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Status of the Atlantic salmon (*Salmo Salar* L.) Stock Of Harry's River/Pinchgut Brook, Newfoundland, 2000

État du stock de saumon atlantique (*Salmo salar* L.) de la rivière Harry et du ruisseau Pinchgut, à Terre-Neuve, en 2000

C.C. Mullins, D. Caines and S. L. Lowe

Department of Fisheries and Oceans
Science Branch
1 Regent Square
Corner Brook, Newfoundland
A2H 7K6

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ABSTRACT

The number of small and large salmon at the counting fence on the Pinchgut Brook tributary of Harry's River in 2000 was 27% and 76%, respectively, lower than in 1999. The proportion of small salmon was 6% higher than in 1999, whereas, the proportion of large salmon was 65% lower than in 1999. The salmon stock on Harry's River achieved only 29% of its conservation requirement in 2000, the second lowest since 1992. This is alarming considering the recreational salmon fishery has been restricted to catch and release angling since 1996 and that the commercial salmon fishery has been closed since 1992. Uncertainties associated with the methodology used to estimate the spawning escapement and potential egg deposition on Harry's River were analysed using a probability density function. The results indicated that there was a greater than 100% probability that the conservation requirement was not achieved on the Harry's River in 2000. Increased juvenile densities in recent years indicate a positive outlook for this stock. However, extremely low water levels and high water temperatures in the river and past evidence of illegal removals continue to raise serious concerns. It is believed that the slow recovery of this stock following the commercial salmon moratorium is not due to over exploitation by the recreational fishery. Therefore, it is recommended that all possible management options including increased enforcement be reviewed in order to address the problem of low salmon abundance on Harry's River in order to maximise the spawning population.

RÉSUMÉ

Le nombre de petits et de gros saumons franchissant la barrière de dénombrement installée dans le ruisseau Pinchgut, tributaire de la rivière Harry, en 2000 était de 27 % et 76 %, respectivement, moindre qu'en 1999. Le pourcentage de petits saumons était de 6 % plus élevé qu'en 1999, tandis que le pourcentage de gros saumons était de 65 % plus bas. Le nombre de saumons de la rivière Harry qui ont atteint les frayères n'ont satisfait qu'à 29 % des impératifs de conservation de ce stock en 2000, soit le deuxième plus faible niveau depuis 1992. Cela est alarmant, surtout à la lumière du fait que la pêche récréative du saumon est limitée à la pêche à la ligne avec remise à l'eau des prises depuis 1996 et que la pêche commerciale du saumon est interdite depuis 1992. La fonction de distribution de probabilités utilisée pour analyser les incertitudes liées aux méthodes d'estimation de l'échappée et de la ponte potentielle dans la rivière Harry a révélé que la probabilité de non satisfaction des besoins au titre de la conservation dans la rivière Harry en 2000 se situe au-delà de 100 %. Par contre, les densités accrues de juvéniles dans les dernières années donnent à penser que les perspectives de ce stock sont bonnes. Mais les niveaux extrêmement bas et la température élevée de l'eau de la rivière, ainsi que des cas prouvés de prises illégales par le passé, continuent à gravement préoccuper. On croit que le lent rétablissement de ce stock après la mise en place du moratoire de la pêche commerciale n'est pas imputable à la surpêche récréative. On recommande donc que toutes les options de gestion possibles, y compris l'application renforcée des règlements, soient passées en revue afin de trouver une solution au problème de la faible abondance du saumon dans la rivière Harry de sorte à maximiser le nombre de reproducteurs.

INTRODUCTION

This is the sixth assessment of the status of the Atlantic salmon stock of Harry's River since 1995. Harry's River has a drainage area of 816 km^2 (Porter et al., MS 1974a) and is the most northerly of the eight scheduled Atlantic salmon rivers flowing into Bay St. George, Salmon Fishing Area (SFA) 13 (Fig. 1). It is one of the few rivers in Bay St. George with a large amount of fish habitat in lakes. Lakes serve as a buffer against severe flooding following heavy rainfall that often occurs in other Bay St. George rivers. The river is highly accessible from numerous abandoned logging roads and railway beds and has a significant amount of cottage development.

Recreational salmon fishing success on Harry's River reportedly peaked during 1953-60 when the mean catch-per-unit-effort (CPUE) for small (< 63 cm) and large (≥ 63 cm) salmon was 0.95 (Appendix 1). In the next 10 years (1961-70), angling effort increased by 119% but the catch did not increase to the same degree resulting in a 48% decrease in CPUE. The highest catches were in 1964 (2,673 small and 373 large), making Harry's River the largest salmon producing river in Bay St. George. This was the largest catch ever recorded from a Bay St. George river (Mullins et al., MS 1989) and represented about 30% of the total Bay St. George catch in that year. In comparison, the catch on Harry's River in 1995 represented only 13% of the Bay St. George total catch. In 1971-77, angling effort continued to increase, but the mean catch of small salmon actually decreased by 24%, and the mean catch of large salmon decreased by 75% compared to the previous 10 year mean. In 1978-83, and again in 1984-89, delaying the opening dates for the commercial and recreational fisheries did not result in improvements in salmon abundance in the river (Claytor and Mullins, MS 1990). The mean catch in 1978-83 was only 524 small and 35 large salmon, suggesting that the stock was continuing to decline. This decline, particularly of large salmon, was evident in all Newfoundland rivers, and in 1984 anglers were restricted to catch and release only of large salmon. In 1987, individual river quotas for small salmon were introduced on several SFA 13 rivers including a quota of 350 small salmon on Harry's River. The low juvenile densities recorded in electrofishing surveys on Harry's River in 1987 and 1988 suggested that future recruitment would be low (Claytor and Mullins, MS 1989). This turned out to be the case with the recreational fishery on Harry's River being open the entire season in only two years since 1986.

In 1993-95, after the introduction of the commercial salmon fishery moratorium, numbers large salmon showed signs of improvement but recreational catches of small salmon remained among the lowest on record. Annual estimates of spawning escapements since 1992 indicated that numbers of both small and large salmon remained at a low level (Mullins et al., MS 1996; Mullins et al., MS 1997; Mullins et al., MS 1999) and that fisheries restrictions have resulted in little improvement in the stock.

The recreational salmon fishery on Harry's River was under quota management until 1995 and has been open for catch and release angling only since 1996.

The present assessment provides an estimate of the spawning escapement of salmon on Harry's River in 2000 based on counts of small and large salmon at a counting fence operated on Pinchgut Brook, the main tributary in the headwaters, and spawning surveys of the entire system conducted in 1995-97. The status of the resource is assessed relative to established conservation requirements and relative to previous years with consideration for associated uncertainties. The methodology closely follows that of previous assessments.

METHODS

RECREATIONAL SALMON FISHERY

Recreational catches and effort in 1996-2000 were based on the licence stub return system (O'Connell et al. MS 1998). This system of collection is not directly comparable to traditional methods used by DFO River Guardians prior to 1996. In addition, season opening and closing dates, bag limits, quotas and closures due to low water levels in some years also limit comparability of catch and effort statistics between years.

SPAWNING ESCAPEMENT – PINCHGUT BROOK

Adult salmon have been enumerated annually at a counting fence on Pinchgut Brook since 1992. Pinchgut Brook is a tributary in the headwaters of Harry's River and flows into George's Lake, approximately 48km upstream from the mouth of Harry's River (Fig. 2). Based on water discharge data recorded in 1986-96, Pinchgut Brook comprises approximately 15% of the total annual water discharge on Harry's River.

Environment Canada and the Newfoundland Department of Environment and Labour, Water Resources Management Division provided water discharge data for Harry's River and Pinchgut Brook. Gauging station number 02YJ003 located at the outflow of Pinchgut Lake near site #12 (Fig. 2) was operated from 1986 to June 1997. Gauging station number 02YJ001 located below the highway bridge near site #3 (Fig. 2) on Harry's River has been in operation since 1968.

The counting fence is located at the mouth of Pinchgut Brook. There have been two changes in the installation of the counting fence since 1992: 1) in 1997-

99, two upstream traps were installed, and 2) in 2000, an upstream and a downstream trap were installed.

The total spawning escapement on Pinchgut Brook tributary (SE_{PGut}) is calculated as:

$$\mathbf{SE_{\mathit{Pgut}} = C - RC - HRM}$$

Where:

C = total count of salmon at the counting fence
RC = total recreational catch above the counting fence
HRM = hook-and-release mortalities (10% of hooked and released fish) above the counting fence.

Angling has not been permitted on the Pinchgut Brook tributary since 1996.

Water temperatures (C) were recorded at the counting fence in 1994-2000 using a ‘Hobo-temp’ temperature logger.

SPAWNING ESCAPEMENT AND EGG DEPOSITION - HARRY'S RIVER

a) Spawning Escapements

The total spawning escapement on Harry’s River (TSE) was calculated based on spawning escapements on Pinchgut Brook according to the formula:

$$\mathbf{TSE = SE_{\mathit{Pgut}} / Prop_{\mathit{Pgut}}}$$

Where:

SE_{Pgut} = spawning escapement on Pinchgut Brook
$Prop_{Pgut}$ = proportion of Harry’s River salmon that spawn in Pinchgut Brook

Spawning surveys were conducted in November of 1995, 1996 and 1997 (Mullins et al., 1997; Mullins et al., 1996) to determine the distribution of salmon spawning on the Harry’s River system. The proportion of Harry’s River salmon that spawned in the Pinchgut Brook tributary was derived based on the average of the proportion of redds observed on Pinchgut Brook in the three surveys. The number of redds counted during the surveys were adjusted based on the proportion of the tributary that was surveyed. Unproductive or inaccessible areas were not surveyed (Claytor and Mullins, MS 1989; Porter et al., MS 1974a; Downer, MS 1968). Spawning surveys were not conducted in 1998-2000.

The total spawning escapement on Harry’s River was apportioned into small and large size categories based on the proportion of small and large salmon observed at the counting fence on Pinchgut Brook. A mark-recapture experiment conducted on Harry’s River in July 1995 provided an estimate of the total spawning escapement that was equal to that derived using this method (Mullins et al., MS 1996).

b) Estimation of Conservation Requirements

The conservation egg deposition requirement, was calculated based on 2.4 eggs/m^2 (Elson, 1975), for fluvial habitat (Elson, 1957) and 368 eggs/ha (O'Connell et al., MS 1991) for lacustrine habitat. The egg deposition rate for fluvial habitat includes an adjustment for egg losses due to poaching and disease, whereas, the egg deposition rate for lacustrine habitat does not include an adjustment.

Conservation requirements (CR) were calculated separately for Harry's River as a whole and for Pinchgut Brook tributary based on the amount of fluvial and lacustrine habitat available to salmon. Calculations were according to the formula:

CR = (fluvial area x 2.4) + (lacustrine area x 368)

The amounts of fluvial and lacustrine habitat available to salmon on Harry's River and Pinchgut Brook tributary are as follows:

River	Fluvial Area (m^2)	Lacustrine Area (ha)
Harry's	2,639,400 (Porter and Chadwick, MS 1983)	4,068
Pinchgut	165,500 (Porter et al., MS 1974a)	1,720* (Mullins et al., MS 1996)

* Includes 684 ha from George's Lake.

Lacustrine habitat measurements for Harry's River include lakes greater than 10 ha in surface area. This value was updated from 3,546 ha used in previous reports (Mullins et al., MS 1996, Reddin and Mullins, MS 1996) based on revised map measurements (T. Anderson, DFO, personal communication).

The surface area of lakes on the Pinchgut Brook system was measured directly from digitised 1:50,000 scale topographic maps (Mullins et al., MS 1996). The total lacustrine habitat for the Pinchgut Brook includes 45% (684 ha) of the surface area of George's Lake. This is equivalent to the percentage of the total length of all tributaries flowing into George's Lake comprised by the Pinchgut Brook system. George's Lake is estimated to have a mean depth of 42.12 m, a maximum depth of 90.22 m and comprises 56% of the total lacustrine habitat on the Harry's River system (Porter et al., MS 1974b).

River	Conservation Requirements			
	Eggs	Spawners		
		Small	Large	Total
Harry's River	7,831,584	4,068	92	4,160
Pinchgut Brook	1,030,160	535	12	547

The conservation requirement expressed in terms of the number of spawners is based on average biological characteristics in 1992-96 (Mullins et al., MS 1997).

c) Potential Egg Deposition

Potential egg depositions (ED) by small and large salmon were estimated based on available biological information:

$$\mathbf{ED = SE \times PF \times F}$$

Where:

SE = spawning escapement
PF = proportion female
F = fecundity

$$\mathbf{F = RF \times MW}$$

Where:

RF = relative fecundity (# eggs/kg)
MW = mean weight of females

The relative fecundity of 1,540 eggs/kg of body weight was used for both small and large salmon (Porter and Chadwick, MS 1983; Anon. 1978). Fecundity data available for Flat Bay Brook in Bay St. George suggests approximately 1,850 eggs/kg (C. Bourgeois, DFO personal communication)

Mean weight and proportion female for small salmon in 2000 were taken from pooled data for 1992-2000 because sample sizes at the counting fence were small (<30). A total of 51 small salmon were sampled at the counting fence in 2000. The whole weights of these fish and the numbers of male and female salmon were added to the database for 1992-1999 and the mean weight and proportion female for small salmon were recalculated for 1992-2000. Sex identification was based on both internal and external sexing. Mean weight and proportion female for large salmon (5.06 kg per female and 0.868) were from samples collected on other rivers in Bay St. George in 1953-94 (Reddin and Mullins, MS 1996). Of five large salmon sampled at the counting fence in 2000, there were three females with a mean weight of 3.75 kg. The biological characteristics used to estimate egg depositions in 2000 were as follows:

Small salmon			Large salmon		
Mean Wt. Females (kg)	**Fecundity**	**Prop. Female (N)**	**Mean Wt. Female (kg)**	**Fecundity**	**Prop. Female (N)**
1.51 (291)	2325	0.727 (374)	5.06	7792	0.868 (7)

There is some uncertainty in the egg deposition estimate because of the possibility of error in the estimated values used in the calculations such as the estimates of spawning escapement and biological characteristics. The uncertainty was expressed in the form of a probability density function using simulation techniques. The technique involved recalculating the egg deposition estimate 5000 times while allowing some of the values used in the calculation to vary with each calculation or simulation. The following parameter values were allowed to vary within a uniform distribution with each simulation step: 1) the proportion of spawning on Pinchgut Brook; 2) the proportion of small and large salmon at the counting fence; 3) fecundity and 4) the proportion of females. Fecundity was allowed to vary by a 20% coefficient of variation. The frequency and probability distributions of the resulting egg deposition estimates were plotted to determine the mode and the 2.5th and 97.5th percentiles.

The percentage of the egg deposition requirement (CR) achieved was calculated according to the formula:

% Achieved = ED (small + large) / CR

JUVENILE DENSITIES

Juvenile salmon densities (#/100 m^2) are available from three sites (Fig. 2) monitored annually on Harry's River in 1987-88 and 1992-2000. Juvenile densities are not available for site 12 in 1999 due to equipment failure. Numbers of juveniles salmon at each site were determined by electrofishing surveys using the depletion method (Zippen, 1958). Calculations are based on computer software developed by Van Deventer and Platts, 1985.

RESULTS

RECREATIONAL SALMON FISHERY

Harry's River remained designated as Class IV for the purpose of the recreational salmon fishery in 2000. It was first designated Class IV in the three-year recreational salmon fishery management plan introduced in 1999. The designation means that the fishery is catch and release angling only. The river has been open only for catch and release angling since 1996. The following table outlines restrictions that have been implemented in the recreational salmon fishery since 1992 in an effort to conserve the declining stock. However, it is commonly recognised that the cause of the continued low stock abundance in recent years is not due to recreational over-fishing.

Year	Season	Bag Limit	Quota	Closures
1992	20 June-7 Sept.	8 (2 per day)	5000 SFA 13; 350 river	Closed 2 August SFA quota reached
1993	12 June-6 Sept.	8 (1 per day)	5000 SFA 13; 350 river	Closed 22 August river quota reached
1994	1 July-15 Aug.	3+3 (2 per day)	350 river	Closed 8 August due to low returns
1995	10 June-4 Sept.	3+3 (2 per day)	Nil	Closed to retention 16 July due to low returns
1996	15 June-2 Sept.	No retention	Nil	Closed above Home Pool
1997	14 June-1 Sept.	No retention	Nil	Closed above Home Pool
1998	13 June-7 Sept.	No retention	Nil	Closed above Home Pool
1999	1 June-7 Sept.	No retention	Nil	1. Closed above Home Pool 2. Closed 24 June - 30 July due to low water levels.
2000	1 June-7 Sept.	No retention	Nil	1. Closed above Home Pool 2. Closed 2-Aug-12 due to low water and high temperatures.

The fishery opened 1 June and closed 7 September 2000, the same as in 1999. The headwaters, upstream of Home Pool (Fig. 2), include the Pinchgut Brook tributary and remained closed to all angling in 2000. Low water levels and high water temperatures from 2-12 August resulted in the river being temporarily closed to angling.

Preliminary analysis of data from licence stub returns indicated that 71 small and 23 large salmon were hooked and released on Harry’s River in 2000 (Appendix 1). This was the lowest catch of small salmon on record and among the lowest for large salmon. The closure due to low water levels in 2000 would have resulted in lower catches. The river classification system introduced in 1999 may also have affected catches on Harry’s River due to transfer of effort to rivers with increased opportunities for retention angling. For example, the retention limit on the Humber River was increased to six fish for the season in 1999. The Humber River is adjacent to Harry’s River and some transfer of effort to Humber River may have occurred, contributing to lower hook and release catches on Harry's River. Effort information was not available from the licence stub return data in 1999 or 2000.

Anglers have reported increased sightings of salmon on Harry's River in recent years, lending support to the results of stock assessments that indicate some improvement in the stock since 1992. However, it is not known whether or not low water levels may have resulted in increased sightings. Snorkel surveys in other rivers in Bay St. George (Porter, MS 1999) indicate that large numbers of salmon tend to hold up in a few pools in the river especially under low water conditions. Salmon would probably be more visible under low water conditions.

ADULT COUNTS – PINCHGUT BROOK

The Pinchgut Brook counting fence was installed 10 June 2000 and removed 19 October 2000. The installation date was ten days earlier than in 1999. The earliest installation date was 24 May 1996 when the peak spring runoff occurred in February. The removal of the counting fence in 2000 was 11 days later than 1999.

A total of 441 small and 15 large salmon were counted at the fence (Table 1, Fig. 3). The number of small salmon was 27% lower than in 1999 and 22% lower than the 1992-99 mean. The number of large salmon was 76% lower than 1999 and 66% lower than the 1992-99 mean. The proportion of large salmon was 65% lower than 1999 and 55% lower than the1992-99 mean.

Year	**Date of Operation of Adult Fence**
1992	4 July to 23 September
1993	17 June to 18 October
1994	22 June to 18 October
1995	19 June to 17 October
1996	24 May to 17 October
1997	13 June to 15 October
1998	12 June to 22 September
1999	20 June to 7 October
2000	10 June to 19 October

The first salmon was counted at the counting fence on 20 June (Fig. 4) four days after the upstream part of the fence became operational. Peak counts of both small and large salmon coincided with peak water levels throughout the season (Fig. 4). Only 1.0% of the total count of small salmon occurred after the end of September even though water levels increased during this period. Hence it is unlikely that salmon entered the tributary before or after the fence operation.

Pinchgut Brook tributary is located 48 km upstream from the mouth of Harry’s River.

Harry’s River is considered a late-run river compared to others in Bay St. George (Reddin and Mullins, MS 1996). Results of a counting fence operation near mouth of the river in 1967 (Downer, MS 1968) indicated that approximately 50% of the run entered the river after mid-July (Mullins et al., MS 1996).

Run timing (defined as the date of 50% of the cumulative count) of both small and large salmon at Pinchgut Brook in 2000 was mid-July (Fig. 5). This was much earlier than in 1999 but similar to1998 and most years since 1992. The water levels at the counting fence in 2000 remained above 30.0 cm (Fig 4) and did not appear to affect the run.

Run timing of small salmon at Pinchgut Brook has been relatively stable (mid-July to mid-August). In the nine years of operation since 1992, (Fig. 6). The only exception was in 1999 when low water levels caused a major delay in upstream migration. Regressions of cumulative weekly counts on total counts of small salmon in 1992-97 were significant for counts to 26 July (R^2=0.8342 $p<0.05$) and after (Mullins et al., MS 1999). This relationship (y=1.0718x + 182.58) successfully predicted the total count in 1998 to within 10%. However, the same relationship under-estimated the count in 1999 by more than 100%. Severe low water conditions such as occurred in 1999 limit the accuracy and usefulness of in-season predictions based on run timing.

SPAWNING ESCAPEMENTS AND EGG DEPOSITIONS

a. Harry’s River

The results show that 1,191 small (min. 1,075; max. 1,336) and 41 large (min. 37; max. 46) salmon spawned on Harry’s River in 2000 based on 37% (min. 33%; max. 41%) of the total spawning occurring on Pinchgut Brook (Table 2). The spawning escapement of small salmon on Harry’s River, 2000 was 27% lower than in 1999 and 19% lower than the 1992-99 mean. The spawning escapement of large salmon on Harry’s River, 2000 was 76% and 65% lower than 1999 and the 1992-99 mean, respectively.

Potential egg depositions on Harry's River in 2000 were 29% of the conservation requirement (Table 2, Fig. 7). This was 41% lower than in 1999 and 33% lower than the 1992-99 mean. Harry's River would require spawning escapements of approximately 4,160 small and large salmon to achieve its conservation egg deposition requirement.

The status of the Harry's River salmon stock in 1992-2000 has remained at a low level compared to the early 1960s when the conservation requirement was exceeded by as much as 30% based on analysis of historical angling catches (Reddin and Mullins, MS 1996) (Fig. 8). The counting fence that was operated near the mouth of Harry's River in 1967 indicated that only 2,002 salmon (+/- 500) entered the river in that year based on partial counts (Downer, MS 1968). The total recreational salmon fishery catch in 1967 was 954 salmon suggesting that low numbers of spawning salmon on this river is not a recent occurrence.

Nevertheless, with the closure of the commercial salmon fishery, the stock showed signs of improvement in 1993-1999 compared to the 1970s and 1980s when 40% or less of the conservation requirement was achieved (Fig. 8). The improvement in the stock in 1993-99 is consistent with the views expressed by anglers, based on sightings of fish in the river. However, the stock has remained at a low level compared to past years when spawning escapements were much higher than experienced in 1993-1999.

b. Pinchgut Brook

The conservation requirement was also not achieved on Pinchgut Brook in 2000. Potential egg depositions on Pinchgut Brook were 82% of the conservation requirement (Table 3). This was 41% than in 1999 and 34% lower than the 1992-99 mean. However, the egg deposition on Pinchgut Brook has increased by more than 100% since 1992. The conservation requirement was exceeded in seven out of nine years on Pinchgut Brook (Table 3) compared to none of the last nine years for Harry's River as a whole (Table 2).

There are several factors that must be considered in the analysis of salmon spawning escapements relative to conservation requirements on Pinchgut Brook and other tributaries relative to Harry's River as a whole. The lower reaches of the main stem of Harry's River has a large concentration of spawning gravel (Porter et al., MS 1974b) but does not appear to be utilised in terms of spawning compared to the tributaries (Claytor and Mullins, MS 1989; Porter et al., MS 1974a-b; Downer, MS 1968). Excluding the lower reaches (0-18 km), 84% of the remaining accessible spawning habitat on Harry's River occurs in the tributaries (Porter et al., MS 1974a). Pinchgut Brook has the second largest portion (16%) of spawning habitat of all the tributaries (Porter et al., 1974a). Pinchgut Brook is the uppermost tributary on Harry's River and accounts for 33-41% of the spawning escapement based on surveys in 1995-97 (Mullins et al., MS 1999; Mullins et al., MS 1996). Therefore, it is not surprising that egg depositions would be high in this part of Harry's River compared to other tributaries and the main stem.

Conservation requirements are based on accessible rearing habitat and not spawning habitat. On Harry's River, only 40% of the total fluvial rearing habitat for salmon parr occurs in the tributaries (Porter et al., MS 1974a). This means that juvenile salmon produced in the tributaries must disperse downstream into George's Lake and other parts of the main stem for rearing. Beall et al. (1994) reported dispersal of one-year-old salmon parr up to 2,400 m downstream from the spawning site in summer.

SOURCES OF UNCERTAINTY

There are several sources of uncertainty associated with the methodology used in the assessment that can be addressed.

a. *Change in Distribution and Timing of Spawning*

Spawning surveys were carried out on Harry's River in 1995-97 to determine the distribution of spawning. The surveys were carried out in mid-November 1995-97. The results showed that Pinchgut Brook tributary, which comprises 21.9% of the total length of accessible tributaries on Harry's River, accounted for 37% of the spawning in 1997, 33% in 1996, 41% in 1995 (Mullins et al., MS 1999). These estimates were comparable with 34.6% estimated in 1967 (Downer, 1968).

The differences indicate a relatively low annual variability in the distribution of spawning. A certain amount of annual variation in the distribution of spawners within a river system is to be expected due to annual differences in water levels and the effect of straying of adult salmon to other tributaries. The higher percentage of spawners on the Pinchgut Brook system in 1997 compared to 1996 may have been due, in part, to such a natural redistribution of spawners within the system.

The adjusted redd counts on the Pinchgut Brook system represented less than one redd per female based on estimates of the percentage of female small and large salmon recorded at the counting fence. It is possible that some redds were not counted in the survey. However, because this type of error would have been consistent throughout the system, it would not have affected the proportion of redds counted on Pinchgut Brook. Results of an experiment in an area of known redd numbers at the beginning of each survey indicated that counting errors and differences between survey crews were low overall. The similarity between crews meant that counting efficiency was similar for all tributaries surveyed. Redd recognition would have improved over the course of the survey.

A change in the time of spawning could affect the results of spawning surveys. Results of daily monitoring at a test site on one tributary from early October until no new redds were observed indicated a low likelihood that spawning was incomplete at the time of the survey. Spawning at the test site peaked when the mean daily water temperature reached 7-12 C and by mid-November no new redds were observed. The substrate in most tributaries of Harry's River is relatively stable. Hence, while some flattening of redds may be expected over time, it is unlikely that redds would have been flattened to the point of being unrecognisable at the time of the survey. Water levels were stable at the test site during the spawning period in 1997.

b. Proportion of small and large salmon

The proportion of small and large salmon in Harry's River was estimated based on the counts at the counting fence, assuming that Pinchgut Brook is representative of the system as a whole. If the proportion of large salmon on Pinchgut Brook were actually lower than in the population as a whole it would result in an underestimation of the number of large salmon and potential egg depositions. Large salmon deposit more eggs per fish than small salmon.

c. Biological characteristics

The relative fecundity value used to estimate potential egg deposition, is a default value derived from estimates for a number of rivers (Anon., 1978). However, it is recognised that there are differences between rivers and annual variations in this value that would affect the calculation of egg deposition. The mean weight and proportion of females are also estimated based on pooled data from a number of years. Uncertainty in using a mean value is introduced by annual differences that are not reflected in a mean value and by varying samples sizes that affect the precision of weight estimates.

d. Simulation of uncertainty

The results of the analysis to simulate uncertainty in the estimate of egg deposition associated with these parameters indicated that the estimate of 2.29 million eggs for Harry's River in 2000 was represented by the mode of the simulated frequency distribution (Fig. 9a). The frequency distribution of the simulated results did not include any points as high as the conservation requirement of 7.8 million eggs (Fig. 9a). Expressed as a probability distribution, there was a 100% probability that the total number of eggs deposited by salmon on Harry's River in 2000 was less than 4.0 million eggs (Fig. 9b)

JUVENILE SALMON DENSITIES

The results of electrofishing surveys conducted at three sites on Harry's River in 1987-2000 (Mullins, et al., MS 1999) indicate that prior to 1999, there appeared to be a general increase in the density of salmon fry (age 0+) and salmon parr (age 1+&up) per 100 sq. m. The highest density of fry at two of the sites was recorded in 1998 but decreased in 1999 and 2000 (Fig. 10a). Fry density at the third site increased in 2000 compared to 1998 (Fig. 10a). Parr density also showed a general decline in 1999-2000 compared to 1998 (Fig. 10b).

Such changes in the juvenile abundance can be caused by variation in the number and distribution of spawning salmon within the river as well as seasonal extremes in water levels and predators. All of these factors can influence the number, distribution and survival of juvenile salmon. However, it is noted that the mean water discharge from mid-May to mid-August in 2000 was similar to the 1994-97 mean when the juvenile densities were increasing (Fig. 11). The mean water discharge in 1998 and 1999 was the lowest recorded (Fig. 11) but juvenile density only decreased in 1999 and 2000 (Fig. 10) suggesting factors other than environmental conditions.

POTENTIAL SOURCES OF MORTALITY

a. Environmental Conditions

Low water levels and high water temperatures, such as occurred in 1998 and 1999, can create continued uncertainty for juvenile survival and subsequent smolt production. This is especially a concern in the smaller headwater tributaries. The most extreme (low) relative condition factors observed in juvenile salmon in 1987, a very dry year, were confined to headwater streams (FitzGerald et al., MS 1998).

Water levels and water temperatures recorded at the counting fence for mid-June to mid-August 2000 were less extreme than in 1999 (Fig. 11; Fig. 12). However, due to the complexity of the freshwater environment, the effect of environmental conditions relative to other potential sources of mortality such as predation is difficult to determine.

Anglers at public consultation meetings in 1997 suggested that the high water levels early in the 1997 season resulted in lower numbers of anglers on the rivers and may have resulted in the higher spawning escapements on all Bay St. George rivers in 1997. Stocks on other rivers in insular Newfoundland in 1997 showed a decline.

b. Illegal Removals

Poaching activity on Harry's River has been classed as high by both anglers and DFO river guardians. There have been 17 known salmon fishery violations in which charges were laid on Harry's River since 1995 (Table 4). There were also seven other violations involving nets for which no charges could be laid. In 2000, only one warning was issued for a violation under the Newfoundland Fisheries Act. The full extent of this type of activity and the extent to which it has contributed to low numbers of spawning salmon on Harry’s River are unknown. It has been suggested that removals by poaching may be as high as 50% of the total run to the river. If this is true, then it is a severe problem that needs to be addressed.

Incidence of net-like marks on salmon captured at the counting fence increased in 2000 (2.6%) compared to 1999 (0.1%) (Table 5). These marks are possibly the results of encounters with both legally and illegally set nets in either freshwater or marine waters. The impact of this activity on returns to the river and spawning escapements is unknown but the higher incidence of net marks in 2000 compared to 1999 could just as likely be the result of a lower netting efficiency as it could a higher incidence of poaching. The higher water levels in the river in 2000 compared to 1999 would certainly have made it more difficult for netting in freshwater.

c. Forest Spraying

There is some indication recently that the Harry's River salmon stock may have been adversely affected by forest spraying of the insecticide Matacil 1.8D in the 1970s and 1980s (Fairchild et al., 1999). The long-term effects of this and other more recent forest spray programs are unknown.

DISCUSSION

The results of the analysis of uncertainties in the estimation of egg depositions on Harry's River indicated a greater than 50% probability that the egg deposition in 2000 was less than 50% of the conservation requirement. This is alarming considering that there was no retention fishery on the river in the last four years and that the commercial salmon fishery was closed in 1992.

If Harry's River had been closed to all angling in 2000, the percentage of the conservation requirement achieved would have been only marginally higher. Salmon mortality below conservation requirements is usually not advisable. However, catch and release angling is considered by some angling and salmon conservation organisations to be an effective means of maximising spawning escapements because the presence of anglers is believed to be a deterrent to poaching. Poaching has been a long-standing problem on this river and may be an important factor in its slow recovery. The stock achieved only 29% of the conservation requirement in 2000 and has been at most 52% of the conservation requirement in the last eight years. This was in spite of increased numbers and proportion of large salmon in recent years. Therefore, it is recommended that all possible management options be reviewed including increased enforcement on Harry's River in order to address the problem of low salmon abundance and to maximise the spawning population.

The main stem of Harry's River is highly accessible to anglers because of the many logging roads but there are also many headwater tributaries that are less accessible. Therefore, these smaller headwater streams should continue to be preserved as sanctuaries for spawning salmon until the stock improves. The headwater tributaries above Home Pool are currently closed to angling. The resulting loss of angling opportunities is considered to be minimal. Angling activity on Pinchgut Brook and other headwater tributaries represented only a small percentage (7.2%) of the total angling on Harry’s River in 1984-89.

Spawning surveys on Harry’s River in 1995-97 indicated that 33-41% of the salmon spawning occurred on the Pinchgut Brook tributary system. Salmon returns to the Pinchgut Brook tributary relative to Harry's River, as a whole, can only be fully understood through knowledge of the total number of salmon entering the system. This could be achieved by installing a counting fence near the mouth of the river supplemented by tagging. The tagging would provide a means of verifying the proportion of salmon spawning on Pinchgut Brook, thus eliminating some of the uncertainty.

ACKNOWLEDGEMENTS

Special thanks to students S. Newman, P. Hollett, D. Power and M. Renouf for their assistance in the operation of the counting fence on Pinchgut Brook and compiling the counts and biological data and to L. Delaney and T. Randell for their assistance with the electrofishing survey. This project was sponsored in part by the Salmon Preservation Association for the Waters of Newfoundland through funding from the Department of Human Resources Development Canada. We are grateful for their continued support.

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Table 1. Counts and proportion of small and large Atlantic salmon at the Pinchgut Brook counting fence, 1992-2000.

Year	Fence Counts			Proportion	
	Small	Large	Total	Small	Large
1992	222	5	227	0.978	0.022
1993	576	43	619	0.931	0.069
1994	563	47	610	0.923	0.077
1995	752	28	780	0.964	0.036
1996	601	38	639	0.941	0.059
1997	613	68	681	0.900	0.100
1998	593	63	656	0.904	0.096
1999	608	63	671	0.906	0.094
2000	441	15	456	0.967	0.033
Mean (92-99)	566	44	610	0.927	0.073

Table 2. Atlantic salmon spawning escapement, potential egg deposition and percentage conservation requirement achieved on Harry's River, 1992-2000.

Harrys River, 1992-2000

	Spawning Escapement				Potential Egg Deposition (x 10^6)			Percent Conservation Egg Deposition*
	Pinchgut	Harrys						
Year	Total	Small	Large	Total	Small	Large	Total	
1967								
1992	217	517	12	529	0.83	0.08	0.91	12
1993	591	1,342	99	1,441	2.25	0.67	2.92	37
1994	592	1,333	111	1,444	2.88	0.75	3.63	46
1995	777	1,827	68	1,895	3.30	0.46	3.76	48
1996	639	1,820	116	1,936	3.28	0.79	4.07	52
1997	681	1,657	184	1,841	2.65	1.24	3.90	50
1998	656	1,596	177	1,773	2.61	1.20	3.81	49
1999	671	1,643	171	1,814	2.68	1.16	3.84	49
2000	456	1,191	41	1,232	2.01	0.28	2.29	29
Min. 2000	456	1,075	37	1,112	1.76	0.25	2.01	26
Max. 2000	456	1,336	46	1,382	2.19	0.31	2.50	32
Mean (92-99)	603	1467	117	1584	0.41	0.79	3.35	43

* The percentage achieved in 1992-95 may have decreased slightly from the values reported in Mullins et al., (MS 1996) due to updated habitat information.

Table 3. Total returns, spawning escapement, and potential egg deposition of Atlantic salmon on Pinchgut Brook, 1992-2000.

Pinchgut Brook, 1992-2000

	Total Returns to Pinchgut Fence			Angling Catch				Spawning Escapement			Potential Egg Deposition (x 10^6)			Percent Conservation Egg Deposition
				Retained		Released								
Year	Small	Large	Total	Small	Large	Small	Large	Small	Large	Total	Small	Large	Total	
1992	222	5	227	10	0	0	1	212	5	217	0.34	0.03	0.37	36
1993	576	43	619	28	0	1	0	548	43	591	0.92	0.29	1.21	117
1994	563	47	610	18	0	10	0	544	47	591	1.18	0.32	1.49	145
1995	752	28	780	3	0	2	0	749	28	777	1.35	0.19	1.54	150
1996	601	38	639	0	0	0	0	601	38	639	1.08	0.26	1.34	130
1997	613	68	681	0	0	0	0	613	68	681	0.98	0.46	1.44	140
1998	593	63	656	0	0	0	0	593	63	656	0.97	0.43	1.40	136
1999	608	63	671	0	0	0	0	608	63	671	0.99	0.43	1.42	138
2000	441	15	456	0	0	0	0	441	15	456	0.75	0.10	0.85	82
Mean (92-99)	566	44	610	7	0	2	0	558	44	603	0.98	0.30	1.28	124

Table 3. Record of salmon fisheries violations on Harrys River, 1995 to 2000.

ACTION	ACT/REG	SECT/PAR	DESCRIPTION	NUMBER
1995-1999				
CHARGES LAID	FA	33	Possess fish caught contrary to the act or regulations	4
CHARGES LAID	FA	62	Obstruction	1
CHARGES LAID	NFLDFR	12	Possession of a net near inland waters	2
CHARGES LAID	NFLDFR	13.1(1)(A)	Catch and retain by angling more than daily quotas	1
CHARGES LAID	NFLDFR	13.3(1)	Catch and retain by angling inland waters salmon 63 cm or more in length	1
CHARGES LAID	NWR	6(4)	Possession of improperly tagged salmon	7
CHARGES LAID	NWR	6(2)	Validation of licence by holding at least one unused tag	1
			TOTAL CHARGES	**17**
SEIZURE PERSONS UNKNOWN	NFLDFR	10(2)	Net fish inland waters	3
OTHER NETTING VIOLATIONS (1996-1998)				4
(C.B. Office)				
2000				
WARNING ISSUED	FA	13(B)	Fishing in closed area	1
Note: FA=Fisheries Act; NFLDFR=Newfoundland Fisheries Regulations; NWR=Newfoundland Wildlife Regulations.				

Table 4. Incidence of net marks and other evidence of potential sources of mortality at Pinchgut Brook, 1992-2000.

Year	Type	NUMBER			PERCENTAGE		
		SMALL	LARGE	TOTAL	SMALL	LARGE	TOTAL
1996	net marks						**0.6**
1997	net marks						**9.3**
1998	net marks						**1.8**
1999	net marks	1	0	1	0.2	0.0	**0.1**
	scars	0	0	0	0.0	0.0	0.0
	fungus	0	0	0	0.0	0.0	0.0
	tot injuries	1	0	1	0.2	0.0	0.1
	unmarked	607	63	670	99.8	100.0	99.9
	total	608	63	671	100.0	100.0	100.0
2000	net marks	12	0	12	2.7	0.0	**2.6**
	scars	37	1	38	8.4	6.7	8.3
	tot injuries	49	1	50	11.1	6.7	11.0
	unmarked	392	14	406	88.9	93.3	89.0
	total	441	15	456	100.0	100.0	100.0

Note: some fish may have had more than one type of mark.

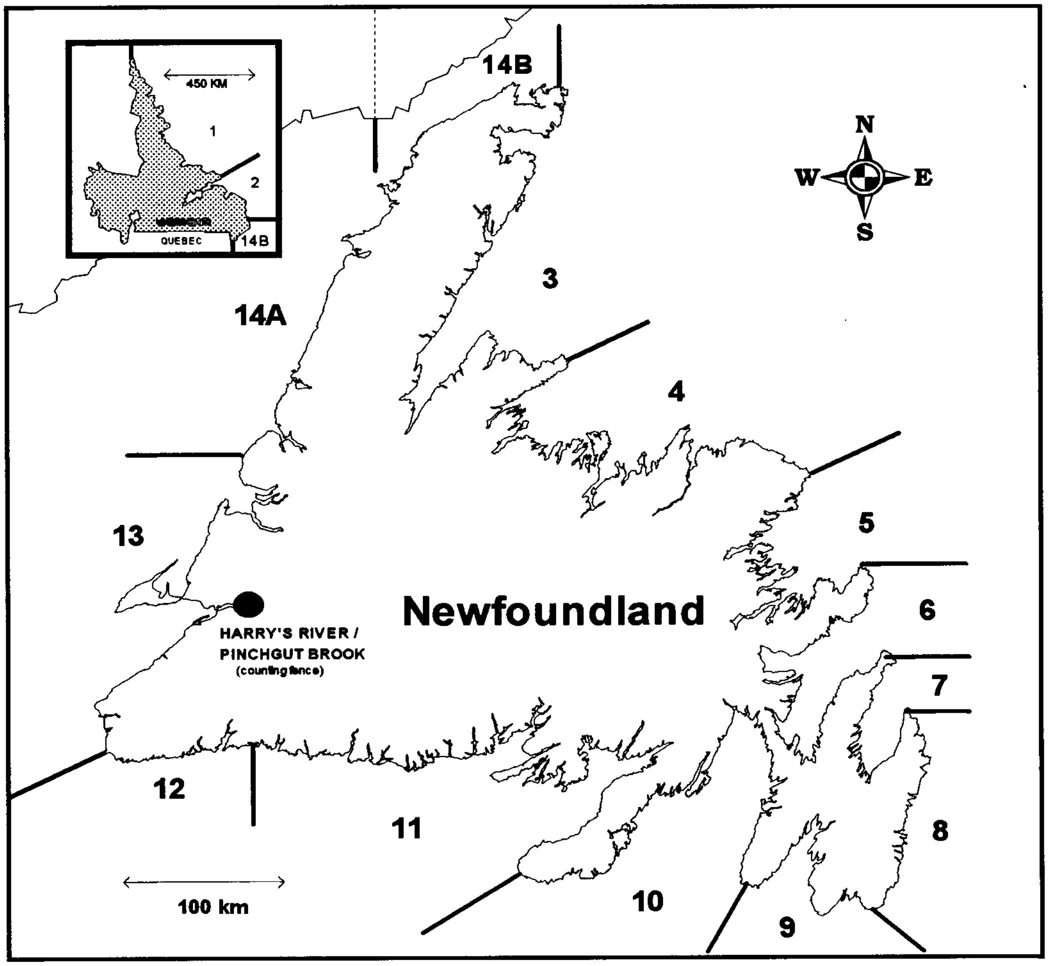


Figure 1. Salmon Fishing Areas (SFAs) of Newfoundland and Labrador.

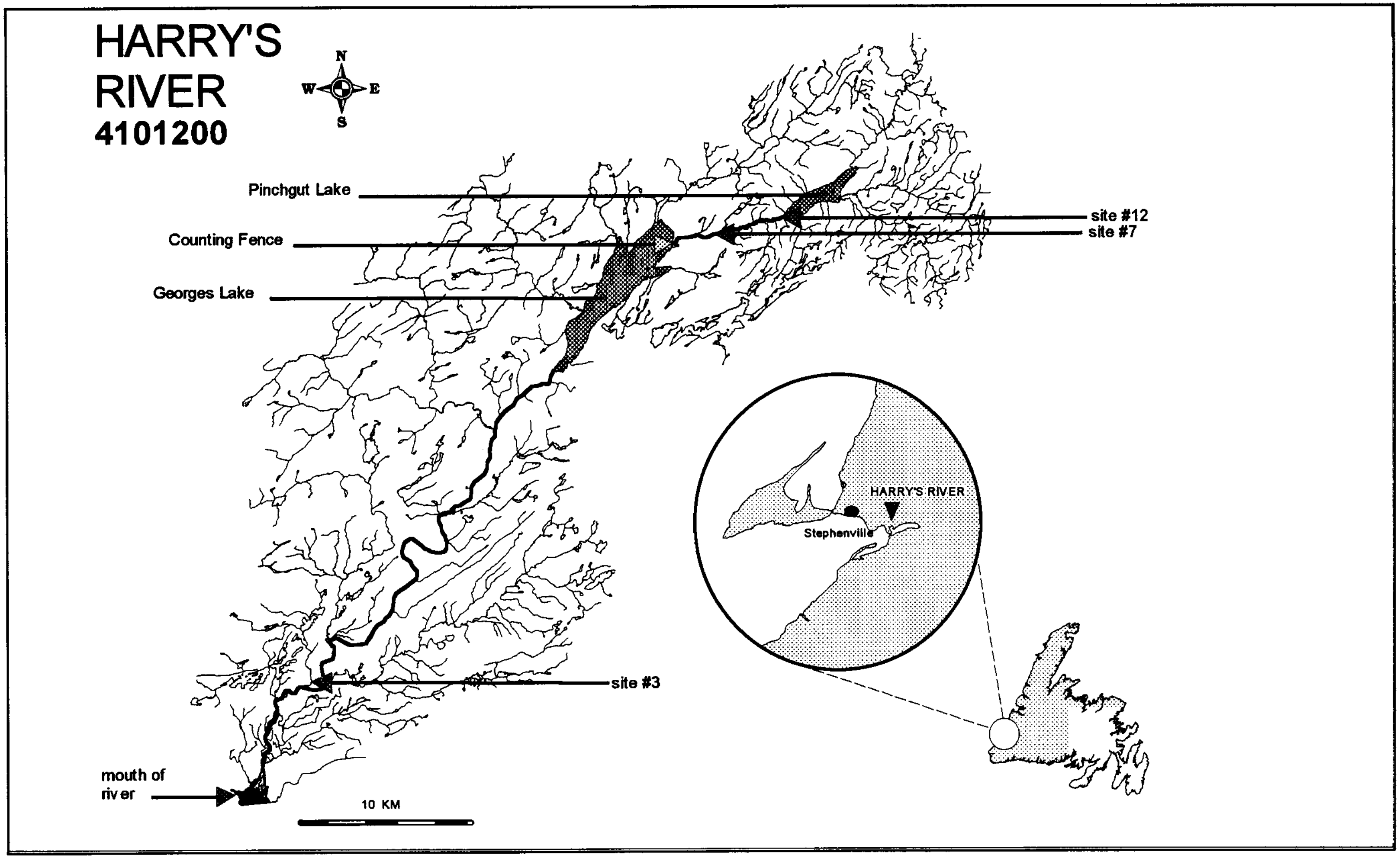
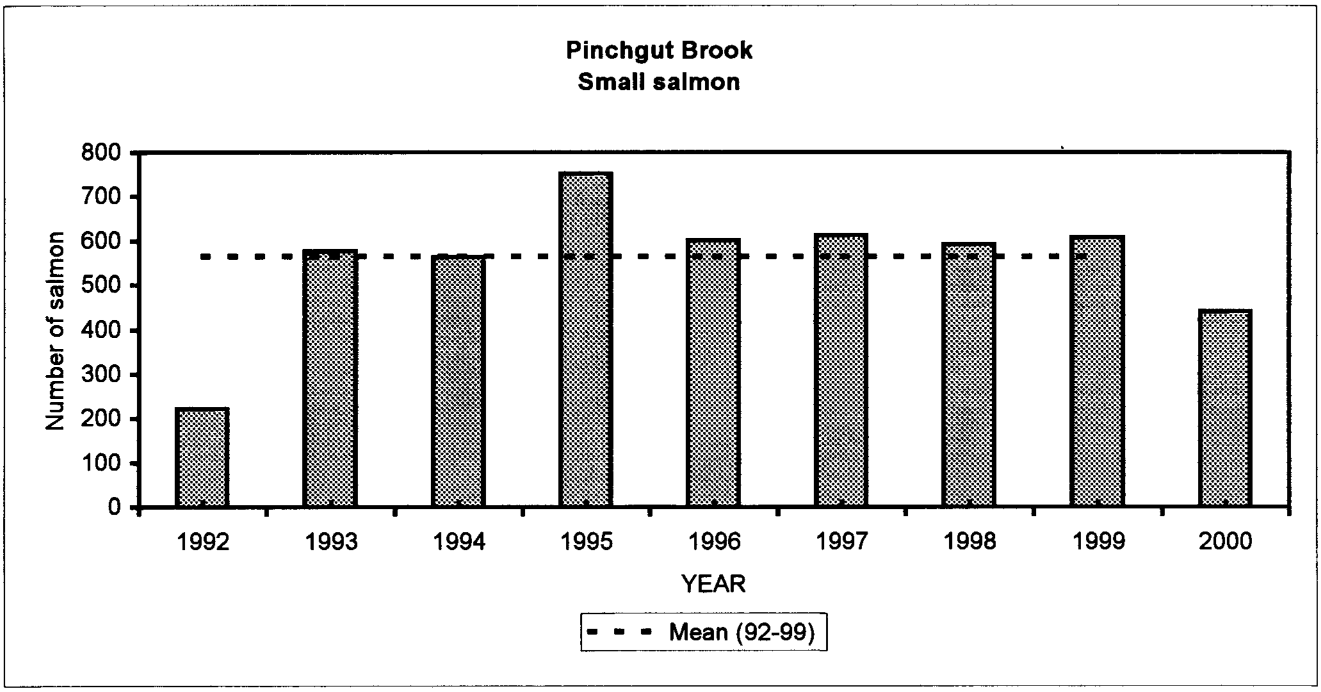


Figure 2. Location of selected features of the Harry's River system.



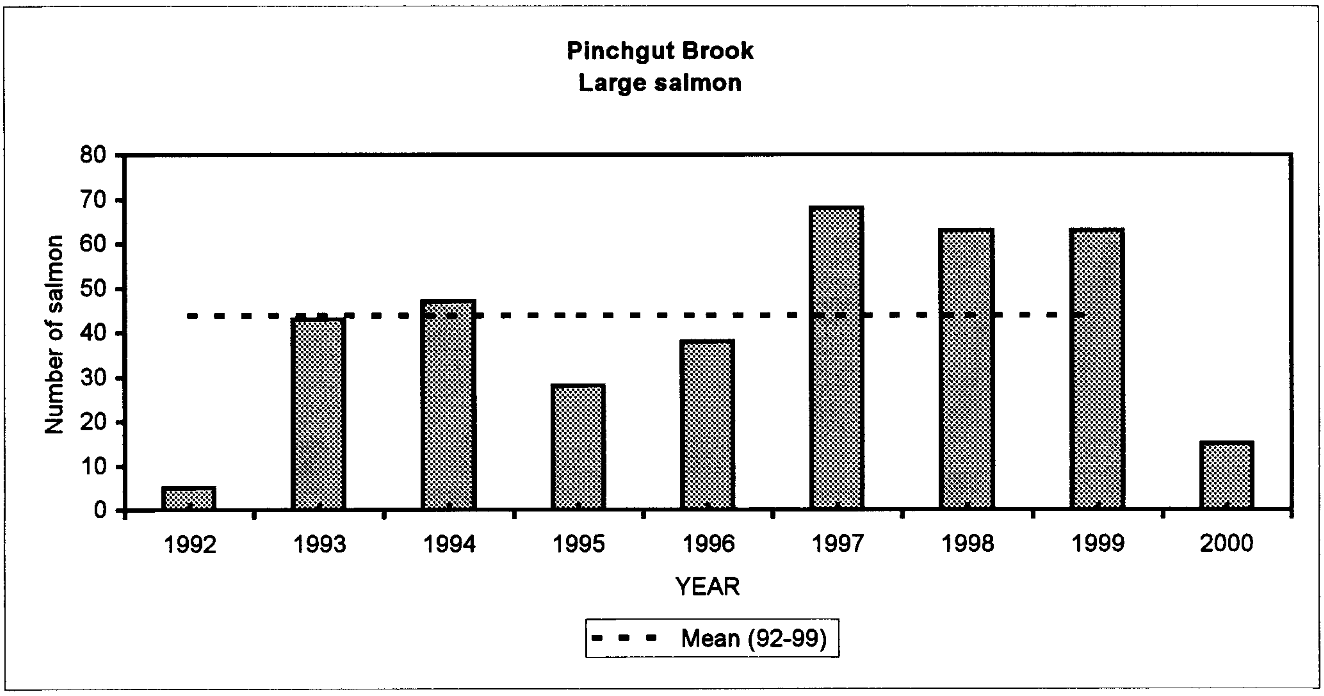


Figure 3. Counts of small and large salmon at the Pinchgut Brook counting fence, 1992-2000.

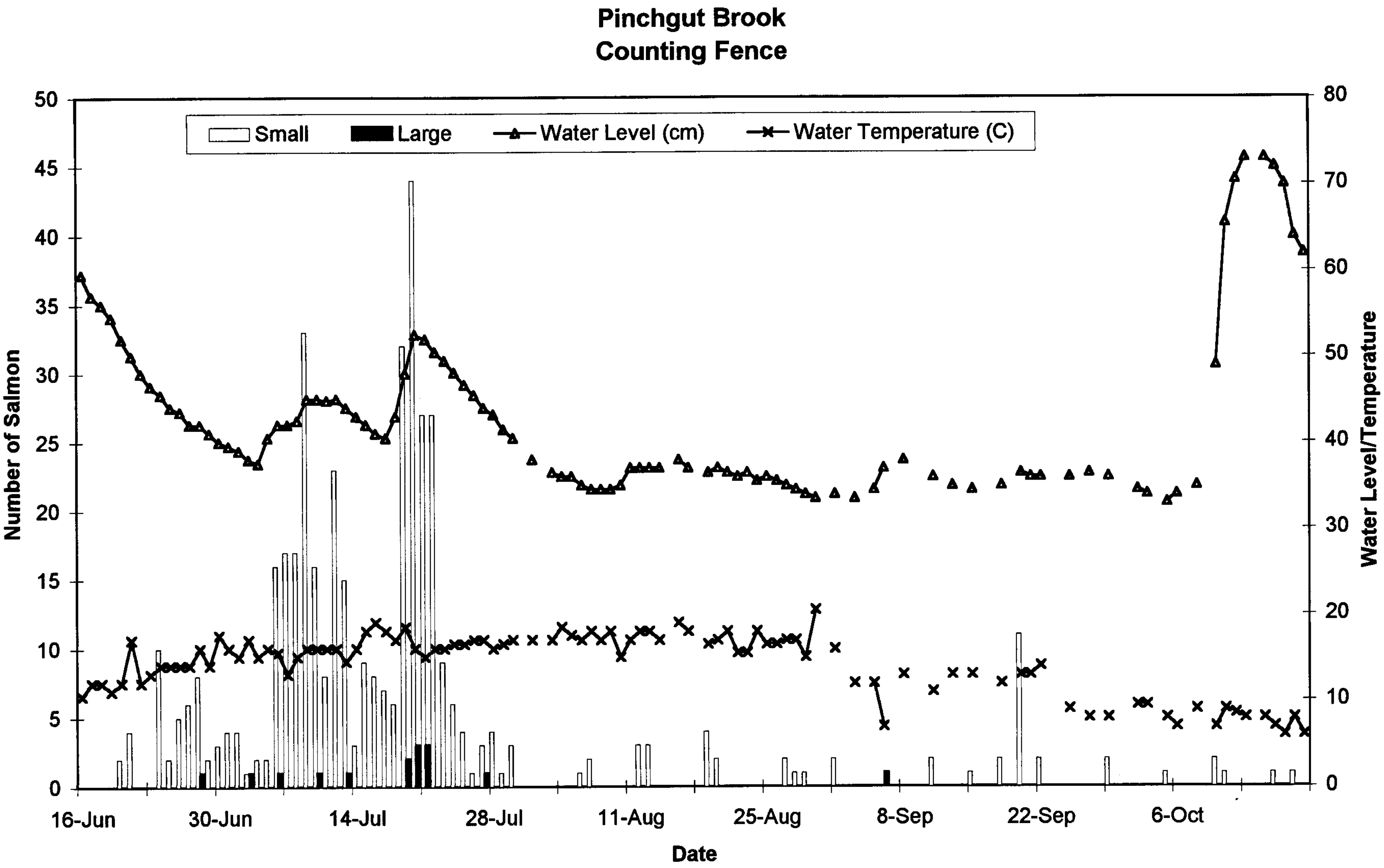
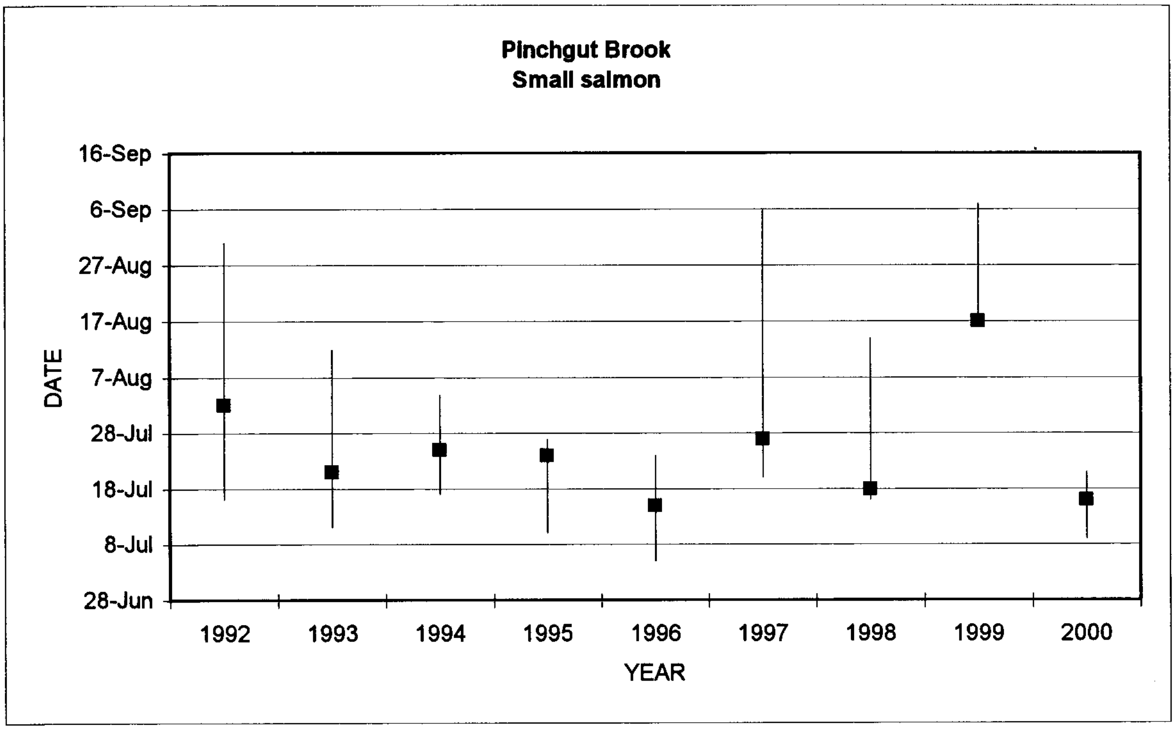


Figure 4. Daily counts of small and large salmon, mean water temperatures and mean water level at the counting fence on Pinchgut Brook, 2000.



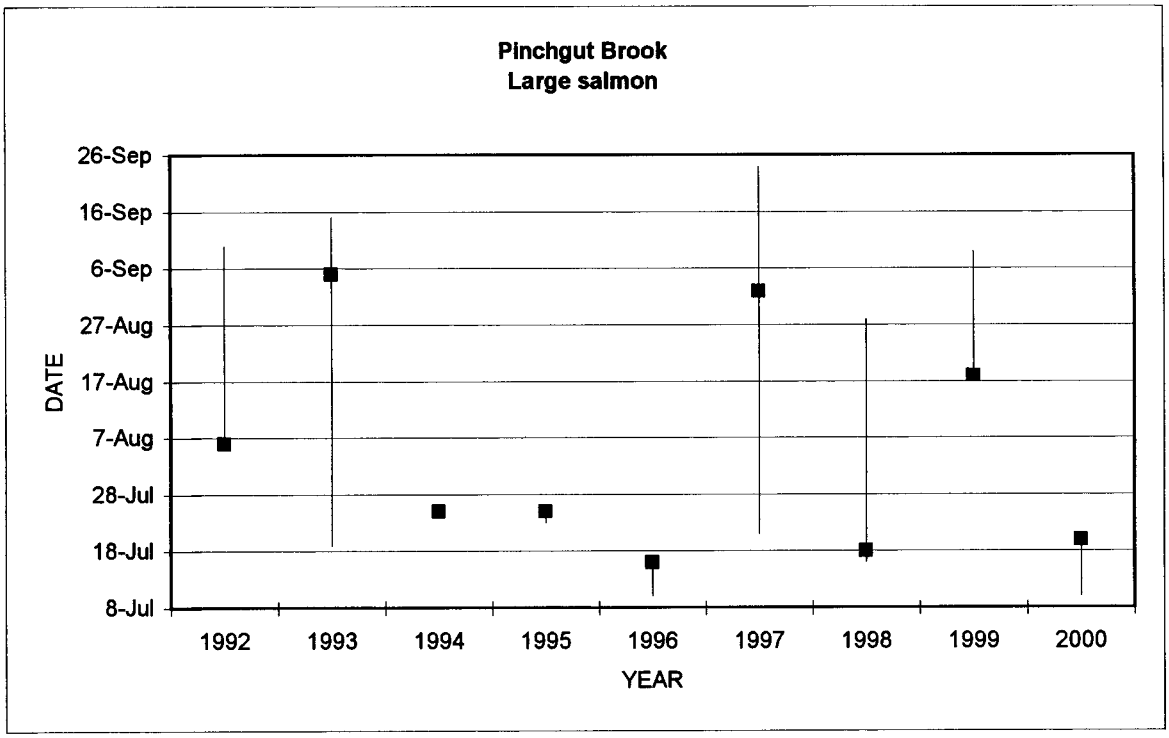


Figure 5. Run timing of small and large Atlantic salmon at the counting fence on Pinchgut Brook, 1992-2000. Vertical bars represent 25% to 75% of the run entering the river. Symbols represent 50% of the run.

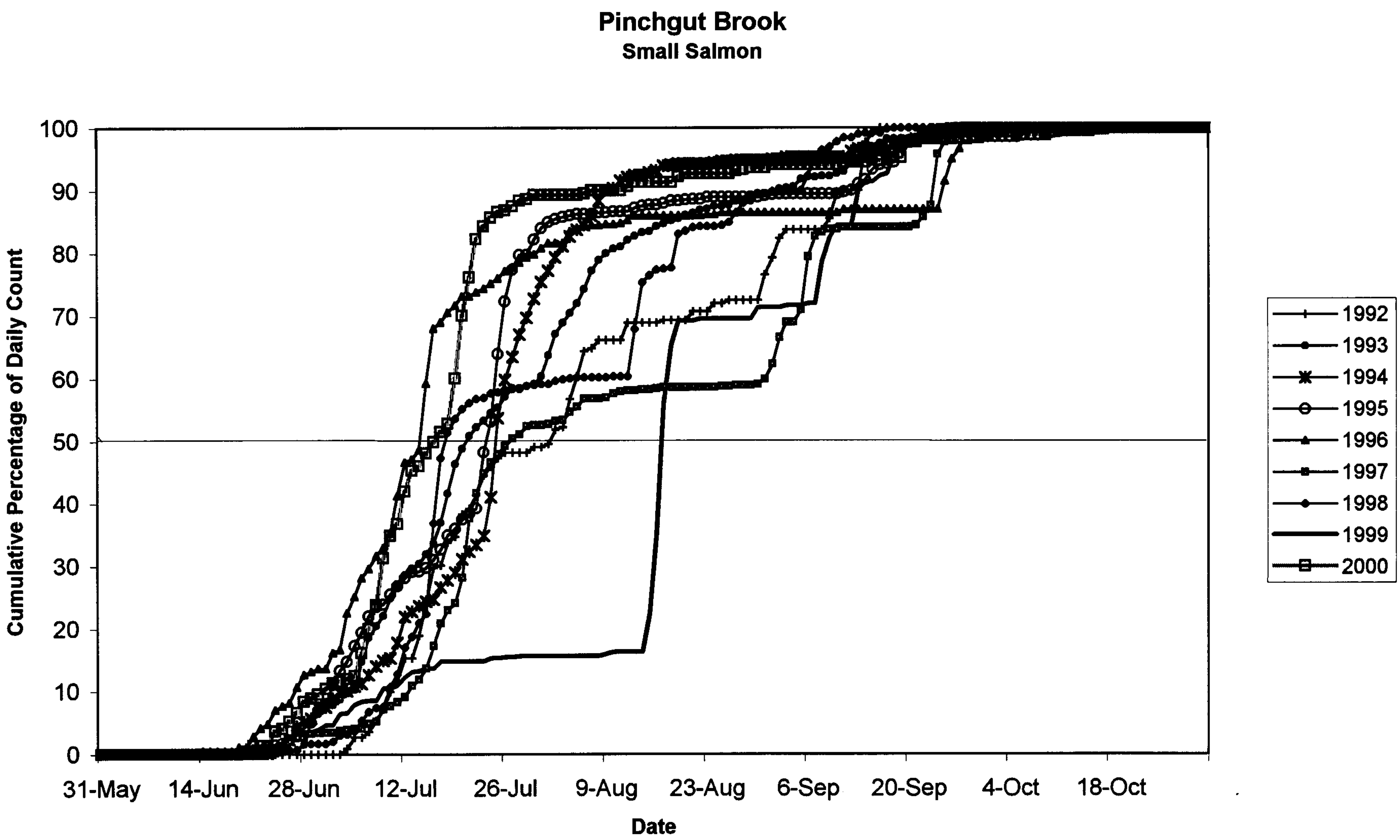
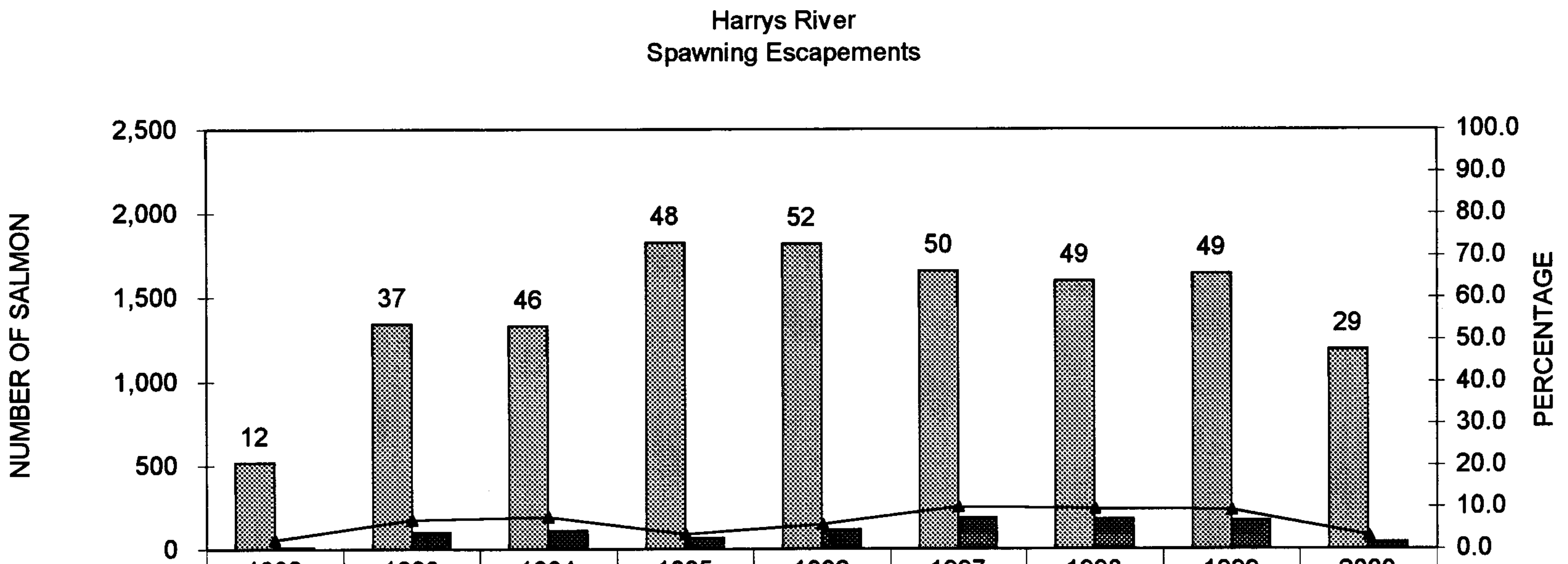


Figure 6. Cumulative daily counts of small salmon at the counting fence on Pinchgut Brook, 1992-2000.



	1992	1993	1994	1995	1996	1997	1998	1999	2000
Small	517	1,342	1,333	1,827	1,820	1,657	1,596	1,643	1,191
Large	12	99	111	68	116	184	177	171	41
% Large	2.2	6.9	7.7	3.6	5.9	10.0	9.6	9.4	3.3

YEAR

Figure 7. Spawning escapement of small and large salmon on Harrys River, 1992-2000. Numbers above bars represent the percentage of the conservation requirement achieved.

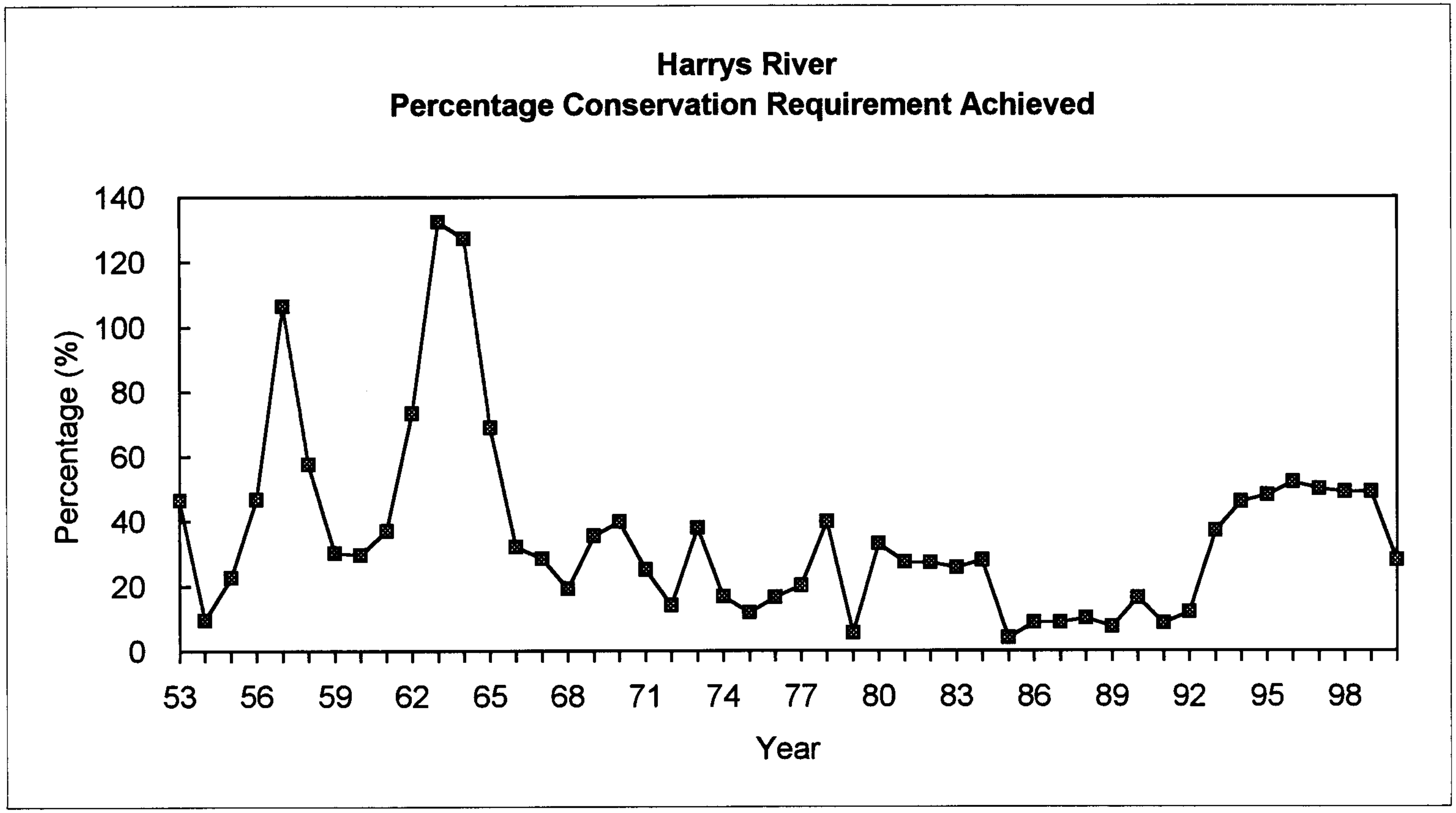


Figure 8. Percentage of the conservation egg deposition requirement achieved on Harry's River, 1953-2000. Results for 1953-1991 are based on angling catch statistics (Reddin and Mullins, MS 1996) and those for 1992-2000 are based on the counting fence at Pinchgut Brook.

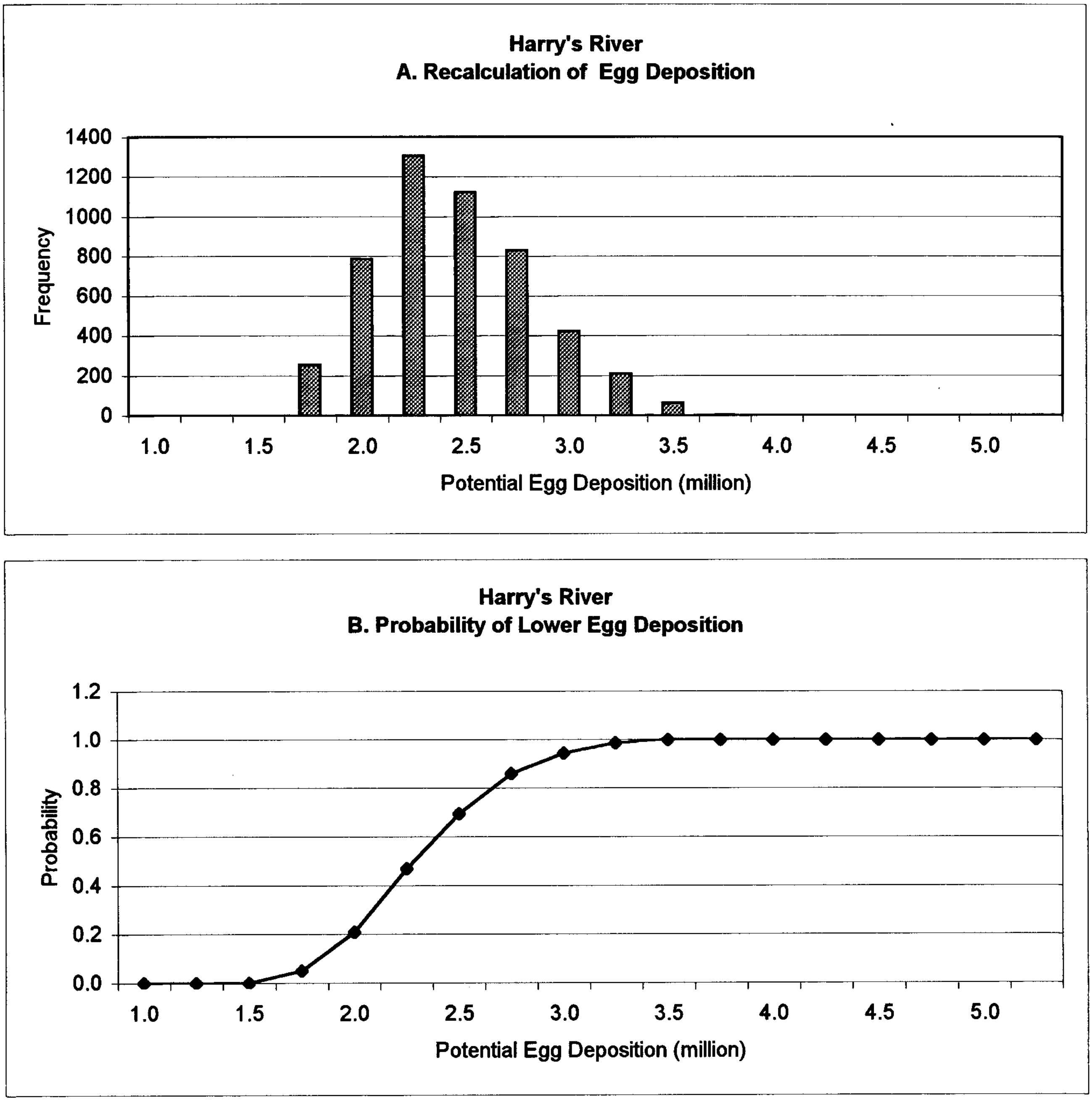
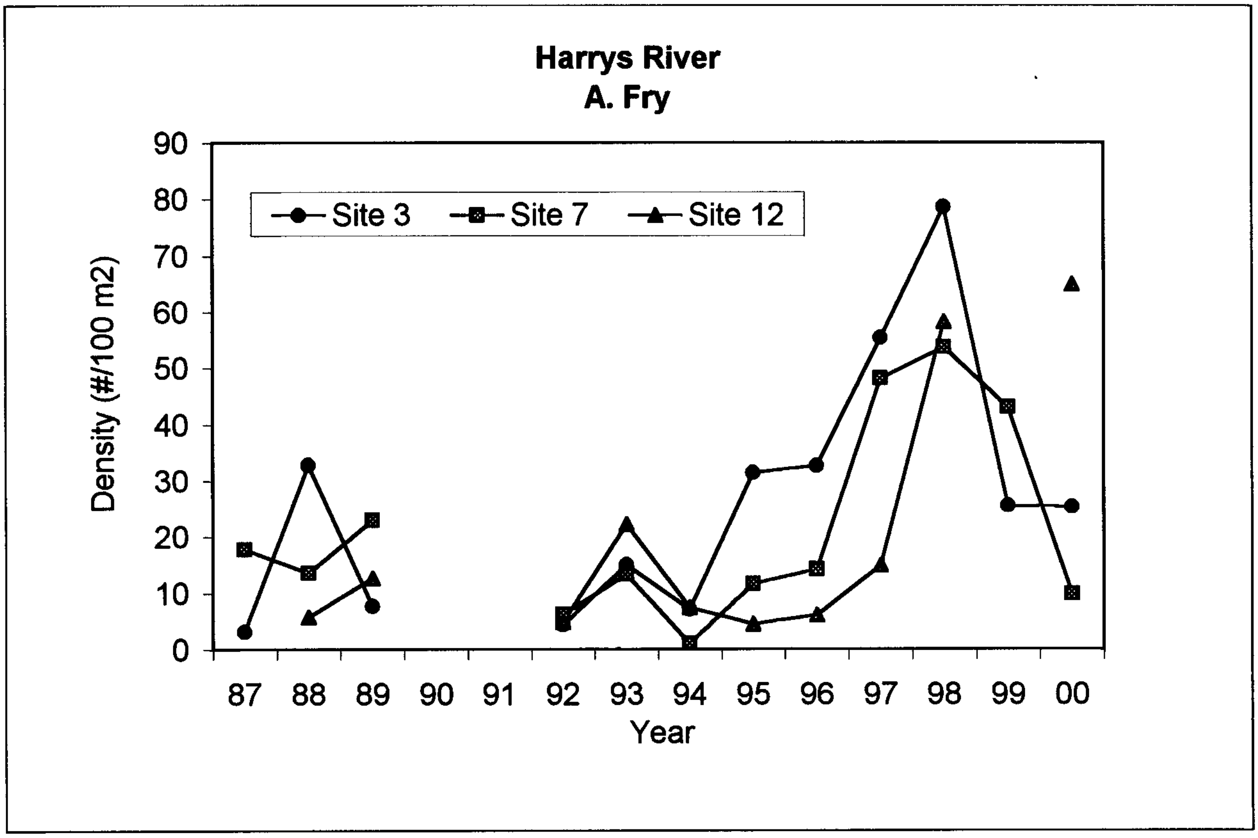


Figure 9. Results of simulation of uncertainty in the calculation of potential egg depositions by Atlantic salmon on Harry's River, 2000. The proportion of small and large salmon was allowed to vary within a uniform distribution based on counts at the fence in 2000 and the proportion of spawning on Pinchgut and fecundity of small and large salmon were allowed to vary within a 20% coefficient of variation.



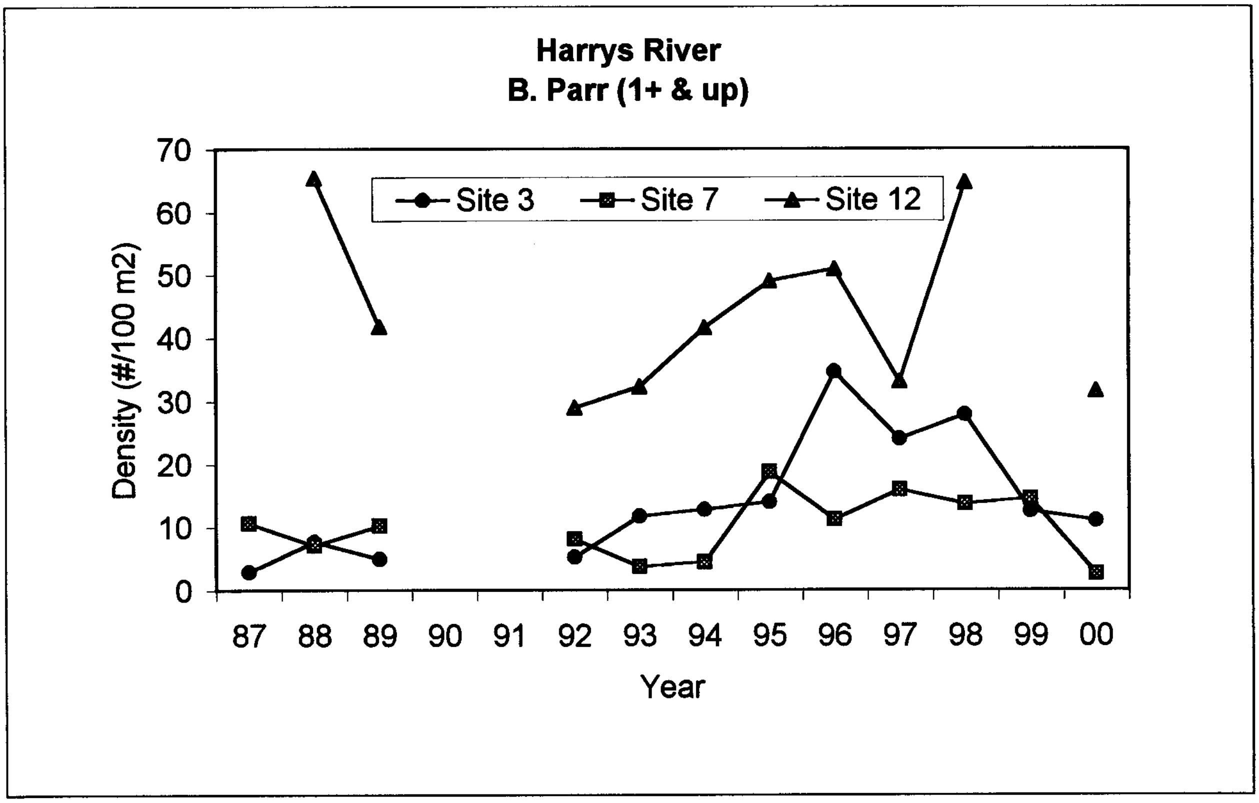


Figure 10. Density of juvenile salmon at sites 3, 7 and 12 on Harrys River, 1987-2000.

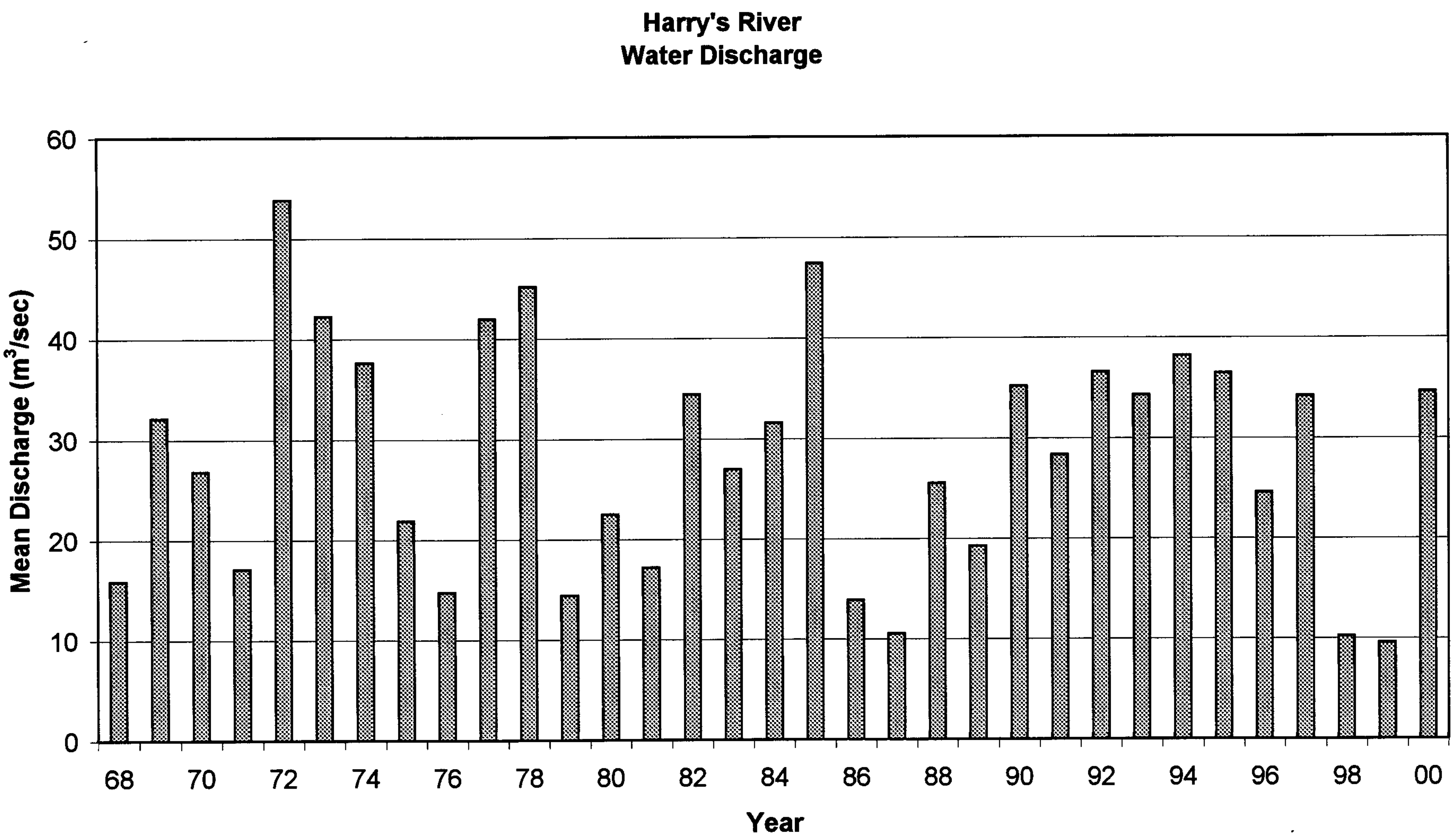


Figure 11. Mean water discharge rate (m3/sec) from mid-May to mid-August on Harry's River, 1968 2000. Data supplied by Environment Canada, the Newfoundland Department of Environment and Labour and the Deer Lake Power Company.

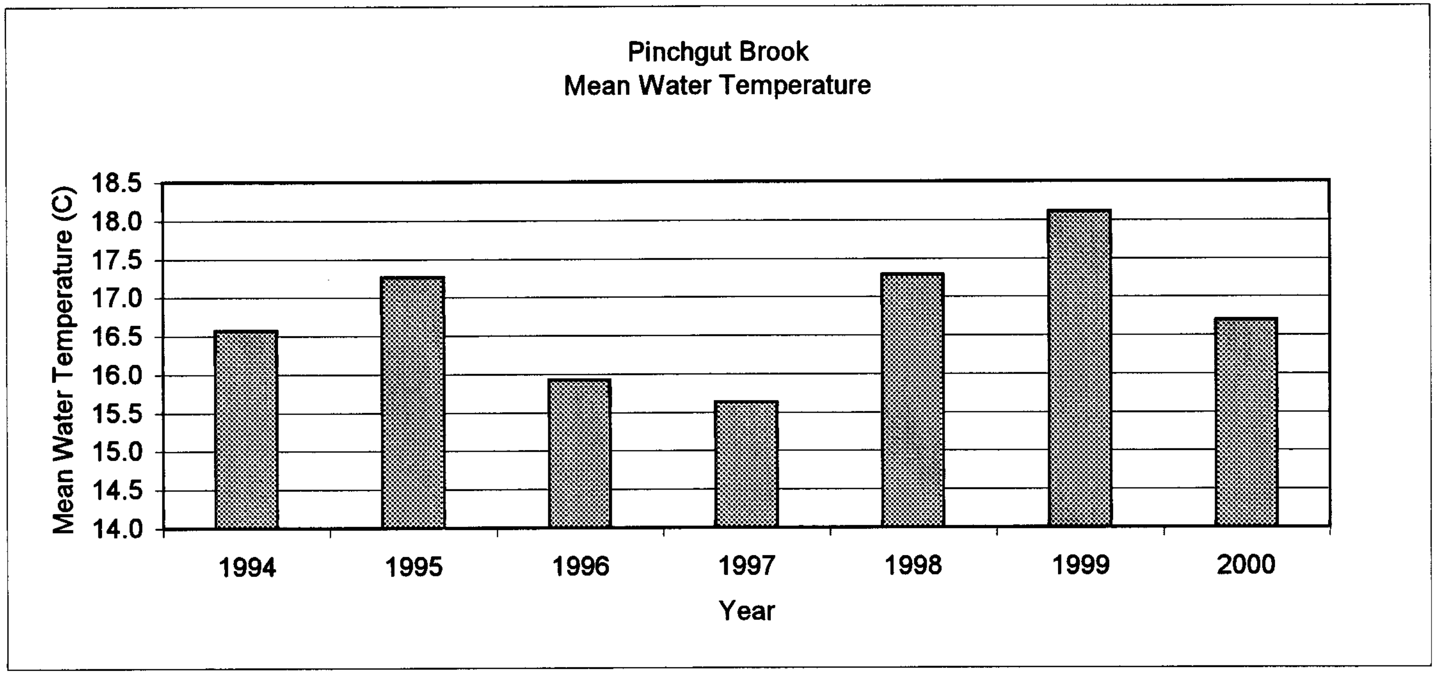


Figure 12. Mean water temperature for mid-June to mid-August recorded at the counting fence on Pinchgut Brook, 1994-2000.

Appendix 1. Recreational salmon fishery catches on Harry's River, 1974-2000.

Year	Effort (Rod days)	Small (< 63 cm)			Large (>=63 cm)			Total (Small+Large)			CPUE
		Ret.	Rel.	Total	Ret.	Rel.	Total	Ret.	Rel.	Total	
1974	4218	941	.	941	34	.	34	975	0	975	0.23
1975	2180	704	.	704	16	.	16	720	0	720	0.33
1976	2893	902	.	902	40	.	40	942	0	942	0.33
1977	3853	1008	.	1008	68	.	68	1076	0	1076	0.28
1978	3142	713	.	713	65	.	65	778	0	778	0.25
1979	755	148	.	148	1	.	1	149	0	149	0.20
1980	1602	518	.	518	65	.	65	583	0	583	0.36
1981	2082	659	.	659	18	.	18	677	0	677	0.33
1982	2141	570	.	570	31	.	31	601	0	601	0.28
1983	2439	533	.	533	30	.	30	563	0	563	0.23
1984	2543	720	.	720	11	.	11	731	0	731	0.29
1985	1686	173	.	173	*	0	0	173	0	173	0.10
1986	2628	382	.	382	*	8	8	382	8	390	0.15
1987	1643	378	.	378	*	8	8	378	8	386	0.23
1988	2077	434	.	434	*	11	11	434	11	445	0.21
1989	1961	324	.	324	*	3	3	324	3	327	0.17
1990	2182	706	.	706	*	22	22	706	22	728	0.33
1991	1456	370	.	370	*	4	4	370	4	374	0.26
1992	2094	311	35	346	*	28	28	311	63	374	0.18
1993	1870	319	23	342	*	50	50	319	73	392	0.21
1994	1518	153	84	237	*	50	50	153	134	287	0.19
1995	1252	149	60	209	*	44	44	149	104	253	0.20
1996**	.	34	1196	1230	*	206	206	34	1402	1436	.
1997**	.	2	591	593	*	139	139	2	730	732	.
1998**	.	0	288	288	*	95	95	0	383	383	.
1999**	.	0	286	286	*	53	53	0	339	339	.
2000**	.	0	71	71	*	23	23	0	94	94	.
Mean (84-89)	2089.7	401.8	.	401.8	.	6.0	6.8	403.7	6.0	408.7	0.19
95% CI	439.0	188.7	.	188.7	.	4.9	4.7	192.8	4.9	192.6	0.07
N	6	6	0	6	0	6	6	6	6	6	6
Mean (86-91)	1991.2	432.3	.	432.3	.	9.3	9.3	432.3	9.3	441.7	0.23
95% CI	434.8	145.4	.	145.4	.	7.2	7.2	145.4	7.2	152.5	0.07
N	6	6	0	6	0	6	6	6	6	6	6
Mean (92-95)	1683.5	233.0	50.5	283.5	.	43.0	43.0	233.0	93.5	326.5	0.19
95% CI	593.1	150.8	43.2	112.7	.	16.5	16.5	150.8	51.2	106.8	0.02
N	4	4	4	4	0	4	4	4	4	4	4

* NO RETENTION OF LARGE SALMON IN INSULAR NEWFOUNDLAND

** DATA OBTAINED FROM LICENSE STUB RETURNS; 2000 DATA ARE PRELIMINARY

NOTE: CPUE IS BASED ON RETAINED+RELEASED FISH FOR 1985-1995 AND ON RETAINED FISH ONLY PRIOR TO 1985.

NOTE: PERIOD INDICATES NO DATA FOR THAT YEAR.