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Salmon as drivers of physical and biological disturbance in river channels

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Large migrations across landscapes and ecosystem boundaries combined with disturbances of riverine spawning habitats through nest construction indicate the huge potential that Pacific salmon (Onchorhynchus sp.) have to disturb and alter regional energy flow. Nutrients derived from ocean-reared dead and decaying salmon are released into surrounding aquatic ecosystems fertilizing the water column, recently disturbed by increased suspended sediments due to nest construction. These opposing forces of disturbance and fertilization on spawning habitat have been demonstrated to impact local geomorphic and ecological cycles within salmon streams. An often cited, yet not fully tested, hypothesis is that this pulse of nutrients provided by decaying salmon can shift freshwater habitats to higher production levels. This hypothesis, however, remains contested and uncertain. Fine sediments are increasingly being recognized as important delivery and storage vectors for marine-derived nutrients (MDNs) in spawning streams. The temporal and spatial significance of these sediment vectors on gravelbed storage of MDN have not been quantified thereby restricting our ability to estimate the impact of gravelbed storage of MDNs on the riverine habitats. The objectives of this study were to i) quantify the magnitude of sediment deposition and retention in an active spawning area and ii) determine the contribution of MDN associated with the fine sediment storage.

The Horsefly River spawning channel (HFC), an artificial salmon stock enhancement stream, was used to examine the biogeomorphic impacts of salmon spawning. We organized the HFC in an upstream-downstream paired treatment approach where the upstream enclosure was kept free of salmon and the downstream enclosure was loaded with actively spawning salmon. We used the difference in suspended sediment concentration between the salmon enclosure and the control enclosure to determine the contribution of salmon nest construction to suspended sediment concentration. To monitor sediment infiltration into the gravelbed we used modified infiltration bag samplers. Lastly, to examine the contribution of salmon nutrients to the infiltrated sediment we sampled for the presence of a marine isotope signature (15N) in the sediment.

Increased sediment in the water column of the salmon enclosure during the active spawn period indicated salmon-mediated sediment resuspension. A gravelbed response to this water column disturbance was detected via increased sediment infiltration during salmon spawning. This stored sediment was enriched in organic matter and 15N indicating a marine salmon signal. Significant relationships between sediment infiltration and salmon enrichment provided further evidence that salmon organic matter, using resuspended sediment as a vector, was infiltrating into the gravelbed. During the post-spawn period organic sediment was elevated in the water column and gravelbed infiltration was reduced reflecting respectively, the release of decay products from salmon carcasses and MDN release from temporary gravelbed storage. This study demonstrated that localized patterns of sediment deposition are regulated by salmon activity, which control gravelbed MDN storage and release. Salmon-mediated, sediment vector influences on riverine habitat have been quantified here on a small experimental scale, but we expect that the effect is replicated and magnified, as it occurs regionally throughout the spawning grounds, with significant ecosystem implications.