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Research Document 2001 / 028 | **Document de recherche 2001 / 028**

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Status of Atlantic salmon at Highlands River, Bay St. George, SFA 13, Newfoundland, 2000

État du stock de saumon atlantique de la rivière Highlands, tributaire de la baie St. George (ZPS 13), à Terre-Neuve

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ISSN 1480-4883
Ottawa, 2001

Canada

Abstract

The status of Atlantic salmon in Highlands River, 2000, was determined from the number of salmon returning to a fish counting fence located on the main stem of the river just above head of tide. Biological characteristics were collected from kelt and updated summaries for past years are provided. Adult returns in 2000 were 58 small salmon and 67 large salmon. This was the lowest number of small salmon recorded at Highlands River and returns of large salmon were the lowest since monitoring resumed in 1993. Marine survival fell to the lowest value recorded for small salmon (0.6%) while survival to large salmon was only 1.1%. Marine survival is still anomalously low given the substantial reductions in directed sea fisheries for Atlantic salmon since 1992. The proportion of the conservation requirement achieved for Highlands River in 2000 was 34.0% with the 5th and 95th percentiles of 26.6 to 41.9%. On average, for the period 1993-2000, Highlands River has achieved 64.5% of its conservation requirement.

Résumé

L'état du stock de saumon atlantique dans la rivière Highlands en 2000 est évalué d'après le nombre de saumon qui a passé à une barrière de dénombrement installée dans le bras principal de la rivière juste en amont de la ligne extrême des eaux de marée. Les caractéristiques biologiques des charognards recueillies sont utilisées pour mettre à jour les résumés de ces données recueillies au cours des dernières années. La remonte totalisait 58 petits saumons et 67 gros saumons, le nombre de petits saumons étant le plus faible enregistré dans cette rivière, alors que le nombre de gros saumons était le plus faible enregistré depuis la reprise de la surveillance en 1993. La survie en mer a chuté à une valeur encore jamais vue pour les petits saumons (0,6 %), tandis que le niveau pour les gros saumons n'atteignait que 1,1 %. La survie en mer demeure anormalement faible malgré la forte baisse de l'effort de pêche dirigée du saumon atlantique en mer depuis 1992. La ponte en 2000 dans la rivière Highlands a satisfait 34,0 % des besoins au titre de la conservation pour ce cours d'eau, l'intervalle entre les 5e et 95e centiles allant de 26,6 % à 41,9 %. En moyenne, la ponte dans la rivière Highlands pendant la période 1993-2000 a satisfait à 64,5 % des besoins au titre de la conservation.

Introduction

Highlands River is a fourth order system located on the south west coast of Newfoundland (48° 11' 38'' N, 58° 53' 40" W), in Salmon Fishing Area (SFA) 13 (Fig. 1). The river drains westerly into Bay St. George from the southern part of the Long Range Mountains, with an average gradient of about 1.2%, over an axial length of 29.0 km. Area of the drainage basin is 183.1 km^2 (Gibson et al. 1987).

The river has long been noted for a fall run of very large salmon, and in the past, for good trout fishing (Palmer 1928). Owing to the decline of angling success, especially of the large salmon component, the river has been closed to angling since 1978 (Chadwick et al. 1978; Porter and Chadwick 1983; Gibson et al. 1987). In the 10-year period prior to the closure this fishery (1968 - 77), catches of small salmon ranged from 16 to 105 fish per year ($\bar{x}$ = 39.0 $year^{-1}$) while catch of large salmon varied from 4 to 25 ($\bar{x}$ = 11.8 $year^{-1}$). Prior to 1968, annual catches of 50 to 97 large salmon were reported (Moores et al. 1978).

Adult salmon spawning escapement and smolt yields were obtained from a fish counting fence that operated from 1980 to 1982, and again from 1993 to 2000. Over the period from 1993 to 1999, adult salmon returns have ranged from 96 to 398 small salmon ($\bar{x}$ = 185) and from 78 to 157 large salmon ($\bar{x}$ = 121). The highest returns occurred in 1997 (Reddin and Whalen 1998). Smolt production from 1993 to 1999 has varied from 5922 to 12383 ($\bar{x}$ = 9623), about 33% fewer than the average number of smolts in 1980 to 1982 ($\bar{x}$ = 14416). The fewest number of smolts occurred in 1997 and 1998. The low smolt runs were believed to have been the result of a severe flood that affected the river in February, 1996 (Reddin and Whalen 1998), the most extreme event recorded since 1982 (Dempson and Clarke 1999). Juvenile salmon population estimates were made in 1980 and 1981, and from 1993 to 1999 but were discontinued in 2000. Surveys carried out from 1997 - 1999 were based on a reduced subset (N = 5) of stations and thus were not as thorough as in previous years.

Based on past assessments (Gibson et al. 1994, 1996; Reddin and Whalen 1998), it was determined that less than 40% of the conservation requirement was achieved at Highlands River from 1980 to 1982. With the closure of the Newfoundland commercial salmon fishery in 1992, the percentage of the conservation requirement attained has averaged 68.9% (1993 – 1999) but in only one year, 1997, has the conservation spawning requirement been attained.

This paper summarizes smolt production and returns of adult Atlantic salmon to Highlands River in 2000. Biological characteristic data are updated along with hydrological conditions at Highlands River for the period 1982 – 2000 (2000 data preliminary).

Methods

1. Environmental conditions

Water temperatures were obtained from a continuous recording Hugrun thermograph set 1 m from the surface at the fish counting fence site located in the lower river and operated from April 27 to October 27, 2000. Discharge information for the period 1982 - 2000 was obtained from Environment Canada records for the gauging station situated where the Trans Canada Highway crosses over the major stem of Highlands River ('River Brook'; Fig. 1). The drainage area above the water gauge is 72 km^2. This represents 39% of the total drainage area for the entire Highlands River watershed.

2. Biological characteristics

Biological characteristic information on smolts, including fork length to the nearest millimeter, whole weight to the nearest one hundredth of a gram, sex, and scales were derived from samples captured at the fish counting fence. Samples of adult salmon were obtained from kelt emigrating in the spring. Data were collected on fork length to the nearest centimeter, scales extracted for aging, and a visual inspection (external) was carried out to determine sex. Some returning adult salmon were also sampled for fork length to the nearest centimeter, scales and sex (external). Adult salmon fork length information (to the nearest 5 centimeters) in the past was obtained from returning adults based on a measuring stick placed along side of salmon in the trap. These data are provided for reference but we caution that, except for 1980 and 1981, the distributions should not be interpreted as reflecting the overall length distribution of the run in each year.

3. Smolt monitoring

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence operated from May 6 until June 26, 2000, while adult salmon were monitored from June 22 to October 23 (Table 1).

4. Kelt tagging

As in 1998 and 1999, some of the kelt counted at the downstream fence in 2000 were tagged and released with individually numbered temperature recording archival tags (N = 14).

5. Adult salmon returns, sea survival and egg deposition

The adult fence was fished with every second conduit removed; therefore, smaller fish counted migrating upstream could be an underestimate since some could pass through the fence and not be counted at the trap. The trap was checked and fish released on a regular 4-hour basis from 0800 hrs to 2000 hrs (during the peak of the runs and during high water levels the trap was checked more frequently). The adult salmon counted were sized in two categories: 1) small salmon were those less than 63 cm in fork length; and 2) large salmon were fish 63 cm or greater.

Marine survival of smolts in year i was determined based on the number of small salmon returning in year i+1 and the number large salmon in year i+2. Adult salmon returning to Highlands River are characterized by several life-history types including virgin one sea-winter (1SW), two sea-winter (2SW), three sea-winter (3SW) and previous spawners of each of these life histories. Thus, an estimate of survival to the 2SW life history stage is also provided, but we caution that age data for adult large salmon are limited.

Spawning escapement

Because Highlands River was closed to angling, total river returns (TRR) or spawning escapement (SE) were simply the numbers of fish enumerated at the fish counting fence. Egg deposition (ED) was calculated separately for small salmon ($<$ 63 cm) and large salmon ($\geq$ 63 cm) and then totaled:

$$ED = SE \times PF \times F$$

where, PF = proportion of females
F = fecundity at size.

For this assessment, egg deposition was been calculated as in the previous assessments (Dempson and Clarke 1999, 2000) using the average biological characteristic information (proportion females and mean lengths) obtained from samples of kelts, separately for small and large salmon, for two time periods 1980 - 1982, and 1993 – 1998. Mean values were used because the numbers of samples obtained in any specific year are generally limited:

Size		1980 - 82	1994 – 98
Small	% female (N)	55.4 (74)	46.1 (191)
	Mean length, cm (N)	52.0 (41)	53.1 (88)
Large	% female (N)	75.0 (80)	69.5 (203)
	Mean length, cm (N)	85.2 (60)	81.6 (141)

Fecundity estimates were taken from Randall (1989):

Small salmon: Ln fecundity = -4.5636 + 3.1718 Ln (FL in cm); and,

Large salmon: Ln fecundity = -1.1862 + 2.3423 Ln (FL in cm).

The above equation for small salmon was originally derived for 1SW Miramichi River fish, while the equation used for large salmon was that derived from a composite of 2SW, 3SW and previous spawners from the Restigouche River.

Conservation egg deposition requirement

The conservation requirement for Highlands River is 1,498,475 eggs. This was derived from:

fluvial habitat	=	6219.26 units @ 240 eggs/unit
lacustrine habitat	=	15.9043 ha @ 368 eggs/ha

(Reddin and Whalen 1998).

6. Avian observations

In 1999 and 2000, observations were made to document the occurrence of potential predators on salmon smolts. Observations were made at a location approximately one-half km downstream from the fish counting fence by counting fence personnel. Observations were taken one half hour after the first release of smolts in the morning and continued for approximately one hour. Time of day, species and number of birds (flying, standing, swimming) were recorded.

Results and Discussion

1. Environmental conditions

Water temperatures - 2000

Mean daily water temperatures were generally cool in the spring, averaging less than 8 °C until May 14. Average daily water temperatures reached 10 °C for the first time on May 22 (Fig. 2), far later than in 1999 (May 7). Overall, May and June water temperatures averaged 8.2 and 14.5 °C, respectively. Temperatures increased quickly during the second half of June, but only reached a mean daily temperature of 20 °C for the first time on July 16 (Fig. 2), two weeks later than the previous year. There were 14 days in 2000 when the mean daily water temperature was 20 °C or warmer. Mean daily water temperature reached a peak value on August 5 at 21.9 °C, with a maximum temperature of 25.7 °C recorded on August 6. Over the entire summer, there were 36 days when maximum temperatures $\geq$ 22 °C were reached and 7 days when maximum temperatures $\geq$ 25 °C were obtained. With one exception, the latter occurred between the dates July 31 to August 6. Mean daily water temperatures declined sharply in late September with mean daily water temperatures remaining below 10 °C from October 12 onward.

Water Discharge – 2000

Preliminary discharge information, obtained from the Environment Canada station on Highlands River, indicated moderately high discharge in mid-May ($\bar{x}$ = 8.5 m^3/sec, May 12-20) with the remainder of the spring and summer characterized by low discharge (Fig. 2). From June through September, 2000, the highest mean daily discharge value was only 3.7 m^3/sec. A peak of 15.95 m^3/sec was recorded on October 20. A summary of past monthly values (mean, minimum and maximum discharges) are provided in Figure 3.

2. Biological characteristics

Table 2 summarizes the updated biological characteristic data of Atlantic salmon from Highlands River. Length and weight of smolts sampled in 2000 were similar to the average from all years (N= 2348; $\bar{x}$ = 129 mm and 20.3 g). Adult salmon have been partitioned into small and large categories with small salmon averaging 542 mm and large salmon 812 mm. All adult salmon data reported were obtained from kelts leaving the river during the spring of the year; only 17 adult salmon were sampled in 2000. The summary includes repeat spawners.

River age distribution of smolts is provided in Table 3. Smolts are predominately 3+ (72.7%) but there is considerable variation among years ranging from 58.1% river age 3 smolts in 1999 to 90.5% in 1998 (Table 3). The estimated contributions of 2+ smolts in 1999 (37.9%) and 2000 (25.6%) are the highest recorded and appear anomalous by comparison with previous information. In light of the 1996 extreme flood event at Highlands River, this could, perhaps, be evidence of a density dependent response given that smolt production at Highlands River in 1997 and 1998 declined by about 40% from the average production from 1993 – 1996. As recommended last year (Dempson and Clarke 2000), smolt age information from 1999 was reanalyzed with updated information contained in the present report.

Maximum, minimum and mean smolt lengths, by age class, are illustrated in Figure 4. Mean length of age 2+ smolts in 2000 was the highest over the past 8 years (back to 1993), and similar to the average sizes estimated in 1980 – 1982. Mean size of age 3+ smolts has similarly increased since 1993 (Fig. 4).

River age distributions of small and large adult salmon are summarized in Table 4. Small salmon are similarly characterized with a river age of 3+ years (73.5%) with 10.1% of the samples over all years having a river age of 2+ years. In contrast, 80.8% of the large salmon sampled had a river age of 3+ years while 16.2% smoltified as 2-year old smolts. As shown by O'Connell and Ash (1993) smaller and slower growing smolts in fluvial systems are often characterized by multi-sea winter large salmon.

Small salmon at Highlands River are predominantly 1SW fish (96.6%; $N_{small} = 328$) (Table 5). In contrast, of 338 large salmon kelt that have been sampled, 60.4% were maiden 2SW salmon while 29.6% were previous spawners (Table 5). Twelve (3.6%) virgin 3SW salmon have been sampled at Highlands River since 1980. These fish ranged from 87.0 to 105.0 cm in fork length.

Length-frequency distributions of adult salmon obtained from estimated lengths of fish in the fish counting fence trap are shown in Figure 5. Lengths were approximated from 93.6% of the adult salmon that returned in 2000.

3. Smolt monitoring

Numbers of smolts migrating downstream each year are summarized in Table 6. Smolt runs in 1997 (6776) and 1998 (5922) were the lowest recorded and believed to be a direct result of the extreme high water discharge events that affected Highlands River in February, 1996. Smolt runs in 1999 and again in 2000 have increased substantially over the 1996-1997 runs, with the 2000 production 36% higher than that of 1999 and the highest obtained over the 1993 to 2000 period.

Smolt run timing at Highlands River is illustrated in Figure 6. For the period 1993 - 1998, the median date of the smolt run was May 31, approximately two weeks later than

the smolt run at Conne River (May 18) (Dempson et al. 2000). The median date of the smolt run in 2000 was May 28, about a week later than in 1999.

In addition to Atlantic salmon parr (N= 806), smolts, and kelt (N = 29), both resident (N = 62) and sea-run (N = 217) brook trout, smelt and eels were enumerated passing downstream in 2000 (Table 6).

4. Kelt tagging

A total of 14 temperature-button tags were applied to kelts in the spring of 2000. The mean fork length was 66.8 cm (range: 54.0 – 96.0 cm). In contrast with the past two years, none of these fish were recovered in 2000. A summary of past kelt tagging and recaptures is provided in Table 7.

5. Adult salmon returns, sea survival and egg deposition

Adult salmon returns

There were 58 small salmon and 67 large salmon enumerated at the fish counting fence in 2000 (Table 8, Fig. 7). This is the lowest number of small salmon observed at Highlands River, and is 68.6% lower than the 1993-1999 average return of small salmon. With respect to the large salmon component, returns in 2000 were the lowest since monitoring resumed in 1993 and 44.4% less than the 1993 – 1999.

Marine survival

Marine survival of smolts that migrated in 1999 to small salmon returns in 2000 fell to 0.60% from 2.47% the previous year (Table 9); this was the lowest survival value recorded for small salmon returns at Highlands River. Estimates of the survival of the 1998 smolt class to large salmon returns and 2SW returns in 2000 were 1.13% and 0.68%, respectively (Table 9). As stated in previous assessments, despite major reductions in directed marine fisheries for Atlantic salmon, marine survival rates remain at disturbingly low values.

Egg deposition

Potential egg deposition by small salmon was:

3088 eggs per fish x 58 small salmon x 0.461 proportion females = 82,567 eggs

Potential egg contribution from large salmon was:
9175 eggs per fish x 67 large salmon x 0.695 proportion females = 427,234 eggs

Total potential egg deposition was: 509,801 of which large salmon contributed 83.8%.

Thus, only 34% of the conservation spawning requirement was achieved in 2000 (509,801/1,498,475 = 34.0%), down from 48.8% in 1999 (Table 10). The average conservation requirement obtained over the period 1993 to 2000 is 64.5%, with the conservation spawning requirement achieved in only one year (1997).

In the above evaluation, only the numbers of small and large salmon returning to Highlands River in 2000 are known with certainty. To account for some of the uncertainty in the potential egg deposition that occurred, we assumed a coefficient of variation of 20% around the fecundity and percentage females of both small and large salmon components and recalculated the estimated egg depositions using 1000 realizations from a uniform distribution.

Based on this level of variation in fecundity and percentage females, the corresponding 5th and 95th percentiles of the percentage of the conservation requirement met varies from 26.6 to 41.9%.

6. Avian observations

Eleven groups or species of birds were observed at Highlands River in 1999 (Appendix 1) and 2000 (Appendix 2). Of these, the common merganser was the most common species observed in 1999 while gulls were the most common in 2000. Gulls were usually observed flying while mergansers were generally observed swimming. There were some instances where various groups were observed feeding, but it was not possible to identify with certainty prey organisms being selected.

7. Outlook for 2001

To achieve 100% of the conservation requirement in 2001, based upon the average egg deposition contribution from small (23.8%) and large salmon (76.2%) respectively over the past 8 years (1993 – 2000), marine survival rates approximating 1.91% for small salmon returns from 2000 smolts (~ 251 small salmon) and 1.86% for large salmon returns from the 1999 smolt class (~ 179 large salmon) would be required. While small salmon survival of this rate has been exceeded in the past (Table 9), a survival to large salmon of 1.86% has yet to be achieved at Highlands River during the years that the fish counting fence has been in operation.

Acknowledgements

We wish to acknowledge the assistance of the following individuals who through their efforts and interest in this project ensured a successful completion of all field operations during 2000: John Pumphrey, Donna Gilbert, Brian McInnis, Allan McInnis, Brian King, and Eric Legge. Special thanks are again extended to John MacPherson, Bay St. George South Development Association, who again coordinated the project and fish counting fence staff.

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Table 1. Summary of fish counting fence operation dates at Highlands River, SFA 13, Newfoundland.

Year	Smolt counts		Adult salmon counts	
	Start	Finish	Start	Finish
1980	May 7	June 30	May 7	Oct 13
1981	April 27	-	-	Sept 9
1982	May 23	-	-	Sept 29
*				
1993	May 18	June 16	June 18	Sept 28
1994	May 18	June 21	June 22	Oct 13
1995	May 14	June 8	June 12	Oct 25
1996	April 26	June 14	June 14	Oct 24
1997	May 23	July 14	June 20	Nov 2
1998	May 6	June 13	June 14	Oct 26
1999	April 29	June 23	June 9	Oct 31
2000	May 6	June 26	June 22	Oct 23

* Not operated from 1983 to 1992

Table 2. Summary of biological characteristics for Atlantic salmon samples from Highlands River, Newfoundland (SFA 13). Specimens of small and large salmon were obtained from sampling kelts when they were leaving the river in the spring of the year.

		Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
Lifestage	Year	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
Smolt	1980	337	132	12.5	100	173	337	22.0	5.9	8.7	44.4	337	2.80	0.47	2	4	324	66
	1981	261	127	9.8	94	159	248	19.5	4.2	9.3	38.0	261	2.89	0.54	2	5	248	70
	1982	324	131	16.5	83	180	324	21.1	7.2	5.4	48.0	324	2.92	0.51	2	5	282	71
	1993	118	118	15.5	76	160	118	16.9	5.9	4.4	37.1	118	2.92	0.63	2	6	117	66
	1994	164	122	10.7	96	154	164	16.5	4.5	7.9	31.8	164	3.21	0.52	2	4	164	63
	1995	178	129	12.8	102	189	177	20.3	6.1	10.7	54.0	178	3.20	0.51	2	5	178	65
	1996	239	127	12.8	85	171	236	19.3	5.7	5.3	43.7	239	2.87	0.53	1	4	208	67
	1997	137	129	11.5	102	165	137	20.2	5.4	11.3	39.9	137	2.92	0.44	2	4	137	63
	1998	126	137	10.8	108	169	126	23.0	5.3	13.0	41.0	126	3.03	0.31	2	4	68	62
	1999	198	129	13.7	101	167	198	20.4	6.5	10.0	39.7	198	2.66	0.55	2	4	102	56
	2000	266	131	13.7	106	197	266	20.9	7.3	10.6	70.5	266	2.76	0.46	2	4	134	69
TOTAL		2348	129	13.7	76	197	2331	20.3	6.2	4.4	70.5	2348	2.90	0.52	1	6	1962	66
Small	1980	34	536	48.6	390	595						34	2.97	0.39	2	4	34	41
	1981	14	552	37.4	490	620						14	2.86	0.36	2	3	14	57
	1982	28	527	33.8	450	600	28	1093	253.8	500	1700	29	3.24	0.51	2	4	26	73
	1994	18	541	45.4	445	600						18	3.17	0.38	3	4	18	28
	1995	8	563	31.1	515	600						8	3.00	0.00	3	3	8	63
	1996	54	529	36.2	400	600						54	3.15	0.49	2	4	54	48
	1997	84	556	46.5	420	625						84	3.07	0.60	2	4	84	39
	1998	27	544	39.5	465	625						27	3.07	0.55	2	4	27	70
	1999	51	539	36.3	460	620						51	2.96	0.56	2	4	8	63
	2000	10	558	53.6	475	620						10	3.00	0.00	3	3	9	44
TOTAL		328	542	42.5	390	625	28	1093	253.8	500	1700	328	3.06	0.51	2	4	282	49
Large	1980	26	896	111.6	710	1100						26	2.62	0.50	2	3	26	65
	1981	43	820	87.7	630	1050						43	2.84	0.37	2	3	43	86
	1982	12	845	102.3	650	1100	12	4100	1009.1	2200	6000	12	2.92	0.29	2	3	11	55
	1994	18	782	82.9	645	1000						18	3.06	0.24	3	4	18	56
	1995	31	782	78.9	630	1000						31	2.90	0.40	2	4	31	77
	1996	40	808	90.7	645	1030						40	2.98	0.28	2	4	40	70
	1997	87	811	90.4	635	1120						87	2.90	0.40	2	4	87	70
	1998	27	819	90.0	630	1035						27	2.74	0.45	2	3	27	67
	1999	47	786	99.9	630	1040						47	2.79	0.51	2	4	26	69
	2000	7	773	135.6	635	960						7	3.29	0.49	3	4	7	71
TOTAL		338	812	96.6	630	1120	12	4100	1009.1	2200	6000	338	2.87	0.42	2	4	316	71

Table 3. Estimated total numbers of smolts in each age class at Highlands River, Bay St. George, Newfoundland. The percentage in each age class is shown in the lower part of the table. Information has been updated from last year following reanalysis of some some smolt ages.

Year	River age (years) 2	3	4	5	6	Total
1980	3426	11151	451	0	0	15028
1981	3152	11467	1093	127	0	15839
1982	2142	9174	1027	37	0	12380
1993	2027	6940	849	85	85	9986
1994	515	7236	2752	0	0	10503
1995	547	8682	2870	61	0	12160
1996	2440	8965	978	0	0	12383
1997	942	5441	393	0	0	6776
1998	190	5359	373	0	0	5922
1999	3651	5598	385	0	0	9634
2000	3359	9617	144	0	0	13120

Year	Percent in each age class 2	3	4	5	6	Number of samples
1980	22.8	74.2	3.0	0	0	337
1981	19.9	72.4	6.9	0.8	0	261
1982	17.3	74.1	8.3	0.3	0	324
1993	20.3	69.5	8.5	0.8	0.8	118
1994	4.9	68.9	26.2	0	0	164
1995	4.5	71.4	23.6	0.6	0	178
1996 *	19.7	72.4	7.9	0	0	239
1997	13.9	80.3	5.8	0	0	137
1998	3.2	90.5	6.3	0	0	126
1999	37.9	58.1	4.0	0	0	198
2000	25.6	73.3	1.1	0	0	266
Total	18.7	72.7	8.4	0.2	0.0	2348

* One river age 1 smolt reported

Table 4. River age distribution (%) of small and large salmon sampled as kelt leaving Highlands River, Bay St. George, Newfoundland.

Small salmon

Year	Percent in each age class 2	3	4	5	Number of samples
1980	8.8	85.3	5.9	0	34
1981	14.3	85.7	0	0	14
1982	3.6	67.9	28.6	0	28
1993	-	-	-	-	-
1994	0	83.3	16.7	0	18
1995	0	100.0	0	0	8
1996	5.6	74.1	20.4	0	54
1997	14.3	64.3	21.4	0	84
1998	11.1	70.4	18.5	0	27
1999	17.7	68.6	13.7		51
2000	0.0	100.0	0.0	0	10
Total	10.1	73.5	16.4	0	328

Large salmon

Year	Percent in each age class 2	3	4	5	Number of samples
1980	38.5	61.5	0	0	26
1981	16.3	83.7	0	0	43
1982	8.3	91.7	0	0	12
1993	-	-	-	-	-
1994	0	94.4	5.6	0	18
1995	13	83.9	3.2	0	31
1996	5.0	92.5	2.5	0	40
1997	13.8	82.8	3.5	0	87
1998	25.9	74.1	0	0	27
1999	25.5	70.2	4.3	0	47
2000	0.0	71.4	28.6	0	7
Total	16.2	80.8	3.0	0	338

Table 5. Sea age distribution of small and large salmon sampled as outmigrating kelt at Highlands River, Newfoundland, where 1SW, 2SW and 3SW refer to virgin sea ages.

	Small salmon (Fork length < 63 cm)				Large salmon (Fork length >= 63 cm)				
Year	Number	1SW	2SW	PS	Number	1SW	2SW	3SW	PS *
1980	34	34			26		13	5	8
1981	14	14			43	2	37	2	2
1982	28	28			12	1	10		1
1994	18	18			18		14		4
1995	8	8			31	5	24	1	1
1996	54	53	1		40		24		16
1997	84	77	1	6	87	1	47	3	36
1998	27	27			27	2	15	1	9
1999	51	48		3	47	7	18		22
2000	10	10			7	4	2		1
Total	328	317	2	9	338	22	204	12	100

* Of the 100 previous spawning large salmon sampled, 78 (78%) had a virgin sea age of 2, 20 (20%) had a virgin sea age of 1, while two (2.0%) had a virgin sea age of 3.

Table 6. Numbers of downstream migrating fish enumerated at the Highlands River fish counting fence.

Year	Numbers of fish migrating downstream							
	Atlantic salmon			Brook trout				
	Parr	Smolt	Kelt	Resident	Sea-run	Smelt	Eels	Killifish
1980	339	15028	73	796	814	35	1486	4
1981	199	15839	63	702	514	13	929	5
1982	375	12380	59	1293	0	19	439	0
1993	877	9986	90	731	0	43	162	0
1994	1345	10503	57	759	204	16	188	0
1995	152	12160*	43	33	503	13	7	0
1996	1111	12383	110	236	303	16	10	0
1997	196	6776	192	56	457	41	9	0
1998	133	5922	69	2	84	6	8	0
1999	295	9634	126	91	473	14	31	0
2000	806	13120	29	62	217	23	239	0

* The 1995 smolt count was adjusted to account for a washout that occurred during the latter part of the smolt run. The unadjusted count was 9009 smolts.

Table 7. Highlands River Atlantic salmon kelt tag release and recapture information, 1998 - 2000.

Release Information				Recapture Information			Area of Recapture				
Tagging Location	Year	Tag Type	Number Tagged	Total Number Recaptured	Year	Number	Highlands River	Humber River	Humber Estuary	Port au Port Sentinel Fishery	Quebec North Shore
Highlands River	1998	Archival	24	6	1998	6	4			1	1
		Carlin	32	6	1998	3	2				1
					1999	3	2		1		
					2000	1	1				
	1999	Archival	29	7	1999	7	6	1			
		Carlin	37	4	1999	4	4				
	2000	Button	14	0							
Total			136	23		24	19	1	1	1	2

Table 8. Numbers of upstream migrating fish enumerated at the Highlands River fish counting fence.

Year	Numbers of fish migrating upstream				
	Atlantic salmon			Brook trout	
	Small	Large	% small	Resident	Sea-run
1980	82	55	59.9	0	10
1981	127	29	81.4	0	11
1982	100	56	64.1	0	15
1993	137	78	63.7	0	63
1994	145	148	49.5	74	208
1995	172	120	58.9	2	16
1996	199	142	58.4	0	10
1997	398	157	71.7	0	6
1998	96	117	45.1	0	0
1999	146	82	64.0	0	0
2000	58	67	46.4	0	2

Table 9. Estimated survival of smolts in year i to small salmon in year i + 1, and to large salmon or 2SW salmon in year i + 2, at Highlands River, Newfoundland.

Year (i)	Number of Smolts (year i)	% survival to small salmon (year i + 1)	% survival to large salmon (year i + 2)	% survival to 2SW salmon (year i + 2)
1980	15028	0.85	0.37	0.31
1981	15839	0.63	-	-
1993	9986	1.45	1.20	0.93
1994	10503	1.64	1.35	0.81
1995	12160	1.64	1.29	0.70
1996	12383	3.21	0.94	0.52
1997	6776	1.42	1.21	0.46
1998	5922	2.47	1.13	0.68
1999	9634	0.60	-	-

* For 2SW survival in 2000, from 1998 smolts, life-history age data from all years combined were used owing to small sample size of large fish in 2000.

Table 10. Values used in the determination of the level of conservation requirements met at Highlands River, Bay St. George, Newfoundland, based upon an egg requirement of 1.498 million eggs.

	Small salmon				Large salmon						
Year	Number	% female	No. of eggs per fish	No. of eggs	Number	% female	No. of eggs per fish	No. of eggs	Total No. of eggs small and large salmon	% contribution from large salmon	% conservation level achieved
1980	82	0.554	2890	131287	55	0.75	10151	418729	550016	76.1	36.7
1981	127	0.554	2890	203335	29	0.75	10151	220784	424119	52.1	28.3
1982	100	0.554	2890	160106	56	0.75	10151	426342	586448	72.7	39.1
1993	137	0.461	3088	195029	78	0.695	9175	497377	692406	71.8	46.2
1994	145	0.461	3088	206417	148	0.695	9175	943740	1150158	82.1	76.8
1995	172	0.461	3088	244854	120	0.695	9175	765195	1010049	75.8	67.4
1996	199	0.461	3088	283290	142	0.695	9175	905481	1188771	76.2	79.3
1997	398	0.461	3088	566580	157	0.695	9175	1001130	1567710	63.9	104.6
1998	96	0.461	3088	136663	117	0.695	9175	746065	882728	84.5	58.9
1999	146	0.461	3088	207841	82	0.695	9175	522883	730724	71.6	48.8
2000	58	0.461	3088	82567	67	0.695	9175	427234	509801	83.8	34.0

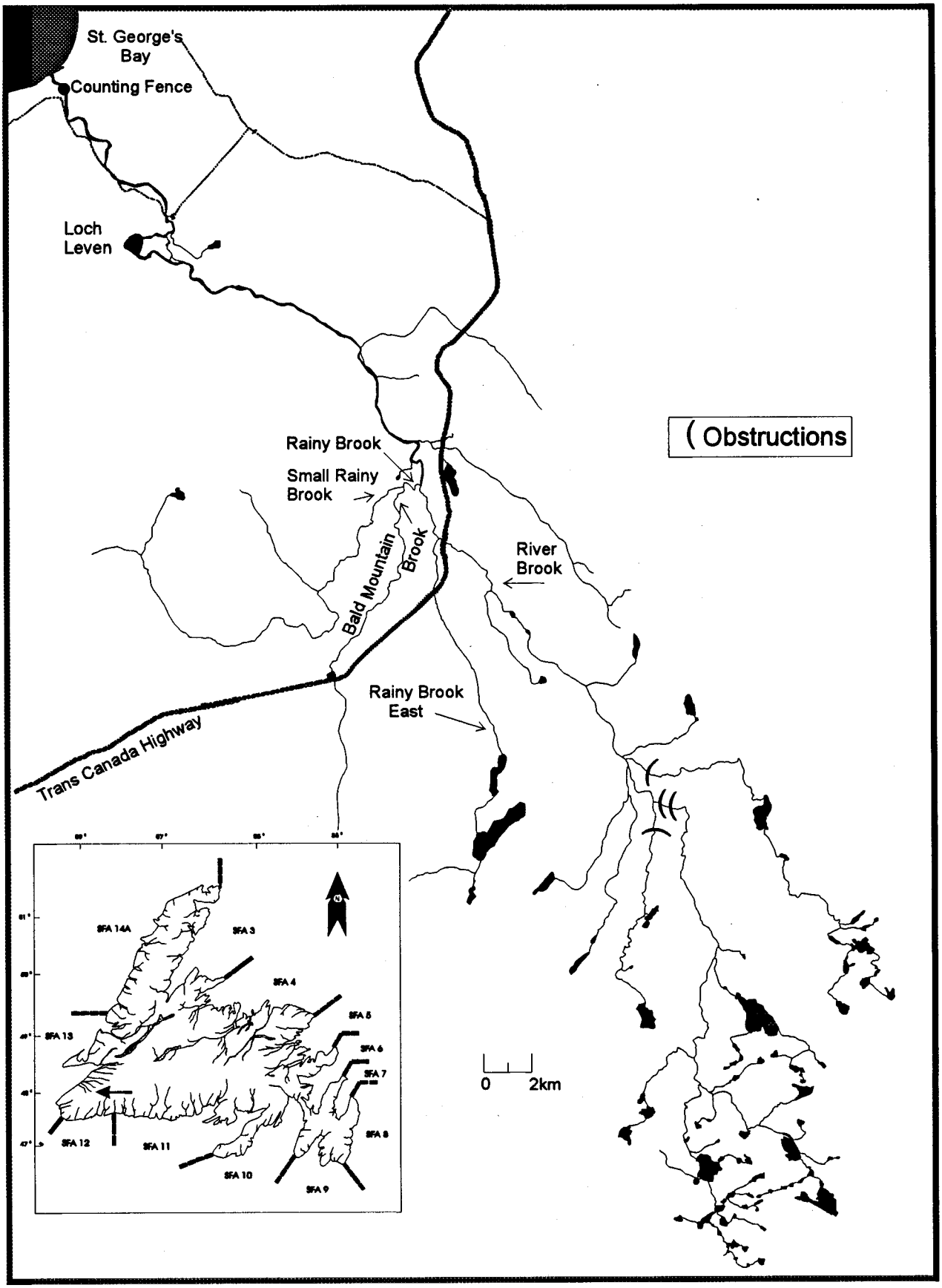

Fig. 1. Location of Highlands River, SFA 13, Newfoundland.

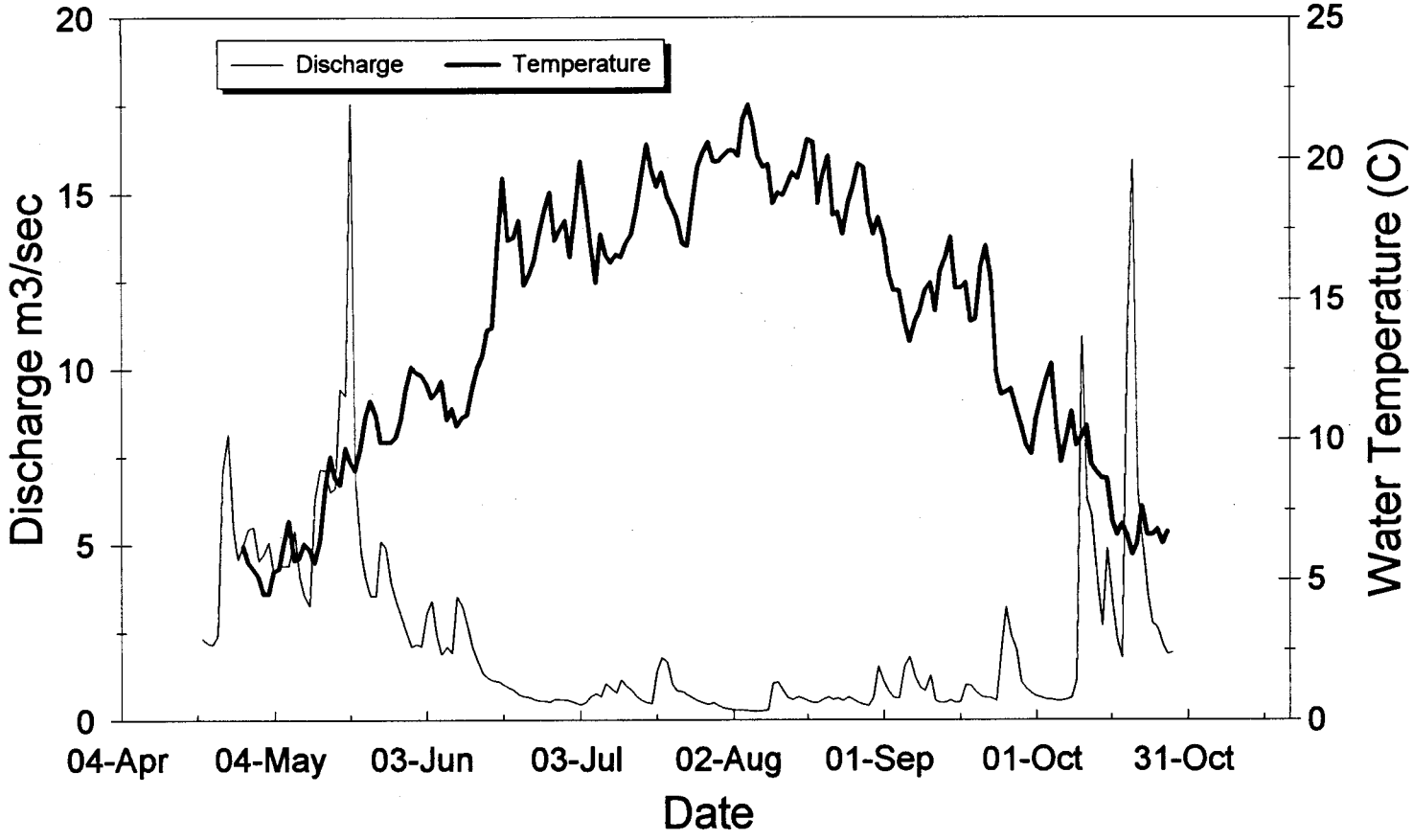

Fig. 2. Mean daily discharge (m3/s) and water temperature (C) at Highlands River, SFA 13, 2000.

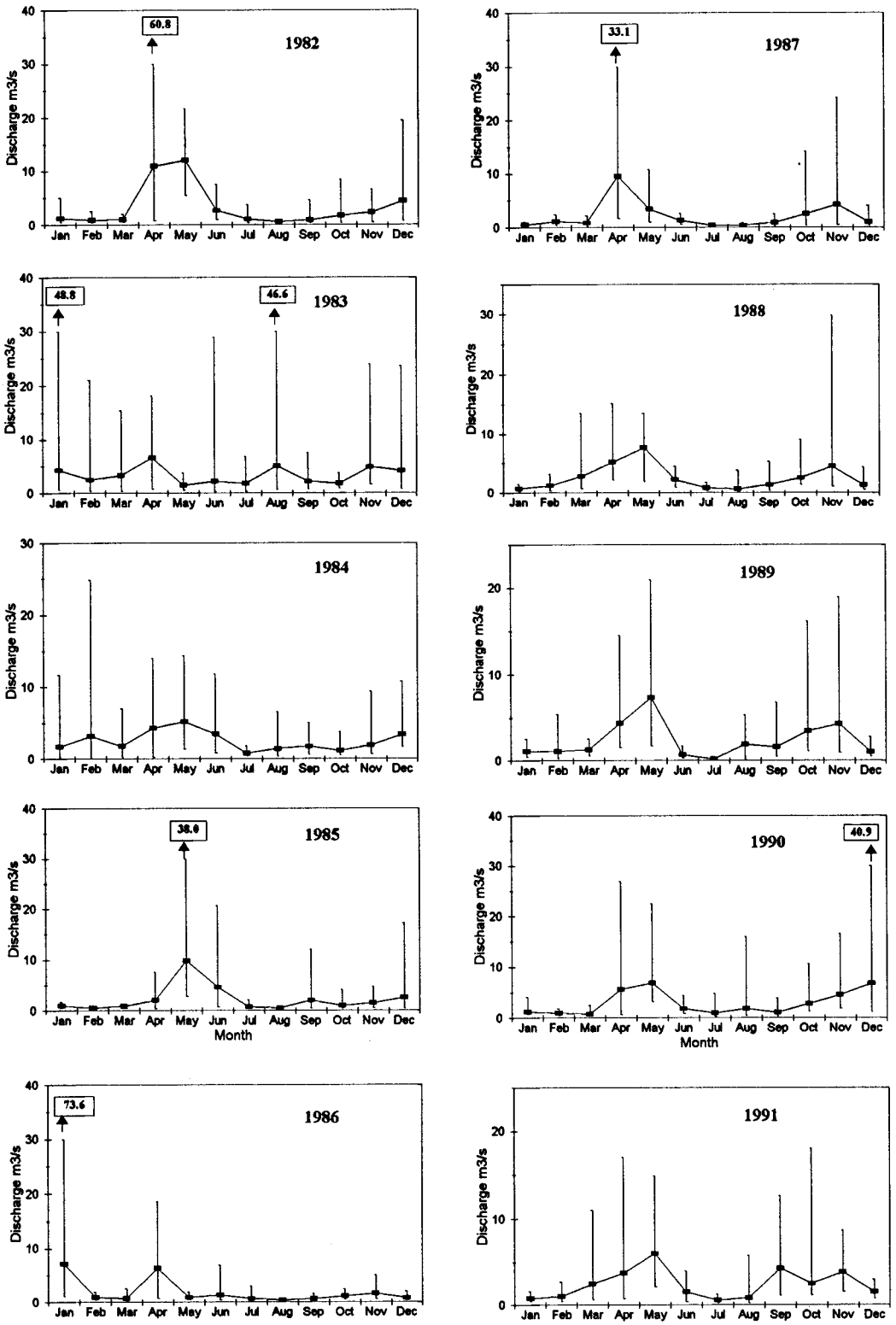

Fig. 3. Summary of maximum, minimum and mean daily discharge by month for Highlands River, Newfoundland, 1982 - 1991. Mean values are joined by a continuous line. Maximum values exceeding 30 m ^{3}/s are shown as a separate box for the respective months in which these high values occurred.

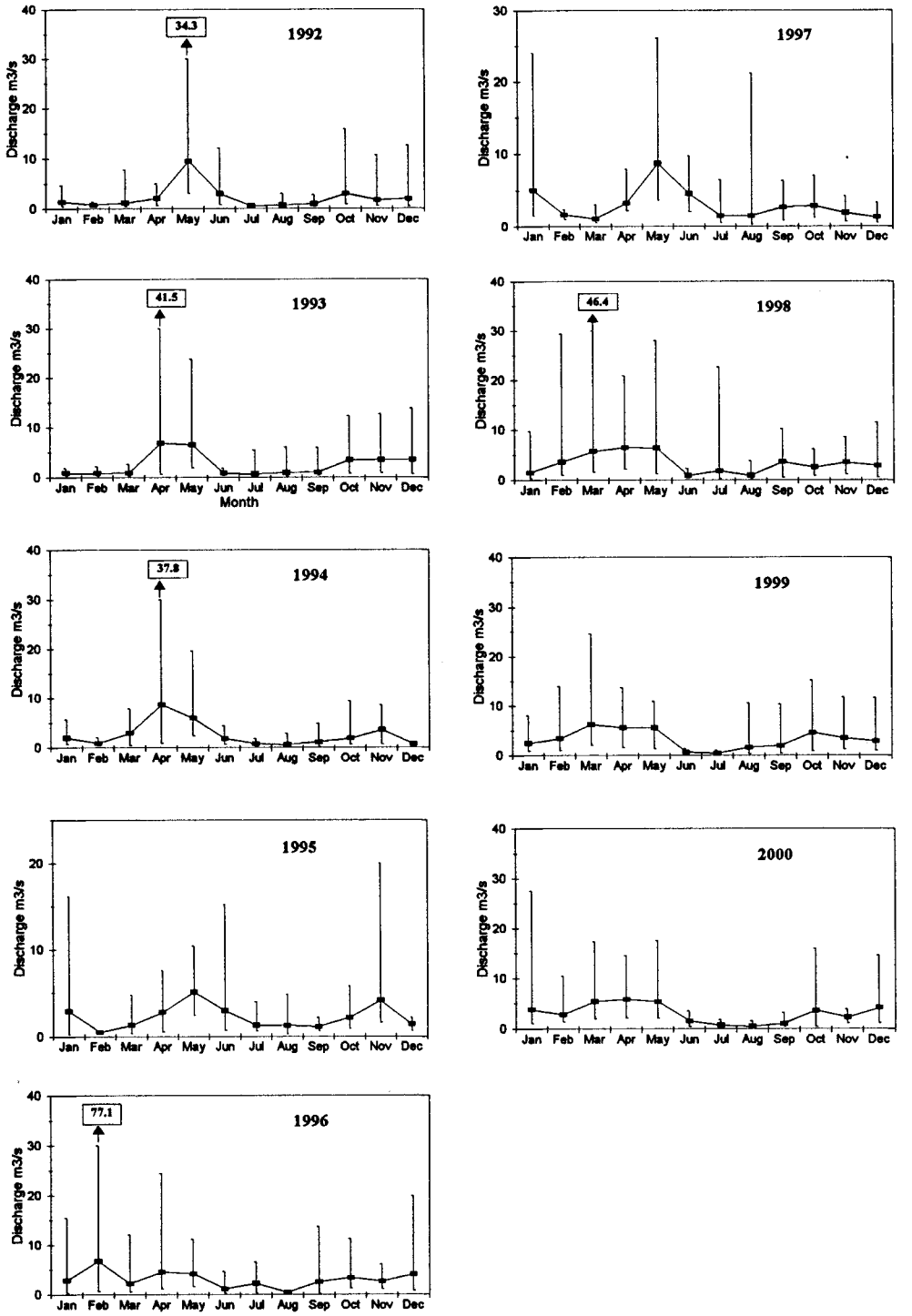

Fig. 3, continued. Summary of maximum, minimum and mean daily discharge by month for Highlands River, Newfoundland, 1992 - 2000. Mean values are joined by a continuous line. Maximum values exceeding 30 m^3/s are shown as a separate box for the respective months in which these high values occurred.
NOTE: information for 2000 is PRELIMINARY.

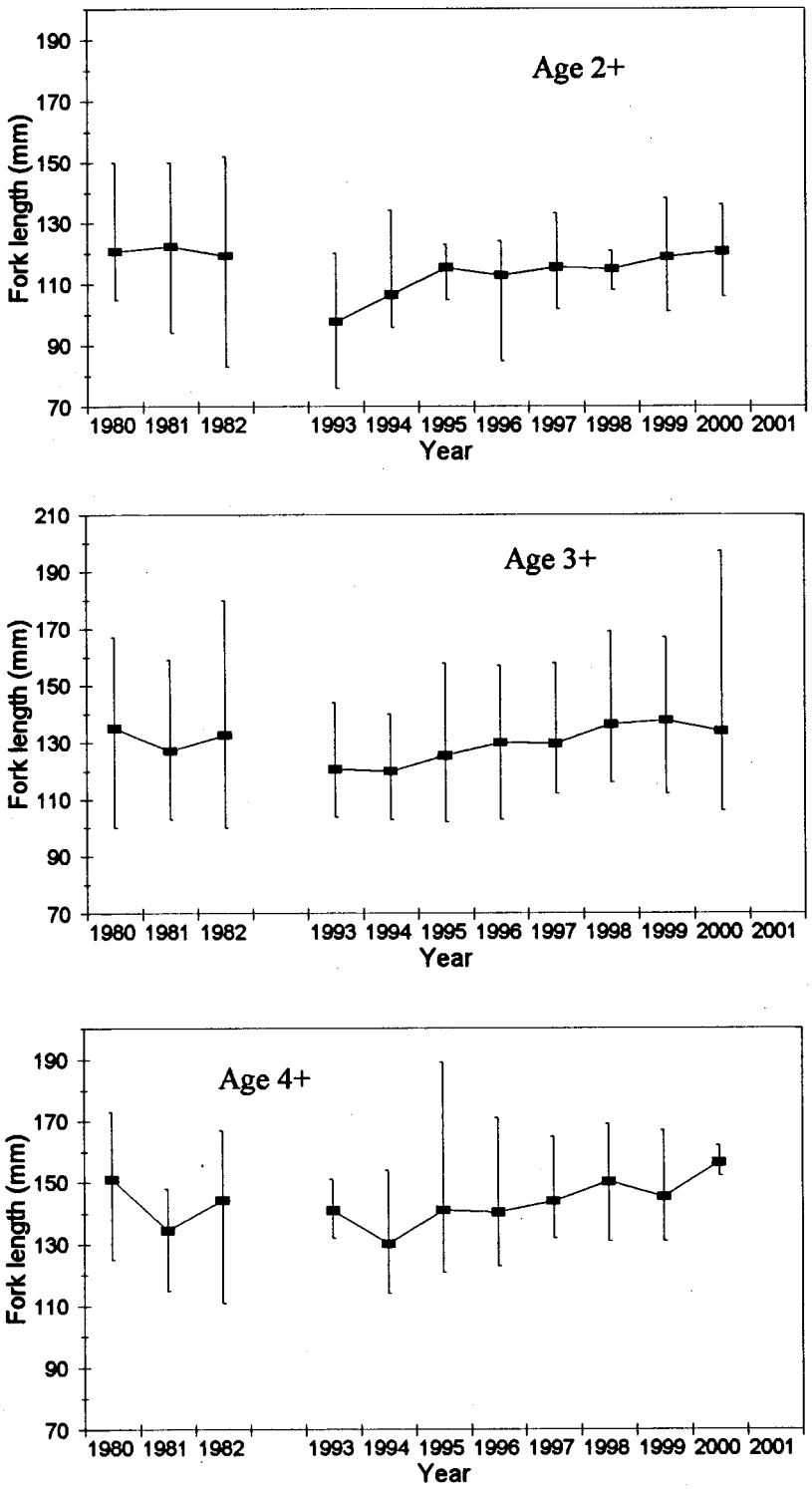

Fig. 4. Minimum, maximum, and mean fork length (mm) of river age 2+, 3+, and 4+ Highlands River smolt, from 1980 - 1982, and 1993 - 2000.

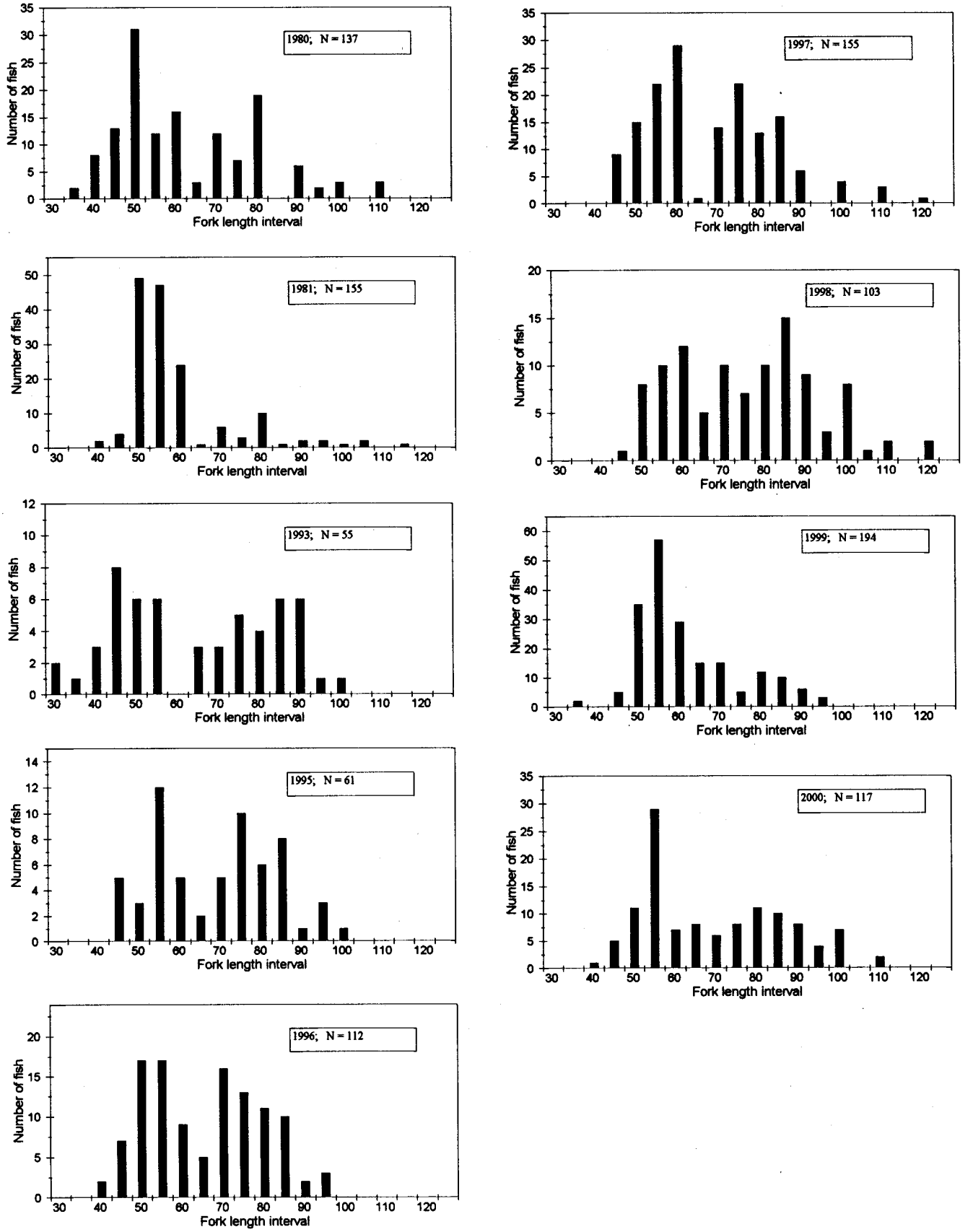

Fig. 5. Length distributions of adult Atlantic salmon estimated from fish in the fish counting fence trap at Highlands River, Newfoundland.

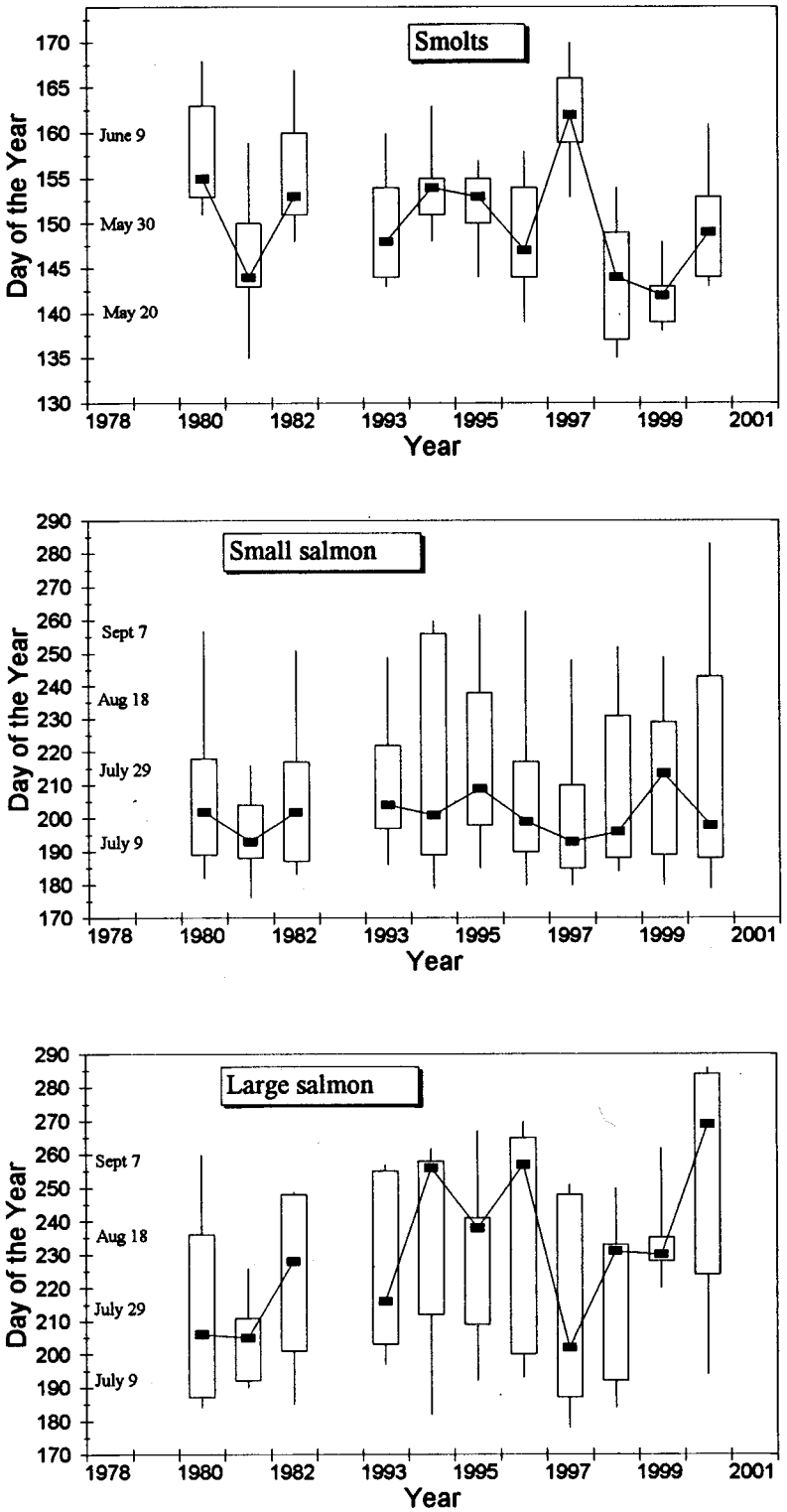

Fig. 6. Annual variation in run timing of Highlands River smolts, small and large salmon. Vertical lines represent the 10th and 90th percentiles of the day of the year of migration, the rectangle is the 25th and 75th percentiles, and the marker within the rectangle is the median run timing.

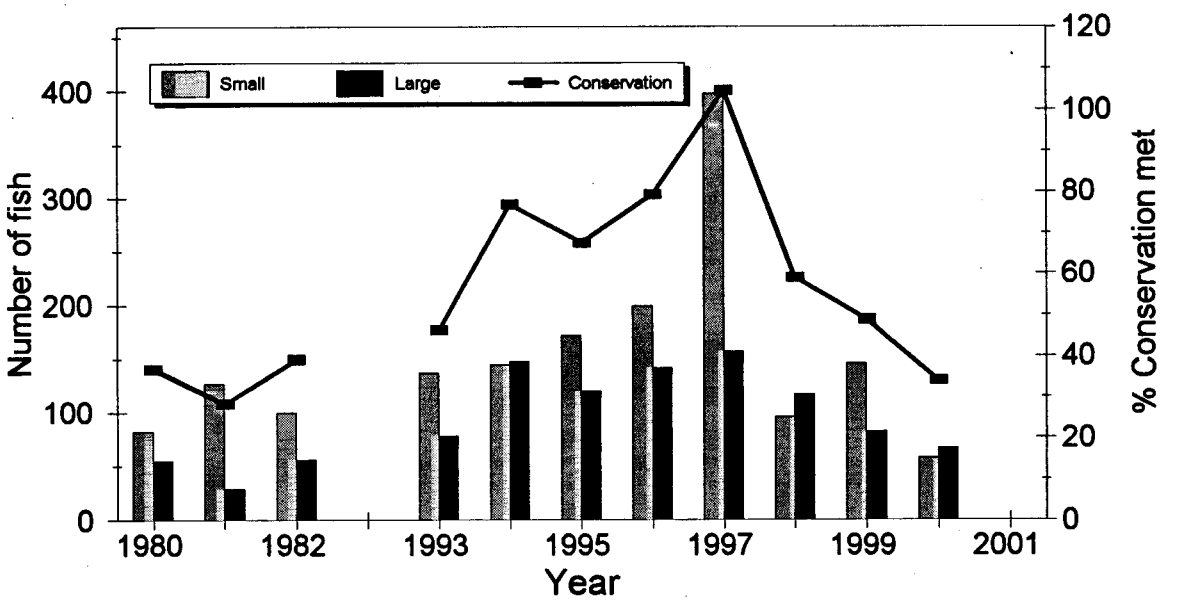

Fig. 7. Total numbers of small and large salmon returning to Highlands River, Newfoundland, along with the estimated percentage of the conservation requirement met.

Appendix 1. Highlands River avian and seal observations, 1999.

Species/Group	Activities observed			
	Flying	Standing	Swimming	Feeding
Common Merganser	4		259	
Kingfisher	5			
Tern	24			6
Seagull	159	1	3	
Bald Eagle	1	2		
Loon			14	
Cormorant	8	34	18	
Hawk	4			
Crow	4			
Osprey	1			
Seals			2	1

Appendix 2. Highlands River avian and seal observations, 2000.

Species/Group	Activities observed			
	Flying	Standing	Swimming	Feeding
Common Merganser	10	2	42	17
Kingfisher	19	4		
Tern	7			6
Gull	151	1	2	8
Crow	6			
Raven	1			
Hawk	1			
Bald Eagle	1			

There were four (4) seals observed at the mouth of Highlands River on the 15th of September 2000 possibly feeding.

STOCK: **Highlands River (SFA 13)** **Drainage area:** 183 km²

CONSERVATION REQUIREMENT: 1.5 million eggs calculated as fluvial area x 2.4 eggs/m² and lacustrine area x 368 eggs/ha

Year	1995	1996	1997	1998	1999	2000 [2]	MIN [1]	MAX [1]
Total returns to home waters								
Small	172	199	398	96	146	58	58	398
Large	120	142	157	117	82	67	29	157
Recreational harvest (small salmon)								
Retained								
Released								
Recreational harvest (large salmon)								
Retained								
Released								
Spawners								
Small	172	199	398	96	146	58	58	398
Large	120	142	157	117	82	67	29	157
Conservation requirement								
% met	67	79	105	59	49	34	28	105
Smolt count	12160	12383	6776	5922	9634	13120	5922	15839
% Sea survival								
Small	1.6	1.6	3.2	1.4	2.5	0.6	0.6	3.2
Large	1.2	1.4	1.3	0.9	1.2	1.1	0.4	1.4
(Adult return year)								

[1] Min and max are for the period of record since 1974.

[2] Preliminary

Data and methodology: Counts of smolt and adult salmon were obtained with a fish counting fence in 1980 - 82 and in 1993 - 2000. Sea survival is calculated for small salmon returning in year i + 1 and for large salmon returning in year i + 2, by dividing the number of returning adults by the number of smolts in year i.

State of the stock: The number of large salmon returning has increased since the closure of the commercial salmon fishery in 1992, but has fallen in each of the past three years since the peak in 1997. Small salmon returns are variable with returns in 2000 the lowest recorded. The conservation spawning requirement was achieved in only one year (1997) and fell to The conservation spawning requirement was achieved in only one year (1997) and fell to 34% of the requirement in 2000.

Forecast: The conservation spawning requirement will likely not be met in 2001 unless there is a substantial increase in marine survival rates. Based upon the average egg deposition contribution from small and large salmon, respectively, over the past 8 years (1993 - 2000), marine survival rates approximating 1.91% for small salmon returns from the 2000 smolt class and 1.86% survival for large salmon returns from the 1999 smolt class would be required. To date, the highest survival to large salmon has been only 1.35%.