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STATUS OF ATLANTIC SALMON (*Salmo salar* L.) STOCKS OF THREE SELECTED RIVERS IN SALMON FISHING AREA 14A, 1998

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ABSTRACT

Returns of small salmon to Lomond River in 1998 were 45% less than in 1997 and 28% less than the 1992-96 mean. Returns of large salmon were the second highest on record and 66% higher than in 1997. Returns of small salmon to Torrent River were 30% higher than in 1997. Returns of large salmon in 1998 were the highest on record and twice the 1992-96 mean. Returns of small salmon to Western Arm Brook were the highest and large salmon were the second highest on record. Sea-survival of returning 1SW salmon to Western Arm Brook was 6.6% in 1998, more than twice that in 1997 which was the lowest since 1992. Conservation requirements were exceeded on all three rivers in 1998. On the basis of the smolt production at Western Arm Brook in 1998 returns of 1SW salmon in 1999 are expected to be less than in 1998 but higher than the 1992-96 mean provided sea survival remains the same. Spawning escapements are expected to exceed conservation requirements on all three rivers in 1999. Given the effectiveness of other catch and effort controls in place in 1998 and current levels of returns, it is suggested that conservation would still be achieved in 1999 if the quota restriction on Lomond River and the hook and release fishery on Torrent River were removed. Expansion of fisheries above the counting facilities on all three selected rivers is not recommended unless there can be an accurate accounting of catches. Based on observations of bird predation in the estuary of Western Arm Brook, incidence of feeding on smolts was low in 1998.

RÉSUMÉ

Les remontées de petits saumons de la rivière Lomond en 1998 étaient de 45 % inférieures à celles de 1997 et de 28 % inférieures à celles de la moyenne de la période 1992-1996. Les remontées de grands saumons étaient les deuxièmes plus élevées jamais notées et de 66 % supérieures à celles de 1997. Celles des petits saumons de la rivière Torrent étaient de 30 % supérieures à celles de 1997 tandis que celles des grands saumons en 1998 étaient aussi les plus élevées jamais notées et correspondaient à deux fois la moyenne de la période 1992-1996. Les remontées de petits saumons du ruisseau Western Arm étaient les plus élevées et celles des grands saumons les deuxièmes plus élevées jamais notées. La survie en mer des saumons unibermarins revenant au ruisseau Western Arm a été de 6,6 % en 1998, soit plus de deux fois la valeur notée en 1997, qui était cependant la plus faible depuis 1992. Les besoins de conservation ont été dépassés dans ces trois cours d'eau en 1998. D'après la production de saumoneaux du ruisseau Western Arm en 1998, les remontées de saumons unibermarins de 1999 devraient être inférieures à celles de 1998, mais supérieures à celles de la moyenne pour 1992-1996, si la survie en mer demeure inchangée. Les échappées de géniteurs devraient excéder les besoins de conservation dans les trois rivières en 1999. Étant donné l'efficacité des autres mesures de contrôle des captures et de l'effort en place en 1998 et les niveaux des remontées actuels, on suppose que les besoins de conservation seraient atteint en 1999 même si les limites imposées de par le quota de la rivière Lomond et la pêche par capture et remise à l'eau de la rivière Torrent étaient retirées. Il n'est pas recommandé d'étendre la pêche en amont des installations de comptage dans aucun des trois cours d'eau sélectionnés, à moins qu'il ne soit possible de dénombrer les captures avec exactitude. D'après les observations d'oiseaux dans l'estuaire du ruisseau Western Arm, la prédation sur les saumoneaux a été faible en 1998.

INTRODUCTION

Lomond River, Torrent River, and Western Arm Brook are three of fourteen scheduled rivers in Salmon Fishing Area (SFA) 14A (Fig. 1). The returns of adult Atlantic salmon to these rivers have been monitored at counting facilities on Lomond River and Torrent River since the 1960s and on Western Arm Brook since 1971. The smolt output has also been monitored on Western Arm Brook since 1971. The fishways on Lomond River and Torrent River are located approximately 5.0 km and 2.0 km, respectively, upstream from the mouth of the river. The counting fence on Western Arm Brook is located just above the head of tide.

Recreational fisheries on these rivers are controlled on an individual river basis. On Lomond River, the fishery is downstream from the fishway (since 1978) and is currently controlled by a river quota of 375 retained small salmon. The quota was increased to 375 fish in 1995 from 350 fish in place since 1986. On Torrent River, the fishery is also downstream from the fishway with catch and release angling only until a minimum spawning escapement of 750 salmon has passed upstream through the fishway. Catch and retain angling is then permitted. This minimum spawning escapement was reduced to 750 fish in 1995 from the 1,000 that had been in place since the 1970s. Prior to 1996, catch and release angling was not permitted prior to the minimum spawning escapement being achieved. The fishery on Western Arm Brook has been closed since 1989.

This was the seventh year of the commercial salmon fishery moratorium implemented in 1992. The moratorium was a major management initiative to provide for increased adult recruitment (also referred to as total population size and/or pre-fishery abundance) and increased returns to rivers. In addition, the recreational fishery has been under stricter control since 1992 in order to provide for increased spawning escapements. Although the commercial salmon moratorium was implemented in SFA 14A in 1992, the commercial cod fishery moratorium was not implemented in this area until August 1993. As a result, there was still a potential, in 1992, for high fishing mortality on salmon at sea due to the presence of cod traps.

The effect of the commercial salmon fishery moratorium on total salmon returns can be examined at Lomond River, Torrent River and Western Arm Brook based on returns to counting facilities in 1992-98 compared to previous years (1984-91). Because recreational catches are known for these rivers, changes in spawning escapements in 1992-98 can also be evaluated relative to previous years. Habitat information and salmon biological characteristics are also known for these rivers, therefore, changes in these stocks can also be evaluated relative to the conservation requirements. The effect of the moratorium on recruitment can also be evaluated by adjusting returns of small salmon to account for commercial exploitation. Similarly, variability in sea survival of smolts in one year to 1SW salmon the following year can be evaluated at Western Arm Brook relative to pre-moratorium years. Following the unexpected decrease in sea survival in 1997, several possible sources of smolt mortality at sea were identified (Dempson et al., 1998) including bird predation (CSAS, 1998a). Predation by birds and presence of birds in the estuary can be evaluated at Western Arm Brook relative to the daily smolt counts.

METHODS

RECREATIONAL FISHERY

Recreational fishery data on Lomond River and Torrent River in 1997 and 1998 were estimated from licence stub returns (O'Connell, et al. MS 1998). Previously, recreational data were compiled from weekly reports of small (<63 cm) and large (>= 63 cm) salmon catches completed by the Department of Fisheries and Oceans (DFO) river guardians (Mullins et al., MS 1989; Mullins and Jones, MS 1993a; and Mullins and Jones, MS 1993b). These are not directly comparable to data from the licence stub return system.

ADULT RETURNS AND SPAWNING ESCAPEMENTS

a) Adult Counts and Run Timing

Counting facilities were operated on all three rivers in 1998. Counting facilities were monitored on a daily basis the same as in previous years. The only exception was that the fishway on Lomond River was not monitored in 1989-91, but fish were observed passing upstream through the fishway. The counts of small and large salmon in those years were estimated based on the mean of the previous three years when fisheries management plans were similar.

Run timing of small salmon was measured as the date that the 25^{th}, 50^{th} and 75^{th} percentiles of cumulative counts occurred at each counting facility.

b) Adult Returns

The total returns to the river (***TRR***) of adult small and large salmon were based on counts at the counting facility and removals in the recreational fishery below the counting facility according to the equation:

$$TRR = (CNT + RET) + (REL \times 0.1)$$

Where:
CNT = count of salmon at counting facility
RET = number of salmon retained
REL = number of salmon released

Total returns of small and large salmon were calculated separately.

Removals in the recreational fishery included retained fish plus an assumed mortality rate of 0.1 on released small and large salmon. This mortality rate was based on consultations with anglers. It was assumed that catch and release mortality occurred only below the counting facilities where angling was permitted. No adjustments were made for any other unrecorded mortality above or below the counting facilities.

Adult salmon returns in 1998 were compared with those in 1997 and the 1992-96 mean. The 1992-96 mean was chosen to reflect years with a consistent management approach in the first five years following the commercial salmon fishery moratorium. Due to the high proportion of river age 3 and 4 salmon, a high proportion of the returns in 1997 and 1998 were expected to be the progeny of spawners in 1992. This would have been the first year-class with a contribution from spawners released as a result of the closure of the commercial salmon fishery. Returns in 1992-96 would have been comprised of year-classes prior to the closure and would have included salmon normally caught in the commercial fishery but not their progeny.

c) Spawning Escapements

Spawning escapements to each river were calculated by subtracting retained catches, mortalities due to catch and release and other known removals from the total returns.

d) Adult Recruitment - Western Arm Brook

O'Connell, et al. (MS 1997) described a technique whereby it was possible to retrospectively construct, in selected rivers with counting facilities, total recruitment of small salmon (or total number of small salmon recruits) prior to any exploitation. Small salmon recruits for Western Arm Brook prior to 1992 were derived based on total returns to the river and an assumed commercial exploitation rate of 0.60. After 1992, in the absence of commercial fisheries, total returns of small salmon were assumed to represent total recruitment.

CONSERVATION REQUIREMENTS AND POTENTIAL EGG DEPOSITIONS

a) Conservation Requirements

Conservation requirements, were calculated in terms of eggs, based on 2.4 eggs/m^2 (Elson, 1975) for fluvial habitat (Elson, 1957) on all three rivers, and 368 eggs/ha for lacustrine habitat on Lomond River and 105 eggs/ha for Torrent River and Western Arm Brook (O'Connell et al., MS 1991). The egg deposition rate for fluvial habitat includes and adjustment for poaching and disease, whereas, the rate for lacustrine habitat does not include an adjustment. It is important to note that for Lomond River, the amount of available fluvial habitat was measured from detailed stream surveys. For Torrent River and Western Arm Brook, available fluvial habitat was based on aerial surveys (Traverse, 1971). Available lacustrine habitat on the three rivers was measured from 1:50,000 scale topographic maps using the appropriate dot grid scale.

Conservation requirements in terms of spawners were calculated based on mean weights and proportion of females for 1992-96. The means of these years were used to account for potential change in mean weight as a result of elimination of selective commercial fishing mortality since 1992. The minimum proportion of large salmon and the maximum proportion of small salmon observed in 1992-96 were used to apportion the spawner requirements into small and large salmon.

Conservation requirements in terms of eggs and the number of spawners that would normally be required to achieve these egg depositions are as follows (Mullins MS 1997):

River	Eggs	Spawners		
		Small	Large	Total
Lomond	1,095,200	557	23	580
Torrent	1,484,235	562	30	592
Western Arm	907,785	284	3	287

b) Potential Egg Depositions

Potential egg depositions above the counting facilities were calculated based on the total spawning escapements, observed biological characteristics (mean weight of females and percent female and a relative fecundity of 1783 eggs/kg of body weight) for small and large salmon. This relative fecundity value was estimated from an average of 3,388 (N=264) eggs per female for Western Arm Brook in 1979-80 (Chadwick et al., 1986) based on a mean weight of 1.90 kg. Egg depositions were expressed as a percentage of the conservation egg deposition requirements estimated for each river.

Biological characteristics used to estimate potential egg depositions were obtained from sampling conducted at the counting facilities and in the recreational fishery. Biological characteristics of salmon on

Lomond River, Torrent River, and Western Arm Brook in 1983-98 are given in Appendices 1-9. Sex composition was usually determined by external examination at counting facilities and by internal examination in the recreational fishery. For small salmon, only information from internally sexed fish was used to estimate egg deposition, whereas for large salmon, information from both internally and externally sexed fish was used. Because samples sizes are small (<30) in some years, pooling of data is sometimes necessary in order to obtain an adequate sample size. This was particularly important for years since 1992 when there was a potential for increased body size due the closure of the commercial salmon fishery.

Pooling of biological charactistics information for 1998 was as follows:
Lomond (small) - mean weight and percent female based on 1992-98 mean.
Lomond (large) - mean weight females based on 1978-98 mean; percent female based on 1993.
Torrent (small) - mean weight and percent female based on 1992-98 mean.
Torrent (large) - mean weight and percent female based on 1980-97 mean.
Western Arm (small) - mean weight and percent female based on 1998.
Western Arm (large) - mean weight and percent female based on 1992-98 mean.

River	Small Salmon				Large Salmon			
	Whole Weight Females (kg)				Whole Weight Females (kg)			
	Mean	STD	N	Proportion Female (N)	Mean	STD	N	Proportion Female (N)
Lomond	1.57	0.39	35	0.619 (84)	3.69	0.64	16	0.857 (7)
Torrent	1.77	0.31	30	0.649 (74)	4.04	0.91	27	0.638 (213)
WAB	2.25	0.36	44	0.746 (59)	4.08	1.19	74	0.788 (99)

SMOLT COUNTS, SEA SURVIVAL AND ANTICIPATED 1SW RETURNS

Annual smolt production has been recorded at the counting fence on Western Arm Brook since 1971.

Sea survival of smolts was taken as the percentage of the smolt production in year ***i*** that returned to the river as virgin one-sea-winter (1SW) adult salmon in year ***i***+1. The number of 1SW returns was calculated from total returns of small salmon based on the proportions of 1SW salmon sampled at the counting fence. One in ten returning small salmon was sampled. The proportion of 1SW salmon used to adjust the river escapements is given in Appendix 9.

Returns of 1SW salmon prior to 1992 were adjusted for a commercial exploitation rate of 0.60.

JUVENILE DENSITIES

Juvenile salmon densities (#/100m^2) are available for three sites monitored annually on Western Arm Brook since 1985. The number of juvenile salmon at each site was determined by electrofishing using the depletion method (Zippen, 1958). Density of each age class was calculated using computer software developed by Van Deventer and Platts (1985). Age was determined from scale samples.

BIRD PREDATION

Activities and numbers of birds at Western Arm Brook in 1998 were observed and recorded from 12 May to 28 June. Three observation points were selected: one at the counting fence and two in the estuary (Fig. 2). Observations at the counting fence were on an hourly basis between 0800 and 1600 hours and twice per day in the estuary at approximately 0900 and 1600 hours. Observations were 15 minutes

duration using both the naked eye and binoculars (10x50mm). The number and species of birds flying, standing, swimming and feeding as well as the type of food, if any, were recorded.

RESULTS

RECREATIONAL FISHERY

Lomond River and Torrent River both opened to angling 20 June 1998. Western Arm Brook remained closed in 1998. Catch and effort statistics for 1974-1998 are given in Appendices 10-11.

a) Lomond River

The quota of 375 small salmon on Lomond River was not reached in 1998. The retained catch of 158 small salmon was the lowest since 1992. DFO River Guardians reported a retained catch of 165 small salmon supporting the results from the licence stub return system. The retained catch was 68% less than in 1997 but the released catch was only 22% less than in 1997 indicating more effort was directed towards catch and release angling in 1998. This was likely due to the retention limit of one small salmon before 5 July. The total retained plus released catch of small in 1998 was 51% less than in 1997. The released catch of large salmon in 1998 was 58% less than in 1997. In the first five years (1992-96) of the commercial salmon fishery moratorium, retained plus released catches of small and released catches of large salmon on Lomond River increased relative to pre-moratorium years (1984-91). Based on license stub return data, this continued in 1997 but not in 1998. However, the changes in the retention limit could have affected catches in 1998.

The river quota on Lomond River has been in place since 1986. In spite of improvements in the stock since 1992, the quota was not reached in 1993, 1994, 1997 or 1998. This was due to other catch and effort controls that were in place in all SFA 14A rivers. These controls include SFA quotas, reduced daily and seasonal bag limits, later opening dates and split seasons among others. In addition in 1997, the quota may have been affected by the closure to retention in mid August to prevent increased exploitation as a result of a transfer of effort from other rivers that were closed due to low returns. Given these other catch and effort controls, vigilant in-season management and improvements in the stock, the current river quota may no longer be effective or necessary in controlling the catch on this river.

Year	Open	Closed	Quota	No. Days to Reach Quota
1986	7 Jun	25 Jul	350	49
1987	6 Jun	13 Jul	350	Closed due to low water
1988	4 Jun	25 Jul	350	52
1989	17 Jun	23 Jul	350	Closed due to low water
1990	16 Jun	24 Jul	350	39
1991	17 Jun	25 Jul	350	39
1992	13 Jun	24 Jul	350	42
1993	12 Jun	20-31 Jul & 8 Aug - 6 Sep	350	SFA quota reached
1994	11 Jun		350	Quota not reached
1995	24 Jun	24 Jul	375	31
1996	22 Jun	13 Aug	375	53
1997	21 Jun	14 Aug	375	Closed to retention
1998	20 Jun	7 Sep	375	Quota not reached

b) Torrent River

The minimum spawning escapement of 750 salmon above the fishway was reached on 1 July 1998, 12 days after the start of the season. The river below the fishway then opened to retention angling until 7 September. The retained catch of small salmon was 37% less than in 1997 but the released catch was only 6% less than in 1997 indicating that more effort was directed towards catch and release angling in 1998. As on Lomond River, the retention limit of one small before 5 July could have resulted in higher released catches compared to 1997. However, this would have had less of an effect on Torrent River than on Lomond because the fishery is not normally opened for retention until the minimum spawning escapement has been reached. This usually occurs in early July. The total retained plus released catch of small salmon was 19% less than in 1997 compared to 51% on Lomond River. The released catch of large salmon was 8% higher than in 1997 compared to 58% less on Lomond River.

During the first five years (1992-96) of the commercial salmon fishery moratorium, with the exception of 1994, retained plus released catches of small and large salmon on Torrent River were the highest since 1965. It appears that except for some slight fluctuation, this continued in 1997 and 1998. Catch per unit of effort (CPUE) also increased in the first two years of the moratorium but then decreased in 1994-96 as a result of increased effort to up to four times the effort in pre-moratorium years. Effort values were not available from license stub returns for 1997 and 1998 (see O'Connell et al., MS 1999).

ADULT RETURNS

Run timing of small salmon to the Torrent River fishway and Western Arm Brook counting fence was either the earliest or second earliest recorded, whereas, run timing to Lomond River fishway was among the latest recorded (Fig. 3). This may be due to the fact that the Lomond River facility is the farthest from the mouth of the river and upstream migration may have been delayed by low water levels experienced on many rivers in SFA 14 A in 1998. Water levels increased in the fall before the closure of the fishway so it is not expected that the total count would have been affected.

Counting Facility Location	**Period of Operation**
Lomond River Fishway	23 June to 10 October
Torrent River Fishway	17 June to 9 October
Western Arm Brook Counting Fence	6 May to 24 September

Total returns of small and large salmon to the three rivers in 1998 are given in Table 1 and in Fig. 4. Returns of small salmon to Lomond River were 46% less than in 1997 and 29% less than the 1992-96 mean. Returns of large salmon were the second highest on record and 64% higher than in 1997. Returns of small salmon to Torrent River were 30% higher than in 1997 and 8% higher than the 1992-96 mean. Returns of large salmon in 1998 were the highest on record. Returns of both small salmon and large salmon to Western Arm Brook were the highest on record.

The total recruitment of small salmon in 1998 on Western Arm Brook was the highest since 1992 and higher than in 1984-91 when a commercial fishery was in place (Fig. 5).

The proportion of large salmon in 1998 based on counts at the three counting facilities were either the highest or the second highest since 1992 and higher than the 1984-91 means (Table 2).

SPAWNING ESCAPEMENTS AND POTENTIAL EGG DEPOSITIONS

Spawning escapements, potential egg depositions by small and large salmon and the percentage of conservation requirements achieved in 1984-98 are given in Table 3.

Conservation requirements above the counting facilities were exceeded on all three rivers in 1998 (151%, 925% and 625%, respectively). The percentage achieved decreased on Lomond River but increased on Torrent River and Western Arm Brook in comparison to 1997 (Table 3).

SMOLT COUNTS, SEA SURVIVAL AND ANTICIPATED 1SW RETURNS IN 1999

The smolt count at Western Arm Brook in 1998 was 28% less than in 1997 but 26% higher than the 1992-96 mean (Table 4; Fig. 6).

It was expected that the number of small 1SW salmon returning to Western Arm Brook in 1998 would increase due to the 64% higher smolt count in 1997 (Mullins, MS 1998). As expected, the number did increase compared to 1997 but was 121% higher than expected because of a higher sea survival of smolts (Table 4).

With the exception of 1997, smolt to 1SW salmon survival at Western Arm Brook has increased since 1992 compared to the 1984-91 mean (Table 4; Fig. 7). However, survival has been quite variable with 1997 being among the lowest recorded. Even with the 1997 data point excluded from the 1992-98 time series, a regression of 1SW returns on smolts in the previous year was not significant at the 95% level. Compared to the survival adjusted for commercial exploitation, sea survival of smolts in 1992-98 has remained low (Fig. 7).

Assuming that sea survival in 1998 will be the same as for 1997 (6.6%), it is expected that 1,131 1SW salmon will return to the river in 1999. This would be a decrease of 28% from 1998. However, it would produce sufficient egg deposition to achieve conservation requirement.

The difference between expected and actual 1SW returns based on this method have been highly variable because of the instability in sea-survival of smolts. However, the differences were positive in five out of seven years indicating higher than expected sea-survivals.

Year	Expected	Observed	% Difference.
1992	297	479	61
1993	550	817	49
1994	826	919	11
1995	659	823	25
1996	1342	1230	-8
1997	1218	429	-65
1998	715	1581	121
1999	**1131**		

BIRD PREDATION

A total of 725 bird observations were made at Western Arm Brook in 1998 - 334 at the counting fence and 391 in the estuary (176 in the inner estuary and 215 in the outer estuary) (Table 5). Seventeen bird species were identified and three prey species. There were two observations of birds feeding on smolts - one of a Herring gull at the counting fence and one of a Merganser feeding either on smolt or smelt in the inner estuary (Table 5). A total of 601 Herring gulls and 173 Mergansers were observed (Table 6). However, the presence of neither Mergansers nor Herring gulls coincided with the presence of smolts in the estuary (Fig. 8). Only the presence of loons and common terns in the estuary appeared to increase with smolts.

JUVENILE DENSITIES

Densities of parr (juveniles of one or more years old) at all three sites showed a declining trend up to 1992 but have been increasing since 1994 (Fig. 9).

DISCUSSION

Salmon stocks of Lomond River, Torrent River and Western Arm Brook exceeded conservation requirements in 1998 as in every year since 1992 due to increasing small and large salmon returns and increasing proportion of large salmon. In contrast to the other two rivers, the returns to Torrent River have shown an increasing trend since the 1970s, possibly due to the successful colonisation of a major portion of the watershed with adult salmon and early high survival of juvenile salmon in the freshwater environment. The potential for continued future growth in these stocks is evidenced by improvements seen in juvenile densities and in smolt production on Western Arm Brook.

Both Lomond River and Torrent River currently support recreational harvests while continuing to exceed conservation requirements. It appears that given the effectiveness of other catch and effort controls in place in 1998 on these two rivers, consideration could be given to removing the quota on Lomond River and the hook and release restriction on Torrent River, without compromising conservation. Currently fisheries are not permitted upstream of the fishways on these two rivers. It is recommended that these restrictions remain in place, to be reviewed along with any revision to habitat estimates and conservation requirements. In addition, because of the long time series of data from counting facilities on these rivers as well as on Western Arm Brook, there exists a rare opportunity to monitor changes in the stocks relative to pre-moratorium years through the relationship between spawners and recruits. This can only be done if counting facilities remain in place to monitor recruits and if there is an accurate accounting of removals in order to determine spawning escapements. Currently spawning escapements are known because angling is not permitted above counting facilities on all three of these rivers. It is recommended that fisheries be supported above these facilities only if the angling catch can be accurately determined. In addition any fisheries harvests should be restricted to levels that would maximise the robustness of the spawner-recruit model.

In spite of the improvements in the status of these stocks there is still reason for caution in the interpretation of assessment results. The annual variability in the effect of atresia on fecundity (O'Connell et al., MS 1997) and the potential for spawner mortality upstream of counting facilities as well as other egg losses in the river mean that estimates of egg deposition should be treated as potential only. The fecundity values used to calculate egg depositions for all three rivers were based on biological characteristics of Western Arm Brook salmon in 1979-80 (Chadwick et al., 1986). Fecundity estimates should be revised for each river, given the potential for change in the body size of returning adults as a result of the moratorium. Cautions associated with parameter values used to estimate conservation requirements were discussed in detail by O'Connell and Dempson (1995). These will not be discussed further here except to point out that the habitat measurements on which these conservation requirements are based were taken from aerial surveys conducted in the early 1970s (Traverse, 1971). These measurements should be verified and

updated based on currently available digitised maps. Until this work is completed, habitat estimates should be viewed as minimum values.

The increased returns and improvements relative to conservation requirements which occurred on these rivers when the commercial fishery closed, created an impression that the total adult recruitment (also referred to as total population size or pre-fishery abundance) of salmon had immediately increased relative to long-term abundance (Mullins, 1998). In fact, the closure of the commercial fishery simply meant that more salmon survived to enter the rivers. The total adult recruitment actually remained the same. The recruitment of Western Arm Brook small salmon in 1992-97 was actually less than in pre-moratorium years when adjustments were made to account for commercial exploitation.

The recruitment of Western Arm Brook small salmon in 1998 was the highest since 1984. The dominant smolt age of Western Arm Brook salmon is four years old. Hence, the record high smolt output of Western Arm Brook in 1997 was produced from spawners in 1992, the first year that the commercial fishery was closed. The record high returns of small salmon in 1998 was due, in part, to the high smolt output but also to the more than two fold increase in sea survival compared to the previous year smolts. In contrast, the dominant smolt age of Lomond River and Torrent River salmon is three years old. Hence, the first actual increase in returns as a result of increased total population size since 1992 had been anticipated to occur in 1997. This did not materialise because of unexpected low sea survival (CSAS, 1998b).

It appears that whether or not the commercial salmon moratorium will be effective in restoring salmon stocks to historic levels will be highly dependent on sea survival. With the exception of 1997, sea survival of Western Arm Brook smolts has increased since 1992. However, given the unexpected low survival in 1997 compared to higher survivals in some pre-moratorium years, factors other than commercial salmon fishing mortality continue to affect survival in marine environment. Preliminary analysis of observations of bird predation in the Western Arm Brook estuary in 1998, indicated declining bird numbers prior to the peak of the smolt run and the low incidence of feeding on smolts. It appeared that smolt mortality from bird predation was low. However, with so few prey types identified, it was impossible determine the contribution of smolts to the diet of the bird species observed.

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REFERENCES

Chadwick, E. M. P., R. G. Randall, and C. Leger. 1986. Ovarian development of Atlantic salmon (*Salmo salar*) smolts and age at first maturity. Can. Spec. Publ. Fish. Aquat. Sci. 89.

CSAS. 1998a. Atlantic salmon abundance overview for 1997. DFO Science Stock Status Report D0-02 (1998).

CSAS. 1998b. 1997 Atlantic salmon Newfoundland and Labrador, Salmon Fishing Areas 1-14B. DFO Science Stock Status Report D2-01 (1998).

Dempson, J.B., D.G. Reddin, M.F. O'Connell, J. Helbig, C.E. Bourgeois, C. Mullins, T.R. Porter, G. Lilly, J. Carscadden, G.B. Stenson, and D. Kulka. MS 1998. Spatial and temporal variation in Atlantic salmon abundance in the Newfoundland-Labrador region with emphasis on factors that may have contributed to low returns in 1997. Can. Stock assess. Sec. Res. Doc. 98/114. 161p.

Moores, R.B. and E.G.M. Ash. MS 1984. Fishway and counting fence operations in Newfoundland and Labrador, 1949-79. Can. Data Rep. Fish. Aquat. Sci. 477:v + 123 p.

Mullins, C. C., J. A. Wright, and R. R. Claytor. MS 1989. Recreational Atlantic salmon catch, 1986, and annual summaries, 1953-1986 for West Newfoundland and South Labrador, Gulf Region. Can. Data Rep. Fish. Aquat. Sci. No. 715. v + 124.

Mullins, C. C. and R. A. Jones. MS 1993a. The status of Atlantic salmon stocks in Gulf of St. Lawrence, western Newfoundland and southern Labrador, 1992. Dept. of Fish. and Oceans Atlantic Fish. Res. Doc. 93/33. 57 pages.

Mullins, C. C. and R. A. Jones. MS 1993b. Recreational Atlantic salmon weekly catch and effort (1989 and 1990) and annual summaries (1974-1990) for western Newfoundland and southern Labrador. Can. Data Rep. Fish. Aquat. Sci. No. 748. vi + 192 p.

Mullins, C.C. MS 1997. Status of Atlantic salmon (Salmo salar L.) stocks of three selected rivers in Salmon Fishing Area 14A, 1996. DFO Can. Stock Assess. Sec. Res. Doc. 97/38, 39 p.

Elson, P. F. 1957. Using hatchery reared Atlantic salmon to best advantage. Can. Fish. Cult. 21:7-17.

Elson, P. F. 1975. Atlantic salmon rivers smolt production and optimal spawning. An overview of natural production. Int. Atl. Salmon Found. Spec. Publ. Ser. 6: 96-119.

O'Connell, M. F., J. B. Dempson, and R. J. Gibson. MS 1991. Atlantic salmon (*Salmo salar* L.) smolt production parameter values for fluvial and lacustrine habitats in insular Newfoundland. CAFSAC Res. Doc. 91/19. 11 p.

O'Connell, M. F., D. G. Reddin, and C. C. Mullins. MS 1997. Status of Atlantic salmon (*Salmo salar* L.) in eight rivers in the Newfoundland Region, 1995. DFO Atl. Fish. Res. Doc. 96/106. 52 pages.

O' Connell, M. F. and J. B. Dempson. 1995 . Target spawning requirements for Atlantic salmon (*Salmo salar* L.) in Newfoundland rivers. Fisheries Management and Ecology, Volume 2: pp 161-170.

O'Connell, M.F., N.M. Chochrane and C.C. Mullins. MS 1998. An analysis of the license stub return system in the Newfoundland Region, 1994-97. DFO CSAS Res. Doc. 98/111. 67 p

Traverse, G.R. 1971. A stream survey of Torrent River. Resource Dev. Br. Fish. and Mar. Serv. Nfld. Region. Prog. Rept. 74:20 p

Van Deventer, J.S. and W.S. Platts. 1985. A computer software system for entering, managing and analyzing fish capture data from streams. Research Note INT-352. Ogden, UT: U.S. Dept. of Agriculture, Forest Service. Intermountain Forest and range Exp. Sta.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

Table 1. Total returns of small and large Atlantic salmon to Lomond River, Torrent River and Western Arm Brook, 1971-98.

Year	Lomond River		Torrent River		Western Arm Brook	
	Small	Large	Small	Large	Small	Large
1971*	60	1	107	9	632	305
1972	283	50	86	6	406	9
1973	394	165	184	15	797	30
1974	365	52	96	7	506	4
1975	**259**	**20**	314	31	639	1
1976	782	36	341	47	552	0
1977	687	45	789	33	373	3
1978	462	41	1002	25	315	2
1979	430	3	2049	42	1578	0
1980	594	32	792	63	465	5
1981	617	53	2268	115	492	1
1982	583	23	2299	525	467	3
1983	471	10	2089	443	1141	4
1984	986	75	1805	288	235	0
1985	393	14	1623	30	**467**	1
1986	725	37	3155	93	**527**	0
1987	652	12	2670	68	437	1
1988	841	24	2388	44	**422**	1
1989	**652**	**22**	1512	60	**455**	0
1990	**777**	**19**	2518	82	**444**	0
1991	**731**	**21**	1591	71	233	1
1992	794	86	2832	170	480	8
1993	816	38	4215	224	947	8
1994	1038	56	3827	332	954	31
1995	1365	101	6168	615	823	33
1996	982	98	7371	509	1230	50
1997	1300	77	4033	674	509	55
1998	721	128	5249	766	1718	128
Mean (92-96)	999	76	4882	370	887	26
95% CL=+/-	285	34	2290	234	337	22
CV	23.0	36.5	37.8	51.0	30.6	69.3
N	5	5	5	5	5	5
Mean (84-91)	720	28	2158	92	403	1
95% CL=+/-	143	17	508	68	91	0
CV	23.8	72.7	28.2	88.8	27.0	107.5
N	8	8	8	8	8	8

* Incorrect sizing suspected at Western Arm Brook (Moores and Ash, 1984)

Table 2. Proportion of small and large Atlantic salmon observed at counting facilities.

Year	Lomond River		Torrent River		Western Arm Brook	
	Small	Large	Small	Large	Small	Large
1971	1.00	0.00	0.93	0.07	0.58	0.42
1972	0.67	0.33	0.96	0.04	0.97	0.03
1973	0.50	0.50	0.89	0.11	0.95	0.05
1974	0.55	0.45	0.93	0.07	0.99	0.01
1975	1.00	0.00	0.88	0.12	1.00	0.00
1976	0.92	0.08	0.88	0.12	1.00	0.00
1977	0.95	0.05	0.96	0.04	0.99	0.01
1978	0.91	0.09	0.98	0.02	1.00	0.00
1979	0.99	0.01	0.98	0.02	1.00	0.00
1980	0.94	0.06	0.93	0.07	0.99	0.01
1981	0.69	0.31	0.96	0.04	1.00	0.00
1982	0.95	0.05	0.80	0.20	0.99	0.01
1983	0.97	0.03	0.82	0.18	1.00	0.00
1984	0.90	0.10	0.86	0.14	1.00	0.00
1985	0.93	0.07	0.98	0.02	1.00	0.00
1986	0.92	0.08	0.97	0.03	1.00	0.00
1987	0.97	0.03	0.97	0.03	1.00	0.00
1988	0.95	0.05	0.98	0.02	1.00	0.00
1989	**0.95**	**0.05**	0.96	0.04	1.00	0.00
1990	**0.96**	**0.04**	0.97	0.03	1.00	0.00
1991	**0.95**	**0.05**	0.95	0.05	1.00	0.00
1992	0.84	0.16	0.93	0.07	0.98	0.02
1993	0.94	0.06	0.95	0.05	0.99	0.01
1994	0.93	0.07	0.92	0.08	0.97	0.03
1995	0.91	0.09	0.90	0.10	0.96	0.04
1996	0.87	0.13	0.93	0.07	0.96	0.04
1997	0.92	0.08	0.85	0.15	0.90	0.10
1998	0.81	0.19	0.87	0.13	0.93	0.07
Mean (92-96)	0.90	0.10	0.93	0.07	0.97	0.03
95% CL=+/-	0.05	0.05	0.02	0.02	0.02	0.02
CV	4.7	41.7	1.8	22.6	1.4	51.4
N	5	5	5	5	5	5
Mean (84-91)	0.94	0.06	0.96	0.04	1.00	0.00
95% CL=+/-	0.02	0.02	0.03	0.03	0.00	0.00
CV	2.4	38.2	4.1	86.3	0.2	113.1
N	8	8	8	8	8	8

Table 3. Total returns, spawning escapement, potential egg deposition and percentage of egg depositionrequirement achieved in Lomond River, Torrent River, and Western Arm Brook in SFA 14(A), 1984-98. Numbers in bold type were estimated based on partial counts.

Year	Total Returns		Spawning Escapement		No. Eggs x 10^6		% Eggs
	Small	Large	Small	Large	Small	Large	Achieved
Lomond River							
1984	986	75	440	47	0.7356	0.0758	74
1985	393	14	189	14	0.3160	0.0226	31
1986	725	37	353	32	0.5901	0.0516	59
1987	652	12	355	11	0.5935	0.0177	56
1988	841	24	437	21	0.7306	0.0339	70
1989	**652**	**22**	382	21	0.6386	0.0339	61
1990	**777**	**19**	391	18	0.6537	0.0290	62
1991	**731**	**21**	403	20	0.6737	0.0323	64
1992	794	86	419	80	0.9495	0.3728	121
1993	816	38	504	33	1.1421	0.1538	118
1994	1038	56	695	49	1.2714	0.2793	142
1995	1365	101	983	95	1.5115	0.5415	187
1996	982	98	601	93	1.0414	0.5244	143
1997	1300	77	783	72	1.3568	0.4060	161
1998	721	128	541	125	0.9450	0.7048	151
Torrent River							
1984	1805	288	1,805	288	3.0902	0.9118	270
1985	1623	30	1,551	30	2.3022	0.0909	161
1986	3155	93	2,815	92	4.9539	0.3913	360
1987	2670	68	2,482	68	2.7027	0.2486	199
1988	2388	44	2,075	44	3.8292	0.1130	266
1989	1512	60	1,367	60	3.1478	0.1874	225
1990	2518	82	2,296	82	3.0851	0.1993	221
1991	1591	71	1,440	71	2.4155	0.2295	178
1992	2832	170	2,344	169	4.1125	0.5364	313
1993	4215	224	4,009	222	7.2739	0.7046	538
1994	3827	332	3,592	331	6.2796	1.5815	530
1995	6168	615	5,800	611	12.4117	2.9193	1033
1996	7371	509	6,923	507	16.4851	2.4955	1279
1997	4033	674	3,659	666	8.7749	3.0607	797
1998	5249	766	4,999	757	10.2389	3.4790	924
Western Arm Brook							
1984	235	0	117	0	0.2746	0.0000	30
1985	**467**	1	416	1	0.7202	0.0017	80
1986	**527**	0	525	0	1.4194	0.0000	156
1987	437	1	378	1	0.9297	0.0025	103
1988	**422**	1	251	1	0.6051	0.0024	67
1989	**455**	0	455	0	1.2907	0.0000	142
1990	**444**	0	444	0	1.4276	0.0000	157
1991	233	1	233	1	0.6129	0.0026	68
1992	480	8	480	8	1.3454	0.0224	151
1993	947	8	947	8	2.5943	0.0219	288
1994	954	31	954	31	2.5321	0.1187	292
1995	823	33	796	30	2.3844	0.2122	286
1996	1230	50	1,189	48	3.4858	0.2839	415
1997	509	55	508	55	1.4985	0.3167	200
1998	1718	128	1,650	128	4.9381	0.7371	625

Notes:

1. Lomond egg depositions in 1984-88 is based on 1983-93 mean biological characteristics and 1992-93 based on 1993 values.

2. Torrent egg depositions in 1990-93 based on 1985-89 mean biological characteristics for 1985-89 for small and large salmon.

3. Western Arm Brook egg depositions in 1984 based on 1974-93 mean biological characteristics for small and large salmon combined.

Table 4. Sea-survival of Atlantic salmon smolts from Western Arm Brook, 1971-98.

Smolt Year (i)	Smolts Year (i)	Small Returns Year (i+1)			
		Small Returns Year (i+1)	% Virgin 1SW	V. 1SW Returns Year (i+1)	% Sea-Survival
1971	5735	406	95.9	389	6.8
1972	11905	797	99.6	794	6.7
1973	8484	506	100.0	506	6.0
1974	11854	639	100.0	639	5.4
1975	9600	552	100.0	552	5.8
1976	6232	373	100.0	373	6.0
1977	9899	315	97.7	308	3.1
1978	13071	1578	99.6	1572	12.0
1979	8349	465	100.0	465	5.6
1980	15665	492	97.0	477	3.0
1981	13981	467	100.0	467	3.3
1982	12477	1141	99.5	1135	9.1
1983	10552	235	100.0	235	2.2
1984	20653	467	98.8	462	2.2
1985	13417	527	100.0	527	3.9
1986	17719	437	100.0	437	2.5
1987	17029	422	84.1	355	2.1
1988	15321	455	100.0	455	3.0
1989	11407	444	97.9	435	3.8
1990	10563	233	100.0	233	2.2
1991	13453	480	99.8	479	3.6
1992	15405	947	86.3	817	5.3
1993	13435	954	96.3	919	6.8
1994	9283	823	100.0	823	8.9
1995	15144	1230	100.0	1230	8.1
1996	14502	509	84.3	429	3.0
1997	23845	**1718**	**92.0**	**1581**	**6.6**
1998	**17139**				**0.0**
Mean (92-96)	13554	893	93	844	6.4
95% CI +/-	4499	273	10	309	2.5
C.V.	20.9	19.3	6.9	23.0	24.3
N	4	4	4	4	4
Mean (84-91)	14945	433	98	423	2.9
95% CI +/-	2845	73	5	76	0.6
C.V.	22.8	20.1	5.6	21.4	26.3
N	8	8	8	8	8

Table 5. Observations of bird species and prey types at Western Arm Brook, 1998.

Count of Total	Loc	Food Name									
	1		1 Total	2			2 Total	3		3 Total	Grand Total
Bird Name	Smolt	(blank)		Flounder	Smolt/Smelt	(blank)		Flounder	(blank)		
Am. Bittern	0	4	4	0	0	1	1	0	0	0	5
Arctic Tern	0	0	0	0	0	1	1	0	0	0	1
Bald Eagle	0	0	0	0	0	0	0	1	0	1	1
Black Back Gull	0	0	0	0	0	14	14	1	21	22	36
Black Duck	0	0	0	0	0	4	4	0	4	4	8
Can.Goose	0	0	0	0	0	12	12	0	30	30	42
CommonTern	0	0	0	0	0	6	6	0	26	26	32
Crow	0	8	8	0	0	4	4	0	10	10	22
Duck (unsp)	0	0	0	0	0	12	12	0	7	7	19
Gr. Scaup	0	0	0	0	0	14	14	0	15	15	29
Herring Gull	1	70	71	0	0	65	65	0	52	52	188
L. Yell.Legs	0	0	0	0	0	3	3	0	1	1	4
Loon	0	1	1	0	0	1	1	0	7	7	9
No birds	0	242	242	0	0	11	11	0	10	10	263
Osprey	0	7	7	1	0	4	5	8	8	16	28
Pintail Duck	0	0	0	0	0	10	10	0	1	1	11
Teal	0	0	0	0	0	1	1	0	0	0	1
Unknown	0	1	1	0	0	0	0	0	0	0	1
Merganser	0	0	0	0	1	11	12	0	13	13	25
Grand Total	1	333	334	1	1	174	176	10	205	215	725

Table 6. Bird counts and prey types at Western Arm Brook, 1998.

Sum of Total	Loc	Food Name									
	1		1 Total	2			2 Total	3		3 Total	Grand Total
Bird Name	Smolt	(blank)		Flounder	Smolt/Smelt	(blank)		Flounder	(blank)		
Am. Bittern	0	5	5	0	0	1	1	0	0	0	6
Arctic Tern	0	0	0	0	0	3	3	0	0	0	3
Bald Eagle	0	0	0	0	0	0	0	1	0	1	1
Black Back Gull	0	0	0	0	0	20	20	1	30	31	51
Black Duck	0	0	0	0	0	33	33	0	19	19	52
Can.Goose	0	0	0	0	0	179	179	0	718	718	897
CommonTern	0	0	0	0	0	10	10	0	84	84	94
Crow	0	9	9	0	0	5	5	0	14	14	28
Duck (unsp)	0	0	0	0	0	68	68	0	27	27	95
Gr. Scaup	0	0	0	0	0	127	127	0	153	153	280
Herring Gull	1	87	88	0	0	402	402	0	111	111	601
L. Yell.Legs	0	0	0	0	0	3	3	0	1	1	4
Loon	0	1	1	0	0	2	2	0	9	9	12
Merganser	0	0	0	0	18	91	109	0	64	64	173
No birds	0	0	0	0	0	0	0	0	0	0	0
Osprey	0	9	9	1	0	4	5	10	10	20	34
Pintail Duck	0	0	0	0	0	27	27	0	4	4	31
Teal	0	0	0	0	0	5	5	0	0	0	5
Unknown	0	1	1	0	0	0	0	0	0	0	1
Grand Total	1	112	113	1	18	980	999	12	1244	1256	2368

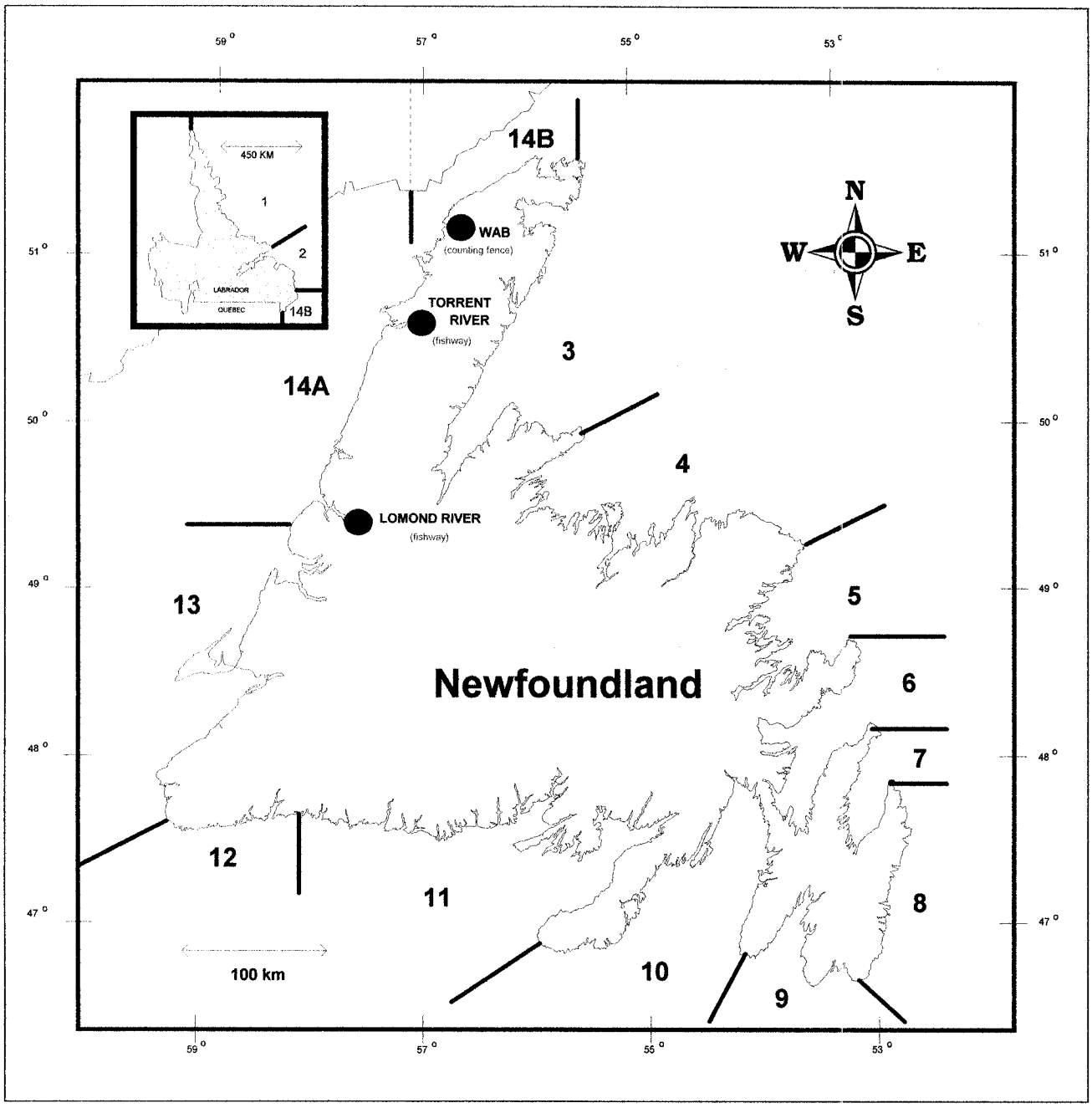

Figure 1. Location of Salmon Fishing Areas (SFAs) of Newfoundland and Labrador and selected rivers in SFA 14A.

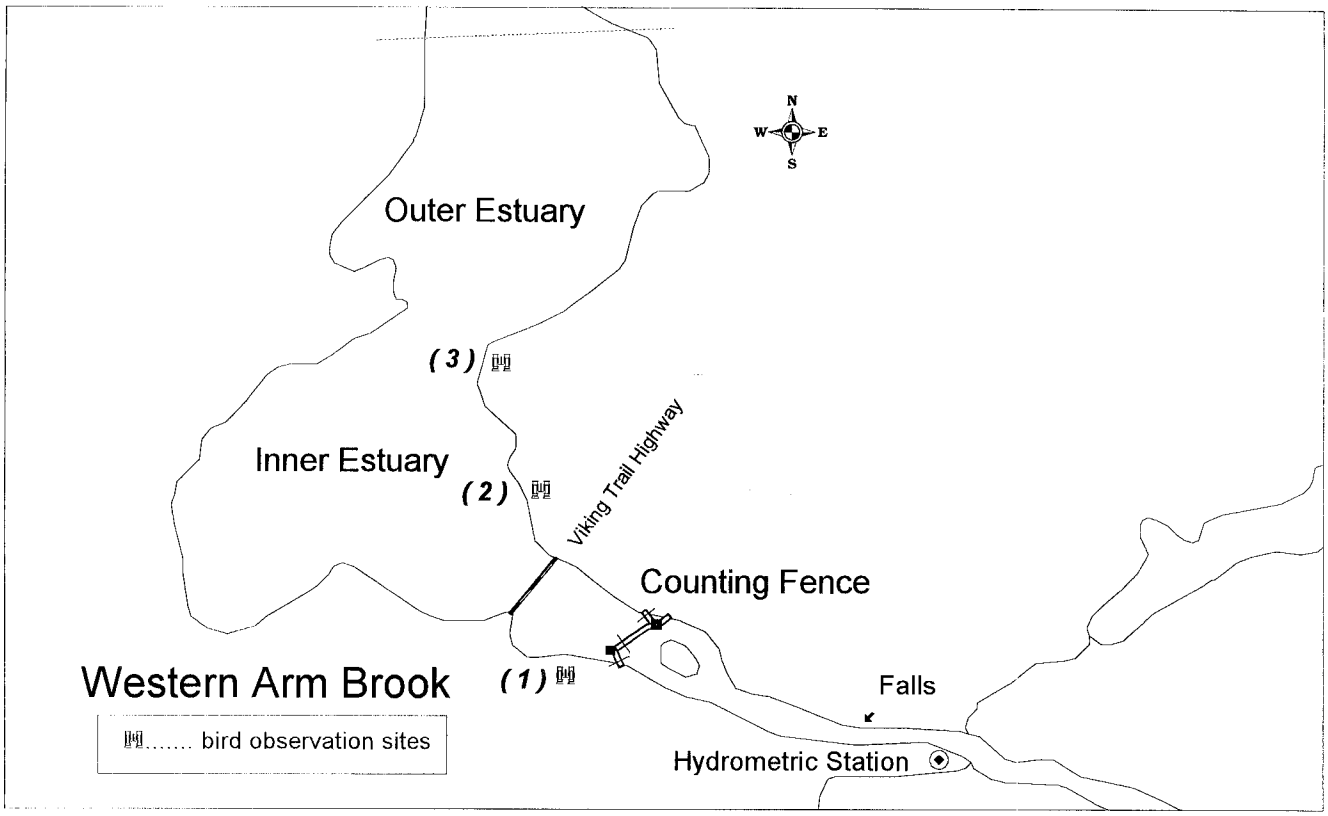

Figure 2. Location of the counting fence and the three bird observation sites at Western Arm Brook, 1998.

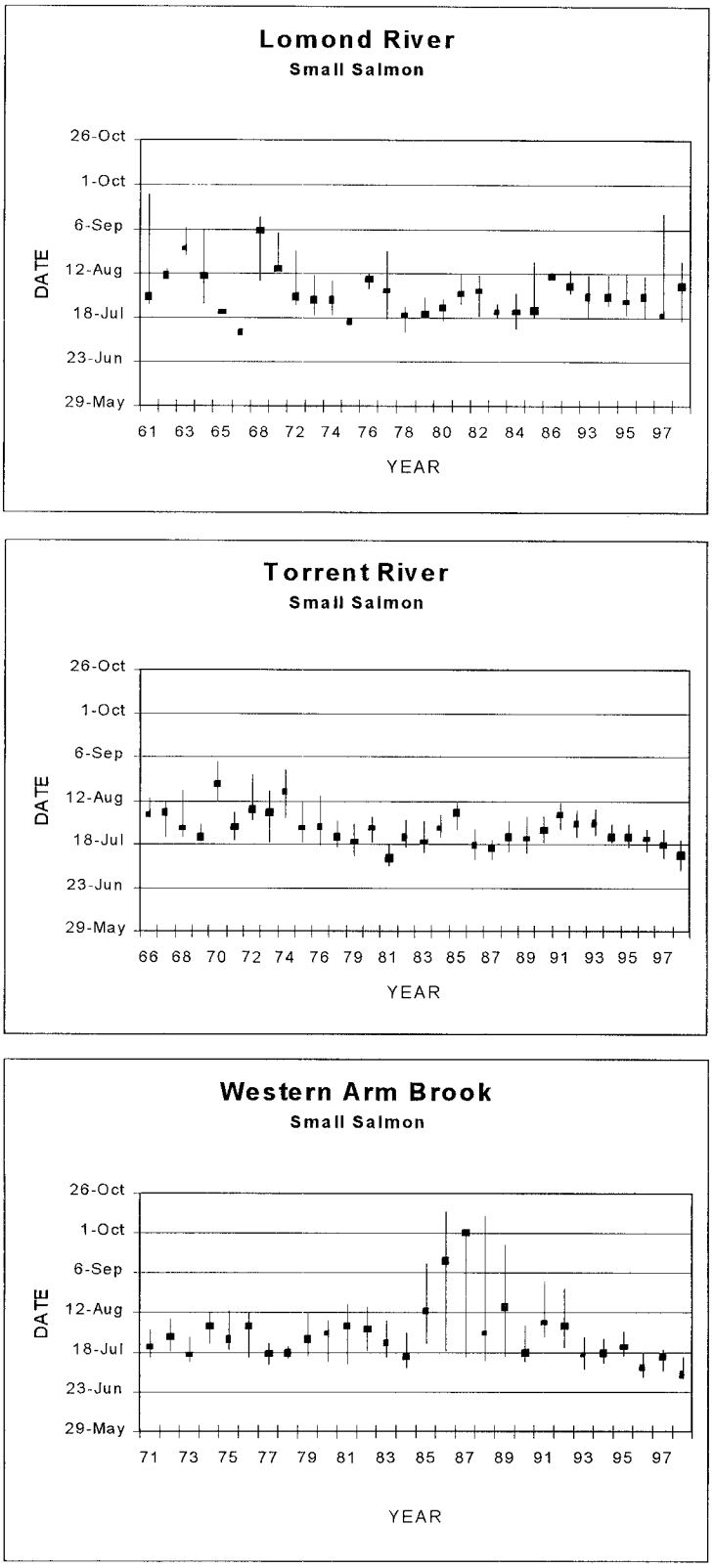

Figure 3. Run timing of small salmon to counting facilities on Lomond River, Torrent River and Western Arm Brook, 1971-98. The square symbols represent 50% of the run, lower vertical lines represent 25% of the run and the upper vertical lines represent 75%.of the run.

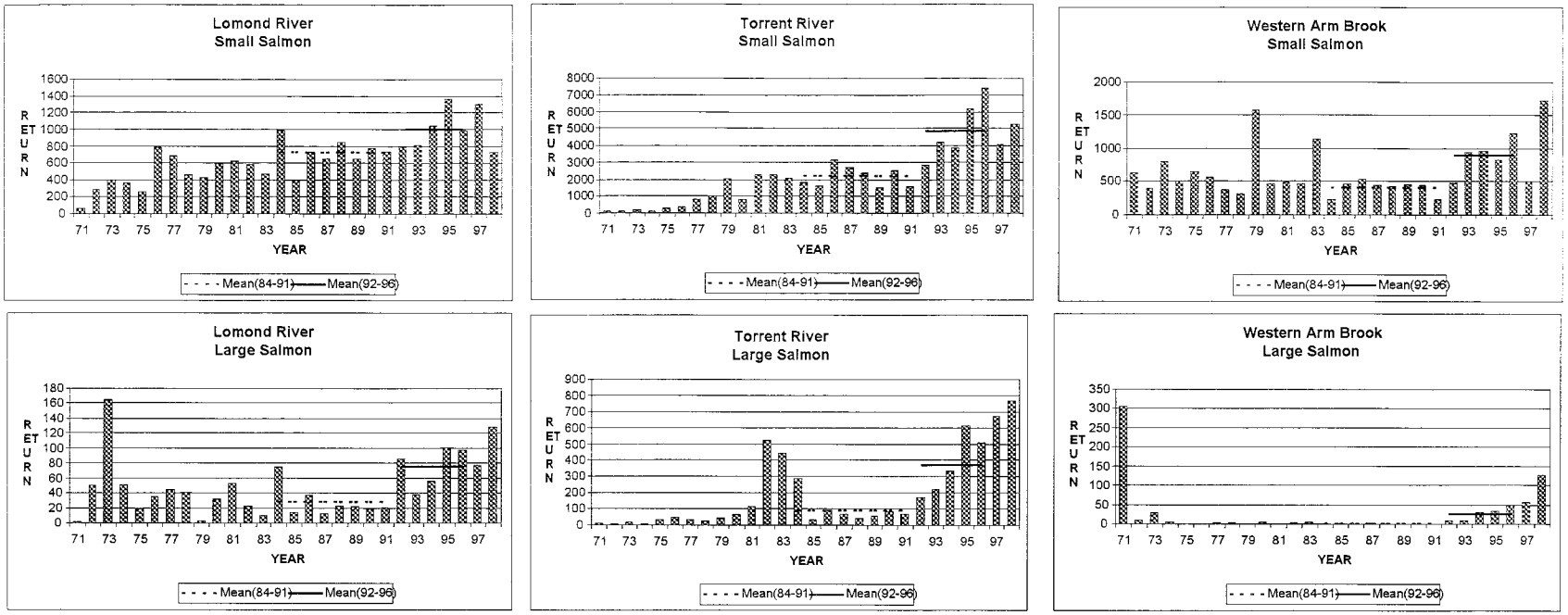

Figure 4. Returns of small and large salmon to Lomond River, Torrent River and Western Arm Brook, 1971-98.

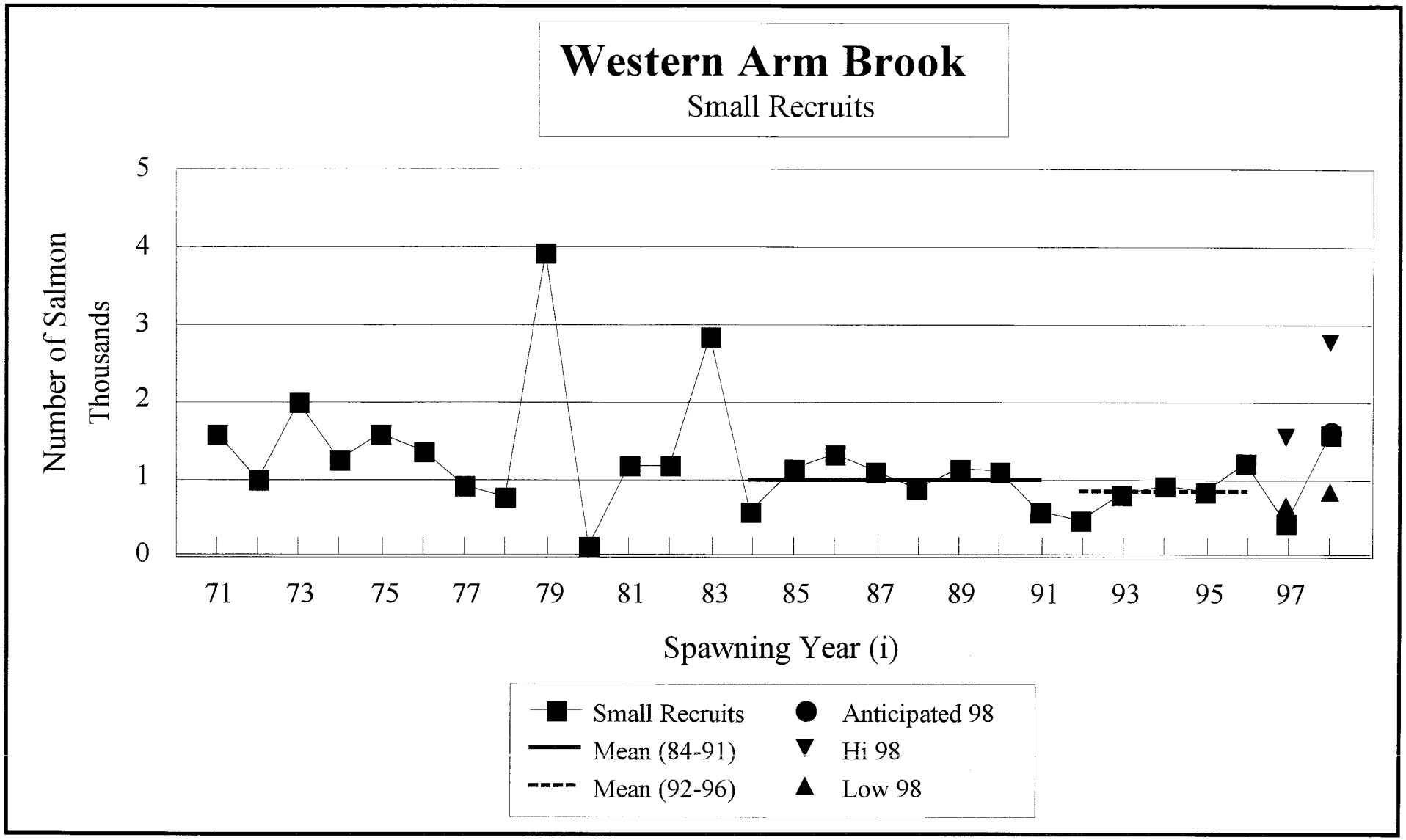

Figure 5. Estimated recruitment of small salmon at Western Arm Brook, 1971-98.

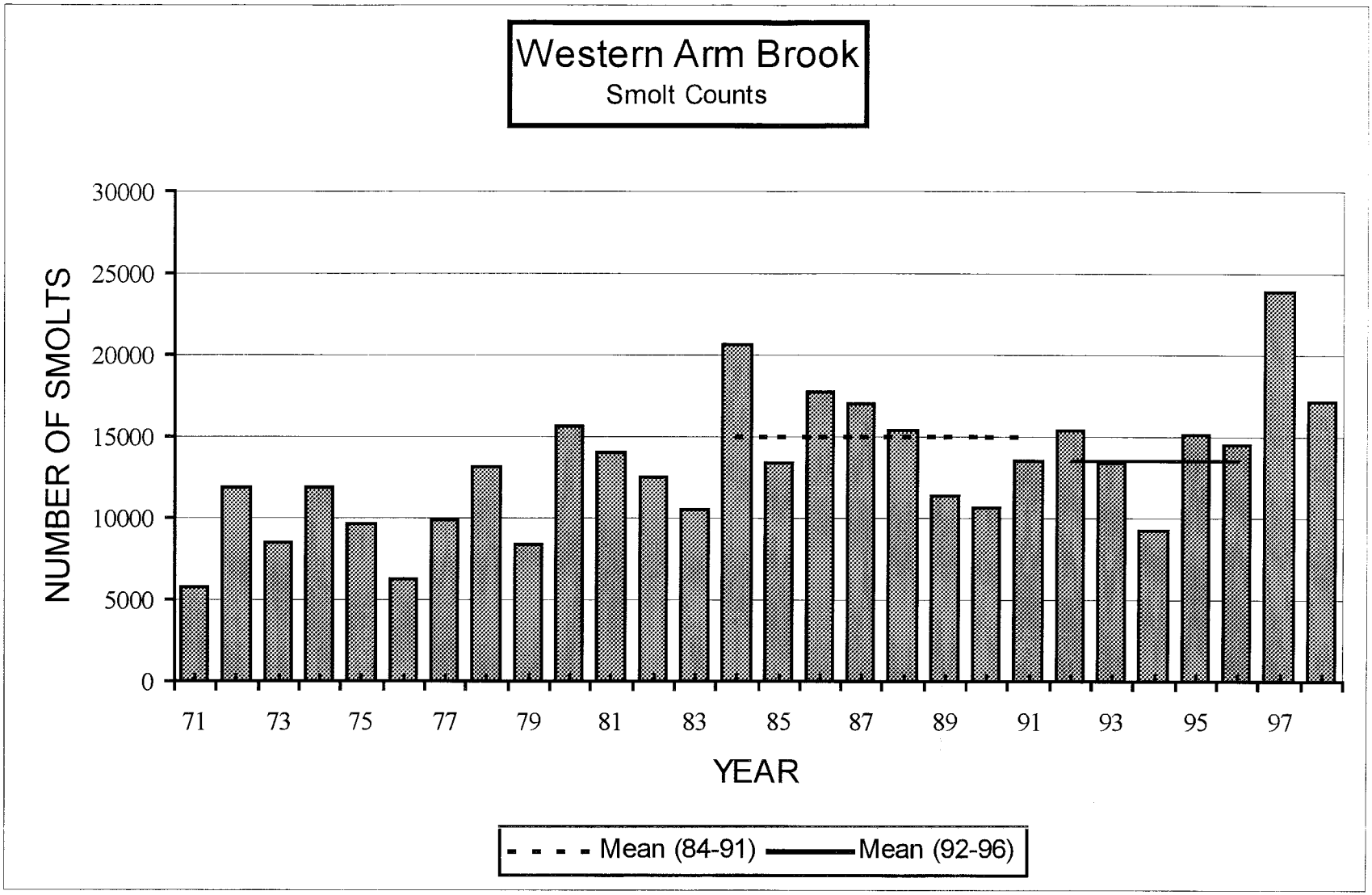

Figure 6. Smolt counts at the counting fence on Western Arm Brook, 1971-98.

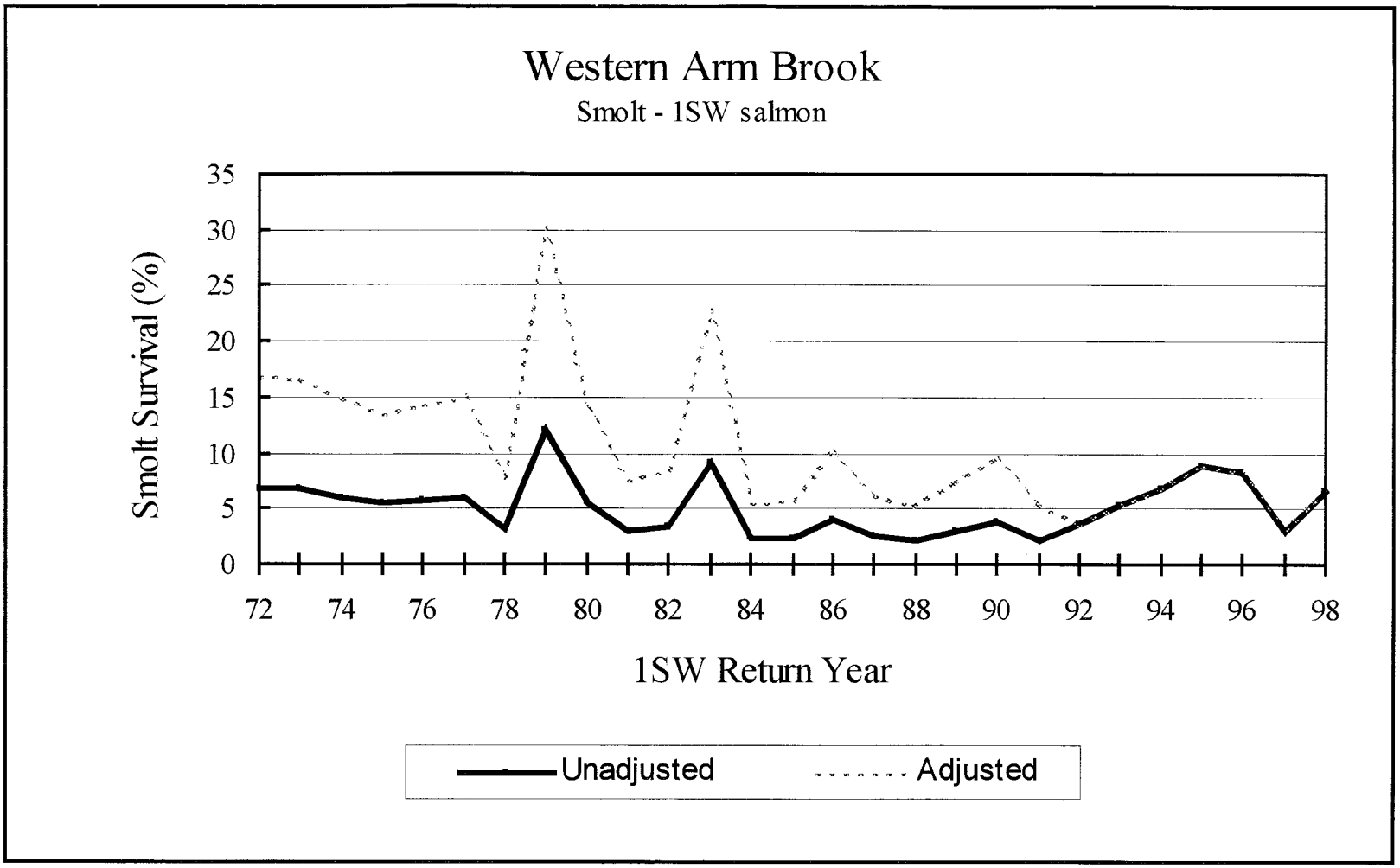

Figure 7. Percentage smolt survival to one sea winter salmon at Western Arm Brook, 1972-98. Dashed line represents adjustment for commercial fishery removals.

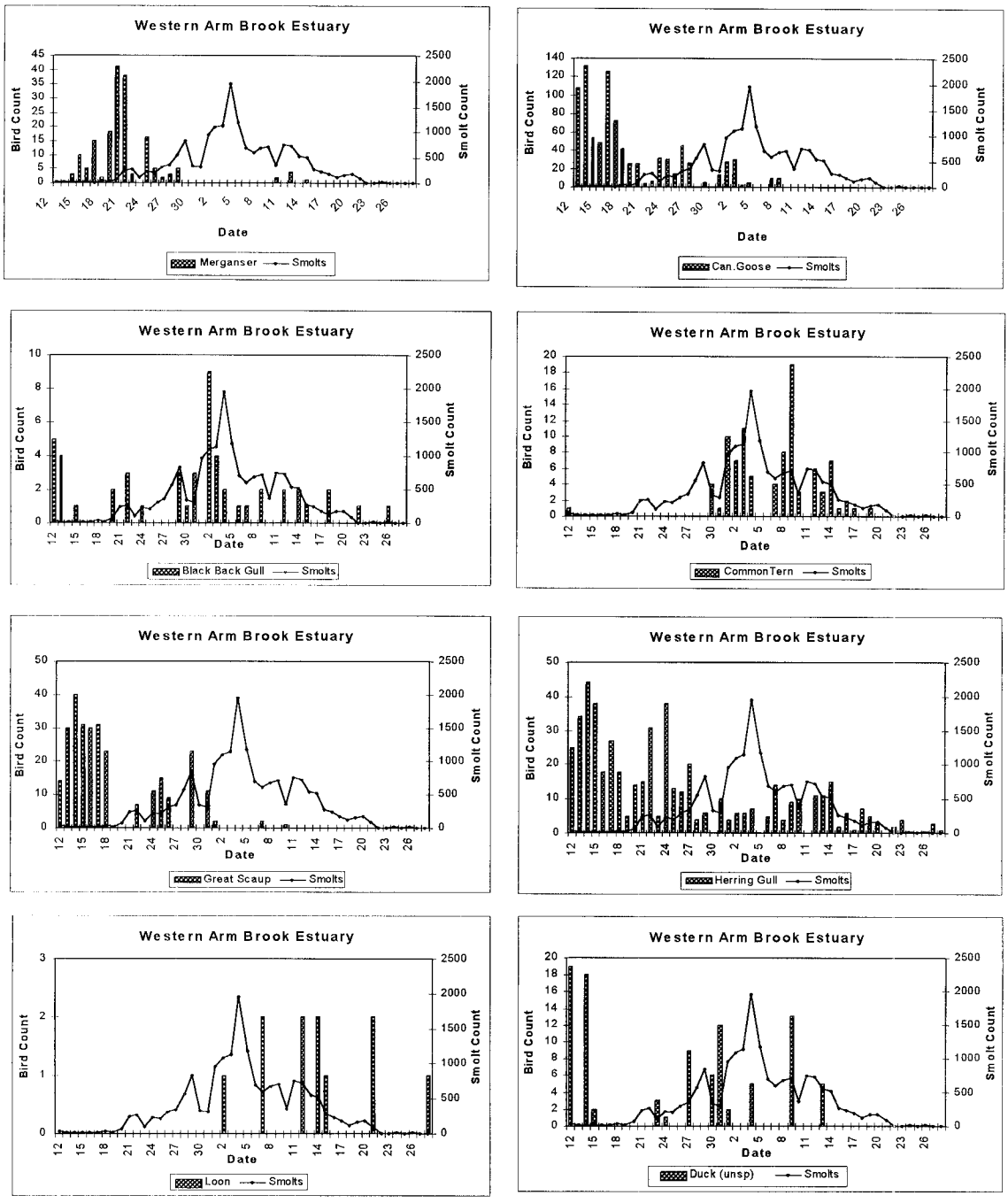

Figure 8. Daily bird counts in the estuary at the counting fence and daily smolt counts on Western Arm Brook, 1998.

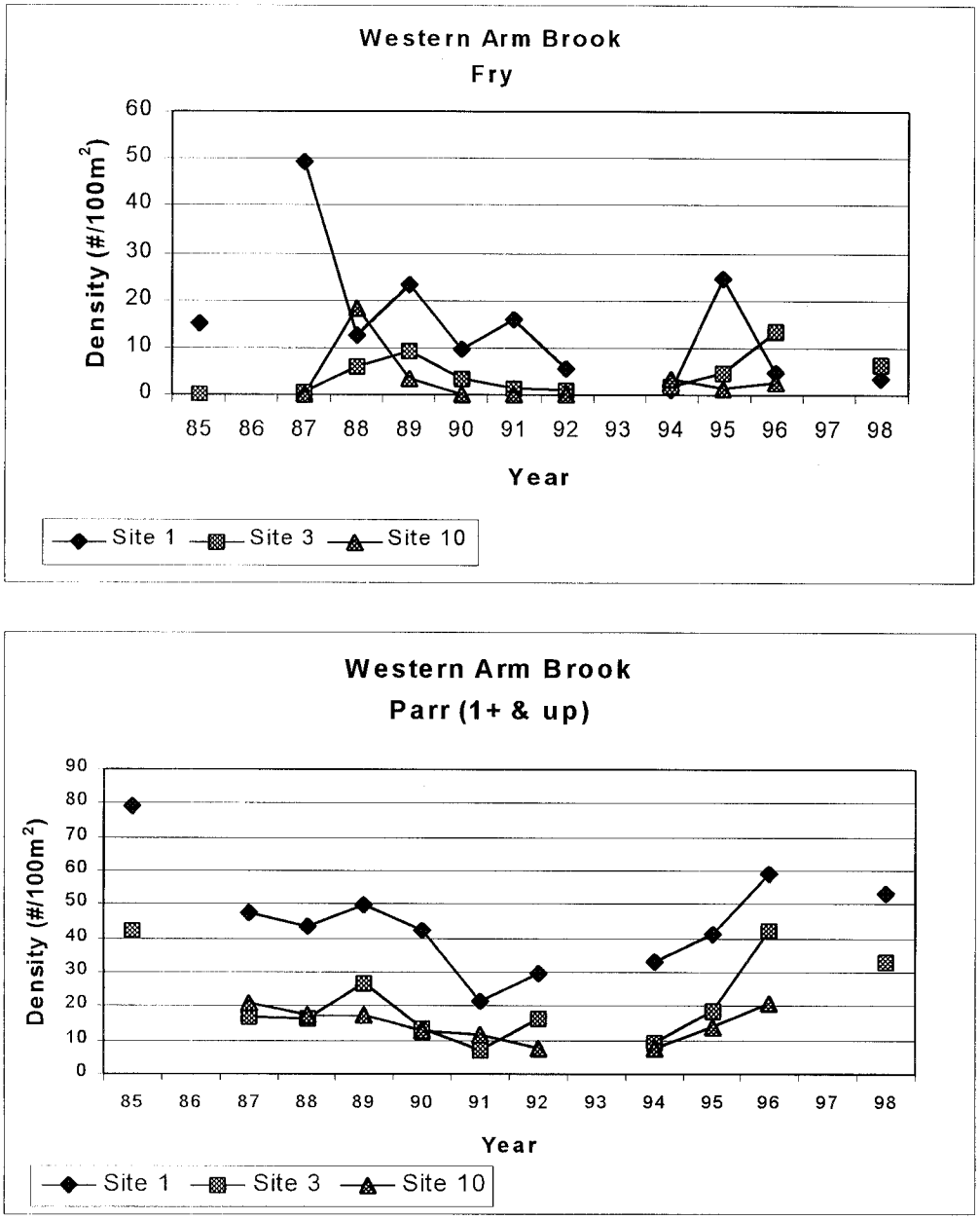

Figure 9. Density of juvenile salmon at sites 1, 3, and 10 on Western Arm Brook, 1985-98.

Appendix 1. Mean fork length, weight and sex composition of small and large female Atlantic salmon.
Note: Sex is determined internally for small salmon and internally and externally for large salmon.
Note: Samples are from recreational fishery and counting fence.
LOMOND

		FORK LENGTH (cm)					WHOLE WEIGHT (kg)					WHOLE WEIGHT FEMALES (kg)					NO.	PERCENT FEMALE	
		N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	SEXED	N	%
LARGE	YY																		
	78	3	69.17	68.0	70.0	1.04	3	3.33	3.2	3.6	0.23	2	3.40	3.2	3.6	0.28	3	2	66.7
	79	1	69.90	69.9	69.9	.	1	3.50	3.5	3.5	.	1	3.50	3.5	3.5	.	1	1	100.0
	80	3	67.90	64.0	71.1	3.60	3	3.74	2.9	4.2	0.69	3	3.74	2.9	4.2	0.69	3	3	100.0
	81	1	75.80	75.8	75.8	.	1	4.80	4.8	4.8	.	0	.	.	.	.	1	0	.
	82	2	70.00	70.0	70.0	0.00	2	3.86	3.6	4.1	0.32	2	3.86	3.6	4.1	0.32	2	2	100.0
	84	4	70.88	66.0	74.0	3.57	4	3.78	3.2	4.2	0.46	2	3.70	3.2	4.2	0.71	2	2	100.0
	92	26	70.51	63.0	77.0	3.36	0	.	.	.	.	0	.	.	.	.	26	1	3.8
	93	7	69.71	66.0	74.0	2.98	6	3.54	2.8	4.3	0.62	5	3.45	2.8	4.3	0.65	7	6	85.7
	94	1	76.80	76.8	76.8	.	1	5.20	5.2	5.2	.	1	5.20	5.2	5.2	.	1	1	100.0
	97	1	66.50	66.5	66.5	.	1	3.50	3.5	3.5	.	0	.	.	.	.	1	0	.
	98	7	71.71	64.6	77.7	4.19	6	3.40	2.4	4.0	0.62	3	3.10	2.4	4.0	0.82	7	3	42.9
	1984-91	4	70.88	66.0	74.0	3.57	4	3.78	3.2	4.2	0.46	2	3.70	3.2	4.2	0.71	2	2	100.0
	1992-98	42	70.63	63.0	77.7	3.53	14	3.60	2.4	5.2	0.72	9	3.53	2.4	5.2	0.89	42	11	26.2
	Total	56	70.48	63.0	77.7	3.39	28	3.67	2.4	5.2	0.62	19	3.60	2.4	5.2	0.68	54	21	38.9
SMALL	YY																		
	75	1	50.80	50.8	50.8	.	1	1.40	1.4	1.4	.	0	.	.	.	.	0	0	.
	78	21	51.25	45.5	60.0	3.26	21	1.47	1.0	2.3	0.27	0	.	.	.	.	0	0	.
	79	30	51.97	41.9	57.2	2.81	39	1.47	1.0	2.0	0.22	0	.	.	.	.	0	0	.
	80	15	51.53	46.0	56.0	3.02	13	1.54	1.1	1.8	0.24	0	.	.	.	.	0	0	.
	81	39	51.50	41.0	62.4	3.50	38	1.70	1.3	2.8	0.32	0	.	.	.	.	0	0	.
	82	5	48.80	45.0	52.0	2.77	35	1.56	1.0	3.6	0.42	0	.	.	.	.	0	0	.
	83	15	52.63	44.0	56.0	3.18	11	1.47	1.3	1.7	0.11	8	1.46	1.3	1.6	0.09	12	9	75.0
	84	53	51.09	46.0	58.0	2.80	49	1.45	1.1	1.8	0.20	31	1.43	1.1	1.8	0.16	52	32	61.5
	85	33	51.81	44.0	60.0	3.69	23	1.54	1.1	2.1	0.25	6	1.43	1.2	2.0	0.29	11	9	81.8
	86	40	52.86	45.0	60.0	3.20	54	1.88	0.5	5.3	0.98	9	1.71	1.3	2.2	0.30	37	15	40.5
	88	6	52.92	50.5	56.0	1.80	6	1.50	1.3	1.6	0.15	1	1.36	1.4	1.4	.	6	1	16.7
	90	1	50.80	50.8	50.8	.	1	1.10	1.1	1.1	.	1	1.10	1.1	1.1	.	1	1	100.0
	91	1	54.60	54.6	54.6	.	1	1.30	1.3	1.3	.	1	1.30	1.3	1.3	.	1	1	100.0
	92	52	53.95	37.0	62.5	4.46	4	1.53	1.3	1.8	0.22	3	1.60	1.4	1.8	0.20	6	5	83.3
	93	79	52.86	40.0	61.2	3.89	58	1.61	0.6	3.0	0.48	8	1.46	0.7	2.0	0.40	35	24	68.6
	94	24	52.97	40.6	57.2	3.77	24	1.49	0.5	2.4	0.36	12	1.50	0.5	2.4	0.46	26	14	53.8
	95	21	53.95	48.2	59.0	2.47	34	1.62	0.8	2.5	0.37	5	1.89	1.5	2.1	0.24	9	5	55.6
	96	64	52.43	40.0	61.0	3.45	22	1.50	1.0	2.0	0.35	3	1.63	1.4	2.0	0.32	8	4	50.0
	97	27	52.56	41.5	59.5	3.64	27	1.84	0.8	2.9	0.42	0	.	.	.	.	0	0	.
	98	54	53.84	46.9	62.0	3.46	51	1.48	0.7	2.6	0.43	4	1.50	1.1	1.8	0.36	9	6	66.7
	1984-91	134	51.90	44.0	60.0	3.18	134	1.64	0.5	5.3	0.67	49	1.47	1.1	2.2	0.24	108	59	54.6
	1992-98	321	53.17	37.0	62.5	3.75	220	1.59	0.5	3.0	0.43	35	1.57	0.5	2.4	0.39	93	58	62.4
	Total	581	52.54	37.0	62.5	3.57	512	1.59	0.5	5.3	0.48	92	1.50	0.5	2.4	0.30	213	126	59.2

Appendix 2. Mean fork length, weight and sex composition of small and large female Atlantic salmon.
Note: Sex is determined internally for small salmon and internally and externally for large salmon.
Note: Samples are from recreational fishery and counting fence.
TORRENT

		FORK LENGTH (cm)					WHOLE WEIGHT (kg)					WHOLE WEIGHT FEMALES (kg)					NO.	PERCENT FEMALE	
		N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	SEXED	N	%
LARGE	YY																		
	80	1	73.60	73.6	73.6	.	0	.	.	.	.	0	.	.	.	.	1	0	.
	85	5	73.80	71.0	76.0	2.17	1	4.25	4.3	4.3	.	1	4.25	4.3	4.3	.	5	2	40.0
	86	9	72.02	64.0	76.0	3.44	9	4.31	2.2	5.5	0.93	5	3.86	2.2	4.7	1.00	9	5	55.6
	87	8	75.18	63.0	87.0	7.85	8	4.10	3.0	5.5	0.96	4	4.45	3.8	5.0	0.64	8	4	50.0
	88	10	70.06	63.0	77.8	5.92	10	3.60	2.3	5.0	1.06	4	4.44	3.5	5.0	0.72	10	4	40.0
	89	15	73.02	65.6	82.4	5.77	8	3.76	2.8	5.3	1.00	4	4.40	3.1	5.3	1.01	15	6	40.0
	90	2	63.50	63.0	64.0	0.71	0	.	.	.	.	0	.	.	.	.	2	1	50.0
	92	1	78.00	78.0	78.0	.	0	.	.	.	.	0	.	.	.	.	1	1	100.0
	93	146	69.51	63.0	81.5	4.77	0	.	.	.	.	0	.	.	.	.	146	104	71.2
	94	3	71.00	70.0	72.0	1.00	2	3.65	3.5	3.8	0.21	1	3.80	3.8	3.8	.	3	1	33.3
	96	2	77.00	72.0	82.0	7.07	2	4.75	3.5	6.0	1.77	2	4.75	3.5	6.0	1.77	2	2	100.0
	97	11	65.92	63.0	73.0	2.95	11	3.45	2.5	5.0	0.76	6	3.20	2.7	4.0	0.44	11	6	54.5
	1984-91	49	72.28	63.0	87.0	5.81	36	3.94	2.2	5.5	0.98	18	4.26	2.2	5.3	0.81	49	22	44.9
	1992-98	163	69.44	63.0	82.0	4.82	15	3.65	2.5	6.0	0.92	9	3.61	2.7	6.0	0.98	163	114	69.9
	Total	213	70.11	63.0	87.0	5.19	51	3.86	2.2	6.0	0.96	27	4.04	2.2	6.0	0.91	213	136	63.8
SMALL	YY																		
	75	0	.	.	.	.	16	1.70	1.1	4.1	0.69	0	.	.	.	.	0	0	.
	79	4	56.38	47.0	62.0	6.57	3	1.82	1.2	2.2	0.58	0	.	.	.	.	0	0	.
	80	58	53.15	32.4	61.0	4.24	0	.	.	.	.	0	.	.	.	.	0	0	.
	81	0	.	.	.	.	10	1.53	1.0	2.0	0.34	0	.	.	.	.	0	0	.
	83	16	53.01	48.5	56.0	2.38	16	1.43	1.0	1.8	0.25	8	1.43	1.0	1.6	0.27	12	8	66.7
	85	154	52.49	44.0	61.5	3.16	6	1.46	1.0	2.3	0.46	0	.	.	.	.	7	3	42.9
	86	305	52.39	40.5	61.5	3.30	303	1.76	0.5	3.0	0.43	16	1.52	1.2	2.0	0.22	24	18	75.0
	87	301	51.96	42.7	60.5	2.86	301	1.57	0.7	2.8	0.38	19	1.44	1.0	2.0	0.25	21	19	90.5
	88	220	53.67	47.0	62.7	3.37	220	1.52	1.0	2.5	0.36	12	1.56	1.0	2.3	0.34	14	12	85.7
	89	108	54.12	45.9	62.0	3.47	101	1.67	0.2	2.6	0.32	0	.	.	.	.	0	0	.
	90	40	53.93	47.0	62.5	3.84	0	.	.	.	.	0	.	.	.	.	5	3	60.0
	91	43	52.61	47.0	59.0	3.10	4	1.78	1.5	2.2	0.31	2	1.90	1.6	2.2	0.42	4	2	50.0
	92	17	53.43	46.7	59.0	3.03	0	.	.	.	.	0	.	.	.	.	4	3	75.0
	93	254	53.18	30.0	62.0	4.20	2	2.10	1.9	2.3	0.28	2	2.10	1.9	2.3	0.28	2	2	100.0
	94	22	54.25	48.0	60.5	3.38	17	1.43	0.9	3.0	0.50	2	1.50	1.4	1.6	0.14	2	2	100.0
	95	19	54.07	48.3	58.4	2.58	17	1.68	1.1	2.1	0.32	10	1.68	1.4	2.0	0.21	17	12	70.6
	96	37	54.22	48.0	60.8	3.09	34	1.57	1.0	2.8	0.37	4	1.71	1.3	2.3	0.45	7	6	85.7
	97	53	56.65	47.0	62.8	3.36	46	2.13	1.0	3.5	0.55	2	2.00	1.8	2.3	0.35	12	9	75.0
	98	44	55.06	47.3	61.0	3.16	28	1.80	1.3	2.5	0.30	10	1.84	1.4	2.5	0.32	30	14	46.7
	1984-91	1171	52.75	40.5	62.7	3.30	935	1.63	0.2	3.0	0.40	49	1.51	1.0	2.3	0.28	75	57	76.0
	1992-98	446	53.96	30.0	62.8	3.94	144	1.80	0.9	3.5	0.50	30	1.77	1.3	2.5	0.31	74	48	64.9
	Total	1695	53.10	30.0	62.8	3.55	1124	1.65	0.2	4.1	0.42	87	1.60	1.0	2.5	0.32	161	113	70.2

Appendix 3. Mean fork length, weight and sex composition of small and large female Atlantic salmon.
Note: Sex is determined internally for small salmon and internally and externally for large salmon.
Note: Samples are from recreational fishery and counting fence.
WESTERN ARM

		FORK LENGTH (cm)					WHOLE WEIGHT (kg)					WHOLE WEIGHT FEMALES (kg)					NO.	PERCENT FEMALE	
		N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	N	MEAN	MIN	MAX	STD	SEXED	N	%
LARGE	YY																		
	73	1	72.00	72.0	72.0	.	1	3.85	3.9	3.9	.	0	.	.	.	.	1	0	.
	77	2	74.50	74.0	75.0	0.71	2	3.94	3.9	4.0	0.08	1	3.88	3.9	3.9	.	2	1	50.0
	80	2	75.00	73.0	77.0	2.83	2	4.55	4.2	4.9	0.49	2	4.55	4.2	4.9	0.49	2	2	100.0
	81	2	69.00	68.5	69.5	0.71	2	2.95	2.3	3.6	0.92	2	2.95	2.3	3.6	0.92	2	2	100.0
	85	1	71.00	71.0	71.0	.	1	3.50	3.5	3.5	.	0	.	.	.	.	1	0	.
	87	1	64.00	64.0	64.0	.	1	2.40	2.4	2.4	.	1	2.40	2.4	2.4	.	1	1	100.0
	88	2	76.00	72.0	80.0	5.66	2	3.40	2.8	4.0	0.85	2	3.40	2.8	4.0	0.85	2	2	100.0
	89	1	63.50	63.5	63.5	.	1	1.60	1.6	1.6	.	0	.	.	.	.	1	0	.
	90	1	64.80	64.8	64.8	.	1	3.00	3.0	3.0	.	1	3.00	3.0	3.0	.	1	1	100.0
	91	1	76.20	76.2	76.2	.	1	4.00	4.0	4.0	.	1	4.00	4.0	4.0	.	1	1	100.0
	92	8	70.85	63.0	79.0	5.73	1	4.50	4.5	4.5	.	1	4.50	4.5	4.5	.	8	5	62.5
	93	4	69.58	67.8	71.5	1.95	4	3.48	2.0	4.2	1.00	4	3.48	2.0	4.2	1.00	4	4	100.0
	94	7	70.11	63.9	78.1	4.68	7	3.67	2.2	5.0	1.00	3	3.83	2.2	5.0	1.46	7	3	42.9
	95	35	73.88	64.8	83.5	3.95	35	4.73	3.0	6.3	0.84	29	4.72	3.0	6.0	0.80	35	29	82.9
	96	26	72.35	63.0	77.4	4.09	26	3.94	1.2	6.0	1.54	21	3.89	1.2	6.0	1.52	26	21	80.8
	97	7	70.16	63.0	74.9	4.05	7	2.84	2.4	4.0	0.63	6	2.65	2.4	3.4	0.40	7	6	85.7
	98	12	72.67	67.8	79.0	4.01	12	4.07	3.2	6.0	0.86	10	3.78	3.2	5.0	0.54	12	10	83.3
	1984-91	7	70.21	63.5	80.0	6.43	7	3.04	1.6	4.0	0.88	5	3.24	2.4	4.0	0.73	7	5	71.4
	1992-98	99	72.38	63.0	83.5	4.28	92	4.14	1.2	6.3	1.20	74	4.08	1.2	6.0	1.19	99	78	78.8
	Total	113	72.27	63.0	83.5	4.36	106	4.04	1.2	6.3	1.19	84	4.01	1.2	6.0	1.16	113	88	77.9
SMALL	YY																		
	71	78	52.76	36.6	61.2	3.12	13	1.51	1.0	1.8	0.21	0	.	.	.	.	0	0	.
	72	67	52.58	37.2	62.5	3.72	76	1.60	0.6	2.6	0.40	0	.	.	.	.	0	0	.
	73	137	53.13	43.8	62.1	2.98	136	1.60	0.8	2.8	0.29	0	.	.	.	.	0	0	.
	74	80	53.10	45.9	59.8	2.56	79	1.62	1.1	2.2	0.23	0	.	.	.	.	0	0	.
	75	24	52.26	33.0	58.5	5.24	24	1.52	0.7	2.3	0.36	0	.	.	.	.	0	0	.
	76	205	53.12	41.0	59.0	2.75	11	1.68	1.4	3.0	0.45	0	.	.	.	.	0	0	.
	77	75	52.90	40.9	60.3	3.58	71	1.37	0.5	2.6	0.39	0	.	.	.	.	0	0	.
	78	73	52.06	45.0	58.0	2.72	28	1.39	0.6	2.1	0.43	0	.	.	.	.	0	0	.
	79	226	51.39	27.5	62.0	3.07	226	1.51	0.5	2.9	0.30	0	.	.	.	.	0	0	.
	80	765	52.55	39.0	59.5	2.40	758	0.96	0.1	7.0	0.38	0	.	.	.	.	0	0	.
	81	73	52.28	43.0	60.0	3.20	73	1.51	0.8	2.5	0.36	0	.	.	.	.	0	0	.
	82	76	53.11	48.0	59.5	2.12	76	1.79	0.7	3.0	0.36	0	.	.	.	.	0	0	.
	83	205	51.42	35.9	60.0	2.90	203	1.52	0.7	2.7	0.31	1	1.80	1.8	1.8	.	1	1	100.0
	84	41	51.14	45.0	59.5	2.71	39	1.27	0.8	2.0	0.33	2	1.30	1.2	1.4	0.14	2	2	100.0
	85	80	52.27	37.5	59.0	3.04	80	1.56	0.9	2.2	0.30	45	1.58	0.9	2.1	0.30	52	45	86.5
	86	38	52.93	46.0	58.5	2.95	38	1.65	1.1	2.2	0.29	0	.	.	.	.	0	0	.
	87	86	53.58	36.0	59.4	3.29	85	1.63	0.5	2.7	0.34	17	1.91	1.5	2.7	0.41	22	18	81.8
	88	66	53.65	36.5	61.0	3.83	64	1.56	0.5	2.4	0.48	16	1.61	0.9	2.0	0.27	24	18	75.0
	89	155	53.51	42.0	60.5	3.17	58	1.60	0.0	2.5	0.51	7	1.89	1.5	2.3	0.28	8	7	87.5
	90	49	55.45	50.8	62.2	3.16	36	1.82	1.0	2.4	0.41	2	1.40	1.4	1.4	0.00	3	2	66.7
	91	228	53.26	46.4	62.2	2.50	81	1.71	0.0	2.1	0.25	0	.	.	.	.	0	0	.
	92	415	53.65	34.0	61.6	2.91	7	1.61	0.7	2.2	0.64	0	.	.	.	.	0	0	.
	93	292	54.02	46.6	62.0	2.74	271	1.82	0.6	4.1	0.53	0	.	.	.	.	0	0	.
	94	112	53.36	11.4	60.9	5.22	110	1.77	0.0	2.8	0.39	11	1.80	1.3	2.3	0.29	12	11	91.7
	95	101	54.09	32.0	62.0	4.03	94	2.10	1.3	3.3	0.36	18	1.99	1.5	2.5	0.28	25	24	96.0
	96	82	54.70	45.0	61.7	3.42	78	1.95	0.8	3.0	0.48	29	2.04	1.3	2.7	0.37	36	29	80.6
	97	57	55.17	42.4	62.0	3.25	38	1.91	0.9	2.9	0.51	1	1.90	1.9	1.9	.	1	1	100.0
	98	129	53.38	20.1	62.5	6.43	123	1.91	0.7	3.4	0.53	44	2.25	1.3	3.0	0.36	59	44	74.6
	1984-91	743	53.29	36.0	62.2	3.12	481	1.61	0.0	2.7	0.38	89	1.66	0.9	2.7	0.34	111	92	82.9
	1992-98	1188	53.87	11.4	62.5	3.83	721	1.88	0.0	4.1	0.49	103	2.09	1.3	3.0	0.37	133	109	82.0
	Total	4015	53.02	11.4	62.5	3.29	2976	1.49	0.0	7.0	0.52	193	1.89	0.9	3.0	0.42	245	202	82.4

Appendix 4. Smolt-age distribution of small and large Atlantic salmon. Virgin spawners only.

LOMOND

		SMOLT-AGE									Total		
		2			3			4					
		N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN
LARGE	YY												
	78	.	.	.	2	100.0	3.0	.	.	.	2	100.0	3.0
	79	.	.	.	1	100.0	3.0	.	.	.	1	100.0	3.0
	80	.	.	.	2	100.0	3.0	.	.	.	2	100.0	3.0
	81	1	100.0	2.0	.	.	.	.	.	.	1	100.0	2.0
	82	.	.	.	2	100.0	3.0	.	.	.	2	100.0	3.0
	84	2	50.0	2.0	2	50.0	3.0	.	.	.	4	100.0	2.5
	92	2	12.5	2.0	14	87.5	3.0	.	.	.	16	100.0	2.9
	93	4	66.7	2.0	2	33.3	3.0	.	.	.	6	100.0	2.3
	94	.	.	.	1	100.0	3.0	.	.	.	1	100.0	3.0
	98	.	.	.	1	33.3	3.0	2	66.7	4.0	3	100.0	3.7
	1984-91	2	50.0	2.0	2	50.0	3.0	.	.	.	4	100.0	2.5
	1992-98	6	23.1	2.0	18	69.2	3.0	2	7.7	4.0	26	100.0	2.8
SMALL	YY												
	75	.	.	.	1	100.0	3.0	.	.	.	1	100.0	3.0
	78	.	.	.	20	100.0	3.0	.	.	.	20	100.0	3.0
	79	7	17.9	2.0	31	79.5	3.0	1	2.6	4.0	39	100.0	2.8
	80	8	53.3	2.0	7	46.7	3.0	.	.	.	15	100.0	2.5
	81	2	5.4	2.0	33	89.2	3.0	2	5.4	4.0	37	100.0	3.0
	82	3	8.1	2.0	31	83.8	3.0	3	8.1	4.0	37	100.0	3.0
	83	5	33.3	2.0	8	53.3	3.0	2	13.3	4.0	15	100.0	2.8
	84	12	21.8	2.0	42	76.4	3.0	1	1.8	4.0	55	100.0	2.8
	85	.	.	.	27	84.4	3.0	5	15.6	4.0	32	100.0	3.2
	86	10	16.1	2.0	47	75.8	3.0	5	8.1	4.0	62	100.0	2.9
	88	2	33.3	2.0	3	50.0	3.0	1	16.7	4.0	6	100.0	2.8
	90	.	.	.	1	100.0	3.0	.	.	.	1	100.0	3.0
	91	.	.	.	1	100.0	3.0	.	.	.	1	100.0	3.0
	92	3	6.0	2.0	47	94.0	3.0	.	.	.	50	100.0	2.9
	93	11	14.7	2.0	59	78.7	3.0	5	6.7	4.0	75	100.0	2.9
	94	.	.	.	16	66.7	3.0	8	33.3	4.0	24	100.0	3.3
	95	3	7.0	2.0	40	93.0	3.0	.	.	.	43	100.0	2.9
	96	2	3.1	2.0	45	70.3	3.0	17	26.6	4.0	64	100.0	3.2
	97	2	7.1	2.0	25	89.3	3.0	1	3.6	4.0	28	100.0	3.0
	98	.	.	.	33	68.8	3.0	15	31.3	4.0	48	100.0	3.3
	1984-91	24	15.3	2.0	121	77.1	3.0	12	7.6	4.0	157	100.0	2.9
	1992-98	21	6.3	2.0	265	79.8	3.0	46	13.9	4.0	332	100.0	3.1

Appendix 5. Smolt-age distribution of small and large Atlantic salmon.
Virgin spawners only.
TORRENT

		SMOLT-AGE												Total		
		2			3			4			5					
		N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN
LARGE	YY															
	85	.	.	.	2	100.0	3.0	.	.	.	.	.	.	2	100.0	3.0
	86	.	.	.	3	75.0	3.0	1	25.0	4.0	.	.	.	4	100.0	3.3
	87	.	.	.	1	100.0	3.0	.	.	.	.	.	.	1	100.0	3.0
	88	.	.	.	1	100.0	3.0	.	.	.	.	.	.	1	100.0	3.0
	89	.	.	.	.	.	.	1	100.0	4.0	.	.	.	1	100.0	4.0
	90	.	.	.	.	.	.	1	100.0	4.0	.	.	.	1	100.0	4.0
	93	.	.	.	51	91.1	3.0	5	8.9	4.0	.	.	.	56	100.0	3.1
	94	.	.	.	1	50.0	3.0	1	50.0	4.0	.	.	.	2	100.0	3.5
	96	.	.	.	.	.	.	1	100.0	4.0	.	.	.	1	100.0	4.0
	1984-91	.	.	.	7	70.0	3.0	3	30.0	4.0	.	.	.	10	100.0	3.3
	1992-98	.	.	.	52	88.1	3.0	7	11.9	4.0	.	.	.	59	100.0	3.1
SMALL	YY															
	75	.	.	.	11	68.8	3.0	5	31.3	4.0	.	.	.	16	100.0	3.3
	79	.	.	.	3	75.0	3.0	1	25.0	4.0	.	.	.	4	100.0	3.3
	80	4	7.3	2.0	47	85.5	3.0	4	7.3	4.0	.	.	.	55	100.0	3.0
	81	.	.	.	8	88.9	3.0	1	11.1	4.0	.	.	.	9	100.0	3.1
	83	1	6.3	2.0	9	56.3	3.0	6	37.5	4.0	.	.	.	16	100.0	3.3
	85	.	.	.	91	61.9	3.0	55	37.4	4.0	1	0.7	5.0	147	100.0	3.4
	86	2	0.7	2.0	226	77.9	3.0	61	21.0	4.0	1	0.3	5.0	290	100.0	3.2
	87	6	2.1	2.0	231	80.5	3.0	50	17.4	4.0	.	.	.	287	100.0	3.2
	88	2	1.0	2.0	158	82.7	3.0	31	16.2	4.0	.	.	.	191	100.0	3.2
	89	3	3.2	2.0	59	63.4	3.0	31	33.3	4.0	.	.	.	93	100.0	3.3
	90	.	.	.	29	82.9	3.0	6	17.1	4.0	.	.	.	35	100.0	3.2
	91	2	5.3	2.0	30	78.9	3.0	6	15.8	4.0	.	.	.	38	100.0	3.1
	92	.	.	.	15	88.2	3.0	2	11.8	4.0	.	.	.	17	100.0	3.1
	93	.	.	.	178	80.2	3.0	43	19.4	4.0	1	0.5	5.0	222	100.0	3.2
	94	.	.	.	10	50.0	3.0	10	50.0	4.0	.	.	.	20	100.0	3.5
	95	.	.	.	17	85.0	3.0	3	15.0	4.0	.	.	.	20	100.0	3.2
	96	.	.	.	12	35.3	3.0	22	64.7	4.0	.	.	.	34	100.0	3.6
	97	.	.	.	38	79.2	3.0	10	20.8	4.0	.	.	.	48	100.0	3.2
	98	.	.	.	21	51.2	3.0	20	48.8	4.0	.	.	.	41	100.0	3.5
	1984-91	15	1.4	2.0	824	76.2	3.0	240	22.2	4.0	2	0.2	5.0	1081	100.0	3.2
	1992-98	.	.	.	291	72.4	3.0	110	27.4	4.0	1	0.2	5.0	402	100.0	3.3

Appendix 6. Smolt-age distribution of small and large Atlantic salmon.
Virgin spawners only.
WESTERN ARM

		SMOLT-AGE															Total		
		2			3			4			5			6					
		N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN	N	%	MEAN
LARGE	YY																		
	85	.	.	.	1	100.0	3.0	.	.	.	.	.	.	.	.	.	1	100.0	3.0
	87	.	.	.	.	.	.	1	100.0	4.0	.	.	.	.	.	.	1	100.0	4.0
	90	.	.	.	1	100.0	3.0	.	.	.	.	.	.	.	.	.	1	100.0	3.0
	91	.	.	.	.	.	.	1	100.0	4.0	.	.	.	.	.	.	1	100.0	4.0
	92	.	.	.	2	66.7	3.0	1	33.3	4.0	.	.	.	.	.	.	3	100.0	3.3
	93	.	.	.	1	33.3	3.0	2	66.7	4.0	.	.	.	.	.	.	3	100.0	3.7
	94	.	.	.	.	.	.	4	100.0	4.0	.	.	.	.	.	.	4	100.0	4.0
	95	.	.	.	1	33.3	3.0	2	66.7	4.0	.	.	.	.	.	.	3	100.0	3.7
	96	.	.	.	.	.	.	1	100.0	4.0	.	.	.	.	.	.	1	100.0	4.0
	1984-91	.	.	.	2	50.0	3.0	2	50.0	4.0	.	.	.	.	.	.	4	100.0	3.5
	1992-98	.	.	.	4	28.6	3.0	10	71.4	4.0	.	.	.	.	.	.	14	100.0	3.7
SMALL	YY																		
	71	.	.	.	22	28.6	3.0	37	48.1	4.0	16	20.8	5.0	2	2.6	6.0	77	100.0	4.0
	72	.	.	.	25	35.2	3.0	36	50.7	4.0	10	14.1	5.0	.	.	.	71	100.0	3.8
	73	1	0.7	2.0	20	14.6	3.0	107	78.1	4.0	8	5.8	5.0	1	0.7	6.0	137	100.0	3.9
	74	.	.	.	12	14.8	3.0	49	60.5	4.0	18	22.2	5.0	2	2.5	6.0	81	100.0	4.1
	75	.	.	.	5	27.8	3.0	13	72.2	4.0	.	.	.	.	.	.	18	100.0	3.7
	76	.	.	.	.	.	.	6	100.0	4.0	.	.	.	.	.	.	6	100.0	4.0
	77	.	.	.	19	35.8	3.0	31	58.5	4.0	2	3.8	5.0	1	1.9	6.0	53	100.0	3.7
	78	.	.	.	27	44.3	3.0	31	50.8	4.0	3	4.9	5.0	.	.	.	61	100.0	3.6
	79	.	.	.	45	21.8	3.0	141	68.4	4.0	20	9.7	5.0	.	.	.	206	100.0	3.9
	80	.	.	.	16	27.6	3.0	39	67.2	4.0	3	5.2	5.0	.	.	.	58	100.0	3.8
	81	.	.	.	27	42.9	3.0	34	54.0	4.0	2	3.2	5.0	.	.	.	63	100.0	3.6
	82	.	.	.	13	17.8	3.0	50	68.5	4.0	10	13.7	5.0	.	.	.	73	100.0	4.0
	83	.	.	.	34	18.2	3.0	130	69.5	4.0	23	12.3	5.0	.	.	.	187	100.0	3.9
	84	.	.	.	8	38.1	3.0	11	52.4	4.0	2	9.5	5.0	.	.	.	21	100.0	3.7
	85	.	.	.	21	26.3	3.0	57	71.3	4.0	2	2.5	5.0	.	.	.	80	100.0	3.8
	86	.	.	.	14	36.8	3.0	22	57.9	4.0	2	5.3	5.0	.	.	.	38	100.0	3.7
	87	.	.	.	27	32.9	3.0	50	61.0	4.0	5	6.1	5.0	.	.	.	82	100.0	3.7
	88	.	.	.	23	44.2	3.0	26	50.0	4.0	3	5.8	5.0	.	.	.	52	100.0	3.6
	89	.	.	.	55	39.6	3.0	82	59.0	4.0	2	1.4	5.0	.	.	.	139	100.0	3.6
	90	.	.	.	24	52.2	3.0	20	43.5	4.0	2	4.3	5.0	.	.	.	46	100.0	3.5
	91	1	0.4	2.0	101	45.1	3.0	120	53.6	4.0	2	0.9	5.0	.	.	.	224	100.0	3.5
	92	3	0.7	2.0	366	89.7	3.0	38	9.3	4.0	1	0.2	5.0	.	.	.	408	100.0	3.1
	93	.	.	.	64	25.9	3.0	183	74.1	4.0	.	.	.	.	.	.	247	100.0	3.7
	94	.	.	.	26	25.5	3.0	74	72.5	4.0	2	2.0	5.0	.	.	.	102	100.0	3.8
	95	.	.	.	21	21.2	3.0	77	77.8	4.0	1	1.0	5.0	.	.	.	99	100.0	3.8
	96	.	.	.	14	18.9	3.0	59	79.7	4.0	1	1.4	5.0	.	.	.	74	100.0	3.8
	97	.	.	.	12	27.9	3.0	31	72.1	4.0	.	.	.	.	.	.	43	100.0	3.7
	98	.	.	.	23	22.5	3.0	78	76.5	4.0	1	1.0	5.0	.	.	.	102	100.0	3.8
	1984-91	1	0.1	2.0	273	40.0	3.0	388	56.9	4.0	20	2.9	5.0	.	.	.	682	100.0	3.6
	1992-98	3	0.3	2.0	526	48.9	3.0	540	50.2	4.0	6	0.6	5.0	.	.	.	1075	100.0	3.5

Appendix 7. Sea-age distribution of small and large Atlantic salmon.
LOMOND

		SEA-AGE								Total	
		1SW		CS 1SW		AS 1SW		2SW			
		N	%	N	%	N	%	N	%	N	%
LARGE	YY										
	78	.	.	1	33.3	.	.	2	66.7	3	100.0
	79	1	100.0	.	.	.	.	.	.	1	100.0
	80	.	.	1	33.3	.	.	2	66.7	3	100.0
	81	.	.	.	.	.	.	1	100.0	1	100.0
	82	.	.	.	.	.	.	2	100.0	2	100.0
	84	.	.	.	.	.	.	4	100.0	4	100.0
	92	1	4.0	2	8.0	7	28.0	15	60.0	25	100.0
	93	.	.	.	.	1	14.3	6	85.7	7	100.0
	94	.	.	.	.	.	.	1	100.0	1	100.0
	97	.	.	.	.	1	100.0	.	.	1	100.0
	98	.	.	.	.	4	57.1	3	42.9	7	100.0
	1984-91	.	.	.	.	.	.	4	100.0	4	100.0
	1992-98	1	2.4	2	4.9	13	31.7	25	61.0	41	100.0
	Total	2	3.6	4	7.3	13	23.6	36	65.5	55	100.0
SMALL	YY										
	75	1	100.0	.	.	.	.	.	.	1	100.0
	78	20	90.9	2	9.1	.	.	.	.	22	100.0
	79	39	100.0	.	.	.	.	.	.	39	100.0
	80	15	100.0	.	.	.	.	.	.	15	100.0
	81	37	94.9	2	5.1	.	.	.	.	39	100.0
	82	36	97.3	.	.	.	.	1	2.7	37	100.0
	83	15	100.0	.	.	.	.	.	.	15	100.0
	84	55	100.0	.	.	.	.	.	.	55	100.0
	85	32	97.0	1	3.0	.	.	.	.	33	100.0
	86	57	87.7	1	1.5	2	3.1	5	7.7	65	100.0
	88	6	100.0	.	.	.	.	.	.	6	100.0
	90	1	100.0	.	.	.	.	.	.	1	100.0
	91	1	100.0	.	.	.	.	.	.	1	100.0
	92	50	96.2	1	1.9	1	1.9	.	.	52	100.0
	93	75	93.8	5	6.3	.	.	.	.	80	100.0
	94	24	100.0	.	.	.	.	.	.	24	100.0
	95	43	100.0	.	.	.	.	.	.	43	100.0
	96	65	98.5	1	1.5	.	.	.	.	66	100.0
	97	27	93.1	1	3.4	.	.	1	3.4	29	100.0
	98	49	89.1	6	10.9	.	.	.	.	55	100.0
	1984-91	152	94.4	2	1.2	2	1.2	5	3.1	161	100.0
	1992-98	333	95.4	14	4.0	1	0.3	1	0.3	349	100.0
	Total	648	95.6	20	2.9	3	0.4	7	1.0	678	100.0

Appendix 8. Sea-age distribution of small and large Atlantic salmon.
TORRENT

		SEA-AGE												Total	
		1SW		CS 1SW		AS 1SW		CS 2SW		2SW		3SW			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
LARGE	YY														
	80	.	.	1	100.0	.	.	.	.	.	.	.	.	1	100.0
	85	.	.	.	.	3	60.0	.	.	2	40.0	.	.	5	100.0
	86	.	.	1	11.1	4	44.4	.	.	4	44.4	.	.	9	100.0
	87	.	.	1	12.5	6	75.0	.	.	1	12.5	.	.	8	100.0
	88	.	.	5	50.0	4	40.0	.	.	1	10.0	.	.	10	100.0
	89	.	.	5	33.3	9	60.0	.	.	1	6.7	.	.	15	100.0
	90	1	100.0	.	.	.	.	.	.	.	.	.	.	1	100.0
	92	.	.	.	.	1	100.0	.	.	.	.	.	.	1	100.0
	93	2	1.4	41	28.7	1	0.7	44	30.8	54	37.8	1	0.7	143	100.0
	94	.	.	1	33.3	.	.	.	.	2	66.7	.	.	3	100.0
	96	.	.	.	.	.	.	1	50.0	1	50.0	.	.	2	100.0
	97	.	.	10	100.0	.	.	.	.	.	.	.	.	10	100.0
	1984-91	1	2.1	12	25.0	26	54.2	.	.	9	18.8	.	.	48	100.0
	1992-98	2	1.3	52	32.7	2	1.3	45	28.3	57	35.8	1	0.6	159	100.0
	Total	3	1.4	65	31.3	28	13.5	45	21.6	66	31.7	1	0.5	208	100.0
SMALL	YY														
	75	15	93.8	.	.	.	.	.	.	1	6.3	.	.	16	100.0
	79	4	100.0	.	.	.	.	.	.	.	.	.	.	4	100.0
	80	55	94.8	3	5.2	.	.	.	.	.	.	.	.	58	100.0
	81	9	90.0	1	10.0	.	.	.	.	.	.	.	.	10	100.0
	83	16	100.0	.	.	.	.	.	.	.	.	.	.	16	100.0
	85	147	95.5	7	4.5	.	.	.	.	.	.	.	.	154	100.0
	86	290	95.1	15	4.9	.	.	.	.	.	.	.	.	305	100.0
	87	288	95.7	11	3.7	1	0.3	.	.	1	0.3	.	.	301	100.0
	88	196	89.1	24	10.9	.	.	.	.	.	.	.	.	220	100.0
	89	92	85.2	15	13.9	.	.	.	.	1	0.9	.	.	108	100.0
	90	36	92.3	3	7.7	.	.	.	.	.	.	.	.	39	100.0
	91	38	92.7	3	7.3	.	.	.	.	.	.	.	.	41	100.0
	92	17	100.0	.	.	.	.	.	.	.	.	.	.	17	100.0
	93	223	87.5	29	11.4	.	.	1	0.4	2	0.8	.	.	255	100.0
	94	20	90.9	2	9.1	.	.	.	.	.	.	.	.	22	100.0
	95	20	90.9	2	9.1	.	.	.	.	.	.	.	.	22	100.0
	96	34	94.4	2	5.6	.	.	.	.	.	.	.	.	36	100.0
	97	48	85.7	8	14.3	.	.	.	.	.	.	.	.	56	100.0
	98	43	97.7	1	2.3	.	.	.	.	.	.	.	.	44	100.0
	1984-91	1087	93.1	78	6.7	1	0.1	.	.	2	0.2	.	.	1168	100.0
	1992-98	405	89.6	44	9.7	.	.	1	0.2	2	0.4	.	.	452	100.0
	Total	1591	92.3	126	7.3	1	0.1	1	0.1	5	0.3	.	.	1724	100.0

Appendix 9. Sea-age distribution of small and large Atlantic salmon.
WESTERN ARM

		SEA-AGE												Total	
		1SW		CS 1SW		AS 1SW		CS 2SW		AS 2SW		2SW			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
LARGE	YY														
	73	.	.	.	.	.	.	1	100.0	.	.	.	.	1	100.0
	77	.	.	.	.	2	100.0	.	.	.	.	.	.	2	100.0
	80	.	.	2	100.0	.	.	.	.	.	.	.	.	2	100.0
	81	.	.	1	50.0	.	.	1	50.0	.	.	.	.	2	100.0
	85	.	.	.	.	.	.	.	.	.	.	1	100.0	1	100.0
	87	1	100.0	.	.	.	.	.	.	.	.	.	.	1	100.0
	88	.	.	.	.	1	50.0	1	50.0	.	.	.	.	2	100.0
	89	.	.	1	100.0	.	.	.	.	.	.	.	.	1	100.0
	90	1	100.0	.	.	.	.	.	.	.	.	.	.	1	100.0
	91	1	100.0	.	.	.	.	.	.	.	.	.	.	1	100.0
	92	2	25.0	.	.	5	62.5	.	.	.	.	1	12.5	8	100.0
	93	1	25.0	.	.	.	.	1	25.0	.	.	2	50.0	4	100.0
	94	2	33.3	1	16.7	.	.	1	16.7	.	.	2	33.3	6	100.0
	95	.	.	.	.	31	91.2	.	.	.	.	3	8.8	34	100.0
	96	2	8.7	1	4.3	13	56.5	6	26.1	1	4.3	.	.	23	100.0
	97	.	.	.	.	.	.	7	100.0	.	.	.	.	7	100.0
	98	.	.	.	.	12	100.0	.	.	.	.	.	.	12	100.0
	1984-91	3	42.9	1	14.3	1	14.3	1	14.3	.	.	1	14.3	7	100.0
	1992-98	7	7.4	2	2.1	61	64.9	15	16.0	1	1.1	8	8.5	94	100.0
	Total	10	9.3	6	5.6	64	59.3	18	16.7	1	0.9	9	8.3	108	100.0
SMALL	YY														
	71	77	100.0	.	.	.	.	.	.	.	.	.	.	77	100.0
	72	71	93.4	.	.	.	.	5	6.6	.	.	.	.	76	100.0
	73	136	99.3	.	.	.	.	.	.	.	.	1	0.7	137	100.0
	74	81	100.0	.	.	.	.	.	.	.	.	.	.	81	100.0
	75	18	100.0	.	.	.	.	.	.	.	.	.	.	18	100.0
	76	6	100.0	.	.	.	.	.	.	.	.	.	.	6	100.0
	77	53	100.0	.	.	.	.	.	.	.	.	.	.	53	100.0
	78	64	98.5	.	.	.	.	.	.	.	.	1	1.5	65	100.0
	79	226	100.0	.	.	.	.	.	.	.	.	.	.	226	100.0
	80	58	100.0	.	.	.	.	.	.	.	.	.	.	58	100.0
	81	63	96.9	2	3.1	.	.	.	.	.	.	.	.	65	100.0
	82	73	100.0	.	.	.	.	.	.	.	.	.	.	73	100.0
	83	189	99.5	1	0.5	.	.	.	.	.	.	.	.	190	100.0
	84	24	100.0	.	.	.	.	.	.	.	.	.	.	24	100.0
	85	79	98.8	.	.	.	.	.	.	.	.	1	1.3	80	100.0
	86	38	100.0	.	.	.	.	.	.	.	.	.	.	38	100.0
	87	82	100.0	.	.	.	.	.	.	.	.	.	.	82	100.0
	88	53	88.3	5	8.3	1	1.7	1	1.7	.	.	.	.	60	100.0
	89	140	100.0	.	.	.	.	.	.	.	.	.	.	140	100.0
	90	46	97.9	1	2.1	.	.	.	.	.	.	.	.	47	100.0
	91	224	100.0	.	.	.	.	.	.	.	.	.	.	224	100.0
	92	407	99.8	.	.	.	.	.	.	.	.	1	0.2	408	100.0
	93	251	86.3	38	13.1	.	.	1	0.3	.	.	1	0.3	291	100.0
	94	104	96.3	4	3.7	.	.	.	.	.	.	.	.	108	100.0
	95	99	100.0	.	.	.	.	.	.	.	.	.	.	99	100.0
	96	76	100.0	.	.	.	.	.	.	.	.	.	.	76	100.0
	97	43	84.3	6	11.8	.	.	2	3.9	.	.	.	.	51	100.0
	98	103	92.0	8	7.1	.	.	1	0.9	.	.	.	.	112	100.0
	1984-91	686	98.7	6	0.9	1	0.1	1	0.1	.	.	1	0.1	695	100.0
	1992-98	1083	94.6	56	4.9	.	.	4	0.3	.	.	2	0.2	1145	100.0
	Total	2884	97.3	65	2.2	1	0.0	10	0.3	.	.	5	0.2	2965	100.0

Appendix 10. Atlantic salmon recreational fishery catches and effort for Lomond River, 1974-98.

Year	Effort	Small			Large			Total Catch			CPUE
	(Rod Days)	Retained	Released	Total	Retained	Released	Total	Retained	Released	Total	
1974	1331	324	.	324	19	.	19	343	.	343	0.26
1975	773	258	.	258	20	.	20	278	.	278	0.36
1976	2045	650	.	650	25	.	25	675	.	675	0.33
1977	1461	495	.	495	34	.	34	529	.	529	0.36
1978	1267	345	.	345	29	.	29	374	.	374	0.30
1979	900	235	.	235	2	.	2	237	.	237	0.26
1980	1218	293	.	293	13	.	13	306	.	306	0.25
1981	1446	507	.	507	3	.	3	510	.	510	0.35
1982	1435	308	.	308	7	.	7	315	.	315	0.22
1983	1112	251	.	251	3	.	3	254	.	254	0.23
1984	1505	546	.	546	28	.	28	574	.	574	0.38
1985	1075	203	.	203	.	2	2	203	2	205	0.19
1986	1164	371	.	371	.	46	46	371	46	417	0.36
1987	1186	297	.	297	.	13	13	297	13	310	0.26
1988	1545	404	.	404	.	25	25	404	25	429	0.28
1989	1714	270	.	270	.	5	5	270	5	275	0.16
1990	1938	386	.	386	.	17	17	386	17	403	0.21
1991	1591	328	.	328	.	10	10	328	10	338	0.22
1992	1612	357	24	381	.	56	56	357	80	437	0.27
1993	2190	281	85	366	.	40	40	281	125	406	0.19
1994	2017	325	116	441	.	58	58	325	174	499	0.25
1995	2043	343	190	533	.	62	62	343	252	595	0.29
1996	2702	371	99	470	.	49	49	371	148	519	0.19
1997**		490	273	763	.	52	52	490	325	815	
1998**		158	214	372		22	22	158	236	394	
Mean (92-96)	2113	335	103	438	.	53	53	335	156	491	0.24
95% CL=+/-	488	43	74	84	.	11	11	43	79	92	0.06
N	5	5	5	5	.	5	5	5	5	5	5
Mean(84-91)	1465	351	.	351	4	15	18	354	15	369	0.26
95% CL=+-	251	86	.	86	23	13	12	93	13	94	0.07
N	8	8	.	8	1	7	8	8	7	8	8
Mean(78-83)	1230	323	.	323	10	.	10	333	.	333	0.27
95% CL=+-	217	103	.	103	11	.	11	104	.	104	0.05
N	6	6	.	6	6	.	6	6	.	6	6

** Based on lic. Stub returns

Appendix 11. Atlantic salmon recreational fishery catches and effort for Torrent River, 1974-98.

Year	Effort (Rod-days)	Small			Large			Total Catch			CPUE
		Retained	Released	Total	Retained	Released	Total	Retained	Released	Total	
1974	400	58	.	58	4	.	4	62	.	62	0.16
1975	364	123	.	123	6	.	6	129	.	129	0.35
1976	.	.	.	0	.	.	0	0	.	0	.
1977	.	.	.	0	.	.	0	0	.	0	.
1978	183	31	.	31	4	.	4	35	.	35	0.19
1979	238	65	.	65	3	.	3	68	.	68	0.29
1980	.	.	.	0	.	.	0	0	.	0	.
1981	656	167	.	167	18	.	18	185	.	185	0.28
1982	535	187	.	187	2	.	2	189	.	189	0.35
1983	354	82	.	82	1	.	1	83	.	83	0.23
1984	.	.	.	.	.	.		.	.	.	.
1985	251	70	.	70	.	0	0	70	0	70	0.28
1986	767	340	.	340	.	5	5	340	5	345	0.45
1987	576	165	.	165	.	0	0	165	0	165	0.29
1988	803	313	.	313	.	0	0	313	0	313	0.39
1989	559	143	.	143	.	0	0	143	0	143	0.26
1990	629	222	.	222	.	4	4	222	4	226	0.36
1991	438	150	.	150	.	1	1	150	1	151	0.34
1992	833	477	75	552	.	6	6	477	81	558	0.67
1993	619	179	266	445	.	15	15	179	281	460	0.74
1994	992	227	82	309	.	9	9	227	91	318	0.32
1995	1816	331	369	700	.	36	36	331	405	736	0.41
1996	2027	421	270	691	.	20	20	421	290	711	0.35
1997**		327	469	796		79	79	327	548	875	
1998**		206	442	648		85	85	206	527	733	
Mean (92-96)	1257	327	212	539	.	17	17	327	230	557	0.50
95% CL=+/-	776	156	160	207	.	15	15	156	174	217	0.24
N	5	5	5	5	.	5	5	5	5	5	5
Mean(84-91)	503	175	.	175	.	1	1	175	1	177	0.30
95% CL=+-	225	96	.	96	.	2	2	96	2	97	0.11
N	8	8	.	8	.	7	8	8	7	8	8
Mean(78-83)	328	89	.	89	5	.	5	93	.	93	0.22
95% CL=+-	252	78	.	78	7	.	7	82	.	82	0.13
N	6	6	.	6	6	.	6	6	.	6	6

** Based on lic. Stub returns