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

1. INTRODUCTION

Over the past 30 years the numbers of Atlantic salmon (Salmo salar) spawning in Scottish headwater streams has declined. Conservation measures to protect this species have focused on preserving the integrity of their upland spawning sites. Discontinuities exist between predicted available spawning habitat derived from suites of hydraulic, sedimentary and hydrochemical variables and the actual spawning sites of salmon. These differences may be due to the physicochemical characteristics of the hyporheic zone within the spawning gravels.

This study investigates the physicochemical influence of groundwater-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 with channel types based on their physicochemical characteristics.
- To observe if in fluvial systems where habitat availability is high, do salmon actively seek to spawn in channels where groundwater dominates by groundwaters.
- 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 (Figure 1).

4. METHODOLOGY

- April-May 2005, every channel of the braids was walked, water quality and hydraulic variables noted and a detailed 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 to examine water exchange and biochemical conditions. PCA and Ordination analysis was used to test if there was any obvious clustering of channel types based on physicochemical patternings (Figure 5)
- During spawning season October – November 2005, every channel was walked and reds were recorded using GPS.
- Post spawning hyporheic water quality sampling devices were inserted 200m into the hyporheic zones of spawning and non-spawning sites and a series of water quality samples were collected (Figure 9).

5. RESULTS

- 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, hillside 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, 10.2% in hillside tributaries, 3.6% main, 3.6% side, and 2.9% in mixed alluvial channel types (Figure 8).
- Clustering and superimposition of redds occurred in areas of strong spawning 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.

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 81-83% of the Atlantic salmon still choose to spawn in locations which displayed strong groundwater signatures.
- Different types of spawning habitat availability across the whole of the braids.
- Excavation of a number of reds to examine juvenile/egg survival.
- The implementation of egg chambers equipment with water quality measuring devices into the hyporheic zone of known groundwater dominated spawning sites.

7. FUTURE WORK

- Repeat redd counts across the braids during spawning season.
- Implementation of egg chambers equipment with water quality measuring devices into the hyporheic zone of known groundwater dominated spawning sites.

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**Table 1:** Water quality parameters across the 5 channel types of the Glen Feshie Braids producing high levels of spatio-temporal variation in hyporheic water quality within spawning gravels.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Main Channel</th>
<th>Side Channel</th>
<th>Mixed Alluvial</th>
<th>Groundwater</th>
<th>Hillside Tributary</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO (mg/l)</td>
<td>5.6 - 8°C</td>
<td>4.1 - 5.5°C</td>
<td>2.1 - 4°C</td>
<td>0.1 - 2°C</td>
<td>2.1 - 4°C</td>
</tr>
<tr>
<td>Gran Alkalinity (Eq/l)</td>
<td>&gt;250</td>
<td>151 - 200</td>
<td>101 - 150</td>
<td>51 - 100</td>
<td>&gt;250</td>
</tr>
</tbody>
</table>

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**Figure 1:** The Feshie Braids