Project Sponsor Response to ISRP 2002-2 Preliminary Province Review

Project ID: 31004
Project Title: Salmon Carcass Enrichment – Willamette (Clackamas) and Sandy Subbasins
Sponsor: U.S. Forest Service
Contact: Dan Shively, phone: (503) 668-1605, email: dshively@fs.fed.us
Date Response Submitted: March 15, 2002
Province: Lower Columbia
Subbasin: Willamette
FY03 Request: $509,858
5 Year Estimate: $1,607,327
Short Description:

Multi-year salmon carcass enrichment project applied over entire 5th field watersheds (with replicates and controls) aimed at restoring native runs of salmon and steelhead in the Clackamas and Sandy Rivers.

Response Needed: Yes (see reply, below)
ISRP Preliminary Recommendation and Comments: A response is needed to the questions listed below.

1. **What is the unique contribution of this project compared to the other projects on carcass placement and nutrient enrichment? Such as those in Canada, Washington, and those funded through the Fish and Wildlife Program's innovative review process (see projects 200105500 and 200101300). Is there some attribute of this project, some synergy, that makes it very fundable? The "innovative" projects are pilot studies to test the efficacy of nutrient supplementation before proceeding with other studies and implementation.**

The unique contribution of this particular salmon carcass enrichment project is that it applies whole watershed treatments within a controlled study design framework. Not only does it accomplish immediate salmon restoration objectives (as highlighted in the original project proposal), it provides for a unique, large-scale comparison of "treatment" versus "control" watersheds to evaluate food web and fish responses. This is the first large-scale proposal of this magnitude utilizing carcasses as the direct nutrient source in North America. This project was conceived and developed in coordination with other principals and project managers who have implemented similar actions in southeast Alaska and British Columbia. Dr. Ken Ashley was instrumental in guiding the development of this project proposal to tier off of other projects and associated studies ongoing in British Columbia utilizing both carcasses and fertilizers (pellet and liquid forms). This project will advance our scientific understanding of the benefits from salmon carcass enrichment efforts at a larger landscape level. Dr. Mark Wipfli, a principal investigator in this proposal, brings his research experience and background on similar projects and related studies from recent work completed in southeast Alaska. The effectiveness monitoring results of this project are expected to be informative to managers in Oregon, Washington, and British Columbia, enabling them to develop and design more effective salmon carcass enrichment projects into the future.

While this project is not considered an “innovative” proposal, it clearly meets RPA #183 for the Biological Opinion (BiOp) prepared by the National Marine Fisheries Service (NMFS) for the operation of the Federal Columbia River Power System (FCRPS). The evaluation of offsite habitat mitigation project effectiveness is critical for addressing compliance with key performance standards. Specific monitoring studies at the Tier 3 level that reduce the uncertainty around reproductive success or life-stage specific survival of naturally spawning salmon are called for. It is recommended that studies be conducted within an explicit experimental framework, including both treatment and control sites. RPA #183 calls for the action agencies to:

> *“Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU. At least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.”*

The 2000 FCRPS BiOp clearly states that each major habitat action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points for evaluation of performance standard attainment. Habitat management actions falling into this category include “enhanced levels of marine-derived nutrients” (page 9-170). Funding for implementation of this project over a three-year timeframe will allow for this evaluation to be completed. If it is the recommendation of the ISRP and/or the NWPPC to fund of this project as an “innovative” proposal, then the project sponsors request this proposal be transferred over to that cycle of project proposals.

2. **What is the direct evidence suggesting that nutrient deficiencies in these streams are a major limitation for salmon production?**

   The evidence suggesting nutrient deficiencies are a major limiting factor for salmon production in tributaries of the Clackamas and Sandy rivers is the significant decrease in natural spawning salmon from historic levels. Historic salmon run sizes for the Clackamas River are estimated at:

   Spring Chinook – 12,000 to 15,000
   Coho – 25,000 to 45,000
   Steelhead – 25,000 to 30,000
   Chum – 3,000 to 5,000

   These estimates were derived from analysis of historic catch records, escapements, and fish counts at North Fork Fish Ladder (Doug Cramer, Fish Biologist, Portland General Electric; personal communication). Based on analysis of similar data and fish counts at Marmot Dam, Taylor (1998) citing Mattson (1955) estimates the historic salmon run sizes for the Sandy River as:

   Spring Chinook – 8,000 to 10,000
   Fall Chinook – 10,000
   Coho – 15,000
   Steelhead – 20,000

   Current average run sizes for all salmon and steelhead species in both river systems is approximately 10 percent or less of historic levels. This huge loss of naturally spawning fish represents a significant reduction in carbon, nitrogen, and phosphorus for aquatic ecosystem. Recent modeling in the Sandy River Subbasin using the Ecosystem Diagnosis and Treatment (EDT) model shows an increase in smolt production with the addition of salmon carcasses for nutrient enrichment.

3. **The sponsors propose to compare smolt production before and after carcass addition. Pre-treatment evaluations occurred over 1-5 year period, depending on the watershed. Given inter-annual variability in smolt production that could arise from variation in stream conditions and adult returns, is the pretreatment evaluation of sufficient duration to provide meaningful comparison with post-treatment smolt production?**

   This is a standard Before After Control Impact Study (BACI) study design. The ability to discern changes will depend on the effect size --the larger the effect size the more likely changes will be significant. Changes resulting from this restoration treatment can be portioning between both before and after as well as between treatment streams and control. While high variability still may result in low statistical power, the BACI design is the best approach when it is impossible to randomize treatment in time and space (Hewitt et al. 2001, Millard et al. 1985). While we think it is prudent to question study designs it is also important to recognize there will always be uncertainty – this study seeks to address certain aspects of this uncertainty while completing a restoration project.

Many current habitat restoration projects within the Columbia Basin have little pre-project data. In contrast this restoration project has considerable pre-project data. Smolt trapping is one of many proposed monitoring techniques. We will also be looking at invertebrates; water chemistry; and carcass retention, use and movement through the reach.

4. **Although the "control" and "treatment" watersheds were randomly selected, they are few in number (five treatments and three controls). How do the watersheds compare with respect to physical parameters such as watershed size, stream size, gradient (long profile), hydrograph, land use patterns, and especially nutrient loads, and biological parameters such as adult returns, juvenile growth and survival, rearing areas, and smolt size and production?**

The objective of this project is to restore fish populations within these streams. The decision to use controls and treatment was solely so the effects of these restoration activities can be monitored. Although sample size may be small it should be large enough to detect biologically significant improvements of carcass supplementation. To increase power due to differences in watershed characteristics, analysis of covariance will be used if assumptions are met. If, at the end of five years, no improvements related to this project can be discerned this project should be discontinued.

Table 1 provides a comparison of physical parameters for "treatment" and "control" watersheds. Data are not readily available to compare streamflow and nutrient loading for the various watersheds.

Table 1. Comparison of Physical Parameters for Treatment and Control Watersheds.

Stream	Status in M&E Design	Watershed Size	Length of Anadromy	Average Stream Gradient	Primary Land Ownership
Clackamas River					
Clear Cr	treatment	46,655 ac	10 mi	1 %	Private
Deep Cr	control	31,344 ac	7 mi	1 %	Private
North Fk Eagle Cr	treatment	17,897 ac	5 mi	2 %	BLM and Private
North Fk Clackamas R	treatment	20,640 ac	3.2 mi	4 %	BLM and PGE
Fish Cr	control	29,773 ac	12 mi	2 %	USFS
Oak Grove Fk	treatment	90,478 ac	3.1 mi	2 %	USFS
Sandy River					
Lost Cr	treatment	7,429 ac	4 mi	3 %	USFS
Still Cr	control	14,420 ac	14 mi	2 %	USFS

However, results from water samples collected for each of the watersheds in November 2001 are shown in Table 2.

Table 2. Results of Water Chemistry Samples Collected in November 2001.

		Dissolved Total P	**Unfiltered Total P**	**Dissolved PO4-P**	**NO3-N +NO2-N**	**NH3-N**
		mg/l	mg/l	mg/l	mg/l	mg/l
N Fk Clack	lower	0.017	0.016	0.004	0.286	*0.000
	upper	0.016	0.016	0.004	0.273	0.007
Oak Grove	lower	0.032	0.033	0.018	0.004	0.003
	upper	0.027	0.03	0.015	0.027	*0.000
Fish Cr		0.016	0.015	0.006	0.025	*0.002
Clear Cr	lower	0.03	0.033	0.008	0.518	0.009
	upper	0.018	0.024	0.005	0.637	0.004
N Fk Eagle	lower	0.018	0.021	0.004	0.657	0.007
	upper	0.009	0.011	*0.001	0.27	0.005
Deep Cr		0.067	0.086	0.042	2.234	0.011
Lost Cr	lower	0.015	0.017	0.005	0.074	0.003
	upper	0.019	0.021	0.009	0.086	*0.000
Still Cr.		0.016	0.016	0.005	0.047	*0.000

*indicates value is below level of detection

Table 3 compares estimated steelhead smolt population sizes for each of the watersheds from 1994 through 2001. No estimate was possible for Lost Creek in 2001 (first year of operation), due to low capture efficiencies.

Table 3. Estimated Number of Steelhead Smolts Migrating from Monitored Sub-basins, 1994-2001 (no estimate possible at Lost Creek in 2001).

	1994		**1995**		**1996**		**1997**		**1998**		**1999**		**2000**		**2001**	
	Est-	CI%*	**Est-**	CI%*	**Est-**	CI%*	**Est-**	CI%*	**Est-**	CI%*	**Est-**	CI%*	**Est-**	CI%*	**Est-**	CI%*
Fish Cr.	**8532**	10	**3857**	11	**1018**	15	**2334**	18	**4697**	12	**2187**	-	**4013**	12	**3451**	6
Oak Gr.	**680**	80	**369**	58	**64**	-	-	-	**1582**	7	**1190**	15	**854**	41	**910**	16
NF Clack.	-	-	-	-	-	-	**1219**	26	**2024**	14	**1805**	27	**1179**	23	**884**	36
NF Eagle	-	-	-	-	-	-	-	-	**1496**	145	**3750**	10	**2248**	40	**1391**	11
Clear Cr.	-	-	-	-	-	-	-	-	-	-	-	-	**6824**	110	**5092**	53
Deep Cr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2403**	31
Still Cr.	**3296**		**1875**		-		**3077**		**6193**		-		**759**		**1776**	

*95% confidence interval is expressed as percentage of population estimate

Table 4 compares estimated coho smolt population sizes for each of the watersheds from 1994 through 2001. Once again, no estimate was possible for Lost Creek in 2001 (first year of operation), due to low capture efficiencies.

Table 4. Estimated Number of Coho Smolts Migrating from Monitored Sub-basins, 1994-2001 (no estimate possible at Lost Creek in 2001).

	1994		1995		1996		1997		1998		1999		2000		2001	
	Est-	CI%*	Est-	CI%*	Est-	CI%*	Est-	CI%*	Est-	CI%*	Est-	CI%*	Est-	CI%*	Est-	CI%*
Fish Cr.	**8276**	16	**65**	-	**106**	-	**129**	57	**13****	-	**243**	-	**1****	-	**0**	-
Oak Gr.	**4249**	25	**96**	-	**70**	-	-	-	**219**	13	**921**	10	0	-	**0**	-
NF Clack.	-	-	-	-	-	-	**30**	75	**4****	-	**77**	124	**61**	34	**2****	-
NF Eagle	-	-	-	-	-	-	**233**	371	**828**	51	**3246**	22	**598**	174	**3005**	31
Clear Cr.	-	-	-	-	-	-	-	-	-	-	-	-	**6529**	55	**11889**	29
Deep Cr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**7387**	12
Still Cr.	**6857**		**1763**		**3330**		**4057**		**5500**		**1707**		**1988**		**1321**	

*95% confidence interval is expressed as percentage of population estimate.
**Represents minimum estimate-traps were operational but counts were too low to expand. Actual capture shown.

Table 5 compares steelhead smolt size for each of the watersheds from 1994 through 2001. Data were collected but have not been analyzed for Lost and Still creeks. Table 6 provides similar data for coho.

Table 5. Steelhead smolt mean forklengths, by monitored basin. 1994-2001 (lengths not available for Lost and Still Creeks).

	1994	1995	1996	1997	1998	1999	2000	2001	Mean
Fish Cr.	**165**	**160**	**161**	**161**	**168**	**163**	**169**	**170**	**164**
Oak Gr.	**143**	**153**	**159**	**-**	**158**	**152**	**148**	**152**	**152**
NF Clack.				**164**	**170**	**165**	**161**	**171**	**166**
NF Eagle				**146**	**145**	**158**	**156**	**161**	**153**
Clear Cr.						**153**	**155**	**167**	**158**
Deep Cr.								**156**	**156**

Hyphen indicates no captures due to trapping difficulties

Table 6. Coho smolt mean forklengths, by monitored basin. 1994-2001 (lengths not available for Lost and Still Creeks).

	1994	1995	1996	1997	1998	1999	2000	2001	Mean
Fish Cr.	**106**	**141**	**113**	**113**	**N/A**	**113**	**N/A**	**N/A**	**111.**
Oak Gr.	**107**	**107**	**97**	**-**	**117**	**109**	**N/A**	**N/A**	**107**
NF Clack.				**106**	**111**	**110**	**113**	**N/A**	**110**
NF Eagle				**111**	**111**	**111**	**113**	**108**	**110**
Clear Cr.						**122**	**119**	**124**	**121**
Deep Cr.								**123**	**123**

Hyphen indicates no captures due to trapping difficulties
N/A indicates no captures due to absence of fish

5. **How far from estimated carrying capacity are the current populations of anadromous fish?**

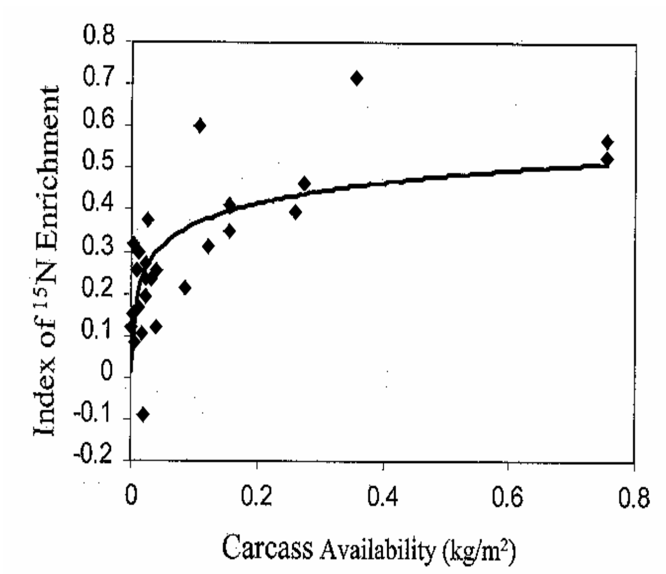
   A carrying capacity analysis has not been completed for all "treatment" and "control" watersheds at this time. However, results from the completed Ecosystem Diagnosis and Treatment modeling in the Sandy River Subbasin combined with the available smolt monitoring data would indicate that current steelhead smolt populations are roughly 31% from estimated capacity for Still Creek. This estimate is based on the 6-year average steelhead smolt yield from Still Creek (Table 3 above) and the estimated current smolt capacity of 9,100 based on EDT.

6. **How will carcasses be dispersed through the watersheds? Will they be dispersed evenly, systematically or clumped in particular locations? How long are the treatment reaches?**

   Salmon carcasses will be distributed evenly throughout the entire reach of anadromy for each treatment watershed. Applications will be made via helicopter at rates no greater than 2,500 lbs. per mile in accordance with a Memorandum of Agreement (MOA) between the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Department of Environmental Quality (DEQ). Placement of fish carcasses from hatcheries into streams is regulated under an NPDES permit issued pursuant to ORS 468B.050 and the Clean Water Act. DEQ believes compliance with the conditions of the NPDES permit will achieve the criteria for water quality management in all treatment streams. The length of treatment reaches are equivalent to the full length of anadromy in each watershed noted above in Table 1. For Clear and North Fork Eagle creeks, salmon carcasses will be dispersed in an even manner by laborers.

7. The sponsors wish to achieve a saturation level of N15 enrichment. What is the evidence that these streams were saturated historically?

In order to maximize the biological response in juvenile salmon without applying excess salmon carcasses, we will be developing application rates that attempt to reach the saturation level of ^{15}N enrichment based on Bilby et al. (2001). The Index of ^{15}N Enrichment of approximately 0.4 will ensure that an excess of salmon carcasses are not applied to streams. As stated in the response to Question 2, above, the historical levels of salmon were much greater in both subbasins. We assume that historical run sizes of salmon and steelhead were more than sufficient to fully saturate streams proposed for treatment. Simple calculations would confirm this.



From Bilby et al. (2001)

8. **The sampling design needs to be described in more detail. Where will the biological samples be taken within each watershed? How many sampling locations in each watershed? How many samples will be taken at each location?**

Biofilm sampling: Biofilm will be sampled from artificial substrates (unglazed clay tiles) placed within each monitored stream. Pilot efforts conducted in 2001 in the Clackamas basin indicate that variation among biofilm sub-samples within the monitored watersheds levels off at 5-6 sub-samples. A power analysis, however, using biofilm accumulation values measured in a neighboring watershed before and after a large influx of adult coho (an influx consistently absent in recent years from the other sub-watersheds in the basin) suggest eight sub-samples will be necessary to detect an increase of the observed magnitude with a 95% chance of correctly detecting an increase and a 90% chance of correctly concluding that there was no increase if none is detected. Based on these results, eight sub-samples will be distributed throughout the lower portions of the anadromous reaches of the monitored streams, randomly placed in low-gradient riffles. Sampling will occur every other week to preempt sloughing at high levels of biofilm accumulation. Subsequent to each sampling occasion, the clay tiles will be replaced with new tiles. Biofilm samples will also be taken at the same time from natural substrates. The data derived from sampling the tiles provides a measure of biomass accumulation per length of time and the data derived from natural substrates indicates standing crop. These protocols are based on results described in Wipfli et al. (1998) and Wipfli et al. (1999). Sampling will be initiated several weeks prior to the placement of carcasses to allow for at least three pretreatment sampling occasions.

Macroinvertebrate sampling: Macroinvertebrates will be sampled from the surfaces of gravel enclosed in .5 inch mesh baskets buried flush in gravel of comparable size in low-gradient riffles, as in Wipfli et al. 1999. Similar sampling in Alaska suggests five baskets per sampling occasion per watershed will be adequate to detect differences in invertebrate biomass due to carcass placement. Baskets will be randomly placed in riffles in the lower portions of the anadromous reaches of monitored watersheds. Sampling of baskets will occur every other week. Subsequent to sampling, baskets will be replaced with new baskets filled with clean gravel. Each of the five baskets for measuring invertebrate biomass will be paired with an additional basket for sampling invertebrate community structure. Sampling will be initiated several weeks prior to the placement of carcasses to allow for at least three pretreatment sampling occasions.

Sampling of smolts: Salmonid smolts will be sampled by rotary screw traps placed near the mouth of each monitored stream. Traps will be checked daily throughout the duration of the smolt emigration (mid-March to mid-June). A mark-recapture protocol will be followed, allowing the generation of an estimate of total emigration. Additionally length and weight data will be collected on each fish to allow the calculation of condition factor. Scale samples will be taken from 10 smolts within each 10 mm size increment throughout their forklength range for calculating length-at-age and weighted average age.

Lipid sampling: Each monitored stream will have lipid samples taken from two locations, low in the anadromous reach and at the upper-most end of the anadromous reach (immediately above the extent of carcass placements in the case of treatment streams). Fish will be captured from any available habitat (riffle or pool). Five fish will be sacrificed from each location per sampling occasion, once before carcass placements in August, and once subsequent to carcass placements in November. Each fish will be considered a sub-sample for its particular location and time.

9. What will be the impact of nutrient addition on fish species other than salmon such as cutthroat trout? Are there exotic species in these watersheds that could benefit from nutrient addition?

We will sample all fish species present. The study is focused on steelhead trout (for the intensive sampling), but we intend to occasionally sample the other fish species present (extensive sampling) to see if they are responding to enrichment as well. The number of samples taken of each species and the frequency of sampling will depend upon the number of other species present during the sampling bouts. Our initial plan is to sample up to two fish of each species for up to half of the sites for lipids, but only sample before and after the salmon runs in the enriched reaches of the selected streams. We make the assumption here that any fish present in a given reach before the salmon run will be there after the run. We fully expect all fish species including non-salmonids to benefit from enrichment, as was the case in a recent study in Alaska that investigated the growth and lipid effects on coho salmon, cutthroat trout, and Dolly Varden char (Wipfli et al, In review). The only exotic

10. How will the data be analyzed?

As described in the response to Question 4, above, we will use the classic BACI analysis for the responses measured in the control and enriched reaches (e.g., biofilm mass and invertebrates) of each stream (Hewitt et al. 2001, Millard et al. 1985). We will analyze each stream independently, upstream versus downstream, before and after enrichment. The three streams where we add no carcasses will also serve as additional controls for contrasting with the enriched streams. Smolt trap data will be analyzed using a paired unbalanced ANOVA.

References

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