Hydraulic and geomorphic effects of placed large wood structures. A two-year case study.

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Introduction

Purposely placed large wood structures (LWS) of a variety of complexity and degree of engineering, have been installed to enhance the habitat of Atlantic salmon (Figure 1). The evidence surrounding the effects of LWS is currently lacking, however.

Figure 1 A lateral, bank attached LWS (LWS2) shortly after installation.

Through repeated drone surveys spanning a two-year period, this case study sought to evaluate the geomorphic and hydraulic effects of nine LWS on a reach of the River Gairn (Figure 2, Table 1). Over the monitoring period, two large flood events occurred (Figure 3) resulting in localised morphological changes. This allowed a short-term assessment of the direct and indirect hydraulic effects of LWS.

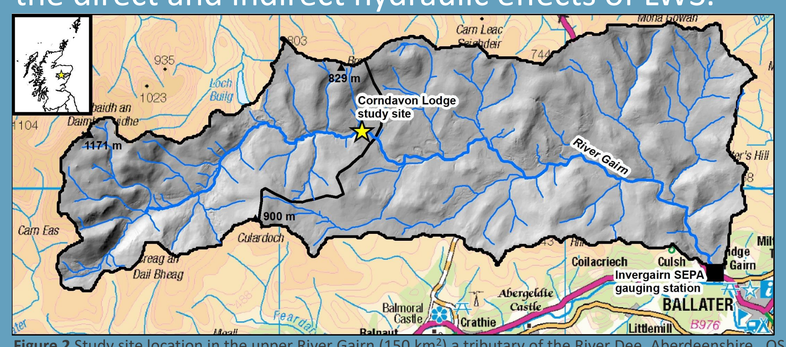

Figure 2 Study site location in the upper River Gairn (150 km²) a tributary of the River Dee, Aberdeenshire. OS map data copyright and database right The James Hutton Institute (2025). Used with permission of the James Hutton. All rights reserved.

Table 1 Study site characteristics.

Catchment area (km²)	47
Reach length (m)	1103
Sinuosity (-)	1.05
Channel bed slope (m/m)	0.01
Mean bankfull channel width (m)	16.1
D_{50} (mm)[1]	114.3
Q_{MED} (m³/s)[2]	17.9
Q_5 (m³/s)[3]	3.1

[1] Median particle size of active riverbed surface based on six pebble counts.
[2] Median annual peak discharge based on catchment area scaled value from SEPA Invergairn gauging station (NRFA station mean flow data for 12006 - Gairn at Invergairn).
[3] 5th percentile discharge based on catchment area scaled value from SEPA Invergairn gauging station.

Figure 3 Stage record at the study site over the period October 2019 to November 2021.

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Heggenes, J., Bagliniere, J.L. and Cunjak, R.A., 1999. Spatial niche variability for young Atlantic salmon (Salmo salar) and brown trout (S. trutta) in heterogeneous streams. Ecology of freshwater fish, 8(1), pp.1-21.

Methods

- SfM photogrammetry methods were used to create DEMs of the study reach using drone aerial imagery acquired on three dates (Table 2).
- HEC-RAS (v6.6) used to model in 2D the hydraulic effects of LWS as represented by the DEM terrain.
- RTK-GPS surveys and flow gauging undertaken to check the validity of DEMs and hydraulic model outputs (Table 2).

Table 2 Survey DEM and model quality evaluation statistics.

Survey	DEM RMSE (wet riverbed)	DEM RMSE (dry gravel)	Calibration model discharge (m³/s)	Observed-modelled depths RMSE	Observed-modelled velocities RMSE
Pre-LW (Sept. 2019)	0.16	0.03	0.97	0.05	0.14
Post-LW (Oct. 2019)	0.24	0.05	1.07	0.14	0.13
Post-LW +2 yrs (Aug. 2021)	0.11	0.05	1.09	0.06	-

Results

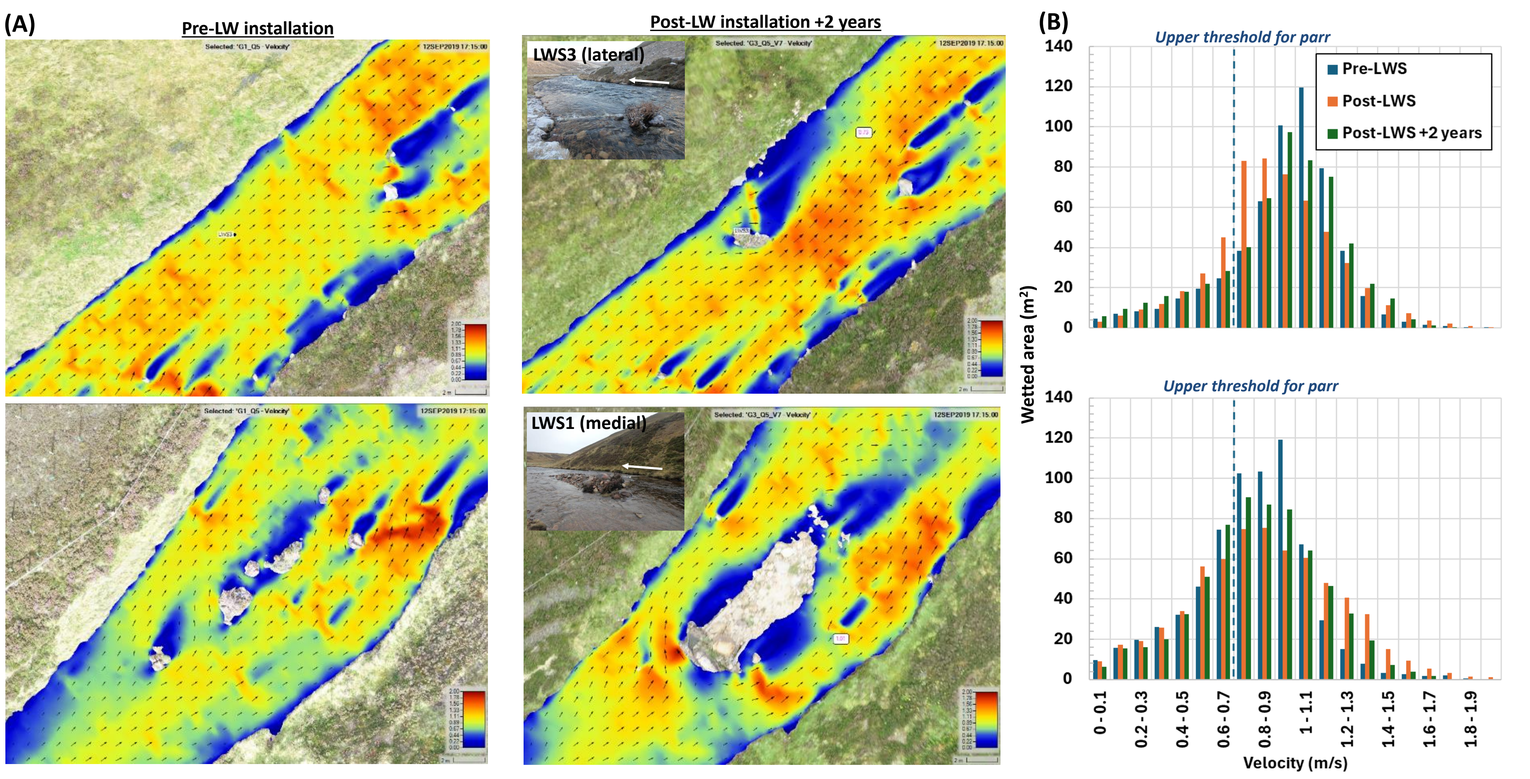

Figure 4(A) Modelled depth averaged water velocities and vectors before and after LW installation for a Q_5 flow (3.1 m³/s). **(B)** Corresponding velocity distributions for each condition relative to theoretical high velocity tolerance threshold for Atlantic salmon parr of 0.7 m/s (based on velocity tolerance range of Heggenes et al. 1999).

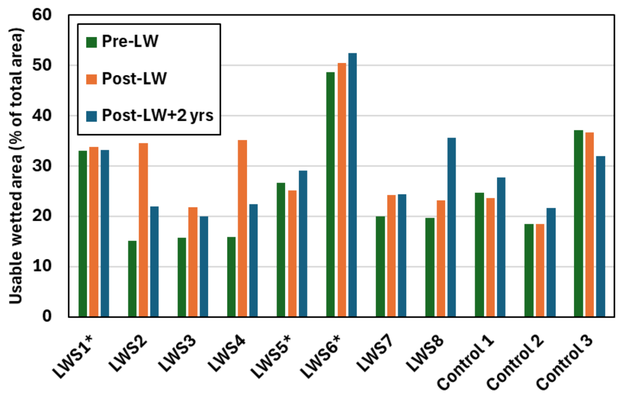

Figure 5 Modelled proportional areas of wetted channel with theoretical tolerable velocities for parr. * denotes medial structures.

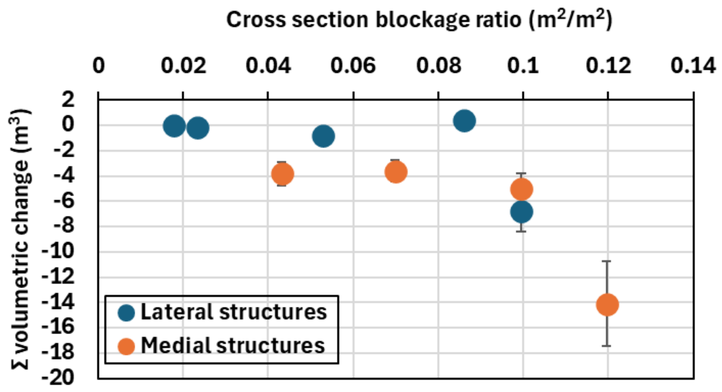

Figure 6 Relationship between frontal LWS cross section bankfull blockage ratio and net morphological change.

Figure 7(A) DEM of difference results for post-LW +2 years minus pre-LW installation. **(B)** Corresponding erosion and deposition volumes for each structure and control area. * denotes medial structures.

Initial findings

- For a Q_5 flow, the structures locally diverted velocities and created slack water areas (Figure 4). Change in usable habitat area for juvenile fish was variable, greater for lateral structures and on average increased by 5.6% after two years (Figure 5).
- Net morphological change was uniformly erosional but often subtle, change was higher for medial structures compared to lateral structures and increased with greater blockage ratios (Figure 6 & 7).
- Further work will explore hydraulic patterns in relation to morphological change and consider different flows.