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REPORT

to

DAVIDSON RADCLIFFE LTD., C. DAVIDSON & SONS,

Mugiemoss Mills, Aberdeen

on

# CATCHES OF MIGRATORY FISH IN THE RIVER DON, ABERDEENSHIRE

by

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# REPORT ON CATCHES OF MIGRATORY FISH IN THE RIVER DON, ABERDEENSHIRE

## INTRODUCTION

A study has been made of the River Don, Aberdeenshire, as to the relationship between the catches of migratory fish on rod and line and the quality of the water, particularly as to the concentrations of dissolved oxygen (DO) since, during some past seasons, when catches have been below average, concentrations of DO at Grandhome have at times also been low. On occasion the DO fell below 5 mg/l which is the minimum sustained concentration tentatively proposed by the European Inland Fisheries Advisory Commission (EIFAC) for the safe upstream passage of Atlantic salmon (Salmo salar) through deoxygenated estuaries, assuming other relevant environmental conditions to be favourable (Alabaster and LLoyd, 1982).

Furthermore, a preliminary examination of annual combined catches of 'salmon' (i.e. salmon that have spent more than one winter at sea before their first return to the river) and grilse (salmon that have spent only one winter at sea before returning to the river), expressed as corresponding proportions of those in the R. Dee, Aberdeenshire, had indicated a slight correlation with annual average DO, (at a low level of statistical significance; P = 0.2-0.05), and a much more significant correlation with river flow (P = 0.01-0.001). However, no firm conclusions could be drawn from that analysis without having access to information on catches in the R. Dee, inter alia.

In seeking to relate catches to DO it has to be bourne in mind that these may be dependent upon a number of other germane factors, as in-

dicated, for example, by the reviews of Banks (1979) and Fraser (1972). In particular, river discharge and water temperature should be considered and are of special interest in the R. Don in which flow has tended to be low and temperature high when DO has been low.

Other relevant factors would be the availability of fish to enter the river from the sea, the number of fish present in the river, the incidence of disease or other circumstance affecting the catchability of the fish, the fishing effort of anglers and also the accuracy of catch returns.

However, in the case of the R. Don there is no specific information on any of these factors and it is thus unlikely that any relationships between catches and environmental factors could be clearly established. Nevertheless, general trends should be apparent, as has already been found, for example, for the effect of river flow when examining similar data for the River Coquet (Alabaster, 1970) and for the River Dee, Aberdeenshire (Alabaster, 1971).

## DATA BASE

Details of total catches of migratory fish in the R. Don as a whole are not available for publication, but monthly catches, expressed as percentages of the respective 30-year monthly means, were obtained from the Department of Agriculture and Fisheries for Scotland for the years 1952-1981. It was possible, however, to obtain some actual monthly catches for part of the R. Don, namely for salmon, grilse and seatrout in the Kintore Burgh fishings (from the Gordon District Council) and for salmon in the Grandhome fishings (from Mr. D. Paton), in each case for the years 1973-1982. In addition daily catches of salmon by individual anglers fishing the Mugiemoss water were obtained from Davidson Radcliffe Ltd. for the years 1979-1982.

Data on instantaneous river flow, measured once a day on alternate days at Parkhill Bridge, and corresponding measurements of DO at Grandhome, were provided by the North East River Purification Board for the

years 1973-1982. Measurements of river temperature, taken once a week at Stoneywood House weir, were supplied by Stoneywood Mill for the years 1973-1978 and values taken every other day were provided by the River Purification Board for the years 1979-1982.

## THE APPROACH

The approach has been to use multiple regression analysis to examine annual variations in catches, month by month, expressed as a percentage of the corresponding mean for the month over several years. This is because of the marked and fairly consistent differences between months caused by the well established distribution of runs of fish in spring, summer and autumn.

Monthly means of river flow, water temperature and DO were calculated and taken as independent variables. The relation between the variables is given by the equation:

$$C = a + bF + cT + dD$$

where C is the catch expressed as percentage of the monthly mean; a, b, and c are regression constants; and F, T and D represent mean monthly values of river flow ($m^3/s$), water temperature (°C.) and DO (mg/l) respectively. Included in the final calculated regressions are only those variables for which a statistically significant correlation with catch is found (P less than 0.05).

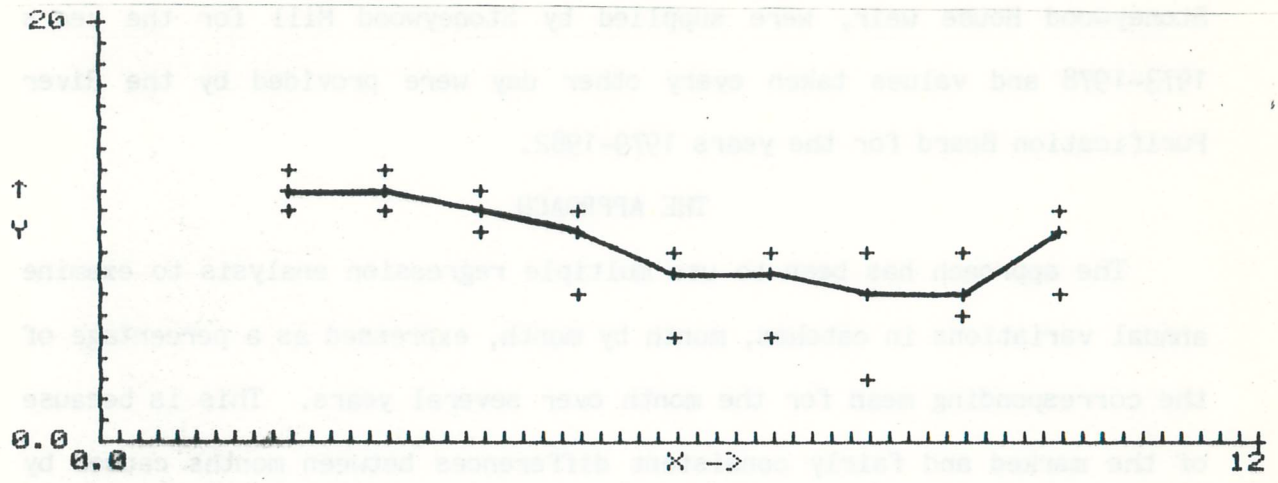
## RESULTS

The distributions of average monthly DO, flow and temperature in the R. Don for the years 1973-1982 are shown in Fig. 1, together with the corresponding maximum and minimum values. This illustrates the tendency for the minima for DO and flow and for the maxima for temperature to occur during the summer months.

The distributions of average monthly catches of salmon for the whole of the R. Don and for the separate fishings at Kintore and Grandhome for

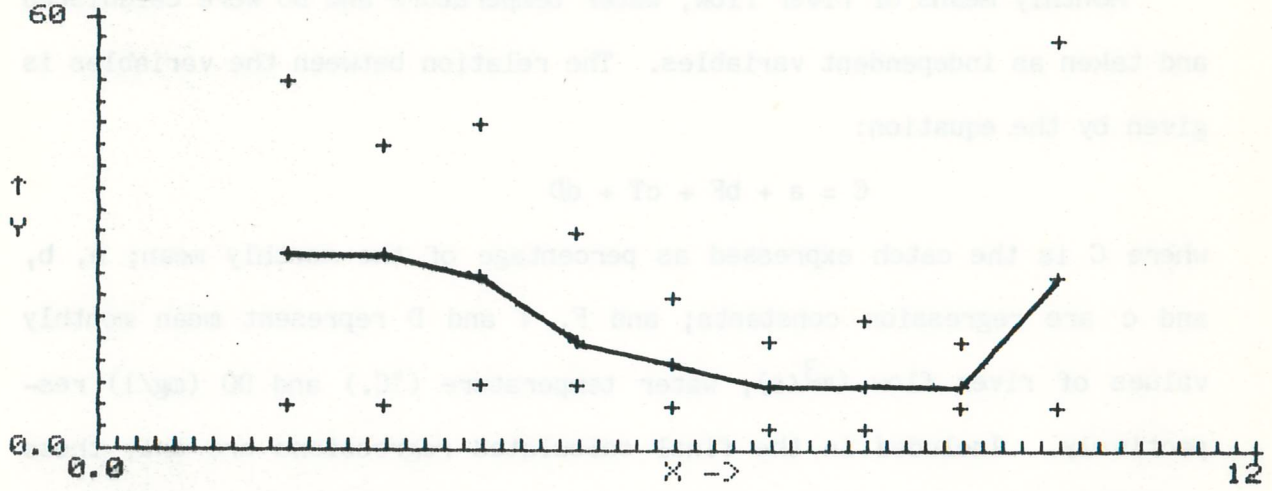
Average + range of monthly[5] mean

FIG. 1. DO, flow and temperature in the R. Don.



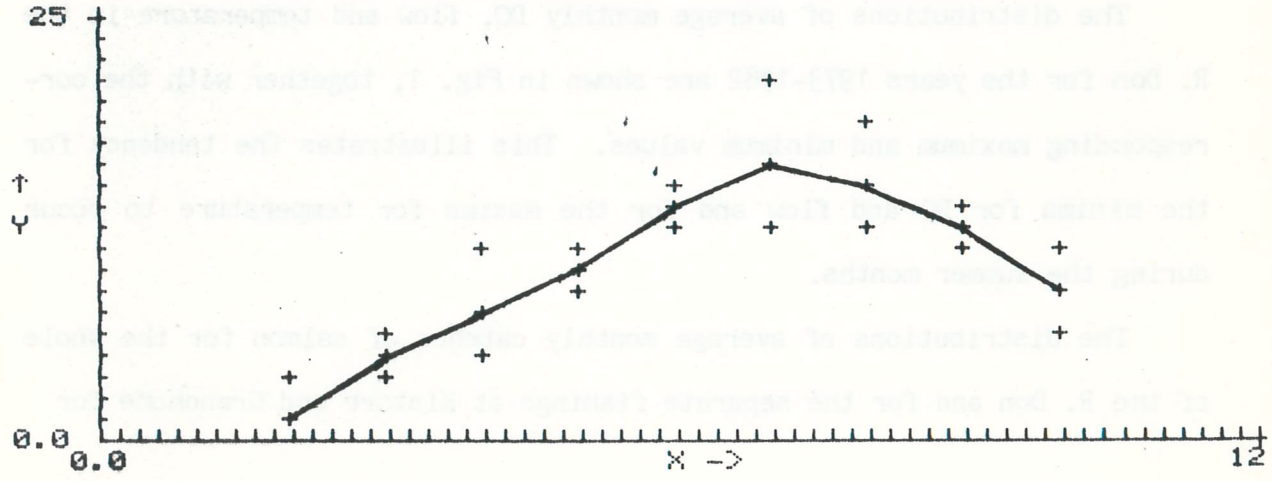

RIVER DON 1973-1982

WHERE:- X IS MONTH OF THE YEAR
Y IS DO - MG PER LITRE




RIVER DON 1973-1982

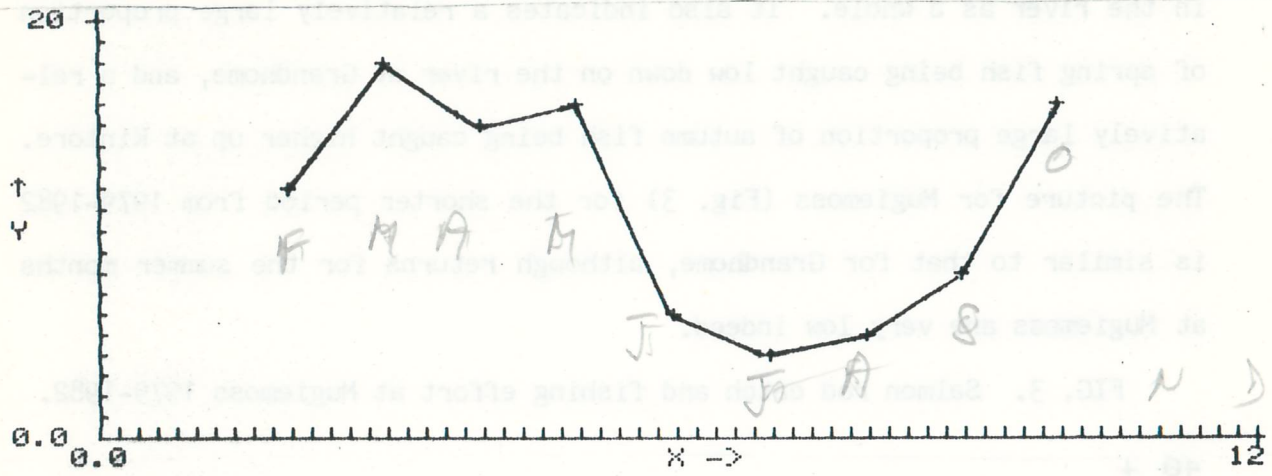
WHERE:- X IS MONTH OF THE YEAR
Y IS FLOW - CUBIC METRES PER SEC.




RIVER DON 1973-1982

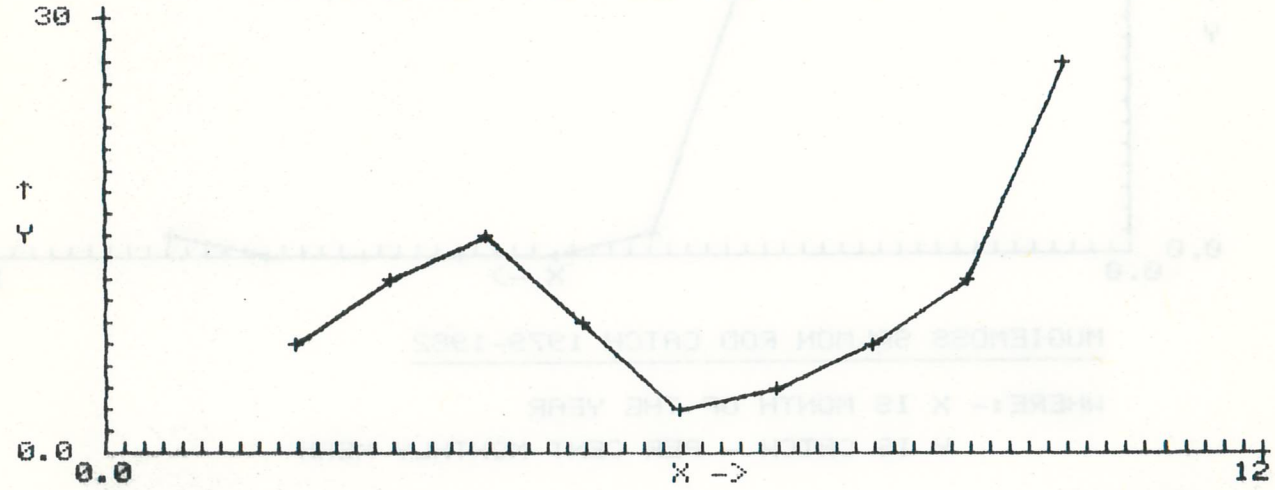
WHERE:- X IS MONTH OF THE YEAR
Y IS TEMPERATURE - DEGREES C.

FIG. 2. Catches of salmon on rod and line in the whole of the R. Don, and in the fishings at Kintore and Grandhome.



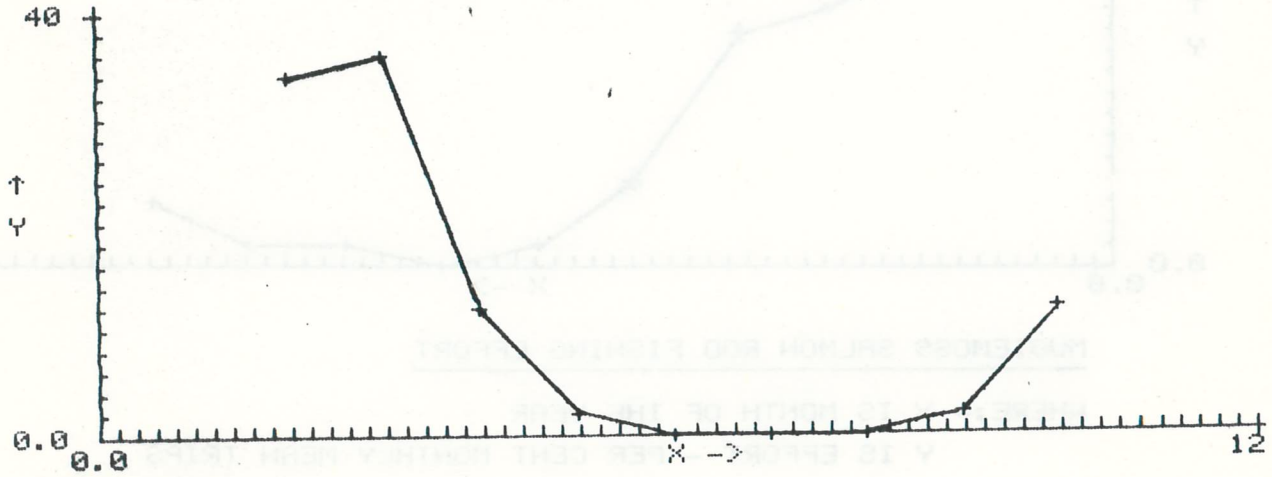

R.DON SALMON ROD CATCH 1973-1981

WHERE:- X IS MONTH OF THE YEAR
Y IS CATCH - PER CENT MONTHLY MEAN




KINTORE SALMON ROD CATCH 1973-1982

WHERE:- X IS MONTH OF THE YEAR
Y IS CATCH - PER CENT MONTHLY MEAN

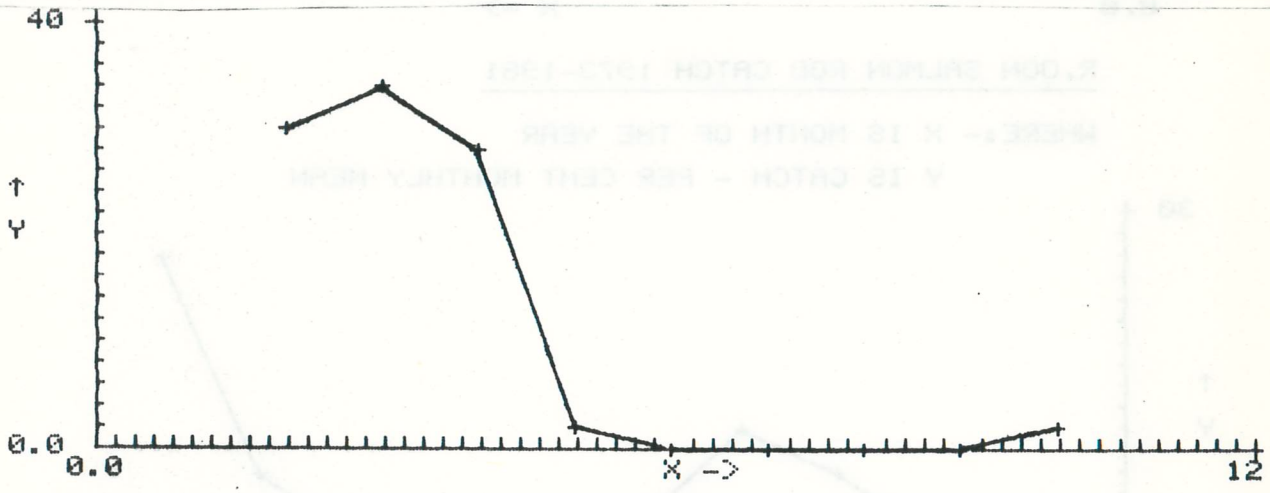



GRANDHOME SALMON ROD CATCH 1973-1982

WHERE:- X IS MONTH OF THE YEAR

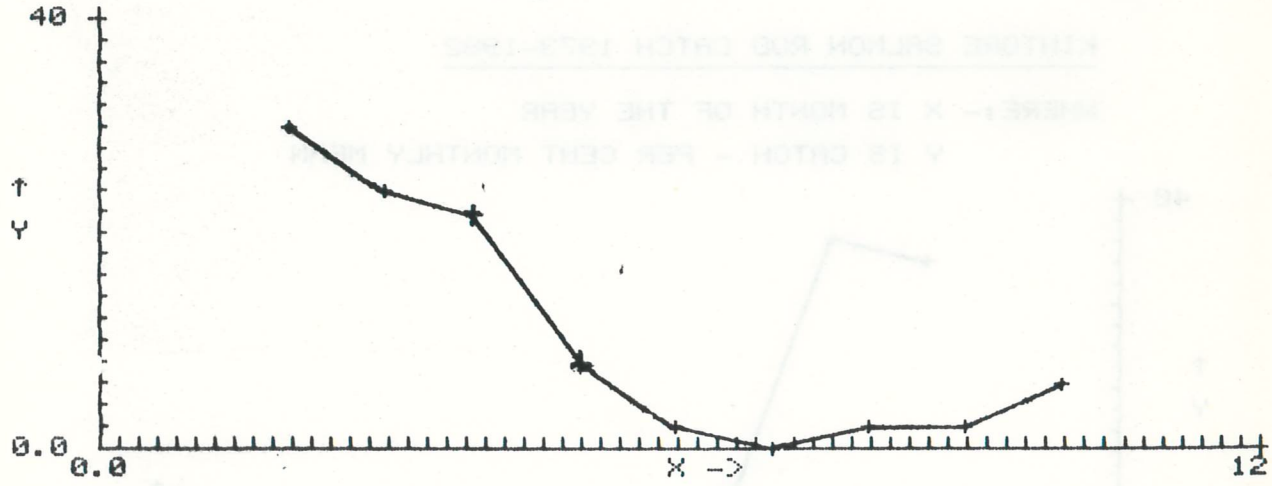
the period 1973-1981 are showm in Fig. 2. This shows that relatively few summer fish and similar proportions of spring and autumn fish were caught in the river as a whole. It also indicates a relatively large proportion of spring fish being caught low down on the river at Grandhome, and a relatively large proportion of autumn fish being caught higher up at Kintore. The picture for Mugiemoss (Fig. 3) for the shorter period from 1979-1982 is similar to that for Grandhome, although returns for the summer months at Mugiemoss are very low indeed.

FIG. 3. Salmon rod catch and fishing effort at Mugiemoss 1979-1982.




MUGIEMOSS SALMON ROD CATCH 1979-1982

WHERE:- X IS MONTH OF THE YEAR
Y IS CATCH - PER CENT MONTHLY MEAN



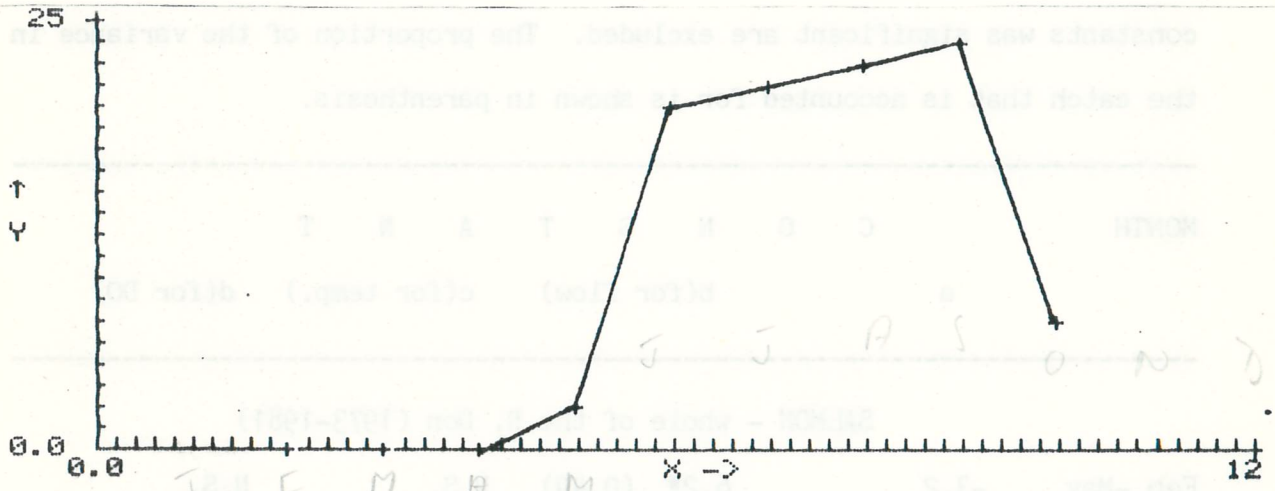

MUGIEMOSS SALMON ROD FISHING EFFORT

WHERE:- X IS MONTH OF THE YEAR
Y IS EFFORT - PER CENT MONTHLY MEAN TRIPS

These low catches for Mugiemoss are largely attributable to the relatively small fishing effort in terms of angler-trips per month (Fig. 3), being only 8 per cent of the total for the season.

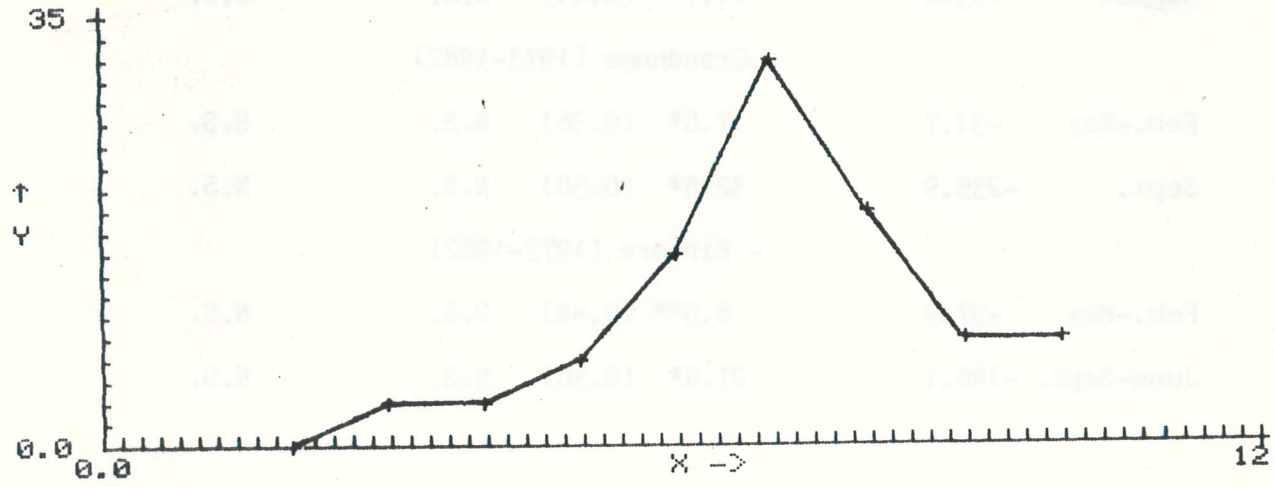
The distributions of catches of grilse and seatrout (Salmo trutta) for the whole of the R. Don (Fig. 4) show that these fish are caught mostly during the summer months. Their actual numbers are relatively small, each comprising only about 4 per cent of the total and, in the Kintore fishery, comprising only 4 per cent and 1 per cent, respectively, of the total, all of which are too low for useful analysis.

FIG. 4. Rod catches of grilse and seatrout in the whole of the R.Don




R.DON GRILSE ROD CATCH 1973-1982

WHERE:- X IS MONTH OF THE YEAR
Y IS CATCH - PER CENT MONTHLY MEAN




R.DON SEATROUT ROD CATCH 1973-1981

WHERE:- X IS MONTH OF THE YEAR
Y IS CATCH - PER CENT MONTHLY MEN

The regression analyses were carried out for all months separately but they were repeated for some groups of months, either because of the low sigificance of some of the regression constants or, in the case of salmon, because the DO was relatively high from Februrary to May. The results are summarised in Table 1.

TABLE 1. Summary of multiple regression analysis of monthly catches of fish on rod and line in the R. Don, Aberdeenshire, expressed as percentages of the respective monthly means over periods of several years. The statistical significance of the regression constants is indicated by: N.S., not significant, P greater than 0.05; *, P = 0.05-0.01; **, P = 0.01-0.001; and ***, P = less than 0.001. Months in which none of the constants was significant are excluded. The proportion of the variance in the catch that is accounted for is shown in parenthesis.

| MONTH | C O N S T A N T | | | |
|---|---|---|---|---|
| | a | b(for flow) | c(for temp.) | d(for DO) |
| | SALMON - whole of the R. Don (1973-1981) | | | |
| Feb.-May | -3.2 | 6.2* (0.49) | N.S. | N.S. |
| June | -185.7 | 23.5***(0.90) | N.S. | N.S. |
| July | -134.9 | 23.0* (0.63) | N.S. | N.S. |
| August | -53.8 | 11.7* (0.44) | N.S. | N.S. |
| | - Grandhome (1973-1982) | | | |
| Feb.-May | -31.7 | 7.8* (0.36) | N.S. | N.S. |
| Sept. | -235.9 | 32.5* (0.50) | N.S. | N.S. |
| | - Kintore (1973-1982) | | | |
| Feb.-May | -97.9 | 8.9** (0.44) | N.S. | N.S. |
| June-Sept. | -146.1 | 21.4* (0.30) | N.S. | N.S. |

TABLE 1 (continued)

| | C O N S T A N T | | | |
|---|---|---|---|---|
| | a | b(for flow) | c(for temp.) | d(for DO) |
| **- Mugiemoss (1979-1982)** | | | | |
| Feb-May | -59.4 | 6.4* (0.36) | N.S. | N.S. |
| Feb-May[1] | -48.3 | 5.9* (0.34) | N.S. | N.S. |
| **GRILSE - whole of the R. Don (1973-1981)** | | | | |
| June | -817.9 | 86.5** (0.7) | N.S. | N.S. |
| July | 1880.2 | N.S. | -34.6* (0.49) | N.S. |
| August | -92.8 | 15.1** (0.63) | N.S. | N.S. |
| Sept. | -183.2 | 25.9* (0.55) | N.S. | N.S. |
| Oct. | -42.6 | 6.4* (0.53) | N.S. | N.S. |
| July-Sept. | -124.7 | 20.8***(0.51) | N.S | N.S. |
| **SEATROUT - whole of the R. Don (1973-1981)** | | | | |
| April | -29.4 | N.S. | N.S. | 2.8**(0.63) |
| May | 66.6 | N.S. | -5.6*(0.52) | N.S. |
| June | -70.2 | 8.3**(0.78) | N.S. | N.S. |
| July | -28.7 | N.S. | -28.7*(0.54) | N.S. |

Note 1: Regression based upon number of salmon caught per angler-trip

The fishing effort of the anglers is known only for those fishing the Mugiemoss water for the years 1979-1982. The results are summarised in Table 2.

TABLE 2. Summary of efficiency of salmon angling by Mugiemoss anglers and comparison with other data for the R. Don.

| Year | Mean catch/trip | Total catch | Total relative catch in R. Don | Mean flow from Feb-Oct. |
|---|---|---|---|---|
| 1979 | 0.41 | 251 | 2.59 | 23.5 |
| 1980 | 0.29 | 98 | 1.18 | 22.8 |
| 1981 | 0.04 | 5 | 0.86 | 16.5 |
| 1982 | 0.56 | 70 | - | 19.1 |

## DISCUSSION

### Regression analysis

On average the multiple regressions (Table 1) account for only about half the variance in catch, which is perhaps to be expected in view of the likely influence of other factors, particularly the availability of fish to be caught. The most frequent and statistically most significant correlations are found with river flow, as has been found in other rivers (Alabaster, 1970; 1971). For salmon, an increaase in flow of 1 $m^3/s$ is correlated with an increase in catch of less than 10 per cent of the monthly mean in spring and no more than about 30 per cent in summer. For grilse the effect is generally greater although the results are more variable, presumably in part owing to the much smaller numbers involved, while for seatrout only a small effect was found (for June).

Relationships with temperature are evident only for grilse in June and for seatrout in May and July. In July, when catches of both species were relatively high, an increase in temperature of 1 degree Centigrade is related to a reduction in catch of about 30 per cent of the monthly mean.

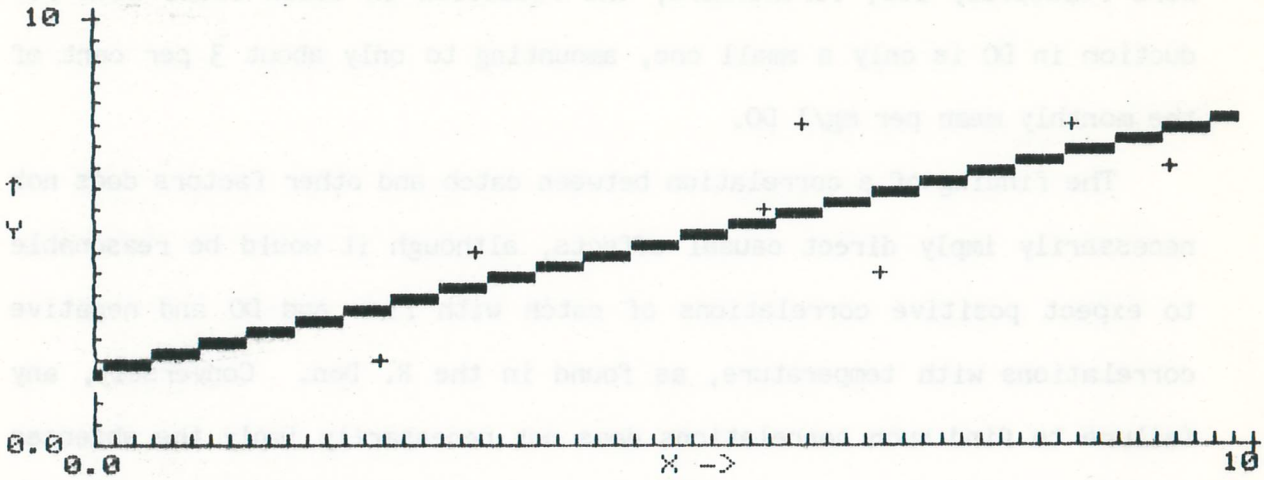
The results fail to show that, during those months when DO was low, monthly catches of migratory fish in the R. Don were related to DO. The

only significant correlation of catch with DO is found for seatrout for the month of April, when DO values were high and in any case the catches were relatively low; furthermore, the reduction in catch found with reduction in DO is only a small one, amounting to only about 3 per cent of the monthly mean per mg/l DO.

The finding of a correlation between catch and other factors does not necessarily imply direct causal effects, although it would be reasonable to expect positive correlations of catch with flow and DO and negative correlations with temperature, as found in the R. Don. Conversely, any failure to find such correlations does not necessarily imply the absences of causal effects, since the effects may be too small to detect with the amount and type of data available and may be swamped by variability caused by other factors. In the case of DO, however, it seems likely that any effect of low values on catches was over-ridden by the more dominant effects of low flow; although DO and flow were correlated, adversely low values for river flow occurred when DO values were still high enough not to have adverse effects.

Thus it appears that if the flow is sufficiently high for normal catches of migratory fish, the DO is also satisfactory. This statement applies to the period 1973-1982 when the DO at Grandhome fell to mean monthly values as low as 3.4 mg/l and annual 95 percentile values ranged between 2.1 and 7.6 mg/l. Examination of the past relation between the annual 95 percentile values of flow and DO, as in Fig. 5, for the years 1973-1979, when no adverse effects of DO on migratory fish could be detected, shows that the annual 95 percentile value of DO corresponding to 4.6 $m^3/s$ is about 4.6 mg/l. In the future, the concentration of DO is likely to be much higher than 4.6 mg/l at the 95 percentile flow, following the planned reductions in loads of biochemical oxygen demand (BOD).

FIG. 5. Relation between annual 95 percentile values of DO and flow in the R. Don (1973-1979).




R.DON DO AND FLOW 1973-1979

WHERE:- X IS ANNUAL 95 PERCENTILE FLOW - CUBIC M/S
Y IS ANNUAL 95 PERCENTILE DO - MG/L

At the Public Inquiry in 1981 a total load of BOD of 4.6 t/d was proposed as the maximum from Stoneywood Mill, Mugiemoss Mill and Persley Sewage Treatment Works combined, assuming the loads were 1.5, 2.8 and 0.3 t/d respectively. This was considered necessary to achieve a minimum DO of 5 mg/l at Grandhome at the 95 percentile flow, which should be sufficient to ensure the maintenance of resident populations of salmonid fish. Clearly a reduction in the load from Mugiemoss to 1.5 t/d by July 1987, as required by the Secretary of State's decision, is bound to result in much higher concentrations of DO in the river, other things being equal.

Fishing effort and efficiency

The fishing efficiency of the Mugiemoss anglers (Table 2) ranged from 0.04 to 0.56 fish/trip and is of the same order as reported elsewhere in Scotland (Jamieson, 1979); figures averaged for 1970 and 1971 ranged, for the R. Conon, from 0.07 to 0.49 and for the R. Blackwater, from 0.08 to 0.38. The differences at Mugiemoss between years appear to be related to

river flow (as would be expected from the regression analyses already described) and they are also reflected in the total numbers of fish caught, showing that the totals are affected more by angling efficiency that by total fishing effort. Catches in the whole of the R. Don also reflect those at Mugiemoss.

Although it is not known to what degree high efficiency in the R. Don (expressed as fish/trip) reflects high numbers of fish present or the presence of good angling conditions, the number of fish caught by all anglers fishing the R. Coquet (expressed as fish caught/fish counted into the river) certainly increased with increase in numbers present. If, as is likely, the situation in the R. Don is similar to that in the R. Coquet then relatively high catches would certainly indicate relatively high numbers of fish having entered the river, especially as angling efficiency, in terms of proportion of fish present being caught, may decrease as numbers present increase.

Daily catches

Daily catches are available only for the Mugiemoss fishery, but their numbers are relatively low and probably too small for useful analysis, especially since the fishing effort was small at times of most interest in relation to DO. There remains the possibility therefore, that day to day numbers of fish entering the river and catches in the R. Don were affected by environmental factors, including DO, although any overall effect is not evident in the monthly catches. In practice however, one would expect that, were the runs of fish on a particular day inhibited by environmental factors, they would be augmented later when conditions became more favourable. Evidence for such compensation has been found on a monthly basis in relation to the effects of flow in the Coquet, but has yet to be studied on a daily basis and for DO.

Effect of aquatic plants

One of the consequences of improved water quality in the river in the

future may be increased plant growth. This could have adverse repercussions on the DO minima at night which might, in turn, adversely affect the upstream migration of adult salmonid fish especially if, as in some rivers, the fish moved principally during the hours of darkness.

## CONCLUSIONS

River flow appears to have been the dominant environmental factor related to monthly catches of migratory fish on rod and line in the R. Don during the years 1973-1982; low DO does not seem to have played a significant role.

In view of the fact that, following reductions in BOD loads, DO concentrations are likely to increase in the future, a river standard of 5 mg/l minimum daytime DO at the 95 percentile flow, is likely to be met. Although present evidence suggests that, because of the effect of river flow, such a standard would be irrelevant to monthly catches of migratory fish on rod and line, it would be reasonable as a criterion for the passage of migratory fish through any deoxygenated zone because present evidence points to a limiting concentration of about 4.5 mg/l. Such a standard would also be adequate for the maintenance of resident salmonid fish populations.

A large amount of the variability in the catches remains unexplained and could well be largely attributable to annual variations in the availability of fish to enter the river. Re-analysis of the data taking this factor into account would provide a better estimate of the relation between catches and environmental factors, especially if more years' data were involved in which catches of fish and DO were low.

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