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Hydrology and Earth System Sciences Discussions

Interactive comment on "Variability in stream discharge and temperatures during ecologically sensitive time periods: a preliminary assessment of the implications for Atlantic salmon" *by* D. Tetzlaff et al.

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General comments:

This reviewer clearly has the erroneous impression that the paper intends to compare how data of different temporal resolution may affect our understanding of biophysical influences on the hydroecology of streams. From the misleading way in which the introduction in the original manuscript was written, we understand why he/she developed this impression. Reviewer 3 was also confused in this manner, though he/she recognises that this issue diverts attention away from the main innovation in the paper - i.e. looking at tools for examining hydroecological associations for juvenile salmonids and returning spawners. The main point which we wish to emphasize regarding data resolu-

tion is that many of the approaches suggested as tools for river management (e.g. setting Ecologically Acceptable Flows) are based on averaged data (e.g. weekly, monthly), which would be insufficient to assess the role of short-term hydrological/thermal dynamics in aquatic ecosystems where Atlantic salmon are an important target species. Also, we would argue that the flow data/velocity estimates that we have are not especially rare. They can be derived from any standard gauging station. Temperature data are much less common, but the most unique aspect of our data (recognised by reviewer 3) is that it represents paired physical and biological data sets. Thus it is the insight as to how short-term dynamics may affect - for example - juvenile feeding opportunities or spawning entry to the study stream that we seek to explore more fully in this paper. We think that such short term understanding needs to be factored into river management strategies for salmon rivers, though - as we acknowledge, and the reviewer recognises - this study represents only preliminary steps along this path. We have clarified our objectives more clearly now in the manuscript and further underlined the preliminary nature of this work, but re-emphasised the importance of such longer-term, paired physical-biological data sets and the need to glean information and understanding from them.

Specific comments:

We have stream lined and clarified the introduction now. It contains less “jargon” and links the background context more clearly to the papers objectives. Regarding issues of data resolution that the reviewer raises these have now been clarified in the methods section. Our original description of how the temperature data were in-filled was unclear; hourly data were used to infill missing data, but the regression equations were developed for individual months (as noted in the response to reviewer 1 above). Also, although our temperature data were collected for a tree-lined section of the catchment; data analysis of spatially distributed temperature loggers have revealed that spatial variations in thermal regime are extremely limited and mainly occur during uncommon, extremely hot conditions when river flows are low (Malcolm et al., 2004). This has in-

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significant implications for the issues of Critical Displacement Velocities. We clarify the justification for our use of one gauging station in response to the comments of reviewer 1 and it is now clearer in the text.

Technical Corrections:

1/2/3/4/5/ Text is modified and more precise. 6. It means, tools and approaches with an ecological context and not just based on engineering design criteria. 7./ 8./9./10/11 Introduction is widely modified. Longer means “monthly” or “yearly”. 12. Rationale is given in methodology section, text in introduction modified and more precise. 13. Text is modified and more precise. 14. Correspondingly in the manner of hydrological and thermal (as said in text). More consistence in referring to Atlantic salmon throughout the manuscript. 15. Smaller than areas of moorland. 16. The authors think that the number of quoted papers and the data sets that they contain allows the term “extensive” to be used in a common sense way. 17. Results and data set relating to hydrology (i.e. different time series, parameter), water quality and geomorphology exist. We want to refer to this literature to direct interested readers to background information. Explaining all parameters within these studies is not directly relevant to this paper. We do not think it is unreasonable to expected interested readers to refer directly to the listed literature for further details. 18. Please see General Comment response to Reviewer #2. 19. The rationale for the periods is now given in the method section (as suggested by Reviewer#3). 20. Text is modified, please see in methodology section. 21. Please also see the responses to Reviewer #1. The gauging was carried out by the Scottish Environment Protection Agency (SEPA) and kindly provided for this study. These gauging are conventionally measured at 0.6 of the depth and this might masks differences in absolute hydraulic conditions. However, this is acknowledged in the methods and discussion section and does not detract from the papers aim of deriving hydraulically meaningful measurements from a pre-existing data set. We recognise that calculation of velocity based on empirical, readily available discharge data is very much a first approximation and relatively simplistic representation of the complex velocity fields that

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will occur in a river such as the Girnock. But the objective of the presented study was to capture temporal variability in flow conditions. In this sense, we view the Littlemill data as being a useful indicator of temporal variability of conditions in the rest of the river system. Of course we recognise that hydraulic conditions will differ in different channel types as the reviewer comments. This is now much more clearly stated in the method section. To represent the range in spatial variability within a whole catchment, high spatial resolution data would need to be collected which would be a major undertaking. Moreover, at most sites even moderately high flows could not be gauged safely. Thus, the authors are convinced that the approach presented is a valuable method in deriving ecologically meaningful insights from hydrological data sets particularly by focussing at this stage on temporal variability in ten hydrologically contrasting years. 22. +/- errors 23. Text is now modified. 24. Correspondingly = unable to hold station and constraints in feeding opportunities. 25. Please see responses to Referee #1, General Comments 4 and revised methodology section regarding using flume-based data. 26. Text is modified. 27. Methodology of estimated growth is now summarised in the methods section. It is fully explained and growth curves are given in given reference, Tetzlaff et al, 2005, Hydrobiologia (In press). Also see response to Reviewer#1 (point 19). 28. Text is modified. 29. We think the scientific readership in a hydrology journal with less biological background might find this summarised information as helpful. 30. Text is modified. 31. Text is modified. 32. Flow duration curves are conventionally used in hydrological publications to show inter- and intra annual variability. 33. Sentence is re-worded. 34. Text is modified. 35. Text is modified. 36. Expresses the low rate of change in discharge during this period thus indicating flow stability. Text is modified. This is a result, therefore written here instead of in methods. 37. As explained in the study site section, discharge is calculated from a calibrated section of the river using standard flow velocity cross-section methods, monitored by SEPA. Such high discharges ($>$ 50 m3 s-1) are impossible to gauge accurately (due to safety legislation constraints) and are therefore calculated using stage-discharge relation with a higher uncertainty than lower discharges, where velocity measurements (and this gauging) is

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possible. 38./ 39./ 40. Text is modified. 41. More variable than the mean temperatures. 42. This is clearly for the results section and information about variability in stream temperature, are needed for understanding of thermal conditions. Exceedence curves are conventionally used in hydrology, therefore the we think that there is no need for any further explanation in (the already lengthy) methods section. 43./44. Text and Figure is modified. 45./46./47. Text is modified. 48. We also report on 0+ fish. See also changes in Figure 8. 49. The authors think figures show the results clearly and it seems unnecessary to repeat in the text what is clear in the figure. 50. We are unclear as to what exactly the reviewer means with this point. The CDV is based on the flume relationship established by Graham et al. (1996). It is a dynamic parameter on daily time steps, as velocity, temperature and fish length change. 51. Our use of CDV is aiming to apply it as an index as to when fish movement may be affected. Of course in the absence of detailed behavioural studies beyond the scope this paper we don't know of the biological relevance directly. As now stressed in the text and noted in the response to Reviewer #1, we were simply inferring it on the basis of reasonable assumptions. 52. The differences are evident from the results (calculated percentage of time when mean stream velocity exceeds CDV) in table 3. 53/54/55/56 Text was modified. 57. Text changed and p value added. 58. We didn't re-analyze the data as noted above, this analysis focussed on "sensitive" periods (the reasons for this are given already in introduction and methods). The authors' opinion was and is that the analyses of the whole hydrological year shows that this results in overly simplistic results. We wanted to highlight that approaches which are still common in many eco-hydrological studies are not satisfying. 59. As noted several times above CoV is an index of complex temporal variability in flow. This is now clarified in the methods. 60./61 Text was modified. 62. Figure 9 has been changed as requested. 63. Our point is that extreme hydrological years (i.e. when flow conditions are highly variable in 1995/96, or not variable (1997/98)) have the most marked influences on spawning access. Thus it seems meaningless to take these data points out of the analysis. Please see also the responses to Reviewer #1, General Comment 5. 64. The text has been modified. 65.

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Interactive Comment

Figure 10 was not originally so small, but was changed within the format process of the EGU production office (to reach standard format). We also think that showing the discharge plots gives important information about the nature of hydrological conditions during this time period. Figure 10 shows clearly the high natural variability in hydrological conditions in relation to spawning. 66. Text is modified. 67. Local adaptation is not revealed through rigid stereotyped behavior but through the modification of the same driving mechanisms to match local variations in environmental conditions. Applicability is therefore likely general, even in the presence of local adaptation, since we are considering the mechanisms. 68. Text is modified and now more clearer. 69/70 Text is modified. 71. Text is more precise. 72. Lower than average. Clear in context. 73. Text has been modified to show that “short-temporal” scale variations in flow that have the main influence. 74. Text has been modified. 75. Text is changed and moved to results. 76/ 77. Text is modified. 78. Discussion has been modified to more properly reflect the objectives of the paper. 79. Text is modified.

Tables and Figures:

80. P values are listed now. Number of samples = 10 hydrological years were basis. 81. Figure 2 has been changed as requested. 82. Figure 6 has been changed as requested.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 691, 2005.