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Impacts of the 1992 Atlantic salmon *(Salmo salar L.)* commercial fishery moratorium - Newfoundland Region

by

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Abstract

The impact of the first year of the Atlantic salmon (Salmo salar L.) commercial fishery moratorium on salmon stocks of the Newfoundland Region was evaluated using recreational fishery data and counts of salmon at fish counting facilities located in several Salmon Fishing Areas (SFAs). For the recreational fishery, overall total catch increased over 1991, but was below the 1984-89 mean. On an individual SFA basis, however, recreational catches in SFAs 3, 4, and 5, were above average. Counts of grilse salmon returning to rivers increased over 1991 in all but two facilities; both of which were located along the south coast of the island of Newfoundland in SFAs 9 and 11. At both of these locations, smolt-to-adult survival back to the river in 1992 was lower than for pre-moratorium years suggesting that natural mortality at sea may have been anomalously high. In general, while salmon returns improved considerably in 1992, it is noted that counts of grilse similar to or greater than those observed in 1992 also occurred in pre-moratorium years. Returns of large salmon were generally above the 1984-89 average except for several salmon stocks in SFAs 9 and 11. Additional impacts of the commercial salmon moratorium should be more detectable and meaningful over the next several years.

Résumé

Au terme de la première année du moratoire sur la pêche commerciale du saumon de l'Atlantique (Salmo salar L.), on a évalué ses effets sur les stocks de saumon de la région de Terre-Neuve, en se fondant sur les données de la pêche sportive et sur des recensements effectués à des installations de dénombrement du poisson dans plusieurs zones de pêche du saumon (ZPS). En ce qui concerne la pêche sportive, les prises totales ont augmenté par rapport à 1991, mais ont été inférieures à la moyenne de 1984-1989. Si on considère les prises sportives dans chaque zone, cependant, celles des zones 3, 4 et 5 ont été supérieures à la moyenne. Le nombre de montaisons de madeleineaux a lui aussi augmenté partout depuis 1991, sauf à deux endroits de la côte sud de Terre-Neuve, dans les ZPS 9 et 11, où le taux de survie du stade de saumoneau à celui de la montaison dans les rivières à l'état d'adulte a été inférieur à celui des années qui ont précédé le moratoire, ce qui pourrait dénoter une mortalité en mer anormalement élevée. En général, s'il est vrai que les montaisons de saumon se sont considérablement améliorées en 1992, force est de constater que dans les années qui ont précédé le moratoire on a enregistré des quantités comparables ou supérieures de madeleineaux. Les montaisons de gros saumons ont été dans l'ensemble supérieures à la moyenne de 1984-1989, sauf en ce qui concerne plusieurs stocks des ZPS 9 et 11. Les effets du moratoire sur la pêche commerciale du saumon devraient être plus importants et plus manifestes au cours des quelques prochaines années.

Introduction

Over the past eight years (1984-92), Atlantic salmon (Salmo salar L.) stocks in eastern Canada have been subjected to various management strategies in an attempt to rebuild depressed stocks. The 1984 Atlantic Salmon Management Plan involved season changes in the commercial fishery and catch restrictions in the recreational fishery, as well as reductions in the numbers of commercial fishermen and amount of licenced commercial gear. Evaluations of the 1984 plan indicated positive benefits in some regions (Randall 1990) while the results in other regions were mixed (O'Connell et al. 1992a).

Management initiatives introduced in recent years have maintained the common theme of rebuilding stocks to ensure target spawning requirements are met in the Maritime provinces, and that spawning levels increase in insular Newfoundland rivers. Average commercial landings for Newfoundland and Labrador from 1984-89 were about 900 t (O'Connell et al. 1991). Quotas (and allowances) were introduced for the first time in the Newfoundland commercial fishery restricting catches to a limit of 662 t in 1990 (O'Connell et al. 1991). Further quota reductions were implemented in 1991 (605 t) along with a reduction in the recreational fishery season bag limit from 15 to 10 fish (O'Connell et al. 1992b). In both years, assessment results suggested an overall low abundance of salmon in Newfoundland and Labrador, particularly in 1991 (O'Connell et al. 1992b).

1992 measures

The most significant change to date in the management of Atlantic salmon occurred in 1992. A five-year moratorium was placed on the commercial Atlantic salmon fishery in insular Newfoundland while in Labrador, fishing continued under quota or allowance catch. The quotas (t) for each Salmon Fishing Area (SFA) (Fig. 1) in Labrador since they were first introduced in 1990 were as follows (bracketed values indicate recorded catch):

SFA	1990	1991	1992
1*	80 (30)	80 (7)	80 (20)
2	200 (149)	200 (79)	180 (132)
		2A=65; 2B=135	2A=60; 2B=120

* allowance catch

In conjunction with the commercial fishing moratorium, a commercial licence retirement program went into effect in insular Newfoundland and Labrador. To date (April 1993), of 2631 eligible licence holders for insular Newfoundland (SFAs 3-14), 2520 (96%) have applied to sell their licences (L. Doyle, DFO, St. John's, personnel communication). In SFA 2, Labrador, 376 people were eligible to apply for licence termination with 215 (57%) having applied so far. Of these, it is estimated that 122 people were still eligible to fish during 1992 (i.e. they did not apply until after the commercial salmon fishing season closed).

A moratorium was also placed on the Northern Cod Fishery affecting SFAs 1-9 in early July. This measure should have eliminated any salmon by-catch in cod fishing gear resulting in increased escapements of salmon into freshwater. Recreational fishery quotas were also introduced in each SFA for the first time, and seasonal bag limits were reduced from 10 to 8 fish. Quotas were assigned for the SFA as a whole and were not administered on an individual river basis. After the quota for retained fish was reached in each SFA, hook-and-release fishing only was permitted.

This paper provides an overview of the impact of the first year of the commercial salmon fishery moratorium on salmon stocks of the Newfoundland Region. The overall status of Newfoundland salmon stocks is reported in O'Connell et al. (1993).

Methods

Impacts of the moratorium on returns of Atlantic salmon to rivers were evaluated using recreational fishery data and counts of salmon at counting facilities located in several SFAs. For the recreational fishery, information for 1992 was compared with historical catch, effort, and catch-per-unit-effort (CPUE) up to the time the quota for retained fish was reached in each SFA. Counts of salmon at fishways or counting fences were compared with 1991, and the 1984-89 and 1986-91 means. The 1984-89 years represented a management plan period that was unaffected by commercial fishing quotas, while the 1986-91 period represented a 5-year interval (1987 omitted from both series due to low water conditions and river closures).

Randomization tests (Edgington 1987) were previously used to compare pre- and post 1984 Salmon Management Plan values of 1/b (Shelton et al. 1990), that is the ratio of $1SW_{t-1}$ salmon counts to MSW_t salmon counts given the simple relationship:

$$MSW_{t+1} = b \cdot 1SW_t$$

In the present paper, ratios of returns of small:large salmon in 1992 were compared, using simple randomization tests, with similar ratios from 1984-89. Years with partial counts, resulting

from periods in the season that counting facilities were temporally inoperable, were excluded. For some rivers, data were not available for the entire series. Reference to Tables 3 and 4 can be used to determine the years included for the various rivers. Although a more appropriate comparison would have been the ratio of small salmon in year i versus large salmon returns in year i+1, these data will only be available beginning in 1993. Nevertheless, the moratorium should have produced a noticeable change in the small:large ratio in the absence of any directed legal fisheries for salmon in insular Newfoundland waters during 1992. Stratified shuffling, to address potential differences among rivers (Shelton et al. 1990), was not carried out due to limited data available at this time.

Results and Discussion

Recreational catch

The recreational catches of grilse and large salmon retained up to the date quotas were reached in 1992 were compared with the catches to the same date for the period 1984-91 (Table 1). The number of grilse retained in Labrador (1882) increased over 1991 (192%) but remained below the 1984-89 (-26%) and 1986-91 (-22%) means (Table 2). The catch of large salmon (543) improved over 1991 and both means (1451%, 74% and 96%, respectively). The below average catch of grilse in Labrador as a whole is attributable to SFA 1.

The total insular Newfoundland catch of grilse (12271) increased over 1991 (186%), decreased slightly from the 1984-89 mean (-6%), and increased over the 1986-91 mean (17%) (Table 2). It should be noted that catches in insular Newfoundland and Labrador overall in 1991 were the lowest recorded since 1967. On an individual SFA basis in insular Newfoundland, with the exception of SFAs 3, 4, and 5, recreational catches of grilse were below average. In insular Newfoundland, effort and CPUE overall increased over 1991 with only marginal changes relative to the means. In Labrador, a similar situation applied to effort but CPUE, which increased over 1991, remained below average.

Angling catches up to the date the quota was caught in each SFA used in terms of indices of abundance should be viewed with caution. There were differences among SFAs in the times quotas were caught (e.g., July 4 in SFA 10, July 24 in SFAs 3 and 4, August 28 in SFA 1). Of particular concern are differences in annual timing of runs into rivers which could confound historical comparisons; for example, notable delays in adult migration occurred in 1985 and 1991.

Fish counting facilities

Counts of grilse (Figs. 2-6 and Table 3) and large (Figs. 7-11 and Table 4) salmon are available for several rivers in various SFAs in insular Newfoundland. Counts of grilse increased over 1991 at all counting facilities except Northeast Brook, Trepassey (SFA 9) (-50%), and Conne River (SFA 11) (-5%) (Table 5). With respect to the means, counts increased along the northeast and east coasts (SFAs 4-5) but generally decreased along the south coast (SFAs 9 and 11) with Grand Bank Brook (SFA 10) the exception (Fig. 13). At most counting facilities, it is evident that counts of grilse similar to or greater than those observed in 1992 occurred in pre-moratorium years.

Smolt-to-adult survival back to the river in 1992 for Northeast Brook, Trepassey, and Conne River was lower than for pre-moratorium years (Table 6, Fig. 12), suggesting that natural mortality at sea may have been anomalously high. With respect to Conne River, in contrast to the other rivers under consideration, this river is characterized by early runs of grilse (since 1986, 70-80% of the run has been completed by early July). The implementation of the 1984 management plan, which delayed the opening of the commercial fishery from mid-May to June 5, should have had a more noticeable impact on Conne River than the 1992 moratorium. Environmental conditions at sea in the spring and early summer of 1991 were among the most severe on record which suggests that heavy mortality could have occurred at the smolt/post-smolt stage (Narayanan et al. 1993). For both rivers, there is a noticeable decline in survival over time (Fig. 12).

Except for Northeast Brook, Trepassey, counts of large salmon increased over 1991 (Table 5); in relation to the 1984-89 and 1986-91 means, increases occurred for all rivers except Biscay Bay River (SFA 9), Northeast Brook, Trepassey, and Conne River (Fig. 13). Again, these rivers are located along the south coast of insular Newfoundland. Most of the fish classified as large salmon in rivers in the insular Newfoundland portion of the Newfoundland Region are repeat (successive) spawning grilse (O'Connell et al. 1992a). The low escapements of large salmon in 1992, therefore, are probably related to low escapements of virgin grilse in 1991.

In the past, Labrador-origin Atlantic salmon have been intercepted in SFA 3, and to a lesser degree in SFAs 4-7, and it is possible that fish normally taken in these SFAs contributed to catches in Labrador in 1992. The quota was not caught in the Labrador commercial fishery for the third year in a row. Overall abundance of both small and large salmon in Labrador in 1992 remained below average (O'Connell et al. 1993).

The change in ratio of small-to-large salmon could also reflect an impact of the moratorium in 1992. A decrease in 1/b, the ratio of small:large salmon, infers a proportional increase in

the number of large salmon returning. As stated above, a more appropriate comparison would have been the ratio of small salmon in year i versus large salmon returns in year i+1, but these data will only be available beginning in 1993. Nevertheless, the moratorium should have produced a noticeable change in the small:large ratio in the absence of any directed legal fisheries for salmon in insular Newfoundland waters during 1992.

Figure 14 summarizes the ratio of small:large salmon for various counting facilities for the 1984-89 mean, in comparison with 1992. For most rivers, there were substantial declines in the ratio inferring proportionally greater returns of large salmon to small salmon in 1992 compared with 1984-89 management plan years. Rivers in SFA 9 and 11 showed little or no change in the ratios. Results of the randomization tests with all rivers (N = 12) did not suggest a significant difference in the ratios (P = 0.118). However, if those rivers in SFAs 9 and 11 which showed little or no difference (Fig. 14, Biscay Bay, Northeast Trepassey, Colinet, and Conne rivers) were omitted, then the difference between the mean index for 1984-89 versus 1992 was significant (P = 0.043).

Expectations of the impact of the salmon moratorium

Over the next several years, the impact of the commercial salmon fishery moratorium should be more detectable, and any evaluation of the impacts, more meaningful. Impacts may be discernable and quantifiable at the (1) adult, (2) freshwater juvenile, and (3) smolt stages. With respect to adult salmon, expectations of changes that may occur include: increased numbers of returning adults; changes in biological characteristics (size of fish), change in ratio of grilse to large salmon with an increase in the proportion of repeat spawners. Juvenile densities should increase, with possible disproportionate changes in abundance in different habitats. Growth rates of parr may change leading to a wider range in age classes present in fresh water. Change in growth rate could potentially affect the proportion of precocious parr in the population. Similarly, the number of smolts produced should increase with perhaps a broader range of age classes represented in the run. Smolt to adult survival rates should, in the long term, exceed those recorded in pre-moratorium years.

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Table 1. Cumulative catch, effort, and catch per unit of effort (CPUE) to the date of closure of the recreational fishery for the retention of Atlantic salmon in each SFA, in 1992.

SFA	Quota	Date quota Caught	Grilse (<63 cm)								Large Salmon (≥63 cm)							
			1992	1991	Mean 84-89*	LCL	UCL	Mean 86-91*	LCL	UCL	1992	1991	Mean 84-89	LCL	UCL	Mean 86-91	LCL	UCL
1	442	Aug 28	164	79	857.5	487.3	1227.7	734.5	225.0	1244.0	286	8	152.7	115.9	189.5	111.5	50.7	172.3
2	2160	Aug 08	1718	565	1689.7	1109.3	2270.0	1671.8	994.4	2349.2	257	27	159.2	68.0	250.3	165.2	73.2	257.1
NF Reg. (Lab.)			1882	644	2547.2	1678.7	3415.6	2406.3	1263.6	3549.1	543	35	311.8	213.9	409.7	276.7	127.3	426.0
3	1300	July 24	1562	704	787.0	380.0	1194.0	854.2	413.4	1295.0								
4	4800	July 24	5290	1932	5541.6	3426.1	7657.1	4124.6	1669.7	6579.5								
5	2000	July 19	1941	461	1407.0	643.0	2171.0	1355.0	449.8	2260.2								
6	200	Aug 09	230	106	288.0	204.7	371.3	238.8	114.2	363.4								
7	40	Aug 04	40	11	71.6	47.4	95.8	55.0	16.2	93.8								
8	Closed																	
9	600	July 13	690	347	1193.6	692.3	1694.9	1079.4	457.1	1701.7								
10	200	July 04	245	34	486.0	249.9	722.1	378.8	63.4	694.2								
11	1700	July 05	2273	692	3300.0	2125.6	4474.4	2385.2	1038.0	3732.4								
NF Reg. (Ins.)			12271	4287	13074.8	9068.2	17081.4	10471.0	4882.2	16059.8								

*1987 Not included in SFAs 3-11

SFA	Date quota Caught	Effort(rod days)								CPUE							
		1992	1991	Mean 84-89*	LCL	UCL	Mean 86-91*	LCL	UCL	1992	1991	Mean 84-89*	LCL	UCL	Mean 86-91*	LCL	UCL
1	Aug 28	675	835	1094.0	745.2	1442.8	1052.2	681.3	1423.0	0.67	0.10	0.92	0.81	1.04	0.80	0.48	1.13
2	Aug 08	2636	1808	2008.0	1528.1	2487.9	2174.5	1845.2	2503.8	0.75	0.33	0.92	0.76	1.08	0.84	0.57	1.12
NF Reg. (Lab.)		3311	2643	3102.0	2342.6	3861.4	3226.7	2566.0	3887.3	0.73	0.26	0.92	0.82	1.02	0.83	0.55	1.11
3	July 24	2884	2262	1498.8	989.8	2007.8	1746.2	1038.0	2454.4	0.54	0.31	0.53	0.38	0.67	0.49	0.29	0.68
4	July 24	15097	10316	17575.6	14144.2	21007.0	14895.4	10791.0	18999.8	0.35	0.19	0.32	0.24	0.39	0.28	0.18	0.38
5	July 19	5830	2395	4801.2	3760.5	5841.9	4070.8	2616.4	5525.2	0.33	0.19	0.29	0.15	0.43	0.33	0.22	0.45
6	Aug 09	2028	1135	2180.4	1706.8	2654.0	2037.0	1351.4	2722.6	0.11	0.09	0.13	0.07	0.19	0.12	0.07	0.17
7	Aug 04	1070	325	885.0	550.6	1219.4	710.6	300.9	1120.3	0.04	0.03	0.08	0.05	0.12	0.08	0.03	0.12
8	Closed																
9	July 13	4956	4561	4976.4	4469.0	5483.8	4942.2	4320.7	5563.7	0.14	0.08	0.24	0.15	0.33	0.22	0.11	0.32
10	July 04	1520	1091	1961.0	1580.4	2341.6	1851.0	1227.1	2474.9	0.16	0.03	0.25	0.15	0.34	0.20	0.10	0.31
11	July 05	5857	3439	8106.0	7117.1	9094.9	6842.8	4367.0	9318.6	0.39	0.20	0.41	0.31	0.51	0.35	0.28	0.43
NF Reg. (Ins.)		39242	25524	41984.4	36219.4	47749.4	37096.0	28023.4	46168.6	0.31	0.17	0.31	0.25	0.37	0.28	0.20	0.36

*1987 Not included in SFAs 3-11

Table 2. Percent chnage in cumulative recreational catch, effort, and catch per unit effort (CPUE) to the date of closure of the recreational fishery for the retention of Atlantic salmon in each SFA in 1992, in relation to 1991 and the 1984-89 and 1986-91 means.

	Grilse (>63 cm)			Large Salmon (≤63 cm)		
SFA	1991	Mean 84-89*	Mean 86-91*	1991	Mean 84-89	Mean 86-91
1	107.6	-80.9	-77.7	3475.0	87.3	156.5
2	204.1	1.7	2.8	851.9	61.5	55.6
NF Reg. (Lab.)	192.2	-26.1	-21.8	1451.4	74.1	96.3
3	121.9	98.5	82.9			
4	173.8	-4.5	28.3			
5	321.0	38.0	43.2			
6	117.0	-20.1	-3.7			
7	263.6	-44.1	-27.3			
8						
9	98.8	-42.2	-36.1			
10	620.6	-49.6	-35.3			
11	228.5	-31.1	-4.7			
NF Reg. (Ins.)	186.2	-6.1	17.2			

*1987 Not included in SFAs 3-11.

	Effort (rod days)			CPUE		
SFA	1991	Mean 84-89*	Mean 86-91*	1991	Mean 84-89*	Mean 86-91*
1	-19.2	-38.3	-35.8	570.0	-27.2	-16.3
2	45.8	31.3	21.2	127.3	-18.5	-10.7
Nf Reg. (Lab.)	25.3	6.7	2.6	180.8	-20.7	-12.0
3	27.5	92.4	65.2	74.2	1.9	10.2
4	46.3	-14.1	1.4	84.2	9.4	25.0
5	143.4	21.4	43.2	73.7	13.8	0.0
6	78.7	-7.0	-0.4	22.2	-15.4	-8.3
7	229.2	20.9	50.6	33.3	-50.0	-50.0
8						
9	8.7	-0.4	0.3	75.0	-41.7	-36.4
10	39.3	-22.5	-17.9	433.3	-36.0	-20.0
11	70.3	-27.7	-14.4	95.0	-4.9	11.4
Nf Reg. (Ins.)	53.7	-6.5	5.8	82.4	0.0	10.7

*1987 Not included in SFAs 3-11.

Table 3. Counts of grilse from fishways and counting fences in insular Newfoundland 1955-92 by Salmon Fishing Area (SFA); also shown are means (X), 95% confidence intervals (CI), and coefficients of variation (CV).

	Fishways									Counting fences				
	SFA 4			SFA 5			SFA 9	SFA 10	SFA 11	SFA 4	SFA 9			SFA 11
Year	1A	1B	2	3	4	5	6	7	8	9	10	11	12	13
1955						53								
1956				323[a]	558	32								
1957			642	28[a]	141	21								
1958			1072	344[a]	677	10								
1959	886[a]		591	294[a]	394	62								
1960	1013	94	291		490	86								
1961	839	319	41		318	74								
1962		1037			496	284								
1963	1202	491			551	372								
1964		1752			418	246								
1965	1228	587			484	334								
1966	829[a]	942			368	134								
1967	1372	822			606	367								
1968		1334			714	409		57[a]						
1969	979	892			660	463								
1970		1023			755	561								
1971	961	902	731		579	316		159						
1972	794	495a	540	838	609	331		236						
1973	205		971	1079[a]	455	340		399[a]						
1974	2538		857	770[a]		162		223						
1975	9218	5531		1119[a]		778		186[a]						
1976	3991	2935				335		294						
1977	6148	4300				371								
1978	3790	2704	755[a]	1403[a]	810	436		390						
1979	6715	3925	404[a]	1350[a]	569	455		454						
1980		4597	997	1712	843	420		433						
1981	8114[a]	4264	2459	2414	1115	619		334[a]						
1982	7605[a]	2796	1425	1281	963	625		86[a]					133	
1983		2952[a]	978	1195	1210	853		233			2330		272	
1984	17219	6300a	1081	1379	1233	904		419			2430	89	359	
1985	16652	5985	1663	904	1557	960		384			1377[a]	124	170	
1986	9697	3072	1064	1036	1051	726		725	211		2516	158	296	7515
1987	9014	2327	493a	914	974	570	80	325a	155a		1302a	91	368	9687
1988	8974	3433	1562	772	1737	795	313	543	149		1695	97	205[a]	7118
1989	7192	1694	596	496	1138	668	168	706	175	7743	889[a]	62	441	4469
1990	6629	1057	328[a]	745	1149	410[a]	401	551	208	7520	1657	71	307[a]	4321
1991	5245	1060	245	562	873	311[a]	211	353	46[a]	6445	394	99	218	2086
1992	12538	3520	1168	1182	1443	886	237	921	101	17296[a]	1298[a]	49	249	1973
1984-89														
X	11458.0	3302.2	1193.2	916.8	1281.7	770.5	187.0	555.4	178.3		2213.7	103.5	326.8	7197.2
95% CI	4541.5	2040.3	534.9	306.4	316.2	153.6	292.4	195.9	77.3		1120.9	34.8	126.1	3406.0
CV	37.76	49.77	36.11	31.84	23.51	18.99	62.94	28.41	17.44		20.38	32.08	31.09	29.74
N	6	5	5	6	6	6	3	5	3		3	6	5	4
1986-91														
X	7791.8	2107.2	866.7	754.2	1153.7	689.7	234.6	575.6	185.7	7236.0	1565.5	96.3	330.7	5866.0
95% CI	1800.9	1060.8	910.4	214.5	319.1	151.5	155.4	186.7	46.8	1724.1	1393.4	35.3	152.3	2875.0
CV	22.02	47.96	66.02	27.10	26.35	13.80	53.37	26.13	15.83	9.59	55.94	34.89	28.94	46.69
N	6	6	4	6	6	4	5	5	4	3	4	6	4	6

1 Exploits River
(a) Bishop's Falls
(b) Gt. Rattling Brook
2 Gander River (Salmon Brook)
3 Middle Brook
4 L. Terra Nova River
5 U. Terra Nova River
6 Rocky River
7 Northeast River (Placentia)
8 Grand Bank Brook
9 Gander River
10 Biscay Bay River
11 Northeast Brook (Trepassey)
12 Colinet River
13 Conne River

[a]Partial counts: not included in means

Table 4. Counts of large salmon from fishways and counting fences in insular Newfoundland 1955-92 by Salmon Fishing Area (SFA); also shown are means (X), 95% confidence intervals (CI), and coefficients of variation (CV).

	Fishways									Counting fences				
	SFA 4			SFA 5			SFA 9	SFA 10	SFA 11	SFA 4	SFA 9			SFA 11
Year	1A	1B	2	3	4	5	6	7	8	9	10	11	12	13
1955						24								
1956				56[a]	37	44								
1957			323	2[a]	41	1								
1958			491	229[a]	195	0								
1959	119[a]		290	14[a]	67	0								
1960	157	9	183		216	0								
1961	118	53	15		100	1								
1962		31			277	4								
1963	65	37			320	34								
1964		116			298	18								
1965	203	190			255	51								
1966	506[a]	470			220	2								
1967	710	382			359	43								
1968		687			376	28		11[a]						
1969	498	290			391	136								
1970		199			469	172								
1971	300	261	494		279	121		21						
1972	113	234[a]	54	10[a]	348	200		34						
1973	89		135	9[a]	303	223		64[a]						
1974	411		9	77[a]		121		9						
1975	1439	505		9[a]		52		36[a]						
1976	460	117				37		56						
1977	581	271				262								
1978	303	81	52[a]	16	20	89		32						
1979	277	124	6[a]	54[a]	170	30		37						
1980		426	15	91	39	17		34						
1981	1695[a]	514	33	39	90	28		62[a]						
1982	181a	122	18	20	19	8		36[a]					116	
1983		302[a]	12	75	57	76		22			88		43	
1984	529	111[a]	38	57	107	98		44			83[a]	33	97	
1985	183	38	26	27	112	60		0			21[a]	41	42	
1986	355	174	12	15	140	58		39	4		101	30	31	397
1987	310	41	9a	19	56	38	1	16a	2a		106a	30	55	498
1988	147	10	24	14	206	45	6	11	2		61	19	16[a]	418
1989	89	14	24	19	142	51	9	15	7	473	104[a]	18	81	319
1990	122	15	7[a]	13	144	34[a]	17	25	15	508	71	9	50[a]	361
1991	99	40	2	14	114	26[a]	16	8	7[a]	670	35	13	18	87
1992	314	242	101	43	270	224	46	46	35	3850[a]	49[a]	10	78	154
1984-89														
X	268.8	55.4	24.8	25.2	127.2	58.3	5.3	21.8	4.3		81.7	28.5	61.2	408.0
95% CI	170.1	84.0	11.4	17.1	52.1	22.1	9.9	23.5	6.2		49.7	9.1	34.0	117.1
CV	60.31	122.20	37.10	64.68	38.99	36.19	75.47	86.70	58.1		24.48	30.53	44.77	18.04
N	6	5	5	6	6	6	3	5	3		3	6	5	4
1986-91														
X	187.0	49.0	15.5	15.7	133.7	48.0	9.8	19.6	7.0	550.3	67.0	19.8	46.2	346.7
95% CI	121.0	65.8	16.9	2.7	51.1	13.5	8.4	15.6	9.1	261.1	43.4	9.0	44.2	147.6
CV	61.66	127.96	68.39	16.56	36.42	17.71	69.39	64.29	81.43	19.10	40.75	43.43	60.17	40.55
N	6	6	4	6	6	4	5	5	4	3	4	6	4	6

1 Exploits River
(a) Bishop's Falls
(b) Gt. Rattling Brook
2 Gander River (Salmon Brook)
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4 L. Terra Nova River
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9 Gander River
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11 Northeast Brook (Trepassey)
12 Colinet River
13 Conne River

[a]Partial counts: not included in means

Table 5. Counts of grilse and large salmon from fishways and counting fences in insular Newfoundland for 1992 expressed as percentage change in relation to 1991, the 1984-89 mean and the 1986-91 mean.

	Grilse			Large salmon		
	1991	$\bar{x}$ 1984-89	$\bar{x}$ 1986-91	1991	$\bar{x}$ 1984-89	$\bar{x}$ 1986-91
FISHWAYS						
SFA 4						
Bishops Falls (Exploits River)	139	9	61	217	17	68
Gt. Rattling Brook (Exploits River)	232	6	67	505	337	394
Salmon Brook	377	-2	35	4950	307	552
SFA 5						
Middle Brook	110	29	57	207	71	174
Lower Terra Nova River[a]	65	12	25	137	112	102
Upper Terra Nova River[a]	185	15	28	761	284	367
SFA 9						
Rocky River	12	27	1	187	768	369
SFA 10						
Northeast River (Placentia)	161	66	60	475	111	135
SFA 11						
Grand Bank Brook[a]	119	-43	-46	400	714	400
COUNTING FENCES						
SFA 4						
Gander River[b]	168		139	475		600
SFA 9						
Biscay Bay River[b]	229	-41	-17	40	-40	-27
Northeast Brook (Trepassey)	-50	-53	-49	-23	-65	-49
Colinet River	14	-24	-25	333	27	69
SFA 11						
Conne River	-5	-72	-66	77	-62	-56

[a]Partial count in 1991 (see text).

[b]Partial count in 1992 (see text)

Table 6. Atlantic salmon smolt-to-adult survival (back to the river) for Northeast Brook, Trepassey (SFA 9) and Conne River (SFA 11).

Year	Northeast Brook			Conne River[1]		
	Smolts year i	Grilse year i+1	% Survival	Smolts year i	Grilse year i+1	% Survival
1986	1117	91	8.2			
1987	1404	97	6.9	74585	7627	10.2
1988	1692	62	3.7	68692	4968	7.6
1989	1708	71	4.2	73724	5383	7.3
1990	1902	99	5.2	56943	2410	4.2
1991	1905	49	2.6	74645	2523	3.4

[1]Includes Native food fishery.

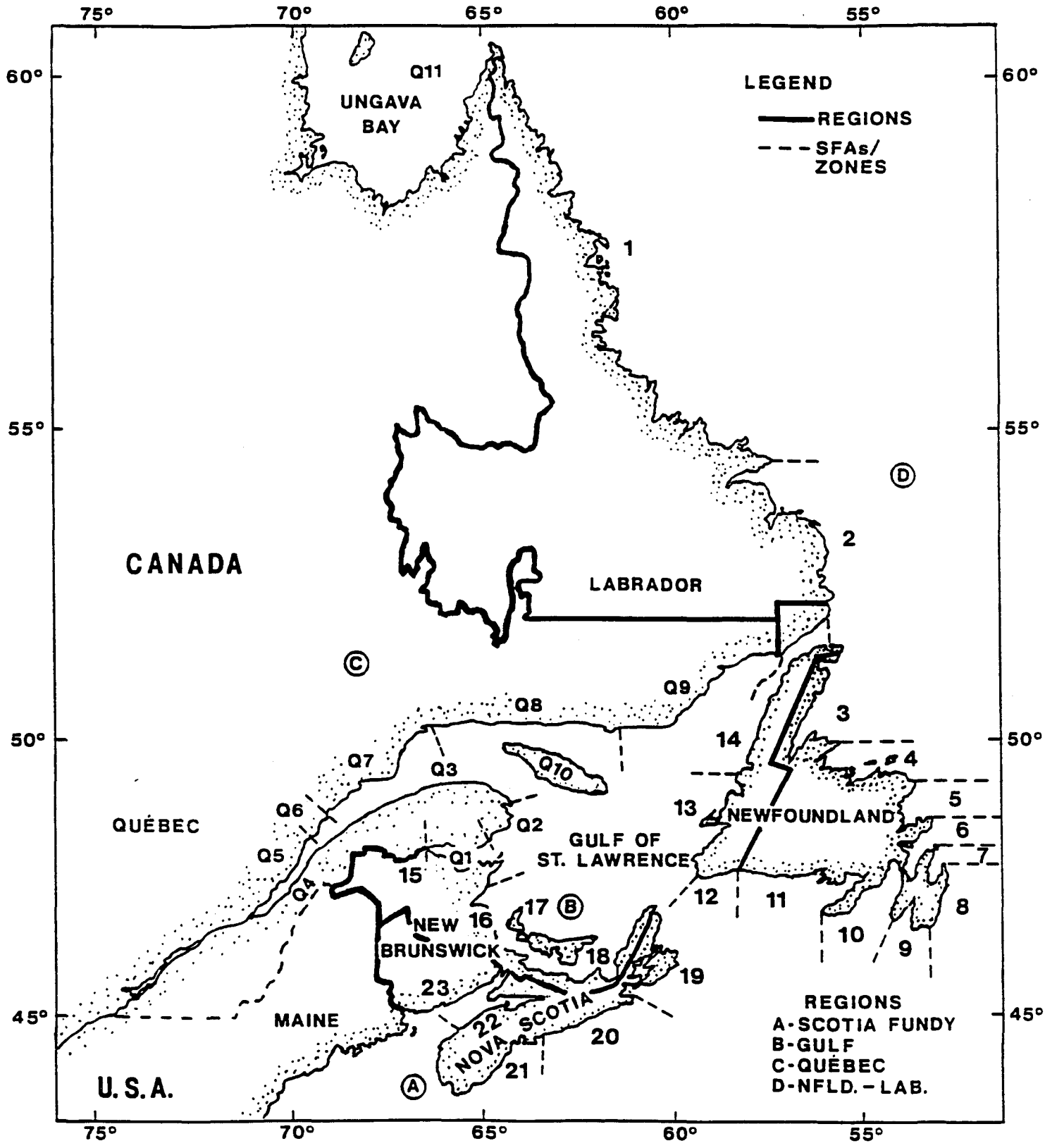


Fig. 1. Map of Atlantic Provinces of Canada showing Salmon Fishing Areas (SFAs) 1-23, Salmon Management Zones of Quebec (Qs) 1-11, and regional boundaries. The Newfoundland Region is comprised of SFAs 1-11.

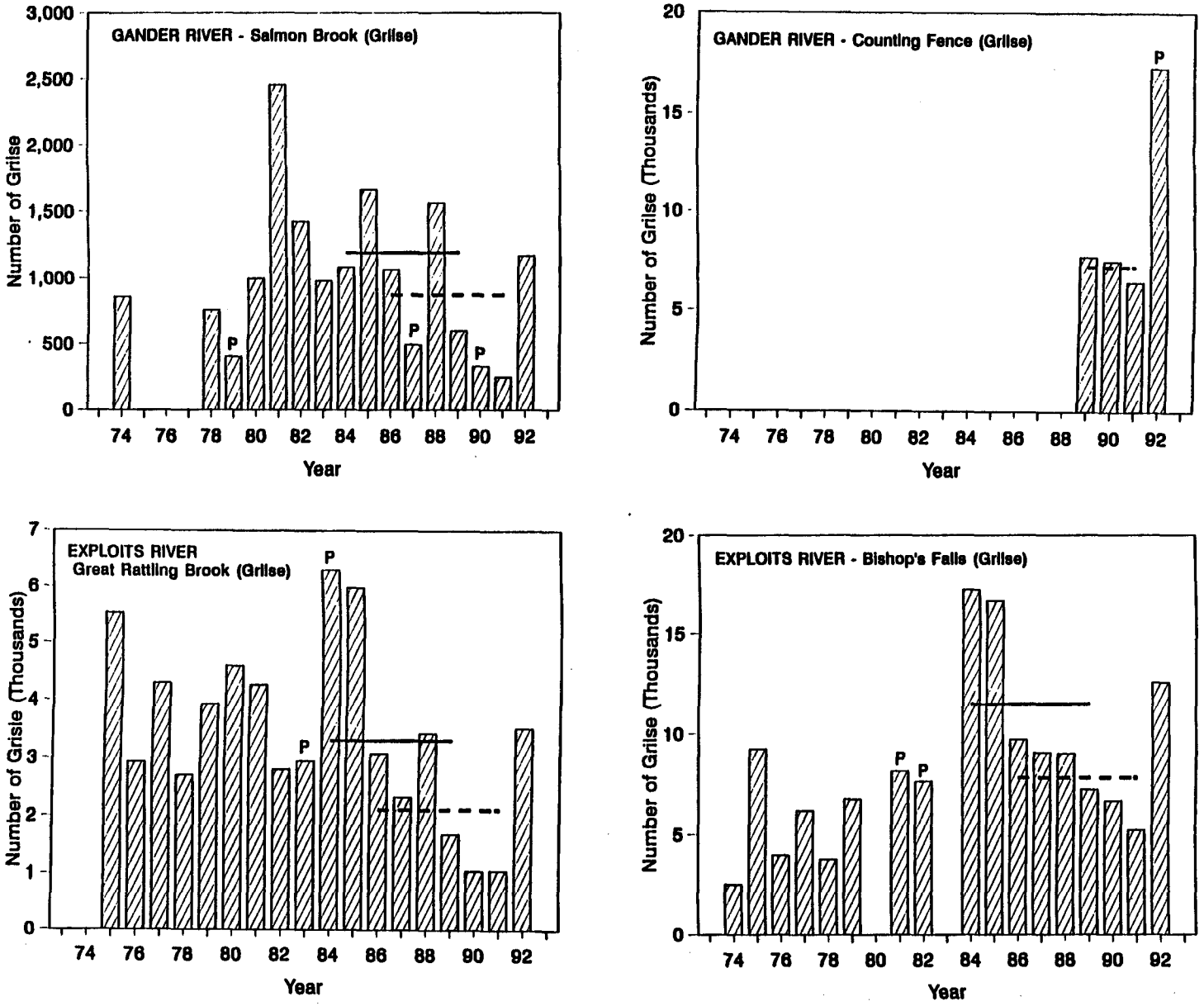


Fig. 2. Counts of grilse at the Gander River counting fence and at the fishway located on the Salmon Brook tributary, and at the Bishop's Falls fishway on the main stem of the Exploits River and the fishway on the Great Rattling Brook tributary, SFA 4. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P refers to years with incomplete or partial counts.

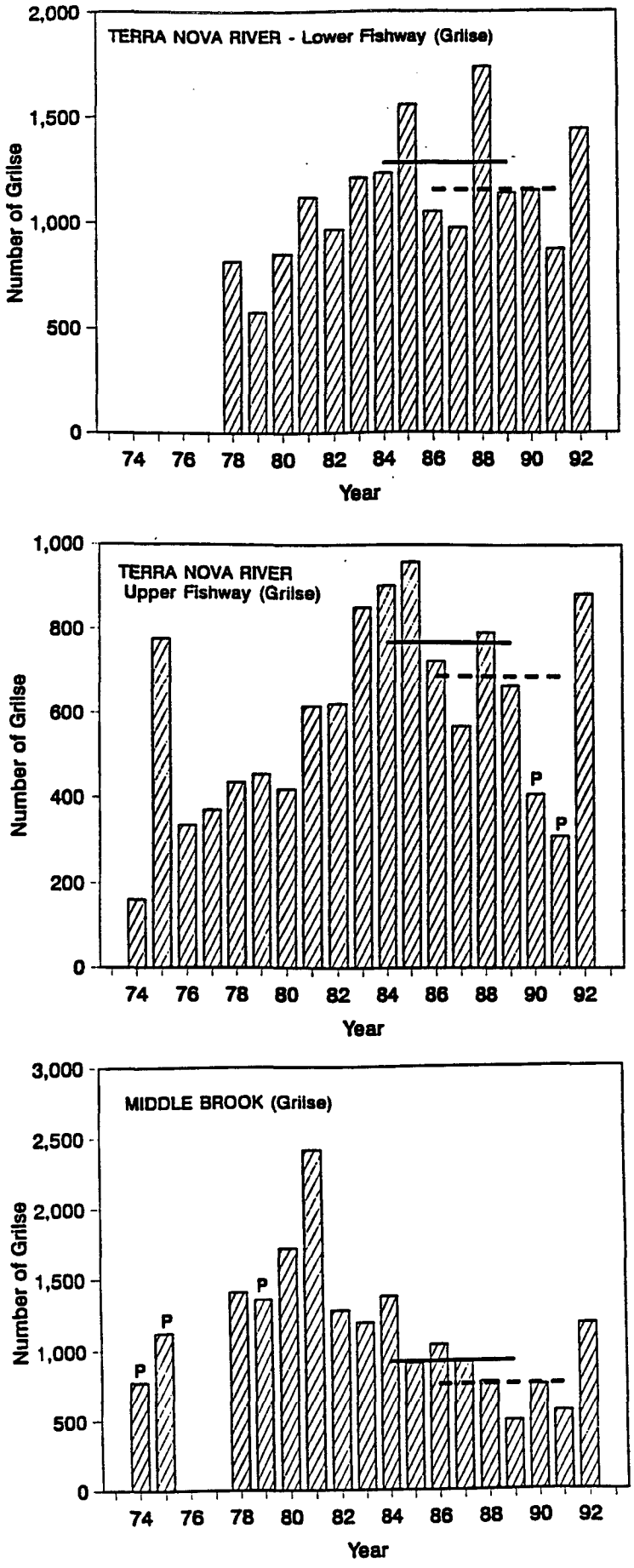


Fig. 3. Counts of grilse at the upper and lower fishways on Terra Nova River and the fishway on Middle Brook, SFA 5. The solid line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

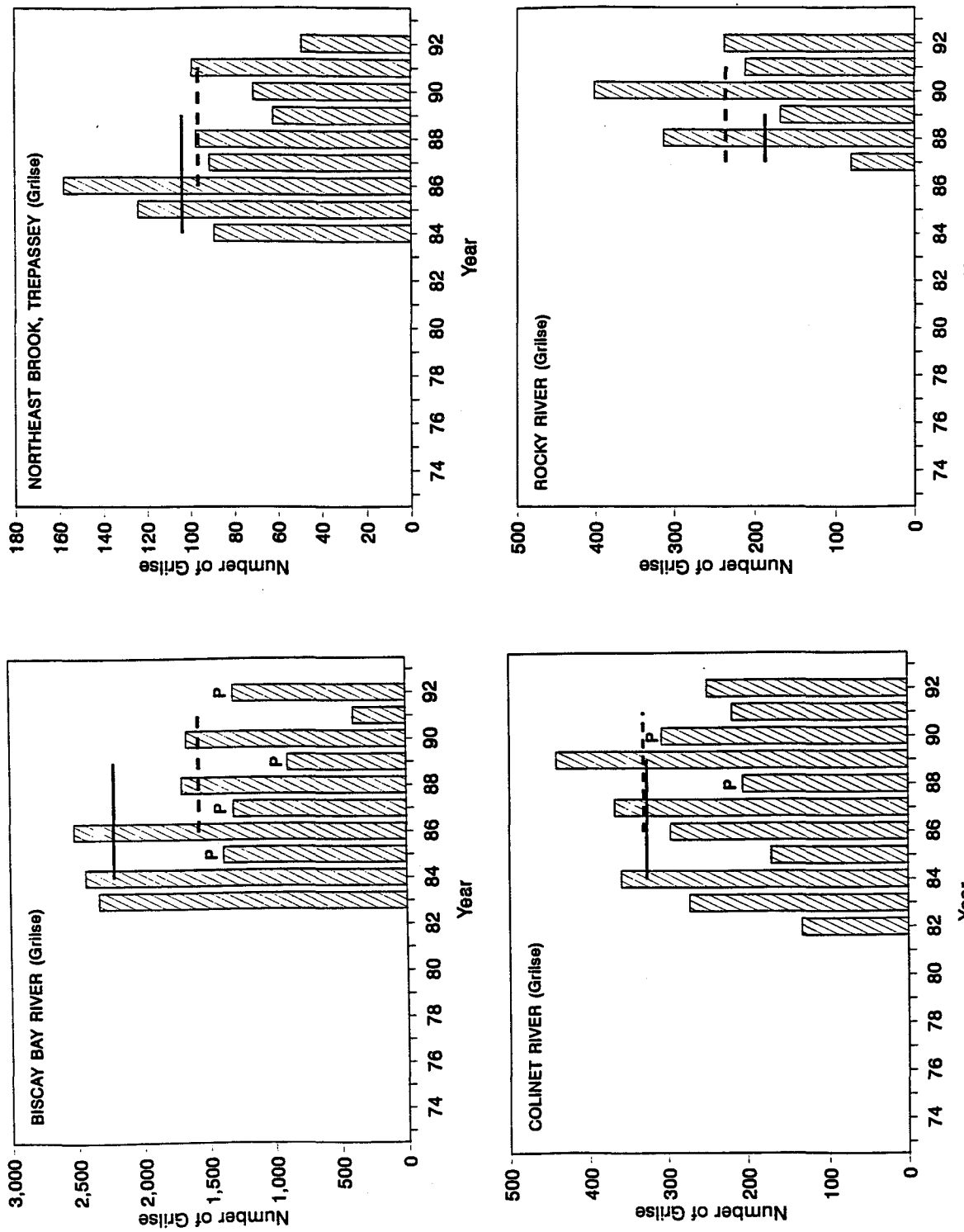


Fig. 4. Counts of grilse at counting fences for Biscay Bay River, Northeast Brook (Trepassey), and Colinet River and the Rocky River fishway, SFA 9. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

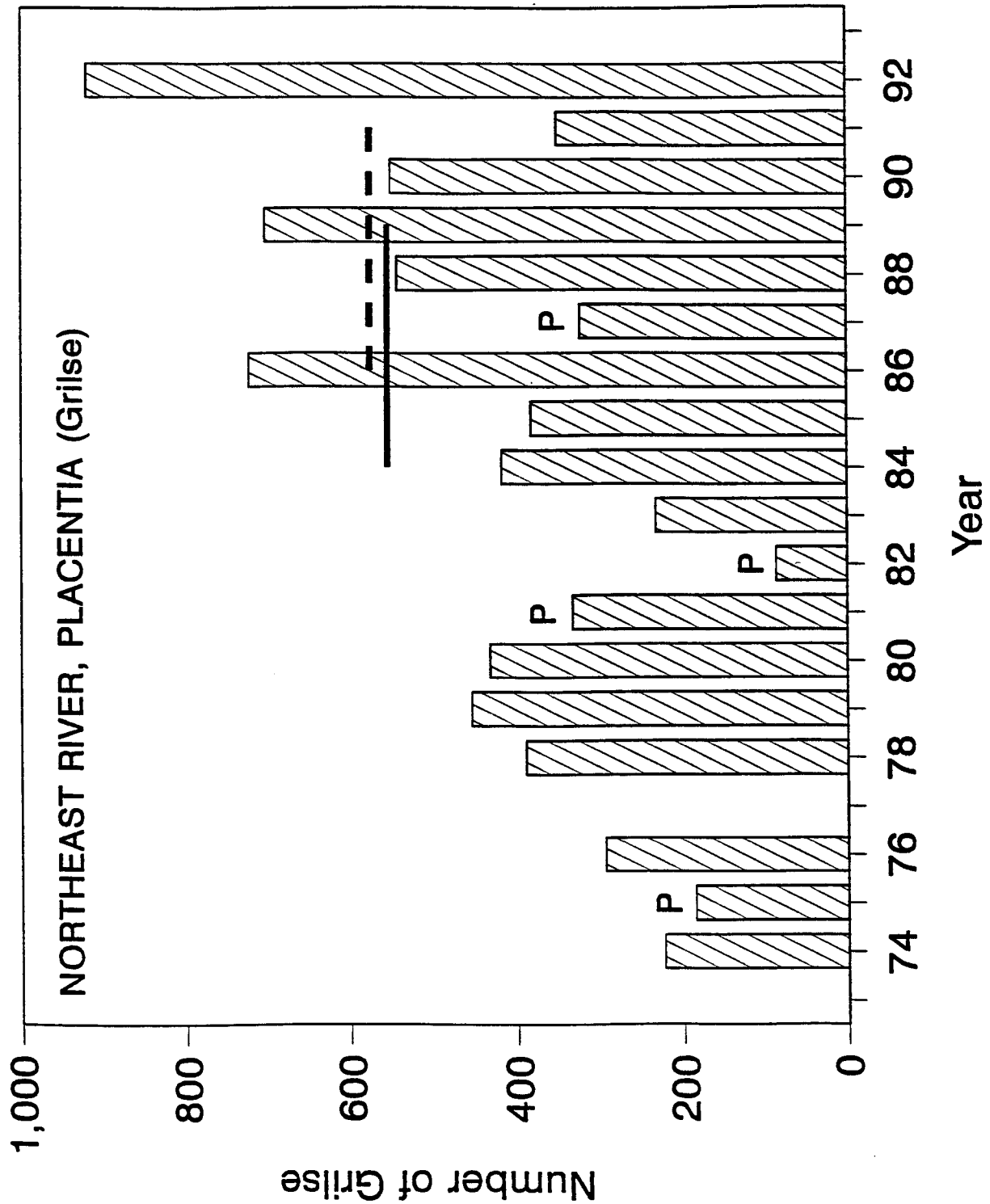
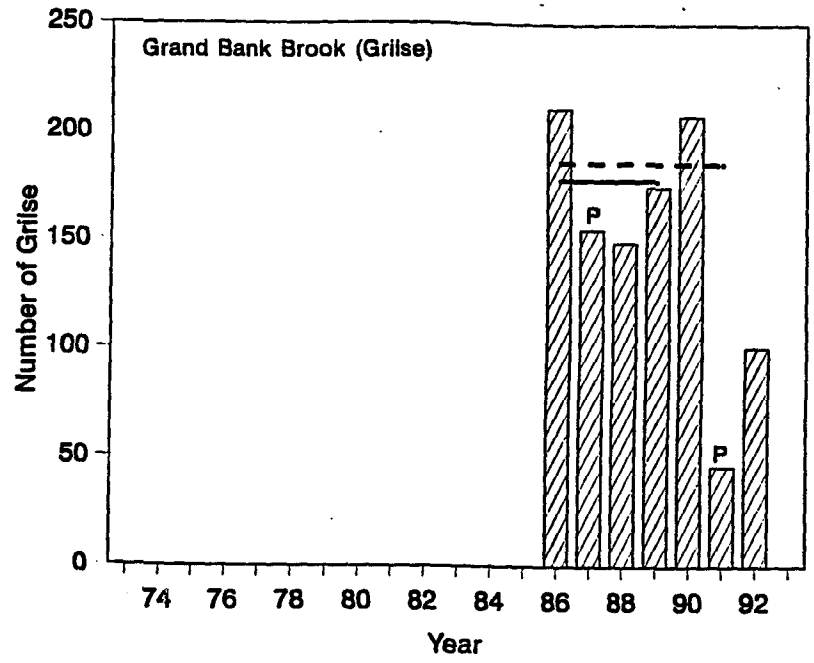


Fig. 5. Counts of grilse at the Northeast River, Placentia fishway, SFA 10. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.



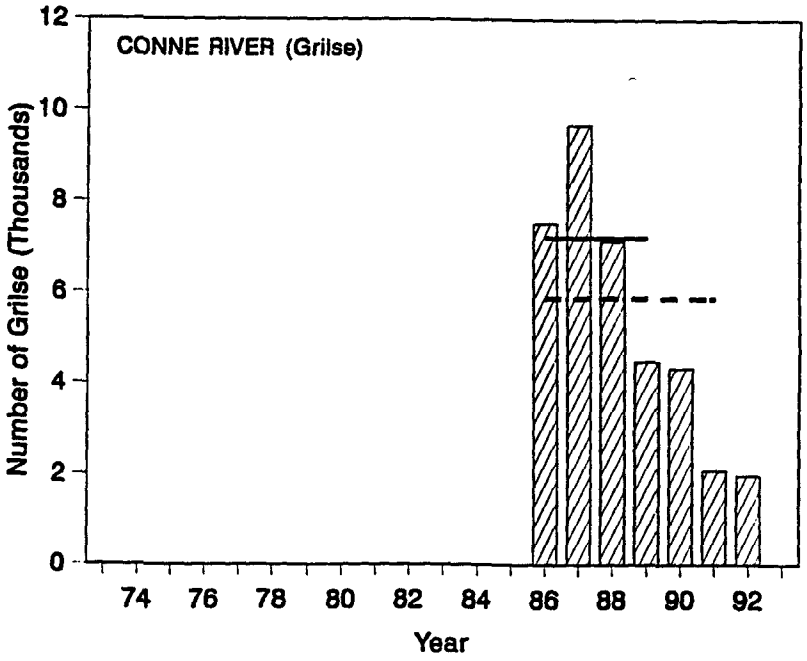


Fig. 6. Counts of grilse at the Grand Bank Brook fishway and the Conne River counting fence, SFA 11. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

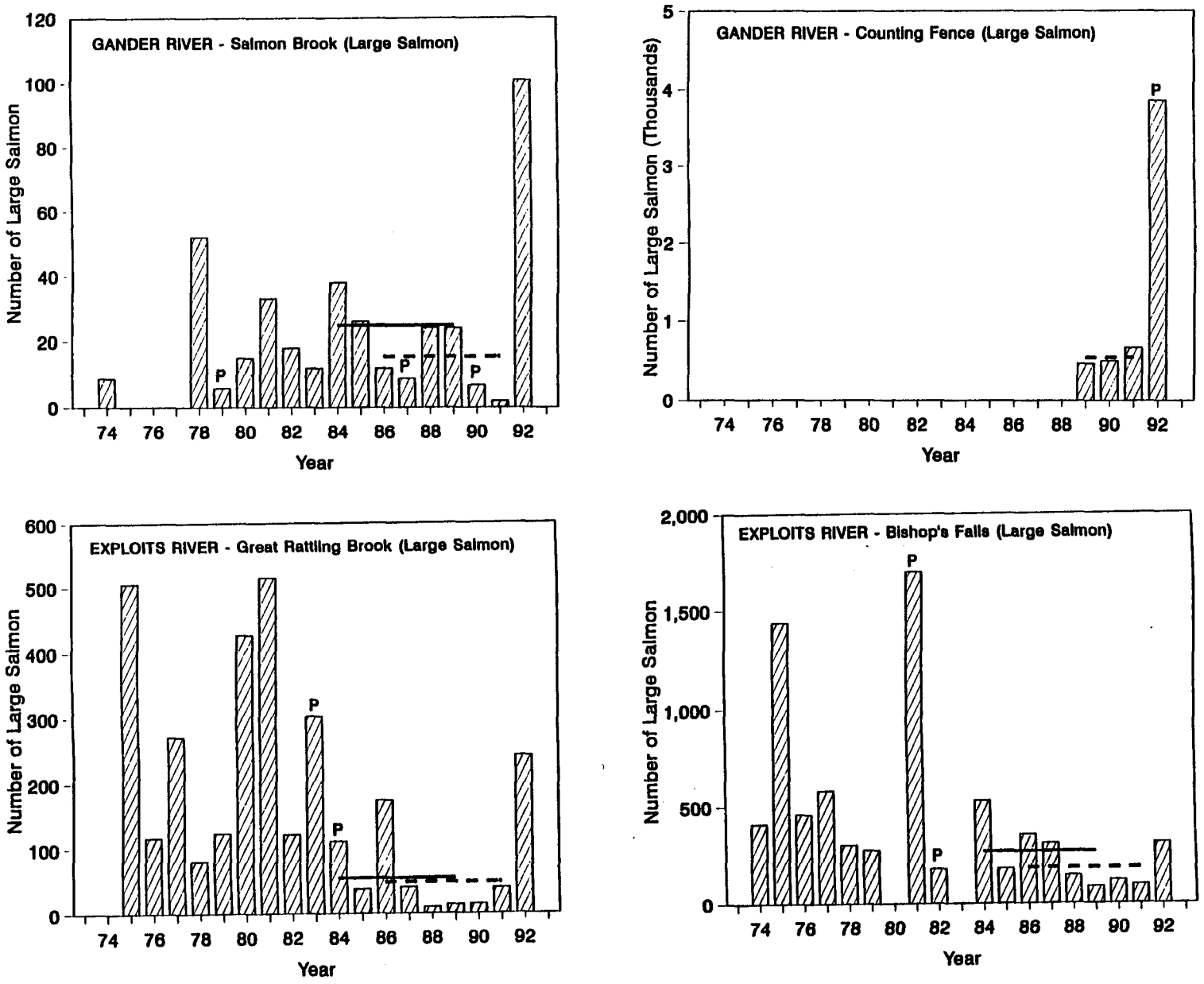


Fig. 7. Counts of large salmon at the Gander River counting fence and at the fishway located on the Salmon Brook tributary, and at the Bishop's Falls fishway on the main stem of the Exploits River and the fishway on the Great Rattling Brook tributary, SFA 4. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

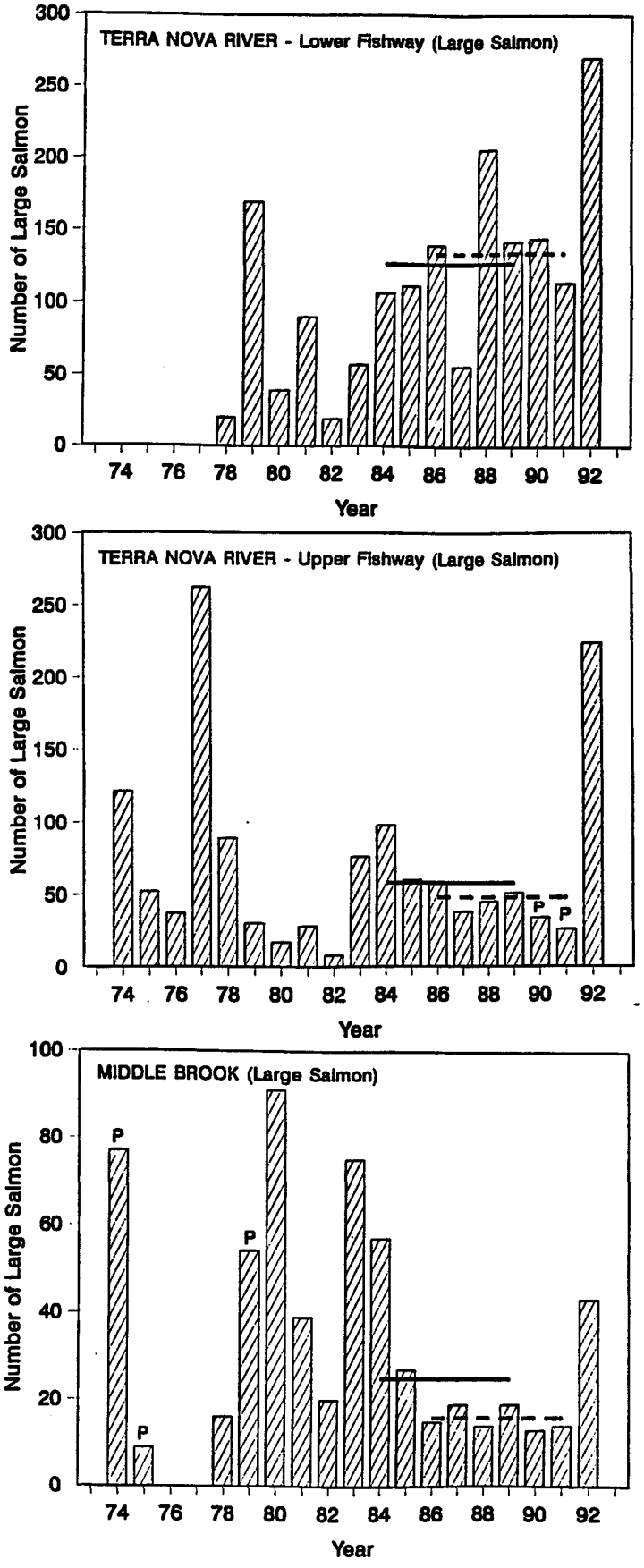


Fig. 8. Counts of large salmon at the upper and lower fishways on Terra Nova River and the fishway on Middle Brook, SFA 5. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

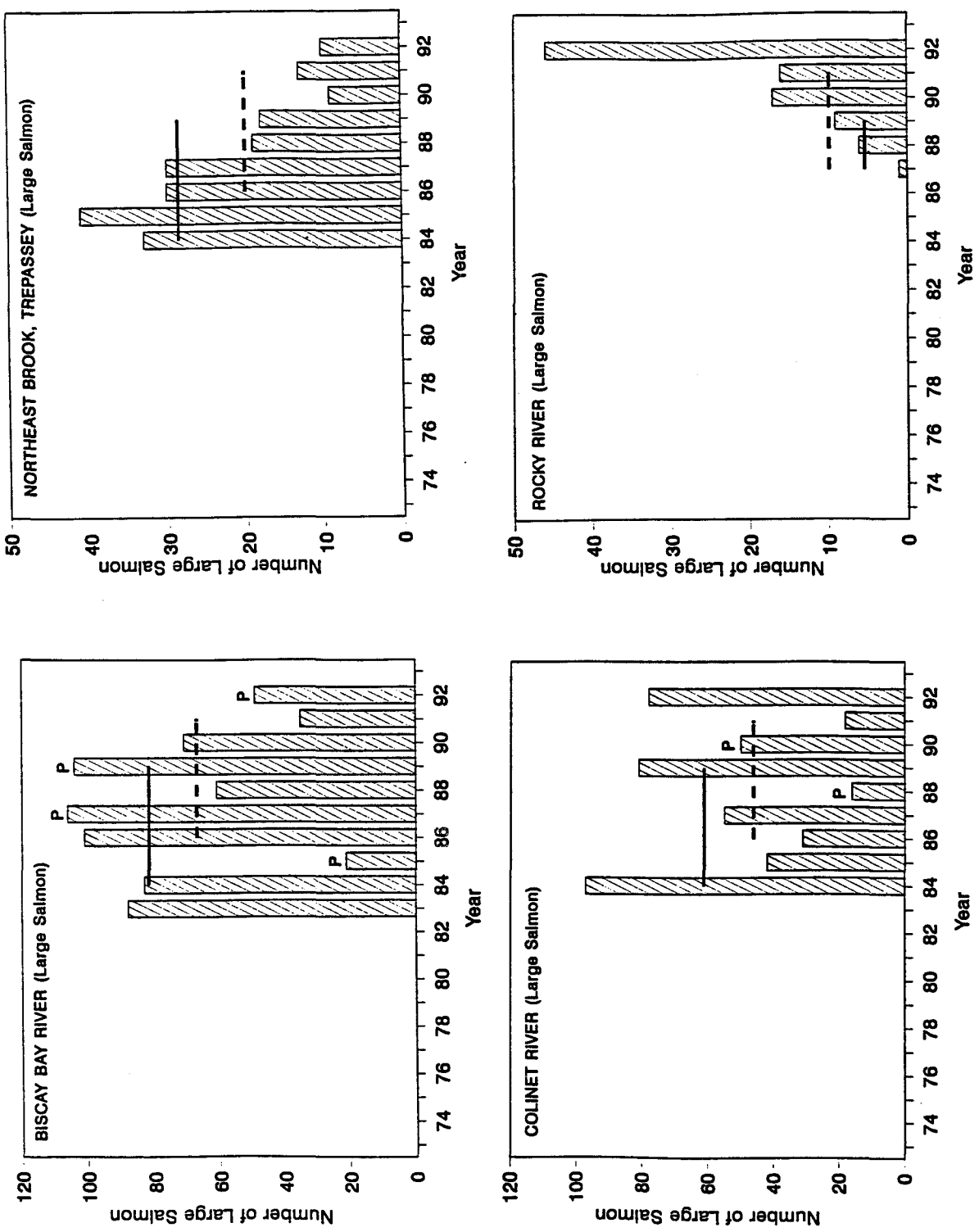


Fig. 9. Counts of large salmon at counting fences for Biscay Bay River, Northeast Brook (Trepassey), and Colinet River and the Rocky River fishway, SFA 9. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

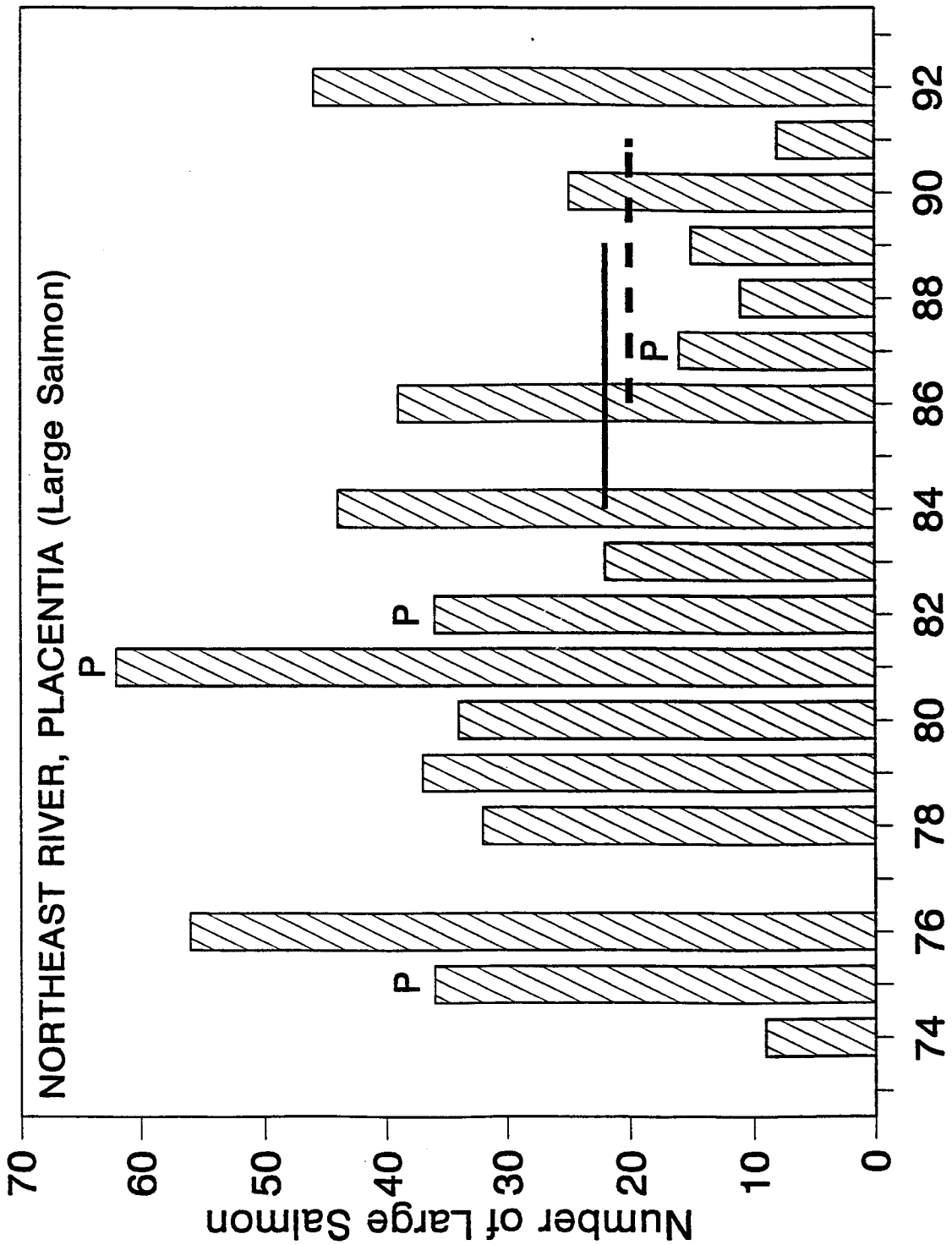


Fig. 10. Counts of large salmon at the Northeast River, Placentia fishway, SFA 10. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

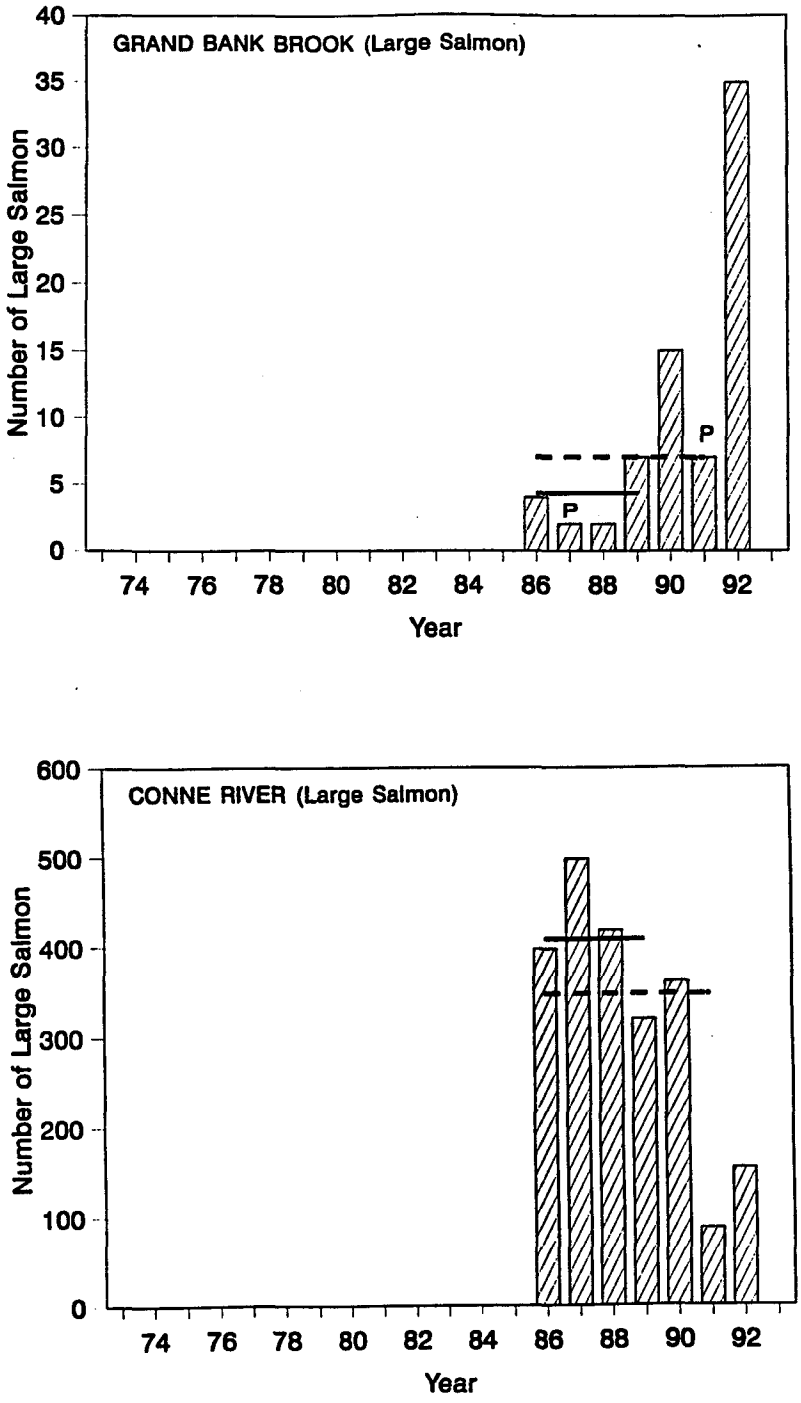


Fig. 11. Counts of large salmon at the Grand Bank Brook fishway and the Conne River counting fence, SFA 11. The solid horizontal line represents the 1984-89 mean and the broken line the 1986-91 mean. P=partial count.

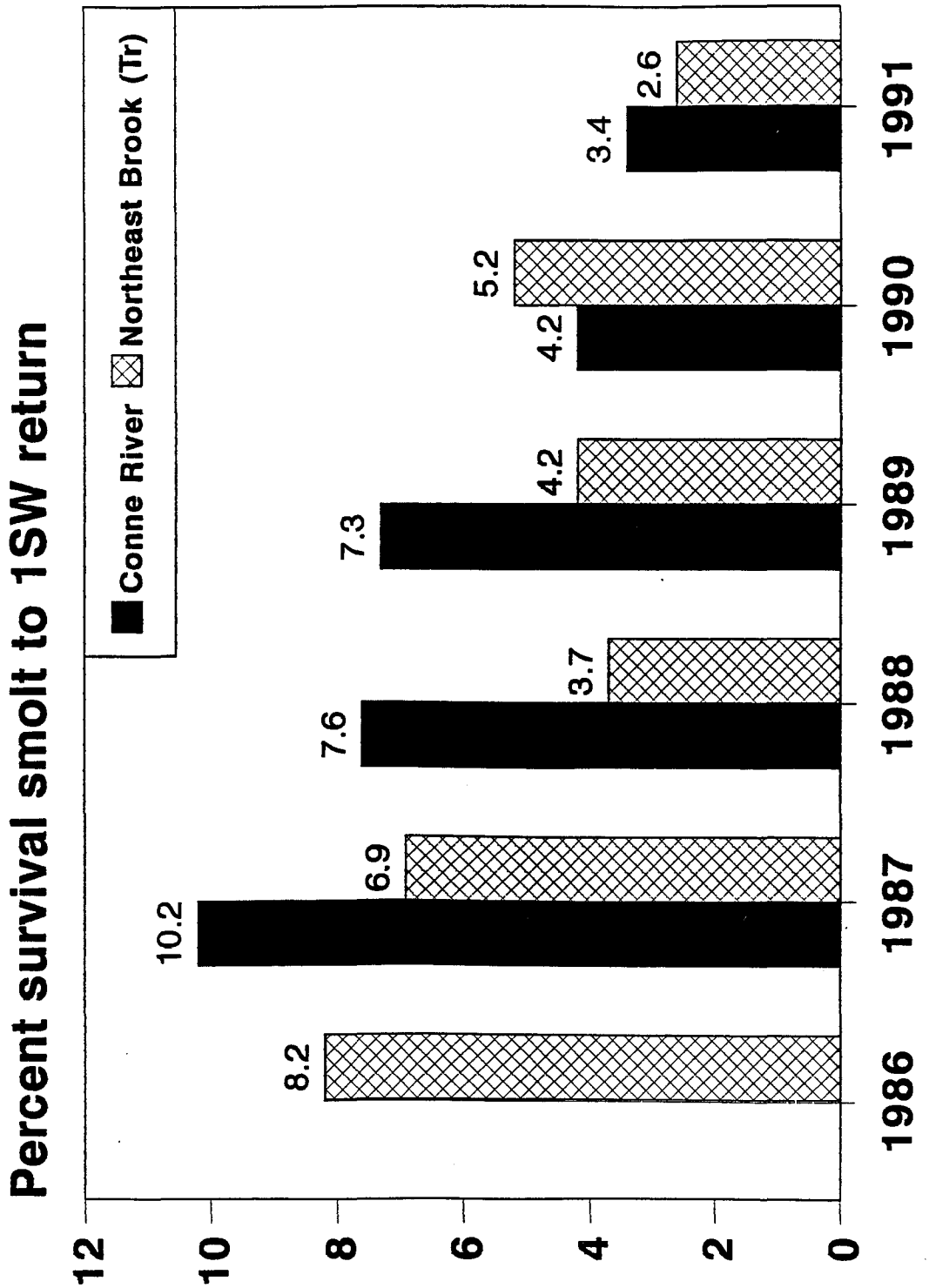
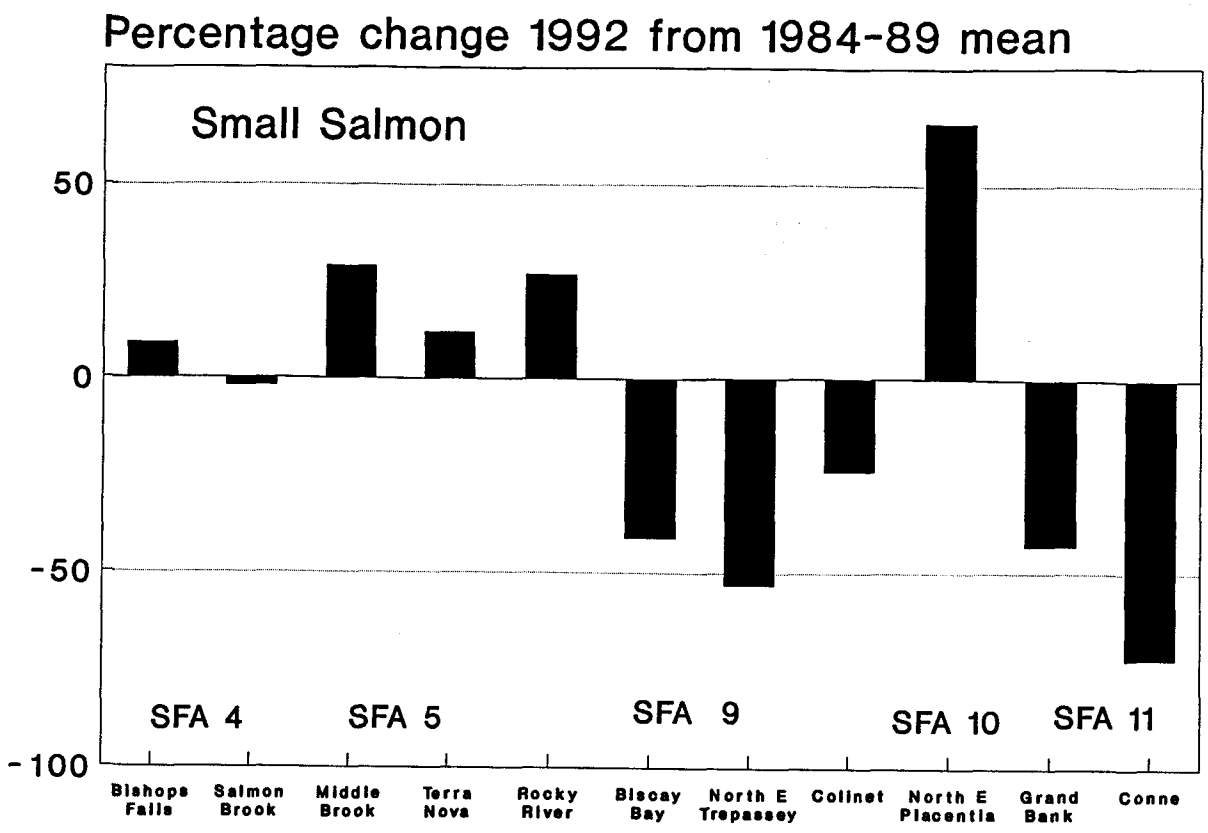


Fig. 12. Smolt to 1SW survival for Northeast Brook, Trepassey (SFA 9) and Conne River (SFA 11), Newfoundland Region.



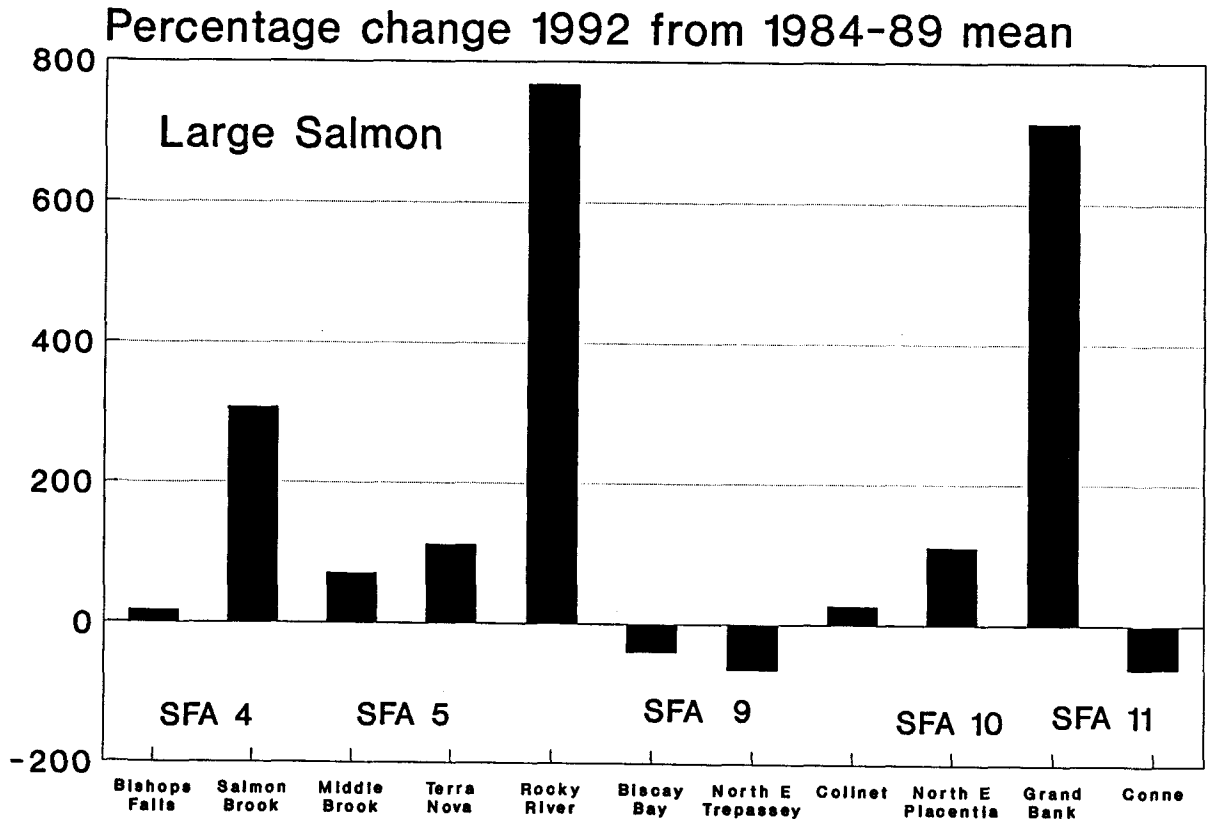


Fig. 13. Counts of small and large salmon from fishways and counting fences in insular Newfoundland indicating 1992 returns as a percentage of the 1984-89 mean.

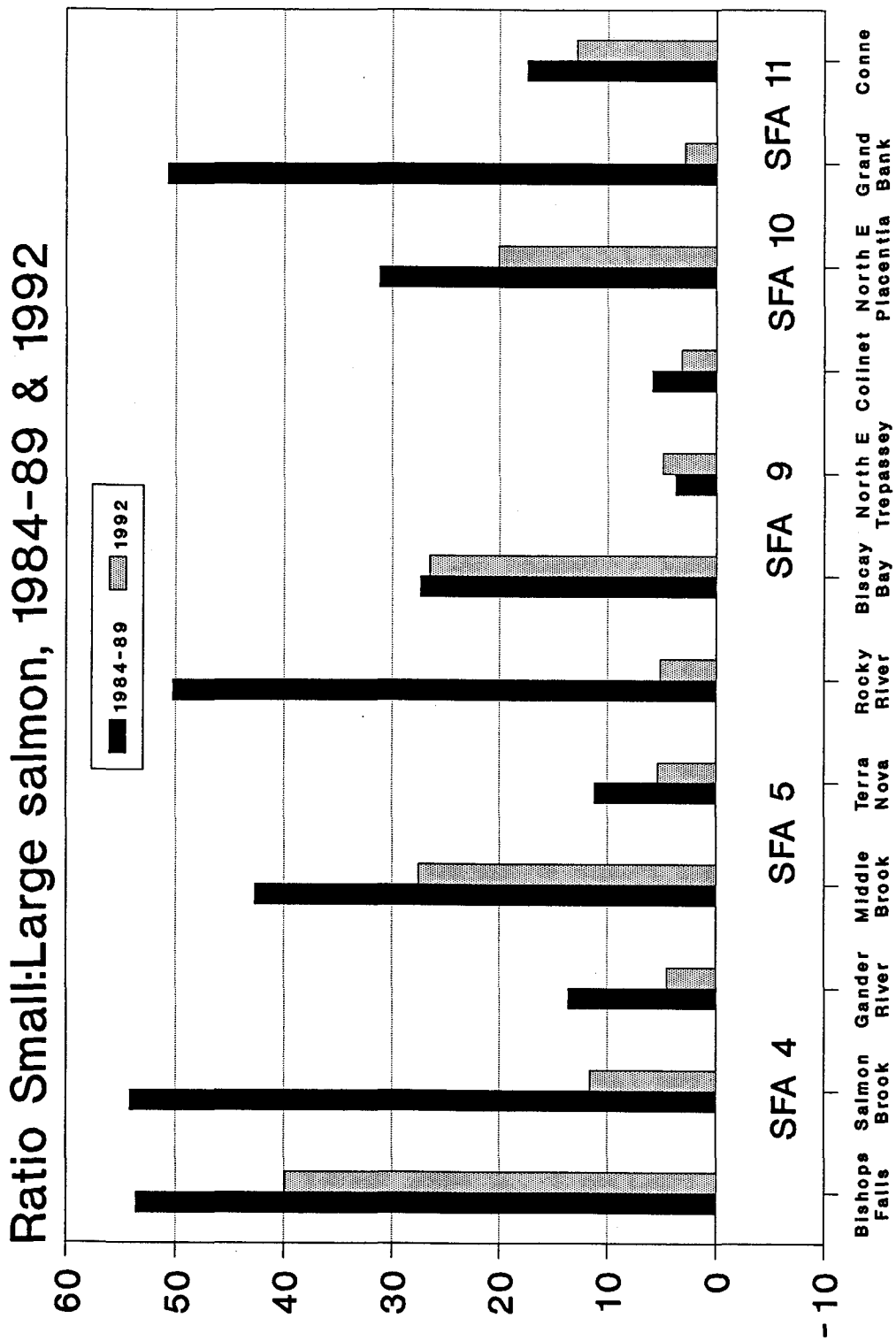


Fig. 14. Comparison of the ratio of small-to-large salmon for 1984-89 and 1992 for various rivers in insular Newfoundland. A lower ratio in 1992 infers a proportional increase in the number of large salmon returning.