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Capture and retention of marine derived nutrient based flocs in low gradient streams: A flume analogue

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Marine derived nutrients (MDN) delivered to natal streams by spawning Pacific salmon can enrich those spawning reaches but studies have shown variable ecosystem responses that range from a net loss to a net increase in stream productivity. This range in productivity response is influenced by the quantity of MDN returned to natal streams as well as the opportunity for those MDN to enter stream food webs. Salmon organic matter flocculation with fine inorganic sediment has been identified as one mechanism for MDN delivery to streambeds; once formed these flocs can settle onto the streambed or become trapped within inter-gravel spaces as surface waters pass through the streambed. Floc delivery to and residence time within the streambed will be influenced by stream geomorphic and hydrologic conditions with low power alluvial channels possibly having a higher probability of retaining MDN than faster high power streams. This study provides a mass balance assessment of MDN storage and retention potential in spawning areas of low gradient streams using four outdoor flow-through flumes (30m*2m*2m). In addition to a control flume, others were concurrently treated with salmon only, salmon and 0.5 mg/l clay, as well as salmon and 5 mg/l clay for a 96-hour period using constant flow delivery systems and then subsequently monitored for 13 days. Selected clay concentrations were based on field observations and represent water column conditions during the post and active spawn period in a productive salmon stream.

Gravel samples were collected using infiltration bags that were installed along riffle crests of six pool-riffle complexes created at similar locations within each flume. Three randomly selected bags were removed from each flume prior to the exposure period as well as 1, 2, 4, 7, and 14 days after the 96 hour exposure. These samples were analyzed for inorganic and organic sediment, effective and absolute particle size, carbon to nitrogen ratios, as well as total, dissolved and ammonium forms of nitrogen. Composite daily water column samples were analyzed for inorganic and organic sediment as well as total, dissolved and ammonium forms of nitrogen. Combined, these data provide estimates of salmon organic matter and clay retained and leaving the flumes. A Laser In-situ Suspended Sediment and Transmissometry (LISST) probe measured particle size distribution of suspended sediments at the front and rear of the flume.

LISST analysis and nitrogen samples indicate that flocs formed in the water column during the exposure and that nitrogen-enriched suspended sediments moved through the water column during the first week after exposure. Flocs forming in the water column settled as identified by a shift toward larger particle size in infiltration bag samples, particularly for the salmon and 5 mg/l clay flume. Similarly, bag samples from the salmon and 5 mg/l clay flume exhibited the highest increase in both inorganic and organic sediment concentrations. Further, total nitrogen concentrations of bag samples from this treatment remained elevated over background conditions up to 13 days after exposure. Although the salmon only and salmon plus 0.5 mg/l clay did not follow the same distinct trends as the salmon and 5 mg/l clay flume, mass balance calculations indicate that the majority of salmon organic matter added to these flumes was also retained. This observation is significant because it identifies the potential for near-field floc-based MDN delivery and retention in low gradient and power salmon spawning reaches during the post-spawn period, conditions observed in many British Columbia interior Pacific salmon streams.