PRELIMINARY RESEARCH PROPOSAL

SUBMITTED TO THE U.S. ARMY CORPS OF ENGINEERS UNDER THE ANADROMOUS FISH EVALUATION PROGRAM

I. BASIC INFORMATION

I.A. Title of Project	Evaluation of juvenile salmon forebay distribution, fish passage efficiency, and survival at Bonneville Dam Second Powerhouse using a Juvenile Salmon Acoustic Telemetry System.
I.B. Project Leaders	Derrek Faber, Thomas Carlson, and Gene Ploskey Battelle PO Box 241 380 Evergreen Dr. North Bonneville, Washington 98639 Tel: 509-427-5838; 503-417-7562 Email: Derrek.Faber@pnl.gov; Thomas.Carlson@pnl.gov; Gene.Ploskey@pnl.gov
I.C. Study Codes	SPE-P-00-7 (SPE-P-02-1, Obj. 3,4)
I.D. Duration	1 February 2005 through 31 January 2006
I.E. Date of Submission	21 July 2005

II. PROJECT SUMMARY

II.A. Goals

The goals of this study are to quantify the 3-dimensional movements, route-specific passage, vertical and horizontal distributions of passage, and route-specific survival of juvenile salmonids entering the forebay of Powerhouse 2 (B2) using a micro-acoustic telemetry system. Forebay-wide movements of smolts 25 m upstream of the B2 Corner Collector (B2CC) are unknown but have important implications for future modifications to the B2CC and gatewells of turbine intakes. This is a proof of concept study to determine if 1000 juvenile salmon implanted with micro-acoustic tags can provide both behavioral data and survival data for downstream routes at Bonneville Dam second powerhouse. There also is the potential to describe the vertical and horizontal distribution of passage within the B2CC channel at the location of the proposed pit-tag detector, which would be valuable for modeling pit-tag detectability. This study will also be able to take advantage of tags released for an estuary survival study conducted in 2005 by using hydrophones that can detect the same tag signals. This information will be provided to that research effort to bolster survival estimates from Bonneville Dam to the Estuary.

II.B. Objectives

1. Describe the vertical/horizontal distribution of fish by species at the entrance to the corner collector (yearling chinook, steelhead, and sub-yearling chinook).

2. Describe the spatial distribution (vertical/horizontal) of fish throughout the forebay by diel period/season/species.
3 Describe the forebay movement, distribution, residence times, efficiency and effectiveness of the B2 corner collector by species of juvenile salmon.
4. Summarize the effects of varied operations at B2.
5. Determine detection probability for fish in the forebay and at downstream hydrophone arrays.
6. Provide the sample numbers of fish that would be needed to estimate FPE (<4%, 95% CI half-width) given the detection probabilities at B2 and survival gates when using micro-acoustic tags.
7. Determine route specific survival for juvenile salmon passing B2 turbines, CC and JBS with the appropriate confidence interval for the number of micro-acoustic tagged fish passing those routes.

II.C. Methodology

A new generation of acoustic telemetry system called the Juvenile Salmon Acoustic Telemetry System (JSATS) will be utilized for this study. This system has several key benefits for conducting this type of investigation:

1. Microacoustic tags weigh just 0.6 g, thereby allowing tag implantation into subyearling chinook salmon as small at 75mm.
2. Tags have a battery life that is up to 5 weeks, allowing for detection of fish throughout their migration from Bonneville Dam to the Columbia River estuary.
3. There are enough unique tag codes to conduct large-scale survival studies.
4. Hydrophone arrays are made up of autonomous hydrophone ‘nodes’ which are more easily installed than cabled systems, at reduced costs than other systems.
5. Tags transmit pressure, thereby allowing nodes to determine the depth of the fish to within 6 inches from nodes placed in a planar array. The geometry of three or more nodes in a planar array allows the resolution of the x-y position of the fish. By placing nodes in a planar array near the water surface negates the use of divers to install deep hydrophones at B2 in order to determine fish depth, which in turn *very significantly* decreases installation and maintenance costs.
6. Time is synchronized without use of cables and centralized signal processing.
7. Error is reduced in the positioning of tags by continuously monitoring the local speed of sound between nodes.
8. The nodes use very low noise hydrophones and digital receivers (near theoretical thermal limits) which increases the detection range of tags.
9. Software has been developed for processing, analysis, and display of fish tracks (TagViz).
10. Data turn around for detections (used for survival) will be swift, due to experience gained from estuary studies using similar nodes.
11. Deployment of autonomous nodes is possible in fish bypass conduits thereby allowing the detection of individual tags in confined spaces such as the JBS (the system can detect and decode tags in small holding tanks).

The JSATS was designed with these key benefits in mind. However, the technology has not been fully implemented and tested near to hydroelectric complexes which offer unique challenges to acoustic technologies. This is the reason that this study is proposed as a ‘proof of concept’. The nodes for JSATS have already been utilized in the harsh environment of the Columbia River estuary and have provided excellent data. We expect similar results for the nodes deployed downstream of Bonneville Dam. A small array of nodes has also been deployed at The Dalles Dam with promising results. This investigation would combine the usually separate juvenile salmon behavioral study and juvenile salmon survival study that have used dissimilar technologies (Radio Telemetry and Acoustic Telemetry) into one study utilizing one technology (JSATS).

II.D. Relevance to the Biological Opinion

Per the NOAA Fisheries, Biological Opinion RPA's 64(MGR), 66 (B2 CC), 67 (STS) & 82(spill survival) the Portland District will be evaluating survival through all juvenile salmonids fish passage routes. With the completion of the new SFB Corner Collector at the second powerhouse, a thorough post construction survival program to estimate project survival, and route specific survival is necessary to further evaluate future fish passage programs and operations at the Bonneville project. Further, one route at the first powerhouse will be evaluated (B1 I&T) for survival to assist in future planning efforts.

III. PROJECT DESCRIPTION

III.A. Background

III.A. 1 Problem Description

The Corps of Engineers (COE) is committed to increasing survival rates for fish passing its projects on the Columbia River. At Bonneville Dam's second powerhouse (B2), several improvements were made to increase the survival of outmigrating juvenile salmon that pass that powerhouse. These include the completion of the Juvenile bypass system (JBS) in 2000, and installation and completion of the surface bypass corner collector (CC) in 2004; both structures were designed to pass juvenile salmon around B2 via non turbine routes and are thought to increase the survival of juvenile salmon passing Bonneville Dam. The Biological opinion has mandated that the survival and passage efficiencies at B2 be determined to assess the performance of the B2CC and JBS at increasing juvenile salmon survival.

Survival studies that utilize Radio telemetry are effective, but require a large number of tagged fish to determine route specific survival due to the downstream detection probabilities. The JSATS was designed with the intent to increase the detection probability of tagged fish at the downstream arrays, thereby reducing the number of tagged fish cost of survival studies by requiring fewer tags to determine the same survival estimates.

III.A. 2 Site Description

Bonneville Dam on the Columbia River is located at river mile 146 (km 245). The dam is composed of two powerhouses and a single spillway, separated by islands. Powerhouse I (B1) has 10 turbine units and is located on the south side of the river between a navigation lock located on the Oregon shore and Bradford Island. Powerhouse II (B2) has 8 turbine units and is located on the north side of the river between the Washington shore and Cascade Island. The dam's spillway located between Bradford Island and Cascade Island; consists of 18 spill gates. The first powerhouse and spillway were completed in 1937 and, to meet growing energy requirements in the Pacific Northwest, the second powerhouse was added in 1981. The Corner Collector (CC) for B2 was completed in 2004, with the intent to provide and alternative surface passage route for juvenile salmon at that powerhouse.

III.A.3. Tagging and Array Setup

We plan to tag 300 juvenile salmon with pressure sensitive tags specifically for this research investigation, including 100 yearling chinook, (*Oncorhynchus tshawytscha*), 100 juvenile steelhead (*O. mykiss*), and 100 subyearling chinook (*O. tshawytscha*), but we also will base distribution and survival estimates on 1000 tagged fish from the estuary survival study. Juvenile salmon will be collected at Bonneville Dam's JBS as well as the downstream migration channel (DSM) at B1. These fish will be tagged and released at the Hood River Bridge (Approximately 24.5 miles - 39.4 km upstream of Bonneville Dam). In 2002, when B2 was the priority powerhouse approximately 39% of juvenile steelhead, 35% of yearling chinook passed via B2 routes (Evans et al. 2002), and 49% of subyearling chinook (Hensleigh et al. 1997) are expected to encounter and pass through the forebay at B2, and the remaining percentages will pass routes via the spillway or at B1. We expect to receive a similar percentage of tagged juvenile salmon at B2 by releasing the juvenile salmon at Hood River Bridge. Releasing fish at this location will give them equal opportunity to pass via B2, the spillway, or B1. However, the percentage of the 300 pressure-tagged fish passing B2 could be increased by throttling back on spill and B1 discharge 2-5 days after those fish are released at the Hood River Bridge.

Tagged fish that will be released below Bonneville Dam as a part of the study to determine survival from Bonneville Dam to the Columbia River Estuary could also be used for this study; however the details on how they might be used are yet to be determined. It is proposed that 3000 individually tagged juvenile salmon will be used for the estuary survival estimate, for which some may be included in the findings of our study. Possibilities for inclusion of these fish are the use of tagged juvenile salmon as control releases below the dam to determine route specific survival at the turbines, JBS, and CC. Also, selected fish could be released upstream of Bonneville dam in order to increase the number of juvenile salmon that are tracked in the forebay of B2. The tags used for the estuary investigation do not include a pressure transducer that transmits depth, and therefore could only be used to determine horizontal distribution and use of the B2 forebay, while the sample of fish that we release will determine vertical distribution in the forebay and near the corner collector. The additional fish will also improve the statistics on making survival estimates, by increasing the number of fish observed passing the CC, turbines, and JBS routes.

We will deploy a total of 15 hydrophone nodes for this study (Figure 1): eight in the forebay of B2, one in the juvenile bypass system and six at downstream locations. The eight nodes that will be deployed in the forebay of B2 will be oriented in a manner that will allow the positioning of all microacoustic tagged fish in the B2 forebay in two or three dimensions dependant on the tags detected (depth transducer, or no depth transducer). This will enable us to determine the route of passage (turbines or corner collector) as well as forebay behavior of individual fish. One node will be placed in the JBS to determine if fish were diverted by screens, and these fish will be subtracted from those observed entering turbine routes from the forebay. Fish observed entering the turbines from the forebay, and not observed in the JBS will be assumed to pass through the turbines at B2. Six nodes will also be placed downstream in three separate locations in order to determine the downstream detection probability and subsequent survival through the JBS, turbines, and B2CC. The downstream gates will be separated sufficiently to ensure independent observations of tagged fish.

If an effort to determine the distribution of fish within the B2CC channel at the future pit detector location were desired, this could be accomplished by deploying three additional receiver nodes in the B2CC channel, releasing a subset of 50 fish with depth tags optimized to maximize pulse-repetition rates. Detections should provide vertical distributions to the nearest 150 mm and lateral distributions to the nearest 500 mm.

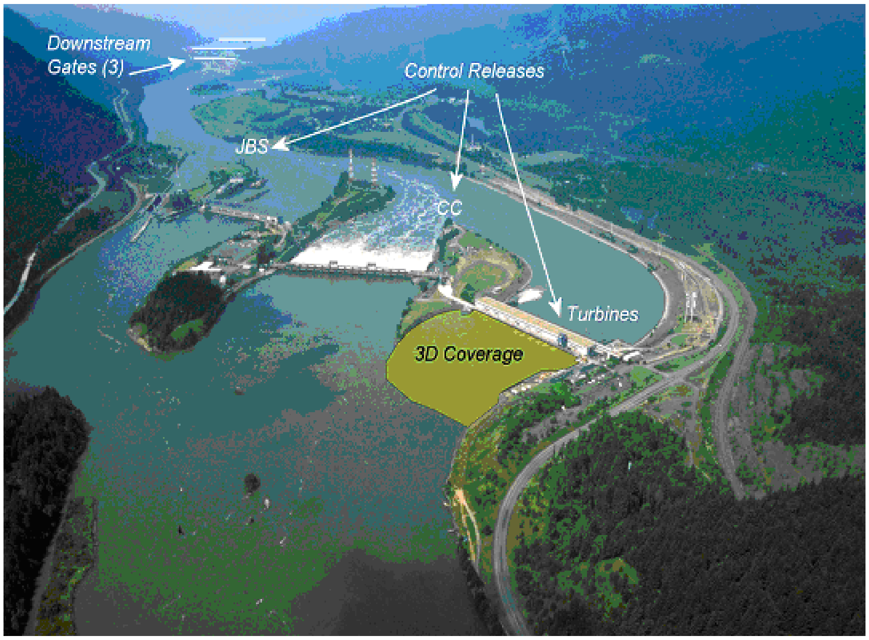

Figure 1. Overhead view of Bonneville Dam showing the area of 3D coverage in the forebay of B2, as well as control release locations for microacoustic tagged juvenile salmon at the Juvenile Bypass system (JBS), Corner Collector outfall (CC) and the turbine tailrace (Turbines) as well as at the approximate locations of the downstream hydrophone locations, or 'gates'. Study fish will be released near the Hood River Bridge across the Columbia River.

III.A.4. Behavioral information in the forebay of B2

Behavioral information about fish distributions and movements in the B2 forebay when the former B2 sluiceway or current B2CC were open are very limited. There were mobile hydroacoustic studies conducted in 1996 and 1997 that indicated high concentrations of smolt-sized fish in the south eddy upstream of the B2 sluiceway and of units 11-12 (Ploskey et al. 1998 and BioSonics, Incorporated 1998). In 2004, PNNL used an acoustic camera on a dual axis rotator and barge near the B2CC entrance to track the 3-dimensional movements of smolts within about 25 m of the B2CC entrance. These data indicate that most fish within about 10 m of the entrance are entrained, but fish 10-25 m upstream either pass into the collector or into the eddy, and flow and debris loading on the boat boom are important factors affecting fish behavior. Surprisingly, most fish detected upstream of the entrance occur in schools. Fish passing into the south eddy may circulate once or multiple times before passing into the collector or a turbine. Does circulation in the eddy expose them to increased predation? Observations with the acoustic camera certainly suggest that predators hold in the eddy along the rip rap particularly when debris accumulates on the west side of the boat protection boom. Does eddy circulation predispose smolts to turbine or B2CC passage? There is no information on whether smolts hold in eddy areas or how long they might do so. In short, a 3-D acoustic telemetry study of smolt movements in the B2 forebay is sorely needed.

III.A.5. Survival Estimates from Tagged Fish Releases

We will follow established protocols for conducting survival studies (Skalski et al, 2002) to estimate survival based upon tagged fish releases This includes the release of fish below each outfall (JBS, turbines, CC) as a control to determine the survival of fish for the reach of river downstream to the detection gate. We will also release tagged fish and dead fish, so that we can determine if it is possible to detect dead fish at our downstream gates. The methods for conducting survival studies are well established, and we will follow all guidelines and assumptions for determining the survival of juvenile salmon at routes downstream of B2.

The results also will be directly comparable to any radio-telemetry study that is concurrent with this research. We will compare our findings with the results from the survival studies that use Radio telemetry to determine survival.

We expect to be successful in determining a survival estimate per downstream route at the JBS, CC and turbines for fish passing the complex at B2. However, this estimate may or may not be within the 4% at 95% CI half-width required by the region. This is due to our uncertainty in the detection probabilities at downstream node locations that is needed to establish the number of fish required for each release of both treatment and control fish by location. We do expect the detection probability to be high, but remain uncertain as to the detection probability by location because we have not deployed the nodes in the areas downstream of Bonneville that will determine the detection probability.

III.A.6. Limitations/Expected Difficulties

We expect few difficulties with completing the planned objectives. Clear and timely communication between Battelle and the Corps will be essential. We have successfully worked with Corps personnel at mainstem hydroelectric projects in the Columbia River basin and at the Bonneville Dam specifically.

We will provide a thorough error analysis of the JSATS positioning accuracy with the use of independently positioned drogues with and without a pressure transducer. The drogues will be equipped with tags identical to those surgically implanted in juvenile salmon, and will be drifted throughout the forebay at B2, as well as at downstream hydrophone locations in order to determine any bias in the positioning estimates.

III.A.7. Expected Results and Applicability

We expect to make several key findings that will enable the use of this technology in future survival and behavioral studies at hydroelectric projects. Those findings include the detection probabilities of juvenile salmon passing hydropower complexes and at the downstream arrays (gates) that are necessary to model juvenile salmon survival through specific routes of passage. Also, we will test the JSATS ability to accurately position tagged juvenile salmon in the forebay of a powerhouse, and if successful, gain valuable insight into the spatial (horizontal and vertical) distribution of juvenile salmon relative to modeled flow, project operations, and also relative to the entrance of the corner collector. With this information, the zone of influence of the corner collector may be determined and can be used for other surface-bypass applications at other U.S. Army Corps of Engineers facilities.

III.A.8. Schedule

Tag encapsulation studies and swimming performance of tagged juvenile salmon will occur from October, 2004 to January, 2005
Spring data collection will occur from April 15 to May 30, 2005
Summer data collection will occur from June 5 to July 15, 2005
Preliminary Survival Report, October 1, 2005
Draft Final Report, December 1, 2005
Final Report, 60 days after receipt of all pertinent comments

We are aware that the study design will be reviewed by various State and Federal agencies, and is subject to the approval of the NOAA Fisheries, under the Endangered Species Act. We understand that this means that the study design may be modified prior to the start up date. We are prepared to be flexible in this regard.

III.B. Facilities and Equipment

III.B.1. Requirements

We plan to use Portland District equipment wherever possible to save money. Additional nodes and tags purchased directly by the Corps will reduce overhead costs. Any additional equipment will be leased. Again, the use of divers will not be required for this study, significantly reducing the installation costs compared to similar studies of this type.

III.B.2. Justification for Special Equipment or Services

The purchase of acoustic telemetry equipment at this time would save the Corps money over the life of a multi-year research program. Currently, the Portland District owns 4 nodes that could be used for this research effort.

III.C. Impacts

III.C.1. Other Research

None. The planned research activities are not dependent on other ongoing or proposed research in the region, however the use of tags used for the Columbia River estuary survival program would benefit this study.

III.C.2. Projects

The nodes for monitoring the B2 powerhouse and JBS will be installed by our staff. This involves coordination with onsite Corps facilitators and researchers, to establish needed guidelines for a safe installation.

III.C.3. Biological Effects

Ultra-sonic tags will be implanted into juvenile salmon. Battelle will obtain all necessary permits from state and federal agencies for the use of tags with ESA listed species, and follow internal guidelines for the care and treatment of vertebrate animals under the supervision of a licensed veterinarian.

III.D. Collaborative Arrangements and/or Sub-Contracts

Battelle will be prepared to coordinate closely and work as a team with other biological researchers at Bonneville Dam. Subcontractors and their roles are listed below under key personnel.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Derrek M. Faber (Battelle) – Co-Project Leader, project management, technical review, scheduling and budget oversight.
Gene R. Ploskey (Battelle) – Co-Project Leader, project management, technical review, scheduling and budget oversight.
John Skalski (UW) – Statistician, technical oversight.
Thomas Carlson (Battelle) – Senior Acoustician, technical oversight
George Keilman (SonicConcepts) – Senior Acoustician, technical oversight
Bruce Butts (SonicConcepts) – Electrical Engineer, technical oversight
Catherine Deters (Battelle) – Fish Surgeon
Dennis D. Dauble (Battelle) – Principal, management and contract performance oversight

V. TECHNOLOGY TRANSFER

The principal means of technology transfer will be reporting and presentations. Attendance and presentations at the Corps annual Anadromous Fish Evaluation Program Review will also be required. Technology transfer activities may also include presentation of research results at regional or national fisheries symposia, and/or publication of results in a scientific journal.

VI. LIST OF REFERENCES

BioSonics, Incorporated. 1998. Hydroacoustic evaluation and studies at Bonneville Dam, Spring/Summer 1997. Contract Report to the U. S. Army Corps of Engineers Portland District, Portland, OR.

Evans, S.D., l.S.Wright, C.D.Smith, R.E.Wardell, N.S.Adams, and D.W.Rondorf. 2002. Passage behavior of radio-tagged yearling chinook salmon and steelhead at Bonneville Dam, 2002. Annual report prepared for the U.S. Army Crops of Engineers, Portland, OR. Contract MIPR E96970020.

Hensleigh, J.E., and 9 coauthors. 1997. Movement, distribution and behavior of radio-tagged juvenile chinook salmon and steelhead in John Day, The Dalles and Bonneville Dam Forebays, 1997. Annual report prepared for the U.S. Army Crops of Engineers, Portland, OR.

Ploskey, G. R., L. R. Lawrence, P. N. Johnson, W. T. Nagy, M. G. Burczynski. Hydroacoustic evaluations of juvenile salmonid passage at Bonneville Dam including surface-collection simulations.

Skalski, J.R., R.Townsend, J.Lady, A.E.Giorgi, J.R.Stevenson, and R.D.McDonald. 2002. Estimating route-specific passage and survival probabilities at a hydroelectric project from smolt radio-tleemetry studies. Canadian Journal of Fisheries and Aquatic Sciences. 59:1385-1393.

VI. BUDGET

A detailed cost breakdown for personnel and equipment will be provided in a full proposal.