REPORT

on

WATER RESOURCE DEVELOPMENT IN EAST DEVON

River Axe Fish Study - Stage 2
Environmental Assessment for River Abstraction
(Supplementary Report)

by

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1. INTRODUCTION

Studies have already been made of the relation between fish catches in the R. Axe and river flow (Alabaster, 1986; 1987; 1989).

The present report deals further with seatrout, as required in July by the South West Water Authority (SWWA), using data made available since my last report in April by the Ministry of Agriculture, Fisheries and Food (MAFF) and SWWA. It should be read in conjunction with all the earlier reports.

2. DATA-BASE

2.1. Catches of seatrout

In addition to the data-base already used (Alabaster, 1986; 1987; 1989), which included monthly data from the Ministry's trap, daily data from MAFF have been obtained for the months of May to September for the years 1962-1966.

Rod licence returns for the the years 1984-1988 have also been received from SWWA.

2.2. River flow

Additional data on daily mean flow in the R. Axe at Whitford for the years 1986-1988 and hourly readings for the period May-September, 1967 have been supplied by SWWA.

2.3. Water quality

Data on water quality in the R. Axe at Whitford Bridge have been provided by SWWA for the period 1986-1988 in the form of daily observations at a frequency of about twice a month.

3. METHODS OF DATA ANALYSIS

Unless otherwise stated, the methods of data analysis are as already described in previous reports.

4. RESULTS

4.1. Distribution of rod-caught seatrout

An analysis has been made of anglers' returns for the R. Axe for the period 1984-1988 when dates and broad location of capture were included, as well as number of fish. A total of 325 seatrout and one salmon was reported. Of the seatrout, most were caught in July (17.5%), August (35.1%) and September (29.8%); in all, 27.7% were caught downstream of the confluence with the R. Yarty (which includes the Whitford area), 15.4% in the R. Yarty, 12.6% upstream of the Yarty confluence and 2.1% in the R. Coly, 42.5% being given no specific location. In terms of the located returns, the percentages are 47.5 downstream of the Yarty confluence, 26.7% in the R. Yarty and 21.9% upstream of the Yarty confluence.

The bulk (21.8%) of the fish caught downstream of the Yarty confluence were taken in August (10.5%) and September (11.1%); they comprised 18.2% and 19.3% respectively, of the total located returns for the season, and they also comprised 47.8% and 83.7%, respectively of the total located returns within each of these two months. However, the bulk of the located returns within each of June and July was in the R. Yarty (43.8% and 43.2%, respectively), although a significant proportion was also found downstream of the Yarty confluence (31.3% and 21.6%, respectively).

Thus, a substantial proportion of the rod-catches of seatrout were taken in the lower half of the river, especially in July, August and September, and might be affected by low water conditions downstream of Whitford.

4.2 River flows at which seatrout were caught on rod and line

In examining daily catches of seatrout on rod and line, the flow on the day of capture has been averaged for each month of each year and compared with the average of the daily flows available each month. These are summarised in Table 1 (the numbers do not match the total catch because dates of capture were sometimes missing).

Table 1. Average daily flows available compared with the average values at which individual seatrout were caught by anglers in the period 1984-1988.

Period	Flow available (m^3/s)	Flow at capture (m^3/s)	Number of fish caught
May	2.66	2.67	8
June	2.35	2.05	20
July	1.75	1.79	54
August	1.86	1.62	105
September	2.16	1.77	91
October	5.38	2.38	24
May-October	2.26	1.81	302

There is a tendency for seatrout to be caught at flows slightly lower than those generally available, especially in September and October. To what extent this is attributable to differences in the catchability of the fish or to selection of conditions by the angler is not known, because fishing effort and blank days of fishing were not recorded. Nevertheless, relatively low natural flows do not appear to have been inimical to successful angling.

It is possible that angling is affected by the concentration of suspended solids (SS) in the water, which tends to increase with increase in water flow. Examination of the relationship between suspended solids and flow, however, indicates that the differences between the concentrations at the flows available and those at the flows at which fish were caught would be small. For example, for flows of 2.26 and 1.81 m^3/s (from the last line of Table 1), they would be 8.6 and 7.6 mg SS/l, respectivley, based upon data for the whole year for the period 1984-1988; and they would be 7.9 and 4.6 mg SS/l, respectively, based on data from only the months of May-September. This suggests that concentration of SS was not a factor affecting the fishing; in any event reduction in flow from water abstraction is unlikely to affect the concentration of SS.

The data for the year 1984, although comprising only 38 fish, have been examined in more detail because flows were then particularly low, the minimum daily value being 0.953 m^3/s on 29 July. The flow when fish were caught was regressed against the average flow available during the month of capture; two relationships were obtained with similar significance ($P = 0.01-0.001$) and standard errors (0.05), although equation 2 is slightly the better:

$$y = 0.4 + 0.59x \quad \text{.......... equation 1}$$

and

$$y = 0.11 + 0.93x - 0.09x^2 \quad \text{.......... equation 2}$$

where y is the flow when fish are caught and x is the mean daily flow, both expressed in m^3/s. The values of y predicted for different selected ambient flows are summarised in Table 2.

Table 2. Flows at which seatrout are caught on rod and line estimated from equations 1 and 2.

Ambient flow	(m^3/s)	Estimated flow for angling success (m^3/s) Equation 1	Equation 2
May-Oct.,1984-88	2.26	1.72*	1.74*
95%ile exceedence	1.2	1.1	1.1
1/8 average daily	0.62	0.76	0.65

* compared with the observed value of 1.81 m^3/s (see Table 1)

These results are in reasonable agreement with those observed for the whole period, and interpolated values are similar for the two equations. The extrapolated value for a flow of 0.62 m^3/s suggests that angling would still be successful at that flow.

4.3. Daily data on trapped seatrout

Numbers of fish

Daily catches of seatrout at the MAFF trap in July and August were categorised as large (40 cm or more in length) and small (less than 40 cm in length). Daily totals were regressed against the average water level utilised by the fish at the trap (for the years 1962-1965) or against the mean daily flow at Whitford (for 1965). Statistically significant results are summarised in Table 3. The predicted values for flows of 1.2 and 0.62 m^3/s for the years 1962-1965 were calculated from the correponding levels using equation 3 in the first report (Alabaster, 1986); data based on measured flow in 1965 are shown in heavy type, and the similarity of the two results for large trout in August, 1965 indicates the general validity of the equation.

Table 3. Regression analysis of daily catch of seatrout at the MAFF trap, 1962-1965 on mean daily water level or (in heavy type) mean daily flow. Predicted catches are shown in parenthesis as a proportion of the relevant observed mean. *, P = 0.05, **, P = 0.01; S.E. = standard error

Type of seatrout	Month	Year	DAILY CATCH Observed mean	Predicted values at flows of 1.2 m^3/s	0.62 m^3/s	S.E.
Large	July	1963**	6.3	2.14(0.34)	2.10(0.33)	19.10
		1965*	4.0	2.90(0.73)	2.60(0.65)	39.00
	August	1962**	3.6	1.26(0.35)	1.28(0.36)	9.50§
		1964*	0.6	0.20(0.33)	0.19(0.32)	1.58
		1965**	1.1	0.74(0.67)	0.73(0.66)	1.26
		1965**	**1.1**	**0.62(0.56)**	**0.61(0.55)**	**1.10**
Small	August	1963*	14.0	5.74(0.41)	5.65(0.40)	85.10
		1965**	**16.7**	**11.50(0.69)**	**11.40(0.68)**	**123.60**

§ 2nd order polynomial.

Catches of seatrout were significantly related to river level or flow for almost half of the year/months examined, most of which related to large seatrout. However, the effect of increase in flow in increasing catches was generally relatively small, as indicated by the similarity between predictions made for flows of 1.2 and 0.62 m^3/s. Also relatively high numbers of fish were predicted to be caught at these low flows, as shown by the predictions expressed as a proportion of the respective observed monthly mean; these range (at 0.62 m^3/s) from 0.33 to 0.65 for large seatrout and from 0.4 to 0.68 for small fish. It should also be noted that the standard error of the estimates is high.

Rate of migration

The rate of migration (in standard deviations per day as described in the previous report - Alabaster, 1989) has been calculated for large and small seatrout for each of the years 1962-1966, and the data relating to July and August, when the lowest flows were generally present, was related to level or flow as was done for numbers of fish in the previous section (Table 3). Statistically significant results are summarised in Table 4.

Table 4. Regression analysis of daily rate of catch (x 100) of seatrout at the MAFF trap in July and August, 1962-1966 on mean daily water level or (in heavy type) mean daily flow. Predicted rates are shown in parenthesis as a proportion of the relevant observed mean. *, P = 0.05; **, P = 0.01; S.E. = standard error; r^2 = proportion of the variance accounted for by the regression.

Type of seatrout	Year	r^2	DAILY RATE OF CATCH Observed mean	Predicted values at flows of: $1.2m^3/s$	$0.6m^3/s$	S.E.
Large	**1962****	0.67	1.9	0.94(0.49)	0.95(0.50)	1.94§
	1963**	0.19	1.8	0.69(0.38)	0.67(0.37)	2.24
	1965*	**0.16**	**1.0**	**0.69(0.72)**	**0.65(0.68)**	**1.83**
Small	1962*	0.32	3.8	1.77(0.47)	1.75(0.47)	10.43
	1963*	0.08	4.3	2.93(0.68)	2.92(0.68)	7.72
	1965**	0.12	3.8	3.70(0.89	3.30(0.86)	9.95
	1965**	**0.24**	**3.8**	**1.92(0.51)**	**1.34(0.35)**	**10.0§§**

§ 2nd order polynomial; §§ log/log.

Again, there are significant, but relatively small reductions in rate with reduction in flow, quite high values at relatively low flows and large standard errors. For most years, only a small amount of the variance is attributable to flow.

Predictions of total monthly catch under different flow conditions

Table 5. Predicted total number of seatrout caught in July and August under different daily flow régimes provided by Mander, Raikes and Marshall. In parenthesis, in heavy type, are values in 1976 and 1984 expressed as a proportion of the corresponding values in 1975 and, in normal type, values for different flow régimes expressed as a proportion of the corresponding historical values (all rounded up)

Year	Historical	FLOW CONDITIONS 22.5Ml/d* $0.6m^3/s$**	22.5Ml/d $0.8m^3/s$	27.5Ml/d $0.6m^3/s$	27.5Ml/d $0.8m^3/s$
Large seatrout					
1975	118	78(0.66)	78(0.66)	74(0.63)	74(0.63)
1976	41**(0.34)**	38(0.93)	40(0.97)	38(0.93)	40(0.97)
1984	82**(0.70)**	65(0.78)	65(0.78)	60(0.73)	61(0.73)
Small seatrout					
1975	979	939(0.96)	939(0.96)	934(0.95)	935(0.96)
1976	901**(0.92)**	898(0.99)	900(0.99)	898(0.99)	900(0.99)
1984	943**(0.96)**	925(0.98)	925(0.98)	921(0.97)	921(0.98)

* abstraction rate; ** minimum residual flow.

The analysis of numbers of fish caught and rates of catch at the trap indicate that these are reduced with reduction in flow, but the total numbers caught over a season will depend, **inter alia**, upon the daily distribution of flows. As a worst case, the total number of fish caught in July **and** August has been calculated from daily catches estimated assuming **causal** relations between daily catch and flow, no interaction between **successive** daily catches and no other factors operating. For this purpose **regressions** for large and small seatrout were recalculated for July and **August**, 1965 combined. The equationns for large and small seatrout **are**, respectively:

$y = 1.49 + 0.29x$ ....equation 4, and

$y = 13.88 + 1.11x$ ....equation 5,

where y **is** the daily catch and x is the mean daily flow in m^3/s. Several **different** distributions of flow that were calculated by Mander, Raikes and **Marshall** (MRM), have been used for the periods July to August 1975, 1976 **and** 1984 – for historical data and also for four distributions resulting **from** minimum residual flows specified at 0.7 or 0.8 m^3/s, each with **either** high or low rates of abstraction (22.5 and 27.5 Ml/d, **respectively**).

The **predictions** are shown in Table 5. Those for historical flows in 1975 (118 **and** 979 for large and small seatrout, respectively) are broadly similar to **those** observed in 1965 (167 and 1088, respectively). Those for small **seatrout** are almost as high in the two drought years of 1976 and 1984 as **they** are in 1975, irrespective of rate of abstraction and minimum residual **flow**, but those of the large seatrout generally show larger predicted **reductions** with abstraction.

For **large** seatrout, the predicted number is generally lowest at the higher rate **of** abstraction and the lower residual flow, but at worst it is still 63% (0.63) of the value for historical flows in 1975 and 73% of the **corresponding** value in 1984 and at least 93% of the corresponding value in 1976, **although** in that latter exceptional year of drought it is much lower of course (34%) than the value for 1975.

It may **be** noted that the effect of the higher rate of abstraction in 1976 is **the reverse**, perhaps, of what one might expect intuitively.

5. SUMMARY

The **daily** catch and the rate of catch of seatrout increase with increase **in river** flow, but the effects are generally moderate in relation to the, **two** minimum residual flows considered (1.2 and 0.62 m^3/s). **Furthermore**, much of the variance is not accounted for by flow.

Assuming simple causal relationships, the impact of a minimum residual **flow** of 0.6 m^3/s and an abstraction rate of 27.5Ml/d would be to have **reduced** trap catches of large seatrout by about 37% in 1975, 27% in 1984 and 7% in 1976 and to have reduced those of small seatrout by no more than 7%.

However, fewer large seatrout were trapped than small seatrout, the ratio of **the** two in 1965, for example, being 1 to 6.5, so that the overall impact on **seatrout** trap-catches (and stocks) would have been less than that for **large** fish. Present stocks probably show a similar biass towards smaller **fish**, judging from some of the returns from the Axe Fly Fishers for 1986-1988. Of 109 fish whose weight was recorded, 102 were less than

2 lbs (mean, 1.02 +0.3 lb) and only 7 were more than 2 lb (mean, 2.95 +1.14 lb). Thus any impact of low flows on stocks of large fish would be expected to be small and unimportant. Rod catches also appear to be successful at relatively low flows.

It is, therfore, concluded that all four abstraction options considered by MRM would not markedly affect the seatrout fisheries and fishing.

6. REFERENCES

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