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REPORT

to

DAVIDSON RADCLIFFE LTD., C. DAVIDSON & SONS,

Mugiemoss Mills, Aberdeen

and

WIGGINS TEAPE (UK) PLC.,

Stoneywood Mill, Aberdeen

on

CATCHES OF MIGRATORY FISH IN THE RIVER DON, ABERDEENSHIRE - CONSIDERATION OF THE AVAILABILITY OF FISH

by

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1. INTRODUCTION

In the first report (Alabaster, 1983) it was concluded that:

(1) river flow appeared to have been the dominant environmental factor relating to monthly returns of migratory fish caught on rod and line in the R. Don during the years 1973-1982, and

(2) low concentration of dissolved oxygen (DO) was generally not significantly related to such catches.

However, since a large amount of the variability in the catches remained unexplained, some of which was conceivably attributable to annual variations in the number of fish available to enter the river, a further analysis to consider this factor has been carried out. This analysis has been confined to salmon and grilse (salmon that have spent one year only at sea before their return to freshwater), because of the relatively small numbers of seatrout involved; it was also confined to the months of June, July, and August when the DO has tended to be at its lowest values.

The caviats already stressed in Report No. 1 still apply, and additional reservations that now become relevant with the widening of the approach to the analysis, are mentioned later in the present report.

2. METHODS

2.1. General approach

The main data-base is the same as in Report No. 1 but, in addition, figures for the age distribution of fish have been obtained from Menzies anf MacFarlane (1924) and the Department of Agriculture and Fisheries for Scotland in respect of salmon and grilse caught in the R. Dee, and from Menzies (1923) for salmon caught in the R. Don.

Essentially the approach has been:

(1) to seek direct and indirect relationships between catches

in one year and corresponding values in preceding years,

(2) to calculate the differences between the observed catches and those indicated from any overall relationships found, and

(3) to use these differences, rather than the actual (relative) catches, in the multiple regression analysis in which the independent variables are river flow, DO and temperature, as in Report No. 1.

2.2 Relation between successive years

The first of these three stages has been approached in several ways in order to estimate the relative numbers of fish available to return to the river, assuming uniformity between years in the survival of the fish.

In the simplest case it is assumed that the escapement from anglers and other hazards, of upstream migrant fish to the spawning grounds, is directly proportional to the catch on rod and line. The number of progeny returning in one particular year is then taken to be directly proportional to the escapement in another particular, earlier, year. This figure is taken as an index of the expected availability of the fish, although in practice it is likely to be affected by spawning success, egg production and survival, hatching success and the survival of fry, parr, smolts and adults in the sea. Most of these factors are ignored in the present analysis.

More realistically, the return of progeny can be assumed to be determined by the age distribution of the population. In this case a calculation is made for all years separately and the contributions of each year's products to a given year's catch are summed.

Also it can be assumed that proportionately more salmon and grilse escape to spawn when rod catches are relatively high, as found for the R. Coquet (Alabaster, 1970) where the relation found (derived from figure 10 of the paper) is:

$$E = 64 + 0.15C \qquad (1)$$

where E is the percentage escapement and C is the catch on rod and line.

2.4. Adjustments used for age of fish

In the present study, an analysis was carried out for grilse based on the overall age distribution of salmon smolt ages found for the R. Dee; this was because no data on the age of smolts of grilse in the R. Don were available and the age structure of stocks in the rivers Dee and Don are broadly similar. The age distribution in the R. Dee was reported by Menzies (1925) as 0.28, 78.7 and 20.6 per cent for 1-, 2-, and 3-year-old smolts respectively; more recent figures (W. M. Shearer, personal communication), which have been used to obtain some of the results quoted in the present report, are 2.8, 75.5 and 20.6 per cent respectively. Thus, in order to derive the index of availability for grilse caught in year 0, the previous catch was calculated as 0.03 of the catch in year -5, plus 0.76 of the catch in year -4, plus 0.21 of the catch in year -3, so allowing one winter for the eggs to hatch and another winter for the fish to remain at sea.

For salmon (as compared with grilse), allowance has also to be made for differences in the number of years spent in the sea before returning to fresh water to spawn. The percentage distribution of 1-, 2- and 3-year-old smolts among salmon in the R. Don returning after 2 sea-winters is 0.7, 56.1 and 35.4 respectively, and for those returning after 3 sea-winters is 0.4, 6.0, and 1.4 respectively (Menzies, 1923). Thus the percentages used to calculate the input to catches derived from other catches made 4, 5, 6, and 7 years previously are 0.7, 56.4, 41.4 and 1.4 respectively. (Corresponding figures for the R. Dee would be 0.1, 63.2, 32.5 and 1.0 respectively, illustrating the broad similarity between the two rivers).

A further refinement in estimating the index of availability was made by trying to allow for the known differences between months in the distribution of fish ages. From data given by Menzies and MacFarlane (1924) for the monthy age distribution of fish in the R. Dee, the percentages applied to catches of grilse made 4 and 5 years prior to the year of interest were 60 and 40 for June, 73 and 26 for July and 79 and 21 for August; for salmon the figures for catches made 5 and 6 years prior to the year of interest were 94 and 10 respectively for June, 69 and 18 for July, and 78 and 22 for August.

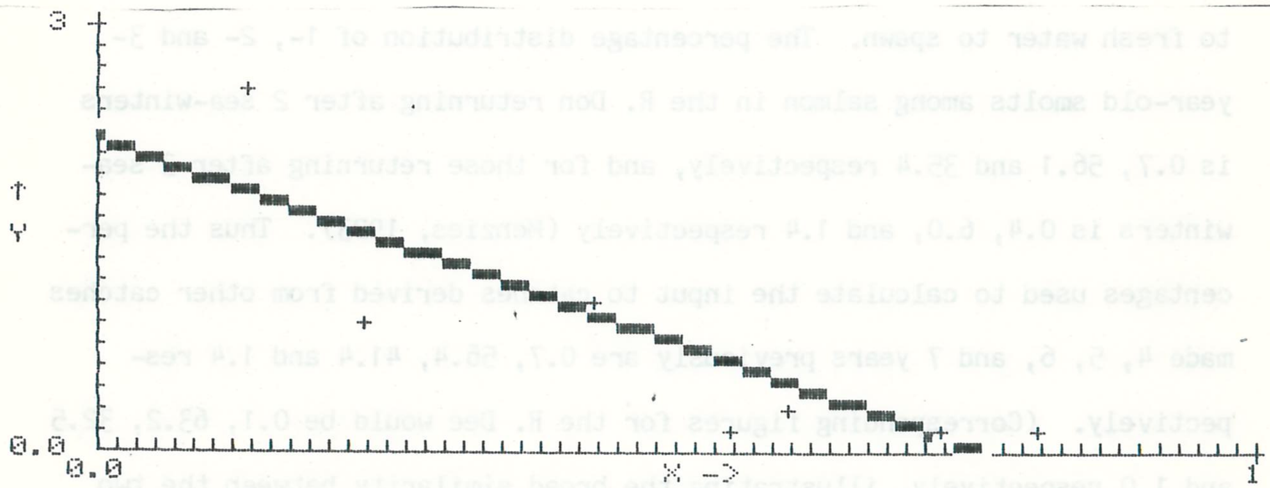
2.4. Dependent variable

In Report No. 1, catch (as a percentage of the 30-year mean) was taken as the dependent variable in the multiple regression analysis. In the present report this is replaced by the difference between the catch and the index of availability and, in addition, by the residuals about the relation between catch and index of availability.

3. RESULTS

3.1 Relation between annual catch and catch in previous years

Fig. 1. Relation between annual catch of salmon on rod and line in the R. Don and catch made 6 years previously.



R.DON SALMON ROD CATCH 1973-1979

WHERE:- X IS CATCH 6 YRS PREVIOUSLY
Y IS CATCH - PROPORTION 30-Y ANNUAL MEAN

A preliminary regression of analysis of annual catch of salmon on annual catch in previous years for the period 1973-1979 shows a slightly significant (P = 0.05-0.01) negative correlation of catch on catch 6 years previously (Fig. 1), and a slightly more significant negative correlation (P = 0.05-0.01) between the logarithms of the respective catches.

Correlations are also indicated for 4- and 5-year periods between the catches but these are smaller and less significant; coefficients from the correlation matrix are -0.64, -0.43 and -0.16 respectively, for catches made 6, 5 and 4 years prior to those taken as the dependant variable.

These results indicate the likely importance of interaction between annual catches made in different years and the potential value of further, more extensive analyses ,covering a longer period, followed by a re-examinion on a monthly basis in relation to environmental variables.

3.2 Relation between monthly catch and catch in previous years

Using data for the period 1952-1981, multiple regressions of catch on catches made 4, 5, and 6 years previously were carried out for all months from March to September for grilse, and for all months from February to September for salmon. Although negative correlations were apparent, none was statistically significant (P = less than 0.05).

The analyses were repeated using the calculated index of availability as the independent variable but, again, none was statistically significant, whether a uniform or variable distribution of fish ages was assumed for all months.

The generally poor correlation found on a monthly basis must be attributable, in part at least, to the much smaller numbers of fish involved and the consequentially increased variability in the data. The largest and most significant correlation of -0.22 (P = 0.2-0.05) was for grilse in July, one of the months with the highest average catches, and it accounted for only about 8 per cent off the variance.

Inclusion of equation (1) in the analysis made little difference to the significance of the results obtained.

3.3 Relation between catch and environmental factors

The results of the multiple regression of the difference between observed catches and index of availability on flow, temperature and DO are summarised in Table 1.

TABLE 1. Summary of multiple regression analysis of difference between catche and index of availability of migratory fish caught on rod and line in the R. Don, Aberdeendhire, 1973-1981, expressed as percentage of respective 30-yr means (1952-1981). (See text for details).

MONTH	C O N S T A N T			
	a	b(for flow)	c(for temp.)	d(for DO)
		SALMON		
June	-258.6	26.7***(0.89)	N.S.	N.S.
July	-234.1	28.9* (0.62)	N.S	N.S
August	-135.1	18.0***(0.70)	N.S.	N.S
June-Aug.	-188.0	22.6***(0.67)	N.S.	N.S.
		GRILSE		
June	-888.4	98.2** (0.73)	N.S.	N.S.
July	N.S.	N.S.	N.S.	N.S.
August	-206.6	23.3* (0.63)	N.S.	N.S.
June-Aug.	-428.2	46.7***(0.49)	N.S.	N.S.

N.S. : not statistically significant; P greater than 0.05

* : P = 0.05-0.01

** : P = 0.01-0.001

*** : P = less than 0.001

These show similar results to those summarised in Table 1 of Report No. 1 although there are a couple of small differences: for salmon in August (cf. Report No. 1, Table 1, page 9) there is a slightly more significant effect of flow, accounting also for a rather larger proportion of the total variance; for grilse in July (cf. Report No. 1, Table 1, page 10) there is no significant correlation with temperature.

In the latter case, the correlation between catch and index of availability had been the most significant found, and therefore the multiple regression was repeated using, as the independent variable, the residual variances of that correlation (based on a second order polynomial regression which was rather more siginficant than a linear regression). This gave a result similar to that originally obtained in Report No. 1, i.e., indicating a significant effect of temperature. The result is shown

TABLE 2 Summary of multiple regression analysis of residual variances (of regression of catch on index of availability) of migratory fish caught on rod and line in the R. Don, Aberdeenshire, 1973-1981, expressed as percentage of respective 30-yr means (1952-1981). (see text for details)

MONTHS	CONSTANT a	b(for flow)	c(for temp)	d(for DO)
		SALMON		
June	-260.9	23.5***(0.90)	N.S.	N.S.
July	-216.1	22.6* (0.63)	N.S.	N.S.
August	-154.6	15.7** (0.72)	N.S.	N.S.
		GRILSE		
June	-925.1	86.6** (0.70)	N.S.	N.S.
July	524.5	N.S.	-35.2*(0.51)	N.S.
August	-220.8	18.8***(0.81)	N.S.	N.S.

in Table 2, together with all the remaining results, for which residual variances of the linear regression of catch on index of availability was used as the independent variable, in place of the difference between catch and index of availability. These results, like those in Table 1, are also generally similar to those given in the First Report, although they tend to account for slightly more of the variance.

In no case was DO shown to be a significant factor in the multiple regressions.

4. DISCUSSION

The index of availability, as presently calculated, clearly fails to account significantly for much of the variability in the monthly catches of migratory fish. However, in calculating the index a number of relevant aspects have had to be excluded for lack of information, perhaps one of the most important being the commercial catch of fish.

Reference was made in the Conclusions Section of Report No. 1 to the limiting concentration of DO for the safe passage of migratory fish through deoxygenated estuaries being 4.5 mg/l. Recent evidence from the Thames estuary (Appendix 1), the most comprehensive of its kind to date, supports this figure.

5. CONCLUSIONS

At the current state of knowledge, the conclusions reached in the Discussion and Conclusions Sections of Report No. 1 remain valid.

6. REFERENCES

Alabaster, J. S. (1970) River flow and upstream movement and catch of migratory salmonids. Journal of Fish Biology, 2, 1-13

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Menzies, W. J. M. (1923) Salmon investigations in Scotland, 1921. I. Salmon of the River Don. Salmon Fisheries 1921, No. III. Fishery Board for Scotland. HMSO Edinburgh. Feb. 1923, 3-5.

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Appendix 1(In Confidence)

Examination of Conditions in the Thames Estuary in relation to the Upstream Passage of Grilse (First Draft 'Short Communication' to Journal of Fish Biology)

Data

From 1979 to 1981 the Thames Water Authority carried out stocking of salmon parr in the fresh waters of the R. Thames and in 1981 it included salmon smolts in the stocking programme.

In the summer and autumn of 1982 the Authority carried out electric fishing in the freshwater reaches of the river, particularly near Molesey Weir which is the first weir upstream of Teddington Weir, downstream of which conditions are tidal.

Once a week the Authority also made measurements of the dissolved oxygen (DO) percentage air saturation (ASV) throughout the length of the estuary from Teddington, 30 km upstream of London Bridge, to a point seawards about 100 km downstream of London Bridge.

Results

Examination of these data shows that in June, July, August and September, total numbers of grilse caught in the river were 0, 18, 45 and 20, of which 0, 18, 19 and 6 respectively were caught at Molesey. They averaged 60 cm in length.

The minimum DO in the estuary was quite low in the summer of 1982 (mean minimum values of 35, 35, 45 and 28 %ASV in June, July, August and September respectively), and the corresponding highest minima were about 19% ASV higher (47, 48, 54 and 37 %ASV respectively).

The results are summarised in Table 1.

TABLE 1. Summary of DO in the estuary and catch of grilse in freshwater in the River Thames, 1982.

Month	Date	Minimum DO (% ASV)	Length at less than 45%ASV (km)	No. grilse
June	1	34	31	
	7	23	54	
	14	34	51	
	21	38	17	
	28	47		
July	5	48		
	12	41	20	
	19	20	46	
	26	31	43	
	28-30			24
August	2	44	5	
	9	38	22	
	10			9
	16	50		
	23	40	11	
	24			10
	31	54		
Sept.	6	37	20	
	13	36	22	
	20	12	33	
	29			6
Oct.	3	42	5	
	7			7
Nov.	11			1
Dec.	6			3

Discussion and conclusions

Conditions in the estuary were evidently such as to allow the passage of grilse, although the exact time of their journeys is not known. Although the fish would be capable of cruising at 1 length/s, which would allow them to traverse the length of the estuary in 2-3 days, their arrival in non-tidal water at Molesey is likely to have been delayed, especially by the physical obstruction of Teddington Weir. This is supported by the absence of sea-lice from all the fish.

The conditions experienced by the fish in passing through the estuary would therefore be represented by measurements made some time before their capture in freshwater.

For the five weeks from 24 May to 21 June, and for the further five weeks between 12 July and 9 August, the minimum DO was less than 45% ASV, and the length over which this condition prevailed was 17-54 km for the first period and 5-46 km for the second. Based on the conclusions of EIFAC, such conditions would be expected to bar the upstream migration of salmon.

However, for the two intervening weeks, from 28 June to 5 July, the minimum DO was 47 and 48 %ASV respectively which, based on the EIFAC assessment, would be sufficient to allow the fish to make the passage.

If, as seems likely, the fish that first appeared from 28 July to 24 August had moved through the estuary between 28 June and 5 July, the transit time of the fish would have been between 23 and 42 days, which seems reasonable, especially in view of the fact that, except for the week of 12 July, river flows were below average between 5 July and 20 September.

If such transit times were also applicable to fish attempting passage in the week of 16 August, the fish would be expected at

Molesey between 8 September and 12 October. And indeed, the next two batches of fish were reported there between these dates, actually on 29 September and 7 October.

It is also probable that conditions improved in October and November to account for the few late arrivals in November and December.

Thus, these observations are concordant with the conclusions of EIFAC on the DO requirements of migratory fish, although the data need to be examined in terms of actual concentrations rather than %ASV.

Acknowledgements

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