International Council
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Anadromous and Catadromous
Fish Committee

Some Observations on the Upstream Movements of Adult Atlantic Salmon in the River Conon and the River Meig, Ross-shire

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Introduction

A number of factors such as change in light intensity, wind (Hayes, 1953), water temperature (Menzies, 1931) variations in water flow and tidal phenomena (Hayes, 1953; Harriman, 1961) have been said to affect the entry of salmon into rivers and their subsequent upstream migration. This paper gives an account of observations of the upstream movements of salmon under rather different conditions, as the observations were made in two rivers with controlled flows, due to hydro-electric developments, at points some 12 miles upstream of tidal influence and above a hydro-electric reservoir.

Site

Observations were made on two branches of the Conon River system, Ross-shire. Traps to take all ascending and descending migrants were erected a short distance below the dam on the River Meig and the dam at the foot of Loch Luichart (Figure 1). Each trap consists of a horizontal grid trap for descending fish and a series of holding pools for ascending fish, except that the trap at Luichart in 1967 consisted of a box trap with a V-shaped entrance. Much of the work carried out at these sites has already been described by Pyefinch and Mills (1963) and Mills (1965).

The summer compensation flow at both trap sites is 37 cusecs and this flow continues downstream from the trap site in the River Meig until its confluence with the River Conon. Below the Luichart trap site, however, flow in the River Conon may be augmented by the discharge from Luichart power station a short distance downstream. Water flow from this station during generation averages 1560 cusecs (ranging from 1100 to 2300 cusecs); generation may continue for a day or more or there may be one or more periods of generation in a day, depending on the patterns of precipitation and the power demand.

The flow in the River Conon below the Conon/Meig confluence, during periods when Luichart power station is not generating, is about 75 cusecs. A short distance further downstream the River Conon runs into Loch Achonachie which is essentially the impoundment formed by Tor Achilty dam. The summer compensation flow below this dam is 290 cusecs and this is again augmented during periods of generation at Tor Achilty power Station. During these periods the flow below Tor Achilty dam ranges from 290 cusecs (the minimum generation flow equals the summer compensation flow) to 2500 cusecs, with an average of about 980 cusecs. This information is set out diagrammatically in Fig. 1.

The flows in the river above and below Loch Achonachie may bear no relation to one another and fish ascending the Borland Pass in Tor Achilty dam from flows equivalent to flood conditions may find themselves, on passing out of the impoundment above, in a river with low summer flows. Further, fish in the River Conon both above and below Tor Achilty dam may sometimes be subject to a wide range of flows a number of times in a day, with the water rising to flood conditions and falling away to low summer flows as often as three times in the 24 hours.

Throughout the period 1957 to 1967 all ascending fish have been passed upstream from the Meig trap, after recording their length and sex, while at the Luichart trap all adult fish were returned downstream except in 1961, 1966 and 1967. In 1965 some adults were passed upstream from September onwards. In 1958 and 1959 the fish in the Luichart trap were fin-clipped in a variety of ways before being returned downstream so that they could be identified on re-entering the trap.

Results

Details of the numbers of adult fish passing upstream through the Meig trap in 1965, 1966 and 1967 are given in Table 1 and those for the Luichart trap in 1966 and 1967 are given in Table 2. The limitations on the length of this report made it necessary to select only part of the data available. The records given for Meig were selected because the largest upstream runs occurred in 1965-67 and the selection for Luichart was made for this reason and because all upstream migrants were passed on upstream in 1966 and 1967.

A preliminary inspection of the data on air and water temperature, barometric pressure and rainfall does not suggest the likelihood of any close correlation between these factors and the upstream migration of adult fish; a fuller analysis is now being made and the results will be published separately. There was, however, some indication that most fish entered the traps during wet weather when there was some run-off from the surrounding land.

Because the water flowing downstream through the traps was regulated, rainfall did not result in a rise in water level either at Meig or Luichart, but attempts were made at Meig, by arranging artificial freshets, to ascertain whether an increase in water flow stimulated upstream movement. During the period of the freshets the flow over the trap was increased from the standard flow of 37 cusecs to a maximum of 121 cusecs over a series of twelve hour periods then decreased again in the same way. The experiments were arranged so that one of the twelve hour periods for each speed of flow occurred during the night and the other during the day. (Here it should be noted that, although fish entered the traps during the hours of daylight and darkness, the Lethlean fish counter at the entrance to the Borland pass upstream of the Meig trap recorded no activity during the hours of darkness.) There was no correlation between the rate of flow in these artificial freshets and upstream movement. Hayes (1953) working on the La Have River, also found that artificial freshets had little effect on upstream movements compared with the effects of rain.

The observations made at the Meig trap therefore showed, (a) that there were considerable variations in the numbers of fish entering the trap over the season, although water flow was constant and (b) that if the water flow were varied, there was no detectable effect on upstream movement, or least over flows ranging from 37 to 121 cusecs.

Because fish were not allowed to pass upstream from the Luichart trap, this provided an opportunity to study another aspect of upstream migration, namely the variation in the degree of persistence shown by fish moving upstream. In the years when the adult fish were fin-clipped and returned downstream the dates and number of times individual fish re-entered the trap were recorded. It was found that many of them re-entered the trap during subsequent weeks and that some fish re-appeared several times. The detailed records are given in Tables 3, 4 and 5 and these records also show that there is some increase in the persistence of upstream movement, particularly in male fish, as the season progresses.

Discussion

Although it has been found that spates may influence upstream movement of fish present in tidal waters (Menzies, 1931, Hayes, 1953), the results presented in this paper suggest that high flows have no detectable effect when fish are in the river system itself and above tidal influence.

However, when Luichart power station is generating the river flow a mile downstream of both the Meig and the Luichart traps may vary considerably. It is not known what effect this might have on ascending fish, and how long this effect lasts after the fish have moved out of it and into the lower compensation flow.

When Luichart power station is operating the flow from the River Conin is much greater than that from the Meig and this might result in more fish moving upstream into the stronger flow past the confluence of the Meig with the Conon.

In addition some of the water from the Meig is diverted into the Conon through a tunnel from Meig reservoir to Loch Luichart. If upstream migrants respond to characteristic tastes or odours in the water (Hasler, 1954; Hasler and Wisby, 1951; Wisby and Hasler, 1954) and as the Conon contains varying amounts of water from the Meig this might be an added incentive for Meig fish to 'stray' up the Conon, although the 'taste' must always be stronger in the water from the Meig.

Recaptures during 1967 of smolts tagged at the Meig trap in 1966 suggest that there is very little straying. A total of 5040 smolts was tagged in 1966 and 1.6% of these were recaptured as grilse in 1967. Of these recaptures 95% were made in the Meig trap and only 5% in the Luichart trap.

The observations described in this paper show that fish will move upstream under low flows and, even when hindered in their ascent, will continue to persist in their movement upstream, particularly near spawning time. The situation is, however, complex because though flow conditions at the two trap sites were virtually stable over nearly all the period of the upstream run, conditions were more variable short distances downstream. Climatic changes during the period of the runs and conditions at the mouth of the river system, which could have a marked effect on the entry of fish, complicate the position further. It would be unwise, therefore, to attempt to draw any wide reaching conclusions from these observations.

Summary

1. Observations were made on the movements of adult salmon at traps on two rivers with controlled flows, due to hydro-electric developments, both situated some twelve miles upstream of tidal influence and above a hydro-electric reservoir.

2. The percentage of the total run of fish ascending each of the two rivers over the same two-month period each year was approximately the same.

3. Although a correlation does not seem likely between the upstream movement of adult fish and either air and water temperature barometric pressure or rainfall, there was some indication that most fish entered the traps during rainy weather.

4. It was found that artificial freshets over a limited range of water flows, had little effect on upstream movements of fish.

5. Fish entered the traps during the hours of daylight and darkness, although a fish counter mounted upstream of the trap recorded no activity during darkness.

6. When adult fish were marked and returned downstream of the trap many of them re-entered the trap during subsequent weeks, some re-appearing several times. There was also some increase in the persistence of upstream movement towards the spawning season.

7. Although large stream flows in one branch of the river might have influenced ascending fish to 'stray', this was not supported by the results of tagging experiments.

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TABLE 1

Numbers of adult fish passing upstream through the Meig trap, 1965-67

Month	10 day period	1965		Year 1966		1967	
June	1	2		5		12	
	2	4		10		12	
	3	14		18		13	
July	1	4		10		7	
	2	14		18		32	
	3[a]	63 (7.6))		52 (9.4))		79 (9.4))	
August	1	110 (13.2))		64 (11.6))		85 (10.1))	
	2	83 (10.0))	80.6%	88 (16.0))	80.2%	119 (14.2))	83.1%
	3[a]	262 (31.6))		63 (11.4))		134 (16.0))	
September	1	102 (12.3))		101 (18.4))		48 (5.7))	
	2	49 (5.9))		74 (13.4))		232 (27.7))	
	3	67		29		35	
October	1	42		10		15	
	2	13		3		10	
	3[a]	0		4		2	
Total		829		549		835	

[a] 11 day period

Figures in brackets denote percentage of total run

TABLE 2

Numbers of adult fish entering the Luichart trap, 1966-67

Month	10 day period	Year 1966		Year 1967	
June	1	0		Trap not in operation	
	2	1		Trap not in operation	
	3	12		2	
July	1	0		7	
	2	1		7	
	3[a]	18 (7.8))		48 (8.7))	
August	1	14 (6.0))		28 (5.1))	
	2	22 (9.5))		51 (9.3))	
	3[a]	8 (3.4))	62.7%	70 (12.7))	69.2%
September	1	66 (28.7))		92 (16.8))	
	2	17 (7.3))		91 (16.6))	
	3	5		36	
October	1	38		67	
	2	4		40	
	3[a]	24		8	
Total		230		547	

[a] 11 day period

Figures in brackets denote percentage of total run

TABLE 3

Numbers of adult fish marked at Luichart trap in 1959 and released downstream and their subsequent re-entry later in the season

Month of marking and release downstream	No. of fish marked	Month of Re-entry and No. of marked fish re-entering trap					
		June	July	Aug.	Sept.	Oct.	Nov.
June	2	0	0	0	0	0	0
July	44	-	0	24	5	12	0
August	122	-	-	9	13	33	3
September	28	-	-	-	2	7	0
October	64	-	-	-	-	7	4
November	10	-	-	-	-	-	1

TABLE 4

Number of times individual marked fish re-entered Luichart trap, 1959

No. of times re-entering	No. re-entering in: August	September	October	November
1	25	13	41	5
2	7	3	11	?
3	1	2	3	0
4	0	2	1	0
5	0	0	3	0
6	0	0	0	1

TABLE 5

Number of males and females marked at and re-entering Luichart trap, 1959

Sex	No. marked							No. re-entering trap					
	June	July	Aug.	Sept.	Oct.	Nov.	Total	July	Aug.	Sept.	Oct.	Nov.	Total
Females	0	20	49	13	14	3	99	0	16	12	15	0	43(43.4)
Males	2	24	73	15	50	70	171	0	18	13	61[a]	10	102(59.6)

[a] Some of these fish could not be assigned an original date of marking because the mark had become obscure. Therefore these fish do not appear in Tables 4 and 5.

FIG. 1 WATER FLOWS IN THE CONON RIVER SYSTEM