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The derivation by analysis of covariance of indeces of total migrant population size from angling catch returns from the River Wye.

by

A. S. Champion

Introduction

Since 1950 the returns of salmon caught by rods on the River Wye have been published in the Annual report of the Authority in the form of a table showing the monthly catch split into classes of under 7 lbs, 7-10 lbs and thence up to 40 lbs by steps of 5 lbs. It has therefore been possible to approximate the grilse, 2 sea winter and 3 sea winter age classes by three weight classes as follows:-

Grilse	=	Salmon under 7 lbs caught after June 1st
2 Sea Winter	=	Salmon under 15 lbs before June 1st Salmon between 7 lbs 15 lbs after June 1st
3 Sea Winter	=	Salmon between 15 and 25 lbs

A preliminary examination of the catch returns so divided showed a very high degree of variability and a generally upward trend in the catches of grilse and 2 sea winter fish. After removal of the trend it was apparent that the high variability was related to monthly mean water level at Hereford and could therefore be removed and indeces of total migrant population size derived with a suitable mathematical model.

Since during the period under consideration the number of licenses issued by the authority also increased it was necessary to include some measure of fishing effort in the calculations and for want of a true measure of effort it was decided to use the number of licence weeks issued in the calculation of monthly catch/unit effort for each age class.

Mathematical Model

It was assumed that the relationship between catch/unit effort and water level could be expressed in the following form:-

$$C_{ij} \propto P_j \, S_i \, L_{ij}^{\beta}(1+\varepsilon_{ij})$$

where C_{ij} is the catch/unit effort in month i of year j

M_i is a seasonal factor due to the monthly variation in estuarine availability of an age class

P_j is an index of total migrant population in year j

L_{ij} is the water level in month i of year j

ε_{ij} is a random error term

β is a constant

thus the catch of a particular age class under constant effort is a proportion of the total migrant population of that age class available during a particular month and this proportion varies according to the water level in that month.

Taking logarithms gives rise to a simple regression equation soluble by the method of least squares of the form.

$$\text{Log}\,(C_{ij}) = \mu + a_{ij} + b_j + \beta\,\text{Log}\,L_{ij} + \varepsilon_{ij}$$

where the Ai and the bj are logarithms of the monthly and annual population indeces respectively.

Resolutes

(a) "Grilse"

The model accounted for 88% of the total sum of squares of the catch unit effort but a significant test of the water level regression coefficient showed that it differed from zero at the 90% level but not at the 95%. The monthly constants differed widely at a high significance level; but the differences in the annual constants were not as clear cut.

(b) "2 Sea Winter" Salmon

The model accounted for 90% of the total sum of squares of the catch/unit effort and a significance test on the water level regression coefficient showed that it differed from zero at the 99% level. The significance levels of the monthly and annual constants were similar to those calculated for the grilse.

Antilogs have been taken of the annual constants which have then been shown in Figure 1 as percentages of their mean with confidence limits of one standard error. The monthly constants are similarly shown in Figure 2. The importance of the water level is demonstrated in Table 1 where for the mean annual population strength estimates of the catches of each age class have been calculated for the minimum, mean and maximum water levels encountered during the 21 year period, assuming an effort of 50,000 licence weeks (the approximate present day level)

Table I. The effect of water level on monthly salmon catch returns.

Age Class	Regression coefficient of Logarithm of Water Level	Month	Logarithm of Monthly Constant	Water Level (inches)			Estimated Catch		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Grilse	0.1537	July	-.427	3	14	34	48	60	69
		August	.026	4	19	51	78	99	115
		September	.411	1	25	66	93	153	177
2 Sea Winter Salmon	.3322	Feb.	-2.360	7	44	84	8	14	18
		March	- .387	10	31	60	76	111	138
		April	,53	10	27	49	190	264	321
		May	1.698	7	23	45	320	476	595
		June	.974	5	17	46	236	355	494
		July	,166	3	14	34	89	148	199
		August	.302	4	19	51	61	103	143
		September	342	1	25	66	74	214	296

Discussion

The model described appears to have been relatively successful in explaining the high variation in angling catches of grilse and 2 sea winter salmon on the River Wye; but it is obviously limited by the assumption that changes in water level have an identical effect in each month considered. However in spite of this approximation it has been shown that catches are related to the mean monthly water level at Hereford and that assuming this to be a true causal relationship due to the tendency of salmon to enter the river on higher than average water levels these have a high degree of practical significance both for the angler and in the interpretation of catch returns.

The monthly constants derived from the model and plotted in figure 2 probably reflect the rate of arrival of migrants in the estuary. It would appear that the "spring" run is fully exploited by the anglers but that the autumn run of 2 sea winter fish and the grilse run largely escape exploitation.

The annual constants may be viewed as indeces of migrant population strength but in view of their low significance levels it would be unwise to attach too much weight to any apparent differences in the 2 sea winter indeces. They certainly do not show a significant drop since the start of the West Greenland fishery and although it can be argued that the grilse population indeces have shown a dramatic rise in recent years and assuming that this has been due to high recruitment the two sea winter indeces should show a similar pattern; there is no evidence of such a relationship in the 1950's.

The effect of water level on catches as shown in Table I is such as to cause fluctuations of up to 65% on either side of the catches estimated for the mean monthly levels. The annual returns are unlikely to show the same degree of dependence on water levels but since the mean water level at Hereford for the period July to September varied from 5 inches in 1961 to 39 inches in 1960 and for the period April to June (Heaviest catches of 2 sea winter salmon) from 8 inches in 1957 to 40 inches in 1956 the effect of variation in water level is sufficient to mask all but very large variations in population size.

Conclusions

1) The monthly catches of grilse and 2 sea winter salmon in the River Wye are positively correlated with the mean monthly water level at Hereford

2) The variation in catches caused by high or low water levels is sufficient to mask all but large fluctuations in population strength unless the effect is extracted by a suitable statistical technique.

3) No significant reduction in population size of 2 sea winter salmon is discernable in the past decade.

References

Wye River Board Annual Reports 1951 - 1965

Wye River Authority Annual Reports 1966 - 1971

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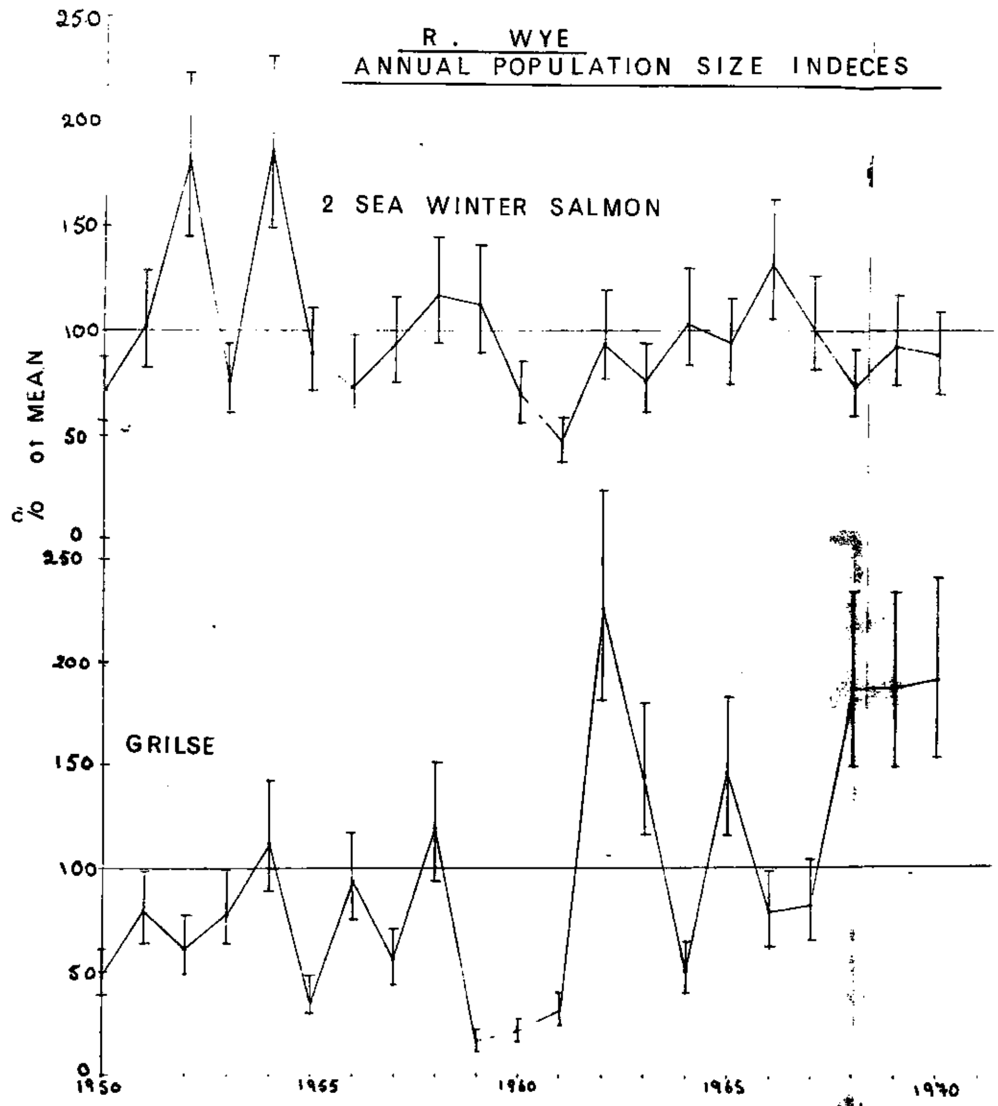

FIG. 1

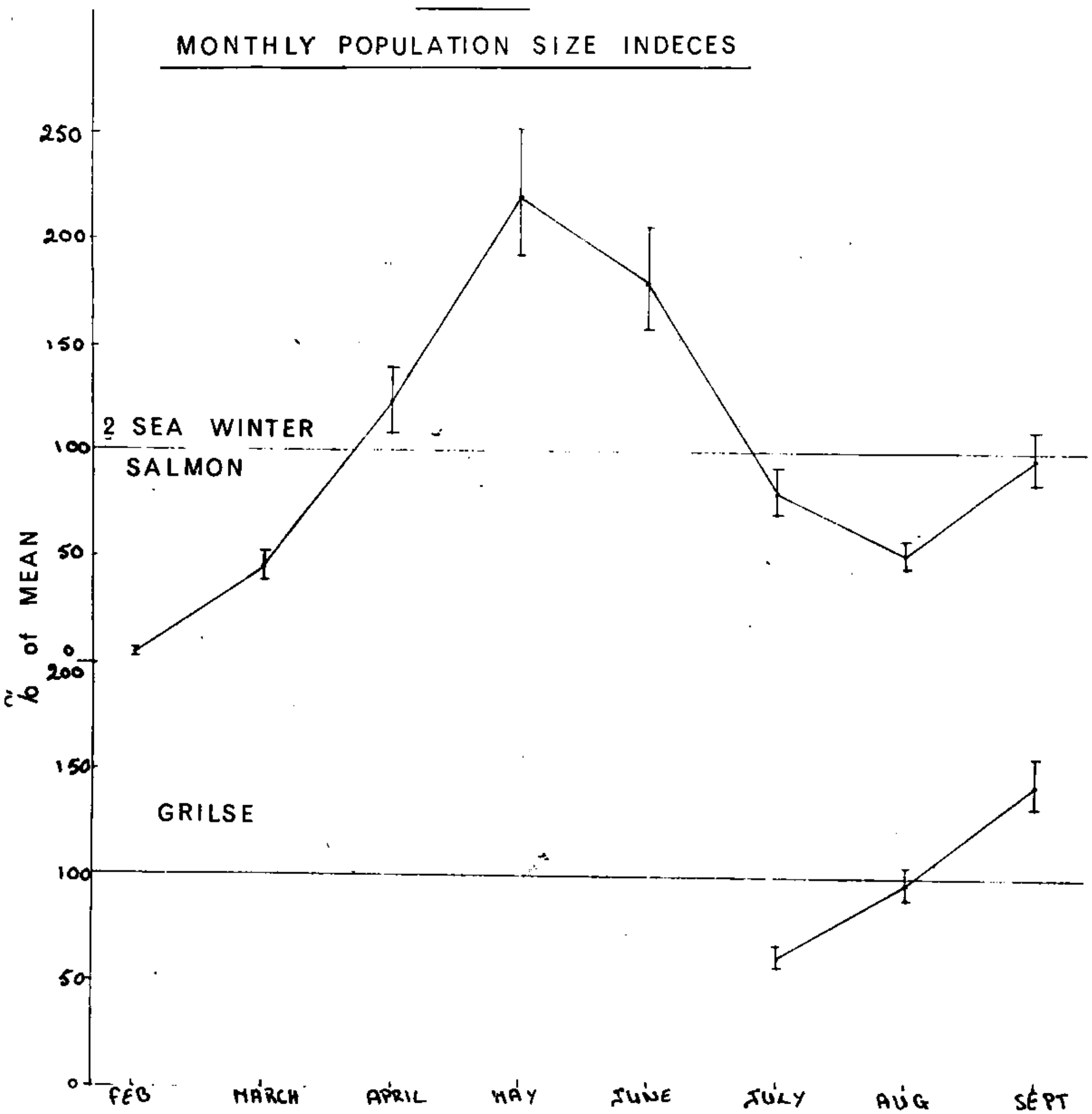
MONTHLY POPULATION SIZE INDECES
% of MEAN
250
200
150
100
50
0
2 SEA WINTER
SALMON
GRILSE
FEB
MARCH
APRIL
MAY
JUNE
JULY
AUG
SEPT

FIG. 2

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