REPORT

on

WATER RESOURCE DEVELOPMENT IN EAST DEVON

River Axe Fish Study - Supplementary Report

by

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1. INTRODUCTION

Further to the evaluation of fish movements in the estuary of the R. Axe (Alabaster, 1986) which was based on the option then under consideration to abstract up to 25 Ml/d (0.289 m^3/s) of surface water from the river near the tidal limit, leaving an assumed minimum residual flow of 0.625 m^3/s, a further evaluation is now made of the likely effect upon fish movement of any abstraction below that minimum. The present report, however, should be read in conjunction with its predecessor.

In addition, an opinion is given on 1) the minimum residual flow that would be appropriate in the R. Coly, and 2) the likely effect on the tributaries of augmentation of the flow using groundwater.

2. DATA-BASE

In addition to the data-base already described (Alabaster, 1986), use has been made of 1) half-hourly observations in May 1967 of trap catches of upstream migrant salmon, and of water level and water temperature, supplied by the Ministry of Agriculture, Fisheries and Food, 2) the results of the survey of fish populations (Freshwater Biological Association, 1986), 3) up to 16 daily spot readings from 1984-1986 of water quality characteristics at a number of sites in the catchment, supplied by the South West Water Authority (SWWA), 4) daily flows at Whitford to December, 1986 and 5) data on spot readings from November, 1986 to March, 1987 of groundwater quality from 4 sites (up to 5 separate days' data), supplied by SWWA.

3. METHOD OF DATA ANALYSIS

The relationships between various factors have been assessed by linear regression, or by linear multiple regression analysis, whilst the distribution of water quality within periods has been examined using probit analysis.

4. RESULTS, DISCUSSION AND CONCLUSIONS

4.1 Mean Residual Flow in the R. Axe downstream of Whitford.

The distribution of trap-catches of salmon within a 24-h period was found to be largely affected by time of day. Therefore, to examine the likely affect of reductions in flow below 0.6 m^3/s, analysis was made of daily data for all occasions during May, 1967 when one or more fish were recorded at the trap, together with occasions when no fish were observed for 24 hours.

River flow accounted for 0.36 of the variance (P = less than 0.001), the equation being:

$$y = 0.5 + 0.36x$$

where y = number of fish counted per day

and x = daily mean flow at Whitford in m^3/s.

Thus, for a reduction in flow of 0.3 from 0.6 m^3/s, the reduction in number of fish counted during the whole month was about 3 fish, which amounts to about 4% of the total (of 77). Similar results were obtained excluding days when no fish were trapped. Data for other months have not been examined but the results would be expected to be somewhat similar to those for May.

Reduction of the mean daily flow to 0.3 m^3/s would, therefore, on the face of it, be expected to have a relatively small and transient effect on the number and proportion of fish entering the river from the estuary, assuming that the normal series of spates occurred and that unusually high water temperatures did not prevail. It must be pointed out, however, that this conclusion involves extrapolating below actual observed flows, a problem that would also apply to the rest of the data available for other months and other years. It is possible that the results that have been obtained were affected by the relatively high base flow, e.g. through the provision of suitable resting places for the fish, affects on river water temperature and effects on salinity gradients in the estuary.

Because of this uncertainty, and because of the information in the initial report on flows that inhibit the movement of fish in other rivers, abstraction to below 0.6m^3/s residual flow is not recommended.

4.2. Mean Residual Flow in the R. Coly upstream of its Confluence with the R. Axe.

In the absence of data on fish catches in the R. Coly, it is reasonable to conclude that the relation between fish movements from the estuary and water flow in the R. Coly would be similar to those found for the R. Axe. It does not necessarily follow, however, that the mean residual flow chosen should bear the same relation to the average flow available as applies to the R. Axe. On the contrary, the regression equations produced by MRM show that the relation between the flow régime in the R. Coly is different from that in the other tributaries of the R.

Axe (taking account of differences in catchment area); the flow in the R. Coly is relatively low, and increases relatively less with that of the R. Axe, than is found elsewhere in the catchment, which could mean that high flows (which are are relatively lower than elsewhere) are less stimulating to fish than the equivalent values are in the rest of the R. Axe catchment. Added to that, there may be special problems associated with the passage of fish through the fish-pass on the R. Coly.

Therefore, a more conservative approach to water abstraction should apply to the R. Coly compared with the R. Axe.

4.3. Effects of Groundwater Augmentation in Tributaries.

Summer water temperature has already been shown to have significant adverse effects on salmon smolts at a flow lower than about 1.5 m^3/s at Whitford which, in turn, has been shown to be associated with maximum and mean water temperatures at Whitford of about 21 and 17°C., respectively (Alabaster, 1986). The associated flow and (probably controlling) water temperature conditions in the headwaters were unknown, but the latter can be estimated from the equations calculated by MRM; comparison of these values with the flows proposed for augmentation from groundwater would then enable the likely effect of augmentation on water temperatures in the recipient streams to be estimated. Since groundwater temperatures will be of the order of 10°C., the effect is likely to be beneficial during summer drought conditions, not only to migratory fish, but also to resident trout.

The general deterioration in water quality in the R. Axe in recent years has already been pointed out (Alabaster, 1986). A significant decline in fish populations is also evident from recent surveys (Freshwater Biological Association, 1986). It is, therefore, to be expected that some of the differences in abundance of fish within the catchment would be attributable to differences in water quality and thus be subject to influence by the quality of any groundwater used for flow augmentation of the surface streams.

An initial analysis failed to establish any statistically significant relation between mean or maximum biochemical oxygen demand, ammonia, nitrate, suspended solids and organic carbon and abundance of either trout or all species, using compatible data for 7 stations for 1986. This result is not altogether surprising because of the log-normal distribution of water quality, the infrequency of sampling and the known relation between water quality and river flow.

A second analysis was therefore carried out using water quality data for 1984-1986. Individual observed values of nitrate and suspended solids were regressed against river flow at Whitford for each of 6 tributaries; the flow in each tributary that was associated with a flow of (an arbitrarily chosen value of) 10 m^3/s at Whitford was calculated from the appropriate equation produced by MRM; and the concentration of nitrate and suspended solids corresponding to that flow was calculated for each tributary using the appropriate regression equation. There was a significant (P less that 0.05) inverse relation between these calculated concentrations of nitrate and the abundance of trout estimated 1986, the equation being:

$$\log y = 0.27 - 2.46 \log x$$

where y = average number of trout/m^2 and
x = concentration of nitrate in mg/l.

The relation for suspended solids was not significant.

This is not to imply that nitrate concentrations per se adversely influence the abundance of trout directly, but rather that water quality characteristics generally related to nitrate are probably involved.

The quality of groundwater in the catchment area varies considerably between locations and within the rather short sampling period to date. The concentration of dissolved oxygen in some samples was low enough to be rapidly lethal to salmonid fish and therefore precautions would need to be take to ensure that it was well aerated before discharge to tributaries where salmonid fish are found. But where the quality of the ground water is shown to be better than that of the surface water to which it is discharged, it could be beneficial to the fisheries, in addition to any benefit likely to be derived from low temperature.

5. SUMMARY

The conclusions already reached about the effects of abstraction from the R. Axe (Alabaster, 1986) remain valid.

In addition, it is concluded that abstraction from the R. Coly should be more conservative than that from the R. Axe.

Furthermore, flow augmentation in the tributaries using ground water is likely to be beneficial to the salmonid populations by reducing maximum summer water temperatures and also, possibly, through the reduction in concentration of undesirable water quality characteristics, provided that steps are taken to aerate the water adequately beforehand, where necessary.

6. REFERENCES

Alabaster, J. S. (1986) Report on Water Resource Development in East Devon: River Axe Fish Study - Evaluation of Fish Movements in the Estuary. July, 1986. 14pp.

Freshwater Biological Association (1986) The Fish Populations of the River Axe Catchment. 23pp. including 2 Figs. & 14 Tables.