unpublished)

Estimates of juvenile salmon densities were made throughout the system at the same sites that were sampled in 1980 and 1981 (Fig.1). In fluvial stations (Figs. 7-16), except for one 'flat' station on the main stem (Fig. 15), 0+ salmon densities were higher than when sampled in 1981, suggesting that spawning escapement in 1992 was higher than when the river was previously sampled.

A section of the pond, Loch Leven, 210 m in length, was seined for a mark-recapture population estimate, providing an estimate of 647 salmon parr. Extrapolating this to the whole pond, as in the previous study, the results give 274/ha (95% C.L. 118-660), with (/ ha) 191 of 1+, 66 of 2+, and 17, 3+. The figures are somewhat higher but similar to those in 1981: 160/ha (95% C.L. 121-222; of which 128 were 1+ and 28, 2+).

Discussion

In addition to closure of the Highlands River to angling in 1978, fishery management initiatives have attempted to alleviate the decline of fish stocks. Commercial fishery quotas were first introduced to each Salmon Fishing Area (SFA) in 1990. In 1991, these quotas changed slightly; the quota for SFA 13 was reduced by 10 t to 25 t. The 1991 commercial fishing quota for SFA 13, which represented 48% of the average catch for the area in 1978-1989, was not caught until one week before the season closed (Mullins and Jones 1992). This suggested a lower availability of salmon. In 1992, the commercial salmon fishery for the island of Newfoundland (SFAs 3 to 13 and 14a) was closed for five years. These changes in management were aimed at increasing river spawning escapements.

Mullins and Jones (1992) reported that the 1991 commercial catches of large salmon in SFA 13 were lower relative to 1990 and the long-term means. The landings of large salmon were 70-80% below 1990 landings and the long-term means. Landings of small salmon were 6% below those of 1990, 34% below the previous 5 year mean and 15% below the previous 10 year mean (Mullins and Jones 1992).

Area K of SFA 13 produced 87% of commercial small salmon landings in 1991 as compared to ~ 63% in past years. Area L produced only 13% of commercial small salmon landings in 1991. This suggests a lower return in Area L.

Recreational salmon catches for SFA 13 in 1991 were below previous years, indicating low returns in 1991. In spite of the reduction in the commercial quota and the increase in recreational catches of small salmon in Statistical Area K, the total recreational catch in SFA 13 did not show a significant improvement in 1991 (Mullins and Jones 1992). The recreational catches of both small and large salmon were below most levels in recent years.

Mullins and Jones (1992) reported that commercial catches of small salmon in 1991 were near the lowest on record for western Newfoundland and southern Labrador since 1974. Catches of large salmon were the lowest on record. The commercial season was essentially the same as years prior to quota introductions, but the total quota was not caught, implying a reduction in stock abundance. Statistical Area K did, however, suggest an increase in recruitment of small salmon.

Fence counts of small and large salmon for 1993 in the Highlands River were higher than in 1980-1982. Caution should be used in interpreting the data for calculating spawning escapement. Adult salmon were not sampled in 1993, therefore, the biological characteristics from the early 1980s, which did not include weight, were used in the calculations. Fecundity was based on results from studies in New Brunswick,

where both large and small salmon were sampled, (Randall 1989), with a comparison of fecundity derived from studies of grilse in the Biscay Bay River (O'Connell unpublished data).

Despite closure of the Highlands R. to angling, similar to other rivers in the area, the salmon stock appears to be below carrying capacity. The complete closure of the commercial fishery in 1992 is the most significant management change to date, and the percentage of target spawning requirement attained in 1993 was 57%, an increase in the proportion of the target spawning escapement attained in 1980 to 1982. However, fluctuations in the intervening eleven years are unknown, and the proportion of the required target spawning escapement remains low.

Smolt counts were less than those of ten years ago, which might be expected if spawning escapement has been low in recent years. The fence was not installed until after the smolt run had started, so that the count was not complete, but the peak of the run appeared to occur after installation of the fence (Fig.4) so that probably only a small proportion of the run was missed.

At most fluvial stations underyearlings were more numerous than had been found in the same stations that were sampled a decade ago. Also, since there were more kelts counted than in the previous study, it is likely that spawning escapement was greater in 1992 than in 1980 - 1982. Continuation of work on juvenile densities in conjunction with smolt counts will assist in determining if escapement has increased since the moratorium, and the probable carrying capacity of the freshwater habitat could be better estimated. The latter will provide a more realistic target egg deposition per unit area of the system. Since the ages of smolt in this system are predominantly 2+ and 3+ (23.8% and 66.7% respectively from a sample of 126 in 1993, and about 29% and 66% respectively in the studies a decade ago), higher grilse returns resulting from increased egg depositions can first be expected in 1996, with a greater increase in 1997. Maximum production of juvenile salmon, and consequently of smolts and adult salmon, therefore may not occur until after this time. The present estimate of rearing habitat is not precise, and proposed stream mapping over the next two years would provide a more accurate estimate of optimum escapement needed to adequately seed the system.

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Table 1. Atlantic salmon recreational fishery catch and effort data for Highlands River, St. Georges Bay (SFA 13), Newfoundland, 1953-82.[△]

River: Highlands River Code : 40008300

YEAR	EFFORT ROD DAYS	GRILSE <2.7KG	SALMON >2.7KG	TOTAL CATCH	CUE	PERCENT GRILSE
1953	133	40	50	90	0.68	.
1954	76	7	33	40	0.53	55
1955	134	42	55	97	0.72	11
1956	313	24	23	47	0.15	65
1957	197	43	59	102	0.52	29
1958	451	14	90	104	0.23	32
1959	369	16	69	85	0.23	17
1960	507	24	64	88	0.17	20
1961	204	8	11	19	0.09	69
1962	690	12	97	109	0.16	8
1963	567	6	92	98	0.17	12
1964	422	3	55	58	0.14	10
1965	200	26	12	38	0.19	20
1966	370	33	15	48	0.13	63
1967	456	27	69	96	0.21	32
1968	269	27	8	35	0.13	77
1969	312	105	9	114	0.37	75
1970	216	63	16	79	0.37	87
1971	179	41	25	66	0.37	72
1972	73	16	4	20	0.27	91
1973	149	19	8	27	0.18	67
1974	247	21	14	35	0.14	58
1975	362	28	8	36	0.10	72
1976	108	23	8	31	0.29	78
1977	239	47	18	65	0.27	56
1978	closed up to present					
		MEANS AND STANDARD DEVIATIONS				
53-57	170.6	31.2	44.0	75.2	0.44	40
S.D.	90.4	15.6	15.4	29.4	0.14	11
58-62	444.2	14.8	66.2	81.0	0.18	24
S.D.	178.7	5.9	33.8	36.1	0.02	7
63-67	403.0	19.0	48.6	67.6	0.17	25
S.D.	134.5	13.5	34.7	27.8	0.02	8
68-72	209.8	50.4	12.4	62.8	0.30	81
S.D.	91.7	35.2	8.3	37.1	0.06	4
73-77	221.0	27.6	11.2	38.8	0.18	66
S.D.	98.5	11.3	4.6	15.1	0.04	5

△(Porter and Chadwick 1983). The % grilse is calculated from the same smolt class of grilse and large salmon, e.g. in 1954, the 55% of grilse is calculated from, 40/(40+33).

Table 2. Estimation of Atlantic salmon egg deposition and percentage conservation requirement achieved on Highlands R. in 1993.

Available habitat:

Fluvial Rearing Units (F) (100 m^2) = 6219
Lacustrine Area (L) (ha) = 15.9

Ratio L/F = 0.26

Reference Level of egg deposition (total target egg requirement, T) =

(6219 × 240) + (15.9 x 368) = 1,498,475

Fecundity		66.7 eggs/cm	
Small - (<63 cm)	%overall	60.9	(fence 1993)
	%female	55.1	
	mean length	523.1	
Large - (≥63 cm)	%overall	39.1	(fence 1993)
	%female	71.4	
	mean length	845.0	

Required Spawners =

$$\frac{\text{Reference Level of Egg Deposition}}{(\%Small \times \%F \times \bar{x}\ length \times fecundity) + (\%large \times \%F \times \bar{x}\ length \times fecundity)}$$

$$= \frac{1498475}{(0.609 \times 0.551 \times 52.3 \times 66.7) + (0.391 \times 0.714 \times 84.5 \times 66.7)}$$

$$\frac{1498475}{1170.57 + 1573.47} = \frac{1498475}{2744.03}$$

= 546 spawners

Given the percentages of Small and Large is 60.9% and 39.1%, respectively, then:

546 × 0.609 = 333 small spawners required
546 × 0.391 = 214 large spawners required

Estimated egg deposition (1):

Fecundity estimates are from grilse in Biscay Bay River (O'Connell unpublished data).

Small salmon (S):

$$= number\ of\ spawners \times \%\ female \times \bar{x}\ length \times fecundity\ at\ length$$

$= 137 \times 0.551 \times 52.31 \times 66.7$
$= 263,380$

Large salmon (L):

$$= number\ of\ spawners \times \%\ female \times \bar{x}\ length \times fecundity\ at\ length$$

$= 88 \times 0.714 \times 84.5 \times 66.7$
$= 354,131$

Total Eggs = S + L = 617,511 eggs (E)

% of Reference level of egg deposition met (1) = E/T = 41%

Estimated egg deposition (2):

The formulae used below for calculating egg depositions of small and large salmon are derived from fecundity estimates of salmon in the Miramichi and Restigouche rivers (Randall 1989).

Small salmon (S):

Log_e Fecundity = -4.5636 + 3.1718 Log_e(FL)
= -4.5636 + 3.1718 Log_e (52.3)
= 2943 eggs/small female salmon

# of small female salmon = # of small salmon * % F
= 137 * .551
= 76 small female salmon

# of eggs = # of small female salmon * # of eggs
= 76 * 2943
= 223,668 eggs

Large salmon (L):

Log_e Fecundity = -1.1862 + 2.3423 Log_e(FL)
= -1.1862 + 2.3423 Log_e (84.5)
= 9957 eggs/large female salmon

# of female large salmon = # of large salmon * % F
= 88 * .714
= 63 large female salmon

# of eggs = # of small female salmon * # of eggs
= 63 * 9957
= 627,291 eggs

Total Eggs = S + L = 850,959 eggs (E)

% of Reference level of egg deposition met (2) = E/T = 57%

Table 3. Summary of downstream enumeration from May 18 to September 27, 1993.

SPECIES	TOTALS
Salmon parr	877
Salmon smolt	9984
Kelt	90
Eel	163
Brook trout	731
Smelt	43
Sticklebacks	13

Table 4. Summary of upstream enumeration from June 18 to September 28, 1993.

SPECIES	TOTALS
Small Salmon	137
Large Salmon	88
Sea-run trout	63

Summary Sheet

Stock: Highlands River, SFA 13
Target: 1.50 million eggs

Recreational catch (1953 - 1977) Closed since 1978

Min.	Max.	Mean
19	114	67

Counts (1993)

Smolt	9984
Small salmon	137
Large salmon	88
% of Minimum reference level met: (small + large)	57

Data and assessment:

Complete counts of salmon were obtained at a fish counting fence in 1980 to 1982 and in 1993.

State of stock:

Potential egg deposition based on 1993 adult salmon returns is: 850,959.

Accessible habitat m^2:

Fluvial = 621,926 Lacustrine = 159,043

Comments:

Despite closure to angling since 1978, egg deposition has remained below the reference 2.4 eggs/m^{-2}. It is possible that this target is too high for the Highlands River system. The study of juvenile densities ten years ago indicated a wide range in relative production, and that the main stem (River Brook) above Loch Leven Pond had a wide range of discharge, sparse optimum spawning habitat above the Trans Canada Highway and relatively low production of juvenile

salmon (about 15% of the total smolt yeild), and yet this reach comprised 28% of the fluvial habitat. It is possible large salmon spawn more effectively than small salmon in the coarse substrate of the upper reaches of River Brook, and that juvenile densities will become relatively greater as the spawning escapement of large salmon increases. Relatively greater production occurred below Loch Leven and in the tributaries. A major tributary with potential rearing habitat of 31,917 m^2 is blocked by a collapsed bridge, and others by beaver dams.

The target egg deposition (1.50 million) is somewhat different from an earlier figure in the March 1994 Stock Status Report (1.55 million eggs) since the area of accessible lacustrine habitat has been revised to 15.9 ha (from 136 ha). Consequently the percentage of target eggs met was also changed, to 57 (from 55).

A proportion of the run is in the fall, so that fence counts should be conducted at least until the end of September. Continuation of this investigation will provide a better estimate of the potential of the river system, and juvenile studies at the higher egg deposition following the moratorium will give a better estimate of the potential production of different reaches within the system, and more accurate estimation of a target egg deposition. Stream mapping is planned to better estimate potential predicted yields of smolts, and to enable removal of obstructions.

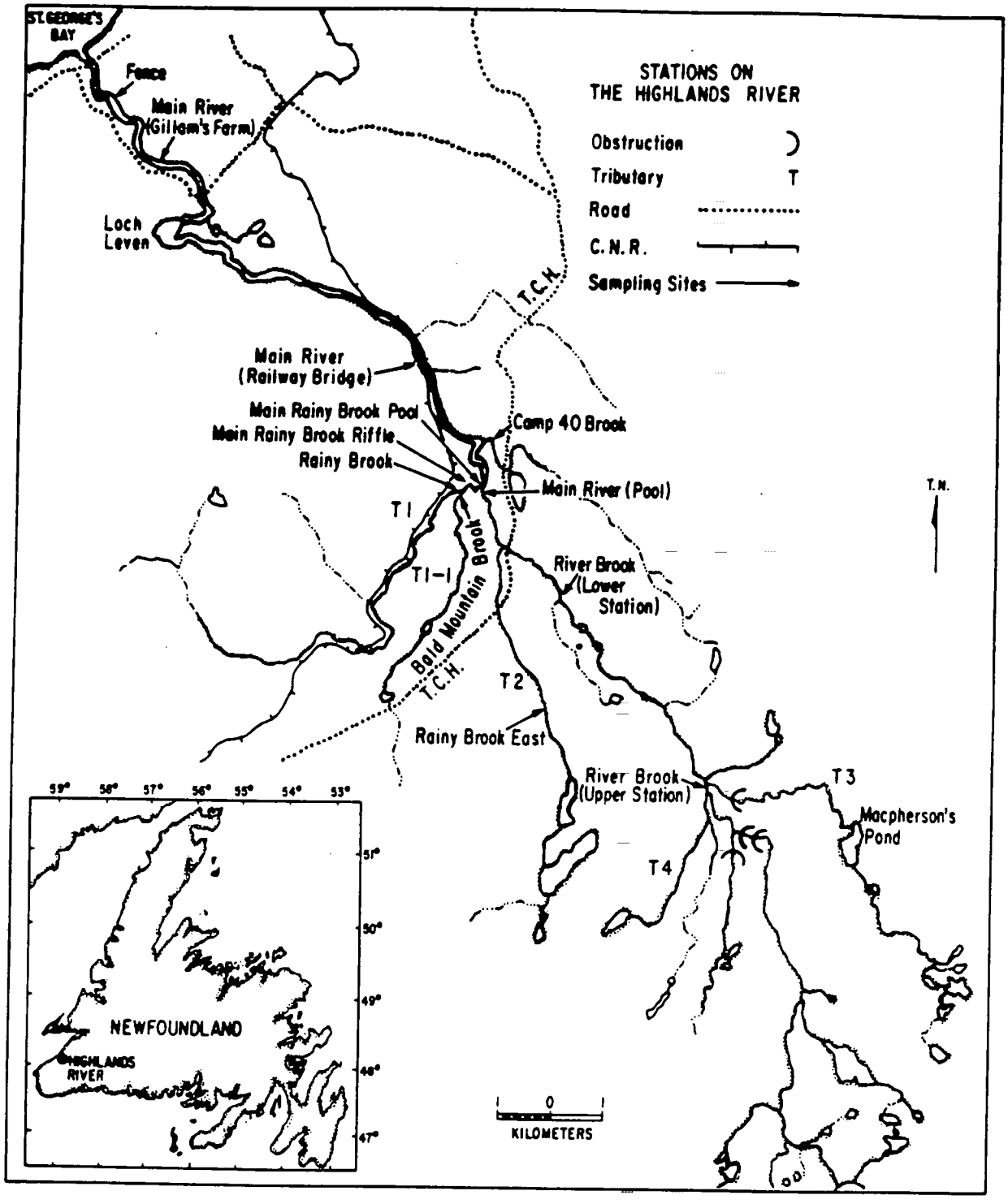
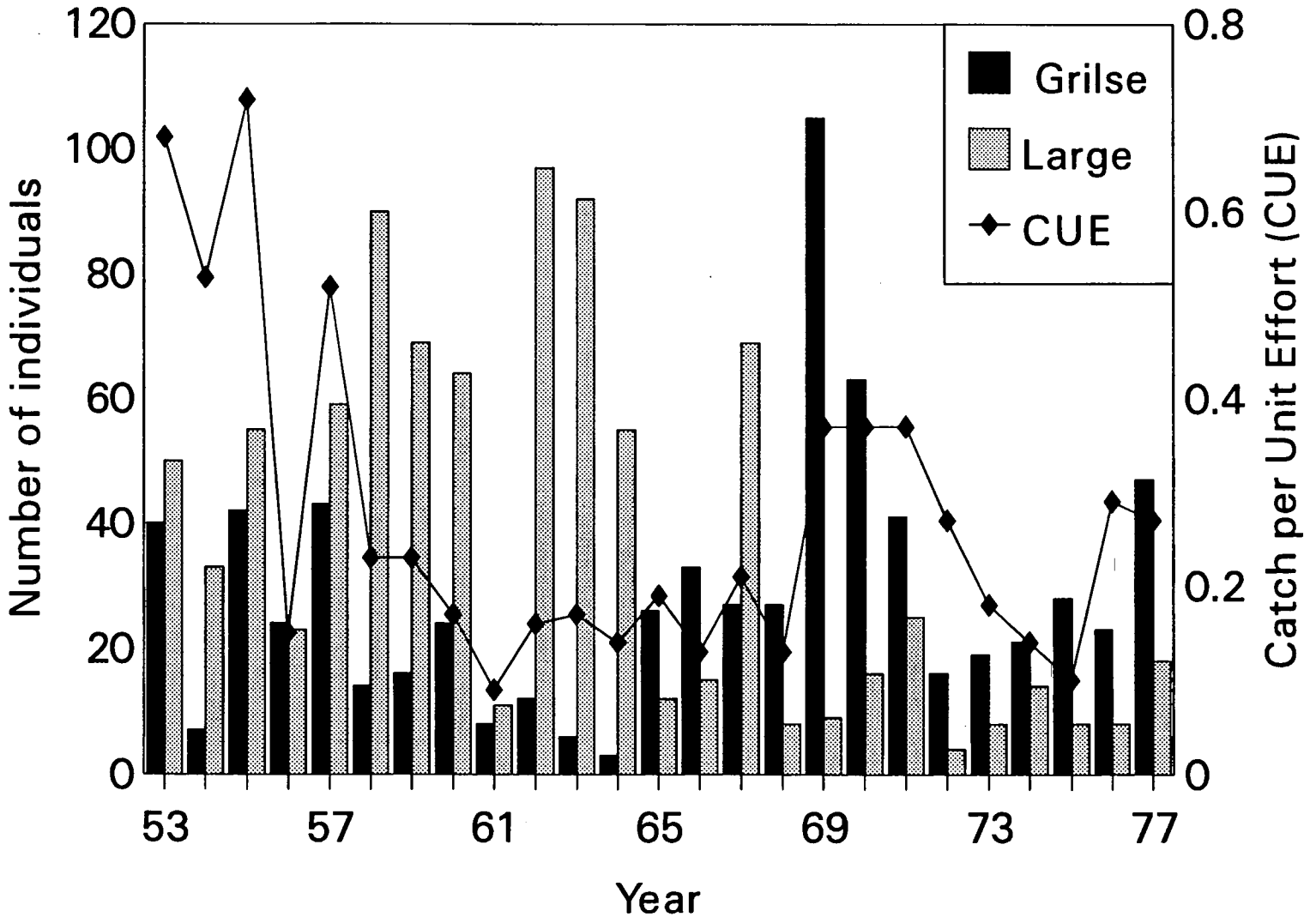


Fig. 1. The Highlands River system, showing the sampling sites, and the location of the river in Newfoundland (inset). Tributaries T1, T1-1, T3, and T4, are second order brooks. Tributary T2 is a third order brook, above which the river is called River Brook.

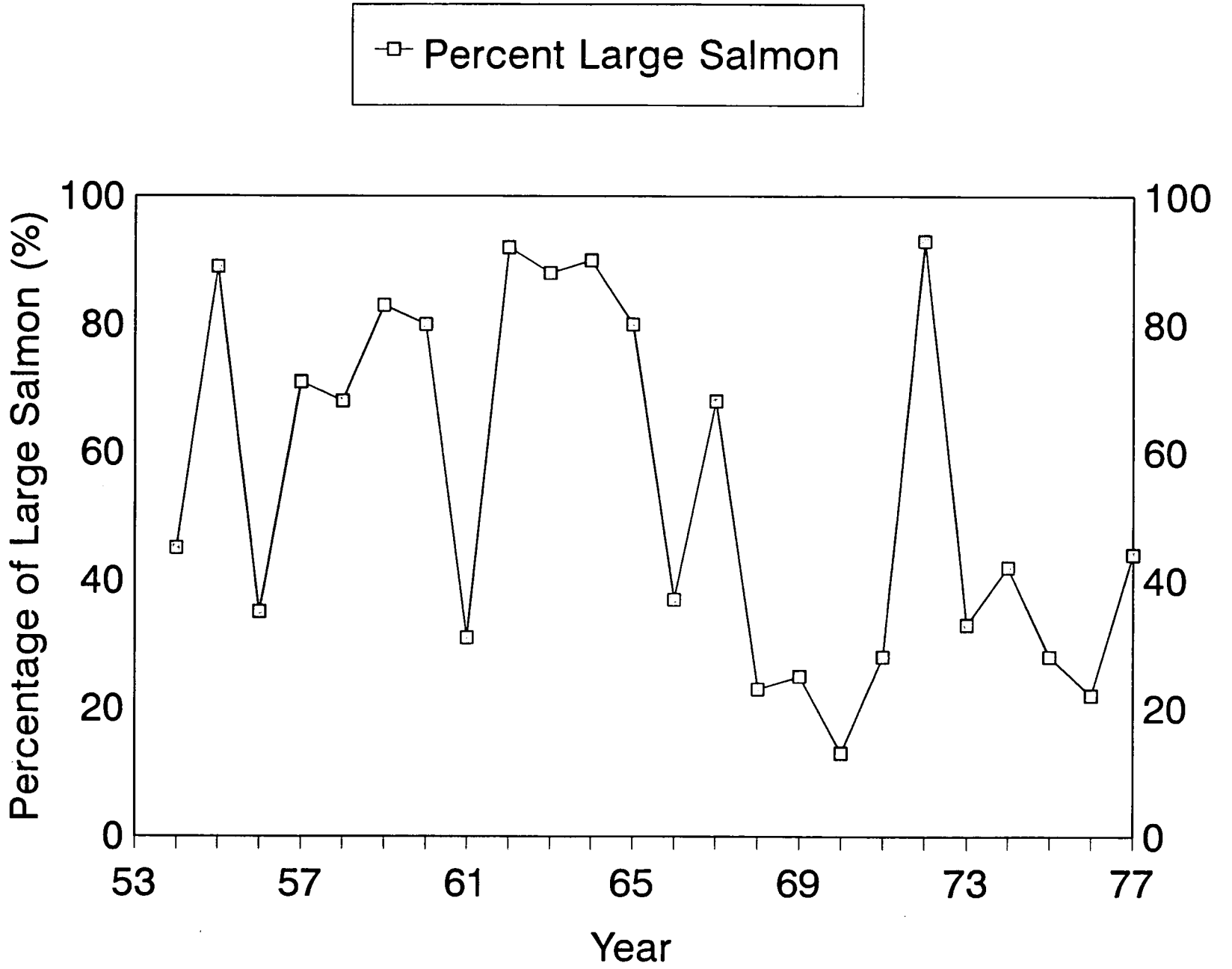
Highlands River

Figure 2: Atlantic salmon recreational fishery catch and effort data 1953-1977



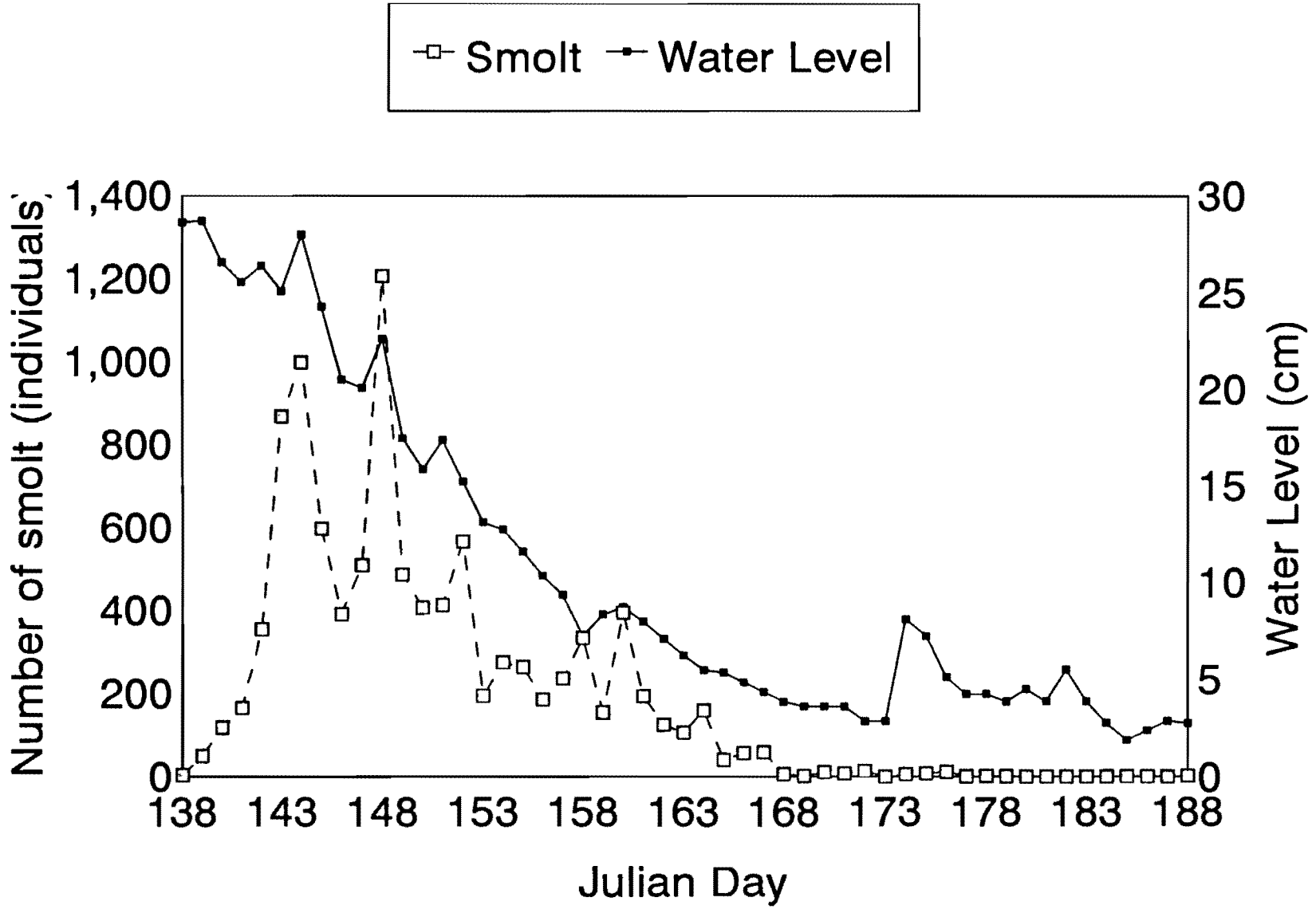
Highlands River

Figure 3: Percentage of large salmon (≥ 63 cm) caught from angling on Highlands River from 1953-1977



Highlands River

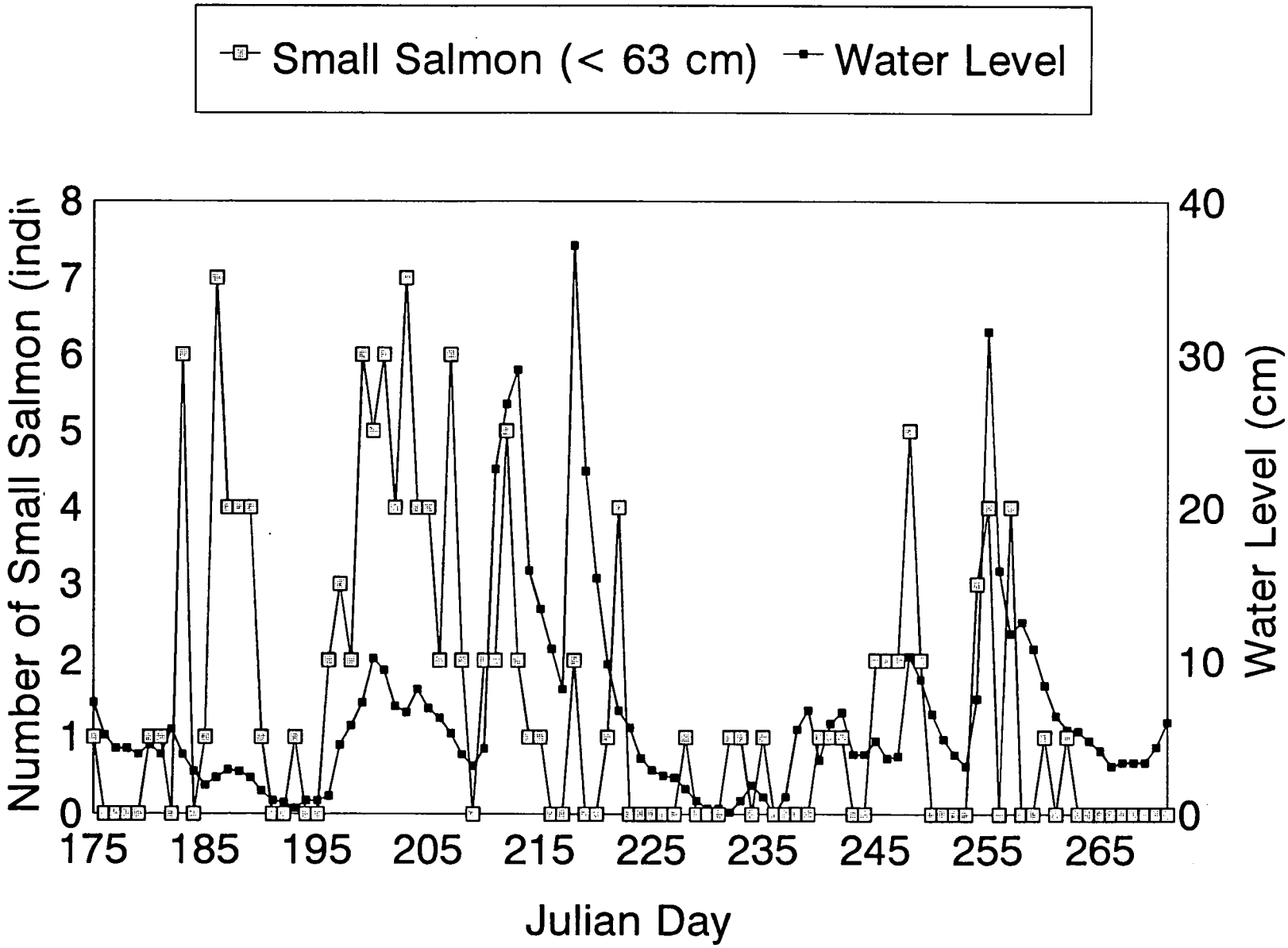
Figure 4: Daily fence counts of smolt and water levels for 1993.



Water level = (mean daily water level - lowest water level in 1993)

Highlands River

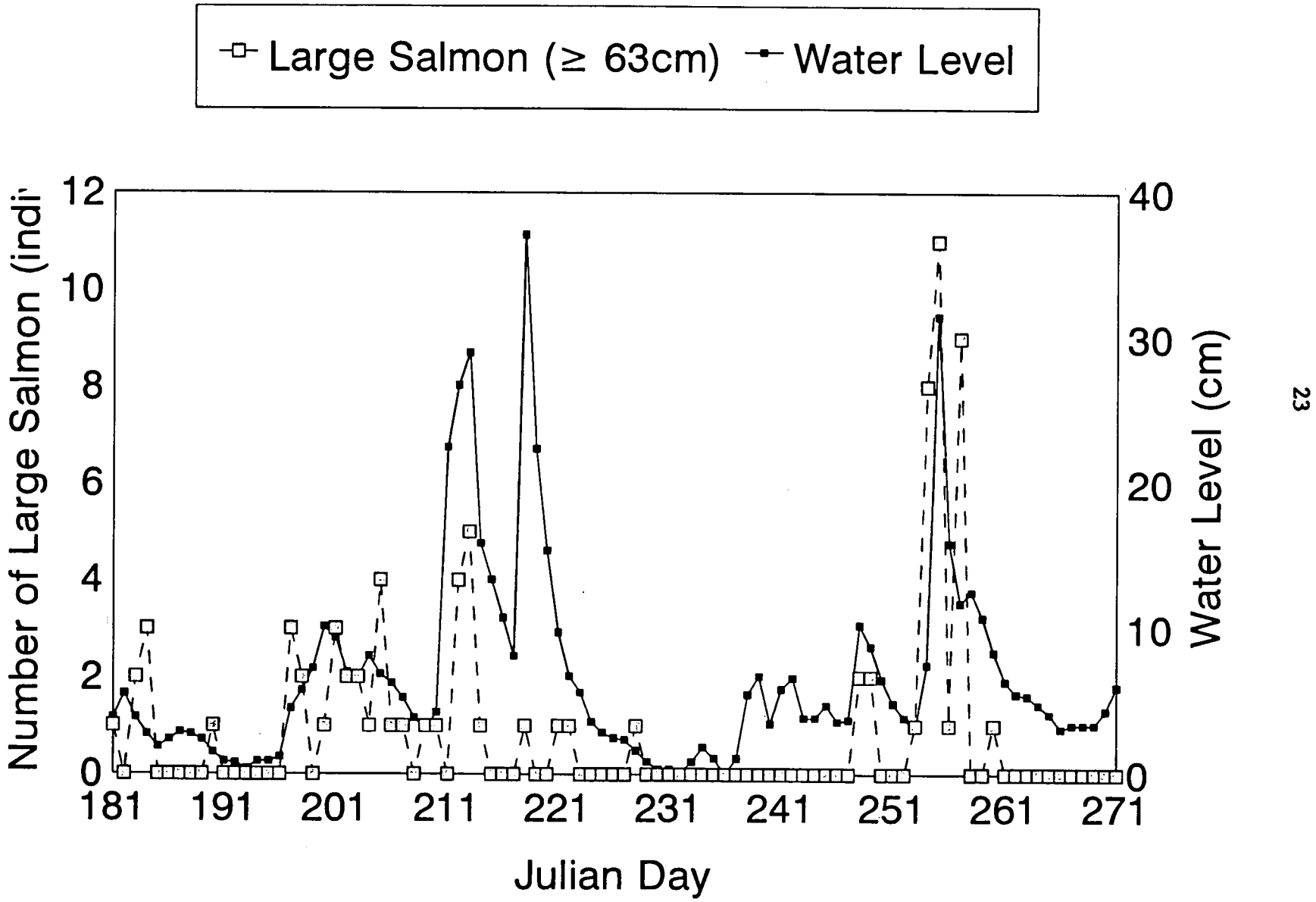
Figure 5: Daily fence counts of small (< 63 cm) salmon and water levels in 1993.



Water level = (mean daily water level - lowest water level in 1993).

Highlands River

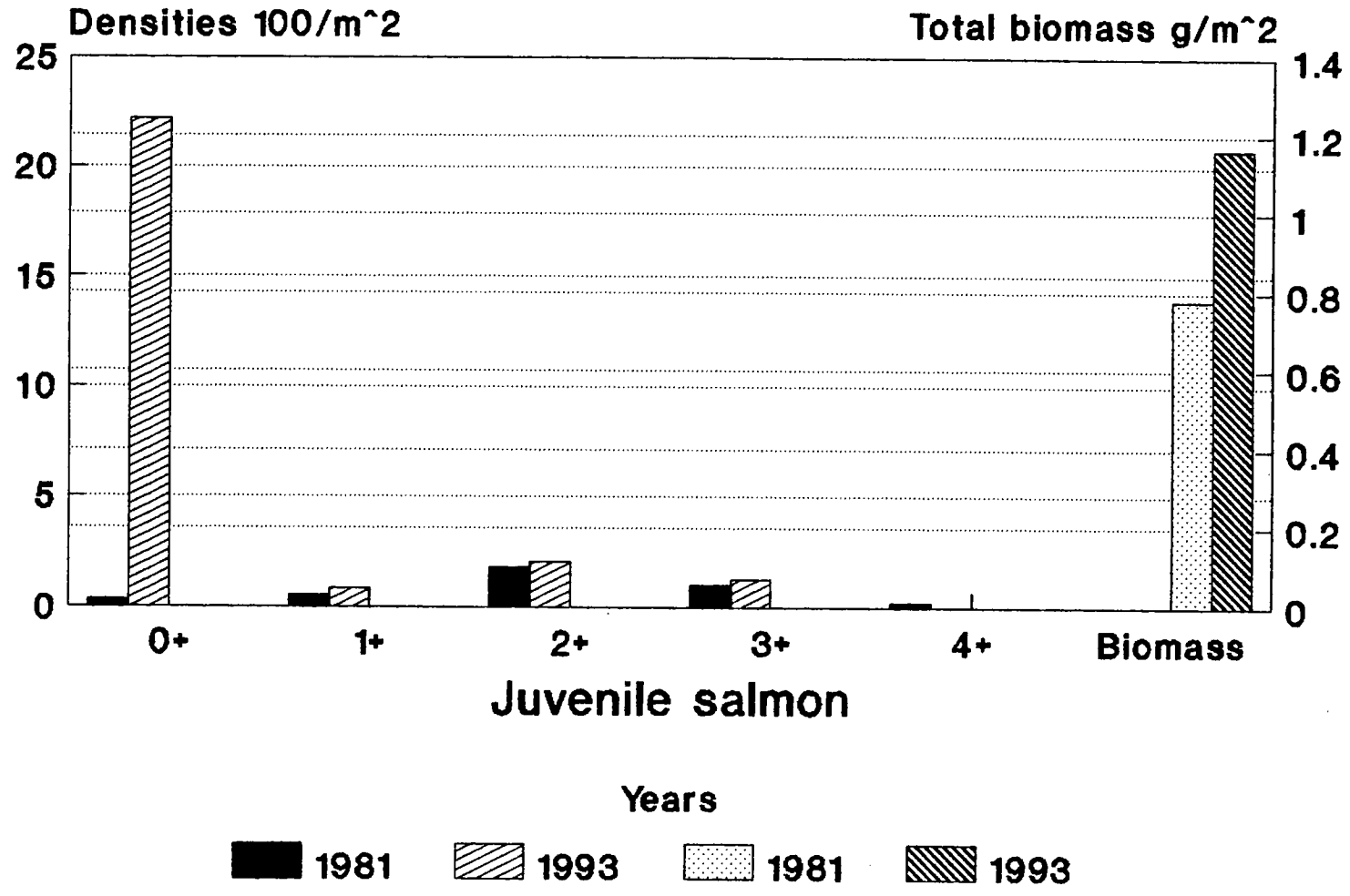
Figure 6: Daily fence counts of large salmon (≥ 63 cm) and water levels in 1993



Water level = (mean daily water level-lowest water level for 1993).

Salmon densities and biomass

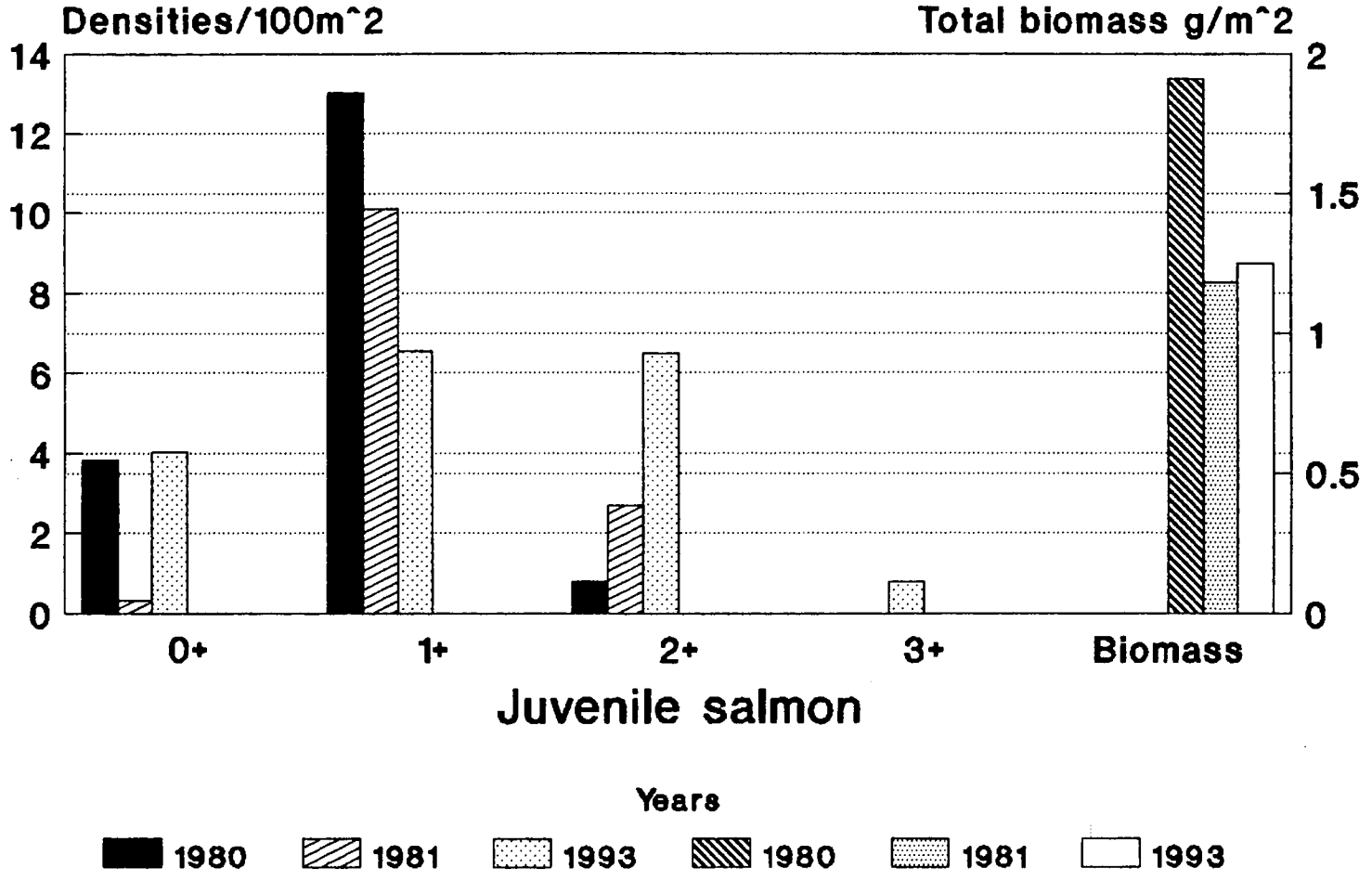
Figure 7. River Brook upper.



Riffle

Salmon densities and biomass

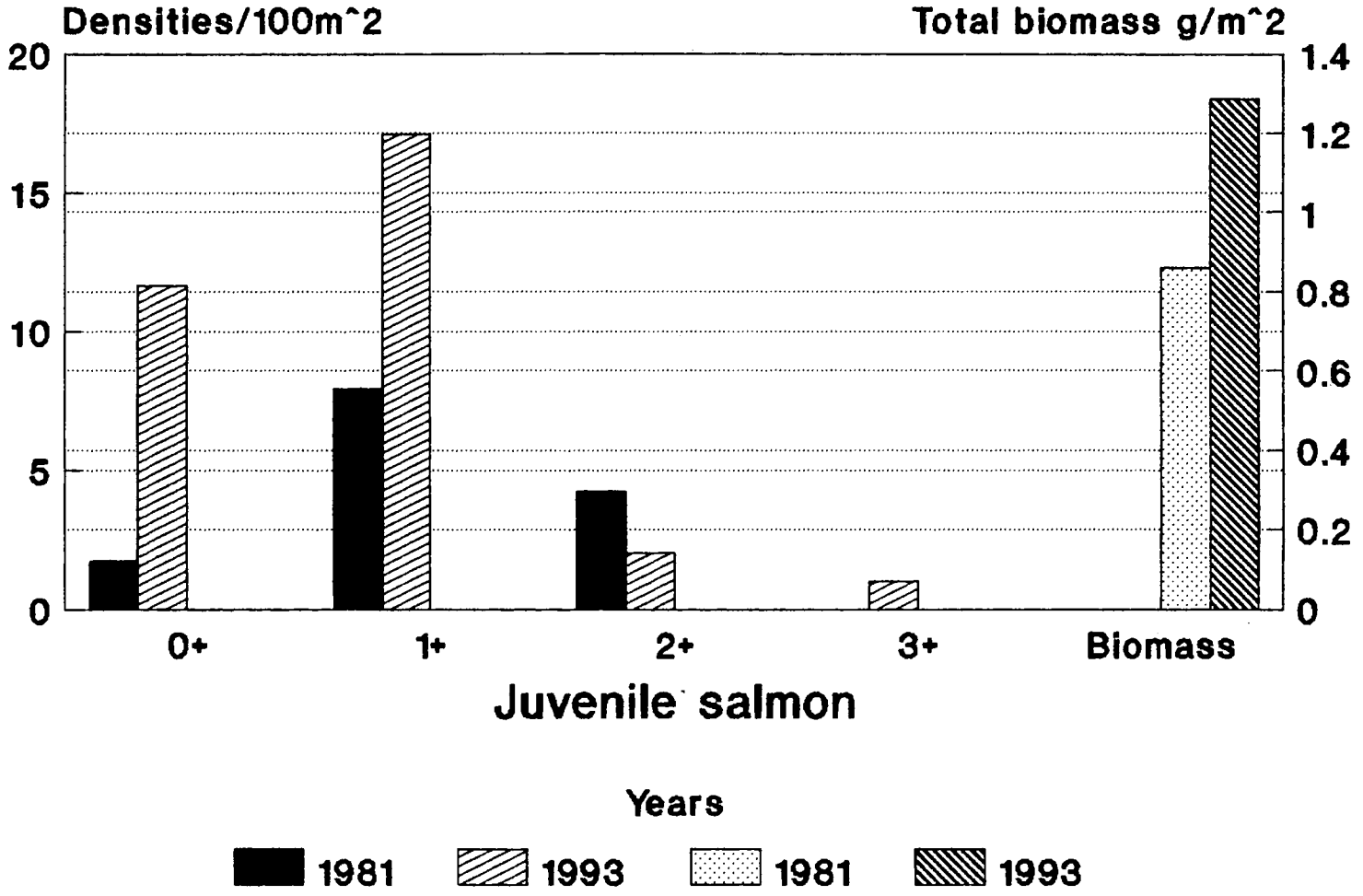
Figure 8. River Brook lower.



Riffle

Salmon densities and biomass

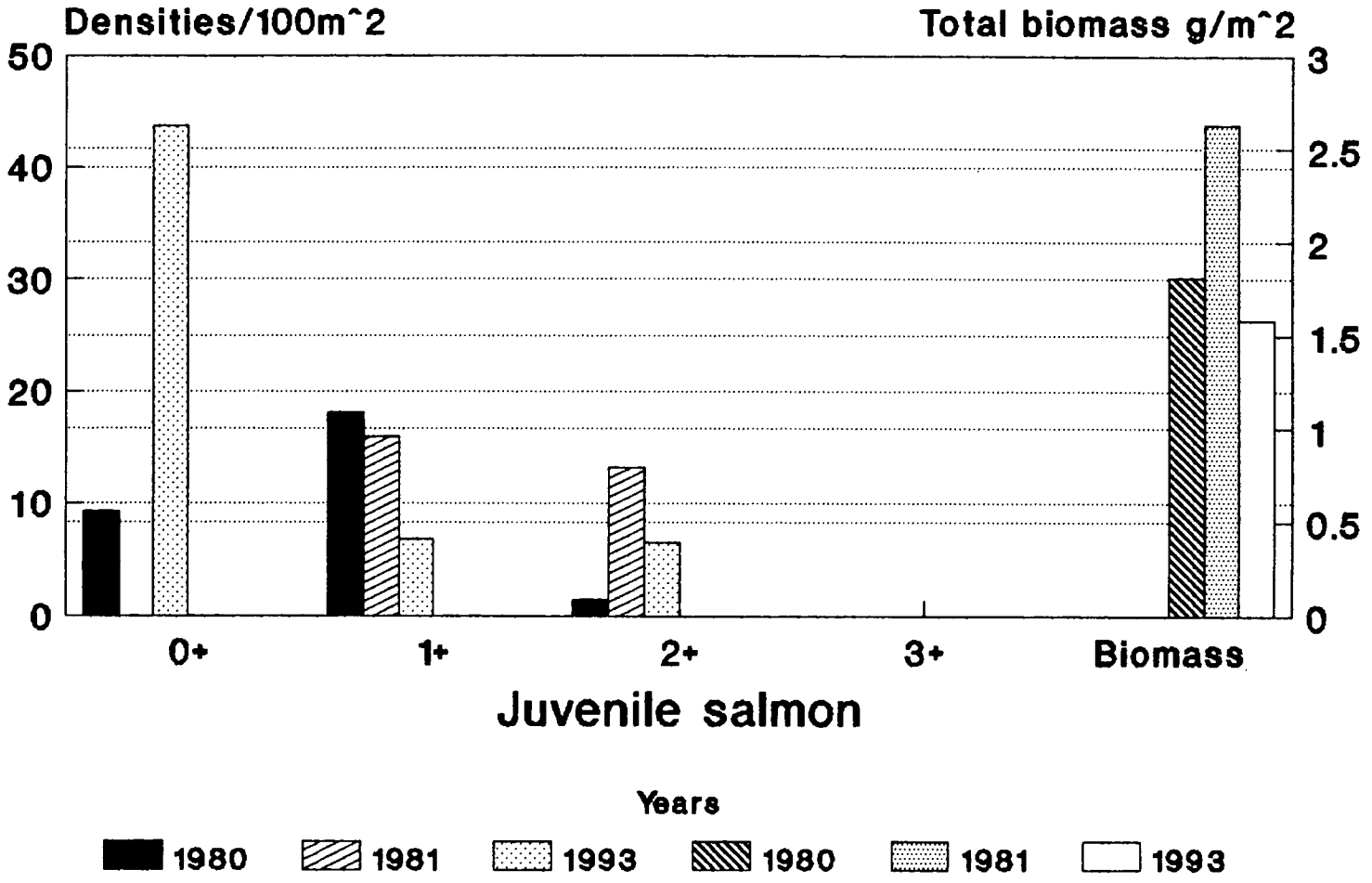
Figure 9. Main River Pool.



Pool

Salmon densities and biomass

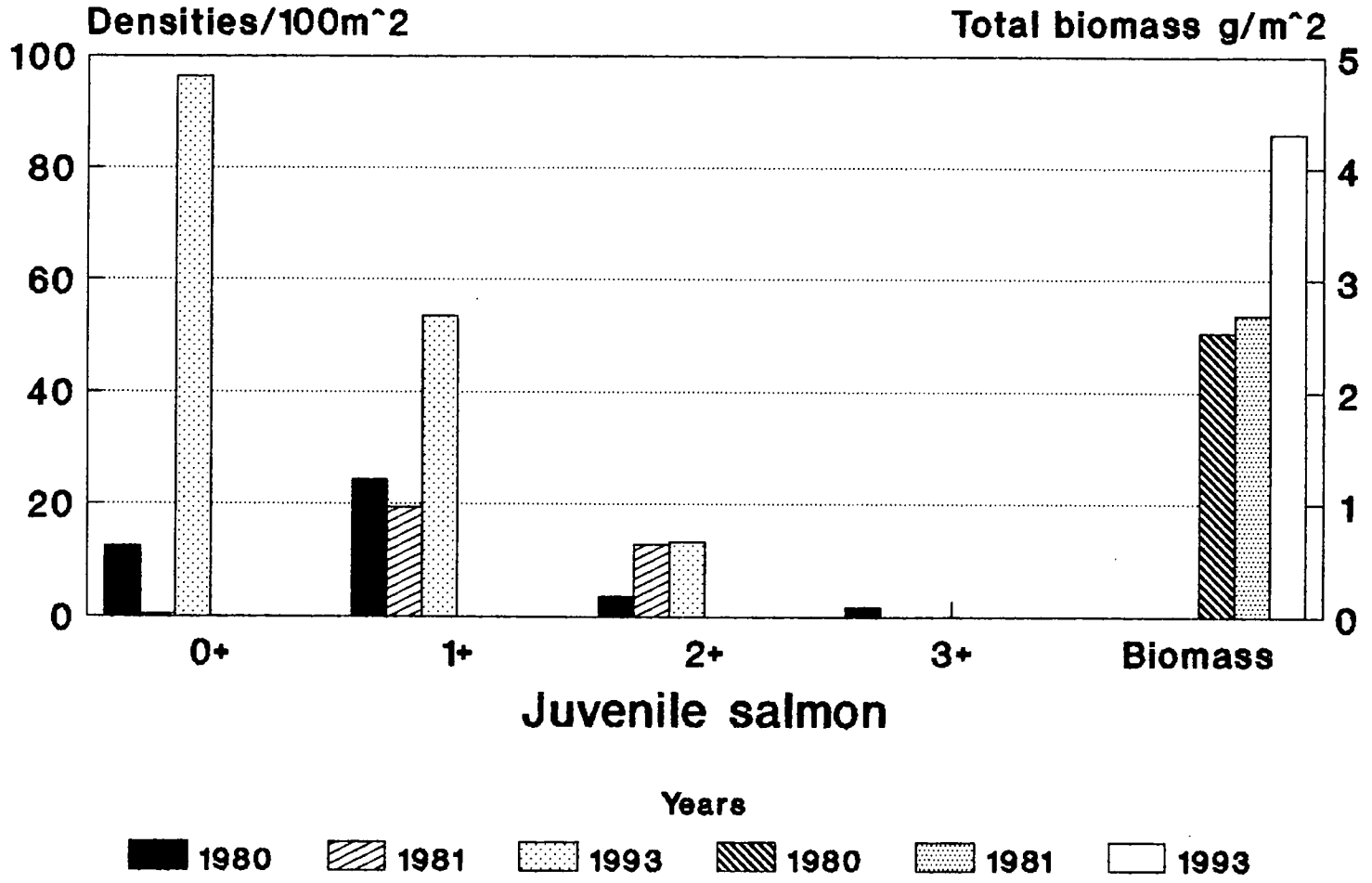
Figure 10. Bald Mountain Brook.



Riffle

Salmon densities and biomass

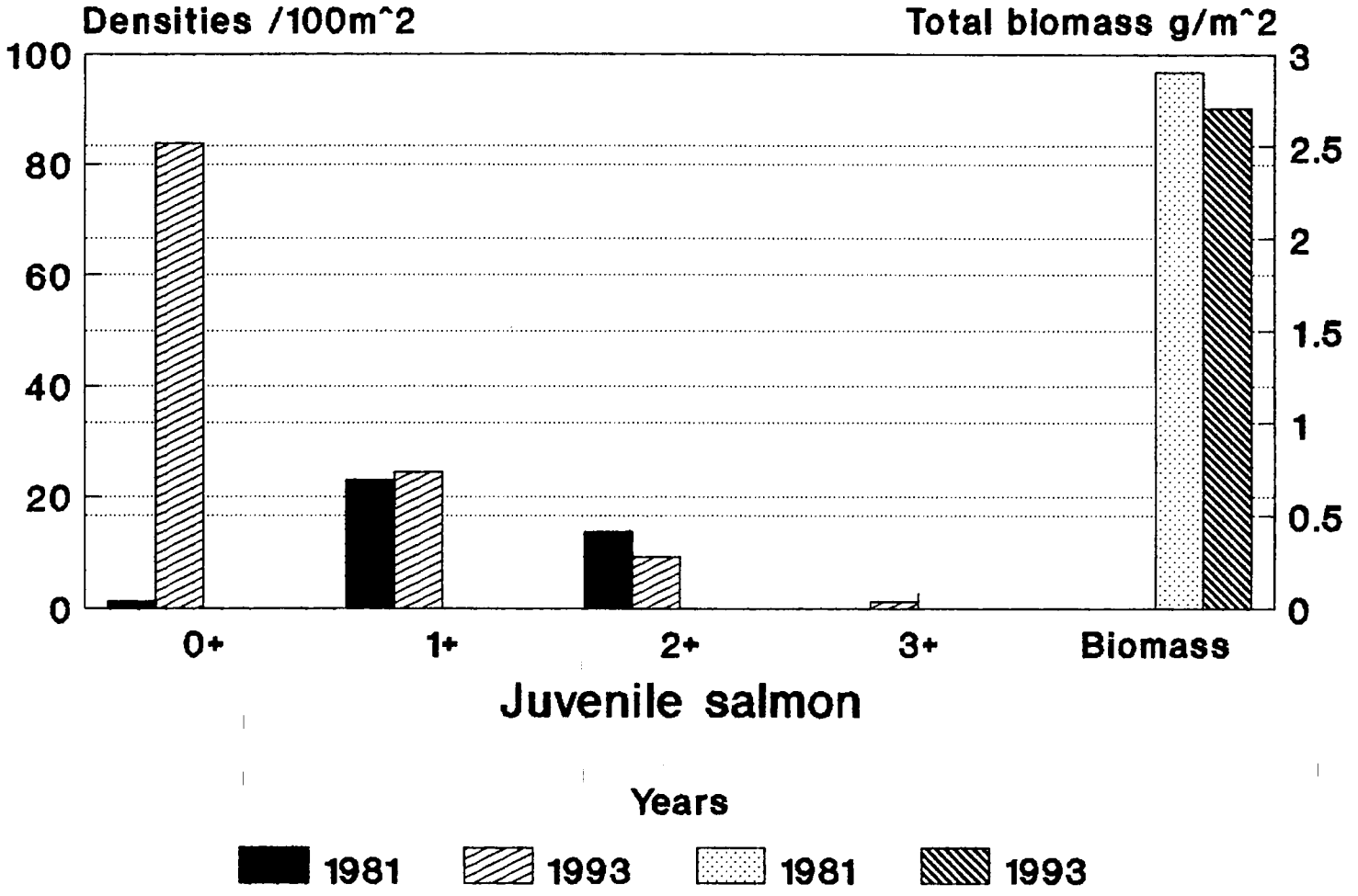
Figure 11. Rainy Brook.



Riffle

Salmon densities and biomass

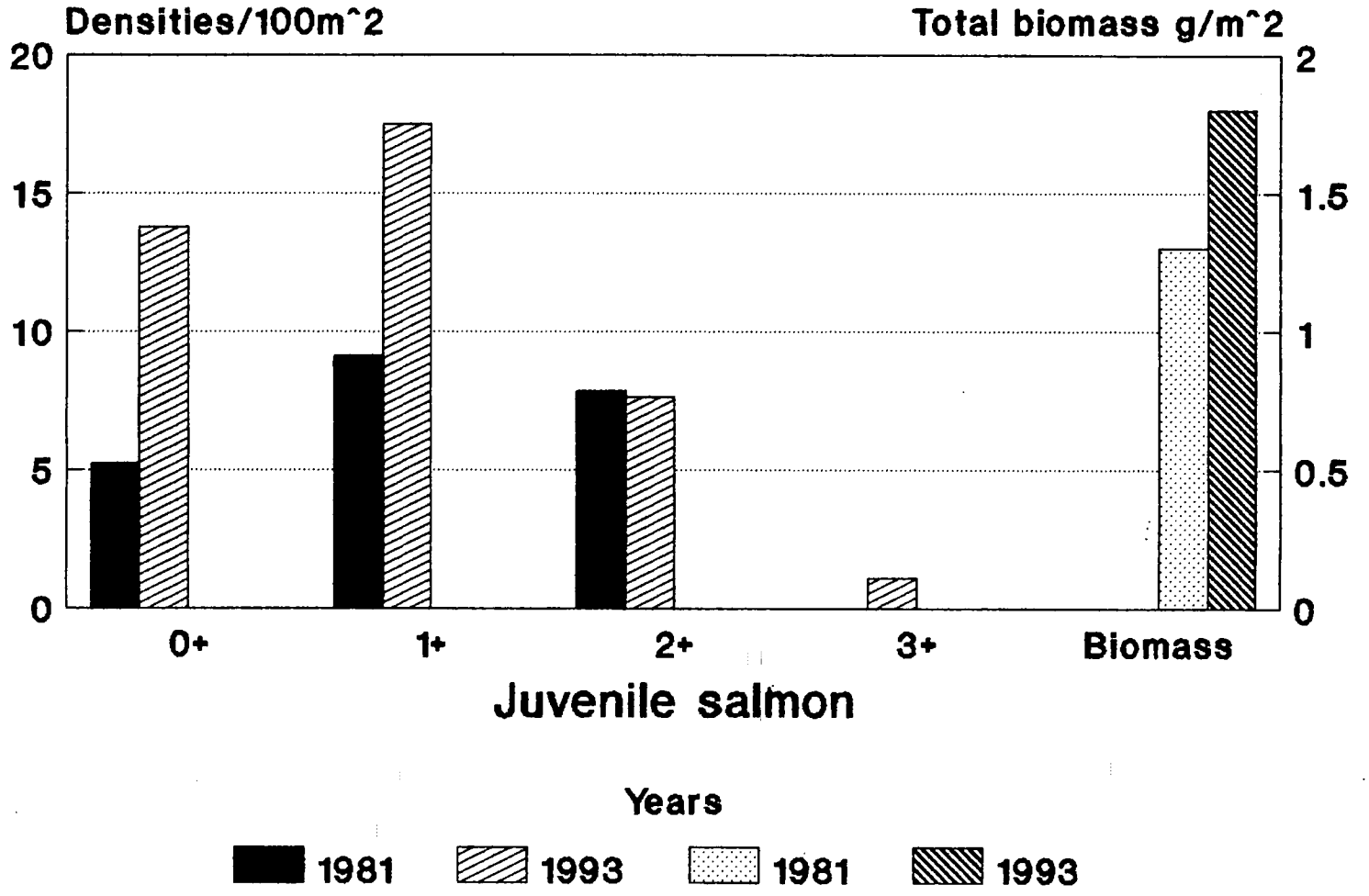
Figure 12. Main Rainy Brook.



Riffle

Salmon densities and biomass

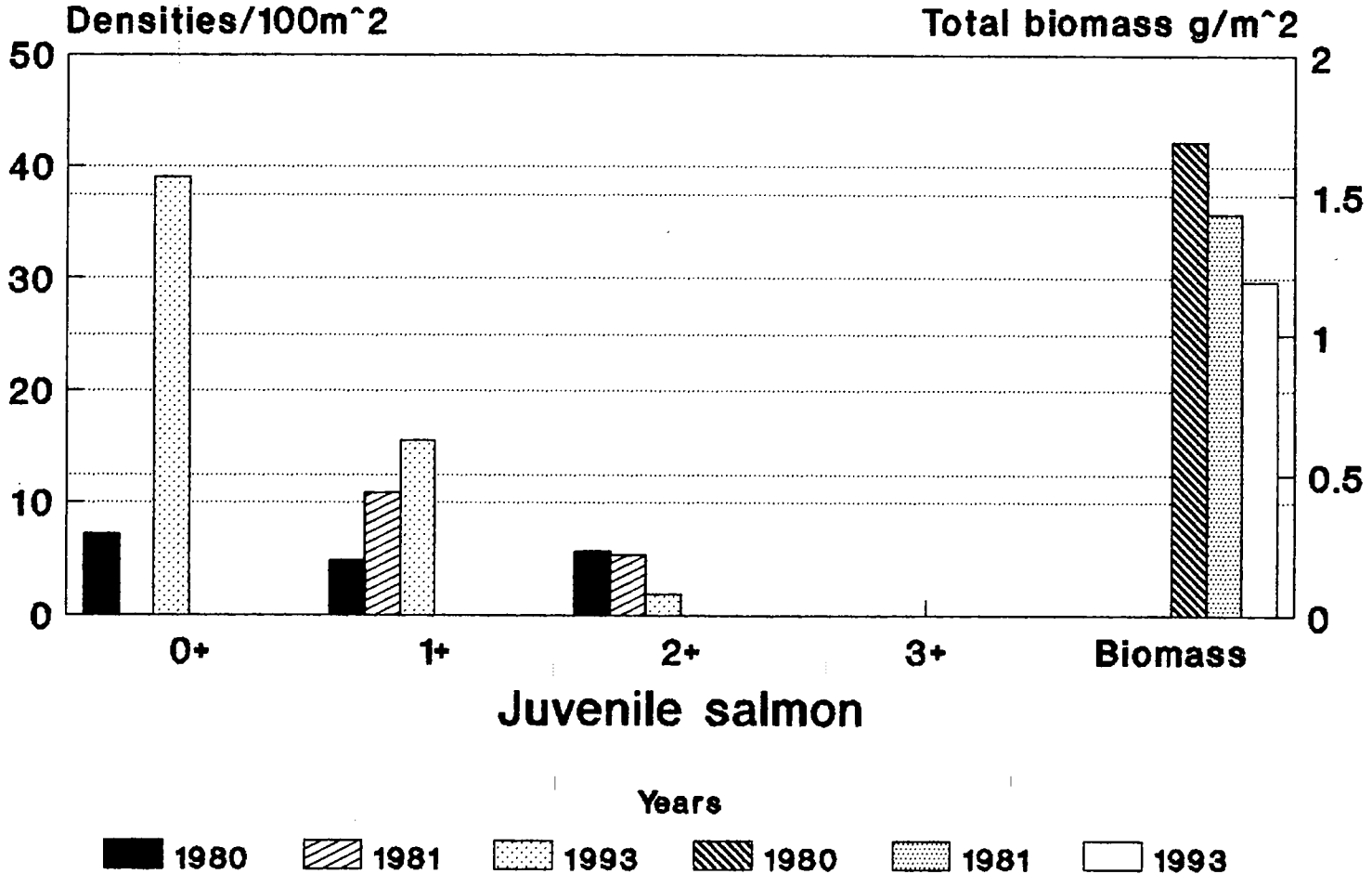
Figure 13. Main Rainy Brook Pool.



Pool

Salmon densities and biomass

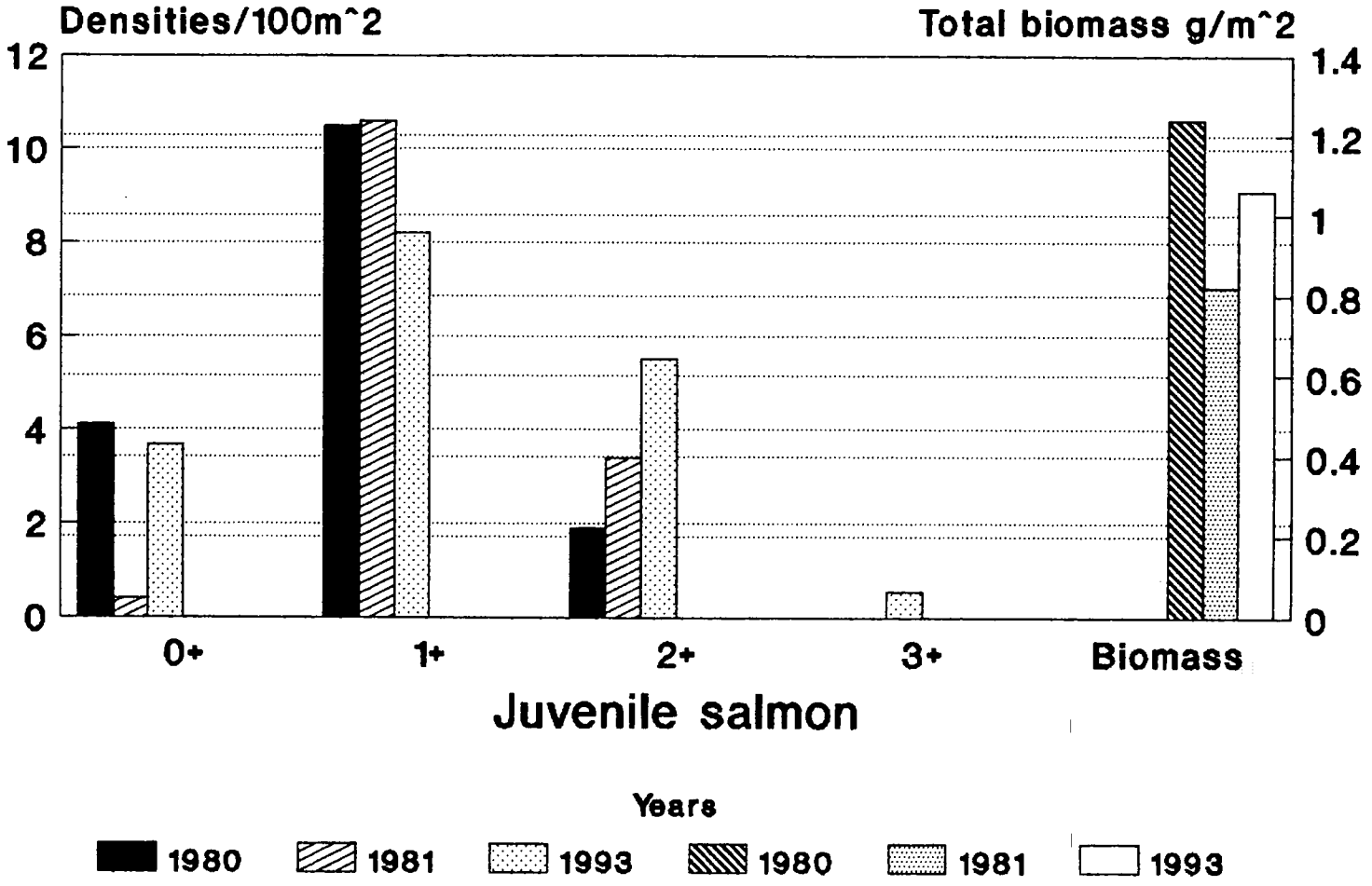
Figure 14. Camp 40 Brook.



Riffle

Salmon densities and biomass

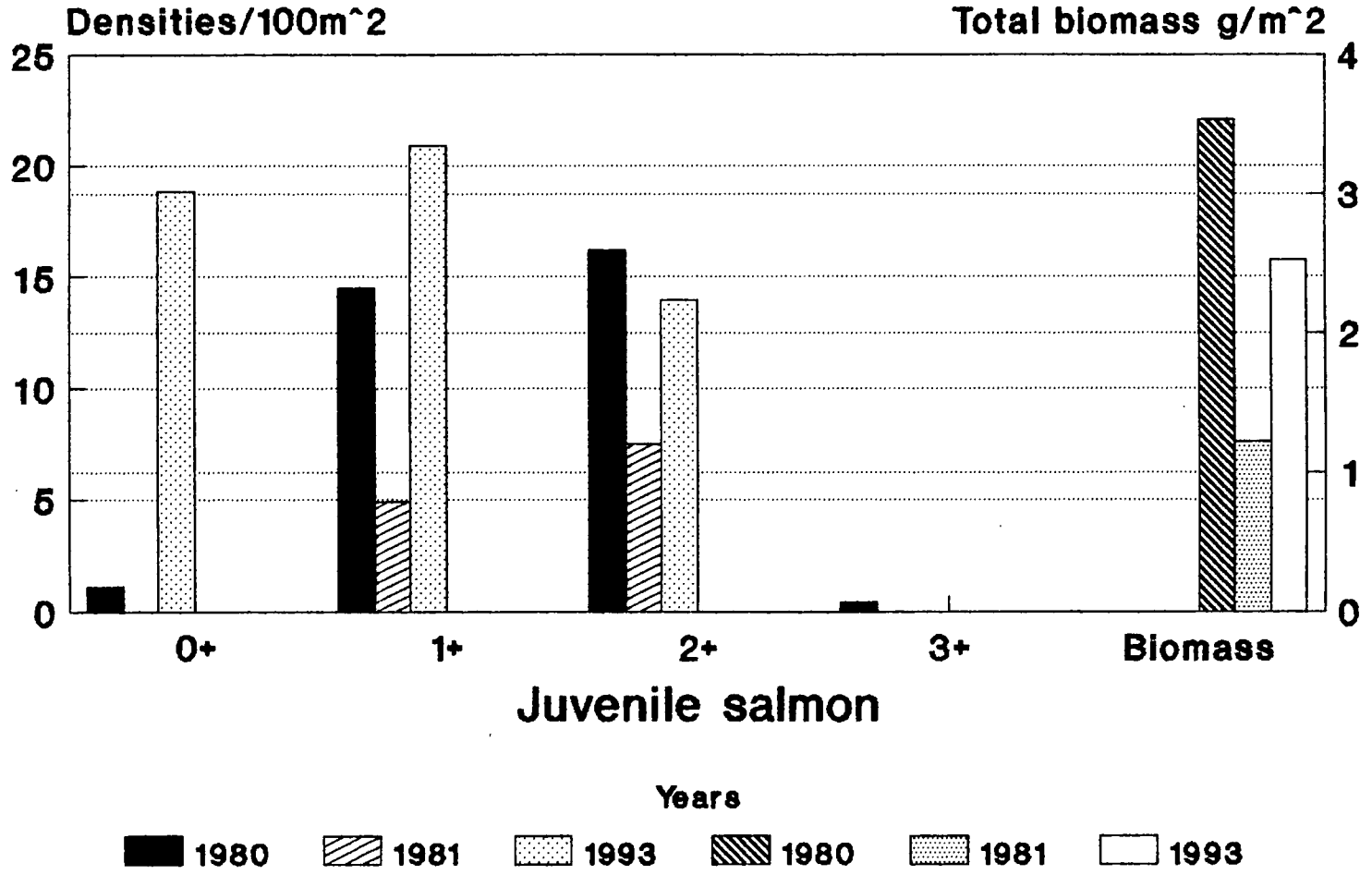
Figure 15. Railway bridge.



Flat

Salmon densities and biomass

Figure 16. Gillams Farm.



Flat