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Juvenile Atlantic salmon (Salmo salar L.) abundance in the Experimental Ponds Area relative to adult returns to the Gander River as an index of marine survival: evidence for increased marine mortality in 1997.

by

R. Knoechel[1], P. M. Ryan[2] and M.F. O'Connell[2]

1. Biology Department
Memorial University of Newfoundland
St. John's, Nfld. A1B 3X9

2. Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Nfld. A1C 5X1

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Abstract

A marine survival ratio index was calculated as the number of adult salmon returning to the Gander River divided by the total juvenile salmon populations in the Experimental Ponds Area at the headwaters of the river in the previous spring. This survival index increased more than four-fold in the first four years (1992-95) following closure of the commercial fishery in 1992. The index dropped moderately in 1996 and then precipitously to pre-closure levels in 1997, suggesting that there has been a sudden decrease in marine survival despite the continued closure of the commercial fishery in insular Newfoundland. The observed 1997 Experimental Ponds Area juvenile abundance of 3112 would yield a predicted return of 25,643 small adults if the high survival observed during the early post-moratorium years (1992-95) was achieved but only 4,979 if the poor survival of 1997 was repeated. It is thus unlikely that the Gander River conservation requirement of 21,828 adult spawners will be met in 1998.

Résumé

Un indice du rapport de survie en mer a été calculé en divisant le nombre de saumons adultes revenant à la rivière Gander par le nombre total de juvéniles des populations de saumon de la zone des lacs expérimentaux, en amont de la rivière, au cours du printemps précédent. L'indice de survie a augmenté par un facteur supérieur à quatre au cours des quatre premières années (1992-1995) suivant la fermeture de la pêche commerciale en 1992. L'indice a fléchi de façon modérée en 1996 et, ensuite, de façon accélérée pour se situer aux niveaux d'avant la fermeture en 1997, ce qui porte à croire à une baisse subie de la survie en mer en dépit du maintien de la fermeture de la pêche commerciale à Terre-Neuve. L'abondance observée des juvéniles dans la zone des lacs expérimentaux, de 3 112 en 1997, devrait se traduire par une remontée de 25 643 petits saumons si le taux de survie élevé noté après le moratoire (1992-1995) est atteint, mais par seulement 4 979 si le taux de taux de 1997 est celui qui prévaut. Il est donc peu probable que les besoins de conservation de la rivière Gander, de 21 828 géniteurs, soient atteints en 1998.

Introduction

The number of adult salmon returning to the Gander River should be primarily a function of the number of smolts migrating to sea the previous year and their subsequent mortality rate at sea because the returning adults are largely one-sea-winter fish. A marine survival ratio index has been developed which is calculated as the number of adult salmon returning to the Gander River divided by the total juvenile salmon populations in the Experimental Ponds Area at the headwaters of the river in the previous spring. This survival index increased more than four-fold following closure of the commercial fishery in 1992 and has been used to predict adult salmon returns to the Gander River one year in advance (Ryan et al. 1995, 1996, 1997). The survival index provides a metric for estimating changes in mortality during the difficult-to-monitor marine phase of the life cycle. We herein present data showing that the index dropped moderately in 1996 and then precipitously in 1997, suggesting that there has been a sudden decrease in marine survival despite the continued closure of the commercial fishery in insular Newfoundland.

Methods

Juvenile salmon populations were assessed at the Experimental Ponds Area (EPA) which is located at the headwaters of the Northwest Gander River (Figure 1). Populations were estimated for Spruce Pond and Headwater Pond (Figure 2) using fyke nets and Schnabel multiple-mark-recapture methods as detailed by Ryan (1990). Headwater and Spruce ponds are shallow (mean depth 1.1 and 1.0 m, respectively), dilute (mean conductance 35 uS . cm^{-1}), brown-water lakes whose physical and chemical characteristics have been detailed by Ryan and Wakeham (1984). The history of ecological assessment in the EPA has been reviewed by Ryan et al. (1994) and reviews of the salmon population dynamics are available in Ryan (1993) and references therein.

An adult counting fence has been operated on the main stem of the Gander River since 1989. Total adult small salmon returns to the Gander River system have been calculated as the sum of the number passing through the fence and the number angled downstream of the fence (O'Connell and Ash 1994) except for this year (1997) when the angled catch was not monitored. We have used adult return counts for the post commercial fishery period of 1992-1997 as updated by O'Connell et al. (1998).

Results and Discussion

The spring 1997 salmon population abundance in both Spruce and Headwater ponds combined was only 3112 which is less than half that observed in 1996 (Table 1) and a sharp reversal of the steadily increasing trend observed from 1994 through 1996 (Figure 3). The juvenile abundance was less than expected based on the past relationship (Ryan et al. 1997) between EPA juvenile abundance and Salmon Brook adult counts four years previous (Figure 4). The 1997 data point lies below the regression line, in strong contrast to 1995 and 1996 which were extreme outliers on the high side. This suggests that freshwater egg to pre-smolt survival rates have suddenly declined to less than the long-term average.

The good correlation between small adult returns to the Gander River as a whole and that observed at the Salmon Brook fishway was maintained in 1997 (Figure 5). The regression relation developed last year (Ryan et al. 1997) yields a predicted river return of 9,929 from the fence count of 465. The actual river return was 10,474 which is only 5.5% higher than predicted.

The total Gander River return of small adults was much lower than expected given the record high juvenile abundance recorded in 1996 (Figure 6). A marine survival ratio index, calculated as the ratio of total Gander River small salmon returns to EPA juveniles the previous year, indicated a major improvement in survival following the commercial fishing moratorium (Table 2). The mean survival ratio index during the first four post-moratorium years was 8.24 as compared to 1.71 in the two pre-moratorium years. The ratio dropped to 5.27 in 1996, suggesting increased marine mortality (Ryan et al. 1997) and declined even further to 1.60 in 1997, a level consistent with that observed prior to closure of the commercial fishery (Figure 7). An analysis of juvenile length-specific weight as a measure of relative condition indicated that the 1996 EPA juveniles were close to the long-term average. Thus there is no reason to suspect higher-than-average mortality during the freshwater portion of the smolt migration and the unexpectedly low adult returns in 1997 most probably result from unknown sources of mortality in the marine environment.

It is difficult to predict an expected adult return for 1998 given the recent variability in the survival ratio index (Figure 7). The observed 1997 EPA juvenile abundance of 3112 would yield a predicted return of 25,643 small adults if the high survival observed during the early post-moratorium years (1992-95) was achieved but only 4,979 if the poor survival observed in 1997 is repeated. It is thus unlikely that the Gander River conservation requirement of 21,828 adult spawners will be met in 1998. Continued monitoring of EPA juvenile abundance and Gander River adult returns will allow future variation in marine survival to be estimated.

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A large number of Fisheries and Oceans staff and Memorial University students have assisted with data collections in the Experimental Ponds Area over the years. We especially appreciate the past assistance of C. E. Campbell, K. D. Clarke, L. J. Cole, D. P. Riche, and D. Wakeham. Graduate and undergraduate students of Memorial University continue to assist with data collection.

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Table 1. Spring Atlantic salmon juvenile population sizes in the EPA, Salmon Brook fishway small salmon (<63 cm) counts, and Gander River small salmon returns to 1997.

Year of Census	Spruce and Headwater ponds total Atlantic salmon juveniles (no.)	Salmon Brook fishway count (no.)(yr N)* (partial count- '79, adjusted count- '90)	Gander River total small salmon returns (yr N)*
1978		755	
1979	4822	404	
1980	3463	997	
1981	2393	2459	
1982	3077	1425	
1983	1603	978	
1984	3226	1081	
1985	3175	1663	
1986	4474	1064	
1987	3199	493	
1988		1562	
1989	4925	596	7743
1990	3642	345	7740
1991	2362	245	6745
1992	3069	1168	18179
1993	2470	1560	26205
1994	2370	963	18080
1995	4492	1600	22264
1996	6558	946	23665
1997	3112	465	10474

* From O'Connell, Reddin, and Ash: DFO Atlantic Fisheries Research Document 98/ (in preparation).

Table 2. Ratios of Gander River small salmon returns to EPA juveniles in the previous year with survival ratio indices before and after the closure of the commercial fishery in 1992.

Year of Census	Spruce and Headwater ponds total Atlantic salmon juveniles (yr N)	Gander River total small salmon returns (yr N+1)	Survival ratio index (adults/juveniles)
1989	4925	7740	1.57
1990	3642	6745	1.85
1991	2362	18179	7.70
1992	3069	26205	8.54
1993	2470	18080	7.32
1994	2370	22264	9.39
1995	4492	23665	5.27
1996	6558	10474	1.60
		Mean ratio	5.40
		Mean pre-closure ratio (S. E.)	1.71 (0.198)
		Mean post-closure ratio (S. E.) (exclusiveof '96)	7.64 (1.549)

Figure 1. Gander River basin of insular Newfoundland with locations of study sites referred to in the text.

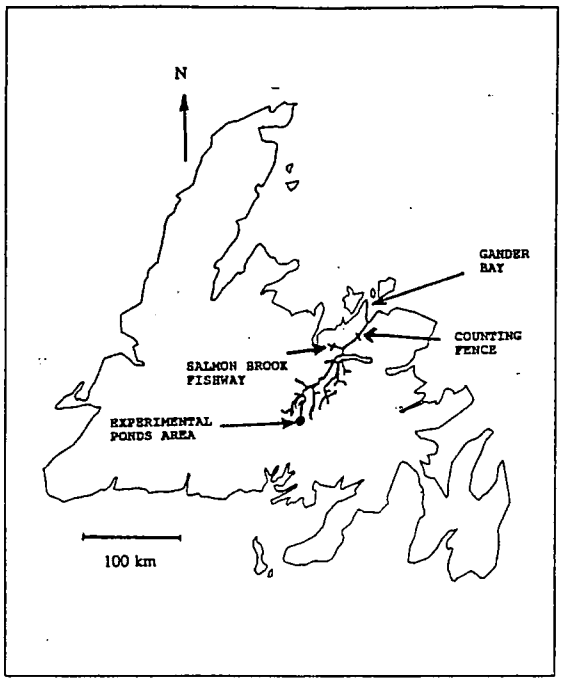
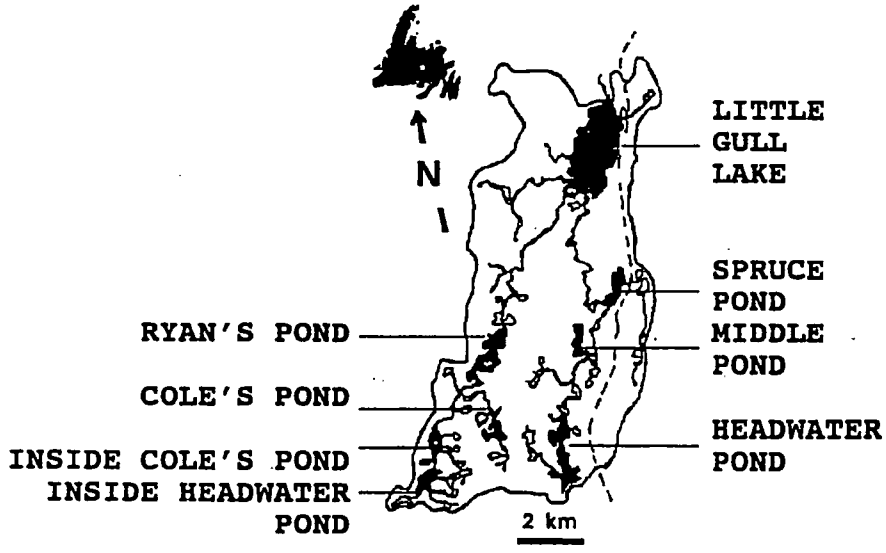


Figure 2. Watershed of the Experimental Ponds Area at the headwaters of the Northwest Gander River, central Newfoundland (inset). The dashed line through the east side of the watershed represents the Bay D' Espoir highway.



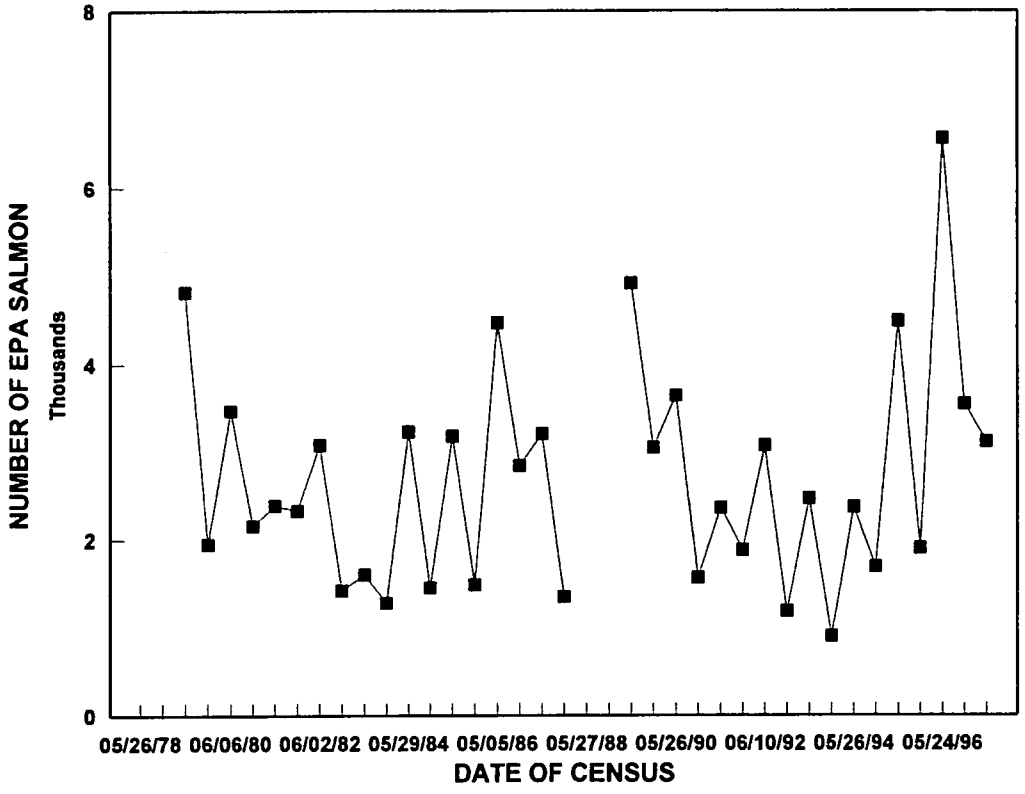


Figure 3. Schnable population estimates of Experimental Ponds Area juvenile salmon (Headwater and Spruce ponds combined) from 1979 through 1997.

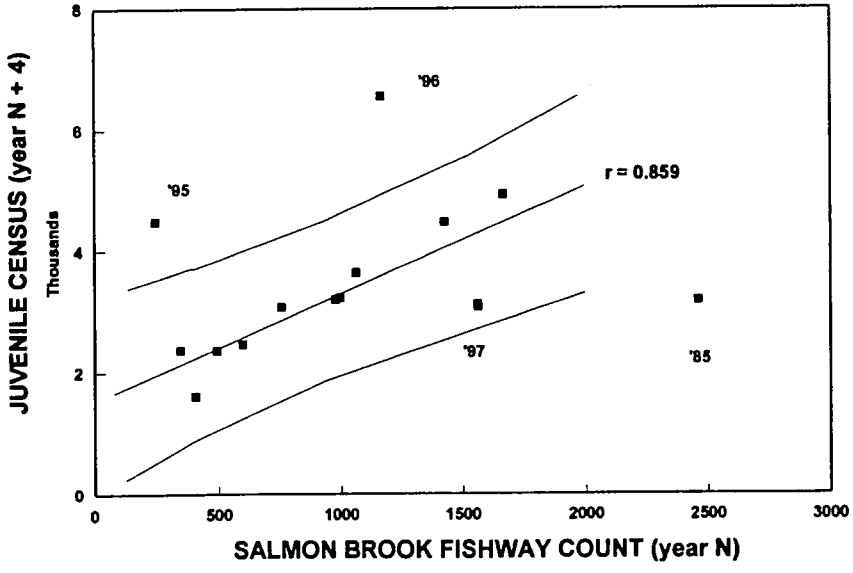


Figure 4. Stock-recruit relationship based upon counts of small adult salmon (< 63 cm.) at the Salmon Brook fishway and the spring census of juveniles in the Experimental Ponds Area. The regression line and 95% confidence limits exclude the outlier year of 1985 and the 1995-97 data.

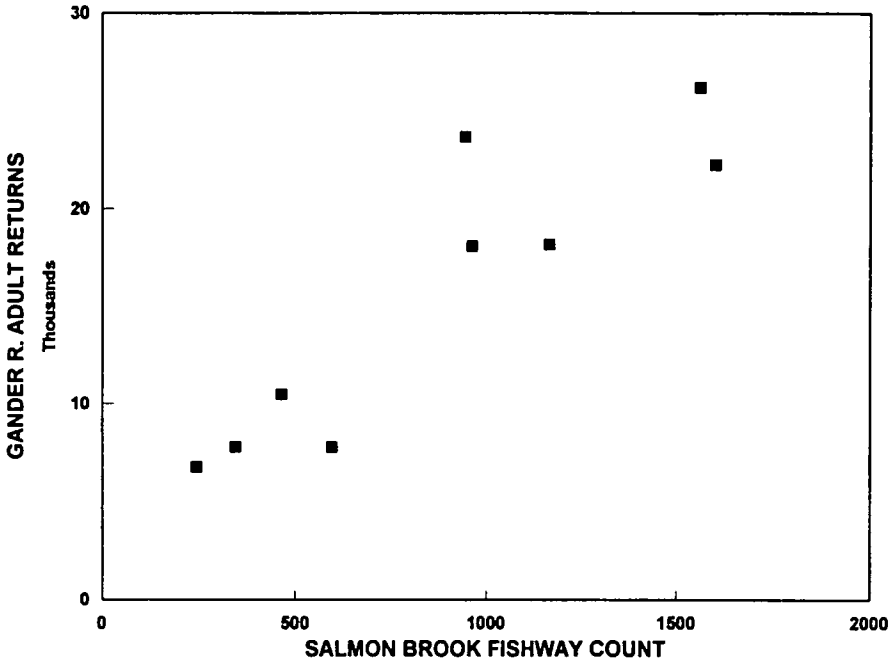


Figure 5. Relationship between total small adult salmon returns to the Gander River and counts of small salmon at the Salmon Brook fishway.

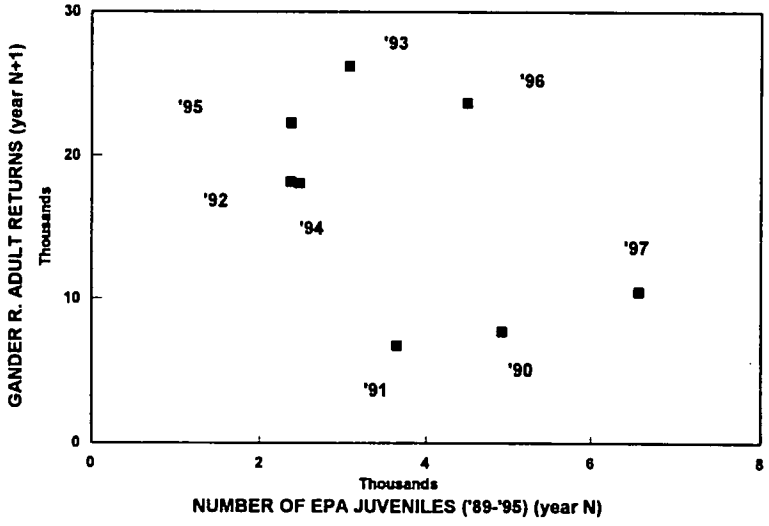


Figure 6. Relationship between total small adult salmon returns to the Gander River in one year and the spring census of Experimental Ponds Area juvenile salmon in the preceding year. Points are labelled according to the adult return year. Values for 1990 and 1991 represent pre-moratorium conditions.

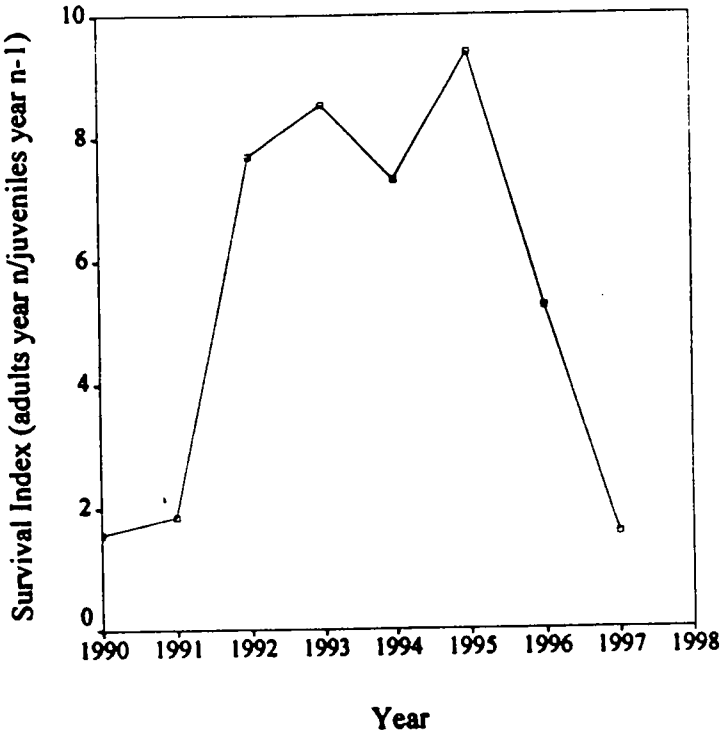


Figure 7. Time series plot of the survival ratio index showing the consistently high level during the first four post-closure years (1992-1995) followed by declining survival in 1996 and 1997.