

NUTRIENT ENRICHMENT OF VANCOUVER ISLAND'S CLUXEWE RIVER, 2007



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ABSTRACT

Pollock bone meal was applied to the Cluxewe River and monitored for its effectiveness as a nutrient source for stream enrichment. A total of 1,280 kg of fertilizer was applied in the spring to boost primary production through the summer growing season. In the fall, 1,506 post-spawn pink salmon carcasses from hatchery activities were re-distributed in upper reaches to provide a direct food source to juvenile steelhead, coho, and trout. Salmon carcasses were pitched directly into the stream and allowed to drift downstream during high flows. The pollock bone meal product was transported in burlap bags (10 kg/bag) and anchored to the stream bottom using large cobbles. Effectiveness monitoring over the treatment period included water chemistry analysis for low-level nutrient concentrations and visual observations in treated and control reaches. Increased algae abundance was evident in sites treated with pollock bone meal. BC Conservation Foundation (BCCF), Kwakiutl First Nation (KFN) and the Northern Vancouver Island Salmonid Enhancement Association (NWISEA) were involved with fertilizer applications, carcass distributions and effectiveness monitoring.

ACKNOWLEDGEMENTS

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Fertilizer application and monitoring crew, left to right: Dave McDougal, KFN; Dave Campbell, BCCF; Kevin Pellett, BCCF; Chrissy Chen, KFN; Jeramy Damborg, BCCC; Parker Humchitt, KFN.

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1.0 INTRODUCTION

The Cluxewe River flows northward into Broughton Strait near the town of Port McNeill on northern Vancouver Island. It is a moderate sized stream (96.3 km², mean annual discharge of 4.1 m³/s; Lill 2002) that supports significant runs of steelhead (*Oncorhynchus mykiss*), coho (*O. kisutch*), and pink salmon (*O. gorbuscha*). In 2002, the steelhead stock status was determined to be near the conservation concern level or 30% of capacity (Lill 2002). Annual index section snorkel surveys conducted by BC Conservation Foundation (BCCF) and/or Quatse Hatchery staff in January and February from 1999 to 2006 have produced peak counts of 27 to 83 adult steelhead. The lowest count (27 fish) was observed in 2005. This past winter saw a modest improvement in observed steelhead abundance with a peak count of 72 steelhead over the 7.4 km index (MoE and BCCF files).

This stream enrichment project was designed to improve the growth and survival of juvenile steelhead, coho and other salmonids through the addition of fertilizer and salmon carcasses. Studies suggest that 6-7% of the historical input of marine-derived nutrients from spawning salmon is currently available in Pacific Northwest streams (Gresh *et al.* 2000). Nutrient addition is recommended as a short-term strategy, in combination with other stream habitat restoration techniques, to replace losses in marine-derived nutrients during periods of poor salmon returns (Larkin and Slaney 1996).

Scientific background, project rationale, and case study examples of stream enrichment are summarized in the Fish Habitat Rehabilitation Procedures, Watershed Restoration Technical Circular No. 9 (Ashley and Slaney 1997), and more recently in Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity (AFS Symposium 34, J. Stockner, editor 2003).

Pre-fertilization low-level nutrient water samples were collected and analyzed in 2000. Samples were collected from the upper and lower river on August 15 and September 25. Three of four results indicated <1 µg/L (minimum detection limit) of ortho-phosphorus. Ortho-phosphorus, also known as soluble reactive phosphorus, is the portion of total phosphorus that is in a soluble form readily available to plant life for synthesis. Following confirmation of nutrient limitation, the Cluxewe was enriched in 2001 with a slow release pellet called 'Nutri-stone' manufactured by Lesco Inc., Ohio (McCusker *et al.* 2002). This product was effective, although there were inconsistencies with the pellet binding process and it is no longer available.

Pollock bone meal fertilizer³ (offal) from Alaska fish processing plants was applied in the spring to stimulate periphyton and insect production (Appendix A, Photo 1). This product was applied in the Cluxewe in the spring and fall of 2005 and spring of 2006 with noticeable increases in periphyton accrual (Wright 2005 and 2006). Pollock bone meal has been distributed in the fall in the upper Cluxewe River to provide a direct food source to juvenile steelhead, coho, and trout. Natural salmon carcasses are a preferred source of fall nutrients, so post-spawn pink salmon carcasses from Quatse River Hatchery were used when available.

³ Dried and heat pasteurized, this product has been determined by MoE labs to be pathogen free.

2.0 METHODS

2.1 Fertilizer Loading Rates

Loading rates for the spring application of pollock were calculated to achieve a target concentration of 2.5-5.0 µg/L of ortho-phosphate. Pollock bone meal is 7.69% P (17.6% P₂O₅) and is estimated to release most of the nutrients over a 90 day period. Table 1 shows a loading rate calculation using an average summer flow of 1.275 m³/s derived from 1999-2001 stream transect data (McKusker *et al.* 2002).

Table 1. Cluxewe River loading rate calculation.

<i>Streamflow during treatment period=</i>				
Average flow (m ³ /sec)	Sec-day ⁻¹	Days	L·m ⁻³	Litres of water
1.275 x	86,400 x	90 x	1000	= 7.78 x 10⁹
<i>Kilograms of fertilizer needed=</i>				
Target concentration. (µg·L ⁻¹ P)	µg fertilizer (µg P) ⁻¹	kg·µg ⁻¹	Litres	Kg of fertilizer needed
2.5 x	1/0.077 x	1 x 10 ⁻⁹ x	7.78 x 10 ⁹	= 322.3

Loading rates for fall applications and salmon carcasses were not calculated to achieve a specific nutrient concentration in the stream. October loading rates are based primarily on the availability of salmon carcasses as cooler fall temperatures and higher stream flows significantly reduce the likelihood of over-enrichment.

2.2 Fertilizer Application

Pollock bone meal was applied to the mainstem Cluxewe in the spring at the following locations: Skidder Main Bridge, K100 spur, the 'Slide', West Main Bridge, and Hartford Pit (Figure 1). Sites were spaced approximately 5 km apart to ensure nutrients were consumed prior to the next application site. The product comes pre-packaged in burlap bags in order to retain the fertilizer at the application site. Also, the 10 kg bags allow the product to be carried into each application site and the burlap rots naturally by the end of the treatment. Bags were anchored with cobbles in moderate velocity riffle habitat with 20-50 cm of depth (Appendix A, photos 1 and 2).

Pink salmon carcasses were pitched from a pick-up truck off the Skidder Main Bridge and allowed to drift downstream as flows dictated. The carcass distribution site is located in the upper river to maximize effectiveness over the entire stream length and provide marine-derived nutrients to areas upstream of where peak spawning occurs⁴.

⁴ Approximately 80% of the pink salmon typically spawn in the lower 4 km of the river (K. Fuller, Quatse River Hatchery Manager, Port Hardy, pers. comm.).

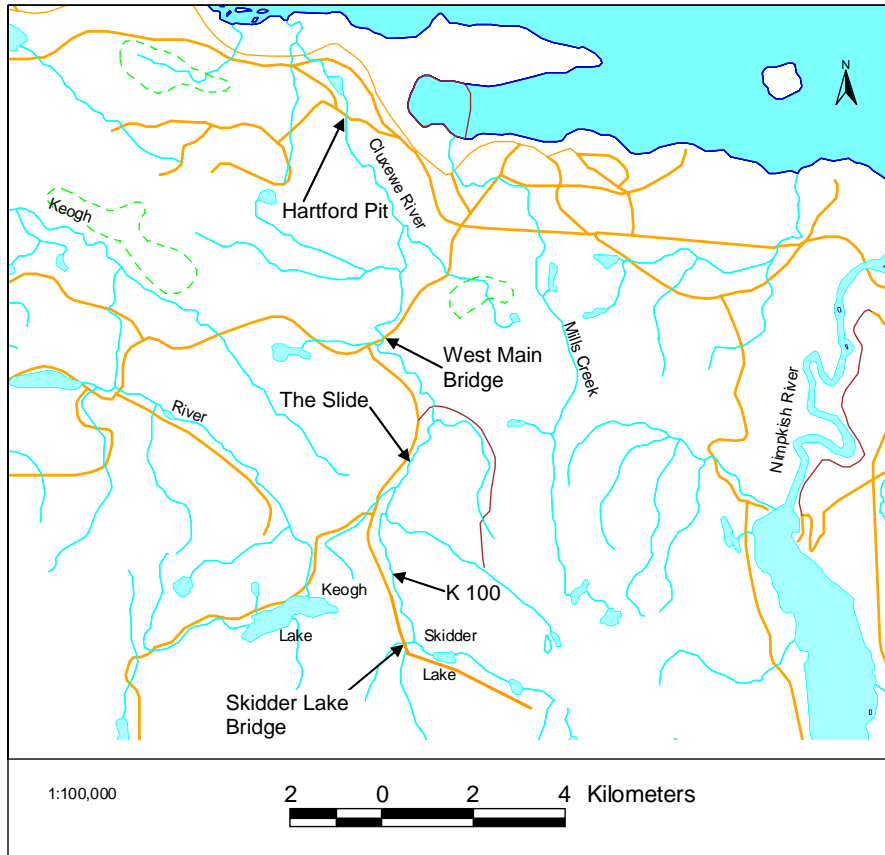


Figure 1. Fertilizer application and monitoring sites on the Cluxewe River, 2007.

2.3 Monitoring of the Spring Pollock Bone Meal Application

Flow Monitoring

Stream discharge was measured opportunistically during fertilizer application and monitoring. Depth/velocity transects were completed using a Swiffer velocity meter (model 2100) at a minimum of 20 stations equally spaced across the wetted width (RIC standards). Transect sites with relatively uniform flow and moderate depth were selected to achieve accurate discharge results.

Water Chemistry

Water samples were collected three times during the spring/summer treatment period on the Cluxewe River. Unfiltered samples were collected in two 1 L plastic bottles supplied by Environment Canada's Pacific Environmental Science Centre (North Vancouver, BC). The bottles were rinsed three times with stream water in the field before being filled with sample water. The samples were packed with ice in a cooler, shipped by courier to the lab within 24 hours and sampled for:

- low-level ortho-phosphate (soluble reactive phosphorus);

- low-level nitrate + nitrite; and
- total phosphorus.

Samples were collected at three sites (Figure 1):

- control (upstream of Skidder Main Bridge – river km 17.6);
- full mix (K100 – river km 15.5); and
- downstream dilution (upstream of Hartford Pit – river km 3.4).

The control site was positioned upstream of all three treatment sites. The full mix site was located 2 km downstream of the uppermost fertilizer site to represent typical water chemistry within a treated reach. The downstream dilution site was located about 5.5 km downstream of the West Main Bridge fertilizer site to determine if nutrient concentrations had returned to background levels.

3.0 RESULTS

3.1 Fertilizer Application

On June 19, a total of 1,280 kg of pollock bone meal was applied to the Cluxewe River (table 2). This was carried out by BCCF and Kwakiutl FN fisheries staff (Appendix A, photo 3). Approximately one third of the bags were sliced open every 3-4 weeks to increase the release of nutrients after fungal caps had formed on the bags. Excellent algal growth was observed on August 30 at the Slide, K 100 and Skidder Lake bridge application sites. Moderate growth was noted below the West Main Bridge and at Hartford Pit. Some scavenging was evident at the Slide as four bags were dragged up on the beach (likely by bears). All remaining bags were slashed at this time to expose the bone meal from under any fungal cap. The burlap bags were rotten at this point and most were opened by stepping on them.

Table 2. Summary of spring fertilizer treatment in the Cluxewe River, June 19, 2007.

Location (distance from mouth, km)	Amount Applied (kg)
Hartford Pit (3.3)	320 (32 bags)
West Main Bridge (9.0)	320 (32 bags)
The 'Slide' (13.0)	320 (32 bags)
K 100 (15.5)	160 (16 bags)
Skidder Main Bridge (17.5)	160 (16 bags)
Total 1,280 kg (128 bags)	

Post-spawn Cluxewe River salmon carcasses from hatchery operations were distributed by Quatse Hatchery staff on September 27, October 3, and October 12, 2007. A total of 1,506 pink salmon were planted which roughly equates to 2,259 kg of biomass (Table 3). No medications were applied during holding and fish were killed by blunt force trauma

during egg takes. Carcasses were transported by pick-up truck and pitched from the Skidder and West Main bridge crossings.

Table 3. Summary of carcass distribution activities on the Cluxewe River by NWISEA staff.

Date	Species	Source	Distribution Site	Number	Biomass (kg)
27-Sep-07	Pink	Cluxewe	Skidder Main, West Main Bridges	862	1293
03-Oct-07	Pink	Cluxewe	Skidder Main Bridge	432	648
12-Oct-07	Pink	Cluxewe	Skidder Main Bridge	212	318
				1,506	2,259

3.2 Monitoring of the Spring Pollock Bone Meal Application

Flow Monitoring

Depth/velocity transects were completed in the lower river over eleven days between June 19 and August 30, 2007 at the Hartford Pit located on Orca Sand and Gravel property. The discharge data is presented below in Figure 2. Depth/velocity transects conducted during the 2007 treatment period produced a mean of 1.72 m³/s compared to 1.41 in 2006 m³/s and 1.47 m³/s in 2005. Flows in 2007 averaged more than the predicted mean summer flow of 1.275 used for loading rate calculations. Loading rates were calculated based on this conservative estimate as to prevent over enrichment later in the season (lowest measured flow was 0.89 m³/s).

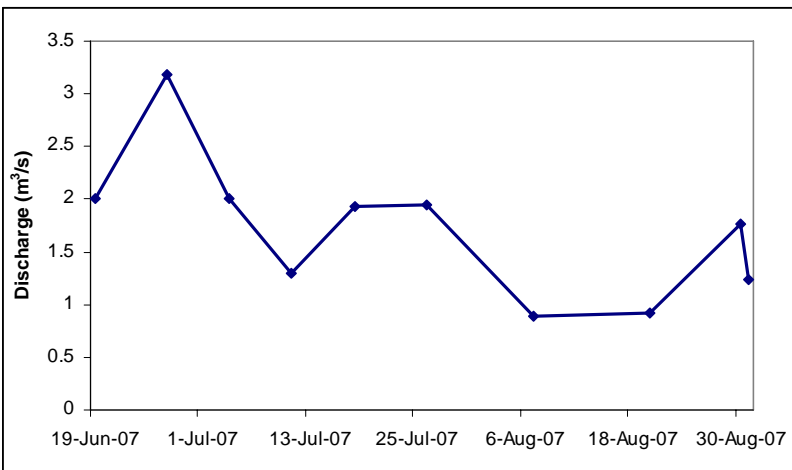


Figure 2. Cluxewe River discharge measurements at Hartford Pit, summer 2007.

Water Chemistry

Water chemistry analysis did not show significant increases in available phosphorus and nitrogen at the “Full Mix” sampling site. Orthophosphate concentrations remained undetectable throughout the treatment period. Total phosphorus concentrations were consistently <2 µg/L, with the exception of both treated sites on July 23. Nitrate+Nitrite concentrations ranged from 23 to 101 µg/L, with little variance between treated and control sites (Table 5). Above average summer flows likely diluted the nutrients at sample sites reducing nutrient concentrations. There was an obvious algal response immediately below the treatment sites, suggesting that most of the available nutrients

were being consumed by periphyton biomass (Appendix A, photos 5, 6 and 8). Additionally, there is often error associated with low-level nutrient analysis, particularly when expected results are very close to detection limits. Sampling results do confirm that there were no instances of over-fertilization or nitrogen limitation.

Table 4. Water chemistry results from samples collected on the Cluxewe River, 2007.

Stream location	Date	Parameters (mg/L)		
		Nitrate + Nitrite	Orthophosphate	Total Phosphorus
* u/s Skidder bridge	23-Jul-07	0.023	<0.001	<0.002
K 100	23-Jul-07	0.034	<0.001	0.004
Hartford pit	23-Jul-07	0.035	<0.001	0.005
*u/s Skidder bridge	19-Aug-07	0.051	<0.001	<0.002
K 100	19-Aug-07	0.053	<0.001	<0.002
Hartford pit	19-Aug-07	0.081	<0.001	<0.002
*u/s Skidder bridge	17-Sep-07	0.094	<0.001	<0.002
K 100	17-Sep-07	0.101	<0.001	<0.002
Hartford pit	17-Sep-07	0.058	<0.001	<0.002

4.0 CONCLUSIONS

Spring bone meal and fall carcass applications on the Cluxewe River were carried out effectively through a partnership of the Kwakiutl First Nation, NWISEA and BCCF. Monitoring results indicated a very positive algal response to fertilizer additions. Water chemistry results did not indicate an increase in low-level orthophosphate concentrations likely due to above average summer flows. Scavenging of bone meal by bears was not as evident this year as in 2006. Only a few bags were disturbed at K 100, the site with the highest bear activity last year. It is recommended that loading rates remain at current levels and that discharge data continues to be collected during future treatments. Additionally, juvenile fish sampling in control and treated reaches will help to quantify the benefits of stream enrichment and is also recommended for future monitoring.

5.0 REFERENCES

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6.0 APPENDIX A. Photo documentation.



1. 10 kg bag of pollock bone meal weighted to stream bed with large cobble.



2. Pollock bone meal in 10 kg burlap bags.



3. Kwakiutl FN fisheries staff distributing pollock at the Skidder Main Bridge site.



4. KFN working with BCCF technician to measure stream flows, June 19, 2007.



5. Exposed bone meal after slicing open bags to increase the release rate, August 30, 2007.



6. Algal growth at the K 100 site, August 30, 2007.



7. Pollock bone meal scavenged by bears at "the Slide" site, August 30, 2007.



8. Brown algal growth on stream substrate typical of pollock bone meal applications.