Groundwater influence in hyporheic zones: a key control on site selection for Atlantic salmon spawning in a braided river system?

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1. INTRODUCTION

- Over the past 30 years the numbers of Atlantic salmon (*Salmo salar* L.), spawning in Scottish headwater streams has declined. Conservation measures to protect this species have focused on preserving the integrity of their upland spawning sites. Discrepancies exist between predicted available spawning habitat derived from suites of hydraulic and sedimentary variables and those favoured by spawning salmon. These differences may be due to the physiochemical characteristics of the hyporheic zone within the spawning gravels.
- This study investigates the physiochemical influence of ground water- surface water interactions occurring within specific channel types on redd site selection.

2. OBJECTIVES

- To identify the sources and flowpaths of waters entering a highland braided system and to separate reaches into channel types based on their physiochemical characteristics.
- To observe if in fluvial systems where habitat availability is high, do salmon actively seek to spawn in channels where the hyporheic zone is dominated by ground waters.

Figure 2: Spawning Atlantic salmon (G. V. Ryckevorsel)

- To correlate spawning site selection to any spatial patterns of water quality across the braids.

3. STUDY SITE

- The Glen Feshie Braids, the biggest braided river system in the UK (Figure1).
- An Atlantic salmon and Sea trout (*Salmo trutta*) spawning tributary of the river Spey Cairngorm Mountains, Scotland (Figures 2&3).

Figure 3: Location of Feshie

- Catchment area is 231 km^2, study area: 3.5 x 3 km.
- Altitudinal range of 230 – 1115 m.
- The complex network of alluvial channels facilitates extensive groundwater-surface water exchange giving rise to high levels of spatio-temporal variation in hyporheic water quality within spawning gravels.

4. METHODOLOGY

- April-May 2005, every channel of the braids was walked, sedimentary and hydraulic variables noted and a detailed GPS/ Arcview map of habitat suitability was constructed (Figure 4).
- During Summer 2005 - Spring 2006 intensive hydrochemical surveys of the braided system were carried out using natural tracers; trace metals, dissolved oxygen (DO) and Gran alkalinity, temperature and chloride.
- PCA and Ordination analysis was used to see if there was any obvious clustering of channel types based on physiochemical parameters.
- During spawning season October – November 2005, every channel was walked daily and redds were recorded using GPS.
- Post spawning hyporheic water quality sampling devices were inserted 30cm into the hyporheic zones of spawning and non-spawning sites and a series of water quality samples were collected (Figure 5).

Figure 4: Mapping channel types

Figure 5: Installation of hyporheic water sampling equipment

Figure 1: The Feshie Braids

5. RESULTS

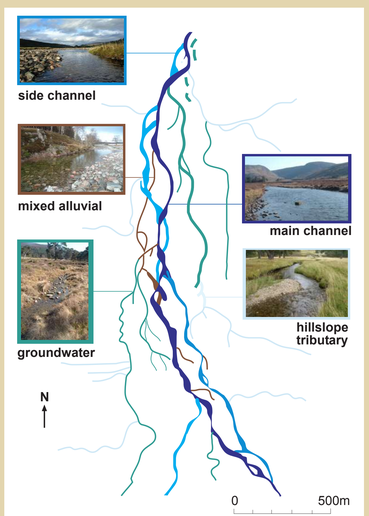

Figure 6: Channel types in Feshie Braids

- Results from the April - May habitat survey of the braids showed habitat suitability across the braids to be high.
- Five main channel types were recognisable: main river channels, side channels, hillslope tributary streams, mixed alluvial and groundwater (Figure 6).
- The hydrochemical surveys showed that there was considerable variation in groundwater surface – water interactions across the floodplain channels (Figure 7).
- 220 redds were recorded. Of these 81.4% occurred in groundwater channels, 10% in hillslope tributaries, 3.6% main, 3.6% side, and 1.4% in mixed alluvial channel types (Figure 8).
- Clustering and superimposition of redds occurred in areas of strong upwelling groundwaters.
- Water quality data from the hyporheic samplers showed that there were marked differences in levels of DO, Gran Alkalinity and temperature between channel types.

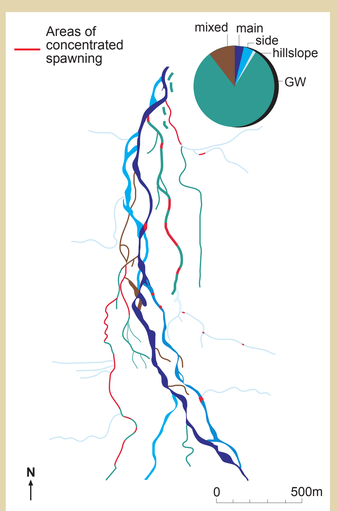

Figure 8: Key spawning sites

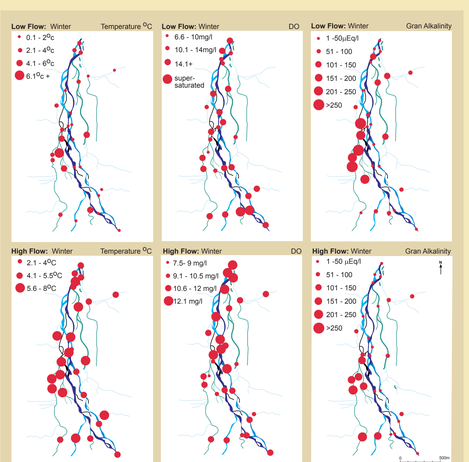

Figure 7: An example of two hydrochemical surveys which show temperature, DO and Gran Alkalinity variability to be high across the braids

6. CONCLUSIONS

- Different types of groundwater-surface water exchange occurs across the 5 channel types of the Glen Feshie Braids producing high levels of spatio-temporal variation in hyporheic water quality within spawning gravels.
- Despite high levels of spawning habitat availability across the whole of the braids, 81.4% of the Atlantic salmon still choose to spawn in locations which displayed strong groundwater signatures.

7. FUTURE WORK

- Repeat redd counts across the braids during spawning season 2006.
- Excavation of a number of redds to examine juvenile/egg survival.
- Implantation of egg chambers equipment with water quality measuring devices into the hyporheic zone of known groundwater dominated spawning sites.

FISHERIES RESEARCH SERVICES

Thanks to Glen Feshie Estate

NATURAL ENVIRONMENT RESEARCH COUNCIL