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STATUS OF ATLANTIC SALMON IN THE NEPISIGUIT RIVER, NEW BRUNSWICK, 1995

by

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Abstract

A minimum of 62% of the target egg deposition for Atlantic salmon in the Nepisiguit River was estimated to have been achieved in 1995. Large salmon spawning escapement (819) was well below the requirement of 1363 fish. Small salmon spawning escapement (425) was also less than the requirement (690 fish). Estimates of spawning escapement in 1995 are considered minima because the spawning run was delayed by low water conditions. It is believed that an unusually large proportion of fish entered the river in late October and early November after removal of the counting fence and trapnets, and termination of the angling season.

The large salmon target has been met only twice (in 1987 and 1988) since 1982, but the small salmon target has been met nine times (most recently, in 1993) during this period.

The total angling catch (estimated by the Nepisiguit Salmon Association) of 450 small salmon (350 retained, 100 released) was the same as that estimated in 1994 (380 retained, 70 released), which was the lowest recorded since 1985. In 1995, the poor catch was attributed to the low, warm water conditions. Fewer small salmon were retained in 1995 than in 1994. The large salmon angling catch of 300 fish was slightly higher than in 1994 (250 fish). Catch per unit effort was slightly higher than in 1994. First Nation harvest was estimated as 44 large and 131 small salmon.

Résumé

On estime que la ponte minimale des saumons atlantiques dans la rivière Nepisiguit en 1995 correspondait à 62 % de la ponte cible. L'échappée de saumons de grande taille (819) était nettement inférieure à la cible de 1 363 géniteurs. L'échappée de petits saumons (425) était elle aussi inférieure aux besoins (690 poissons). Les estimations de l'échappée de géniteurs en 1995 sont considérées comme minimales du fait que la remonte a été retardée par le bas niveau des eaux. On pense qu'une proportion inhabituellement grande de la remonte a pénétré dans la rivière à la fin d'octobre et au début de novembre, après l'enlèvement de la barrière de dénombrement et des filets-trappes et la fin de la saison de pêche à la ligne.

La cible de saumons de grande taille a été atteinte deux fois seulement (en 1987 et 1988) depuis 1982, mais la cible de petits saumons a été atteinte neuf fois (en 1993 pour la dernière fois) pendant la même période.

Le total des prises de la pêche à la ligne (estimé par la Nepisiguit Salmon Association), soit 450 petits saumons (dont 350 ont été gardés et 100 remis à l'eau) était le même que celui de 1994 (380 gardés, 70 remis à l'eau), niveau le plus bas noté depuis 1985. En 1995, on a attribué la faiblesse des prises aux conditions des eaux, qui étaient basses et chaudes. Le nombre de petits saumons conservés a été plus bas en 1995 qu'en 1994. En 1995, les prises de grands saumons à la ligne (300) étaient légèrement plus élevées qu'en 1994 (250). Les prises par unité d'effort étaient légèrement plus élevées qu'en 1994. On estime les captures des Premières Nations à 44 grands saumons et 131 petits saumons.

Summary Sheet

STOCK: Nepisiguit River, SFA 15
TARGET: 9.6 million eggs (1363 large salmon, 690 small salmon)
ACCESSIBLE REARING AREA: 3,973,000 m^2, 30% of SFA 15

	1990	1991	1992	1993	1994	1995	MIN	MAX	MEAN
Angling									
Large (Released)	300	300	270	258	250	300	60	600	276
Small (Retained)	500	700	800	470	380	350	229	1000	570
Small (Released)	100	150	330	85	70	100	70	550	147
First Nation Harvest									
Large	n/a	n/a	n/a	50	0	44			
Small	n/a	n/a	n/a	200	120	131			
Spawning escapement									
Large	1117	1026	336	925	773	819	109	2381	835
Small	1593	2164	1092	836	501	425	309	2900	1237
Total returns									
Large	1390	1290	642	1084	892	1037	545	2700	1267
Small	2152	2930	1974	1511	1018	918	562	2930	1917
% egg target met	89	85	29	72	59	62	9	187	67

MIN and MAX: 1982-1995, MEAN: 1990-1994

Landings: Small salmon angling harvest was the lowest since 1985. Large salmon catch was average. Native harvest in 1995 was estimated as 131 small and 44 large salmon.

Data and assessment: Salmon spawning escapement was estimated from returns to a counting fence in conjunction with harvest estimates. For the years 1990, 1991, 1993-1995, counting fence returns were estimated using the historic relationship between fence counts and angling catch above the fence. This estimate represents minimal returns in 1995 because of low water conditions; a higher proportion of fish than usual remained in the estuary or lower river until after the end of the angling season. Spawning escapement below the fence was estimated using the ratio of spawning redds above and below the fence. Total return below the fence was the sum of spawning escapement plus removals.

State of the stock: The estimated spawning escapement of large salmon was 819, less than the requirement for the system. Small salmon spawning escapement of 425 was also less than the requirement. Returns of large salmon were 18% below average (1990-1994), and returns of small salmon were 52% below average.

1 - Introduction

Atlantic salmon occur naturally in the lower 32 km of the Nepisiguit River and its tributaries (Fig. 1). The river is also stocked with hatchery- and incubation box-reared juvenile salmon. Stocking commenced over a century ago, when Restigouche salmon were stocked in an attempt to produce an early run of large salmon in the Nepisiguit River. Angled large salmon averaged 9 kg after stocking compared to 5.5 kg prior to stocking (N.B. Commissioner of Fisheries, 1892). However, the success of the nineteenth-century stocking program was not sustained. The current stocking program commenced in 1974 with the objectives of (1) restoration of a population decimated by overfishing and pollution, and (2) enhancement of the early run. Until 1986, broodstock collections from the Nepisiguit River were supplemented with early-run broodstock from the Restigouche and Miramichi rivers. Since 1987, all broodstock have been collected from the Nepisiguit River.

This report documents the status of Atlantic salmon in the Nepisiguit River in 1995. Barrier fence and estuarine trapnet counts, run timing, redd counts, estimates of angling catch, electrofishing surveys of juvenile abundance, and stocking data are summarized. Egg depositions are estimated from calculated total returns, removals and spawner abundances. A modelling approach to evaluating the hatchery stocking program is also presented.

In the terminology utilised herein, salmon are subdivided into two size classes. Small salmon are adults less than 63 cm in fork length (1SW, one sea-winter salmon or grilse). Large salmon are adults greater than or equal to 63 cm in fork length (MSW or multi-sea-winter salmon).

2 - Description of fisheries

Salmon fisheries in the Nepisiguit River include recreational angling and angling by members of Pabineau First Nation. The recreational angling season was June 1 to October 15. Hook-and-release fishing only was permitted for large salmon, with a daily hook-and-release limit of four fish. Seasonal and daily bag limits for small salmon were eight and two fish, respectively. Anglers were required to stop fishing once the daily small salmon limit was reached.

3 - Target

The target egg deposition for the Nepisiguit River is **9.535×10^6 eggs (1,363 large, 690 small salmon)**. This estimate is based on the following;

- accessible rearing habitat = 3.973×10^6 m^2 (Anon. 1978)
- optimal egg deposition = 2.4 $eggs \cdot m^{-2}$ (Elson 1975)
- average fecundity of females = 1,760 $eggs.kg^{-1}$ (Elson 1957)
- proportion of females in the large salmon population = 0.71, and in the small salmon population = 0.17 (Locke et al. 1994)
- mean weight of large salmon = 5.6 kg, of small salmon = 1.4 kg (weights estimated at counting fence)

4 - Fishery data

4.1 - First Nation fishery

First Nation anglers retained 150 to 200 salmon (B. Paul Jr., Pabineau First Nation, personal communication). For stock assessment, it is assumed that 175 salmon were retained, 25% of which were large salmon, and that all were angled in waters above the counting fence. First Nation harvest was therefore estimated as 44 large and 131 small salmon.

4.2 - Nepisiguit Salmon Association angling catch estimate

Angling catches estimated by the Nepisiguit Salmon Association were 350 retained and 100 released small salmon, and 300 released large salmon (Table 1). Compared to the five-year mean of 717 small salmon and 276 large salmon, the 1995 angling catch of small salmon was down by 27% and large salmon catch was up by 12% (Table 2, Fig. 2). The 1994 and 1995 angling catches of small salmon, each totalling 450 fish, were the lowest recorded since 1984.

Fishing effort in 1995 (2900 rod-days) was 23% lower than the mean of 3760 rod-days (Table 2). As in 1994 (Locke et al. 1995), most of the angling effort occurred in September (1200 rod-days) and October (700 rod-days; Table 1).

Monthly catch per unit effort (CPUE) peaked in October at 0.35 fish·rod-day^{-1} (Table 1). CPUE for the full season was 0.26 fish·rod-day^{-1}, the same as the five-year mean (Table 2), 37% higher than the 1994 CPUE of 0.19 fish·rod-day^{-1}.

4.3 - FISHSYS angling catch estimate

Preliminary data obtained from the FISHSYS angler survey of the New Brunswick Department of Natural Resources and Energy (DNRE) in 1995 were similar to the NSA estimate of small salmon retained catch (250 fish) and total rod-days (3070 rod-days), but substantially lower in large salmon catch (20 fish) (Table 2c). FISHSYS does not provide an estimate of the small salmon released catch. Before 1984, both FISHSYS and DFO estimates of catch indicated very low catches of both small and large salmon. With the exception of values estimated in 1994 and 1995, FISHSYS estimates of catch and effort since 1984 were substantially higher than the estimates of the NSA (Fig. 2). Both estimates indicate a reduction in both catch and effort in the past two years, with an overall decline in CPUE since 1986.

4.4 - Angler logbooks

Angling logbooks completed by thirteen members of the Nepisiguit Salmon Association indicated increased angling success and effort in 1995 compared to 1994 (Table 3). The number of angled large salmon almost tripled in 1995, and angled small salmon increased by 30%. CPUE increased by 19%. Effort by logbook anglers increased by 23%.

The higher CPUE observed in 1995 compared to 1994 was mainly due to higher catches below the counting fence (Table 3). As in 1994, approximately two-thirds of the angling effort occurred below the counting fence. CPUE was similar above and below the fence in 1994 (21% higher below the fence) but in 1995 CPUE below the fence was clearly higher (240%) than CPUE above the fence. Low CPUE above the fence was consistent with the late upstream migration of salmon observed in 1995.

5 - Research data

5.1 - Juvenile stocking and broodstock collection

In 1995, the Charlo Salmonid Enhancement Centre released 12,105 adipose-clipped early-run and 78,801 unmarked late-run fall fingerlings (total releases of 90,906) (Table 4) into the Nepisiguit River and its tributaries below Grand Falls (Mile 20 on Fig. 1). An additional 6,000 adipose-clipped late-run fall fingerlings from Nepisiguit broodstock were released into the Tetagouche River.

The Nepisiguit Salmon Association stocked 105,000 unmarked swim-up fry from incubation boxes at Grand Falls (Table 4). Loss of water flow from the dam at Grand Falls, on the night before stocking was to take place, reduced the egg-to-fry survival rate to 30%. Survival rate in these incubation boxes has typically exceeded 90% in previous years (Nepisiguit Salmon Association, unpub. data).

All broodstock used to produce eggs for this stocking were collected from the Nepisiguit River in 1994. In 1995, 162 large and 9 small salmon were collected as broodstock for 1996 enhancement projects. Most of these were 'late run' fish collected in September-October at the counting fence.

5.2 - Counting fence

A salmon counting fence was operated by the Pabineau First Nation in collaboration with DFO from July 6 to October 20. The fence was located at the site used by the NSA before 1992, approximately 0.5 km below the mouth of the Pabineau River, just above Gray's Ledge Pool. This site is approximately 1 km below the site used in 1992-1994. Delays in funding resulted in installation of the fence approximately 1 month later than most previous years (Table 5).

Salmon captured at the fence during their upstream migration were counted, and during high-water and low-temperature conditions salmon were also measured, a scale sample was collected and fish were externally sexed if possible. These data were not collected during low-water, high-temperature periods in order to reduce handling of fish which were already stressed. Adipose fin clips (indicating hatchery origin) or numbered Carlin tags (indicating that fish were tagged at the downriver assessment traps (see Section 5.3)) were noted. Salmon were released above the fence or retained as broodstock to be sent to Charlo Salmonid Enhancement Centre.

In total, 181 small salmon were counted at the fence. Eight small salmon were adipose fin-clipped (Table 6). In total, 359 large salmon were counted (12 fin-clipped). Small salmon counts were 32% lower than in 1994, but large salmon counts were 54% higher.

Returns of both small and large salmon were concentrated in September and October (Fig. 3). Few salmon returned to the fence during the low-water conditions of July and August. Compared to previous years, the timing of small salmon returns was atypical, with virtually no returns during Julian weeks 29 through 35 (Fig. 4). The tendency of large salmon to return during the late run (after week 32, i.e. mid-August) was typical of previous years (Fig. 4).

To adjust returns for the late installation date, the number of salmon counted at the fence was estimated by regression on the number of fish angled above the fence (NSA data). The regression equation was based on 1982-1992 data, and was also used to adjust the 1993 and 1994 fence counts (Locke et al. 1994, 1995).

Large salmon returns to fence = 6.47 * Large salmon angled above fence (R^2=0.92)

Small salmon returns to fence = 3.18 * Small salmon angled above fence (R^2=0.81)

The adjusted returns to the fence were 577 small and 782 large salmon (Table 6). These estimated returns are probably lower than the actual returns because fish were still returning to the fence after October 15, the end of the angling season on which these adjustments are based. As well, the logbook angling catch was distributed more below the fence in 1995 than in 1994 (Table 3), again indicating that angling catch above the fence would underestimate salmon returns to the fence.

The proportion of adipose-clipped salmon observed at the fence was highest in August for large salmon (25% were adipose-clipped), and July (13%) for small salmon (Table 7). Overall, 3% of large salmon and 5% of small salmon were adipose-clipped.

5.3 - Trapnets

Two research trapnets were installed just downstream of the Highway 11 bridge (Fig. 1). Because of funding constraints, trapnets were operated only during anticipated peak periods of salmon movement, identified from the 1982-94 data of Fig. 4. Dates of operation of the trapnets were June 10-July 13 and Sept. 6-Oct. 23. Trapnet construction and location were described in Appendix 1 of Locke et al. (1995) (double-gated fair-tide picket trap and floating two-way trap).

In total, 150 small and 63 large salmon were caught in the traps (Fig. 5). The picket trapnet caught the majority of these (128 small salmon, 45 large salmon). All salmon were measured (fork length), scale-sampled, and released. A numbered blue Carlin tag was attached posterior to the first ray of the dorsal fin of 140 small and 37 large salmon (Table 8).

Timing of salmon captures in the trapnets was similar to that observed at the counting fence (Fig. 6). Large salmon captures peaked in weeks 36-37 (first two weeks of September) and

40 (first week of October). Small salmon captures peaked in weeks 37 (second week of September) and 39-41 (last week of September through mid-October). Similar numbers of small salmon were caught at the trapnets and fence during their peak abundance, but substantially fewer large salmon were captured at the trapnets than at the fence.

As in 1994, tag recaptures were few, and therefore no mark-recapture estimate of abundance was made. Three tagged small salmon were recaptured (two by anglers, one at the counting fence; Table 8). Three tagged large salmon were recaptured at the counting fence. No large salmon tags were returned by anglers.

Movement of tagged salmon from the trapnets to the counting fence was more rapid as the season progressed. The time required for large salmon to move from the trapnets to the counting fence varied from 75 days for the fish tagged in June to 7 and 12 days for the two salmon tagged in September. Small salmon tagged in October were recaptured within 1-5 days at or just below the counting fence. The small number of recaptures suggests that many fish tagged at the trapnets did not ascend the river before the end of the angling season (October 15) and removal of the counting fence (October 20).

5.4 - Redd counts

Redd counts were conducted by the Nepisiguit Salmon Association both above and below the fence (Table 9). Despite incomplete coverage of the area above the fence, total redd counts above the fence were the second highest on record, exceeded only by the counts in 1988. Redd counts below the fence were the third lowest ever recorded. Total (incomplete) redd counts in 1995 were similar to those recorded in 1994 and 1986, and were exceeded only by the totals for 1987 and 1988.

5.5 - Juvenile densities

Estimates of juvenile densities were obtained at 10 sites in the Nepisiguit River, 3 sites in Gordon Meadow Brook, and 6 sites in the Pabineau River electrofished by the Nepisiguit Salmon Association. Densities were estimated by the DeLury (1958) method, using removal from sites enclosed by barrier nets. Juvenile salmon were separated into age classes using fixed length categories (0+ parr, ≤5.5 cm; 1+ parr, 5.6-10.5 cm; 2+ parr, ≥10.6 cm).

Mean density of 0+ parr at 19 sites in 1995 was the lowest recorded in five years (Fig. 7). With the exception of the cohort produced in 1992, 0+ parr densities have been increasing since 1988. Mean density of 1+ parr was intermediate between those of the previous two years, and did not reflect the very high 0+ parr densites of the same cohort sampled the previous year. Density of 2+ parr was similar to that of the previous four years.

6 - Estimation of returns, removals and spawning escapement

Calculations of spawning escapement and returns were carried out by the methods used in the 1993 stock assessment (Locke et al. 1994), as follows:

(1) Spawning escapement above the fence

Spawners = salmon counted at fence (in 1995, this number was adjusted by regression, as described in section 5.2) - (broodstock removals + mortalities at fence + angling mortality + First Nation harvest)

(2) Spawning escapement below the fence

Spawners = (spawners above fence) x average (redd count below fence) / (redd count above fence)

(3) Returns below the fence

Returns = spawners + angling mortality + First Nation harvest + commercial harvest.

Notes:
(a) Angling mortality: This was calculated using angling removals and releases estimated by the Nepisiguit Salmon Association. To separate total removals and releases into above- and below-fence components, the average distribution of angling above (40.3%) and below (59.7%) the fence was calculated based on returns of scale samples by anglers (Table 10), which include information on the angling location. Angling mortality of released fish was calculated for an assumed 3% hook-and-release mortality rate.

(b) Redd distributions above and below the fence: Mean proportions of redds above (69.5%) and below (30.5%) the fence (Table 9) were used to estimate the number of spawners below the fence, assuming that fish spawning in the two areas produce similar numbers of redds·fish^{-1}.

(c) Effects of fence location: It was assumed that the effects of counting fence location are minimal. The two sites (one used in 1982-1992 and 1995, the other in 1993-1994) are 1 km apart.

7 - Assessment results

7.1 - Abundance estimates

Returns of large salmon were estimated as 255 below the fence and 782 above the fence (Table 11). Returns of small salmon were estimated as 341 below the fence and 577 above the fence (Table 12).

Total returns were estimated as 1037 large and 918 small salmon (Table 13). Spawning escapement was estimated to be 819 large and 425 small salmon. Large salmon returns and spawning escapement increased relative to 1994 but small salmon returns and spawning escapement decreased (Table 13, Fig. 8).

Based on these estimates, 62% of the target egg deposition was met in 1995 (Table 14). Spawning requirements have been exceeded in only two years (1987 and 1988) of the fourteen in which salmon stocks have been assessed on this river (Fig. 9). The two years in which target egg deposition was exceeded were also the only two in which the large salmon spawning escapement target was exceeded (Table 13). Small salmon spawning escapement was exceeded in nine years, although not in either 1994 or 1995 (Table 13). Egg deposition has declined since 1989, but has remained at approximately 60-70% of target over the past three years (Fig. 9). Estimates of spawning escapement in 1995 are probably conservative because of the late spawning run.

7.2 - Comparison of estimated egg deposition, redd counts and juvenile abundances

Density of 0+ parr (time-lagged to year of spawning), redd counts, and estimated egg deposition followed similar increasing trends from 1982 to 1988 (Fig. 10). However, the relationship between mean 0+ parr density and estimated egg deposition has been poor in recent years. Age 0+ parr density continued to increase from 1989-1991 despite decreases in estimated egg deposition. High 0+ parr densities suggest that the Nepisiguit salmon stock may be more abundant than indicated by estimated egg deposition rates. Even in 1992, when egg deposition was estimated at 29% of target, mean parr densities remained above those recorded in 1987, when target egg deposition was exceeded by 34%. Stocking of 0+ parr is not sufficient to account for the divergence between parr densities and egg depositions (Locke, unpub. data). Redd counts were also high in the two years sampled since 1988, compared to estimates of egg deposition. Egg depositions estimated by R. Baker of the Nepisiguit Salmon Association (pers. comm.) follow a similar trend to that of the egg depositions summarized here.

8 - Ecological considerations

8.1 - Species interactions

Predation by piscivorous birds, primarily mergansers, on juvenile salmon is a major concern of some anglers on the Nepisiguit River. Merganser surveys carried out by the Nepisiguit Salmon Association in June-October 1995 and by the N.B. Dept. of Natural Resources and Energy in July-August 1994 counted similar numbers - a maximum of about 1.7 mergansers·river km, with up to 45 birds on the Nepisiguit River below Grand Falls. Craig Wood of Noranda Technology Centre (240 Hymus Blvd., Pointe-Claire, PQ, H9R 1G5) proposed a merganser removal study to evaluate effects on juvenile salmon populations in 1995 but the Canadian Wildlife Service declined to issue a permit for the merganser manipulation.

8.2 - Environmental conditions

Water temperature at the counting fence (sampled daily at approximately 0800 h) exceeded 20 C through the latter half of July and the first half of August. Temperatures in excess of 25 C were recorded for several days in the first week of August (Fig. 3). Temperatures sampled in early morning were probably the lowest temperatures of the day; afternoon water temperatures of 30 C were observed at the fence during this period (F. Mowbray, personal observation).

9 - Evaluation of the stocking program

9.1 - General comments

Over eight million juvenile salmon have been stocked to the Nepisiguit River over the past seventeen years (Table 4). Proponents of the stocking program feel that it has been extremely successful (e.g., Baker 1979), and both angling (Table 2) and stock assessment (Table 13) data indicate that salmon abundance increased subsequent to stocking, especially in the 1970's and 1980's. However, there has been no scientific review of the program. In order to conclude that the program has been successful, it is necessary to show that more adult salmon have returned as a result of the program than would otherwise have been produced - in other words, that adult salmon removed as broodstock contributed more than if they had been left alone to spawn in the wild. Although survival of eggs to juveniles prior to stocking is believed to be higher than that of the equivalent stages in the wild, poor survival subsequent to stocking could offset or negate this advantage.

Evaluating the stocking program would be a straightforward process if all stocked fish had been marked by fin-clipping or other means. In most years, fewer than 100% (sometimes 0%) of fish stocked from DFO hatcheries were fin-clipped (Table 4). Swim-up fry hatched in incubation boxes could not be fin-clipped and have not been marked by other means. Because stocked fish have not been marked at a consistent rate, it was necessary to model expected rates of return of marked fish from known stocking rates of marked and unmarked juveniles and estimated "wild" egg deposition, using a range of survival rates. Two approaches were used: the first examined returns of marked adult fish relative to expectations based on stocking of marked juveniles. The second approach examined the contribution made by broodstock relative to the contribution these fish would have made if they had spawned in the wild.

9.2 - Evaluation based on returns of marked fish

The first question addressed was "Do adipose-clipped adult salmon return to the counting fence in proportions consistent with expectations based on the number of fin-clipped juveniles stocked?". The stocking program would be considered successful if:

(1) fin-clipped adults were present in higher proportions than expected (i.e., stocked salmon had higher survival than wild salmon)

or (2) fin-clipped adults were present at expected proportions (i.e., stocked salmon survived as well as wild salmon).

If fin-clipped adults were present in lower proportions than expected, it would indicate that they did not survive as well as wild salmon.

The method used to address this question was the application of a range of survival rates to predict the proportion of fin-clipped salmon that would have returned to the fence in a given year, adjusted for the proportions of stocked, marked and unmarked individuals and the estimated wild egg deposition in a given cohort.

The data used were:

1. Estimated wild egg deposition.
2. Numbers of stocked juveniles, age and proportion fin-clipped.
3. The proportion of returning fin-clipped large and small salmon counted at the fence each year.

The assumptions made in this analysis were:

1. The survival rates of wild individuals are in the range identified by Symons (1979):
   (a) survival of 0+ parr to 1+ parr is 0.28 to 0.44
   (b) survival of 1+ parr to 2+ smolt is 0.28 to 0.57
   (c) survival of eggs to 2+ smolt is 0.009 to 0.057
2. Survival rates of hatchery and wild individuals are either:
   (a) equal
   or (b) unequal, where wild individuals survive 10 times better than hatchery individuals during their first year at large. After the first year at large, survival rates are equal.
3. All fish smoltify at age 2+.
4. All large salmon are aged 2-sea winters.
5. Sea survival is constant from year to year: the actual survival rate at sea is irrelevant.
6. Fin-clipped and non-fin-clipped stocked fish have equal survival rates.

From these assumptions and data, a range of proportions of fin-clipped small and large salmon expected to return in a given year was calculated for each of the two scenarios of assumption 2, i.e. one range for equal survival rates and another for unequal survival rates. Expectations of marked fish returns are lower for the unequal survival rate scenario. Within each scenario, expectations are lower at the higher survival rate than the lower survival rate, since more wild fish survive to the smolt stage and the advantage of hatchery-reared fish is reduced.

Comparison of observed and expected proportions of fin-clipped salmon (Fig. 11) showed that with an assumed equal survival of wild and stocked fish, fin-clipped small salmon returns exceeded expectations 4 years, were within the range of expectations 3 years and below expectations 2 years. Fin-clipped large salmon returns were above expectations in 3 years, within expectations in 2 years and below expectations in 3 years. Thus salmon returns were more often above expectations than not.

With an assumed tenfold survival advantage of wild salmon during the first year after stocking, fin-clipped small salmon returns were above expectations 6 years, within 2 years and below 1 year. Fin-clipped large salmon returns were above expectations 4 years, within 3 years and below 1 year.

The results of this model suggest that the hatchery stocking program has been at least moderately successful.

9.3 - Evaluation based on broodstock contribution

The second question addressed was "Did broodstock removed for hatchery spawning contribute more recruits than if they had spawned in the wild?".

The percentage of hatchery contribution to each year's cohort was calculated and compared to the contribution that hatchery-spawned eggs would have made if the broodstock had been allowed to spawn in the wild.

The data used were:
1. Broodstock removals and estimates of potential wild egg deposition of these fish.
2. Estimated spawning escapement and egg depositions.
3. Hatchery contribution to each smolt cohort, as a percentage of total, calculated as in section 9.2.

The same assumptions were used as in section 9.2.

The model indicated that the hatchery contribution would exceed the value of the same fish spawning in the wild only if survival rates in the wild were low (i.e. only 0.9% of eggs survive to smolts) (Fig. 12). The value of the hatchery contribution was greatly increased if stocked fish had survival rates equivalent to wild fish. At high survival rates in the wild (5.7% of eggs survive to smolt) the hatchery contribution did not exceed the potential the broodstock would have made as wild spawners, regardless of assumptions of the relative survival rates of wild vs. stocked juveniles.

By this model, the success or failure of the hatchery program was dependent on the survival rate of wild juveniles. Whether survival was closer to the upper or lower limits of the range identified by Symons (1979) has not been determined.

10 - Management considerations

Target spawning escapement was not met in 1995. Total egg deposition was estimated at 62% of target. A spawning target of 2.4 eggs$\cdot m^{-2}$ appears to be appropriate for this river.

Almost eight million juveniles have been released to the Nepisiguit system in the past fourteen years. It is not possible to evaluate the success of this stocking program because the majority of the released fish have not been marked. Two approaches to modelling the stocked population are inconclusive results as to the success of the stocking program in increasing the population size.

In-season forecasting of salmon returns following the method described by Locke et al. (1994) would not have been successful in 1995 because of the delayed salmon run. In most years, in-season forecasting can be used to predict early (prior to week 34) returns beginning in week

30 (July 23), and total returns beginning in week 36 (Sept. 3; Locke et al. 1994). This approach to forecasting is evidently not appropriate in years of low water conditions during the summer.

11 - Research recommendations

1. Continue operation of the counting fence in preference to the estuarine traps. Use the ratio of redds above and below the fence to estimate population size below the fence.

2. Use existing data of the Nepisiguit Salmon Association to examine the effects of merganser predation on juvenile salmon survival rates. Reanalyse juvenile salmon size data collected during electrofishing surveys to assign ages based on length-frequency distributions rather than predetermined size classes. Use these data to examine rates of parr mortalities from 0+ to 1+ age classes, and compare to other rivers with lower merganser abundances.

12 - Acknowledgements

Much of the data was collected by the Nepisiguit Salmon Association and Pabineau First Nation; we especially thank R. Baker, president of the NSA. Trapnet and fence operations were assisted by R. Pickard and A. Steeves (DFO). P. Cameron and L. Anderson supplied DFO hatchery stocking data. W. Hooper and L. McCabe supplied DNRE FISHSYS statistics.

13 - Literature Cited

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Table 1. Monthly angling catches, effort, and catch per unit effort (CPUE) of Atlantic salmon on the Nepisiguit River in 1995. Information provided by the Nepisiguit Salmon Association.

Month	Small salmon catch		Large salmon catch	Angling effort	CPUE (catch·rod-day)
	Retained	Released	Released	(Rod-days)	
June	15	0	25	300	0.22
July	75	10	25	500	0.17
August	25	5	0	200	0.14
Sept.	135	50	140	1200	0.27
Oct.	100	35	110	700	0.35
TOTAL	350	100	300	2900	0.26

Table 2. Estimates of angling catch of Atlantic salmon in the Nepisiguit River, 1951-1995. Based on DFO (C&P) statistics in 1951-1983 and 1985, Nepisiguit Salmon Association statistics in 1984, 1986-1995, DNRE Fishsys angler surveys from 1969-1995.

(a) Data for bright and kelt fisheries, collected by DFO C&P, 1951-1983. All fish caught are assumed to have been retained.

	Bright Fish			Kelts			
Year	Small	Large	Total	Small	Large	Total	Total rod-days
1951	.	.	286	.	.	40	1776
1952	.	.	415	.	.	30	1765
1953	.	.	595	.	.	42	2035
1954	.	.	1255	.	.	42	1640
1955	.	.	783	.	.	148	2275
1956	.	.	389	.	.	117	1686
1957	.	.	590	.	.	135	3130
1958	.	.	963	.	.	85	3540
1959	.	.	376	.	.	85	2150
1960	.	.	193	.	.	50	905
1961	.	.	313	.	.	25	1360
1962	.	.	446	.	.	70	1570
1963	.	.	334	.	.	10	878
1964	.	.	232	.	.	213	557
1965	473	20	493	120	6	126	371
1966	407	38	445	.	.	354	818
1967	410	46	456	.	.	42	604
1968	189	5	194	.	.	55	551
1969	38	5	43	.	.	32	480
1970	2	0	2	.	.	0	97
1971	16	1	17	.	.	0	192
1972	16	10	26	.	.	0	165
1973	0	95	95	.	.	0	1000
1974	28	140	168	.	.	7	1227
1975	77	95	172	8	14	22	1457
1976	335	100	435	3	0	3	576
1977	28	38	66	0	0	0	678
1978	40	69	109	0	0	0	1215
1979	44	6	50	0	15	15	614
1980	135	103	238	.	.	.	1515
1981	130	179	309	46	62	108	1730
1982	130	187	317	25	30	55	1780
1983	117	176	293	.	.	.	1343

Table 2. Continued.

(b) Angling data collected by Nepisiguit Salmon Association (except 1985, which is based on DFO C&P data), showing removals and releases for the bright fishery.

Year	Removed		Released		Rod-days	Catch per rod-day
	Small	Large	Small	Large		
1984	600	0	150	150	3015	0.30
1985	229	0	--	--	1734	----
1986	800	0	400	500	3600	0.47
1987	800	0	550	500	4250	0.44
1988	1000	0	400	600	5000	0.40
1989	600	0	100	490	4000	0.30
1990	500	0	100	300	3400	0.26
1991	700	0	150	300	3700	0.31
1992	800	0	330	270	4700	0.30
1993	470	0	85	258	3300	0.25
1994	380	0	70	250	3700	0.19
1995	350	0	100	300	2900	0.26

Table 2. Continued.

(c) Angling data from DNRE FISHSYS angler surveys, 1969-1995, showing estimates of retained small salmon and released large salmon for the bright fishery.

Year	Small salmon (removed)	Large salmon (released)	Total Rod-days	CPUE (catch/rod-day)
1969	46	9	150	0.37
1970	41	0	196	0.21
1971	0	0	38	0.00
1972	23	20	352	0.12
1973	0	14	294	0.05
1974	39	12	633	0.08
1975	8	8	57	0.28
1976	207	79	633	0.45
1977	52	0	221	0.24
1978	18	30	473	0.10
1979	14	0	1052	0.01
1980	752	145	2952	0.30
1981	1033	170	3599	0.33
1982	522	81	3429	0.18
1983	430	50	4140	0.12
1984	814	289	2444	0.45
1985	1135	653	7084	0.25
1986	2018	939	7365	0.40
1987	1903	1072	7498	0.40
1988	1429	703	6578	0.32
1989	778	795	5433	0.29
1990	1035	528	9781	0.16
1991	1628	792	10869	0.22
1992	1153	705	11861	0.16
1993	1546	1013	12393	0.21
1994	484	147	5044	0.13
1995	490	20	3070	0.17

Table 3. Angling records from logbooks distributed to Nepisiguit Salmon Association members, 1995. Numbers of landed fish only.

Angler	Rod-days			Small salmon					Large salmon			Total catch		Catch/rod-day		
				Retained		Released			Released			Small+Large				
	Above fence	Below fence	Total	Above fence	Below fence	Above fence	Below fence	Total catch	Above fence	Below fence	Total catch	Above fence	Below fence	Above fence	Below fence	Total
1	13	4	17	0	4	0	0	4	1	3	4	1	7	0.08	1.75	0.47
2	3	0	3	1	0	0	0	1	0	0	0	1	0	0.33		0.33
3	8	1	9	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
4	0	8	8	0	3	0	0	3	0	0	0	0	3		0.38	0.38
5	2	8	10	0	2	0	0	2	0	0	0	0	2	0.00	0.25	0.20
6	1	12	13	0	2	0	0	2	0	1	1	0	3	0.00	0.25	0.23
7	0	6	6	0	2	0	0	2	0	1	1	0	3		0.50	0.50
8	0.5	14.5	15	0	5	0	0	5	0	8	8	0	13	0.00	0.90	0.87
9	12.5	4.5	17	1	0	0	0	1	0	0	0	1	0	0.08	0.00	0.06
10	9	13	22	1	2	0	0	3	0	1	1	1	3	0.11	0.23	0.18
11	5	11	16	1	2	0	0	3	0	1	1	1	3	0.20	0.27	0.25
12	2.5	5.5	8	0	0	0	0	0	0	1	1	0	1	0.00	0.18	0.13
13	2.5	33.5	36	0	0	2	12	14	0	8	8	2	20	0.80	0.60	0.61
Mean	4.5	9.3	13.8	0.3	1.7	0.2	0.9	3.1	0.1	1.8	1.9	0.5	4.5	0.12	0.41	0.32
1994	3.8	7.4	11.2	0.8	0.6	0.2	0.8	2.4	0	0.7	0.7	0.9	2.2	0.24	0.29	0.27

Table 4. Number of juvenile salmon stocked to the Nepisiguit system. Value in parentheses is percentage of salmon marked (AC=adipose fin clip, NT = magnetic wire nose tag, CT = Carlin tag). Source: 1976-1981, Newbould 1983; 1982-1992, Nepisiguit Salmon Association; 1993-1995, Charlo Salmonid Enhancement Centre). Swim-up fry from streamside incubation boxes, all other life stages from hatcheries.

Year	Swim-up fry	Feeding fry (3 cm)	Fingerling fry (7 cm)	1+ parr	2+ smolt	YEARLY TOTAL
1976	----	----	78,196 (unmarked)	----	33,101 (100% AC)	111,297
1977	----	----	----	----	----	0
1978	----	----	166,283 (100% AC)	5,320 (100% AC)	----	171,603
1979	----	138,600 (unmarked)	86,947 (100% AC)	4,229 (100% AC)	2,002 (100% AC&CT)	231,778
1980	----	----	178,047 (100% AC)	6,978 (100% AC)	23,588 (100% AC&NT)	208,613
1981	----	176,440 (unmarked)	498,301 (100% AC)	3,819 (100% AC)	7,635 (100% AC&NT)	686,195
1982	----	----	293,140 (100% AC)	2,980 (100% AC)	----	296,120
1983	----	216,172 (unmarked)	298,453 (100% AC)	10,645 (100% AC)	10,454 (100% AC)	535,724
1984	----	65,576 (unmarked)	261,141 (100% AC)	18,667 (100% AC)	10,752 (100% AC&NT)	356,136
1985	25,669 (unmarked)	----	316,618 (100% AC)	11,153 (100% AC)	10,650 (100% AC)	364,090
1986	48,312 (unmarked)	98,734 (unmarked)	268,277 (unmarked)	2,540 (100% AC)	12,937 (100% AC&NT)	430,800
1987	144,450 (unmarked)	82,306 (unmarked)	206,814 (unmarked)	1,872 (100% AC)	10,706 (100% AC&NT)	446,148

Table 4. Continued.

Year	Streamside incubation	Feeding fry (3 cm)	Fingerling fry (7 cm)	1+ parr	2+ smolt	YEARLY TOTAL
1988	293,465 (unmarked)	141,000 (unmarked)	208,000 (unmarked)	----	10,000 (100%AC&NT)	652,465
1989	335,533 (unmarked)	----	284,004 (28% AC)	----	10,000 (100%AC&NT)	629,537
1990	342,981 (unmarked)	----	400,000 (35% AC)	6,500 (100%AC)	11,700 (100% AC&NT)	761,181
1991	243,016 (unmarked)	----	177,000 (100% AC)	----	9,700 (100% AC&NT)	429,716
1992	335,801 (unmarked)	118,542 (unmarked)	146,950 (10% AC)	12,441	11,641 (100% AC)	625,375
1993	336,277 (unmarked)	----	149,522 (65% AC)	30,944 (100% AC)	----	516,743
1994	255,000 (unmarked)	168,000 (unmarked)	----	----	----	423,000
1995	105,000 (unmarked)	----	90,906 (13% AC)	----	----	91,011

TOTAL STOCKED, 1976 - 1995: 7,967,532

Table 5. Dates of operation of the Nepisiguit counting fence, 1982-1994.

YEAR	OPERATION DATES
1982	May 28-Nov. 1
1983	May 26-Nov. 4
1984	May 27-30, June 4-Nov. 7
1985	May 30-Nov. 8
1986	June 2-Nov. 5
1987	June 4-July 12, July 17-Nov. 5
1988	June 3-Oct. 23
1989	June 5-Aug. 14, Aug. 17-Nov. 6
1990	June 15-July 25, Aug. 4-11, Aug. 26-Sept. 4
1991	June 22-July 5, July 9-12, July 16-19, July 23-26, July 30-31, Aug. 1-2, Aug. 6-9, Aug. 13-15, Aug. 19-22, Aug. 26-30, Sept. 3-13
1992	June 25-Oct. 23
1993	July 2-Oct. 25
1994	June 29-Oct. 26
1995	July 6-Oct. 20

Table 6. Salmon counts at the fence, subdivided into adipose fin-clipped (AC) and unclipped salmon.

	Small salmon			Large salmon		
Year	AC	not AC	Total	AC	not AC	Total
1982	211	784	995	138	234	372
1983	70	236	306	29	262	291
1984	125	831	956	102	310	412
1985	160	349	509	194	627	821
1986	496	913	1409	363	581	944
1987	734	1000	1734	477	905	1382
1988	552	1865	2417	460	1392	1852
1989	90	386	476	323	757	1080
1990*	65 (564)	87 (755)	152 (1319)	59 (303)	125 (641)	184 (944)
1991*	15 (226)	104 (1570)	119 (1796)	22 (175)	88 (698)	110 (873)
1992	182	930	1112	13	428	441
1993*	14 (100)	104 (742)	118 (842)	20 (80)	177 (709)	197 (789)
1994*	24 (52)	242 (525)	266 (577)	6 (17)	227 (635)	233 (652)
1995*	8 (26)	173 (551)	181 (577)	12 (25)	359 (757)	371 (782)

* numbers in parentheses are estimated counts at fence, obtained by regression analysis as explained in the text.

Table 7. Monthly returns to the fence of adipose fin-clipped salmon. Numbers in parentheses are percentages of nose-tagged fish (included in adipose-clipped percentages).

(a) Percentage of adipose-clipped large salmon relative to total large salmon counted at the fence, by month.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1982	100	65 (3)	51 (3)	29 (3)	26	19 (1)	40	37
1983	100	5	13 (3)	29 (18)	9	11 (2)	0	10
1984	--	19	34	38	18	19	14	25
1985	--	48	32	21	13	12	0	24
1986	--	72	61	34	18	16	14	38
1987	--	58	58	36	30	22	0	34
1988	--	66	46	23	25	13	--	25
1989	--	62	36	35	23	15	12	30
1990	--	42	32	13	20	--	--	32
1991	--	40	29	21	7	--	--	20
1992	--	4	5	0	2	0	--	3
1993	--	--	15	7	6	0	--	10
1994	--	0	3	0	2	1	--	2
1995	--	--	8	25	9	0	--	3

(b) Percentage of adipose-clipped small salmon relative to total small salmon counted at the fence, by month.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1982	0	39 (11)	18 (2)	19	21 (3)	21 (3)	12	21
1983	--	18 (9)	37 (8)	25 (8)	19	8	0	23
1984	--	7	19	10	4	4	0	13
1985	--	100	49	12	13	3	0	31
1986	--	37	42	34	36	26	33	35
1987	--	78	62	48	26	17	0	42
1988	--	61	41	29	24	8	--	23
1989	--	54	32	6	15	15	0	19
1990	--	44	61	14	20	--	--	43
1991	--	0	0	14	7	--	--	13
1992	--	41	26	7	1	2	--	16
1993	--	--	20	4	0	5	--	13
1994	--	0	22	14	2	0	--	10
1995	--	--	13	0	5	1	--	5

Table 8. Summary of Carlin tags applied to Atlantic salmon at trapnets and recaptured at counting fence and by anglers in Nepisiguit River, 1995.

Tag applications:

Trapnet	No. of small salmon tagged	No. of large salmon tagged
Floating trap	19	6
Picket trap	121	31
Total	140	37

Tag recoveries:

Small salmon:

Tag No.	Date applied	Date recaptured	Days at large	Recapture location
64162	Oct. 7	Oct. 11	4	Gray's Ledge
64164	Oct. 7	Oct. 12	5	Fence
64184	Oct. 12	Oct. 13	1	Pumphouse

Large salmon:

Tag No.	Date applied	Date recaptured	Days at large	Recapture location
65013	June 28	Sept. 11	75	Fence
65016	Sept. 11	Sept. 23	12	Fence
65020	Sept. 20	Sept. 27	7	Fence

Table 9. Redd counts in the Nepisiguit River and tributaries. Above and below fence refer to the 1991 fence location. Both tributaries are located below the fence. (--) indicates that no observations were made.

Year	Nepisiguit River			Pabineau River	Gordon Meadow Brook	% of redds above fence
	Above fence	Below fence	Total			
1981	--	--	--	17	8	--
1982	149	87	236	52	66	63.1
1983	1164	414	1578	--	--	73.8
1984	1014	564	1578	--	--	64.3
1985	1341	513	1854	--	--	72.3
1986	2250	692	2942	337	91	76.5
1987	2447	1383	3830	158	64	63.9
1988	3017	1468	4485	177	39	67.3
1989	732[a]	43[a]	775[a]	--	--	--
1990	--	--	--	--	--	--
1991	--	--	--	--	--	--
1992	--	--	--	--	--	--
1993	1647	--	1647[a]	--	--	--
1994	2198	754	2952	--	--	74.5
1995	2763[a]	163	2926[a]	--	--	--
						Mean = 69.5%

[a] Incomplete counts

Table 10. Distribution of angling above and below the fence, based on angler scale data returns.

Year	Large salmon		Small salmon		Combined
	Above fence	Below fence	Above fence	Below fence	% Above fence
1982	5	21	19	64	22.0
1983	3	8	5	4	40.0
1984	-	-	-	-	--
1985	-	-	24	33	42.1
1986	-	-	15	43	25.9
1987	-	-	20	25	44.4
1988	-	-	16	28	36.4
1989	-	-	18	32	36.0
1990	-	-	26	33	44.1
1991	-	-	20	21	48.8
1992	-	-	36	36	50.0
1993	-	-	22	24	47.8
1994	-	-	21	25	45.7
1995	-	-	12	36	25.0
					MEAN = 39.1 %

Table 11. Calculations of total returns and spawners for large salmon.

(a) Above the fence.

Year	[1] Returns to fence	[2] Brood-stock	[3] Mortality at fence	[4] Native harvest	[5] Angling mortality	[6]=[1]-[2]-[3]-[4]-[5] Spawners
1982	372	68	0	59	74	171
1983	291	87	0	59	70	75
1984	412	92	1	59	2	258
1985	821	111	0	59	0	651
1986	944	104	0	59	6	775
1987	1382	150	0	59	6	1167
1988	1852	151	0	59	7	1635
1989	1080	164	0	59	6	851
1990	944	114	0	59	4	767
1991	873	104	1	59	4	705
1992	441	147	1	59	3	231
1993	789	128	3	20	3	635
1994	652	112	0	0	3	537
1995	782	162	3	44	4	569

(b) Below the fence.

Year	[6] Spawners above fence	[7]=[6] x 0.439 Spawners below fence	[8] Angling mortality	[9] Native harvest	[10] Commer-cial harvest	[11]=[7]+[8]+[9]+[10] Returns below fence
1982	171	78	113	91	14	296
1983	75	34	106	91	23	254
1984	258	118	3	91	68	280
1985	651	297	0	91	0	397
1986	775	353	9	91	0	453
1987	1167	532	9	91	0	632
1988	1635	746	11	91	0	848
1989	851	388	9	91	0	488
1990	767	350	5	91	0	446
1991	705	321	5	91	0	417
1992	231	105	5	91	0	201
1993	635	290	5	30	0	295
1994	537	236	4	0	0	240
1995	569	250	5	0	0	255

Table 12. Calculations of total returns and spawners for small salmon.

(a) Above the fence.

Year	[1] Returns to fence	[2] Brood-stock	[3] Mortality at fence	[4] Native harvest	[5] Angling mortality	[6]=[1]-[2]-[3]-[4]-[5] Spawners
1982	995	84	0	20	51	840
1983	306	17	0	20	46	223
1984	956	4	7	20	239	686
1985	509	4	0	20	90	395
1986	1409	5	1	20	321	1062
1987	1734	6	0	20	323	1385
1988	2417	5	0	20	400	1992
1989	476	6	0	20	238	212
1990	1319	6	0	20	199	1094
1991	1796	10	1	20	279	1486
1992	1112	16	6	20	320	750
1993	842	0	2	79	187	574
1994	577	15	0	60	154	348
1995	577	9	0	131	142	295

(b) Below the fence.

Year	[6] Spawners above fence	[7]=[6] x 0.439 Spawners below fence	[8] Angling mortality	[9] Native harvest	[10] Commer-cial harvest	[11]=[7]+[8]+[9]+[10] Returns below fence
1982	840	383	79	30	50	542
1983	223	102	71	30	53	256
1984	686	313	366	30	474	1183
1985	395	180	139	30	0	349
1986	1062	484	491	30	0	1005
1987	1385	632	494	30	0	1156
1988	1992	908	702	30	0	1640
1989	212	97	365	30	0	492
1990	1094	499	304	30	0	833
1991	1486	678	426	30	0	1134
1992	750	342	490	30	0	862
1993	574	262	286	121	0	669
1994	348	153	228	60	0	441
1995	295	130	211	0	0	341

Table 13. Annual estimates of total returns and total spawners for large and small salmon. Spawner numbers in bold type exceeded the target spawning escapement of 1363 large salmon, and 690 small salmon.

Year	Large salmon		Small salmon	
	Returns	Spawners	Returns	Spawners
1982	668	249	1537	**1223**
1983	545	109	562	325
1984	692	376	2139	**999**
1985	1218	948	858	575
1986	1397	1128	2414	**1546**
1987	2014	**1699**	2890	**2017**
1988	2700	**2381**	4057	**2900**
1989	1568	1239	968	309
1990	1390	1117	2152	**1593**
1991	1290	1026	2930	**2164**
1992	642	336	1974	**1092**
1993	1084	925	1511	**836**
1994	892	773	1018	501
1995	1037	819	918	425

Table 14. Annual estimates of egg deposition relative to target egg deposition of 9.535 x 10^6 eggs.

Year	No. of eggs (x10^6)			% of spawning
	Large salmon	Small salmon	Total	requirement met
1982	1.742	0.512	2.254	24
1983	0.763	0.136	0.899	9
1984	2.631	0.418	3.049	32
1985	6.634	0.241	6.875	72
1986	7.893	0.648	8.541	90
1987	11.889	0.845	12.734	134
1988	16.662	1.215	17.877	187
1989	8.670	0.129	8.799	92
1990	7.816	0.667	8.483	89
1991	7.180	0.906	8.086	85
1992	2.351	0.457	2.808	29
1993	6.472	0.350	6.822	72
1994	5.409	0.210	5.619	59
1995	5.731	0.178	5.909	62

Assumptions:
Mean weight: large salmon, 5.6 kg; small salmon, 1.4 kg
% females: large salmon, 71%; small salmon, 17%
fecundity: 1760 eggs.kg^{-1}

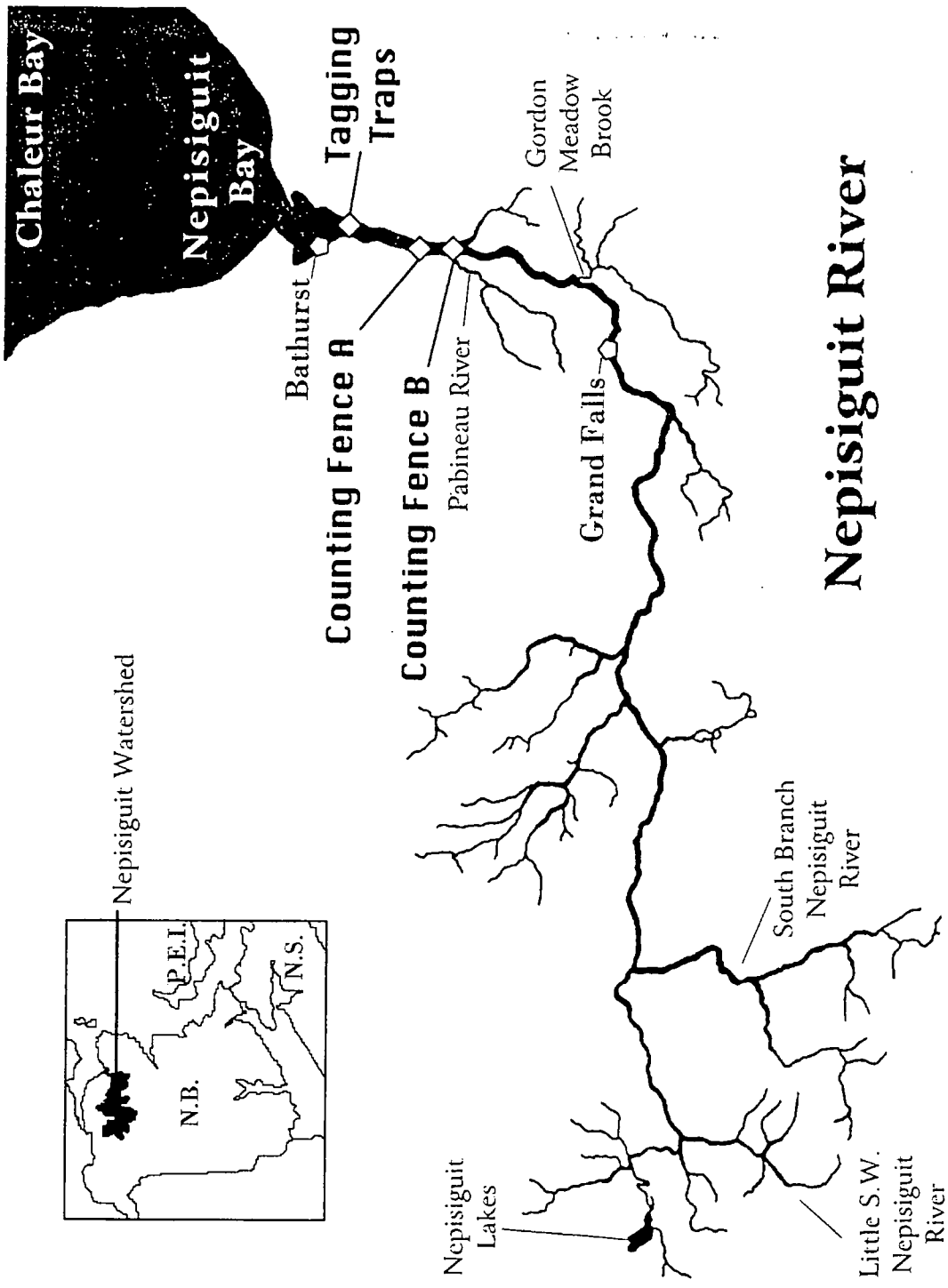


Figure 1. Map of the Nepisiguit River system, showing locations of the counting fence in 1981-1991 and 1995 (A) and 1992-1994 (B), and the tagging traps in 1994-1995.

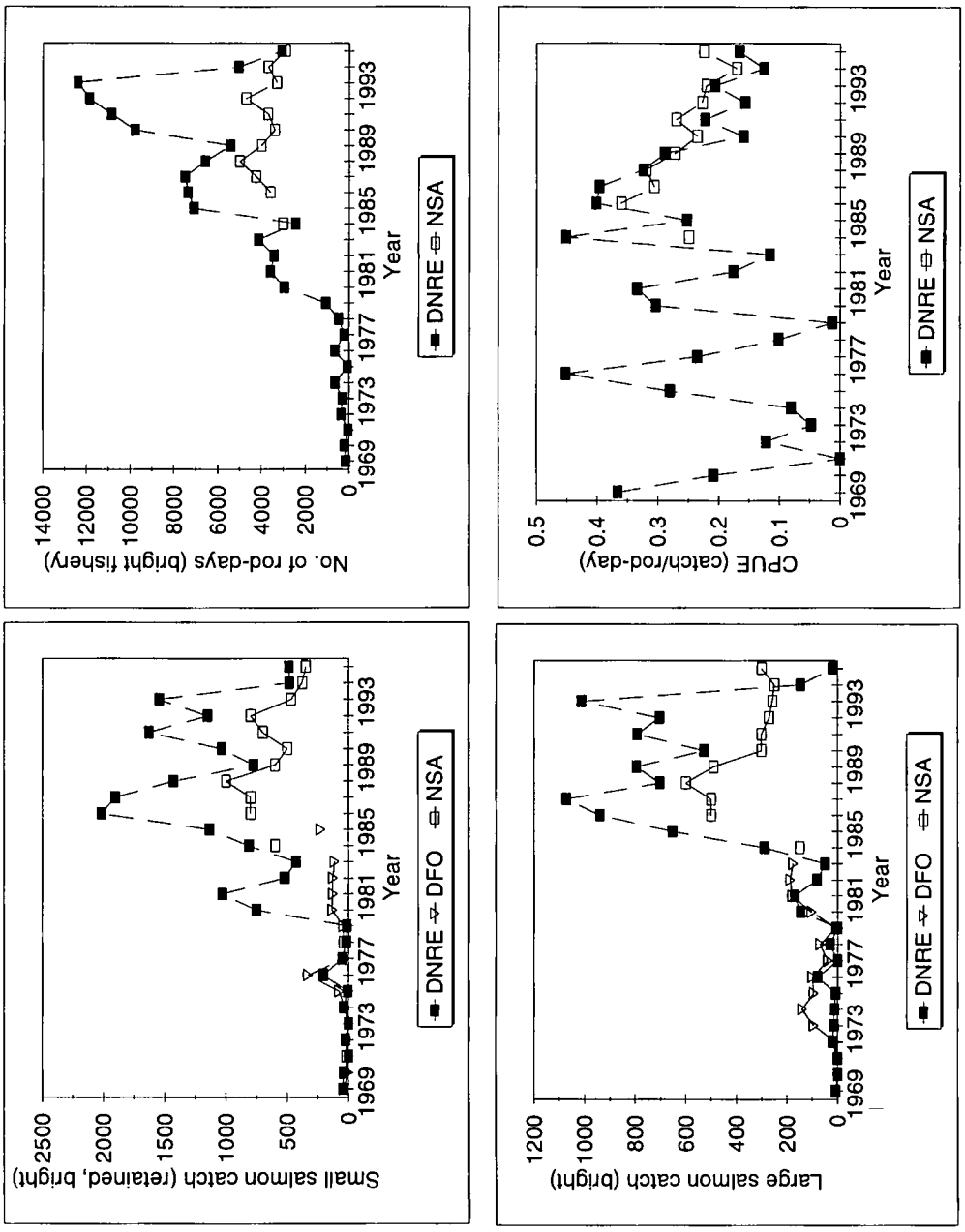


Figure 2. Angling catches of bright Atlantic salmon on the Nepisiguit River, 1969-1995, according to estimates by Nepisiguit Salmon Association (NSA), Dept. of Fisheries and Oceans Conservation and Protection officers (DFO) and Dept. of Natural Resources and Energy (DNRE) FISHSYS. Estimates of rod-days and catch per unit effort (CPUE) are compared for DNRE and NSA data.

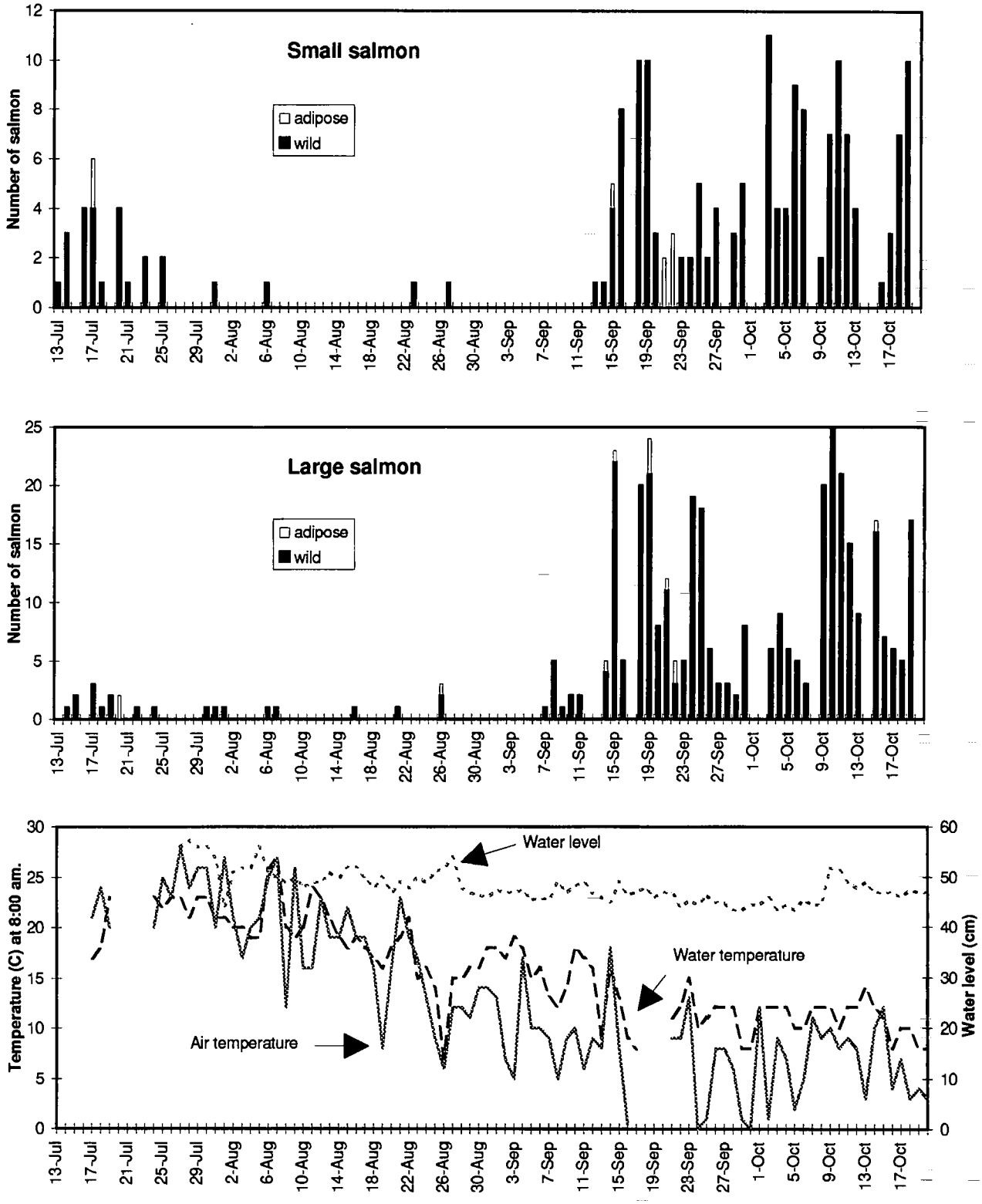


Fig 3. Daily returns of small and large salmon, and environmental conditions at the Nepisiguit River counting fence, 1995.

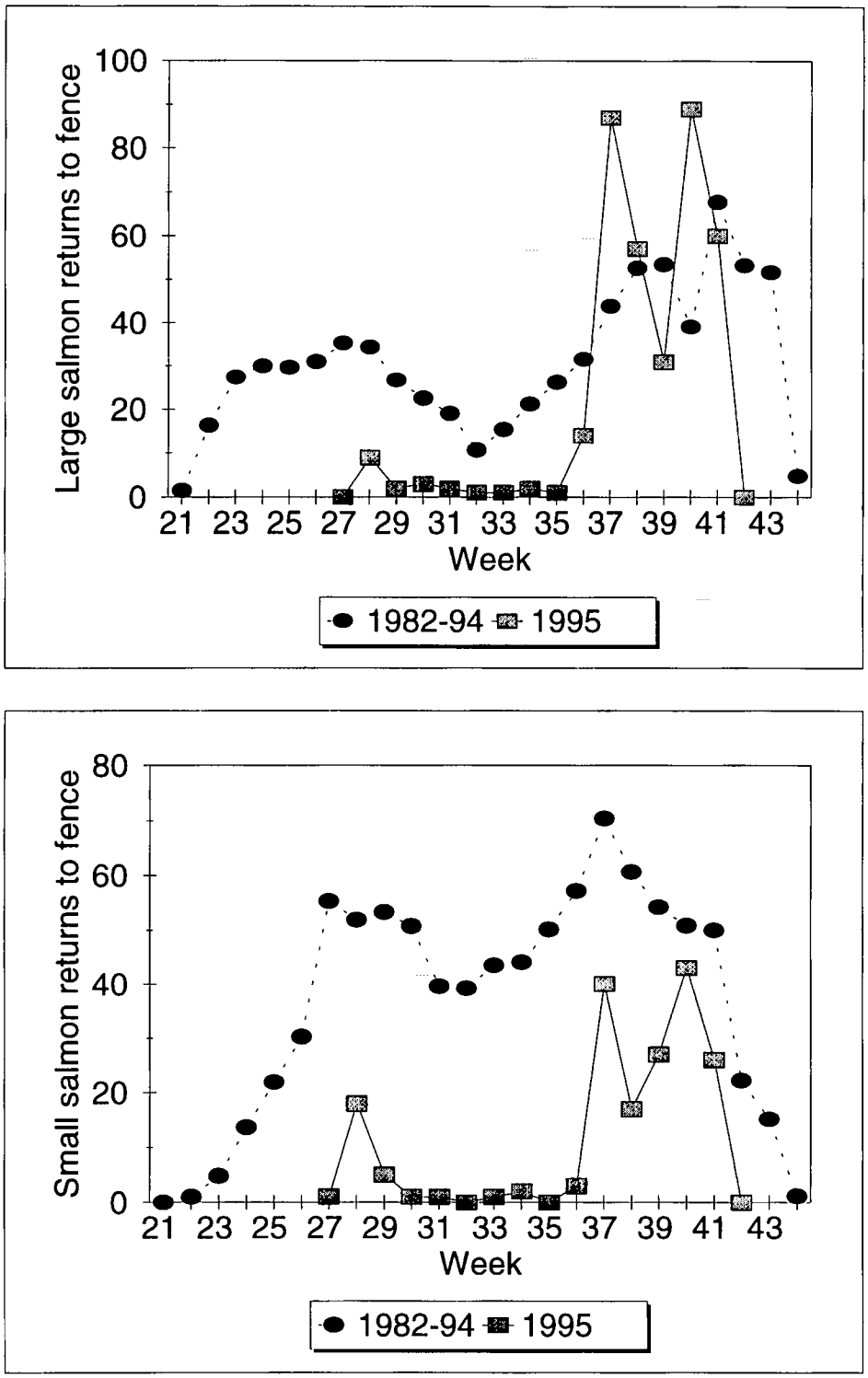


Figure 4. Timing of large and small salmon returns (summed by week) to the counting fence in 1995 compared with mean timing (1982-1994).

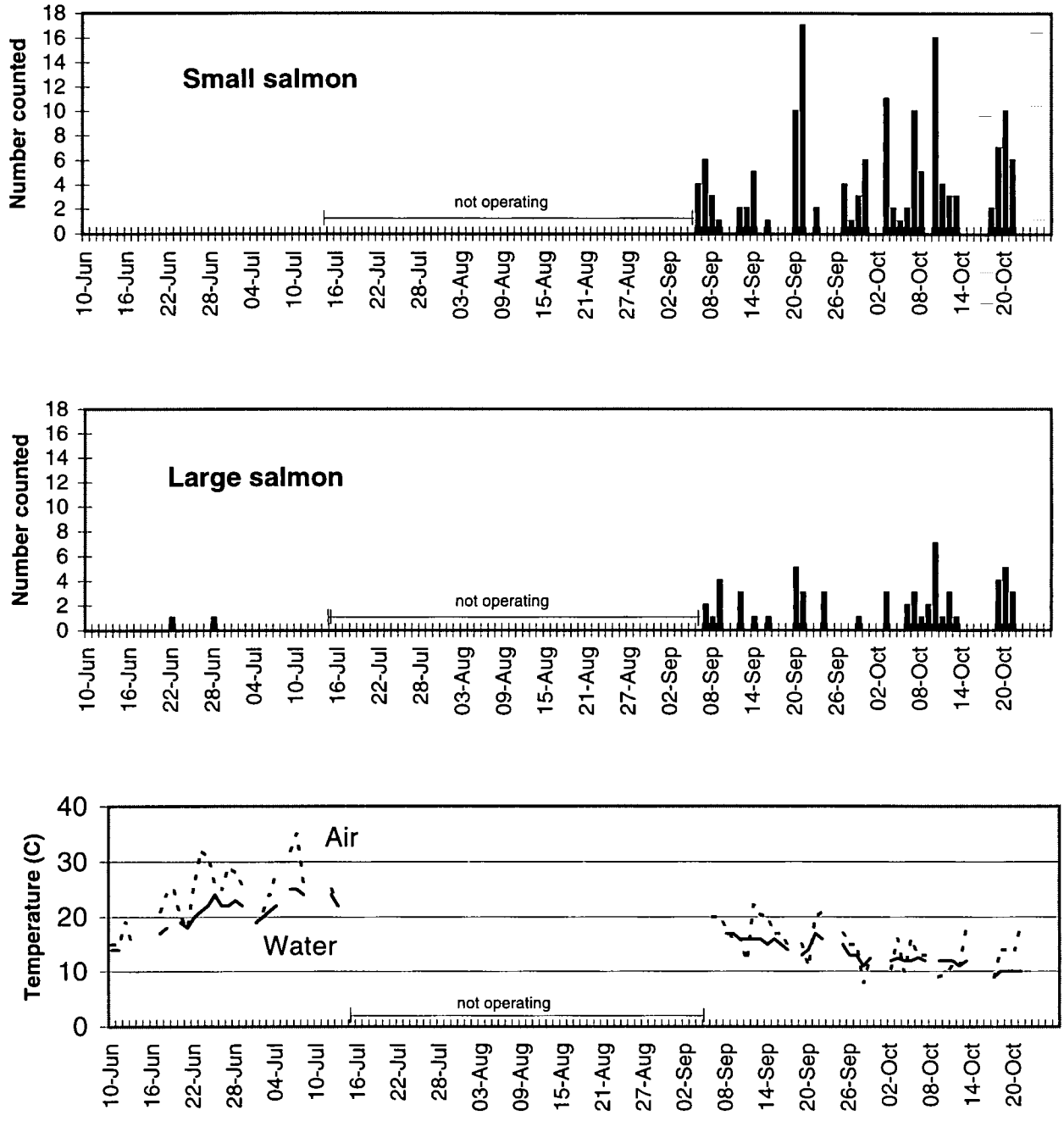
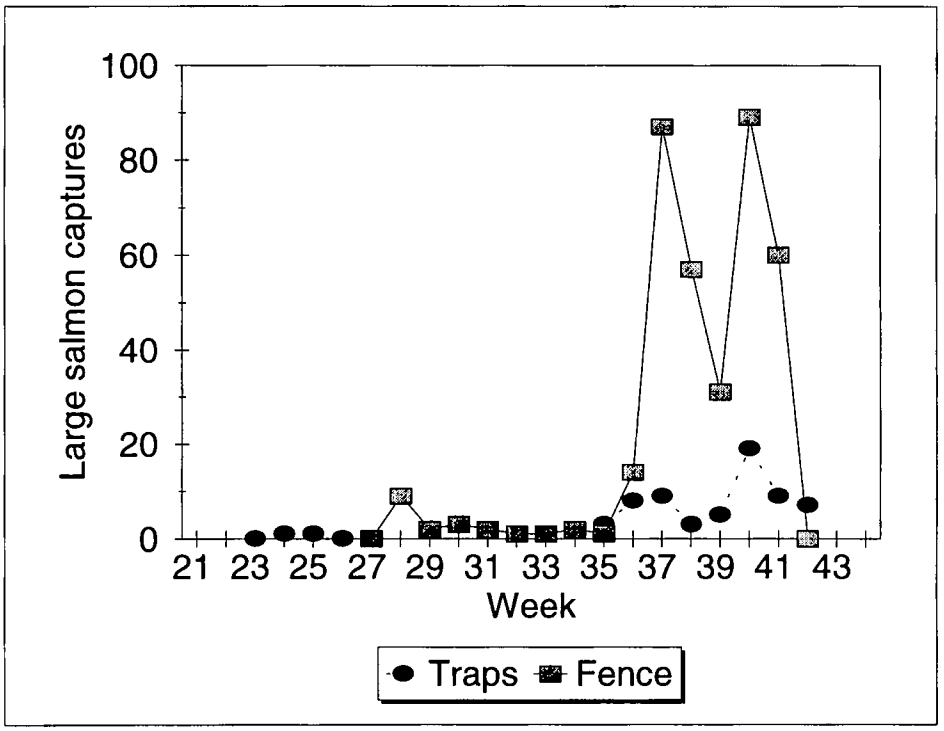


Figure 5. Daily catch of small and large salmon, and air and water temperatures at the Nepisiguit River research trapnets, 1995.



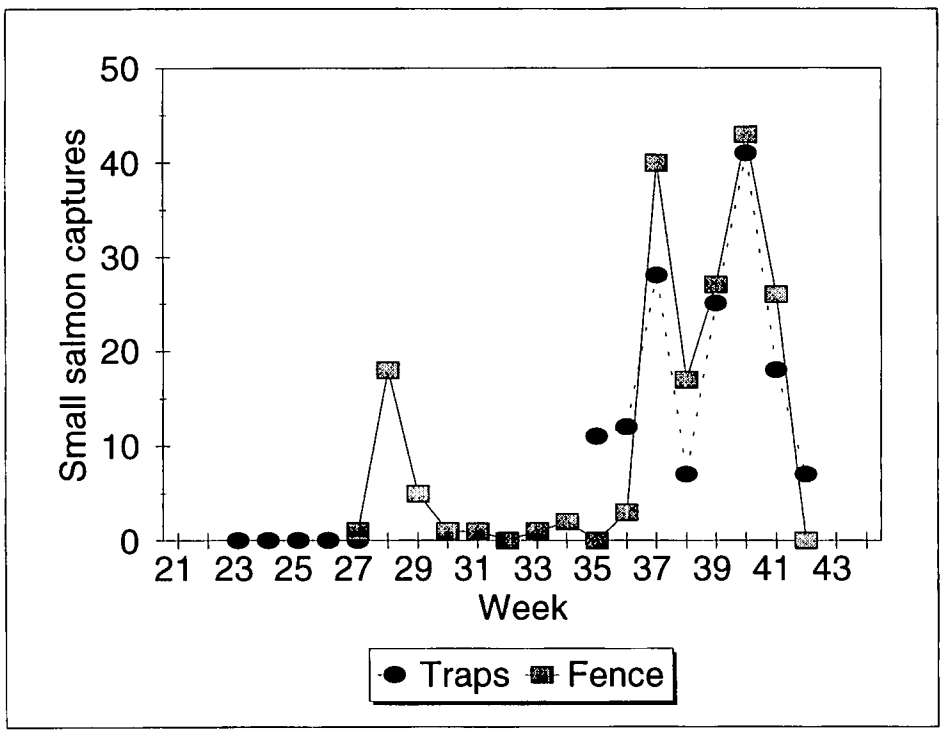


Figure 6. Comparison of run timing of large and small salmon at the Nepisiguit River counting fence and trapnets, summed by week, 1995.

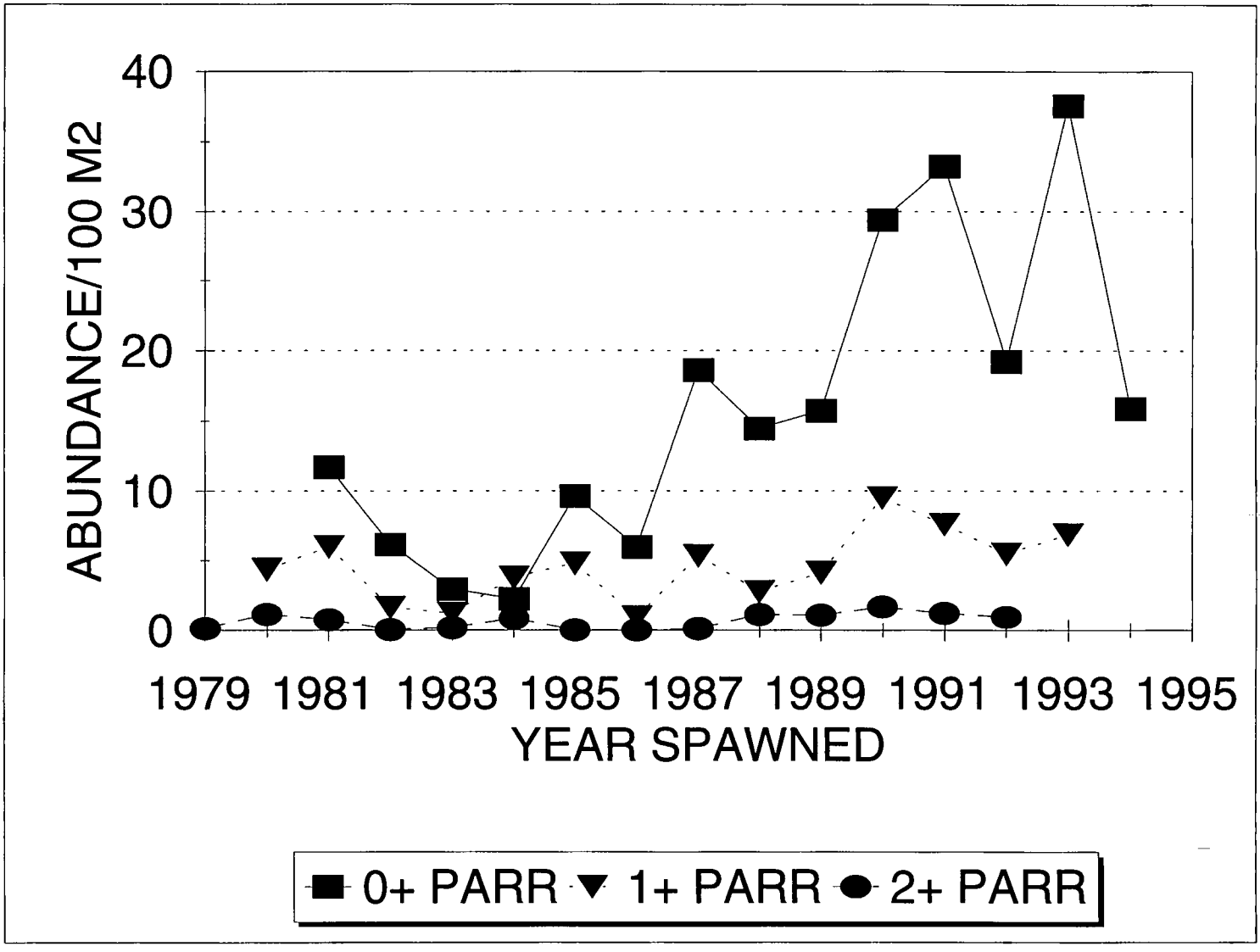


Figure 7. Mean juvenile salmon abundance at electrofishing sites on the Nepisiguit River below Grand Falls, Pabineau River and Gordon Meadow Brook, by year of egg production.

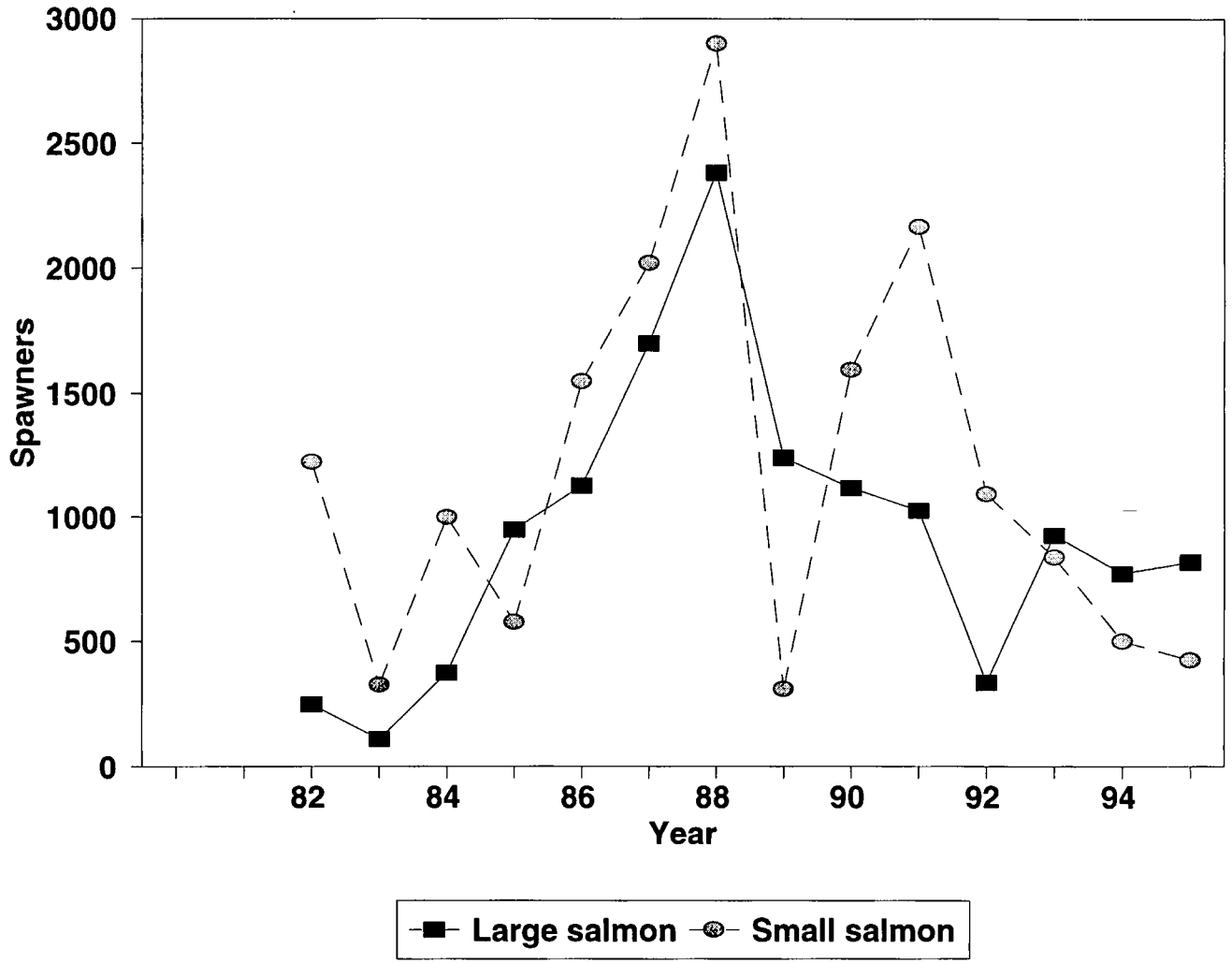


Figure 8. Estimated large and small salmon spawners in the Nepisiguit River, 1982-1995.

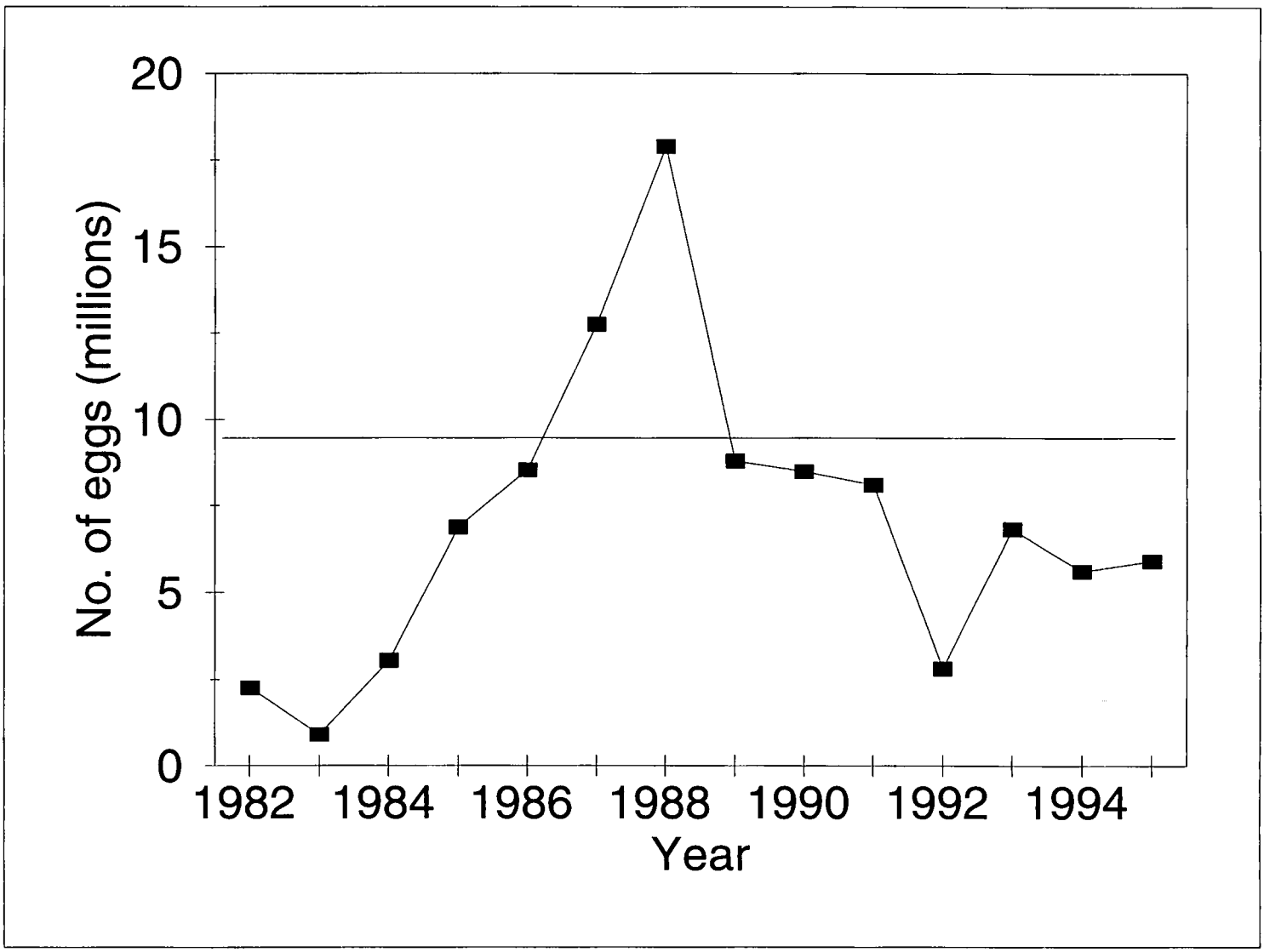
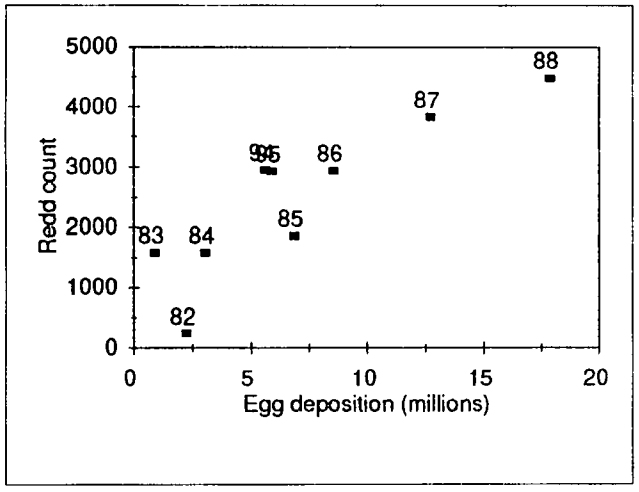
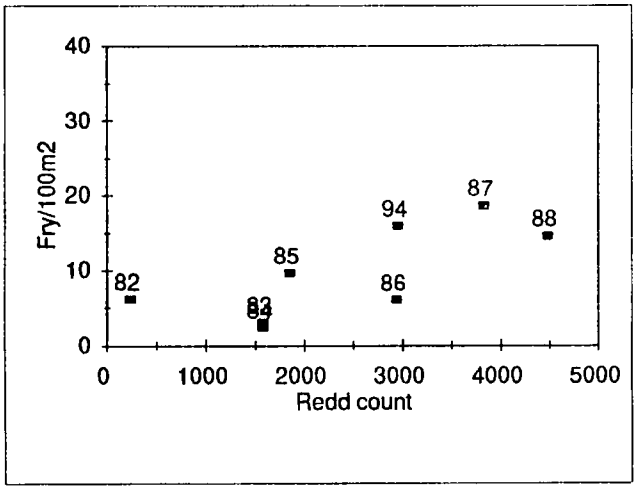


Figure 9. Estimated egg deposition of small and large Atlantic salmon combined, Nepisiguit River, 1982-1995. The horizontal line at 9.5 x 10^6 eggs is the target egg deposition.





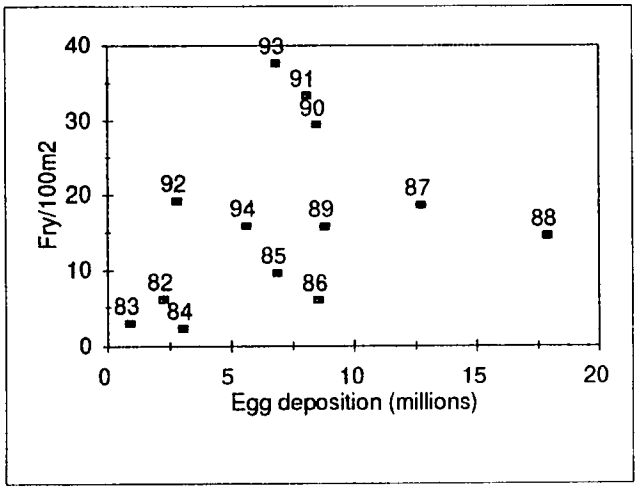
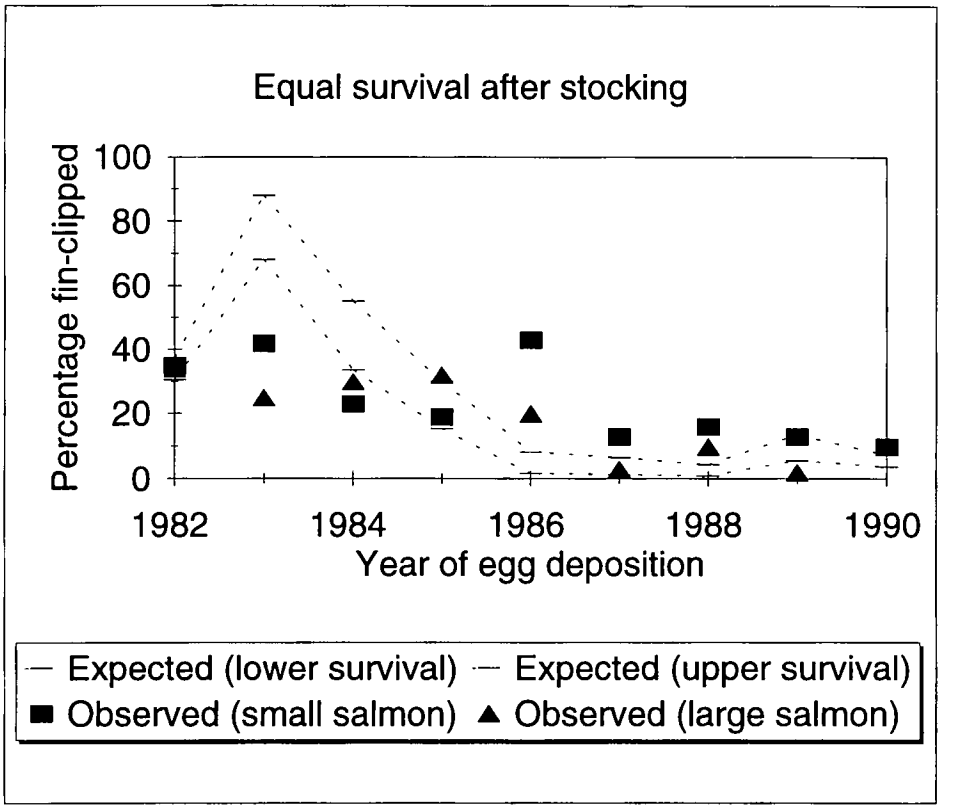


Figure 10. Comparison of estimated egg deposition, redd counts and mean age 0 parr abundances by year of spawning, in the Nepisiguit River from 1982 to 1995.



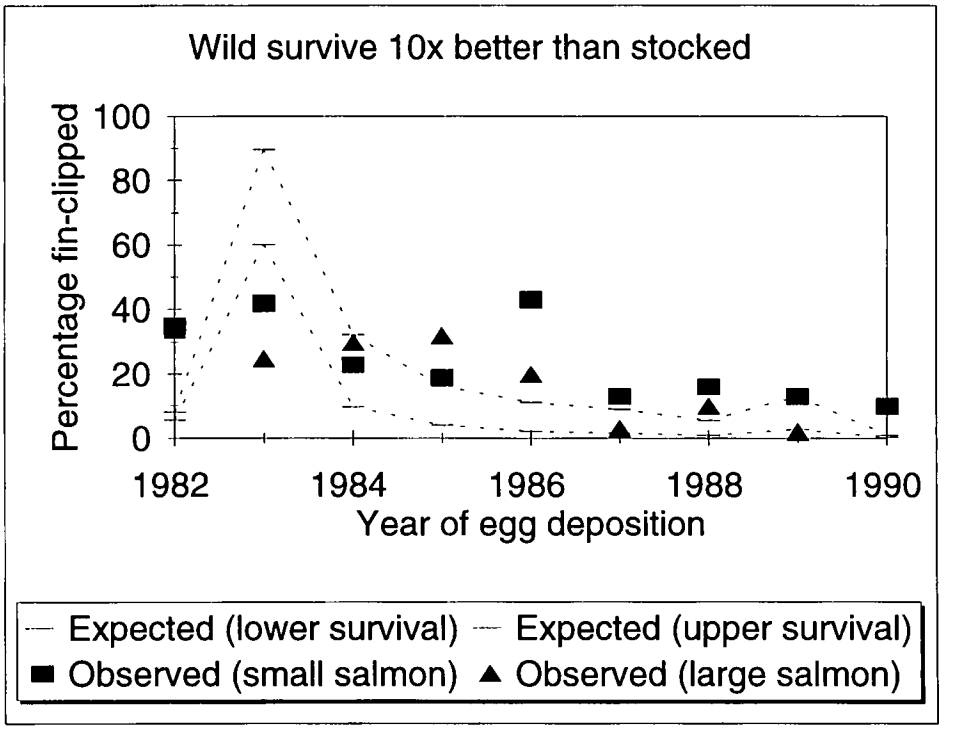


Figure 11. Observed and expected proportions of fin-clipped adult salmon returning to the Nepisiguit River counting fence, by year of egg deposition. Broken lines indicate the range of expected rates of return, assuming upper and lower juvenile survival rates of Symons(1979) and either (i) equal survival of wild and stocked juveniles or (ii) 90% reduction in first-year survival of stocked fish.

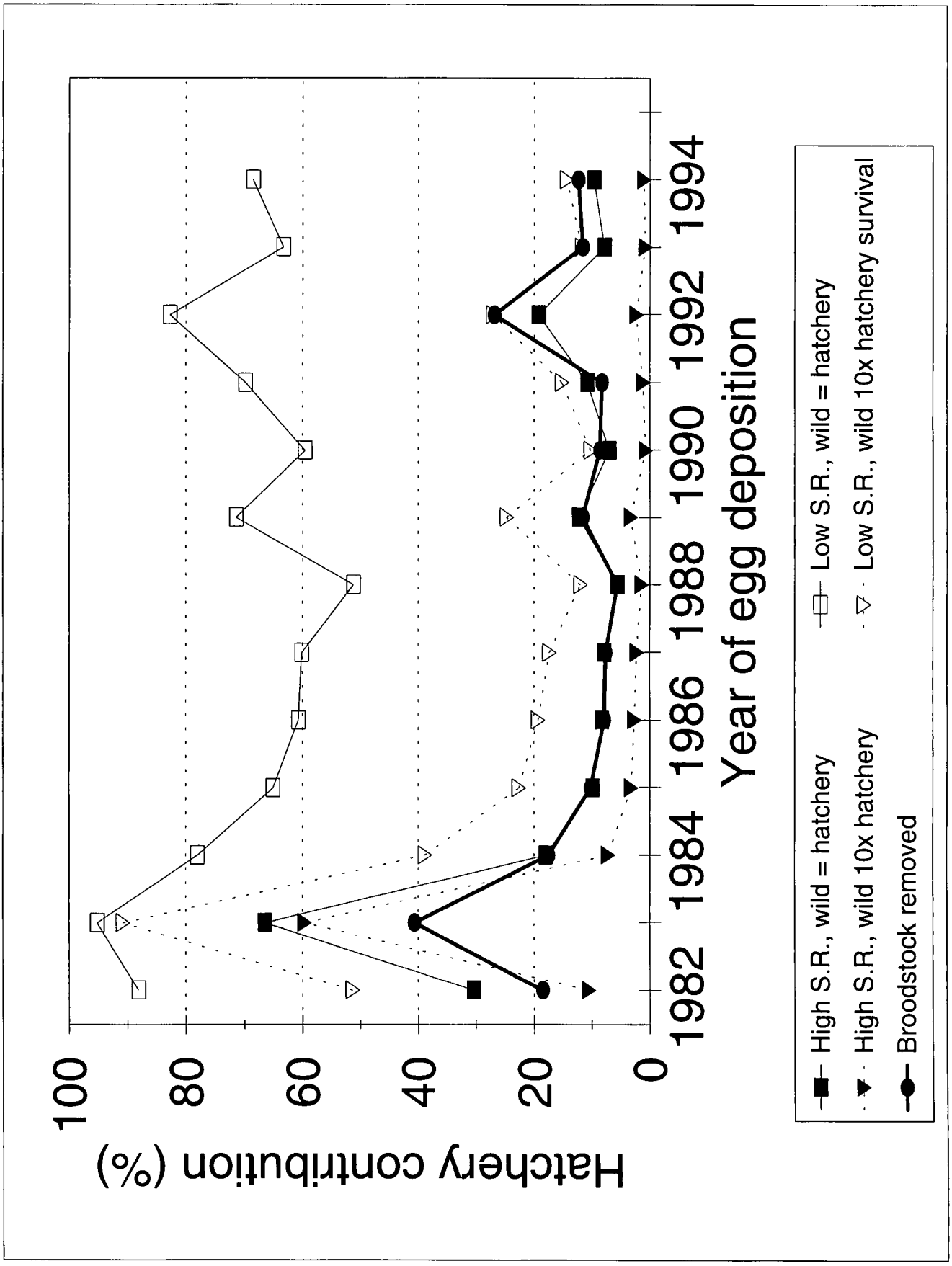


Figure 12. Expected contribution of hatchery-spawned eggs to smolt production, compared to expected contribution that the broodstock would have made if they had spawned in the wild. Survival rates as in Figure 11.

Appendix 1. Supporting data for the model of potential smolt production from wild and hatchery-reared stock, and contribution of broodstock.

(1) Assuming equal survival rates of wild and hatchery-stocked juveniles.

Year (x)	Wild Eggs (million) (in year x)	Wild smolts in year x+3 at 0.009	at 0.057	Hatchery stocking of stock spawned in year x: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	survival of stocked 0+ to 1+ at 0.28	at 0.44	sum of survivors plus newly stocked 1+ at 0.28	at 0.44	survival of stocked 1+ to 2+ at 0.28 of lowest	at 0.57 of highest	sum of survivors plus newly stocked 2+ lowest	highest
1982	2.254	20286	128478	0	216172	298453	18667	10650	144095	226435	162762	245102	45573	139708	56223	150358
1983	0.899	8091	51243	0	65576	261141	11153	72937	91481	143755	102634	154908	28737	88298	101674	161235
1984	3.049	27441	173793	25669	0	316618	2540	10706	95840	150606	98380	153146	27547	87293	38253	97999
1985	6.875	61875	391875	48312	98734	268277	1872	10000	116290	182742	118162	184614	33085	105230	43085	115230
1986	8.541	76869	486837	144450	82306	206814	0	10000	121400	190771	121400	190771	33992	108739	43992	118739
1987	12.734	114606	725838	293465	141000	208000	0	11700	179890	282685	179890	282685	50369	161130	62069	172830
1988	17.877	160893	1018989	335533	0	284004	6500	9700	173470	272596	179970	279096	50392	159085	60092	168785
1989	8.799	79191	501543	342981	0	400000	0	11641	208035	326912	208035	326912	58250	186340	69891	197981
1990	8.483	76347	483531	243016	0	177000	12441	0	117604	184807	130045	197248	36413	112431	36413	112431
1991	8.086	72774	460902	335801	118542	146950	30944	0	168362	264569	199306	295513	55806	168442	55806	168442
1992	2.808	25272	160056	336277	0	149522	0	0	136024	213752	136024	213752	38087	121838	38087	121838
1993	6.822	61398	388854	255000	168000	0	0	0	118440	186120	118440	186120	33163	106088	33163	106088
1994	5.655	50895	322335	350000	0	90906	0	0	123454	193999	123454	193999	34567	110579	34567	110579
1995	6.393	57537	364401													

Smolt survival from year x (summarized from above)

Year	Wild Lowest	Highest	Hatchery Lowest	Highest	Hatchery/total (%) Lowest	Highest
1982	20286	128478	56223	150358	30	88
1983	8091	51243	101674	161235	66	95
1984	27441	173793	38253	97999	18	78
1985	61875	391875	43085	115230	10	65
1986	76869	486837	43992	118739	8	61
1987	114606	725838	62069	172830	8	60
1988	160893	1018989	60092	168785	6	51
1989	79191	501543	69891	197981	12	71
1990	76347	483531	36413	112431	7	60
1991	72774	460902	55806	168442	11	70
1992	25272	160056	38087	121838	19	83
1993	61398	388854	33163	106088	8	63
1994	50895	322335	34567	110579	10	68
1995	57537	364401				

(2) Assuming wild juveniles survive 10x better than hatchery-stocked juveniles during first year after stocking; equal survival thereafter.

Year (x)	Wild Eggs (million) (in year x)	Wild smolts in year x+3 at 0.009	at 0.057	Hatchery stocking of stock spawned in year x: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	survival of stocked 0+ to 1+ at 0.028	at 0.044	survival of experienced 1+ to 2+ at 0.28 of lowes	at 0.44 of highe	survival of newly stocked 1+ to 2+ at 0.028	at 0.044	sum of survivors plus newly stocked 2+ lowest	highest
1982	2.254	20286	128478	0	216172	298453	18667	10650	14410	22644	4035	9963	523	821	15207	21434
1983	0.899	8091	51243	0	65576	261141	11153	72937	9148	14376	2561	6325	312	491	75811	79753
1984	3.049	27441	173793	25669	0	316618	2540	10706	9584	15061	2684	6627	71	112	13461	17444
1985	6.875	61875	391875	48312	98734	268277	1872	10000	11629	18274	3256	8041	52	82	13309	18123
1986	8.541	76869	486837	144450	82306	206814	0	10000	12140	19077	3399	8394	0	0	13399	18394
1987	12.734	114606	725838	293465	141000	208000	0	11700	17989	28268	5037	12438	0	0	16737	24138
1988	17.877	160893	1018989	335533	0	284004	6500	9700	17347	27260	4857	11994	182	286	14739	21980
1989	8.799	79191	501543	342981	0	400000	0	11641	20803	32691	5825	14384	0	0	17466	26025
1990	8.483	76347	483531	243016	0	177000	12441	0	11760	18481	3293	8132	348	547	3641	8679
1991	8.086	72774	460902	335801	118542	146950	30944	0	16836	26457	4714	11641	866	1362	5581	13003
1992	2.808	25272	160056	336277	0	149522	0	0	13602	21375	3809	9405	0	0	3809	9405
1993	6.822	61398	388854	255000	168000	0	0	0	11844	18612	3316	8189	0	0	3316	8189
1994	5.655	50895	322335	350000	0	90906	0	0	12345	19400	3457	8536	0	0	3457	8536
1995	6.393	57537	364401													

Smolt survival from year x (summarized from above)

Year	Wild Lowest	Highest	Hatchery Lowest	Highest	Hatchery/Total (%) Lowest	Highest
1982	20286	128478	15207	21434	11	51
1983	8091	51243	75811	79753	60	91
1984	27441	173793	13461	17444	7	39
1985	61875	391875	13309	18123	3	23
1986	76869	486837	13399	18394	3	19
1987	114606	725838	16737	24138	2	17
1988	160893	1018989	14739	21980	1	12
1989	79191	501543	17466	26025	3	25
1990	76347	483531	3641	8679	1	10
1991	72774	460902	5581	13003	1	15
1992	25272	160056	3809	9405	2	27
1993	61398	388854	3316	8189	1	12
1994	50895	322335	3457	8536	1	14
1995	57537	364401				

(3) Broodstock contribution.

Year	Broodstock removals: Large salmon	Small salmon	Egg dep. (million)	Wild Egg dep. (million)	Broodstock/ Total egg. dep. (%)
1982	68	84	0.511	2.254	23
1983	87	17	0.616	0.899	69
1984	92	4	0.645	3.049	21
1985	111	4	0.778	6.875	11
1986	104	5	0.730	8.541	9
1987	150	6	1.052	12.734	8
1988	151	5	1.059	17.877	6
1989	164	6	1.150	8.799	13
1990	114	6	0.800	8.483	9
1991	104	10	0.732	8.086	9
1992	147	16	1.035	2.808	37
1993	128	0	0.896	6.822	13
1994	112	15	0.790	5.655	14
1995	162	9	1.137	6.393	18

Appendix 2. Supporting data for analysis of returns of fin-clipped adult salmon, relative to releases of fin-clipped juveniles.

(1) Assuming equal survival of wild and hatchery-stocked juveniles.

Year (x)	Wild Eggs (million) (year x)	Wild smolts in year x+3 at 0.009	Wild smolts in year x+3 at 0.057	Hatchery stocking of stock spawned in year x: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	Percent finclipped: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	stocking of 0+ finclipped	stocking of 0+ not finclipped	survival of stocked 0+ to 1+ finclipped at 0.28	finclipped at 0.44	not finclipped at 0.28	not finclipped at 0.44	Newly stocked 1+ finclipped	Newly stocked 1+ not finclipped
1982	2	20286	128478	0	216172	298453	18667	10650	0	0	100	100	0	298453	216172	83567	131319	60528	95116	18667	0
1983	1	8091	51243	0	65576	261141	11153	72937	0	0	100	100	100	261141	65576	73119	114902	18361	28853	11153	0
1984	3	27441	173793	25669	0	316618	2540	10706	0	0	100	100	100	316618	25669	88653	139312	7187	11294	2540	0
1985	7	61875	391875	48312	98734	268277	1872	10000	0	0	100	100	100	268277	147046	75118	118042	41173	64700	1872	0
1986	9	76869	486837	144450	82306	206814	0	10000	0	0	0	100	100	0	433570	0	0	121400	190771	0	0
1987	13	114606	725838	293465	141000	208000	0	11700	0	0	0	100	100	0	642465	0	0	179890	282685	0	0
1988	18	160893	1018989	335533	0	284004	6500	9700	0	0	0	0	100	0	619537	0	0	173470	272596	0	6500
1989	9	79191	501543	342981	0	400000	0	11641	0	0	28	0	100	112000	630981	31360	49280	176675	277632	0	0
1990	8	76347	483531	243016	0	177000	12441	0	0	0	35	100	100	61950	358066	17346	27258	100258	157549	12441	0
1991	8	72774	460902	335801	118542	146950	30944	0	0	0	100	0	100	146950	454343	41146	64658	127216	199911	0	30944
1992	3	25272	160056	336277	0	149522	0	0	0	0	10	0	100	14952	470847	4187	6579	131837	207173	0	0
1993	7	61398	388854	255000	168000	0	0	0	0	0	65	100	0	0	423000	0	0	118440	186120	0	0
1994	6	50895	322335	350000	0	90906	0	0	0	0	0	0	0	0	440906	0	0	123454	193999	0	0
1995	6	57537	364401						0	0	13	0	0	0	0	0	0	0	0	0	0

Year (x)	sum of 1+ survivors from 0+ plus newly stocked 1+ finclipped lower	finclipped upper	not finclipped lower	not finclipped upper	survival of stocked 1+ to 2+ finclipped at 0.28	finclipped at 0.57	not finclipped at 0.28	not finclipped at 0.57	newly stocked 2+ finclipped	newly stocked 2+ not finclipped	sum of survivors to 2+ plus newly stocked 2+ finclipped lower	finclipped upper	not finclipped lower	not finclipped upper	Total unclipped, wild plus hatchery lower	Total unclipped, wild plus hatchery upper	Expected % of finclipped 2+ smolts survival rates: lower	Expected % of finclipped 2+ smolts survival rates: upper	Observed % of finclipped adult returns to fence grilse	Observed % of finclipped adult returns to fence salmon
1982	102234	149986	60528	95116	28625	85492	16948	54216	0	10650	28625	85492	27598	64866	47884	193344	37	31	35	34
1983	84272	126055	18361	28853	23596	71851	5141	16446	72937	0	96533	144788	5141	16446	13232	67689	88	68	42	25
1984	91193	141852	7187	11294	25534	80856	2012	6438	10706	0	36240	91562	2012	6438	29453	180231	55	34	23	30
1985	76990	119914	41173	64700	21557	68351	11528	36879	10000	0	31557	78351	11528	36879	73403	428754	30	15	19	32
1986	0	0	121400	190771	0	0	33992	108739	10000	0	10000	10000	33992	108739	110861	595576	8	2	43	20
1987	0	0	179890	282685	0	0	50369	161130	11700	0	11700	11700	50369	161130	164975	886968	7	1	13	3
1988	0	0	179970	279096	0	0	50392	159085	9700	0	9700	9700	50392	159085	211285	1178074	4	1	16	10
1989	31360	49280	176675	277632	8781	28090	49469	158250	11641	0	20422	39731	49469	158250	128660	659793	14	6	13	2
1990	29787	39699	100258	157549	8340	22628	28072	89803	0	0	8340	22628	28072	89803	104419	573334	7	4	10	
1991	41146	64658	158160	230855	11521	36855	44285	131587	0	0	11521	36855	44285	131587	117059	592489	9	6		
1992	4187	6579	131837	207173	1172	3750	36914	118088	0	0	1172	3750	36914	118088	62186	278144	2	1		
1993	0	0	118440	186120	0	0	33163	106088	0	0	0	0	33163	106088	94561	494942	0	0		
1994	0	0	123454	193999	0	0	34567	110579	0	0	0	0	34567	110579	85462	432914	0	0		
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57537	364401	0	0		

(2) Assuming wild juveniles survive 10x better than hatchery-stocked juveniles during first year after stocking; equal survival rates in subsequent years.

Year (x)	Wild Eggs (million) (year x)	Wild smolts in year x+3 at 0.009	Wild smolts in year x+3 at 0.057	Hatchery stocking of stock spawned in year x: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	Percent finclipped: 0+ swim-up fry	0+ feeding fry	0+ fingerling fry	1+ parr	2+ smolt	Stocking of 0+ finclipped	Stocking of 0+ not finclipped	survival of stocked 0+ to 1+ finclipped at 0.028	finclipped at 0.044	not finclipped at 0.028	not finclipped at 0.044
1982	2	20286	128478	0	216172	298453	18667	10650	0	0	100	100	0	298453	216172	8357	13132	6053	9512
1983	1	8091	51243	0	65576	261141	11153	72937	0	0	100	100	100	261141	65576	7312	11490	1836	2885
1984	3	27441	173793	25669	0	316618	2540	10706	0	0	100	100	100	316618	25669	8865	13931	719	1129
1985	7	61875	391875	48312	98734	268277	1872	10000	0	0	100	100	100	268277	147046	7512	11804	4117	6470
1986	9	76869	486837	144450	82306	206814	0	10000	0	0	0	100	100	0	433570	0	0	12140	19077
1987	13	114606	725838	293465	141000	208000	0	11700	0	0	0	100	100	0	642465	0	0	17989	28268
1988	18	160893	1018989	335533	0	284004	6500	9700	0	0	0	0	100	0	619537	0	0	17347	27260
1989	9	79191	501543	342981	0	400000	0	11641	0	0	28	0	100	112000	630981	3136	4928	17667	27763
1990	8	76347	483531	243016	0	177000	12441	0	0	0	35	100	100	61950	358066	1735	2726	10026	15755
1991	8	72774	460902	335801	118542	146950	30944	0	0	0	100	0	100	146950	454343	4115	6466	12722	19991
1992	3	25272	160056	336277	0	149522	0	0	0	0	10	0	100	14952	470847	419	658	13184	20717
1993	7	61398	388854	255000	168000	0	0	0	0	0	65	100	0	0	423000	0	0	11844	18612
1994	6	50895	322335	350000	0	90906	0	0	0	0	0	0	0	0	440906	0	0	12345	19400
1995	6	57537	364401						0	0	13	0	0						

Year (x)	survival of experienced 1+ to 2+ finclipped at 0.28 of lowes	finclipped at 0.57 of highes	not finclipped at .28 of lowest	not finclipped at .57 of highest	newly stocked 1+ finclippe	newly stocked 1+ not finclip	survival of newly stocked 1+ to 2+ finclipped at 0.028	finclipped at 0.057	not finclipped at 0.028	not finclipped at 0.057	newly stocked 2+ finclipped	newly stocked 2+ not finclipped	sum of survivors plus newly stocked 2+ finclipped lowest	finclipped highest	not finclipped lowest	not finclipped highest	Sum of unmarked smolts plus wild lowest	Sum of unmarked smolts plus wild highest	Expected percent marked returns lowest	Expected percent marked returns highest
1982	2340	7485	1695	5422	18667	0	523	1064	0	0	0	10650	2863	8549	12345	16072	32631	144550	8	6
1983	2047	6549	514	1645	11153	0	312	636	0	0	72937	0	75297	80122	514	1645	8605	52888	90	60
1984	2482	7941	201	644	2540	0	71	145	0	0	10706	0	13259	18792	201	644	27642	174437	32	10
1985	2103	6728	1153	3688	1872	0	52	107	0	0	10000	0	12156	16835	1153	3688	63028	395563	16	4
1986	0	0	3399	10874	0	0	0	0	0	0	10000	0	10000	10000	3399	10874	80268	497711	11	2
1987	0	0	5037	16113	0	0	0	0	0	0	11700	0	11700	11700	5037	16113	119643	741951	9	2
1988	0	0	4857	15538	0	6500	0	0	182	371	9700	0	9700	9700	5039	15908	165932	1034897	6	1
1989	878	2809	4947	15825	0	0	0	0	0	0	11641	0	12519	14450	4947	15825	84138	517368	13	3
1990	486	1554	2807	8980	12441	0	348	709	0	0	0	0	834	2263	2807	8980	79154	492511	1	0
1991	1152	3686	3562	11395	0	30944	0	0	866	1764	0	0	1152	3686	4428	13159	77202	474061	1	1
1992	117	375	3691	11809	0	0	0	0	0	0	0	0	117	375	3691	11809	28963	171865	0	0
1993	0	0	3316	10609	0	0	0	0	0	0	0	0	0	0	3316	10609	64714	399463	0	0
1994	0	0	3457	11058	0	0	0	0	0	0	0	0	0	0	3457	11058	54352	333393	0	0
1995																				