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Status of Atlantic Salmon *(Salmo salar L.)* in the Highlands River, St. George's Bay (SFA 13), Newfoundland, 1995

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 14 to October 25, 1995. Previous fence counts have been made in 1980, 1981, 1982, 1993 and 1994. Population estimates of juvenile salmon (*Salmo salar*) were made at 19 sites in late August and early September. The smolt count was 9009, but high water washed out the fence from June 8 - 12, shortly after the peak of the run, and probably close to a third of the run was uncounted. Ages from a smolt sample consisted of 4% of 2+, 51% were 3+, 42% were 4+, and 3% were 5+, showing a slight increase in the older age groups from earlier years. Counts of small (172) and large (120) salmon, although similar to counts in 1994 (145 small and 148 large), are greater than in the previous years, especially with the large salmon component. Nevertheless egg deposition remains below the target figure (68%). Improved returns in 1993 - 1995, compared to 1980 - 1982 are attributed to closure of the commercial fisheries. Sea-survival of large and small salmon from the 1993 smolts was 2.65%, which is low, but is more than double that of the smolt run in 1980 (1.2%). Juvenile population estimates showed higher densities of underyearlings compared to estimates in 1980 - 1981, especially in River Brook, the uppermost part of the main stem, which has coarser substrate than most other parts of the system, and more likely to be used for spawning by large rather than small salmon. Trends in the estimates of older juveniles were equivocal, possibly related to studies being undertaken later in the year than usual, when water levels were higher. The river mapping has progressed from the mouth of the river to Loch Levin. A number of beaver dams on small tributaries were removed to allow access to adult salmon. Improperly placed culverts on some tributaries are barriers to migration to adult and juvenile fish. Sedimentation from logging roads and erosion may have negative effects on production.

RÉSUMÉ

Une barrière de dénombrement, installée dans la rivière Highlands située dans la partie sud-ouest de l'île de Terre-Neuve (SPS 13), était en service du 14 mai au 25 octobre 1995. Des dénombrements à l'aide d'une barrière ont déjà eu lieu en 1980, 1981, 1982, 1993 et 1994. Des estimations de la population de saumons juvéniles (*Salmo salar*) ont été effectuées à 19 endroits à la fin d'août et au début de septembre. On a compté 9 009 smolts, mais de forts débits d'eau ont emporté la barrière entre le 8 et le 12 juin, peu de temps après le pic de la remonte, et probablement près du tiers de la remonte n'a pas été dénombré. Les âges établis à partir d'un échantillon de smolts étaient les suivants : 4 % étaient d'âge 2+, 51 % d'âge 3+, 42 % d'âge 4+ et 3 % d'âge 5+, ce qui montre une légère augmentation des groupes plus âgés par rapport aux années précédentes. Les dénombrements des petits saumons (172) et des grands saumons (120) sont similaires à ceux de 1994 (145 petits et 148 grands); mais, par rapport aux années précédentes, leur nombre est supérieur, en particulier celui des grands saumons. Pourtant, la ponte demeure inférieure à l'objectif visé (68 %). Des retours plus nombreux pour la période de 1993-1995, par rapport à la période de 1980-1982, sont attribués à la fermeture des pêches commerciales. La survie en mer des saumons de grande et de petite taille, qui sont les smolts de 1993, était de 2,65 %, ce qui est faible, mais elle est plus du double de la remonte de smolts de 1980 (1,2 %). D'après les estimations de la population de juvéniles, les densités d'alevins de moins d'un an étaient plus élevées en comparaison des estimations de 1980-1981, en particulier dans le ruisseau River (partie la plus en amont du bras principal) dont le substrat est plus grossier que dans la plupart des autres parties du réseau; les grands saumons sont plus susceptibles d'y frayer que les petits saumons. Les tendances des estimations des juvéniles plus âgés étaient équivoques, liées probablement à des études entreprises plus tard que d'habitude dans l'année, lorsque le niveau d'eau était plus élevé. La cartographie de la rivière touche l'embouchure de la rivière jusqu'au lac Levin. On a enlevé un certain nombre de barrages de castors sur les petits affluents pour permettre le passage des saumons adultes. Sur certains affluents, des ponceaux mal placés constituent des obstacles à la migration des adultes et des juvéniles. La sédimentation attribuable aux chemins d'exploitation et l'érosion peuvent avoir des effets négatifs sur la production.

Introduction

The Highlands River is a fourth order system located on the south west coast of Newfoundland (48° 11' 38" N, 58° 53' 40" W), in Salmon Fishing Area (SFA) 13. The river drains westerly into St. George's Bay from the southern part of the Long Range Mountains, with a general gradient of about 1.2%, over an axial length of 29.0 km (Fig. 1). Area of the drainage basin is 183.1 km^2 (Porter et al. 1974). The river has long been noted for a fall run of large salmon, *Salmo salar*, (Palmer 1928). Due to the decline of the fishery, especially of the large salmon component, as measured by angling success at the time, the river has been closed to angling since 1978 (Chadwick et al. 1978; Porter and Chadwick 1983).

Adult spawning escapement and smolt yields have been estimated with a counting fence in 1980, 1981, 1982, and from 1993 to 1995. Juvenile salmon population estimates were made in 1980 and 1981, (Gibson et al. 1987), and from 1993 to 1995. The earlier studies a decade and a half ago, originally planned as a long term experiment, were undertaken partly to use Highlands R. as an index river for St. George's Bay, and partly to study production of juvenile salmon related to types of habitat and stock-recruitment relationships, in order to provide better advice on required optimum spawning escapement. The background data have made the river useful to follow changes that have occurred since the moratorium was imposed on the salmon commercial fishery in 1992. In addition the continuation of the freshwater studies have allowed better estimates of carrying capacity in habitat types of rivers of the area. The studies since 1993 were undertaken under the auspices of the Cooperation Agreement for Salmonid Enhancement/Conservation (CASEC) programme, and funded through the Bay St. George South Area Development Association. The present document reports on the findings of work undertaken in 1995, with comparisons of spawning escapements, smolt yields and juvenile densities in the previous years.

Methods

Counting fence

The counting fence in 1995 was installed on May 14. Two traps for downstream migrating fish operated until June 8, at which time exceptionally high waters following heavy rain washed out the fence. The downstream traps were not re-installed, since the smolt run was declining, and when compared to the timing of previous years, the greater proportion of smolt would have emigrated, and the remaining smolt most likely would have left the system during the period of high discharge. In order to estimate the proportion of smolts which were uncounted when the traps were lost, the distributions of the smolt emigration related to time of year, temperatures and water levels, were examined for previous years, and compared to the run in 1995 (Figs. 2, 3, 4). The time of the smolt run in 1995 was later than in 1993, but similar to that which occurred in 1994. By inspection, in all years the greater proportion of smolts emigrate after water temperatures reach 10°C, over 13 - 18 days, followed by a more extended migration of reduced numbers with minor peaks related to water levels and temperatures. In 1993 the major run was over by June 2, with the peak of the run about May 24 - 28, and in 1994 the peak occurred between May 30 and June 2. The major peak in 1995 was June 1 - 3, with counts continuing for a further five days before the flood, the time of which would be equivalent to stage of the run of June 2 in 1993, and June 7 in 1994. The proportion of the latter part of the run after this time was 2659/7327 = 0.36, in 1993, and 2145/8358 = 0.34 in 1994.

Two percent of smolt, parr, and brook trout (*Salvelinus fontinalis*) were sampled. The majority of kelt were measured (F.L.), the sex recorded, and a scale sample taken. Most of the brook trout and parr passing through the fence had length recorded.

A trap was installed for catching upstream migrating adult salmon on June 12, and remained fishing until taken out on October 25. All fish were counted, and sizes of adult immigrating salmon were estimated, with 10% being sampled for size, sex recorded from external characteristics, and a small scale sample removed for age determination. Fish were released alive, with no mortalities.

Since the river is closed to angling, no adult fish were killed for more detailed sampling. Fecundity estimates were those derived by Randall (1989).

The target egg deposition for Highlands River was calculated by applying a required egg deposition rate of 240 eggs.100 m^{-2} for fluvial habitat (Elson 1975) and 368 eggs.ha^{-1} for lacustrine habitat (O'Connell et al. 1991; O'Connell and Dempson 1995) to the estimate of habitat available (Gibson et al. 1987). The available habitat consists of 621,926 m^2 of fluvial area and 159,043 m^2 of lacustrine habitat.

Juvenile salmon population estimates

Population estimates were conducted during August and early September in 19 sites representing the major habitat types (riffle, flat, pool, lake), stratified in fluvial habitats by reaches as far as possible according to geomorphology and stream order. Stations were sampled as in previous years (Gibson et al. 1987), but with the addition of eight sites. The new stations were picked to give a better representation of habitat types in each stretch of river, and therefore a more complete picture of the populations in the different reaches and throughout accessible salmon habitat. Densities of small salmonids were estimated by the depletion method in riffles and flats with the use of an electrofisher. A beach seine, plus in some cases the electrofisher, was used to catch fish for the mark and recapture method in pools and in the lake. Habitat variables were measured at each site. Methodology is described in Gibson et al. 1993.

Results

Counting fence

Movements of smolt and adult salmon through the fence in 1995 are recorded below, and compared with previous years.

A total of 9,009 smolt were counted before the traps were lost (Fig. 4). The distribution of the smolt emigration in 1995 was compared to those in the previous two years, and by using an estimated proportion of 0.35 we can calculate the latter uncounted part of the run in 1995 to have been 3,150, to give a total estimated run of 12,159, which can be rounded to 12,160. Alternatively, by simply using the proportion of the run that emigrated in 1994 after June 8, the total run could be estimated as 10,802.

Unlike most other rivers on the island the adult salmon immigration continues through the season, with a substantial late season (post-August) run (Fig. 5). The final salmon was captured on October 24. Since water levels were relatively low, some salmon were thought to still be holding up in a pool below the fence. After heavy rainfall on October 16, 9 large salmon and 5 grilse were counted through the fence the same day. Therefore some fish may have ascended after removal of the fence.

In addition, moving downstream were: 152 parr; 33 resident brook trout; 503 silvery (sea?) trout; 7 eels (*Anguilla rostrata*); and 13 smelt (*Osmerus mordax*); and upstream: 74 resident brook trout and 208 sea trout. The adult fence was fishing with every second conduit removed. Therefore counts of brook trout after the smolt trap was removed are an underestimate, as most would pass through without enumeration.

	Downstream		Upstream	
Year	Smolt	Kelt	Grilse	Large salmon
1980	15,130	73	82	55
1981	15,839	63	127	29
1982	12,373	58	100	56
1993	9,986	90	137	78
1994	10,503	57	145	148
1995	9,009*	43	72	120

*Incomplete. Estimated total 1995 smolt run = 12,160 (or 10,802 if estimated by using the proportion in 1994 emigrating after June 8).

Mean length of the small salmon measured (n = 17) was 54.1 cm (range 49.0 - 58.5 cm). Mean length of the large salmon was 83.2 cm (n = 9), with a range of 74.5 - 99.5 cm. The proportion of female grilse was 0.46, and of female large salmon, 0.33.

Scales were read of 14 small salmon (grilse, or 1 sea-winter). Of these one had been a 2+ smolt (7%), eleven had a river age of 3+ (79%), and two of 4+ (14%). With a sample of eight large maiden, all 2-sea winter (2SW), salmon, one had been a 2+ smolt (13%), and seven had a river age of 3+ (88%). A returning respawning salmon (a consecutive spawner, i.e., after spawning, returning to spawn the following season), with two sea winters as a maiden fish, and of F.L. 82.5 cm, had a river age of 3+.

Mean fork length of grilse kelts was 59.4 cm (n = 12), range 51.5 cm - 68.0 cm, and of large salmon kelts 80.0 cm (n = 29), range 71.5 - 100.0 cm. The proportion of female grilse kelts was 0.50, and of female large salmon kelts, 0.86. All the grilse kelts (n = 12) had a river age of 3+. Of the 27 salmon kelts whose river age could be determined, four of the large salmon had a river age of 2+ (15%). Twenty-two had a river age of 3+ (81%), and one had a river age of 4+ (4%). One of the large salmon kelts, with a river age of 3+, had spawned consecutively three times. It had a fork length of 100.0 cm. All large salmon kelts had been maiden fish of 2 SW, except one a maiden of 3 SW, which had a fork length of 91.5 cm.

Spawning escapement.

Fecundity estimates are taken from Randall (1989):

Small salmon
Ln fecundity = -4.5636 + 3.1718 Ln (F.L.,cm);
Large salmon
Ln fecundity = -1.1862 + 2.3423 Ln (F.L.cm);

Since the sample size was small, we combined the sex ratios of the kelt for all years (1980,1981,1982,1994,1995), and used the proportion of females as 0.51 for the small salmon, and 0.71 for large salmon. Also, we took mean fork lengths for the adult salmon (bright and kelt) from all samples measured in 1994 and 1995: 54.4 cm for small salmon; 79.3 cm for large. This was similar to sizes and proportions assumed in previous years. O'Connell (unpublished data) reported for the Highlands R., from 1980 - 1982, the mean fork lengths of small salmon to be 52.3 cm, and of large salmon to be 84.5 cm, and relative proportions of females to be 0.551 for small and 0.714 for large salmon.

Therefore, using mean fecundity values and proportion of females in the run:

Potential egg deposition by small salmon was:
3334*172*0.51 = 292500.

Potential egg contribution from large salmon was:

8580*120*0.71 = 731050.

Total potential egg deposition therefore was: 1023549.

Accessible rearing habitat consists of (m^2):

Fluvial = 621926;

Lacustrine = 159043.

The reference figure for target egg deposition is 240/100 m^2 for fluvial habitats (Elson 1975) and 368/ha for lacustrine habitat (O'Connell et al. 1991; Anon. 1992). Target egg deposition therefore is:

6219.26*240 + 15.9043*368 = 1498475

Spawning escapement as a proportion of the target figure therefore was:

1023549/1498475 = 0.68.

Age distribution of the smolt

A sample of 178 smolts was aged. Eight (4%) were 2+, 90 (51%) were 3+, 74 (42%) were 4+, and 6 (3%) were 5+. The proportion of 2+ smolt may have decreased, possibly related to greater densities of 1+ parr resulting from increased spawning escapement in 1992 and following years, and related density dependent growth. A similar phenomenon has been recorded before (Gibson 1978).

	Age class of smolt				
Year	2+	3+	4+	5+	6+
1980	5.5	63.4	1.2		
1981	34.4	64.5	1.1		
1982	16.2	69.8	12.5		
1993	23.8	66.7	7.9	0.8	0.8
1994	3.6	70.7	25.7		
1995	4.5	50.6	41.6	3.4	

Juvenile salmon population estimates

Relative densities from habitat types at 14 stations are presented in Figures 6 - 8, and ten stations are compared with previous years (Figs. 9 - 18). These indicate that, except in two "flat" stations in the lower river (Railway Bridge flat and Gillam's Farm flat), which provide poor fry habitat, underyearling densities were high compared to those estimated in 1980 and 1981. Highest biomass of salmon occurred in a riffle habitat of Bald Mountain Brook (2.3 $g.m^{-2}$), although a similar biomass occurred in a riffle habitat of Rainy Brook (2.1 $g.m^{-2}$), and a pool of Bald Mountain Brook (2.1 $g.m^{-2}$). The 0+ were absent in a riffle habitat in the uppermost station of Small Rainy Brook (Fig. 8), possibly because this was upstream of a beaver dam, which may have been an obstruction to adults, but parr may have been able to migrate through the interstices of the dam.

Discussion

The upper river and mid-river riffle stations (River Brook) showed exceptional increases in density of underyearlings compared to a previous sampling time in 1981 (Figs. 9 and 10). This is probably due to the increase in spawning escapement of large salmon. Substrate is generally very coarse in River Brook and less suitable for grilse spawning. Earlier anecdotal observations (Palmer 1928) suggest that only the large salmon migrate up River Brook, and it is possible that the restrictive availability of mainly coarse type of spawning substrate has imposed a selective pressure for spawning of large salmon in favour of grilse in this reach of the river. High velocities and large particle size for spawning favour larger fish (Hartman 1969). Two large salmon were seen spawning here, and a number of redds were observed, on October 26, 1994. Parr were few relative to other sites, possibly related to the shallow water depths, and there may be migration of parr to habitats more suitable for the larger stages. At the lower station in River Brook habitat appears to be more suitable for parr, at least for the 1+ (Fig. 10).

Pool habitats have relatively higher densities of larger fish (Gibson et al. 1993). However, in 1995 the large parr were fewer than in previous years in the pool station in the lower part of River Brook (Fig. 11) and in the pool at the lower end of Rainy Brook (Fig. 15). This could be due to the fact that we were obliged to do these stations in September, and the water was higher and colder. Also in 1995 the pool in Rainy River had changed considerably in the spring flood. Previous dense instream debris had gone, and the pool had a greater proportion of silt.

Riffle stations in Rainy and Small Rainy Brook and Bald Mountain Brook had high densities of all year classes and showed an increase in 0+ over the earlier study (Figs. 12-14). Salmon densities for Rainy Brook are somewhat less than the previous year, which we cannot explain. There may be unknown problems such as the later sampling time in 1995, and poaching (we did find a net stashed in the bushes in 1994). We noticed heavy silting in Rainy Brook during a rain storm, originating in logging roads, but except in main Rainy Brook pool an increase in silt substrate was not noticed.

The flat habitats in the main stem (Figs. 16 and 17) are downstream from the major spawning areas, and do not show any marked changes in densities that could be explained by changes in spawning escapement.

Densities and biomass in Loch Leven (Fig. 18) are lower than in the fluvial habitats, as would be expected (Gibson et al. 1993). Underyearlings, or fry, are relatively sparse in lakes, but if the spawning escapement increased in 1992, as is suggested by higher fry densities in 1993 at other sites, it would be expected that the 1+ would be more numerous in 1994 and the 2+ in 1995. In fact 1+ densities showed greatest numbers in 1993, although the 2+ were higher in 1995. The estimates in the lake are not as accurate as at the other sites, because only a section of the lake was sampled, and it could not be enclosed. However, sampling a previous year (unpublished data) showed that the day after marking very few marked parr were found away from the station. Other stations in the lower river (Figs. 11, 16, 17) showed relatively higher 1+ densities in 1993, so that this indication of high 1+ densities in 1993 may be valid. Although numbers are fewer than in other habitats, using the approximate method derived in an earlier study (Gibson et al. 1987) Loch Leven may have provided rearing for yield of 812 smolts in 1996, or 51 smolts/ha.

Not only are some sections of river more productive than others, but distribution within sections is patchy, related to such variables as, substrate, mean depth, water velocity, etc. The eventual point of the exercise is to incorporate habitat variables in order to develop a predictive model describing potentially maximum densities of respective age classes for certain habitat types (similar to the multiple linear regression models in Gibson et al. 1987). If the river were mapped, accurate estimates could be made of the population of each year class in a year throughout the river, and subsequently of survivorship between year classes. We have data to undertake most of this work, but still lack the river mapping, although a start has been made. One hundred and forty-six sections of the river were mapped to delineate habitat types. The river is now mapped from the mouth up to Loch Levin, although the data have yet to be computerised.

The increase in underyearlings compared with the previous studies suggests that the moratorium on the commercial fishery is allowing the river to reach its full potential for producing salmon. Although we did not have a counting fence on the river in 1992, the first year of the moratorium, the relatively high densities of 0+ in 1993 suggest that the spawning escapement had increased compared to the earlier years. The low smolt output compared to the studies a decade and a half ago, when the stock was low, suggest that spawning escapement prior to 1992 had been very low. Movements of salmon parr complicate the picture for estimating survival rates or changes in their numbers from previous years, so that a range of habitat types need to be examined, including deeper riffles and pools, a design that is usually ignored in most studies of the juvenile stages.

The increase of grilse in recent years compared to previous studies is most likely the result of the moratorium on commercial fishing, and is reflected, with the same smolt classes, in the increase of large salmon in 1994 and 1995, and of maiden multi-sea winter and repeat spawners. In addition closure of the commercial fishery is most likely the cause for the relatively greater increase in the proportion of large salmon, and possibly for some larger sized grilse, since the fishery selected for the larger fish. Using the grilse counts in one year followed by the large salmon counts the following year, i.e., the same year of smolt emigration, in 1980 and 1981 the proportion of large salmon was 26%, and in 1981 and 1982 the proportion was 31%. Since the moratorium it has been 52% and 45%. The later fishing period of the fence in 1995 (to October 25), compared to other years (to October 13 in 1994, and October 1 in 1993) would have augmented counts somewhat, although our major conclusions remain the same.

The potential egg deposition is now 68% of the target figure, higher than in the studies fifteen years ago (Fig. 19). However, the fecundity estimates need to be validated. Anecdotal evidence suggests that the salmon in Highlands River are "stockier" than in other local runs, so that in fact fecundity may be higher than estimated. In addition mean sizes of the adults need to be validated with more data. For example, many of the kelts showed growth after the spawning mark (B. Short, pers. comm.), indicating some feeding after spawning, possibly in the lake, where *Fundulus diaphanus, Gasterosteus aculeatus* and possibly smelt occur (Gibson et al. 1987). This could explain the slightly larger size of the grilse kelts (59.4 cm) compared to fresh run grilse (54.1 cm), suggesting that perhaps the kelt data should not be included for deriving mean lengths of immigrating fish. The optimum spawning escapement will likely be attained after returns of higher smolt outputs in 1996 and following years, and continuation of the work would provide accurate figures for a more realistic figure for optimum escapement.

Sea survival of grilse and salmon from the 1993 smolt output was 2.65%, which is low, but is more than double that of the survival to the river of smolts in 1980 (1.21%).

Smolt output remains relatively low, at about $1.5/100m^2$ of fluvial habitat, probably to be expected if stocks were low prior to the moratorium, but in the absence of a commercial fishery spawning escapement is close to the optimum theoretical figure, which however has yet to be validated for this river. The 0+ densities remain high. Smolt are aged predominantly 3+, so that higher smolt runs from the 1993 year class can be expected in 1996, with therefore adult returns expected to be relatively greater in and following 1997, possibly allowing a surplus for angling of grilse, especially if a major part of the run ascends after the angling season (Fig. 5). The Highlands River has the best background data over a critical period for salmon stocks in St. George's Bay, for both the grilse and the large salmon components, and should be retained as an index river for the region.

There are possibilities for enhancement. A collapsed logging road on Rainy Brook East had been an obstruction to upstream migration, but was washed out in recent years. As salmon re-colonise the Rainy Brook East system, there will be additional smolt output from this tributary. To help restore this run salmon could be stocked in the upper tributaries. In addition salmon could be stocked in extensive suitable habitat areas above natural obstructions. Since the large salmon in the Highlands River may have a genetic determinant of age at maturation, gametes should be taken from the large salmon component. Several culverts were noted on a number of tributaries to be barriers to upstream fish migration, and these should be made passable, for both adults and juveniles. After heavy rain dense siltation originating from an old logging road was noted in Bald Mountain Brook and in Rainy Brook. This problem should be alleviated as vegetation regenerates, and could be hastened by suitable planting.

Although not reported here, habitat characteristics were measured at all juvenile salmon sampling sites, so that models can be derived describing the potential production of juvenile salmon related to types of habitat. In addition, brook trout, similarly to the salmon, had population densities measured, and these studies will be included in later reports. As salmon densities increase a better estimate can be made of carrying capacity for juvenile salmon of various year classes in various habitat types and the potential smolt production from habitats throughout the system. Density dependent growth models (Elliott 1993; Gibson 1995) will indicate the densities and production potentials in various habitat types. These data will be valuable for refining models related to carrying capacities of habitats, production, and interactions, and provide a more accurate target figure for spawning escapement in similar types of rivers in the region.

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STOCK: Highlands River (SFA 13)

TARGET: 1.50 million eggs

Year	1980	1981	1982..	1993	1994	1995	MIN	MAX	MEAN
Recreational catch[1] (closed since 1978)							19	114	67
Fence Counts									
Smolt	15130	15839	12373	9986	10503	10802[2]			
Small	82	127	100	137	145	172			
Large	55	29	56	78	148	128			
%Target eggs met:									
(small+large)	32%	26%	34%	47%	77%	68%			

[1]Recreational fishery data are available for 1953-1977 only since the river was closed to angling from 1978 to present.

[2]Adjusted from actual count of 9009 to account for smolt that migrated after June 8 when fence became inoperable.

[3]Based on weighted average percent female of kelt sampled over all years 1980-82 and 1993-95 and mean length of kelt 1993-95 and bright salmon 1995.

Data and assessment: Counts of smolt and adult salmon were obtained with a fish counting fence in 1980-82 and in 1993-95. Juvenile densities were measured at 19 stations to determine changes in juvenile salmon production. Juvenile studies at the higher egg deposition following the moratorium will give a better estimate of the potential production of different reaches and a more accurate estimation of the target egg deposition.

State of the stock: Egg deposition in 1995 is slightly lower than in 1994 but higher than that observed in 1993 and much higher than in 1980-82. The improved returns in 1993-95, compared to 1980-82, are attributed to the closure of the commercial fisheries. Sea survival of the 1993 smolt-class to adult salmon returns (small + large salmon) was 2.4%, which is higher than the 1.2% observed from the 1980 smolt-class. Despite closure to angling since 1978, egg deposition has remained below the reference 2.4 eggs/m^2. A major tributary was blocked by a collapsed bridge until recently, but has not yet naturally re-colonized. Some small tributaries are obstructed by beaver dams.

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

Fence counts 1995:

Smolt	12,160 (estimated; minimum 9009)
Small salmon	172
Large salmon	120

% of target egg deposition met = 68%

Data and assessment:

Complete counts of salmon were obtained at a fish counting fence in, 1980, 1981, 1982, 1993, 1994 and 1995.

Potential egg deposition: 1,023,549 (292,500 contributed by grilse, and 731,050 contributed by large salmon).

Accessible habitat (m^2):

Fluvial = 621,926; Lacustrine = 159,043.

Figure legends

1. The Highlands River system, showing location of the river in the southwestern part of the province. The major tributary, upstream from the Trans-Canada Highway, is a third order river called River Brook.

2. Smolt counted through the fence in 1993.

3. Smolt counts for 1994.

4. The smolt run in 1995. Total smolts counted = 9,009. The latter part of the run could not be enumerated, due to loss of the traps in high water. Estimated total smolt run = 12,160 (or 10,802 if the proportion after June 8 was similar to that in 1994).

5. Counts of adult salmon through the upstream trap. Counts are by week (n = 24), beginning June 12, and ending October 25. The last week should theoretically have gone from October 16-22, but the fence was taken out on October 25.

6. Densities and biomass of salmon in riffle habitats, 1995.

7. Densities and biomass of salmon in flat habitats, 1995.

8. Densities and biomass of salmon in pool habitats and in a riffle at the uppermost station in small Rainy Brook, 1995. No salmon occurred in the pool in the lower main river (fourth order).

9. Densities and biomass of juvenile salmon over four years (1981, 1993, 1994, 1995) in a riffle habitat at the upper end of River Brook (third order).

10. Densities and biomass of juvenile salmon in a riffle station at the lower end of River Brook (third order), estimated in 1980,1981,1993,1994 and 1995.

11. Estimates of densities and biomass of juvenile salmon in 1981, 1993, 1994 and 1995, in a pool at the lower end of River Brook (third order river).

12. Estimates of densities and biomass of juvenile salmon in 1980, 1981, 1993, 1994, and 1995 in a riffle station in Bald Mountain Brook, a second order stream.

13. Estimates of juvenile salmon densities and biomass in 1980, 1981, 1993, 1994, and 1995 in a riffle station of Small Rainy Brook (second order stream).

14. Estimates of juvenile densities and biomass in a riffle station in the main stem of Rainy Brook (third order stream), in 1981, 1993, 1994 and 1995.

15. Densities and biomass of juvenile salmon in a pool at the lower end of Rainy Brook (third order stream), in 1981, 1993, 1994, and 1995.

16. Estimates of juvenile salmon densities and biomass in a flat station on the main river, just above the old railway bridge (fourth order river), in 1980, 1981, 1993, 1994 and 1995.

17. Estimates of juvenile densities and biomass at the Gillam Farm station, in a flat habitat at the downstream end of the river (fourth order river), in 1980, 1981, 1993, 1994 and 1995.

18. Estimates of juvenile salmon densities and biomass in Loch Leven.

19. Potential egg depositions of grilse and large salmon in 1980, 1981 and 1982, compared with post moratorium depositions in 1993, 1994 and 1995.

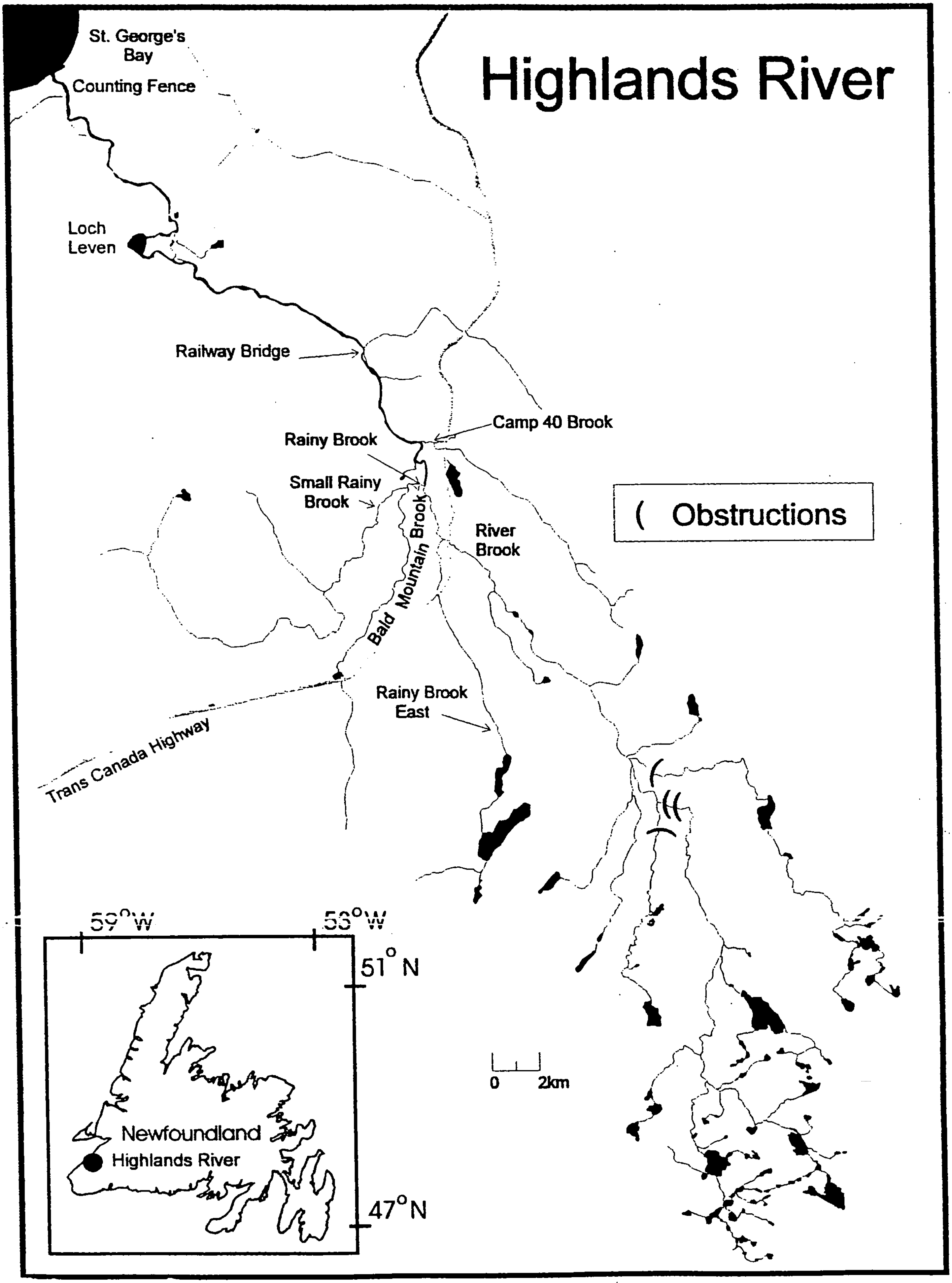
Highlands River
St. George's Bay
Counting Fence
Loch Leven
Railway Bridge
Camp 40 Brook
Rainy Brook
Small Rainy Brook
Bald Mountain Brook
River Brook
(Obstructions
Rainy Brook East
Trans Canada Highway
59°W
53°W
51° N
47°N
Newfoundland
Highlands River
0
2km

Figure 1.

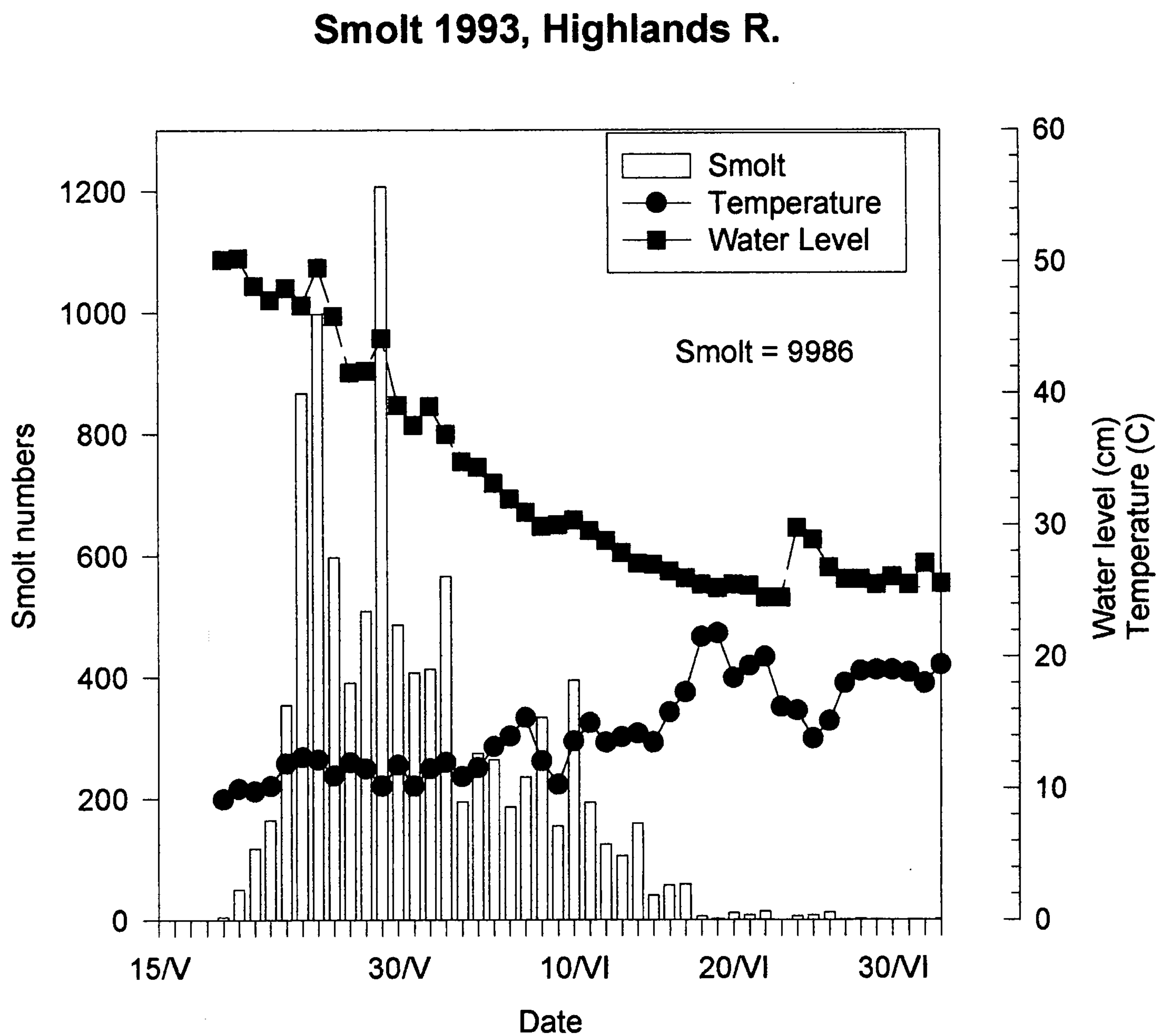

Figure 2. Smolt counted through the fence in 1993.

Smolt 1994, Highlands R.

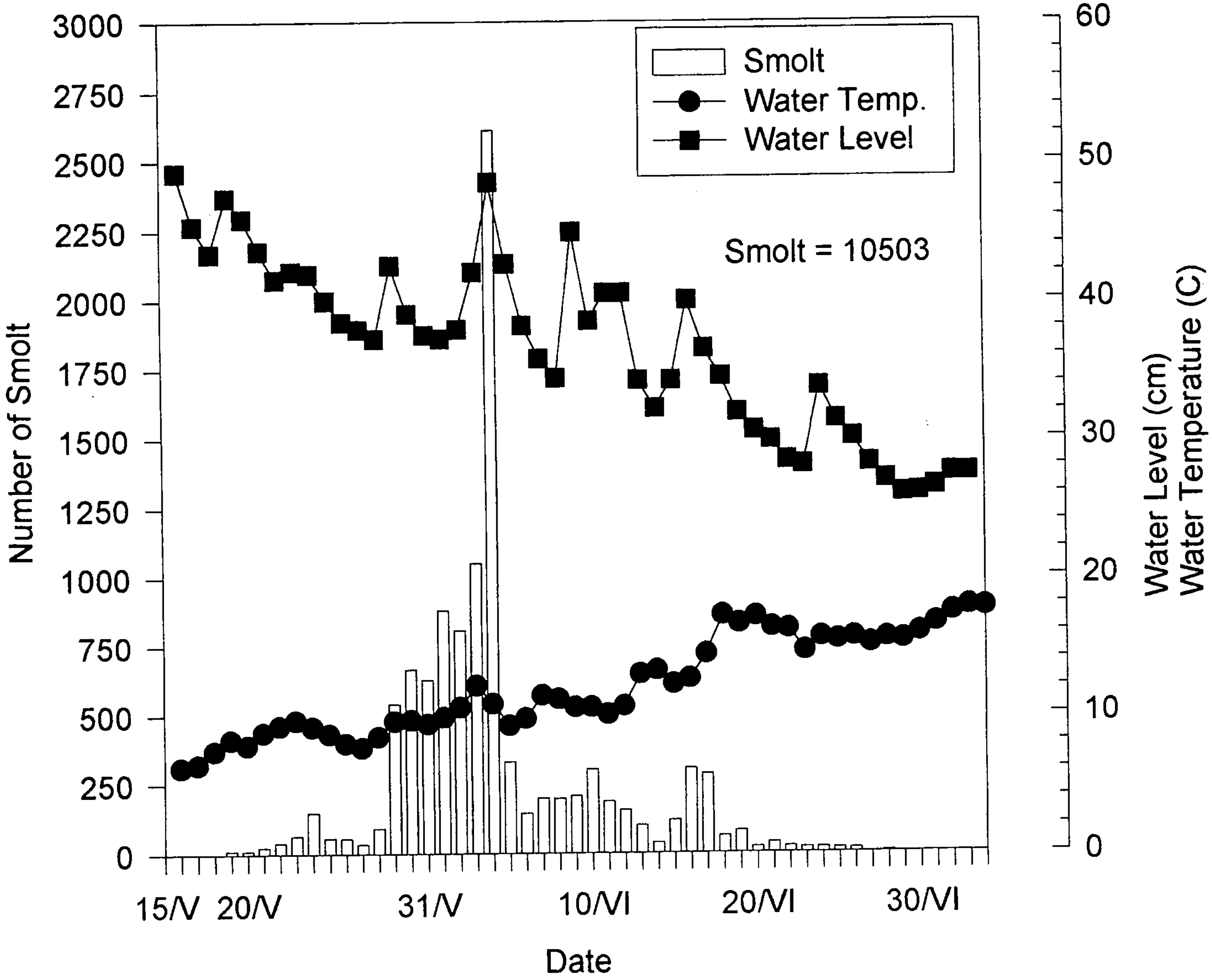

Figure 3. Smolt counts for 1994 in the Highlands river.

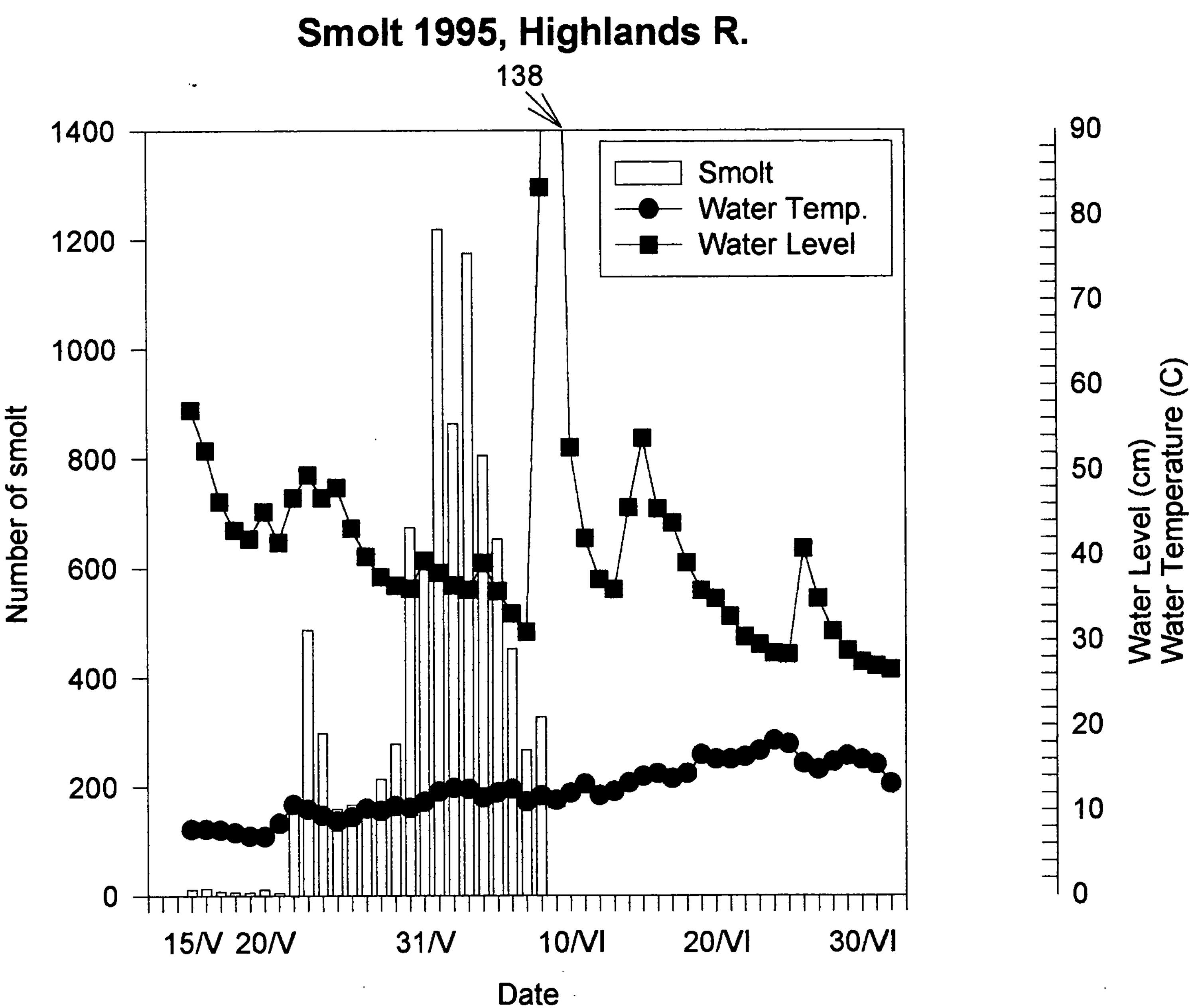

Figure 4. The smolt run in 1995. Total smolts = 9009; (estimated total = 12,160).
The latter part of the smolt run could not be enumerated, due to loss of the traps in high water.

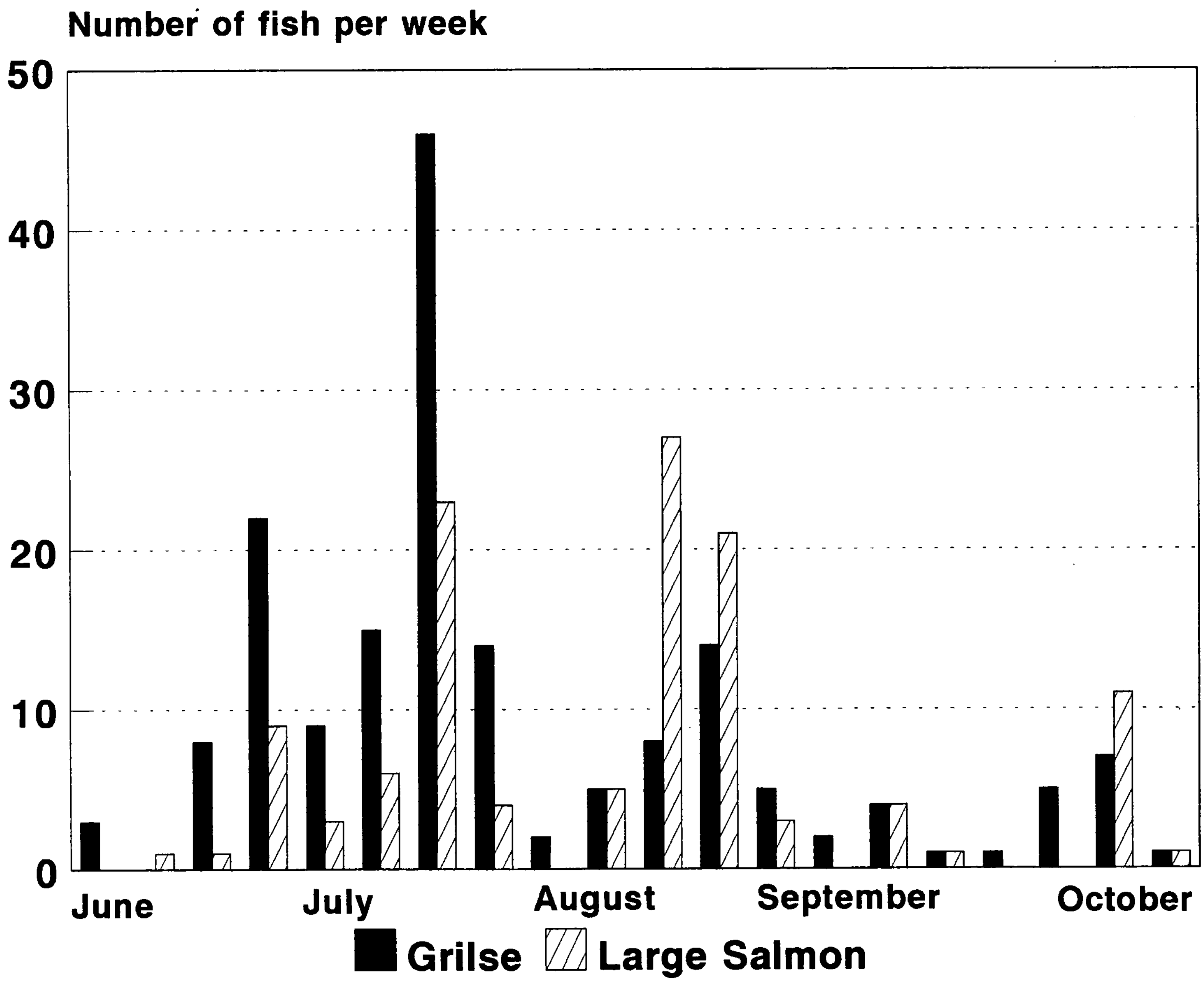

Figure 5. Counts of adult salmon through the upstream trap, June 12 - October 25, 1995.

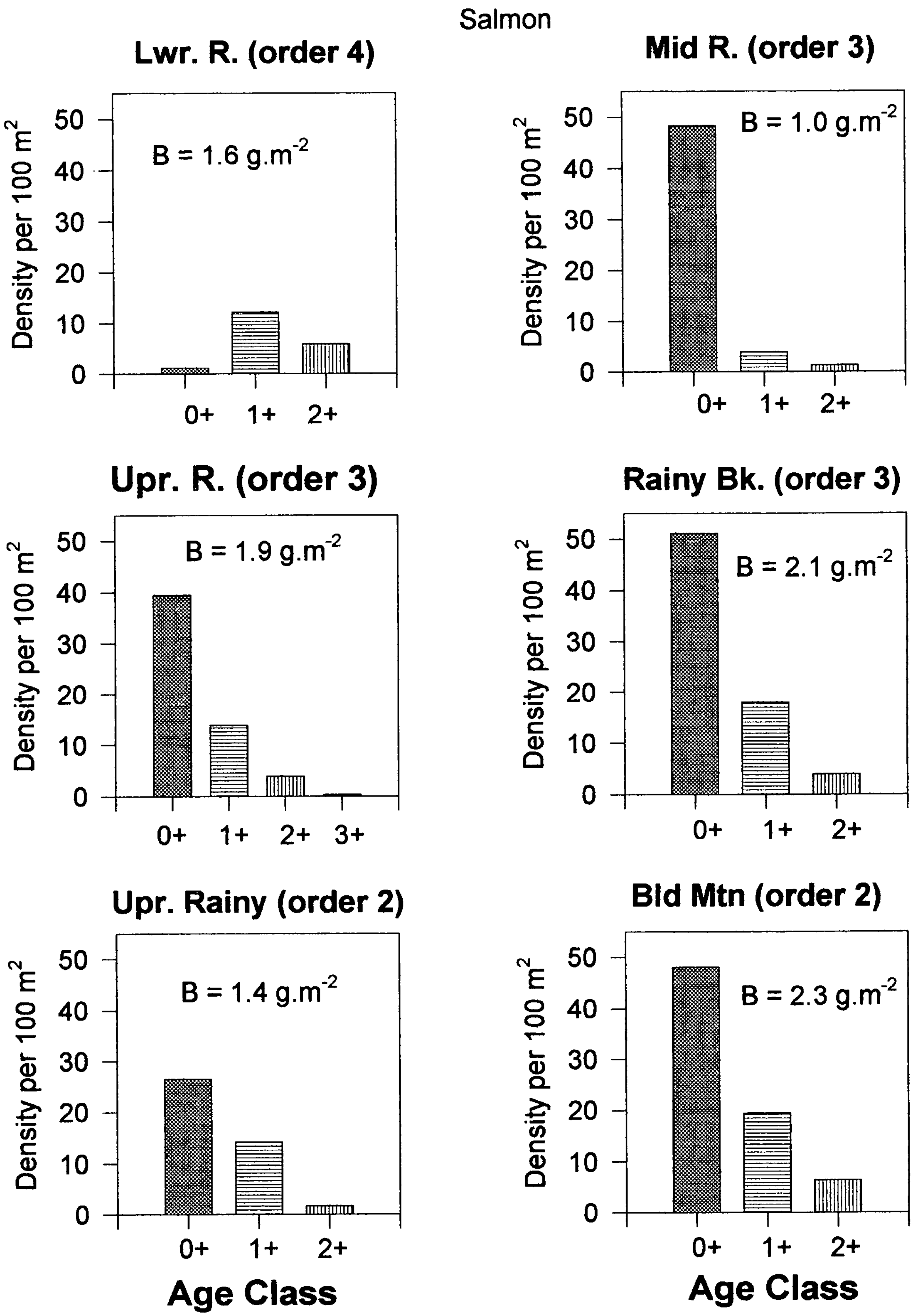

Figure 6. Riffle Habitats, Highlands R., 1995

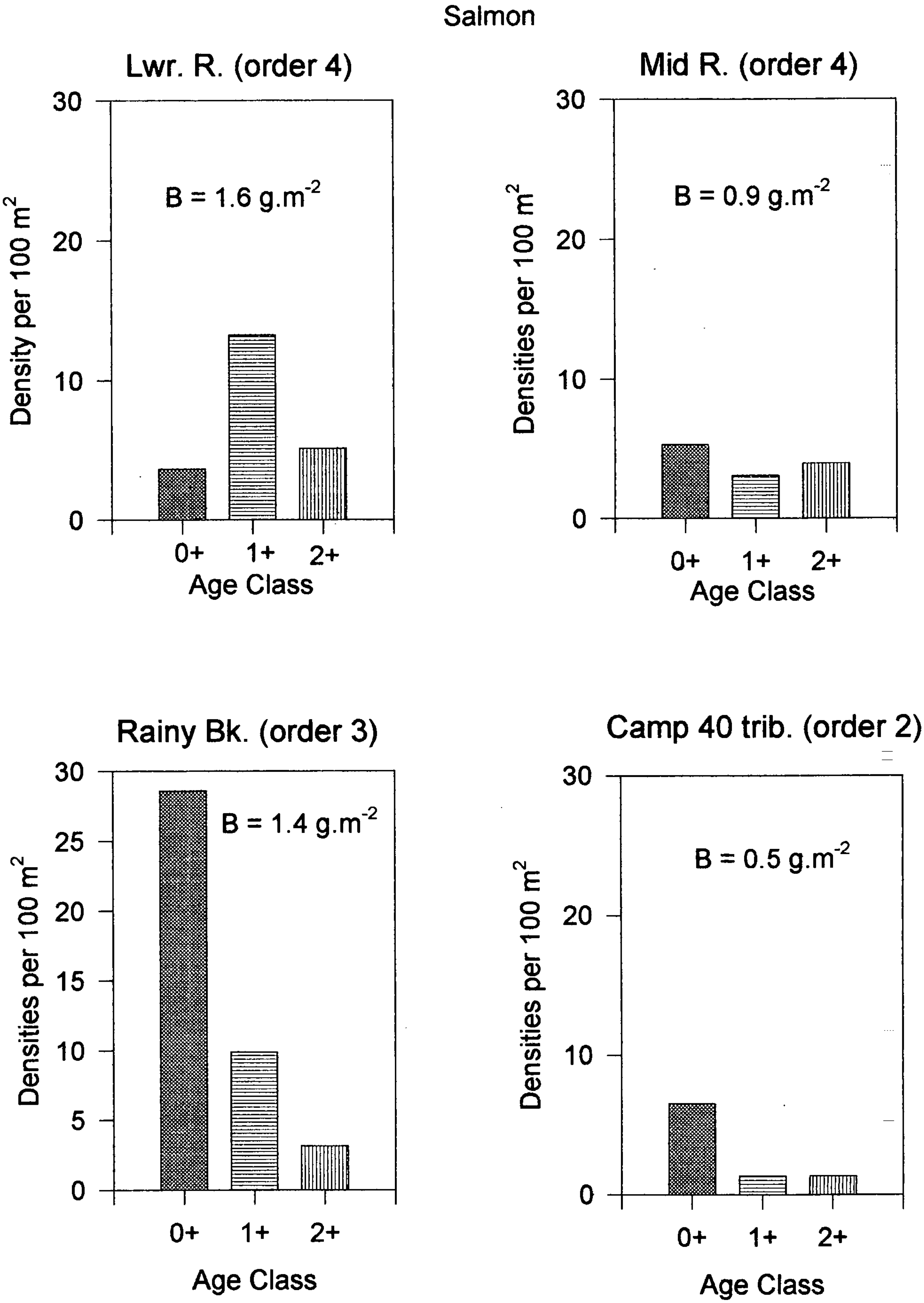

Figure 7. Flat Habitats, Highlands R., 1995.

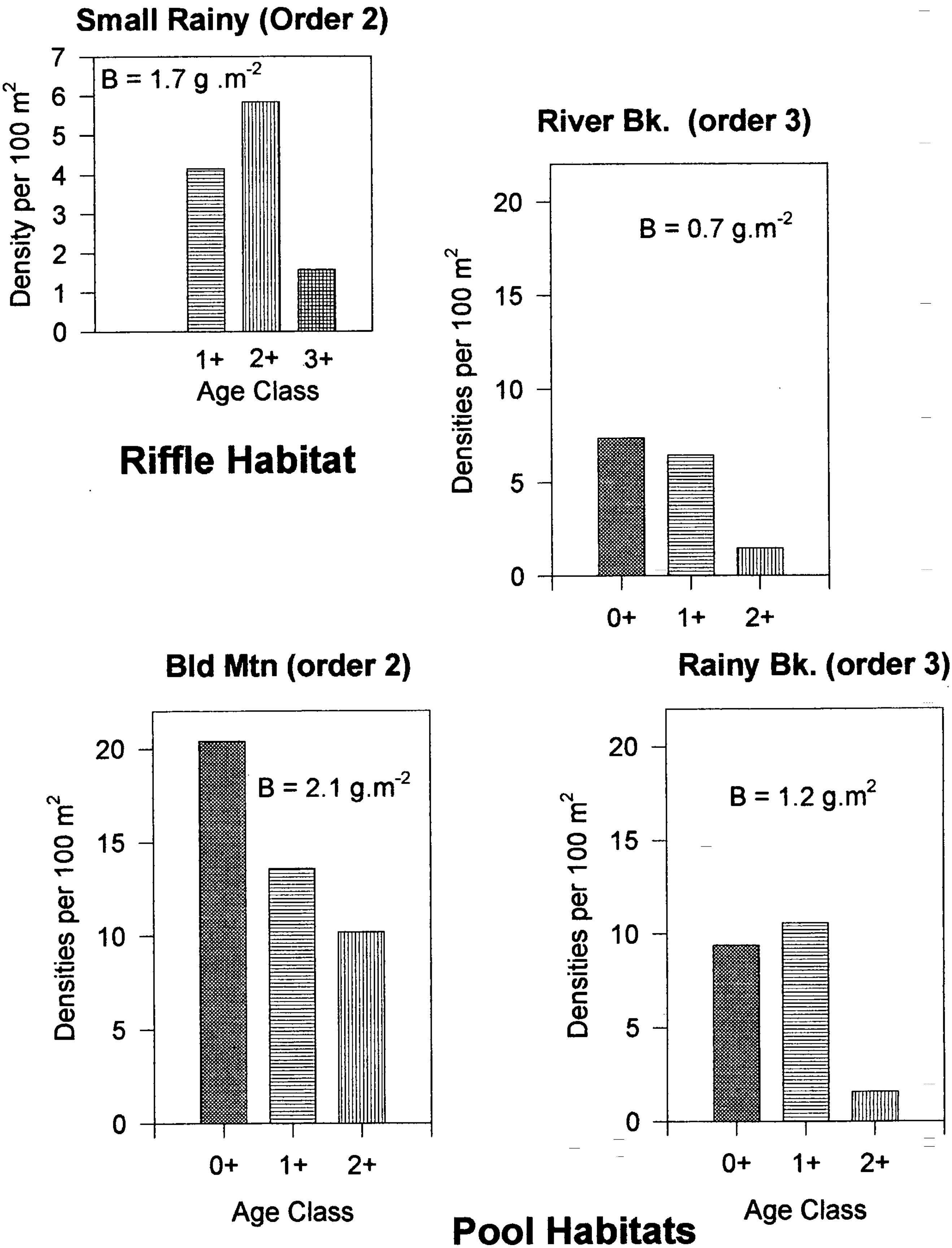

Figure 8. Densities and biomass of salmon in pool habitats and in the uppermost station in a riffle in Small Rainy Bk., 1995.

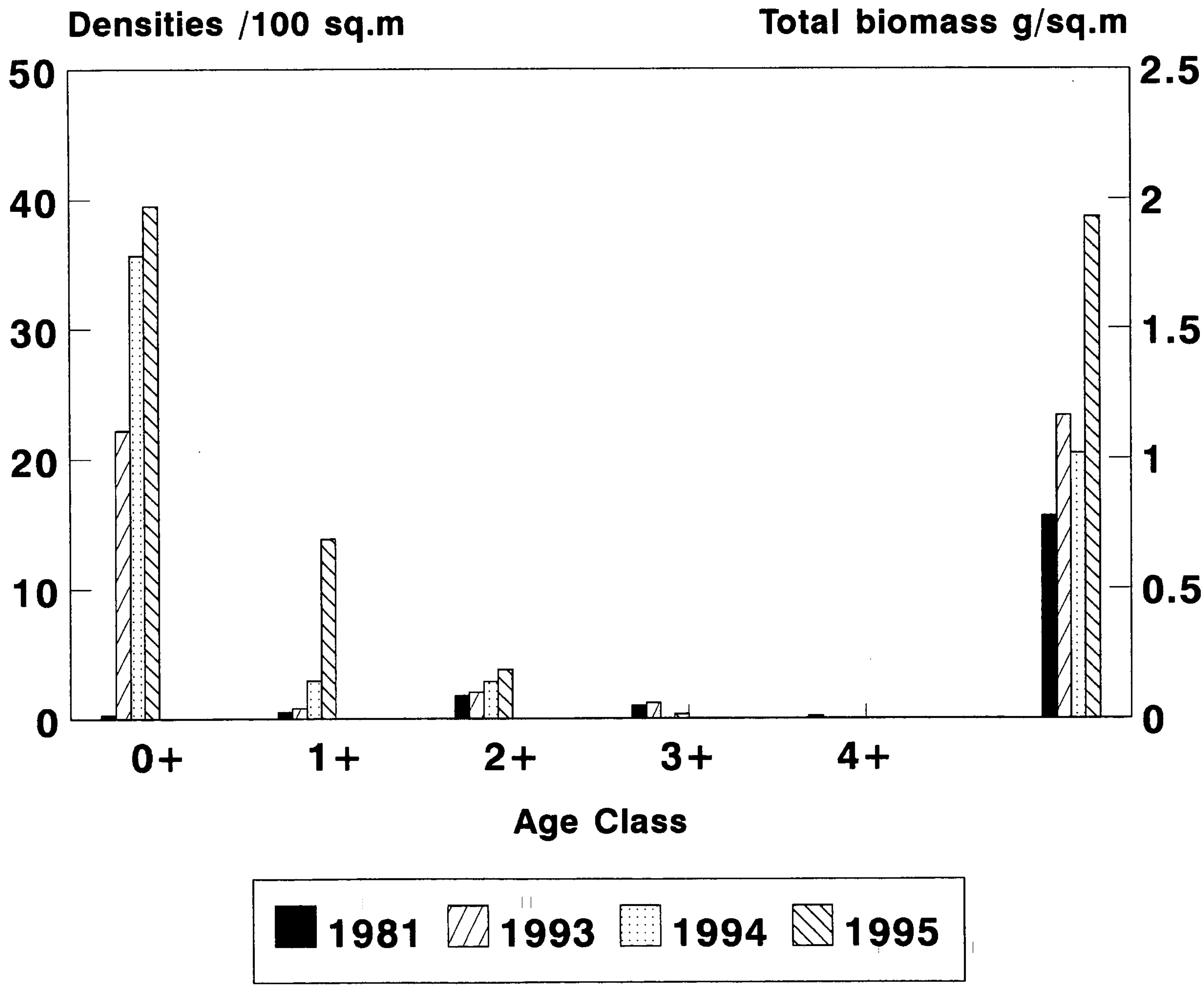

Figure 9. Juvenile salmon, River Brook upper - riffle.

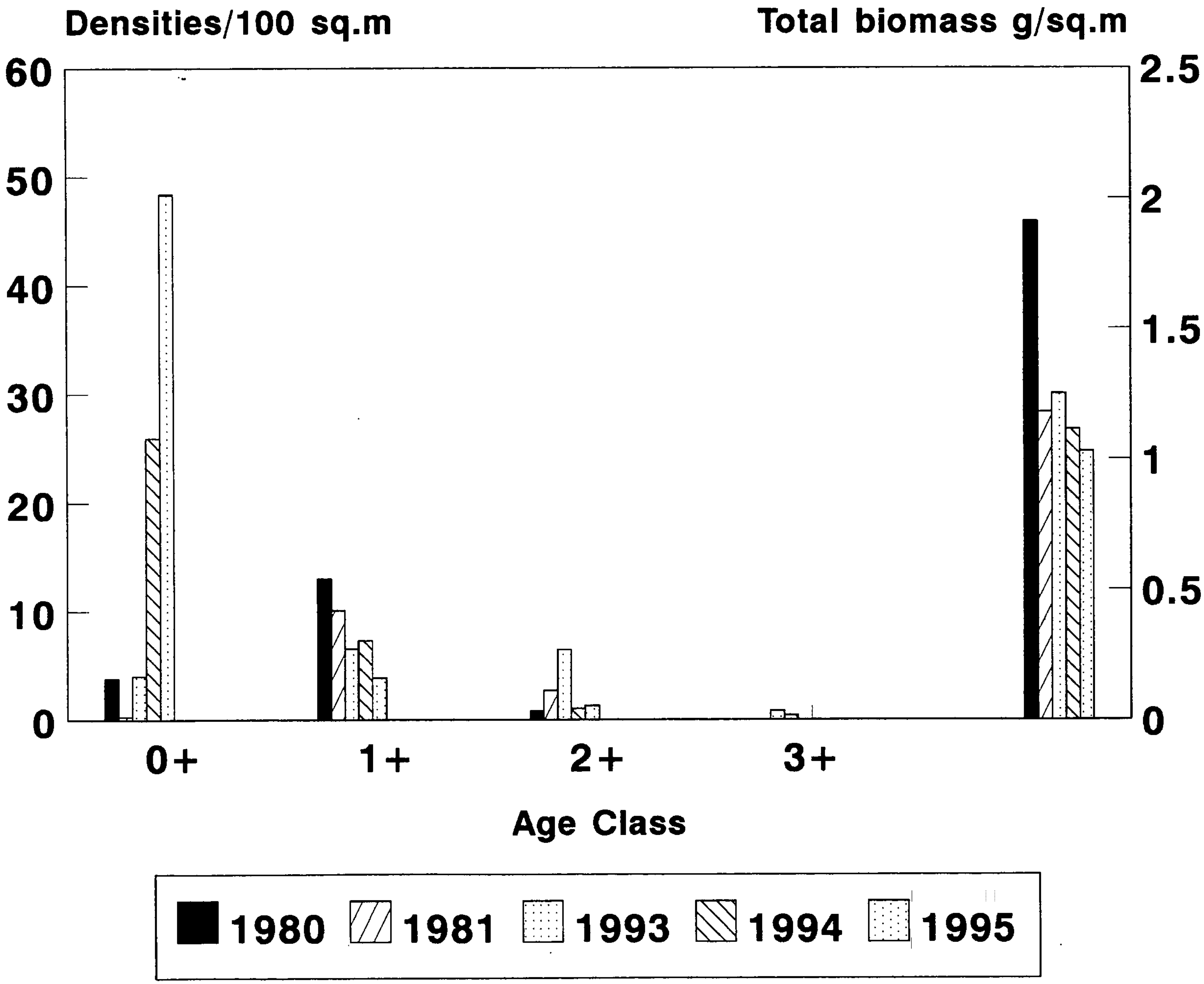

Figure 10. Juvenile salmon, River Brook lower - riffle.

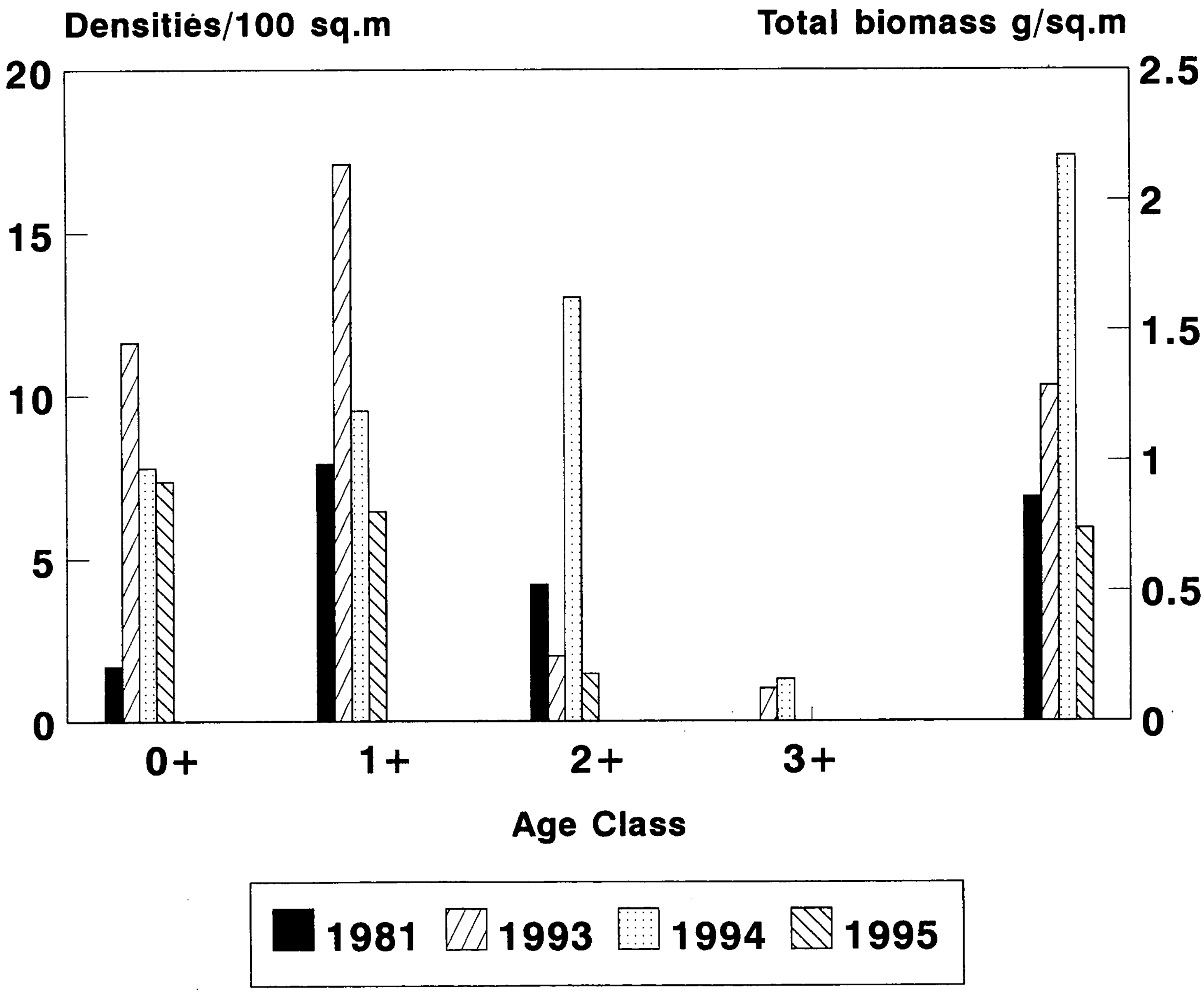

Figure 11. Juvenile salmon, River Brook pool.

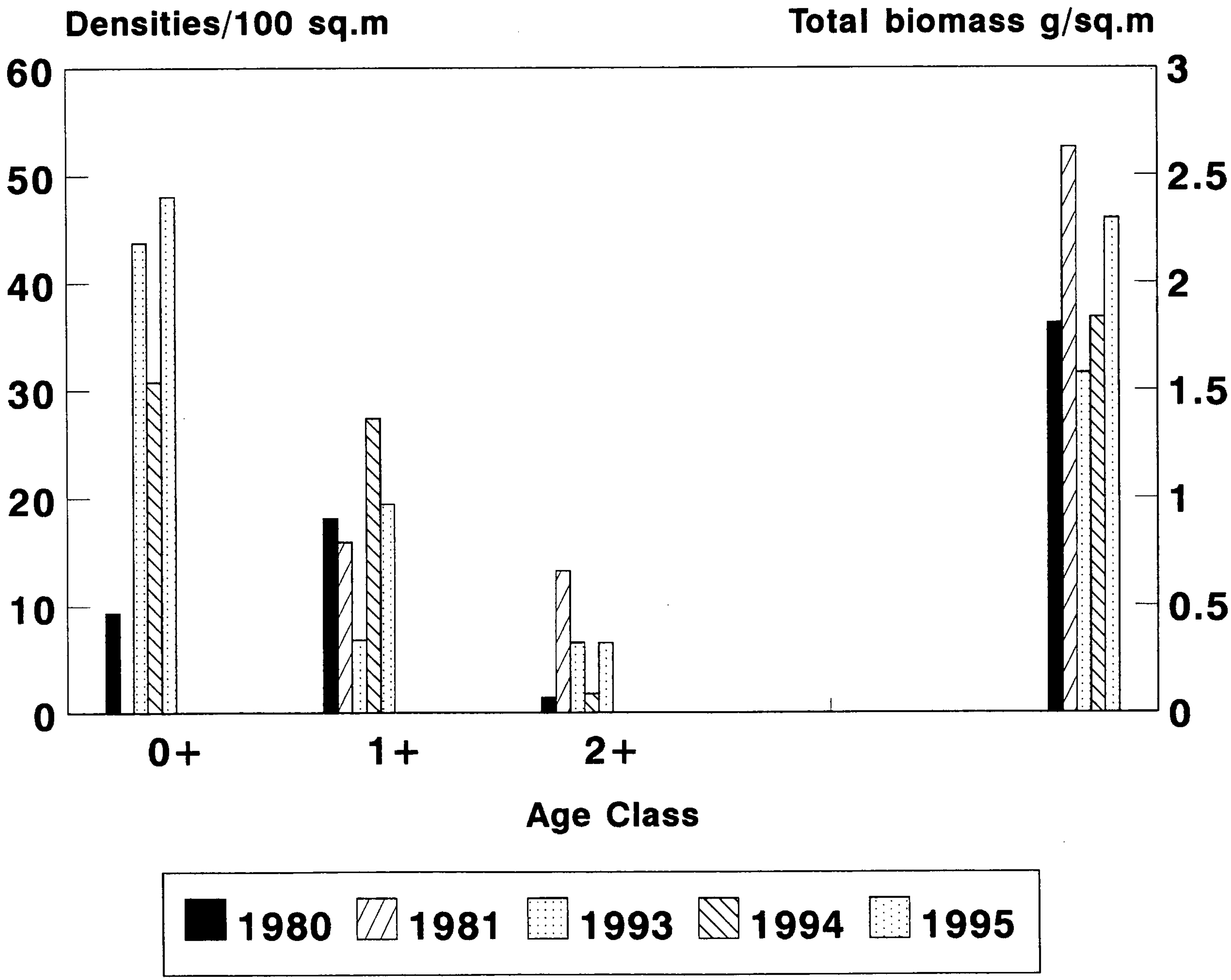

Figure 12. Juvenile salmon, Bald Mountain Brook - riffle.

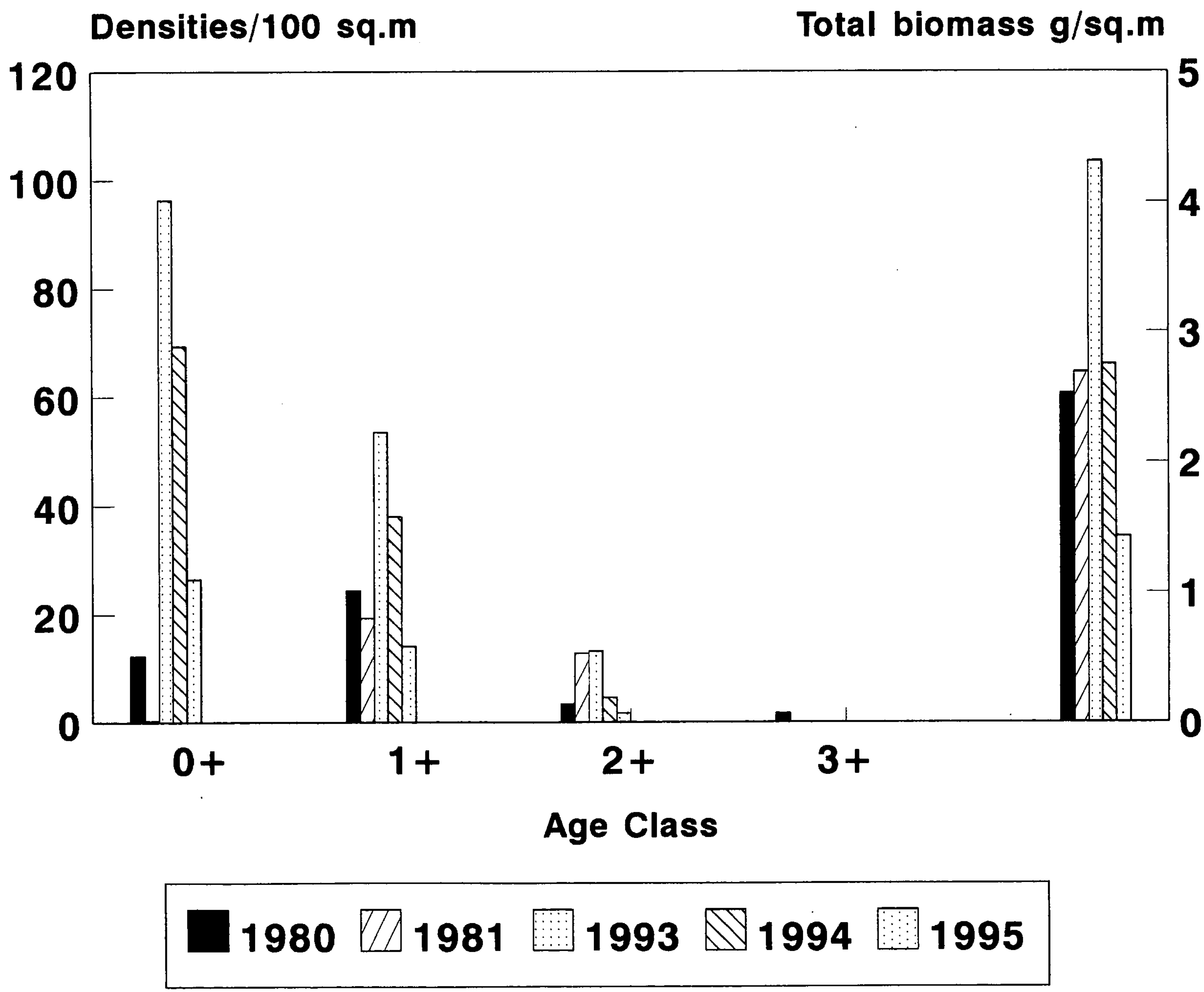

Figure 13. Small Rainy Brook - riffle.

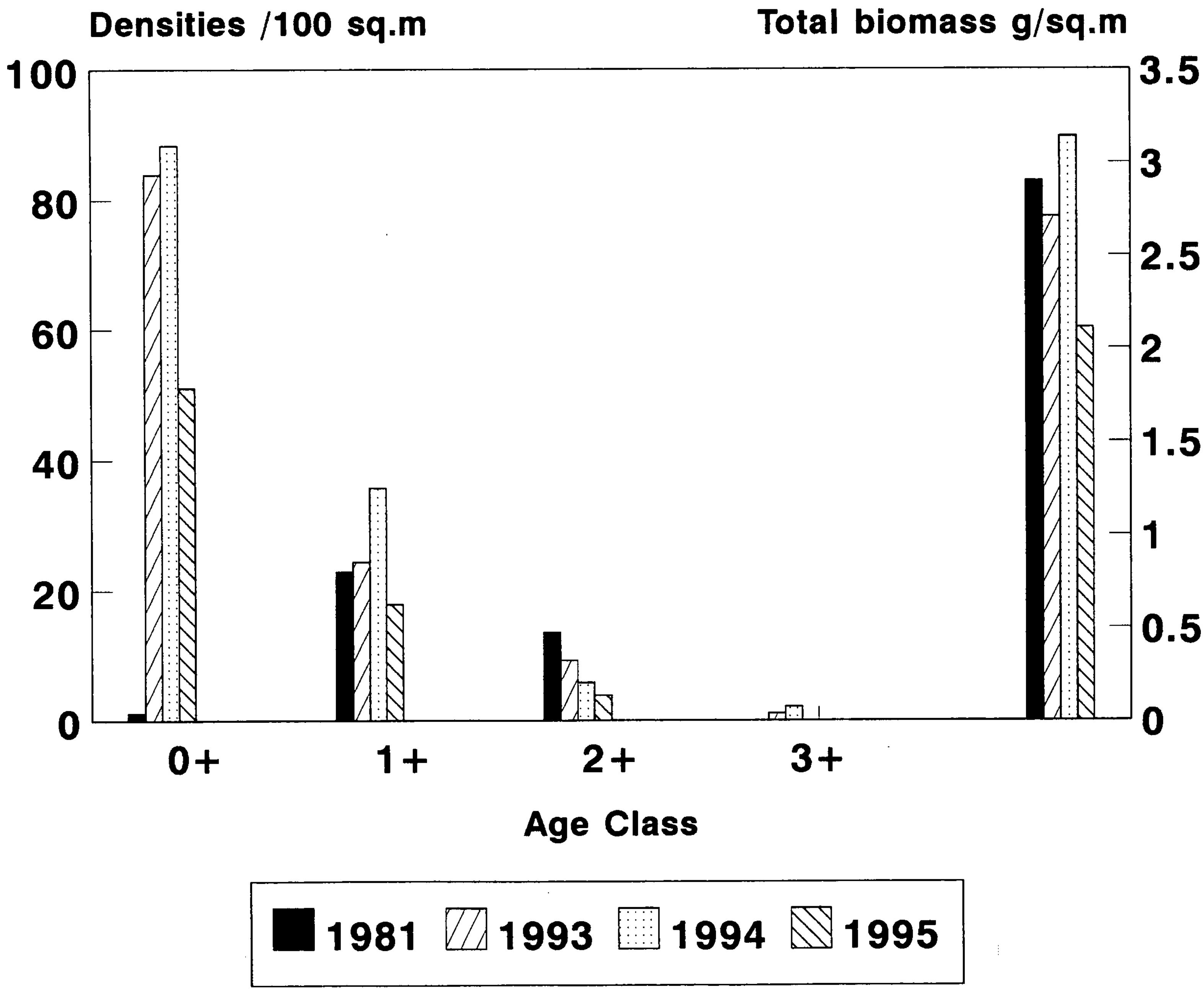

Figure 14. Juvenile salmon, Rainy Brook - riffle.

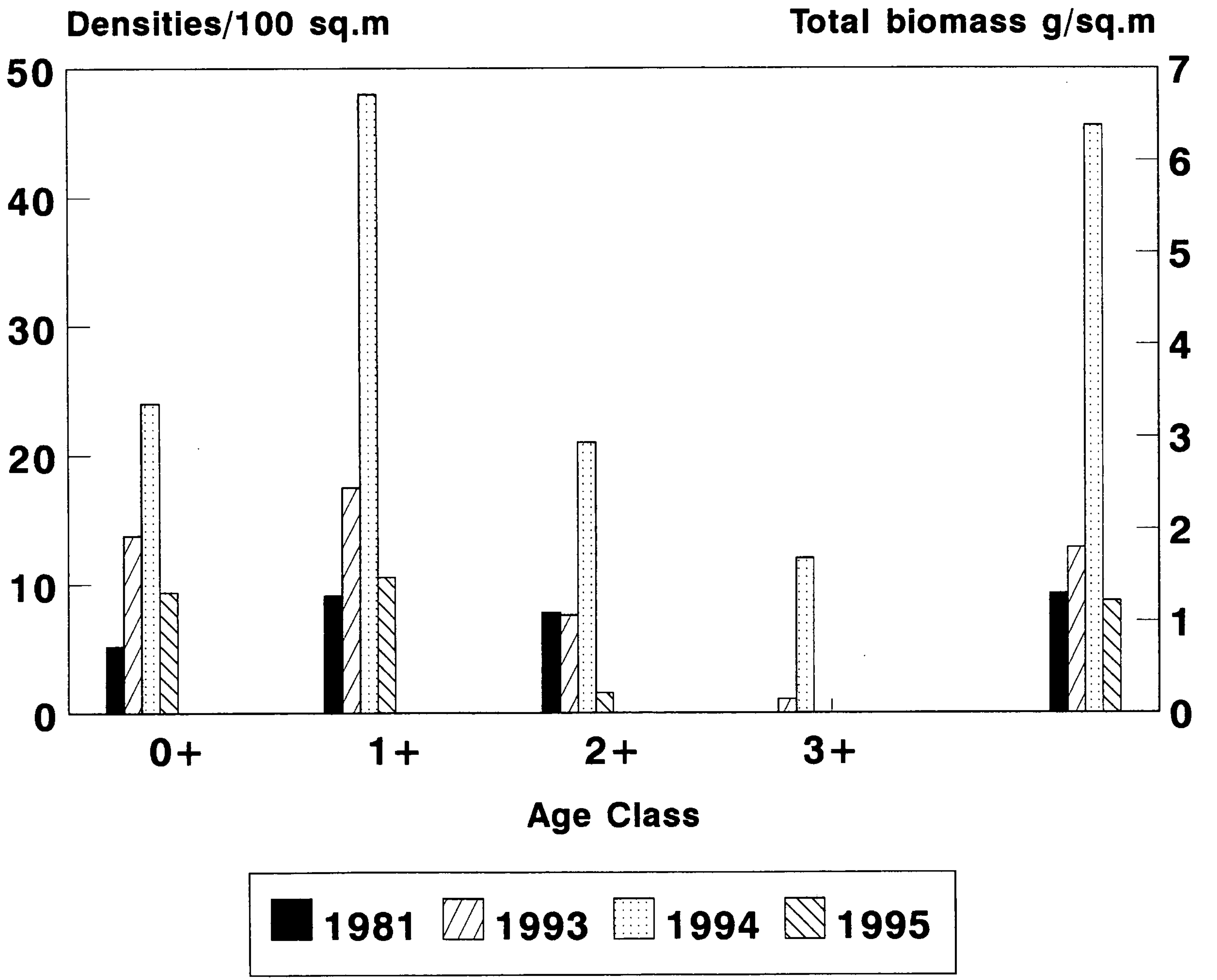

Figure 15. Juvenile salmon, Rainy Brook pool.

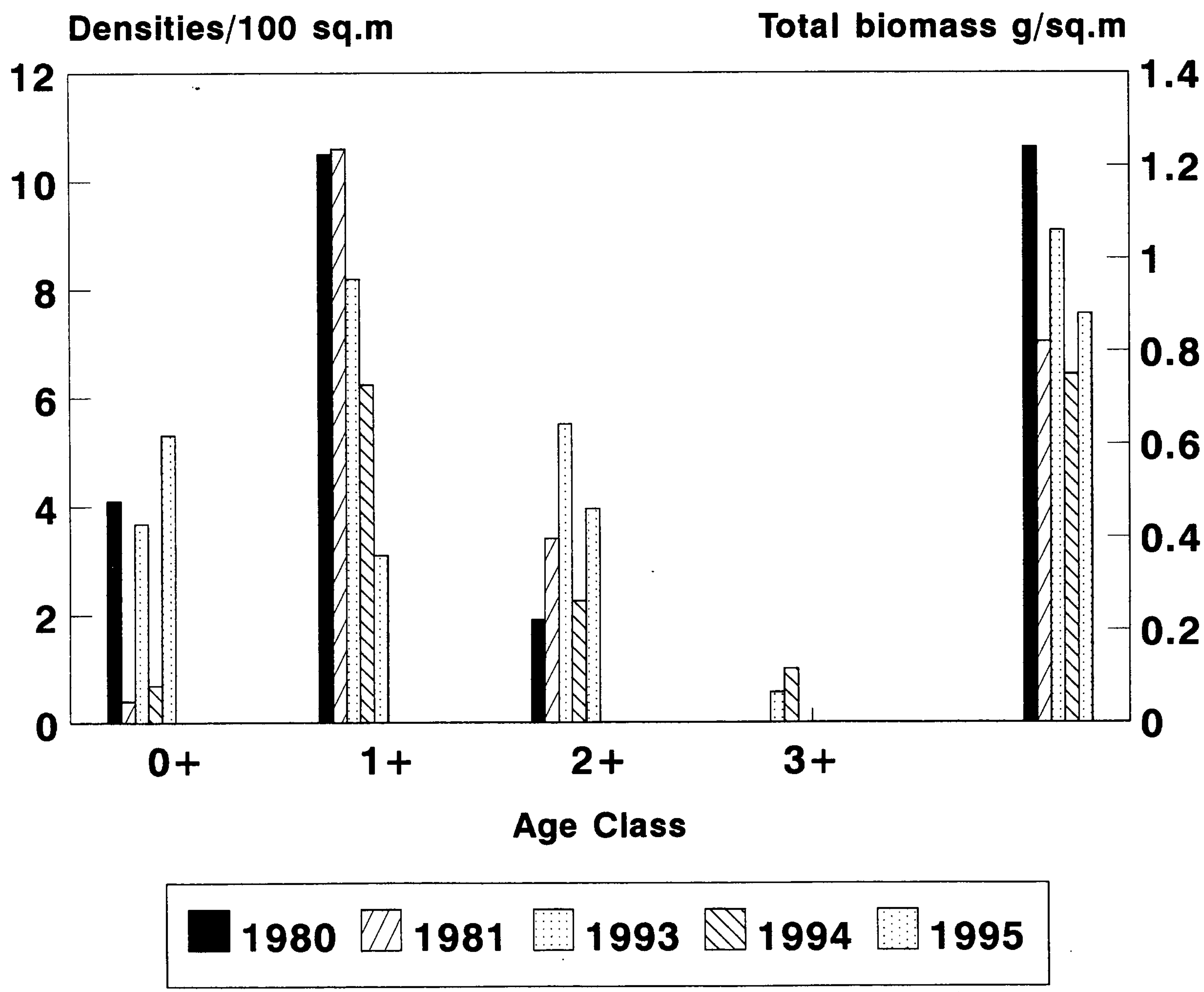

Figure 16. Juvenile salmon, Railway Bridge, main river - flat.

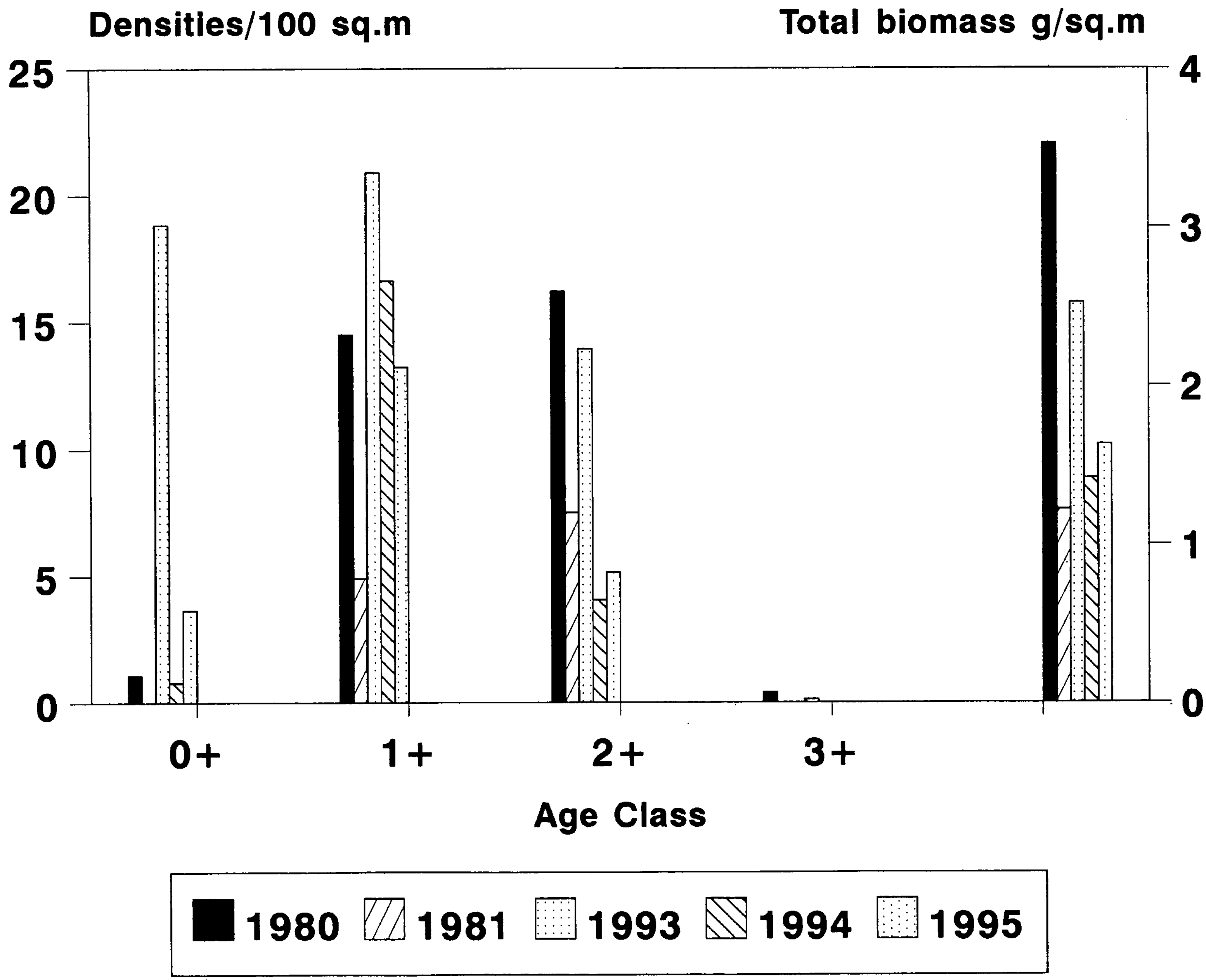

Figure 17. Juvenile salmon, lower river, at Gillam's Farm station - flat.

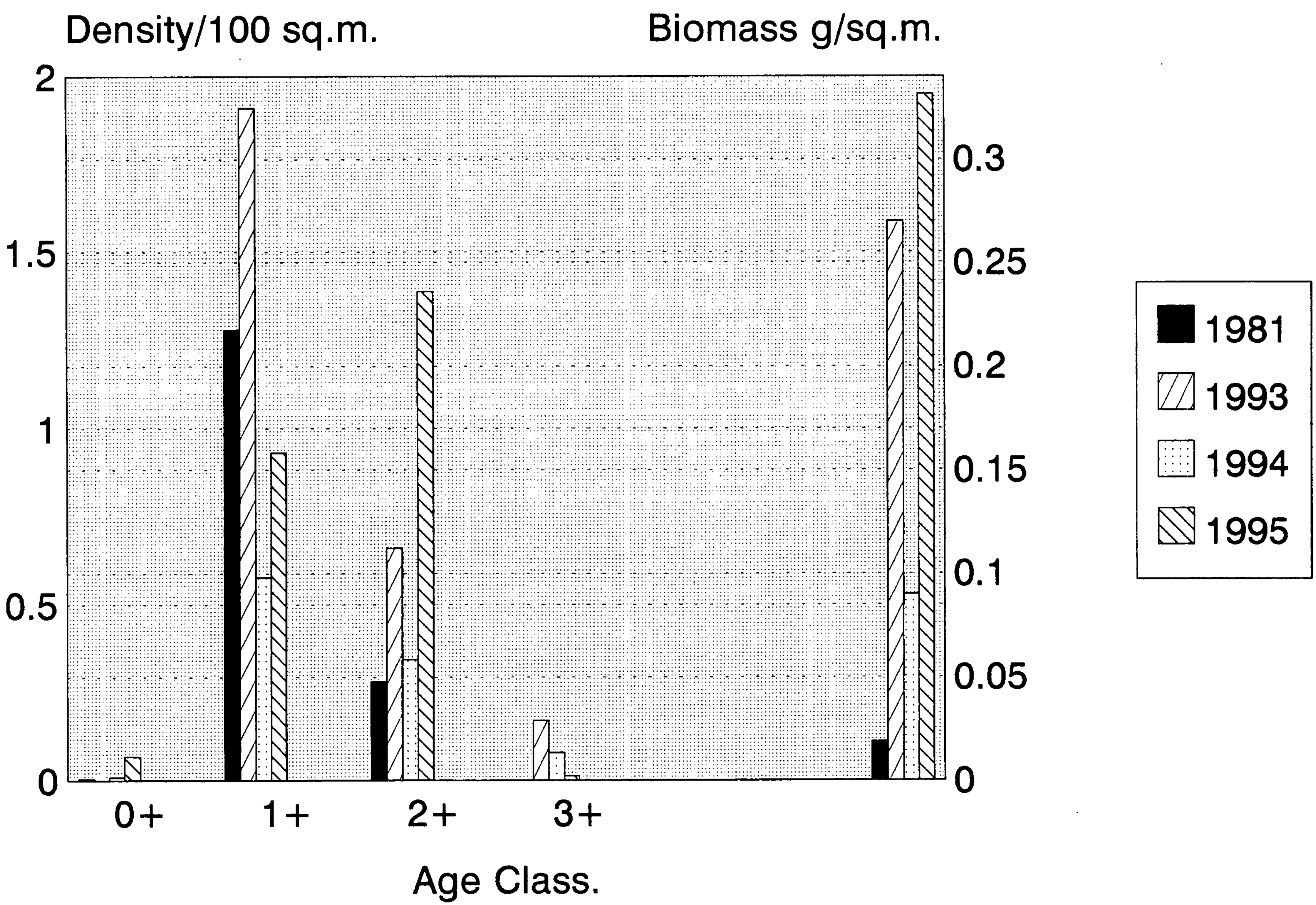

Figure 18. Juvenile salmon, Loch Leven - lake habitat.

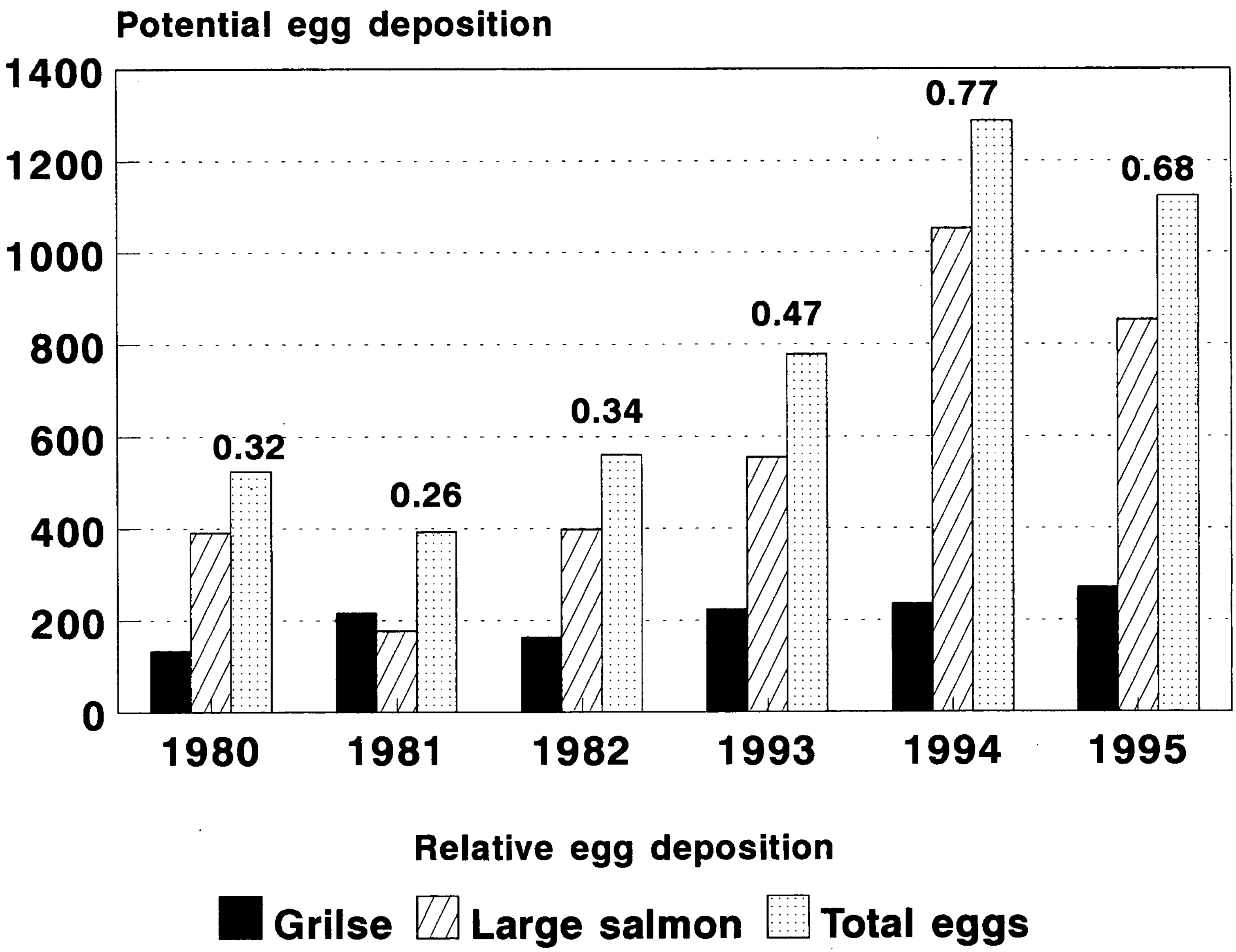

Figure 19. Potential egg depositions. Target eggs = 1.5 million. Proportion achieved is given above the total eggs column