

Table 1. Proposal Metadata

Project Number	2008-503-00
Proposer	Columbia River Inter-Tribal Fish Commission
Short Description	Sockeye Studies
Province(s)	Columbia Cascade
Subbasin(s)	Okanogan and Wenatchee
Contact Name	Jeff Fryer
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A. Abstract

This project seeks to expand our knowledge on the factors limiting production of Okanogan and Wenatchee sockeye salmon stocks. A primary factor affecting the Okanogan stock is believed to be survival upstream of Wells Dam. To quantify this mortality, this project will fund PIT tag detection antennas at McIntyre and Zosel dams on the Okanogan River as well as a Vertical Diversion Structure upstream of Osoyoos Lake. In addition, an acoustic tag antenna network will be developed upstream of Wells Dam. Sockeye will be PIT tagged at the Bonneville Dam adult fish facility (as part of another MOA project, Upstream Migration Timing) as well as at the Wells Dam east bank fish trap. Sockeye will also be acoustic tagged at Wells Dam. Between the acoustic and PIT tags, Okanogan sockeye salmon mortality will be partitioned by reach upstream of Wells Dam and we hope to then be able to correlate survival with river and lake conditions, hopefully allowing survival to be increased through better Okanogan River management.

This project will also standardize smolt abundance estimation methodologies between the two stocks by conducting annual hydroacoustic surveys of Lake Wenatchee to compare with those being conducted in Osoyoos Lake. Given that the strength of the Wenatchee run relative to the Okanogan run has greatly declined in recent years, a plan for further Wenatchee sockeye research will be developed.

B. Technical and/or scientific background

Sockeye salmon, *Oncorhynchus nerka*, is one of the species of Pacific salmon native to the Columbia River Basin. Prior to white settlement of the region, it is estimated the Columbia Basin supported an annual sockeye salmon run averaging over three million fish (Northwest Power Planning Council 1986, Fryer 1995). Since the mid-1800's, however, this sockeye salmon population has severely declined. The estimated number of sockeye salmon passing Bonneville Dam over the most recent four year period (2004-2007) averaged 64,400 fish per year, though as recently as 1995-1998, the mean

escapement was only 24,900 per year (DART 2008, Fish Passage Center 2008). The 2007 estimate of 24,376 sockeye salmon at Bonneville Dam was the lowest since 1999; however the 2008 Bonneville estimate of 213,607 was the largest since 1955.

The Columbia Basin sockeye salmon run was once composed of at least eight principal stocks (Fulton 1970, Fryer 1995). Today, only two major stocks remain (Figure 1); the first originating in the Wenatchee River-Lake Wenatchee System (Wenatchee stock) and second in the Okanogan River-Osoyoos Lake System (Okanogan stock). A third remnant stock, comprising well under 0.1% of the run, returns to Snake River-Redfish Lake (Snake stock) and is listed under the Endangered Species Act. From 1969 to 1995, dam counts¹ indicated that the Okanogan stock averaged 53.2% of the total run and the Wenatchee stock 46.8% of the run. However, since 1995, the Okanogan stock has predominated in 12 out of 13 years and has averaged 71.1% of the total run, with the Wenatchee stock averaging 29.9% of the run.



Figure 1. Map of the Columbia Basin showing fishery Zones 1-5 and 6, mainstem dams, and the two major sockeye salmon production areas.

The Okanogan run is the Columbia Basin’s sole remaining transboundary stock. The fish spawn in the Canadian portion of the Okanogan River, then rear in Osoyoos

¹ The Okanogan percentage was estimated as the Rocky Reach count divided by the Rock Island count while the Wenatchee percentage was estimates as the difference between the Rocky Reach and Rock Island counts divided by the Rock Island count.

Lake, through which runs the border between the United States and Canada. This run has persisted despite one of the longest, most difficult migrations of any salmon stock in the world. The stock migrates 986 km between the spawning grounds and the ocean through a series of irrigation control structures and one dam on the Okanogan River as well as nine mainstem Columbia River dams. Production of this run has long been believed to be limited by upstream and downstream migration survival as well as habitat factors in the spawning and rearing areas (Fryer 1995). Recent work has pointed increasingly at high temperature and low oxygen in Lake Osoyoos as adversely adult migration as well as juvenile rearing (Hyatt and Rankin 1999).

The Wenatchee stock spawns in tributaries to Lake Wenatchee and rears in the lake. This stock migrates 842 km through two Wenatchee River dams and seven mainstem Columbia River dams. Since the spawning grounds and lake are relatively pristine, the production of this run is believed limited by upstream and downstream survival as well as the low productivity of the oligotrophic Lake Wenatchee (Fryer 1995). Since 1995, the abundance of this stock relative to the Okanogan stock has declined, although the reasons are unknown. Although this project will focus at first primarily on Okanogan sockeye, we do plan to standardize smolt abundance estimates with those in Osoyoos Lake by conducting annual hydroacoustic and trawl surveys (ATS) of smolt abundance in Lake Wenatchee. Standardizing smolt abundance estimates in ATS units will allow calculations of SAR estimates, which can then be compared at face value with the longer series of SARs for Okanogan Basin sockeye (1997-2008).

Since both stocks are believed to be limited, at least in part, by upstream survival, in 2006 the Columbia River Inter-Tribal Fish Commission initiated a three year study funded by the Pacific Salmon Commission to examine upstream survival and timing by inserting Passive Integrated Transponder (PIT) tags in sockeye sampled at Bonneville Dam. These PIT tags were then detected at upstream dam fish ladders with detection capability (McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells dams on the Columbia River, Ice Harbor and Lower Granite dams on the Snake River, and in 1998, Tumwater Dam on the Wenatchee River). Results of this study have estimated survival rates (excluding fishery effects) from Bonneville Dam to Rock Island Dam of 80% (Fryer 2007, 2008). Results have also indicated that the Wenatchee stock migrates through Bonneville Dam earlier than the Okanogan stock, suggesting that the Okanogan stock has higher mortality on the upstream migration than the Wenatchee stock as results also indicate that later migrating sockeye salmon have higher mortality than earlier migrating fish. Although this project was scheduled to expire in 2008, it will be continued as part of our BPA MOA-funded Upstream Migration Studies project (2008-518-0).

This project will expand our Upstream Migration Studies project by funding deployment of PIT tag detection antennas as well as an acoustic tag network in the Okanogan Basin. This will allow sockeye salmon to be tracked through the Okanogan Basin, thereby allowing us to extend our migration survival estimates into the Okanogan River. We also will be able to determine where in the Okanogan River-Osoyoos Lake mortality is occurring, which may then allow for the development of different river management actions to reduce this mortality. It is hoped that, depending on where

mortality is occurred, better flow management techniques to optimize adult survival can be developed. The PIT tag network we develop as part of this project may also improve data on steelhead and Chinook use of the Canadian portion of the Okanogan Basin.

C. Rationale and significance to regional programs

Upstream migration of adult salmon is considered of critical importance to regional programs. PIT tagging adults allows these fish to be tracked through the hydrosystem, and their reaction to changing conditions to be monitored. For example, the ISRP and ISAB Example Summary Research Plan list as critical uncertainties the following:

1. What is the relationship between levels of flow and survival of juvenile and adult salmon and steelhead (including kelts) through the Columbia hydrosystem? Do changes in spill and other flow manipulations significantly affect water quality, smolt travel rate, and survival during migration? How do effects vary among species, life-history stages, and migration timings? What is the role of hydrodynamic features other than mid-channel velocity in fish migration?
2. What are the effects of multiple dam passages, transportation, and spill operations on adult salmon migration behavior, straying, and pre-spawn mortality, and SARs?
3. What is the effect of hydrosystem flow stabilization, flow characteristics, and channel features on anadromous and resident fish species and stocks?
4. What are the optimal temperature and water quality regimes for salmonid survival in tributary and mainstem reaches affected by dams, and are there options for hydrosystem operations that would enable these optimal water quality characteristics to be achieved? What would be the effects of such changes in operations and environment on anadromous and resident fishes, shoreline and riparian habitat, and wildlife?

Questions 1-3 will be a focus of our Upstream Migration Studies project, while this study will provide more information on the fourth question.

From page 90 of the Okanogan Basin Subbasin Plan (Page 90),

“Presently, within the basin, the [sockeye] population is believed to be chiefly limited by reduced rearing habitat in the north basin of Osoyoos Lake because of high temperatures and low oxygen, and by mortalities associated with delayed adult migration during high water temperature events (Hyatt, K D., M. Stockwell and D.P. Rankin. 2003). Climate change and the recent arrival of *Mysis relicta* into Osoyoos Lake are exacerbating the situation. Recovery efforts will likely include an extension of the run into the more hospitable rearing lakes they once occupied (Wright et al. 2007) as well as attempted improvements of current rearing conditions through the use of flushing flows and perhaps aeration. To be effective, these recovery efforts will have to be closely linked with other limiting

factors such as passage at the mainstem hydroelectric project, water withdrawals and habitat loss. Also, attention will need to be paid to losses and delays during migration. Schools of adult sockeye stage at the mouth of the river to wait for a drop in water temperatures, which is often brought on by an upstream rain event. Annual migration from Wells Dam to the spawning grounds ranges from one to three weeks, but temperature-induced delays of several days to several weeks have been observed (Hyatt pers. com.). This may be partially or wholly responsible for annual losses averaging about 50% between Wells Dam and the spawning grounds.”

Visual counts of fish passage at Wells and Zosel dam suggest a loss of 53.2% between Wells and Zosel dams in 2008, 20.5% in 2007, and 12.1% in 2006 (DART 2008). Additional losses are likely between Zosel Dam and the spawning grounds.

The plan goes on (Page 273) to call for “mark and recapture or radio tagging to determine where and why losses are taking place.”

This study directly addresses the call for better data on mortality upstream of Wells Dam.

The issues affecting the Wenatchee stock are less clear than the Okanogan stock. The Wenatchee Basin Subbasin Plan (2004) states (page 178)

“Rearing habitat for fry and parr is considered to be a limiting factor in Lake Wenatchee. Since Lake Wenatchee is an oligotrophic lake, it is unlikely that increases in fry-smolt production can be obtained unless increases in nutrients are introduced into the lake (e.g. Hyatt and Stockner 1985). This could be accomplished by either an increase in spawning salmon upstream of the lake or by artificial means.”

Under near term opportunities, the plan calls for (page 305)

“Increasing understanding of those factors that affect juvenile survival (primarily in Lake Wenatchee) would aid in the ability to improve production of this species. Investigations regarding increased nutrient loads in Lake Wenatchee should be undertaken to determine the benefits and potential risks of this management action (e.g. Hyatt et al. 2004).”

For the Wenatchee, annual hydroacoustic surveys of Lake Wenatchee will be conducted to standardize smolt abundance estimation methodologies with those conducted in Lake Osoyoos. This estimate will be used to estimate juvenile survival and will be compared to Wenatchee River smolt trap smolt estimates. A plan for further Wenatchee research will also be developed as part of this project.

D. Relationships to other projects

This project will run simultaneously with our Upstream Migration Timing (2008-518-00) as well as Pacific Salmon Commission-funded Bonneville sockeye salmon sampling program.

E. Project history (for ongoing projects)

N/A

F. Proposal biological objectives, work elements, and methods.

Biological Objectives

- 1) Estimate, using PIT tags, timing and survival of Okanogan sockeye salmon from Wells Dam to Zosel Dam, a vertical diversion structure upstream of Osoyoos dam, and McIntyre Dam.
- 2) Use acoustic tags to estimate survival in the three Osoyoos Lake subbasins and to determine sockeye salmon usage of selected Okanogan River tributaries. .
- 3) Standardize smolt abundance estimates between Osoyoos Lake and Lake Wenatchee.
- 4) Produce a plan to assess the status of the Wenatchee sockeye salmon stock.
- 5) Organize a sockeye workshop at 2011 American Fisheries Society meeting in Seattle.

Methods:

This project will be phased in over three years. In the first year, PIT tag antennas will be installed at an Okanogan River Vertical Diversion structure as well as at McIntyre Dam. An acoustic tag network will also be installed in the Okanogan Basin and sockeye salmon acoustic tagged at Wells Dam. In the second year, if approval can be obtained from necessary parties, PIT tag antenna installation is planned for Zosel Dam fish ladders and the Okanogan Basin acoustic network will be expanded. In addition, work will commence on Wenatchee Basin sockeye salmon to generate standardized ATS estimates of Wenatchee smolt abundance for ready comparison with similar estimates from Osoyoos Lake. In the second year of this project, we will develop a plan assessing the Wenatchee stock. In either the second or third year of this project, depending on funds available (both from this project and possible matching funds), an acoustic network will be developed in the Wenatchee Basin and acoustic tagging moved from Wells Dam to Priest Rapids Dam.



Figure 2. Map of Osoyoos Lake from Google Earth showing the three lake basins. Proposed acoustic receiver sites are denoted by red asterisks while proposed PIT tag detection sites are denoted by white asterisks.

Work Element 1.1 Install Fish Monitoring Equipment at a downstream Vertical Diversion structure in the Okanagan River

A PIT tag detection system will be installed at one of the lowest three Vertical Diversion Structures in the Okanagan River. The exact structure will be chosen after a site visit by Biomark. The system will detect tagged fish as they pass over any of the five spillways that make up each Vertical Diversion Structure. Data will be automatically uploaded via satellite to PTAGIS.

Work Element 1.2 Install Fish Monitoring Equipment-McIntyre Dam

Depending on cost and design considerations (to be determined after a site visit), a PIT tag detection system will also be installed at McIntyre Dam (which is going to be modified to allow fish passage in 2009). McIntyre Dam is located approximately 24 km upstream from Osoyoos Lake at the outlet to Vaseaux Lake. This system will detect fish PIT tagged adults as they pass upstream and automatically upload this information via satellite to PTAGIS.

Work Element 1.3 Install Fish Monitoring Equipment-Zosel Dam

Depending on cost and design considerations (to be determined after a site visit) as well as approval from those agencies involved with Zosel Dam operations, a PIT tag detection system will be installed at Zosel Dam in 2010. The system will detect tagged fish as they pass through either of the two adult fish ladders at this dam. This system will detect fish PIT tagged fish as they pass and automatically upload this information via satellite to PTAGIS.

Work Element 1.4 Mark/Tag Animals (PIT tagging)

Sockeye salmon sampled at Bonneville Dam will be PIT tagged as part of MOA project (2008-518-00). Up to 400 additional sockeye salmon will be PIT tagged at Wells Dam while conducting acoustic tagging (Work Element 2.1). Sampling will occur at both Wells and Bonneville Dams, on a weekly basis, throughout the entire run.

Work Element 1.5 Disseminate Raw/Summary Data and Results

Standard data (CBFWA 1999) on fish PIT tagged will be uploaded to the PTAGIS database via satellite feed. Summary data will be disseminated in an annual report; however anyone with knowledge of the PTAGIS database should be able to easily summarize the data as soon as it is uploaded.

Work Element 1.6 Analyze/Interpret data-sockeye migration mortality and timing,

Each fish PIT tagged will be monitored on the upstream migration. PIT tags will be used to estimate survival and escapement to the PIT tag installation sites funded by this project.

Work Element 2.1 Mark/Tag Animals (Acoustic tagging)

Acoustic tags will be implanted into sockeye salmon at the Wells Dam east bank fish trap. The number of fish to be tagged will depend on our available budget after PIT tag antenna installation as well as potential cost shares from other funding agencies; however we anticipate a minimum sample size of 50 for 2009. This will be expanded in subsequent years. All fish acoustic tagged will also be PIT tagged (or acoustic tags with integrated PIT tags used). Acoustic tag receivers will be placed at a minimum of eight locations upstream of Wells Dam (Figure 2); in the lower Okanogan River, Columbia River upstream of the Okanogan River confluence, lower Similkameen River, Zosel Dam tailrace, Zosel Dam forebay, channel between central and southern basins of Osoyoos Lake, channel between the central and northern basins of Osoyoos Lake, and near Vertical Diversion Structure 1 just upstream of Osoyoos Lake. If a cost match can be found, additional acoustic receivers will be

placed elsewhere in the Okanogan River to monitor migration passage as well as in the lower Methow River (where, in most years, sockeye salmon have been observed spawning), and Okanogan River tributaries such as Omak Creek and Tonasket Creek to determine if any sockeye stray or hold in these locations. If no cost match is found for 2009, these additional sites will be deployed in 2010.

Work Element 2.2 Disseminate Raw/Summary Data and Results

Data will be downloaded from the acoustic receivers every two weeks. Summary data will be disseminated in an annual report.

Work Element 2.3 Analyze/Interpret data-sockeye migration mortality and timing,

Acoustic tags will be used to estimate mortality rates and migration timing from Wells Dam to the lower Okanogan River, Zosel Dam, and through the three basins of Osoyoos Lake.

Work Element 2.4 Disseminate Raw/Summary Data and Results

Raw and summary acoustic data will be incorporated into an annual report.

Work Element 3.1 Collect/Generate/Validate Field Data-Wenatchee smolt abundances

Beginning in 2009, ATS techniques will be applied at Lake Wenatchee to estimate sockeye salmon smolt abundance.

Work Element 3.2 Disseminate Raw/Summary Data and Results. Data will be incorporated into an annual report.

Work Element 3.3 Analyze/Interpret data Lake Wenatchee hydroacoustic estimates will

be compared with those from Osoyoos Lake as well as smolt abundance estimates from downstream Wenatchee River smolt traps.

Work Element 4.1. Develop Wenatchee stock assessment plan. This plan will be developed in 2010.

Work Element 5.1. Outreach and Education. Organize a symposium on Columbia Basin sockeye stocks for the 2011 American Fisheries Society in Seattle.

Project Administration

Work Element 6.1 Manage and Administer Projects- Project administration

Work Element 6.2 Produce/Submit Scientific Findings Report- Produce quarterly milestone reports

Work Element 6.3 Produce/Submit Scientific Findings Report- Submit annual reports, a final report, and scientific journal article.

Methods: Managing and administering this project, quarterly reports, and annual reports, as well as a final report will be done by CRITFC staff.

G. Facilities and equipment

PIT Tag array purchase and installation at a Vertical Diversion Structure, McIntyre Dam, and Zosel Dam will be achieved through a contract with Biomark. Acoustic antennas and tags will be purchased for this project.

H. References

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I. Key personnel

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CURRICULUM VITA

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Education

- 1995 University of Washington Ph.D. (Fisheries). Dissertation title: Columbia Basin sockeye salmon-causes of their past decline, factors contributing to their present low abundance, and the future outlook.
- 1985 University of New Brunswick at Fredericton, New Brunswick, Canada. M.Sc. (Computer Science)
- 1979 University of New Brunswick at Fredericton. B.Sc.(Computer Science) with the equivalent of an honors in Statistics and a minor in Economics

Appointments

October 1989 to present: Fisheries scientist and project leader at the Columbia River Inter-Tribal Fish Commission. Duties have included the supervision of sockeye and Chinook salmon stock identification projects. The stock identification project has required designing and implementing stock identification experiments, field sampling, reading scales for age, measuring scale circuli, creating computer programs, spreadsheets, and databases to manage and analyze data, making presentations at technical and professional meetings, and publishing technical reports and journal articles.

June 1987 to September 1989: Graduate research assistant at University of Washington.

September 1985 to June 1987: Teaching assistant at the University of Washington.

Selected Publications

- Fryer, J.K. 1998. Frequency of pinniped-caused scars and wounds on adult spring-summer Chinook and sockeye salmon returning to the Columbia River. *North American Journal of Fisheries Management*. 18: 46-51.
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