

PRELIMINARY RESEARCH PROPOSAL (COE)(FY07)

Title: Alternative barging strategies to improve survival of transported juvenile salmonids

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PROJECT DURATION: March 1, 2007 to February 28, 2008

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PROJECT SUMMARY

The goal of the 2007 alternate barge release site study is to determine whether releasing barged fish at River kilometer (Rkm) 10 (approximately 10 km downstream of the Astoria Bridge) will improve the smolt to adult return (SAR) rate of spring Chinook salmon and steelhead. The strategy is to minimize the time spent moving into and through the estuary and to document fish condition, which will provide insight into the vulnerability of a smolt to predators. The general approach is to tag transported smolts with passive integrated transponders, collect samples for pathogen analysis, and release fish at the current barge release site downstream of Bonneville Dam (Skamania Landing) and at Rkm 10. Data on fish movement, timing, and survival will be collected for comparison with currently available data and evaluation of the concept.

There are two objectives for this study. The first objective is to compare SARs of spring Chinook and steelhead released at Skamania Landing to their cohorts transported downstream and released at Rkm 10. Allowing for fish availability, we will PIT tag

sufficient numbers of juvenile spring Chinook and steelhead smolts at Lower Granite Dam (LGR) to test a 1.3 transport-Rkm 10-release-to-transport-Skamania release ratio (T_A / T_S) based on an expected SAR of 1.0 for adults returning to LGR. If the SARs of Astoria released fish are improved by 30% or more this would be a considerable increase in adult returns that might warrant a change in the transportation program.

The second objective provides ancillary data that can be provided at minimal logistical and financial cost. The second objective is to determine *Renibacterium salmoninarum* prevalence and infection severity for each release group along with the presence of *Nucleospora salmonis*. The prevalence and severity of *R. salmoninarum* and *N. salmonis* will then be correlated with survival rates and SARs when possible.

PROJECT DESCRIPTION

Background

Fish passage around the hydroelectric facilities along the lower Snake River has been facilitated by guidance from screens located in the top portion of the turbine intake. This collection process has been used to minimize the number of smolts passing directly thru turbines as they migrate downstream. Juvenile salmonids have then been transported by either truck or barge to a release site downstream of Bonneville Dam for release in an ongoing effort to enhance their downstream survival.

Transported smolts have survived to return as maturing adults at a different rate than smolts which migrate downstream inriver. The transport to inriver ratio of smolts is examined to determine the difference in post-Bonneville dam passage survival. The difference has been termed differential delayed mortality and a solution to this issue is the endeavor of this work. This research will continue an ongoing effort by the Anadromous Fish Evaluation Program (AFEP) to discern changes that can be implemented to the existing fish transportation program to improve post-Bonneville release survival. Fish condition has been assessed in previous years prior to and after transportation (Pascho and Elliott, 1989; Elliott and Pascho, 1991, 1993; Elliott et al., 1997; Congleton, 2004; Schreck et al., 2005). Although stress and stressors have been examined in detail in previous years, the correlation with a particular parameter to develop a solution to the issue has been elusive. Efforts undertaken in this scope of work shall be directed at acquiring information that leads to a better understanding of the differential delayed mortality experienced by transported smolts.

The goal of the 2006 alternate barge release site study is to determine whether releasing barged fish at Rkm 10 (approximately 10 km downstream of the Astoria Bridge) will improve the smolt to adult return (SAR) rate of spring Chinook salmon and steelhead (Figure 1). The strategy is to minimize the time spent moving into and thru the estuary and to document fish condition that will provide insight into the vulnerability of a smolt to predators. The general approach is to tag transported smolts with passive integrated transponders, collect samples for pathogen analysis, and release fish at the current barge release site downstream of Bonneville Dam (Skamania Landing) and at

Rkm 10. Data on fish movement, timing, and survival will be collected for comparison with currently available data and evaluation of the concept.

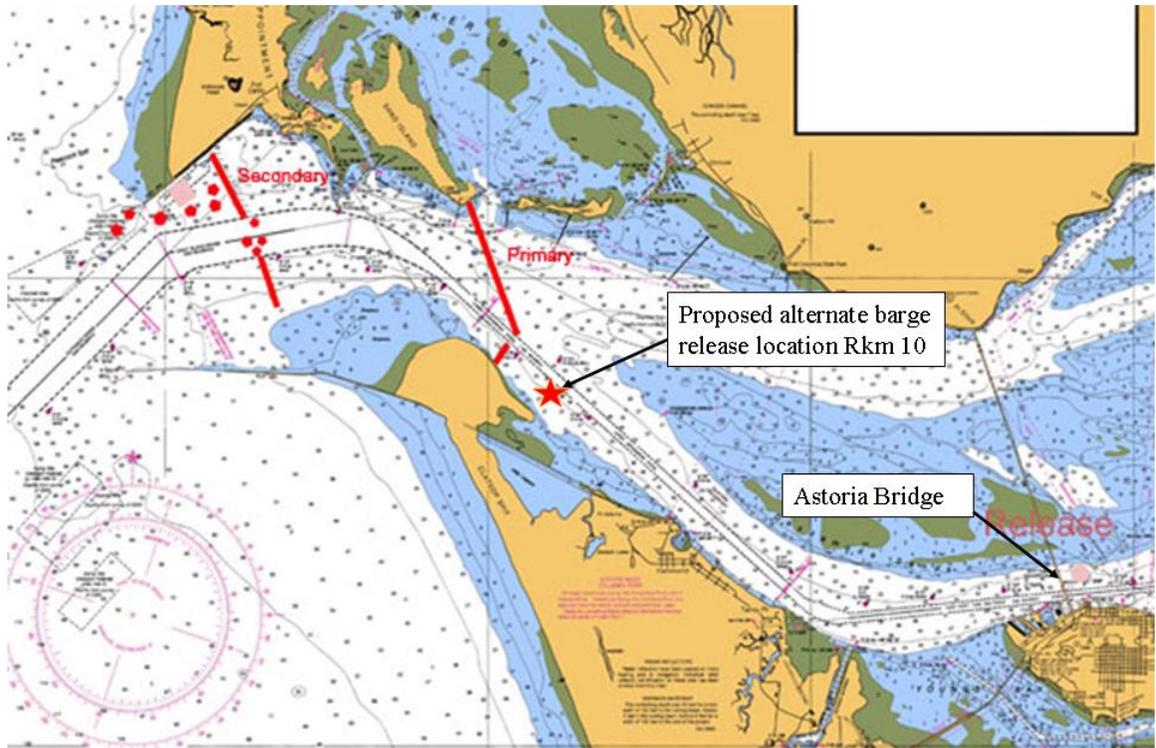


Figure 1. The red lines are the locations of the hydro-acoustic arrays in the estuary in 2005 and the red star is the proposed alternate barge release location at Rkm 10.

Fish are currently released after transportation downstream of Bonneville Dam near Skamania Landing and this work will compare smolt movement and survival between the current location and one alternate release site at Rkm 10. Objectives for this study will be:

Objective/Methods

Objective 1

Compare SARs of spring Chinook and steelhead released at Skamania Landing to their cohorts transported downstream and released at Rkm 10.

Task 1.A During spring 2007, PIT tag two groups of spring Chinook salmon smolts at Lower Granite Dam, one group will be loaded on the normal transportation barge to be released at Skamania Landing the second group will be loaded on an alternate barge and released at Rkm 10. This effort will be repeated for steelhead smolts. In spring 2007, we will PIT tag sufficient numbers of spring Chinook salmon smolts at Lower Granite Dam (LGR) to test a 1.3 transport-Rkm 10-release-to-transport-Skamania release ratio (T_A / T_S) for adults returning to LGR. The 1.3 T_A / T_S ratio is based on an expected SAR of 1.0 for the Rkm 10 release group (Table 1). Concurrently we will do the

same comparisons for steelhead smolts. For both spring Chinook and steelhead we will tag both hatchery and wild in proportion to the fish that enter the juvenile bypass facility. While the 1.3 ratio sets our tagging number at 53,000 for each species we will request extra tags to increase tagging numbers if fish supply and logistics permit so that in the event of a lower SAR we might still get meaningful data. The extra tagging would primarily be focused on Chinook since the expected SARs are generally lower for Chinook than steelhead.

T_A/T_S Ratio	Expected Astoria SAR	Number PIT tagged at Lower Granite	
		Astoria Release	Skamania Release
1.2	1.00	48,000	57,000
1.2	0.75	64,000	76,000
1.2	0.50	95,000	114,000
1.3	1.00	23,000	30,000
1.3	0.75	31,000	40,000
1.3	0.50	46,000	58,000

Since the releases at Rkm 10 will require an extra barge and transport vessel, tagging will be conducted on six Sundays throughout the migration season. Additional tagging will be conducted on Saturdays during the final two weeks, which will facilitate reaching our weekly target numbers. Both the Rkm 10 and Skamania releases will be tagged on Sundays, on Mondays the Skamania releases will be loaded on a normal transportation barge and the Rkm 10 releases will be loaded on a 2000 series barge. Loading density and water volume replacement times will be targeted to match the specifications of the two newer versions of the transport program barges (Table 2; Series 4000 and Series 8000). The Skamania release groups will be transported and released with the normal transportation fish.

Barge Series	Pounds	Gallons	Inflow	lbs/gal	Replacement Rate
2000	23,000	85,000	4,600	0.27	18.48
4000	50,000	100,000	10,000	0.50	10.00
8000	75,000	150,000	15,000	0.50	10.00

The 2000 series barge will be towed with a separate vessel mirroring the path of the normal barge. Once passing Bonneville Dam the 2000 series barge will continue downstream to Rkm 10. The releases at Rkm 10 will be coordinated to occur on the ebb tide at night to help avoid avian predation in the Columbia River estuary (Tables 3 & 4).

Release	29-Apr	30-Apr	-May	2-May
Release 1	Tag at LGR	Load Barges	Skamania Release transfer 2000 series barge.	Release at Rkm 10
	6-May	7-May	-May	10-May
Release 2	Tag at LGR	Load Barges	Skamania Release; Transfer 2000 series barge.	Release at Rkm 10
	13-May	14-May	-May	17-May
Release 3	Tag at LGR	Load Barges	Skamania Release; Transfer 2000 series barge.	Release at Rkm 10
	19, 20-May	21-May	-May	24-May
Release 4	Tag at LGR	Load Barges	Skamania Release; Transfer 2000 series barge.	Release at Rkm 10
	26, 27-May	28-May	-May	31-May
Release 5	Tag at LGR	Load Barges	Skamania Release; Transfer 2000 series barge.	Release at Rkm 10
	3-June	4-June	-June	6-June
Release 6	Tag at LGR	Load Barges	Skamania Release; Transfer 2000 series barge.	Release at Rkm 10

Tagging Date	Load Date	Release Date	High Tide	Release Times Between
29-Apr	30-Apr	1-May	1:07am	2:25am to 4:25am
		2-May	1:32am	2:45am to 4:45am
		3-May	1:58am	3:15am to 5:15am
6-May	7-May	9-May	8:22pm	9:40pm to 11:40pm
		10-May	9:15pm	10:30pm to 12:30am
		11-May	10:03pm	11:20pm to 1:20pm
13-May	14-May	16-May	12:48am	2:05am to 4:05am
		17-May	1:31am	2:45am to 4:45am
		18-May	2:14am	3:30am to 5:30am
19, 20-May	21-May	23-May	8:31pm	9:45pm to 11:45pm
		24-May	9:20pm	10:35pm to 12:35am
		25-May	10:03pm	11:20pm to 1:20pm
26,27-May	28-May	30-May	12:19am	1:35am to 3:35am

		31-May	12:51am	2:05am to 4:05am
		1-June	1:23am	2:40am to 4:40am
2-Jun	4-Jun	6-Jun	6:51pm	8:05pm to 10:05pm
		7-Jun	7:38pm	8:55pm to 10:55pm
		8-June	8:25pm	9:40pm to 11:40pm

Subtask 1.A.2. Acquire study fish from the collection facility at Lower Granite Dam. This task will be completed in cooperation with Doug Marsh of NOAA. See Table 1 for study sample sizes.

Task 1.B: Recover study adults utilizing the PIT-tag detection system in the fish ladder at Lower Granite Dam and analyze adult return data. Lower Granite Dam will serve as the principal recovery site for adults. Data acquired from other areas will be considered ancillary. To analyze results, statistical tests will be applied when adult returns for the study are complete. The CIs for the T_A/T_S will be calculated using the ratio (survival) estimate (Burnham et al. 1987) and its associated empirical variance. The study will produce an overall, statistically-bound T_A/T_S estimate at Lower Granite Dam.

Objective 2

Determine *Renibacterium salmoninarum* prevalence and infection severity profile for each release group and document relationships between SARs and prevalence and levels of *R. salmoninarum* infection. Determine the prevalence of *Nucleospora salmonis* for each release group and document relationships between SARs and prevalence of *Nucleospora salmonis* infection.

Task 2.B: Compare data on *Renibacterium salmoninarum* prevalence and levels, and data on *Nucleospora salmonis* prevalence, to fish performance measures. Diane Elliott, USGS, will lead this task. Data on *R. salmoninarum* prevalence and levels, and data on *Nucleospora salmonis* prevalence, will be compared to SARs for sampled groups. Gill filament samples for determining the presence and levels of *R. salmoninarum* in tagged fish will be collected from fish representing each of the release groups throughout the migration season. Sample collection methodology will follow the protocol for non-lethal detection outlined Schrock et al. (1994). Samples will be placed in individual labeled tubes of 95% ethanol at room temperature (below 70°F), and forwarded to the USGS Western Fishery Research Center for analysis. Data on which microacoustic tag ID associated with each gill sample will be collected and reported.

This task is to provide fish condition data for evaluating potential risks to survival of smolts. Salmonids in the Columbia River are very susceptible and routinely exposed to BKD. Infected fish can survive or perish depending on their overall condition and levels of other stressors they encounter. The influence of BKD on

survival, migration route and timing has been ignored recently due to the inability to acquire information non-lethally. This work will utilize newly available polymerase chain reaction (PCR) technology to provide information on percent incidence and levels of *R. salmoninarum* infections in smolts at the time of tagging. A sub-sample of PIT-tagged smolts will be tested to provide the estimate of percent prevalence of *R. salmoninarum* infection and the distribution of infection levels for each particular release group. The sub-sample will include about 150 steelhead and 150 Chinook salmon per release group. Gill samples will be tested for *R. salmoninarum* by quantitative PCR (qPCR; Elliott and Pascho 2004) and nested PCR (Chase and Pascho 1998). Both techniques have been used successfully to detect active (moderate level or greater) infections in gill samples from Chinook salmon (Elliott and Pascho 2004). Although the sensitivity of the nested PCR may be somewhat higher than that of the single amplification qPCR, only the qPCR can provide a measure of the infection levels in fish. Thus, testing a single sample by both PCR techniques is desirable to provide the most information. This information can then be used during data analysis as a factor that may influence fish behavior or survival.

In addition to gill tissue samples from fish, water samples will be taken from the containers in which fish are held before tagging, and tested for *R. salmoninarum*. Preliminary results from testing the 2005 samples suggested a higher prevalence of *R. salmoninarum* in gill samples than in kidney samples. It is possible that some of the gill samples may have become contaminated by high numbers of *R. salmoninarum* being shed into the water of the holding containers by infected fish. Furthermore, the presence of high numbers of *R. salmoninarum* in the water may enhance the transmission of this pathogen during the tagging procedures (Elliott and Pascho 2004). Water samples will be taken periodically from the fish holding containers throughout each tagging day and tested for *R. salmoninarum* by solid phase laser scanning cytometry. This technology provides rapid and sensitive detection and quantification of bacteria in water samples (Lemarchand et al. 2001, Lisle et al. 2004).

This task will also provide a measure of the prevalence of *Nucleospora salmonis*, an intranuclear microsporidian parasite that has been reported from several salmonid species, including Chinook salmon and steelhead, in the western U.S. and Canada (Georgiadis et al. 1998), and occurs in the Columbia River and Snake River basins. This parasite primarily infects lymphoblast cells resulting in a chronic, severe lymphoblastosis and a leukemic-like condition. Natural infections have been associated with acute or chronic mortality, particularly in Chinook salmon (Elston et al. 1987; Hedrick et al. 1990; Morrison et al. 1990). Chronic disease can result in poor growth, secondary infections, and low-grade mortality (Hedrick et al. 1990). A sensitive nested PCR procedure has been developed for detection of *Nucleospora salmonis* genomic DNA in fish (Barlough et al. 1995; Georgiadis et al. 1998). Although anterior kidney is the principal tissue sampled for *N. salmonis*, the parasite has been detected in gill tissue (Barlough et al. 1995). Kidney and gill samples taken from fish in this study for *R. salmoninarum* analysis would also be tested for *N. salmonis* by the nested PCR procedure of Barlough et al. (1995).

Facilities and Equipment

At Lower Granite Dam tagging for this study will require the use of an additional raceway on Sundays and Mondays for the releases at Rkm 10 (Table 4). In addition it will require the use of the NOAA PIT tagging buildings installed adjacent to the juvenile fish facility. Arrangements for the use of this facility have been coordinated with Doug Marsh, the primary user of this facility. For the Rkm 10 release fish it will require the use of a 2000 series barge as well as a separate tow vessel. The tow vessel and barge will be required for six trips between April 20 and June 10.

Table 4. Raceway usage for 2006 at Lower Granite Dam on tagging dates (April 29; May 6, 13, 20 & 26-27; June 2-3).

East (Upstream) Raceways at LGR				
Raceway 10	Raceway 9	Raceway 8	Raceway 7	Raceway 6
Tagged Astoria bridge release fish	Rejects and Brad's tagged control fish			(General collection)
Load on 2000 series barge Monday	Load on normal transport barge Monday			Send rejects and tagged controls to Raceway 9 and tagged Astoria bridge fish to Raceway 10
After tagging these fish would be top-loaded to bring up density				

Impacts

We plan on tagging 53,000 spring Chinook and steelhead each throughout the spring of 2006. We will tag both hatchery and wild fish proportionate to what is collected at the juvenile fish facility. Passage indexes from previous years will be used to calculate the proportion of wild fish that we will handle to apply for ESA permits.

REFERENCES

- Barlough JE, McDowell TS, Milani A, Bigornia L, Slemenda SB, Pieniasek NJ, Hedrick RP. 1995. Nested polymerase chain reaction for detection of *Enterocytozoon salmonis* in chinook salmon *Oncorhynchus tshawytscha*. Dis. Aquat. Org. 23:17-23.
- Chase D.M., Pascho R.J. 1998. Development of a nested polymerase chain reaction for amplification of a sequence of the p57 gene of *Renibacterium salmoninarum* that provides a highly sensitive method for detection of the bacterium in salmonid kidney. Dis. Aquat. Org. 34:223-229.
- Cormack, R. M. 1964. Estimates of survival from sightings of marked animals. Biometrika 51: 429-438.
- Elliott, D.G., and R.J. Pascho. 1991. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Annual Report, 1989 (Contract E86880047) prepared by the U.S. Fish and Wildlife Service, Seattle, WA, for the U.S. Army Corps of Engineers, Walla Walla, WA. 305 p.
- Elliott, D.G., and R.J. Pascho. 1993. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Annual Report, 1991 (Contract E86910058) prepared by the U.S. Fish and Wildlife Service, Seattle, WA, for the U.S. Army Corps of Engineers, Walla Walla, WA. 179 p.
- Elliott, D.G., Pascho RJ. 2004. Studies on the detection, transmission, and development of *Renibacterium salmoninarum* infections in Great Lakes salmonid fishes. Final report, Project No. 1999.51 (1999.12), Great Lakes Fishery Trust, Lansing, MI. www.glift.org
- Elliott, D.G., R.J. Pascho, L.M. Jackson, G.M. Matthews, and J.R. Harmon. 1997. Prevalence and levels of *Renibacterium salmoninarum* infection in spring/summer chinook salmon (*Oncorhynchus tshawytscha*) smolts at dams on the Columbia and Snake rivers. Journal of Aquatic Animal Health 9:114-126
- Elston RA, Kent ML, Harrell LH. 1987. An intranuclear microsporidian anemia in chinook salmon, *Oncorhynchus tshawytscha*. J. Protozool. 34:274-277.
- Giorgiardinis MP, Gardner IA, Hedrick RP. 1998. Field evaluation of sensitivity and specificity of a polymerase chain reaction (PCR) for detection of *Nucleospora salmonis* in rainbow trout. J. Aquat. Anim. Health 10:372-380.
- Hedrick RP, Groff JM, McDowell TS, Willis M, Cox WT. 1990. Hematopoietic intranuclear microsporidian infection with features of leukemia in chinook salmon *Oncorhynchus tshawytscha*. Dis. Aquat. Org. 8:189-197.

Lemarchand K, Parthuisot N, Catala P, Lebaron P. 2001. Comparative assessment of epifluorescence microscopy, flow cytometry, and solid-phase cytometry used in the enumeration of specific bacteria in water. *Aquat Microb. Ecol.* 25:301-309.

Lisle JT, Hamilton MA, Willse AR, McFeters GA. 2004. Comparison of fluorescence microscopy and solid-phase cytometry methods for counting bacteria in water. *Appl. Environ. Microbiol.* 70:5343-5348.

Morrison JK, MacConnell E, Chapman RL. 1990. A microsporidium-induced lymphoblastosis in chinook salmon *Oncorhynchus tshawytscha* in fresh water. *Dis. Aquat. Org.* 8:99-104.

Pascho, R.J., and D.G. Elliott. 1989. Juvenile fish transportation: impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. Annual Report, 1988 (Contract E86880047) prepared by the U.S. Fish and Wildlife Service, Seattle, WA, for the U.S. Army Corps of Engineers, Walla Walla, WA. 319 p.

Peven, C., A. Giorgi, J. Skalski, M. Langeslay, A. Grassell, S.G. Smith, T. Counihan, R. Perry, and S. Bickford. 2005. Guidelines and recommended protocols for conducting, analyzing, and reporting juvenile salmonid survival studies in the Columbia River Basin. Published electronically; available in PDF electronic format from chuckp@chelanpud.org.

Schrock RM , Beeman J.W., Rondorf D.W., Haner P.V. 1994. A microassay for gill sodium, potassium-activated ATPase in juvenile Pacific salmonids. *Trans. Am. Fish. Soc.* 123:223-229