PRELIMINARY PROPOSAL FOR FY 2007 FUNDING

Title: Retrospective analyses of radio-tagged fish passing through turbines at COE Columbia and Snake River hydroelectric projects with respect to turbine operating conditions

Study code:	TSP-05-1
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PROJECT SUMMARY

RESEARCH GOAL

The goal of this study is to assess the effects of passing through turbine units operated at different operational levels (± 1% peak efficiency levels) at Federal Columbia River Power System hydroelectric projects on the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout. To accomplish this goal we propose to reevaluate past data collected at Columbia and Snake River projects by regrouping releases of radio-tagged fish into groups that have passed through turbines at different operational levels. We will then assess the relation of fish survival to turbine operations.

STUDY OBJECTIVES

Our study objectives are: 1) Evaluate the effects of turbine operating conditions that are ± 1% peak efficiency levels on the survival of radio-tagged juvenile salmonids at hydroelectric projects where the USGS has conducted past survival evaluations that will allow an assessment of turbine survival, and 2) Evaluate the effects of turbine operating conditions that are ± 1% peak efficiency levels on the survival of radio-tagged juvenile salmonids of different sizes at hydroelectric projects where the USGS has conducted past survival evaluations that will allow an assessment of turbine survival and 3) Assess the potential effects of pressure cycles at hydroelectric projects.

METHODOLOGY

We will conduct retrospective analyses of data from 49 USGS evaluations of survival of radio-tagged juvenile salmonids at ACOE Columbia and Snake River dams.

UPA MEASURE:

Hydrosystem Substrategy 1.1; Key Alternatives Under Development – Turbine survival Improvements for The Dalles and John Day dams; Powerhouse Modernization for McNary Dam; Project Configuration RM&E – Turbine Studies; Hydrosystem Studies on Turbine Survival

PROJECT DESCRIPTION

BACKGROUND AND JUSTIFICATION

Current guidelines for turbine operations at Snake and Columbia River dams stipulate that operating turbines be within ± 1.0% of peak efficiency during the juvenile fish passage season. Juvenile salmonid survival is assumed to be greatest within this peak efficiency range. However, some research suggests that survival may not be highest for fish passing during these operations. Skalski et al. (2002) found that peak passage survival did not coincide with observed turbine operating peak efficiency and that the difference between maximum survival and survival at peak turbine efficiency was as much as 3.2%. Skalski et al. (2002) also observed that for three sites peak survival occurred within the ± 1.0% of peak efficiency range of operations. Questions remain about the effects of turbine operations within the recommended operating range on the survival of juvenile salmonids passing through turbines at ACOE operated projects.

Survival estimates for juvenile salmonids passing turbines at FCRPS dams remain highly variable despite the turbine operation criteria. For instance, survival for turbine passed yearling Chinook salmon at Bonneville Dam's Powerhouse 2 has been estimated at approximately 95% (Counihan et al. 2005) while at John Day Dam survival averaged 84% (Counihan et al. 2006). Even estimates within season at a particular project can be highly variable (Hardiman et al. 2005) suggesting that there is variability in the survival of fish passing within the established turbine operations criteria of ± 1.0% of peak efficiency.

Recently, the effects of being subjected to the pressure cycle during turbine passage have been suggested as a causal mechanism for the observed mortality in juvenile salmonids. Until recently, the effects of the pressure cycle on migrating juvenile salmon have been assumed to be negligible (Carlson and Abernathy 2005). Carlson and Abernathy (2005) demonstrate that changes in pressure can cause physical trauma and mortality and suggest that the effects could be worse for radio-tagged juvenile salmonids that have been used to assess survival through ACOE projects (Figure 1). Further unpublished research by Duncan and Carlson, (PNNL, presentation entitled "Turbine Characterization at Ice Harbor, John Day, and Bonneville 2 Projects Using the Sensor Fish Device") also suggests that the pressure cycle is highly variable between projects, that Nadir values of <10 psia (pounds per square inch absolute) are more prevalent at the upper 1% operational level, and that Nadir values for the upper 1% operational level are generally lower than those for the lower 1% operational level for each project. Given the potential for pressure cycles to vary between and within projects, the effects of turbine operations could account for the observed variability in turbine survival.

Given that the effects of turbine operations, and potentially the pressure cycle associated with these operations, could have resulted in biased estimates of survival through turbines because of their effect on radio-tagged juvenile salmonids, we propose to assess the effects of passing through turbine units operated at different operational levels (± 1% peak efficiency levels) at Corps of Engineer operated hydroelectric projects on the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout.

To accomplish this goal we propose to reevaluate past data collected by the USGS at Columbia and Snake River projects and then regroup releases of radio-tagged fish into groups that have passed through turbines at different operational levels. We will then assess the relation of fish survival to turbine operations.

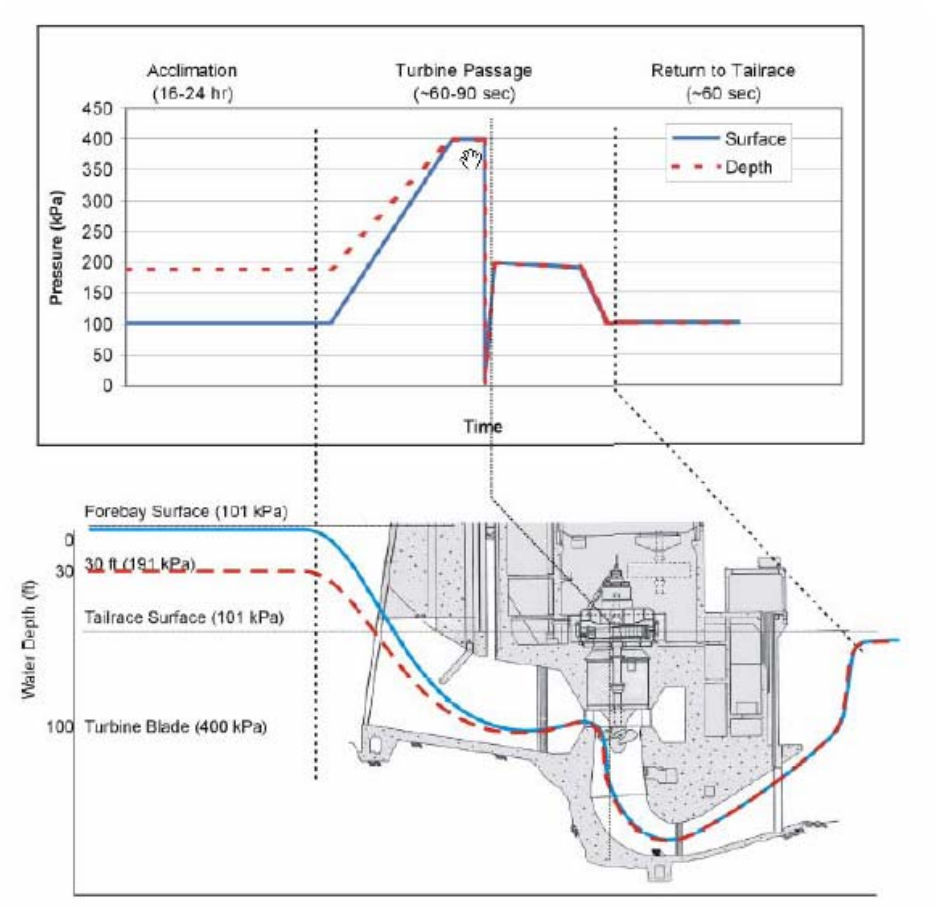

Figure 1. Pressure Cycling of Hyperbaric Test Chamber to Match Pressure Experienced by Fish during Actual Turbine Passage (from Carlson and Abernathy 2005).

PROJECT OVERVIEW

The USGS-BRD has studied juvenile salmonid behavior in dam forebay and tailrace environments since the early 1990's. Our work has focused on many aspects of fish bypass/collection concepts at Columbia and Snake River dams. Consequently, we have a large dataset that we can use to conduct these retrospective analyses (Table 1).

Table 1. Survival studies conducted by the U.S. Geological Survey from 1999-2006. CH1 = yearling Chinook salmon, CH0 = subyearling Chinook salmon, STH = steelhead trout, PRRM = Paired release-recapture model, RSSM =Route-specific survival model, SRM = Single release model, SR/RSSM = Single release route-specific survival model.

Lower Granite Dam

Year	Species	Number released	Release locations	Model
2003	CH1	1260	Blyton Landing (19 km above dam) & tailrace	PRRM
2005	CH1	1638	Blyton Landing (19 km above dam) & tailrace	RSSM
	CH0	2129	Blyton Landing (19 km above dam) & tailrace	RSSM
2006	CH1	1630	Blyton Landing (19 km above dam) & tailrace	RSSM
	STH	1930	Blyton Landing (19 km above dam)	SR/RSSM
	CH0	2000	Blyton Landing (19 km above dam) & tailrace	RSSM

Little Goose Dam

Year	Species	Number released	Release locations	Model
2005	CH1	1965	Central Ferry (21 km above dam) & tailrace	RSSM
	CH0	1059	Central Ferry (21 km above dam)	SR/RSSM
2006	CH1	2000	Central Ferry (21 km above dam) & tailrace	RSSM
	STH	2000	Central Ferry (21 km above dam)	SR/RSSM
	CH0	2000	Central Ferry (21 km above dam) & tailrace	RSSM

McNary Dam

Year	Species	Number released	Release locations	Model
2004	CH1	1896	Hat Rock (10 km above dam) & tailrace	RSSM
	STH	1888	Hat Rock (10 km above dam) & tailrace	RSSM
	CH0	1919	Hat Rock (10 km above dam) & tailrace	RSSM
2005	CH1	4039	Hat Rock (10 km above dam) & tailrace	RSSM
	STH	966	Hat Rock (10 km above dam)	SR/RSSM
	CH0	2726	Hat Rock (10 km above dam) & tailrace	RSSM
2006	CH1	3000	Hat Rock (10 km above dam) & tailrace	RSSM
	STH	1000	Hat Rock (10 km above dam)	SR/RSSM
	CH0	3000	Hat Rock (10 km above dam) & tailrace	RSSM

Table 1 (cont.). Survival studies conducted by the U.S. Geological Survey from 1999-2006. CH1 = yearling Chinook salmon, CH0 = subyearling Chinook salmon, STH = steelhead trout, PRRM = Paired release-recapture model, RSSM =Route-specific survival model, SRM = Single release model, SR/RSSM = Single release route-specific survival model.

John Day Dam

Year	Species	Number released	Release locations	Model
1999	CH1	672	Rock Creek (23 km above dam) & below JBS outfall	PRRM
	STH	684	Rock Creek (23 km above dam) & below JBS outfall	PRRM
2000	CH1	708	Rock Creek (23 km above dam) & tailrace	SRM & PRRM
	STH	722	Rock Creek (23 km above dam) & tailrace	SRM & PRRM
2002	CH1	2158	Rock Creek (23 km above dam) & tailrace	SRM & RSSM
	STH	1166	Rock Creek (23 km above dam) & tailrace	SRM & RSSM
	CH0	4384	Rock Creek (23 km above dam) & tailrace	SRM & RSSM
2003	CH1	3211	Rock Creek (23 km above dam) & tailrace	RSSM
	CH0	6936	Rock Creek (23 km above dam) & tailrace	RSSM

The Dalles Dam

Year	Species	Number released	Release locations	Model
2000	CH1	435	Turbines & tailrace	PRRM
	CH0	345	Turbines & tailrace	PRRM
2002	CH1	1952	JDA JBS, JDA tailrace, TDA tailrace	RSSM
	CH0	4475	JDA JBS, JDA tailrace, TDA tailrace	RSSM
2004	CH1	5225	JDA tailrace, TDA tailrace	RSSM
	CH0	9127	JDA tailrace, TDA tailrace	RSSM
2005	CH1	4340	JDA tailrace, TDA tailrace	RSSM
	CH0	4538	JDA tailrace, TDA tailrace	RSSM

Bonneville Dam

Year	Species	Number released	Release locations	Model
2000	CH1	552	Hood River (41 km above dam) & tailrace	PRRM
	CH0	489	Hood River (41 km above dam)	SRM
2001	CH1	985	Hood River (41 km above dam) & tailrace	PRRM
	CH0	595	Hood River (41 km above dam) & tailrace	PRRM
2002	CH1	1197	TDA tailrace & BON tailrace	RSSM
2004	CH1	5762	TDA sluiceway, TDA tailrace, & BON tailrace	RSSM
	STH	5672	TDA tailrace & BON tailrace	RSSM
	CH0	9775	TDA tailrace & BON tailrace	RSSM
2005	CH1	5682	TDA sluiceway, TDA tailrace & BON tailrace	RSSM
	STH	5557	TDA tailrace & BON tailrace	RSSM
	CH0	7466	TDA sluiceway, TDA tailrace & BON tailrace	RSSM

OBJECTIVES AND METHODOLOGY

Objective 1. Characterize the turbine operations at hydroelectric projects during years of past survival evaluations.

Rationale

Juvenile salmonid survival is assumed to be greatest within the peak efficiency range. Operations that conform to these criteria can encompass a relatively wide range of discharges. For instance, at John Day Dam (JDA), turbines can be operated from ~11.0 kcfs up to ~ 21.0 kcfs and still be within the 1% peak efficiency range. To focus our efforts to conduct this retrospective analysis, we propose to evaluate the range of operations during the years that we have conducted survival evaluations. If we determine that there is insufficient variability to conduct the analyses, then we would not continue and the project will end.

Task 1.1 Obtain, process and summarize turbine operation data at Columbia and Snake River projects (see Table 1).

Activity 1.1.1

Contact appropriate COE staff to obtain records
Schedule: January 2007

Activity 1.1.2

Summarize operation data with respect to year and release schedules for past survival study evaluations.
Schedule: February 2007

Activity 1.1.3

Assess adequacy of data to meet the stated objectives of the project and communicate the results to COE staff.
Schedule: January-April, 2007

Objective 2. Evaluate the survival of yearling and subyearling Chinook salmon and steelhead trout with respect to turbine operations.

Rationale

Survival estimates for juvenile salmonids passing turbines at FCRPS dams remain highly variable despite the turbine operation criteria. For instance, survival for turbine passed yearling Chinook salmon at Bonneville Dam's Powerhouse 2 has been estimated at approximately 95% (Counihan et al. 2005) while at John Day Dam survival averaged 84% (Counihan et al. 2006). Even estimates within season at a particular project can be highly variable (Hardiman et al. 2005) suggesting that there is variability in the survival of fish passing within the established turbine operations criteria of ± 1.0% of peak efficiency. Questions still remain regarding the mechanisms of turbine mortality; the effects of fish size, relative position during passage within the turbine units (e.g., tip, mid-blade, and hub), pressure cycles, and mechanical injury are considered plausible causes of turbine mortality.

Given that the effects of turbine operations, and potentially the pressure cycle associated with these operations, could have resulted in biased estimates of survival through turbines because of their effect on radio-tagged juvenile salmonids, we propose to assess the effects of passing through turbine units operated at different operational levels (± 1% peak efficiency levels) at Corps of Engineer operated hydroelectric projects on the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout. Further, there is evidence to suggest that the effects of turbine passage may vary with fish size; we will also examine the effects of turbine passage with respect to fish size. However, due to the size constraints associated with implanting radio-tags in juvenile salmonids, we have a limited size distribution to draw from. To accomplish these objectives we propose to reevaluate past data collected by the USGS at Columbia and Snake River projects and then regroup releases of radio-tagged fish into groups that have passed through turbine at different operational levels. We will then assess the relation of fish survival to turbine operations.

Task 2.1 Create working capture history databases from archived data.

Activity 2.1.1

Retrieve archived databases and create working databases and associated metadata.
Schedule: January-February 2007

Activity 2.1.2

Create database of turbine passed fish where appropriate from larger database.
Schedule: February-March 2007

Activity 2.1.3

Merge operations database with capture history database and tag individual fish records with pertinent operational value based on passage timing.
Schedule: March 2007

Activity 2.1.4

Create new release groupings based on the passage timing of turbine passed fish.
Schedule: March 2007

Task 2.2 Estimate the survival of release groups using the single release recapture model.

Activity 2.2.1

Conduct survival modeling and assumption tests.
Schedule: March-April 2007

Activity 2.2.2

Summarize results by project.
Schedule: April 2007

Activity 2.2.3

Create master database that includes all records.
Schedule: April 2007

Task 2.3 Assess relation of fish survival to turbine operating efficiencies using the methods described in Skalski et al (2002).

Activity 2.3.1

Assess relation of survival to turbine operation by species, project, and fish size grouping.
Schedule: April-May 2007

Activity 2.3.2

Assess relation of survival to turbine operation by species and fish size grouping.
Schedule: April-May 2007

Task 2.4 Compose and submit research report.
Schedule: June-September 2007

FACILITIES AND EQUIPMENT

No specific facilities or equipment will be required to complete the fixed monitoring component of this study as we have previously established methods and protocols for these activities.

IMPACTS

None

COLLABORATIVE ARRANGEMENTS AND SUBCONTRACTS

None

LIST OF KEY PERSONNEL AND PROJECT DUTIES

Dennis Rondorf	Section Leader
Tim Counihan	Principal Investigator
Noah Adams	Principal Investigator
Jill Hardiman	Analysis/QA/QC
Amy Puls	Analysis/QA/QC

TECHNOLOGY TRANSFER

Results from this study will be disseminated in the form of preliminary reports, annual reports of research, oral presentations and briefings, and peer-reviewed journal publications. The draft annual report of research will be submitted to the COE by September 30, 2007. Comments from the COE will be accepted for 45 d from receipt of the draft final reports, after which the USGS will provide a final report to the COE within 60 d.

REFERENCES

Carlson, T.J, and C.S. Abernathy. 2005. Pilot Study of the Effects of Simulated Turbine Passage Pressure on Juvenile Chinook Salmon Acclimated with Access to Air at Absolute Pressures Greater than Atmospheric. Final Report. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon. Contract DE-AC05-76RL01830

Counihan, T.D., J. Hardiman, C. Walker, A. Puls, and G. Holmberg. 2005. Survival Estimates of Migrant Juvenile Salmonids through Bonneville Dam Using Radio Telemetry, Final Report of Research. 2005. U.S. Army Corps of Engineers, Portland District, Contract No. W66QKZ50458521.

Counihan T., G. Holmberg, C. Walker, and J. Hardiman. 2006. Survival Estimates of migrant Juvenile Salmonids in the Columbia River through John Day Dam using Radio-Telemetry, Draft Report of Research. 2003. U.S. Army Corps of Engineers, Portland District, Contract No. W66QKZ31005684.

Hardiman, J.M., T.D.Counihan, G.Holmberg, C.Walker, and A.Puls. 2005. Temporal Trends in Survival of Migrant Juvenile Salmonids through Bonneville Dam, 2004. Presentation at the Annual Meeting of the American Fisheries Society. Anchorage, AK. Sept. 11-15, 2005.

Skalski, JR; Mathur, D; Heisey, PG. 2002. Effects of Turbine Operating Efficiency on Smolt Passage Survival North American Journal of Fisheries Management. Vol. 22, no. 4, pp. 1193-1200. 2002.