BC HYDRO BRIDGE COASTAL FISH & WILDLIFE RESTORATION PROGRAM: PROJECT #02.Ca.61

CAMPBELL RIVER ADULT SALMON CARCASS NUTRIENT SAMPLING PROJECT

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Prepared for: BC Hydro Bridge Coastal Fish & Wildlife Restoration Program
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Executive Summary

During the fall of 2002, adult salmon carcasses collected from brood stock sorting and spawning at Quinsam Hatchery were distributed to the upper Campbell River. Numbers of fish and approximate biomass of carcasses was noted. Four water-sampling sites were selected, one above the carcass distribution site and three below. Monthly samples were collected and analyzed for nutrient levels beginning in August 2002 (pre-carcass distribution), and ending the following February 2003 after carcasses had been introduced. The resulting data can be used to assess the affects and trends to these levels over time, and determine the benefits of distributing salmon carcasses into the upper river area that is inaccessible to returning adult salmon.

1. Introduction

It is generally recognized that salmon carcasses are an extremely important part of coastal ecosystems (Cederholm et al, Gresh et al, Wipfli et al). They add marine based nutrients

back into the rivers and surrounding terrestrial habitats, and are also a critical food supply for fish and wildlife. This nutrient cycle is the basis for the productivity of a watershed, and without it, production of all species within that ecosystem is negatively affected. Declining freshwater habitat on the Campbell River associated with BC Hydro operations and other human activities have affected the number of salmon returning. Also, adult migration is limited to the lower 5.5 km of river by impassable falls in the canyon area. This has historically restricted the amount of salmon-borne nutrients returning to the watershed. As a consequence, there is a need for nutrient supplementation and assessment of the results.

To this end, artificial distribution of adult salmon carcasses from hatchery activities has been carried out during the fall period by Quinsam River Hatchery (a Fisheries & Oceans Canada operated Salmon Enhancement Project). Thousands of native stock salmon carcasses are available from hatchery egg-takes, and are deposited to upper areas of the Campbell River where there is a lack of spawning adults. This has been done on an annual basis since 1998, (5 years). The distribution location for the upper Campbell is at the John Hart Dam spill, which empties directly into the river at Elk Falls canyon. This location is easily accessible by tank-truck for off-loading the carcasses, and allowed measurement of downstream impacts because of a good control site immediately upstream of the spill at John Hart Lake.

The purpose and objective of this project was to collect and analyze data to determine if there was a change in phosphate and nitrate levels (the main nutrient indicators) after the addition of salmon carcasses. Using the lake area (no carcasses) as a control, affects of salmon carcass deposits were measured at three downstream intervals over a distance of approximately 4 kilometers. This information will be used to determine the affects and trends from carcass distribution.

2. Study Area

The Campbell River originates east of Vancouver Island mountain ranges and flows in an easterly direction for 65 km into Discovery Passage near the city of Campbell River. The drainage of the Campbell River is 1,460 sq. km., of which only 5.5 km upstream of the estuary is

passable to fish, (blocked by natural falls and a hydroelectric dam). Habitat in the river has been seriously impacted by various man-made influences over the past 50 years, with gravel loss being a major limiting factor to salmon abundance. Returns of adult salmon to the Campbell have been correspondingly low for many years, and many habitat improvement projects have been completed to address this situation. Low returns of adult salmon have reduced the productivity of the river, (low salmon carcass abundance, low nutrient returns). The Campbell has one major tributary, the Quinsam River, which joins the Campbell approximately 2 km upstream of the estuary. This river supports large numbers of spawning salmon, and is the site of a major salmon enhancement facility, (Quinsam River Hatchery).

3. Methods

3.1 Water Sampling

Four sample sites were chosen for this study, including:

- Site 1: John Hart Lake (control)
- Site 2: Moose Falls
- Site 3: John Hart Generating Station
- Site 4: Elk Falls Pulp Mill pump-house

The area covered was above any tributaries (in particular the Quinsam River) to avoid any affects from nutrient additions from other sources. This confined the sample area and affects to the upper Campbell River only, where there is a minimal amount of natural spawning, (Figure 1).

Water sampling for nutrient levels began in August 2002, (before adult salmon spawning began), and was done once per month until October. In October, the sampling rate was increased to 2 times per month to assess any short-term changes during the peak carcass abundance period. Sampling for the remaining months (November 2002 to February 2003) was dropped back to once per month in order to ensure funding for the remainder of the sampling program.

Samples were collected in 1 liter amber glass bottles, and shipped in chilled coolers by overnight courier to Norwest Laboratories in Surrey B.C. for analysis. No filtration or other procedures were performed on the samples, (as directed by the lab for this type of nutrient analysis). Samples were taken using Fisheries & Oceans standard procedures for water sampling.
Ken Ashley, (Biologist for the Ministry of Water, Lands, & Air Protection) gave direction for the type of nutrients to be analyzed for and the required detection limits. This included:

- Total Dissolved Solids: Detection limit 5 mg/l
- Alkalinity: Detection limit 5 mg/l
- Total Reactive Phosphate (Orthophosphate): Detection limit of .001 mg/l (1ppb)
- Total Dissolved Phosphate: Detection limit of .001 mg/l (1ppb)

- Nitrite + Nitrate: Detection limit of .001 mg/l (1ppb)
- Ammonia: Detection limit of .001 mg/l (1ppb)

Initially, the lake control site and the Moose Falls site (Sites 1 & 2) were analyzed for all of the parameters listed, while sites 3 & 4 were analyzed for all parameters with the exception of

alkalinity and total dissolved solids. The upper sites were chosen for more intensive analysis (alkalinity and total dissolved solids), to gather baseline data. After initial results had been recorded, these two parameters were discontinued in order to reduce analysis costs.
In the field, temperature and pH was recorded at every sample location, (using an Oakton Temp 5 Acorn Series portable temperature meter, and a VWR Scientific portable pH meter).

3.2 Carcass Distribution

Adult salmon carcasses were transported and distributed from the John Hart dam spill site on the Campbell River from September 24th to November 15th of 2002. Pink, Chinook, and Coho salmon carcasses were taken from egg-takes at Quinsam Hatchery, loaded into a 2,000-liter tank mounted on a 10-ton truck, and moved to the distribution site. The carcasses were released from the tank directly over the spill structure from the road access point, and into the upper reaches of the Campbell River, (Figure 8).
All Chinook carcasses were cut in half to differentiate them from naturally spawning fish, (to avoid re-counts in the adult assessment program being undertaken in the lower river by DFO staff). All carcasses distributed were from naturally occurring stocks from this watershed, and had been anesthetized with carbon dioxide gas (ensuring that they were cleared for consumption). Normally, carcasses were trucked from the hatchery the day after the egg-take, so distribution was with fresh carcasses that had not decomposed.

4. Results

4.1 Water Sampling

Measurement of water nutrient parameters, temperature, and pH are recorded in Table 1. A baseline level of alkalinity and total dissolved solids was determined at Site 1 & 2 during August, September, October & November. This was discontinued for the remainder of the sampling period after no significant changes had been observed. Sampling parameters were restricted to the target nutrients, orthophosphate, total dissolved phosphate, nitrite/nitrate, and ammonia.
A total of 8 sampling trips were carried out between August 2002 and February 2003.

4.2 River Flows

Campbell River flows during the sampling period are found in Figure 2. It is recognized that flows from the John Hart Dam penstocks and spill will affect the nutrient levels by controlling the flushing and dilution rate in the river. However, no correlation is attempted in this report and the data is presented for review.

4.3 River Temperatures

Campbell River water temperatures during the sampling period are found in Figure 3. It is recognized that temperature will have an affect on the decomposition rate of carcasses, but no attempt is made in this report to correlate this to nutrient trends.

4.4 Carcass Distribution

Details of carcass distribution to the upper Campbell River, (species, number, estimated weight), are taken from records of adults used at Quinsam Hatchery for brood stock purposes. This can be viewed in Table 2.

An estimated 22,930 kilograms of adult salmon carcasses were distributed to this area over the period September 24, 2002, to November 15, 2002. This was carried out on 8 separate days with the period between loads ranging from 1 to 12 days (average spread was 7 days).
The species proportion distributed by weight were mainly Pinks at 52%, followed by Chinook at 27%, and Coho 22%. All carcasses were dropped from the tank truck to the canyon below the spill gates and into the flow of water being released from the dam.
In general, the carcasses were washed down into the lower cascades and pools almost immediately, and had largely distributed down river over the next few days.

5. Discussion

Target levels for the critical nutrient parameters were set from personal communications with Biologists Ken Ashley and Craig Wightman, Ministry of Water, Air, and Land protection (MWLAP). These levels were 3 –5 ppb (orthophosphate), and 30 ppb (nitirite/nitrate).

5.1 Orthophosphates

Analysis of samples taken in August and September (before carcass distribution) indicated that levels of Orthophosphates at the 2 uppermost sites (John Hart Lake and Moose Falls), were below the target level. The two lower sites however, met and slightly exceeded the target level in the August sample, then dropped off to below detection limits in September. Orthophosphate levels during the fall and winter period remained below target and detection limits for all of the sites except site 3 in January (Generating Station) which had a level of 1ppb (Figure 4).

5.2 Nitrite/Nitrate

In August & September, levels between sample sites were similar and less than half the target levels. These levels dropped throughout the system in October, with no significant increase until November when all of the sites were close to or met the target.
It should be noted that in November, the John Hart Lake nitrite/nitrate levels were higher than the lower river sites, (which were below the carcass distribution location). This indicates some biological activity occurring in the reservoirs from other processes that are contributing nitrogen to the watershed.
Nitrite/Nitrate levels remained similar between all sample sites until January when the lower river locations peaked with a significant rising trend over the John Hart Lake control.
All sites met and exceeded the target nitrite/nitrate level in January, indicating a delayed and positive affect of over 3 months from the time of the first carcass load. However in February, the sample shows a declining trend that is below the target (Figure 5).

5.3 Total Dissolved Phosphate (TDP)

TDP levels were very similar between the four sample sites in August and September (before carcass distribution). In October there was an increase in TDP at all the sites, but did not indicate that it was a result of carcasses because the lake level was higher than the downstream sites. The November to February period saw a decrease in TDP to below detectable levels at all the sites (Figure 6).

5.4 Ammonia

Ammonia levels showed a significant correlation with the addition of carcasses. In August and September all sites had undetectable levels, but in October, this rose significantly at the 2 sites closest to the carcass distribution point. This trend declined slowly after the peak carcass abundance period, but shows a clear affect (Figure 7). The peak ammonia levels measured in October were high, (.023 mg/l), but consistent with levels measured in the Quinsam River during the fall when there are high numbers of spawning salmon.

These trends in nutrient levels suggest that there are other processes at work in the lakes and reservoirs above the point of carcass distribution. It appears that nutrients are being added to the reservoir system from other sources and are in addition to the salmon carcasses being distributed at the dam spill. There may also be some sampling bias at the John Hart Lake site because water samples were taken from the shore at the surface and not at depth. The water entering the Campbell River canyons from the spill comes from the bottom of the lake, so there may be some difference in nutrient levels from the surface to the bottom of the reservoir.

A significant delay of several weeks for nitrites/nitrates to disperse into the lower river after salmon carcasses had been added was observed. This may be related to the water temperature and decomposition rate of the various species, with the smaller Pinks having a faster rate than the much larger Chinook.

6. Recommendations

The data presented should be peer reviewed to assess the trends of the nutrient cycle occurring in the upper Campbell River, and the benefits of distributing carcasses to the area. Future water sampling should consider the possible bias of surface sampling at John Hart Lake for a control, as it may not accurately represent the water quality coming out of the spill and entering the canyons. Additional sampling sites in the Elk Falls canyon area are also recommended to establish nutrient levels downstream of the spill and before it is diluted at the John Hart generating station with penstock water taken from sub-surface at the lake. However, access to this area is very limited and hazardous.

Benthic studies should also be undertaken in the Campbell River canyon area to determine the abundance and diversity of the aquatic life residing there. Snorkel swim surveys performed by BC Hydro, MWALP, and DFO staff during the fall of 2002, observed salmon carcasses and particles of carcasses in the canyons, and juvenile salmon and trout foraging on this food supply. Visual observations of the algae and aquatic insects indicated an increase in productivity to the area from swims done in previous years, (C. Wightman, MWLAP). Other factors including managed flow for fish in the canyon have contributed to this productivity increase, but salmon carcass additions at the spill may have also had significant beneficial affects.

Pending review and recommendations from others, carcass distribution to the upper Campbell River should be continued, as there does not appear to be any negative affects to water quality at this time, and in fact is showing some positive benefits.

Acknowledgements

The author wishes to express his appreciation to BC Hydro Bridge Coastal Fish and Wildlife Restoration Program for providing the funding to conduct this program. The author would also like to thank Joan Bennett for doing the fieldwork, Alistair McLean and Tom Veary for

providing river flow data and access to the John Hart Dam area, and Al Derby and Drew Warga for carrying out the carcass distribution. The assistance of Craig Wightman and Ken Ashley in providing expert advice for the water-sampling plan is also greatly appreciated.

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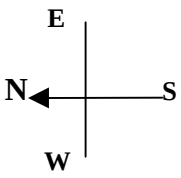
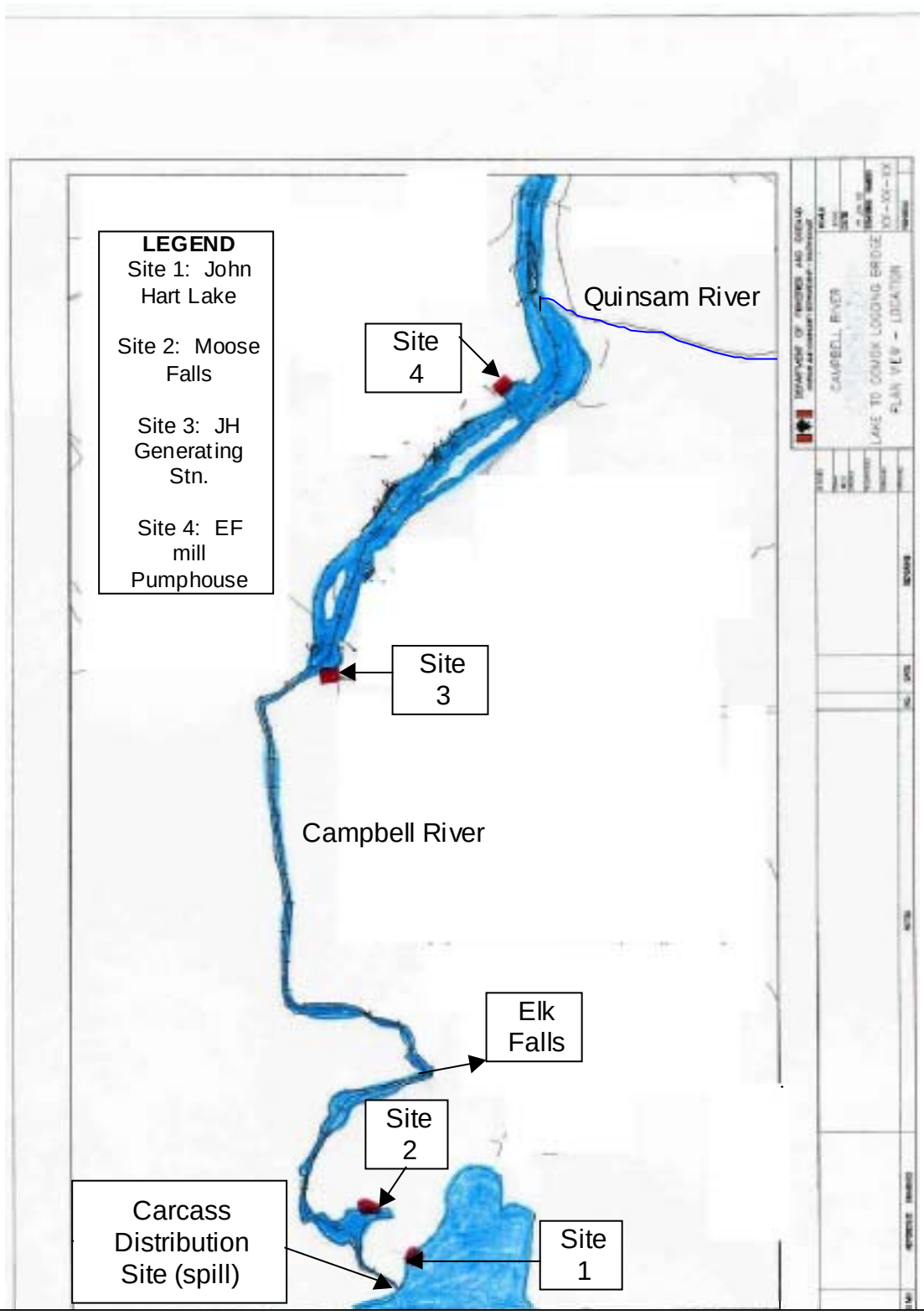
FIGURE 1.

Water Sampling Sites & Carcass Distribution Location.




LEGEND
Site 1: John Hart Lake
Site 2: Moose Falls
Site 3: JH Generating Stn.
Site 4: EF mill Pumphouse
Quinsam River
Site 4
Site 3
Campbell River
Elk Falls
Site 2
Carcass Distribution Site (spill)
Site 1

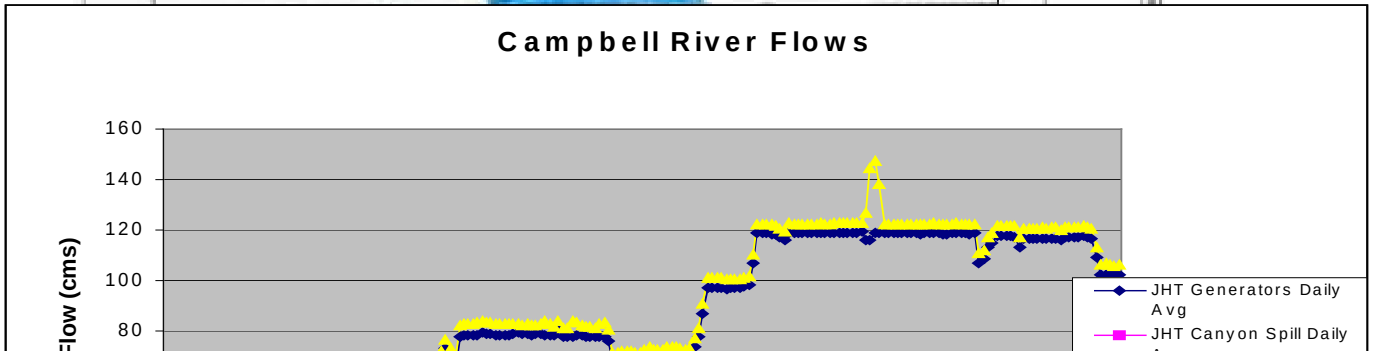

Campbell River Flows
Flow (cms)
160
140
120
100
80
JHT Generators Daily Avg
JHT Canyon Spill Daily

FIGURE 3.

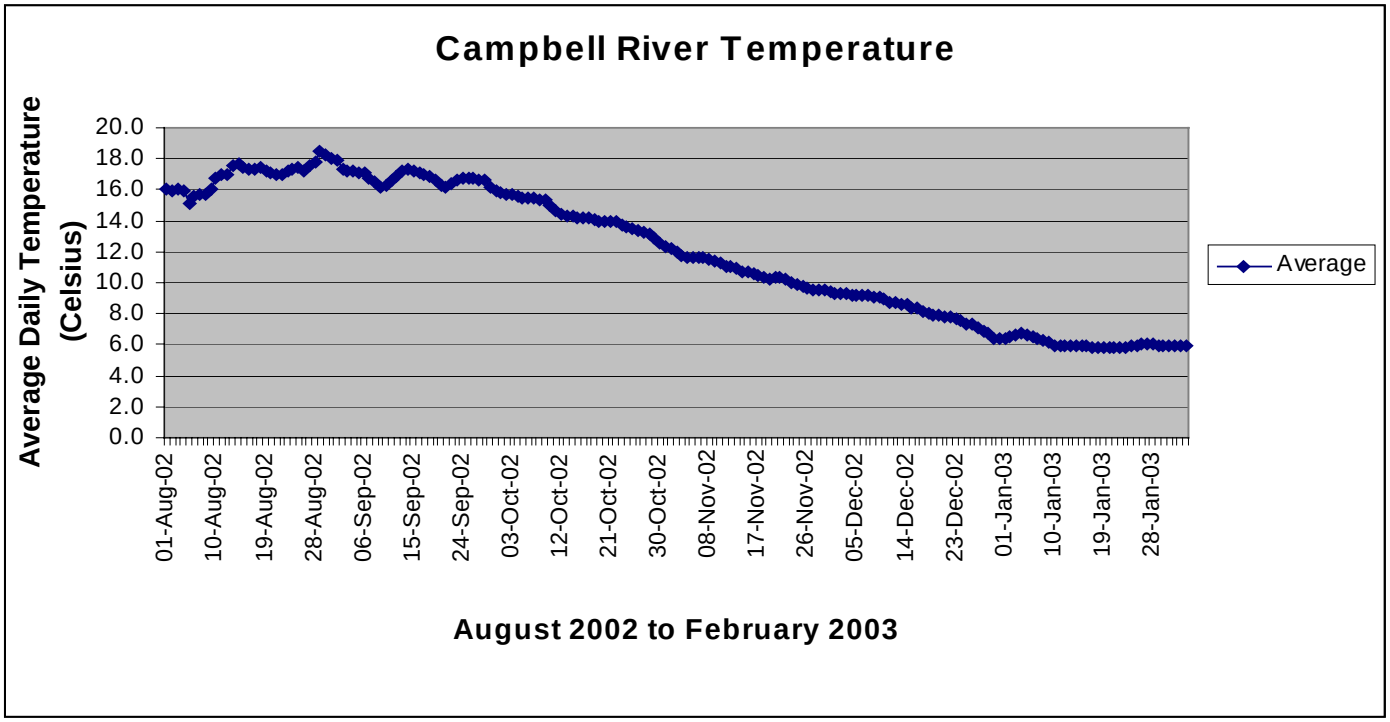


FIGURE 4.
Orthophosphate Levels

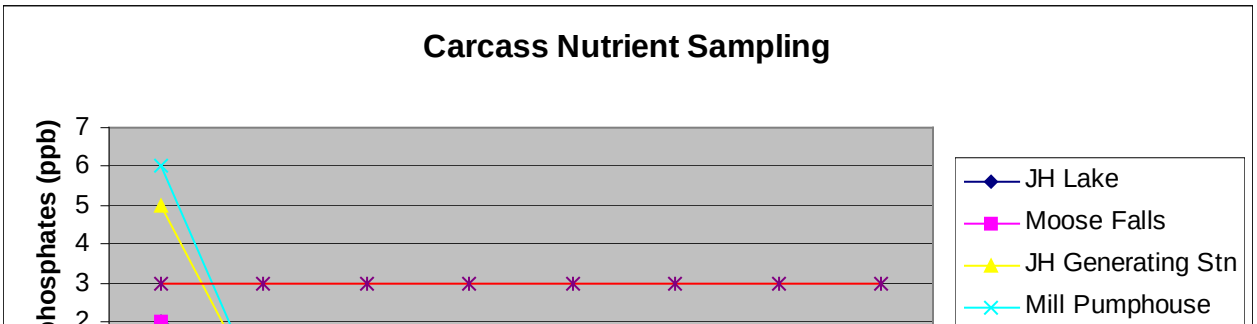


FIGURE 5.
Nitrite/Nitrate Levels

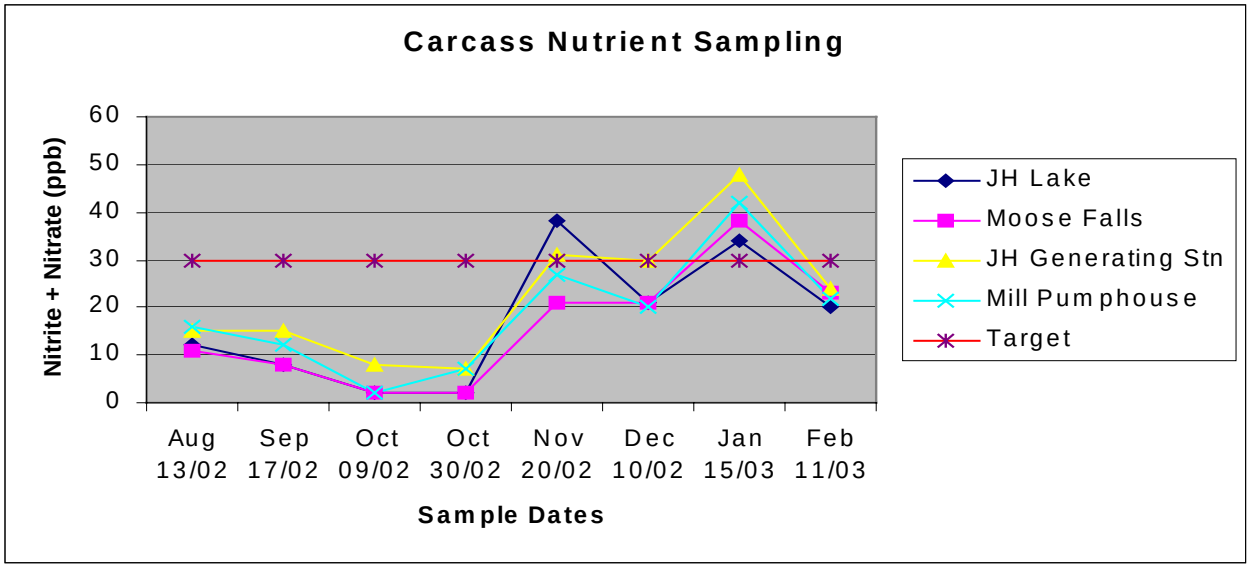


FIGURE 6.
Total Dissolved Phosphate Levels

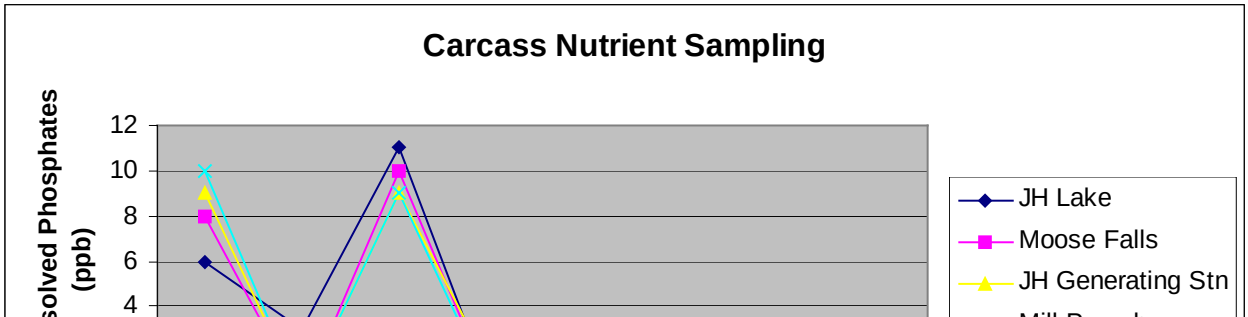


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FIGURE 7.
Ammonia Levels

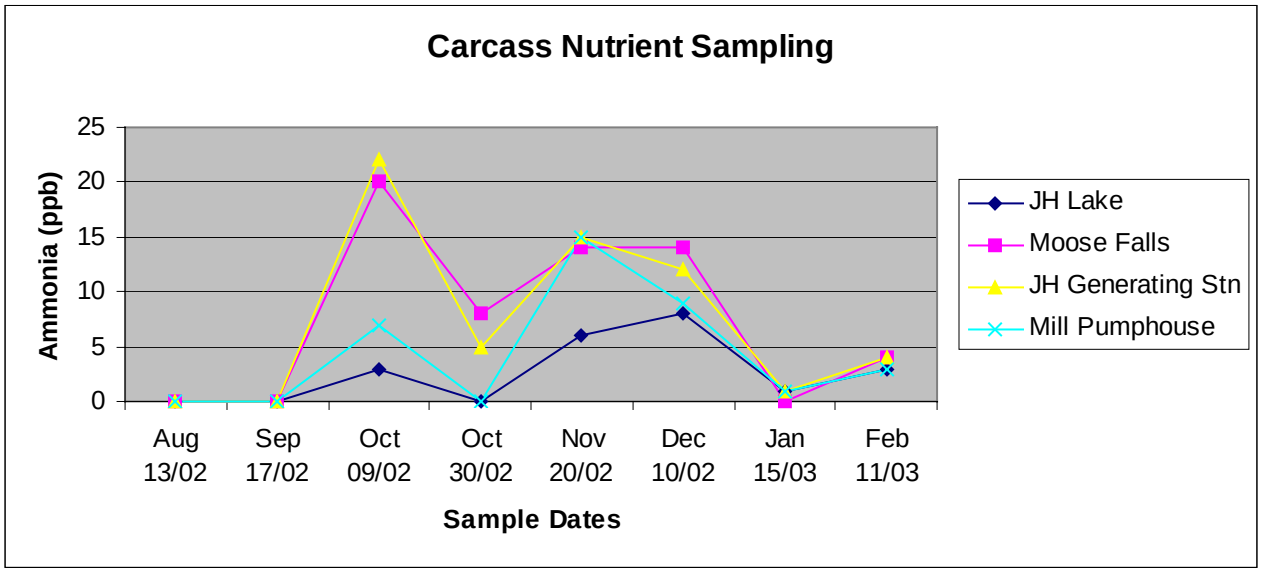

FIGURE 8.
Photographs of carcass distribution & sampling.

Carcass distribution Tank-truck

John Hart Dam Spill/distribution Location

Quinsam Hatchery Coho Carcasses

John Hart Lake Sample Site 1.

TABLE 1 NUTRIENT SAMPLES

	Optimum

Site 1	John Hart Lake	Level	Aug 13/02	Sep 17/02	Oct 09/02	Oct 30/02	Nov 20/02	Dec 10/02	Jan 15/03	Feb 11/03
	Water Temp (C)		17.9	17.0	15.2	12.5	10.2	8.8	5.6	5.8
	pH		7.97	7.60	7.48	7.58	7.26	n/a	7.33	6.93
	Tot Diss Solids (mg/L)		35	46	87	-	<5	-	-	-
	Alkalinity (mg/L)		24	24	25	-	23	-	-	-
	Orthophosphate (ppb)	3 - 5 ppb	2	1	<1	<1	<1	<1	<1	<1
	Tot Diss Phos (ppb)		6	3	11	<1	<1	<1	<1	<1
	Nitrite + Nitrate (ppb)	30 ppb	12	8	2	2	38	21	34	20
	Ammonia (ppb)		<50	<1	3	<1	6	8	1	3
Site 2	**Moose Falls**									
	Water Temp (C)		16.6	16.5	15.0	12.1	10.2	8.7	5.7	5.6
	pH		7.99	7.76	7.78	7.78	7.74	n/a	7.20	7.07
	Tot Diss Solids (mg/L)		35	42	73	-	<5	-	-	-
	Alkalinity (mg/L)		25	22	25	-	22	-	-	-
	Orthophosphate (ppb)	3 - 5 ppb	2	<1	<1	<1	<1	<1	<1	<1
	Tot Diss Phos (ppb)		8	<1	10	<1	<1	<1	<1	1
	Nitrite + Nitrate (ppb)	30 ppb	11	8	2	2	21	21	38	23
	Ammonia (ppb)		<50	<1	20	8	14	14	<1	4
Site 3	**John Hart Gen Stn**									
	Water Temp (C)		16.4	16.0	14.8	11.3	10.4	8.7	5.8	5.5
	pH		7.96	7.75	7.78	N/a	7.69	n/a	7.15	7.23
	Orthophosphate (ppb)	3 - 5 ppb	5	<1	<1	<1	<1	<1	1	<1
	Tot Diss Phos (ppb)		9	<1	9	1	<1	<1	1	1
	Nitrite + Nitrate (ppb)	30 ppb	15	15	8	7	31	30	48	24
	Ammonia (ppb)		<50	<1	22	5	15	12	1	4
Site 4	**Pumphouse**									
	Water Temp (C)		17.8	16.9	15.2	12.5	10.2	8.8	5.8	5.6
	pH		7.91	7.73	7.65	N/a	7.63	n/a	7.09	6.92
	Orthophosphate (ppb)	3 - 5 ppb	6	<1	<1	<1	<1	<1	<1	<1
	Tot Diss Phos (ppb)		10	<1	9	<1	<1	<1	<1	1
	Nitrite + Nitrate (ppb)	30 ppb	16	12	2	7	27	20	42	22
	Ammonia (ppb)		<50	<1	7	<1	15	9	1	3

TABLE 2. CARCASS LOADS

DATE	RIVER	AREA	SPECIES	ESTIMATED NUMBER		ESTIMATED WEIGHT
				ADULTS	JACKS	KG
24-Sep	Campbell	John Hart Dam Spillway	Pinks	2,941		2,941
25-Sep	Campbell	John Hart Dam Spillway	Pinks	4,008		4,008
1-Oct	Campbell	John Hart Dam Spillway	Pinks	3,435		3,435
11-Oct	Campbell	John Hart Dam Spillway	Pinks	1,518		1,518
18-Oct	Campbell	John Hart Dam Spillway	Chinook	338		3,606
30-Oct	Campbell	John Hart Dam Spillway	Chinook	186	0	1,460
30-Oct	Campbell	John Hart Dam Spillway	Coho	47	73	169
7-Nov	Campbell	John Hart Dam Spillway	Chinook	5		21
7-Nov	Campbell	John Hart Dam Spillway	Coho	585	18	1,752
15-Nov	Campbell	John Hart Dam Spillway	Chinook	41	0	170
15-Nov	Campbell	John Hart Dam Spillway	Coho	1331	363	3850
					TOTAL:	**22,930**

Estimated carcass weight by species
Brood Chinook = 10.67kg
Pinks = 1.0 kg
Carcass Chinook = 4.16kg
Brood Coho = 3.057kg
Carcass Coho = 1.88kg
Jack Coho = 0.338kg

APPENDIX A
Financial Statement and invoices of expenditures.

APPENDIX B
Confirmation of BCRP recognition and project support