Environmental influences on the patterns of behaviour of anadromous salmonids during the holding phase of upstream migration

Cefas

A. M. Walker, P. Davison, B. Bendall and G. Fenwick
Centre for Environment, Fisheries & Aquaculture Science, Lowestoft
www.cefas.co.uk

Introduction

Upstream migration of adult Atlantic salmon involves three phases: migration, searching and holding.

We know little of their experiences and behaviour during the holding phase, despite this accounting for perhaps >75% of their stay in freshwater (Tyne salmon 2005-2006: pers. obs).

Given finite energy resources, we might expect fish to minimise activity during the holding phase.

However, here we describe regular and consistent movements of salmon holding in large pools of the River Tyne, England, which are derived from a large-scale salmon and sea trout tracking programme.

Methods

Salmon were caught at sea, internally tagged with Vemco V13TP acoustic transmitters (pulse interval 20 to 40 sec) and released (Figure 1).

Upstream migrations and in-pool activities were monitored with strategically placed VR2 receivers (detection range 50-150 m).

River temperature was recorded by Tinytag instruments every 10 min. Daily mean flows (cumecs) were provided by the Environment Agency.

Figure 1: Atlantic salmon captured in the estuary of the River Tyne, England.

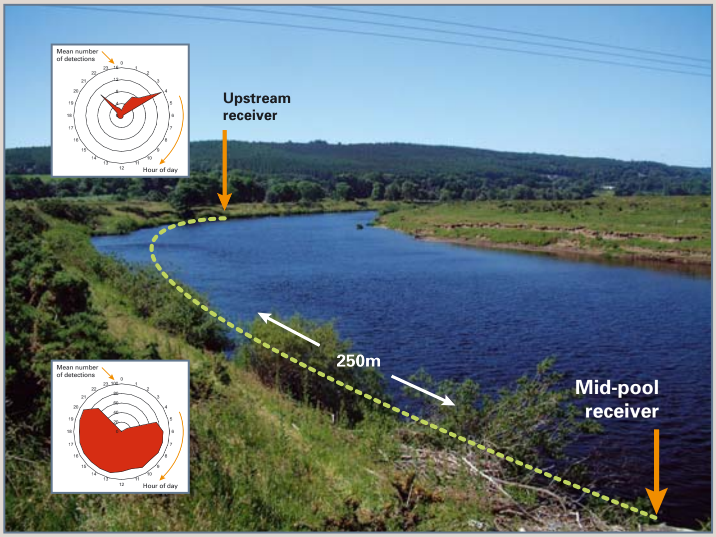

Figure 2: Positions of two VR2 receivers in the holding pool occupied by a tagged salmon in 2005. Insets show the distribution of transmitter detections over a 24 hour period at mid-pool and upstream receivers during study period.

Results

In **2005**, a male salmon (86 cm FL) occupied a holding pool 21 km from the estuary between 12th July and 14th August. The pool is 1400 m long, with mean width 66 m, mean depth 1.6 m, and max. depth 3.6 m.

The fish was detected by the mid-pool receiver during daylight every day (Figure 2), but then either:

1. Moved beyond the upstream receiver towards the head of the pool in late evening (mean 9 minutes after sunset: $P<0.001$, $r = 0.88$, n = 16) before returning in the early morning (mean 15 minutes before sunrise: $P<0.001$, $r = 0.88$, n = 16). This occurred for 12 days consecutively and for 18 days in total, coinciding with summer level river flow (mean 7.3 cumecs) and high temperatures (mean 18.4 °C); or

2. Remained between the two receivers or close to mid-pool throughout the 24h period. This occurred up to 7 days consecutively and for 13 days in total, coinciding with peaks in flow (mean 13.9 cumecs) and minimum water temperatures (mean 16.0 °C).

The minimum in-pool distance travelled during this period was estimated at 19.6 km. In comparison, distance from estuary to spawning location was 63 km.

In **2006**, a male salmon (70 cm FL) with a depth sensing transmitter occupied a holding pool 20 km from the estuary between 16th June and 20th October. The pool is 600 m long, with mean width 77 m, mean depth 1.5 m, and max. depth 5.4 m.

Although the fish remained within the detection range (~75 m bankside) of the mid-pool VR2 throughout the 124 days, regular changes in depths provided further evidence of circadian behaviours.

Periods when the fish occupied specific depth ranges at different times of the day and night lasted for between 3 and 26 consecutive days, and accounted for 78 of the 124 days (Figure 3).

Over 23 days from 5th August to 26th September, the fish typically moved to shallow depths (mean 1 m) in the evening (mean 32 min before sunset, $P<0.001$, $r = 0.93$, n = 23) and returned to deeper water (mean 3.9 m) in the early morning (mean 51 min before sunrise, $P<0.001$, $r = 0.98$, n = 23).

This pattern was absent during and soon after periods of higher flow and lower water temperatures, when the fish was continuously recorded at shallow depths (Figure 4).

Three other salmon (male and female) in different holding pools displayed similar consistent depth utilisation behaviours over this period.

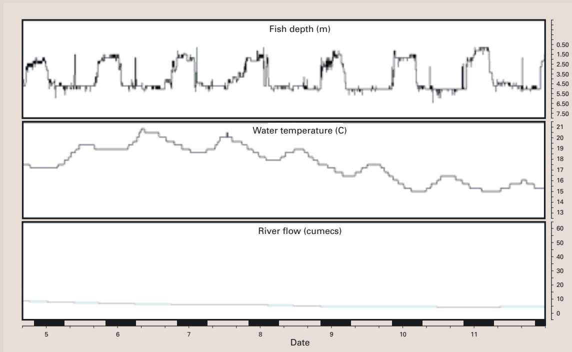

Figure 3: Circadian patterns in depth utilisation of a tagged fish from 5th to 11th August 2006, along with water temperature and river flow measures. Black bars along x-axis represent periods of darkness.

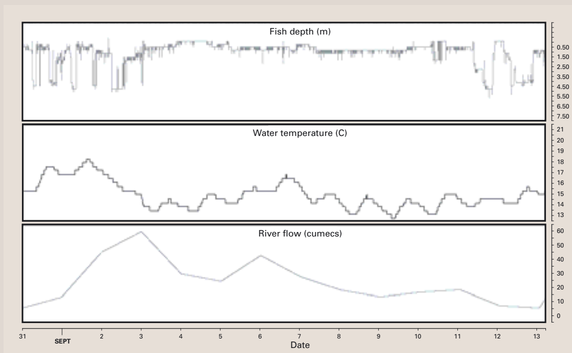

Figure 4: Cessation of circadian pattern of depth utilisation coincided with peak in river flow and low water temperatures.

Conclusions

These results demonstrate that adult salmon in holding pools can make regular and sometimes extensive in-pool movements during this so-called 'resting' phase.

Behavioural patterns appear to be influenced by flow and/or thermal regimes, although the two environmental factors are linked and distinguishing between them is difficult.

alan.walker@cefas.co.uk