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A Stock-Recruitment Relationship for Atlantic Salmon in Western Arm Brook

by

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ABSTRACT

Recruitment of smolt on Western Arm Brook was calculated from a significant ($p < 0.05$) relationship between egg deposition and an index of winter temperature. The index of winter temperature was the sum of mean temperatures for December, January, February and March for St. Anthony. Egg deposition was estimated from adult escapements 1971-1978. Number of smolts per year-class was calculated from aged samples of 1971-80 smolt migrations. It appears that the very cold winters in 1972 and 1973 had a negative affect on egg survival.

RESUME

Une relation significative ($p < 0,05$) entre le recrutement, l'ampleur de la ponte et un indice de la température hivernale a été utilisée pour calculer le recrutement des smolts du ruisseau Western Arm. L'indice de température est la somme des températures moyennes de décembre, janvier, février et mars à St. Anthony. L'ampleur de la ponte a été estimée à partir du nombre de saumons qui avaient échappé à la capture de 1971 à 1978. Des échantillons de smolts en voie de migration entre 1971 à 1978. Des échantillons de smolts en voie de migration entre 1971 et 1980 et dont l'âge était connu ont servi au calcul du nombre de smolts par classe d'âge. Il semble que les hivers exceptionnellement froids de 1972 et 1973 aient eu un effet négatif sur la survie des oeufs.

INTRODUCTION

Recruitment of smolt on Western Arm Brook (WAB) was calculated from two variables, egg deposition and an index of winter temperature. The relationship between winter temperature and egg survival was previously suggested in another paper (Chadwick 1980).

METHODS

Egg deposition was calculated from the 1971 to 1978 adult migrations. Sex ratios were determined in each year, except in 1977 where the mean value of 75% female was used. Fecundity (F) was estimated for fork length (L) using $\mathrm{Log}_{10} F = 2.3345 \mathrm{Log}_{10} L - 0.582$ (Pope et al. 1961). The estimated number of eggs in each year of spawning is given in Table 1.

The index of winter temperature was the sum of mean temperatures for December, January, February and March for St. Anthony (Anon. 1971-78). Temperature at this location was assumed to be comparable to WAB, although it is 90 km northwest of the river mouth.

Smolt year-class strengths were regressed on egg deposition and the index of winter temperature. Year-classes were calculated from aged samples in 1971 to 1980 smolt migrations (Chadwick, in prep.). A year-class was assumed to hatch from eggs deposited in the previous year. Winter temperature was assumed to affect egg survival. Estimates of the numbers in the 1977 and 1978 year-classes were made from the regression.

A year-class migrates from WAB over three years, as 3+, 4+ and 5+ smolt. The proportion at each age determines the mean smolt age of a year-class. The latter is significantly ($p < 0.01$) correlated to the mean annual temperature in St. Anthony (Chadwick, in prep.). Thus, in cold years the smolt age is low. There is also a significant relationship ($p < 0.05$) between temperature and the percentage of 3+ smolt in a year-class (op. cit.). These relationships were used to predict the mean age of the 1977 and 1978 year-classes so that the magnitude of the 1981 smolt migration could be estimated. The 1980 count of 3+ smolt (1977 year-class) was compared to the predicted value.

RESULTS AND DISCUSSION

The relationship of smolt year-class strength to egg deposition and winter temperature was significant ($p < 0.05$). The 1977 and 1978 year-classes were predicted to be 21,630 and 28,595 smolt respectively (Table 2). There was also a significant ($p < 0.05$) relationship between winter temperature and smolt year-class strength. Winter temperature accounted for much of the annual variation in year-class strength. However, the egg deposition variable improved this relationship. It appeared that the very cold winters in 1972 and 1973 had a negative affect on egg survival. This could be the result of freezing and drying of redds. There is no plausible reason why egg survival should be greater during warm winters. Consequently the predicted 1977 and 1978 year-classes could be over estimates.

The mean smolt age of the 1977 and 1978 year-classes was estimated to be 4.0 and 3.9 years respectively, of which 29% and 30% were 3+ smolt (Table 3). The estimated number of 3+ smolt for the 1977 year-class was 6,272 fish (21,630 x 0.29) which was very close to the actual count in 1980 of 6,264 smolt. The estimated 3+ smolt for the 1978 year-class was 8,579 fish (28,595 x 0.30). Assuming that 5+ smolt were approximately 8% of the migration, 971 fish would migrate in 1981 and 1730 fish in 1982. The number of 4+ smolt in 1981 would be 13,636 fish (21,630-(6,264 + 1730)). The magnitude of the 1981 smolt migration would be 23,186 fish (8,579 + 13,636 + 971) (Table 4). These results indicate that smolt production can be predicted with reasonable accuracy, at least in this system, up to three years in advance. This allows for better lead time in management of the commercial fisheries.

REFERENCES

Anonymous. 1971-78. Monthly record meteorological observations in Eastern Canada.

Chadwick, E.M.P. 1980. Atlantic salmon kelt (*Salmo salar* L.) as an index of spawners. ICES C.M. 1980/M:29, 9 p.

Pope, J. A., D. H. Mills and W. M. Shearer. 1961. The fecundity of Atlantic salmon (*Salmo salar* L.). Freshw. Salm. Fish. Res. 26: 1-12.

Table 1. Egg deposition on WAB. Fecundity (F) was estimated from fork length (L) using, $Log_{10}F = 2.3345\ Log_{10}L-0.582$ (Pope et al. 1961).

Year of spawning	Number adults	Sample: Mean fork length (cm)	Sample: Percent female	Sample: Number sampled	Number of eggs x 10^{-3}
1971	732	52.8	72	80	1,450
1972	214	52.4	81	63	468
1973	380	53.2	78	144	830
1974	319	53.4	84	84	757
1975	394	53.5	56	18	626
1976	420	53.2	73	11	858
1977	351	53.5	75*	61	747
1978	286	52.4	82	61	634

* Value estimated from mean of all years.

Table 2. Prediction of smolt year-class strength (Z) from egg deposition (X) and an index of winter temperature (Y) using stepwise multiple regression.

Year-class	X Number of eggs x 10^{-3}	Y Index of winter temp. (°C)	Z Number of smolt*
1972	1,450	-46.5	8,178
1973	468	-46.3	5,966
1974	830	-40.1	13,234
1975	757	-39.5	12,378
1976	626	-39.4	12,153
1977	858	-29.9	(21,630)
1978	747	-21.8	(28,595)

$r_{ZX} = -0.058$ $Z = 46163 + 2.63X + 895.98Y$

$r_{ZY} = 0.943$ $r = 0.988$ $df = 2$ $p<0.05$

$r_{XY} = -0.352$ $r_{ZX.Y} = 0.879$

* Values in parentheses were estimated from above equation.

Table 3. Prediction of smolt age and percent 3+ smolt of WAB, year-class from mean annual temperature at St. Anthony.

		X	Y	
			1	2
Year-class	Number smolt	Mean annual temp. °C	Mean age	Percent 3+ smolt*
1968	11169	1.5	4.0	9
1969	11035	2.9	4.2	13
1970	9224	1.6	3.9	14
1971	8026	1.5	3.9	17
1972	8178	-1.6	3.6	42
1973	5966	0.9	4.0	16
1974	13234	-0.4	3.7	40
1975	12378	0.5	3.7	39
1976	12143	0.4	3.9	19
1977	-	1.6	(4.0)	(29)
1978	-	1.2	(3.9)	(30)
1 $r = 0.90$	$df = 7$	$y = 3.77 + 0.13\ X$		
2 $r = 0.82$	$df = 7$	$y = 29.96 - 0.31\ X$		

* Values in parentheses were estimated from the above equations.

Table 4. Calculation of the 1981 smolt migration on WAB.

Year	Smolt age*			Total smolt migration
	3	4	5	
1979	2256	6580	564	9400
1980	6264	8926	469	15659
1981	(8579)	(13636)	(971)	(23186)
1982	-	-	(1730)	1976 year-class = 12,153 smolt
				1977 year-class = 21,630 smolt

* Values in parentheses were estimated.