Table 1. Proposal Metadata

Project Number	2008-503-00
Proposer	Columbia River Inter-Tribal Fish Commission
Short Description	Sockeye Studies (Studies into factors limiting the abundance of Okanagan and Wenatchee sockeye salmon)
Province(s)	Columbia Cascade
Subbasin(s)	Okanagan and Wenatchee
Contact Name	Jeff Fryer
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The Columbia Basin Fish Accords (Accords) are ten year agreements between the federal action agencies and states and tribes. The Accords are intended to assist the action agencies in meeting obligations under the Endangered Species Act by producing substantial biological benefits for Columbia Basin fish and they supplement the Northwest Power and Conservation Council's Fish and Wildlife Program. The Accords also acknowledge the tribes' and states' substantive role as managers of the fish resource and provide greater long-term certainty for fish restoration funding and biological benefits for fish. Ongoing projects supported and new projects developed under these agreements, such as this one, are designed to contribute to hydro, habitat, hatchery and predation management activities required under the 2008 FCRPS Biological Opinion. In addition, projects within the agreement assist BPA in meeting its mitigation obligations under the NW Power Act.

A. Abstract

This project seeks to expand our knowledge on the factors limiting production of Okanagan[1] and Wenatchee sockeye salmon stocks. This project will initially focus on the Okanagan stock as there are a number of projects which can be immediately implemented that will build on present supplementation, habitat restoration, and water management programs. A plan for Wenatchee sockeye research will be developed in the first two years of this project, after which the focus of this project is expected to shift more to this stock.

A primary factor affecting the Okanagan stock is believed to be survival upstream of Wells Dam. To quantify this mortality, this project will fund PIT tag detection antennas at McIntyre Dam on the Okanagan 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

[1] In this proposal, the Canadian spelling for Okanagan, as opposed to the American spelling (Okanogan) will be used.

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, Okanagan sockeye salmon mortality will be partitioned by reach upstream of Wells Dam and survival correlated with river and lake conditions. This information can then be added into the models currently used for Okanagan 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.

This narrative covers work to be done for the first year of this project (March 1, 2009-February 1, 2010).

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 highest since 1955 (Figure 1).

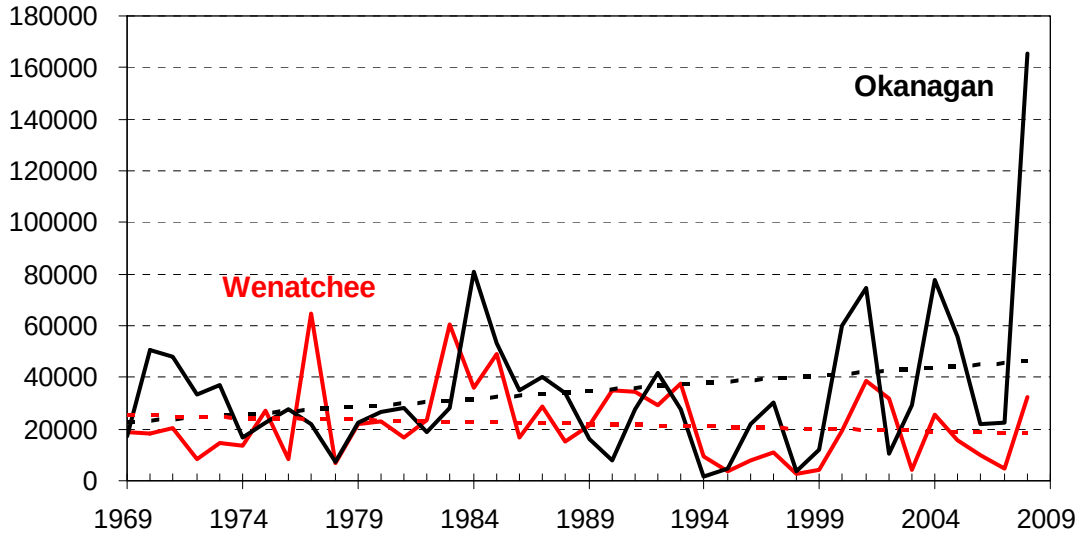

Figure 1. Okanagan and Wenatchee stock sockeye escapement, with linear trend lines, to the mid-Columbia River as estimated from counts at mainstem dams 1969-2008

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 2); the first originating in the Wenatchee River-Lake Wenatchee System (Wenatchee stock) and second in the Okanagan River-Osoyoos Lake System (Okanagan 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 counts[2] indicated that the Okanagan stock averaged 53.2% of the total run and the Wenatchee stock 46.8% of the run (Fish Passage Center 2008). However, since 1995, the Okanagan 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 2. Map of the Columbia Basin showing fishery Zones 1-5 and 6, mainstem dams, and the two major sockeye salmon production areas being investigated in the Wenatchee and Okanagan river systems.

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

[2] The Okanagan 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.

a series of irrigation control structures and one dam on the Okanagan River[3] 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 research has pointed to high temperatures and low oxygen levels in Lake Osoyoos as likely being a significant source of mortality for juveniles rearing in the lake as well as adults migrating through the lake (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 commonly considered 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). Over the past 20 years, the abundance of this stock has declined, while the Okanagan stock has increased. The reason for this decline, despite the introduction of a hatchery program in 1988, is unknown. Hypotheses proposed include increasing winter rain on snow events resulting in floods that scour redds, an increase in predatory bull trout in Lake Wenatchee, a decrease in survival through the hydrosystem (possibly from modifications in the hydrosystem adversely affecting the generally smaller Wenatchee smolt more than larger Okanagan smolt), changing lake conditions, and competition in Lake Wenatchee from juvenile sockeye salmon raised in a hatchery program. There is little data to support or discredit any of these hypotheses. Although this project will initially focus on Okanagan sockeye as there are a number of projects which can be immediately implemented that will build on present supplementation, habitat restoration, and water management efforts; one need which has been identified is to standardize smolt abundance estimates with those in Osoyoos Lake by conducting annual hydroacoustic trawl surveys (ATS) of smolt abundance in Lake Wenatchee. Standardizing smolt abundance estimates in ATS units will allow calculations of smolt to adult return (SAR) estimates, which can then be compared at face value with the longer series of SARs for Okanagan Basin sockeye (1997-2008) which has been collected by the Canadian Department of Fisheries and Oceans and the Okanagan Nation Alliance. A potential issue with ATS is differentiating sockeye smolt from kokanee. Kokanee populations are very small in both Lake Wenatchee and Osoyoos Lake (estimated at about 3% of the sockeye population based on spawning ground estimates [K. Hyatt, DFO, personal communication]). Biosamples will also be taken using a mid-water trawl net to confirm the relative abundance of sockeye salmon and kokanee.

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. At the Bonneville Dam Adult Fish Facility, sockeye selected for sampling are examined for tags (including scanning for existing PIT tags), fin clips, wounds, and condition,

[3] Currently, on the Okanogan River, only Zosel Dam has fish ladders. McIntyre Dam, the current terminus of sockeye migration, is scheduled to be modified in summer, 2009 to allow sockeye salmon to pass upstream. The upstream barrier at that point will be a dam at the outlet of Skaha Lake.

measured for length, and four scales removed for later age analysis and measurement for our stock identification project. Data is recorded on datasheets. PIT tags are inserted into the body cavity of the sockeye salmon using standard techniques (CBFWA 1999). The fish are scanned for the PIT tag number which is recorded. If no tag is detected due to either the tag being shed or a malfunctioning tag no effort was made to implant another tag to eliminate the possibility of double tagging. Sockeye salmon are allowed to recover prior to release in a small recovery tank which was checked daily for shed tags. All PIT tag and sampling information is uploaded to the Columbia Basin PIT tag information system (PTAGIS) database (www.ptagis.org). PIT tags are 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 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 Okanagan stock, suggesting that the Okanagan 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 Okanagan Basin. Battery powered acoustic receivers, with a battery life of at least six months) will be placed at a minimum of eight locations upstream of Wells Dam (Figure 3):

1.) Just upstream of the mouth of the Okanagan River.
2.) Columbia River upstream of the Okanagan River confluence.
3.) Lower Similkameen River
4.) Zosel Dam tailrace
5.) Zosel Dam forebay
6.) Channel between the central and southern basins of Osoyoos Lake (Oka
7.) Channel between the central and northern basins of Osoyoos Lake
8.) Just upstream of whichever vertical control structure is chosen for PIT tag detection.

The network we are proposing will allow sockeye salmon to be tracked on their upstream migration through the Okanagan Basin, allowing us to determine stream and lake reaches where survival may be low. It is theorized that the southern and central basins of Osoyoos Basin are the most inhospitable for migrating sockeye salmon due to high temperatures at the surface and low oxygen levels in deeper waters during in July and August (Hyatt et al. 2003). The northern basin of Osoyoos through July and August offers the best potential as a refuge for migrating adults as well as rearing juvenile sockeye salmon, though even in that basin only a thin layer of suitable habitat may exist for adults and juveniles sockeye salmon. Water parameters such as oxygen, phosphorous, nitrogen, and temperature are regularly monitored in Osoyoos Lake (McQueen et al. 2007a, Hyatt et al. *in preparation*). Osoyoos Lake northern basin water

quality is highly affected by the Okanagan River with increasing flows resulting in mixing which increases oxygen levels while decreasing temperatures. If we could quantify the levels at which these water temperature and/or oxygen become critical for sockeye salmon, it maybe possible to increase inflows as needed. While PIT tags can be used to track sockeye salmon entering Osoyoos Lake (if PIT tag detection were installed at Zosel Dam) and leaving Osoyoos Lake (at a vertical diversion structure), acoustic (or radio) tags offer the only method of tracking fish as they travel between basins. In addition, by placing acoustic receivers in key tributaries, we can determine if sockeye salmon may use these tributaries as thermal refuges on their upstream migrations. Acoustic tag data will also allow sockeye mortality in the lower Okanagan River to be estimated.

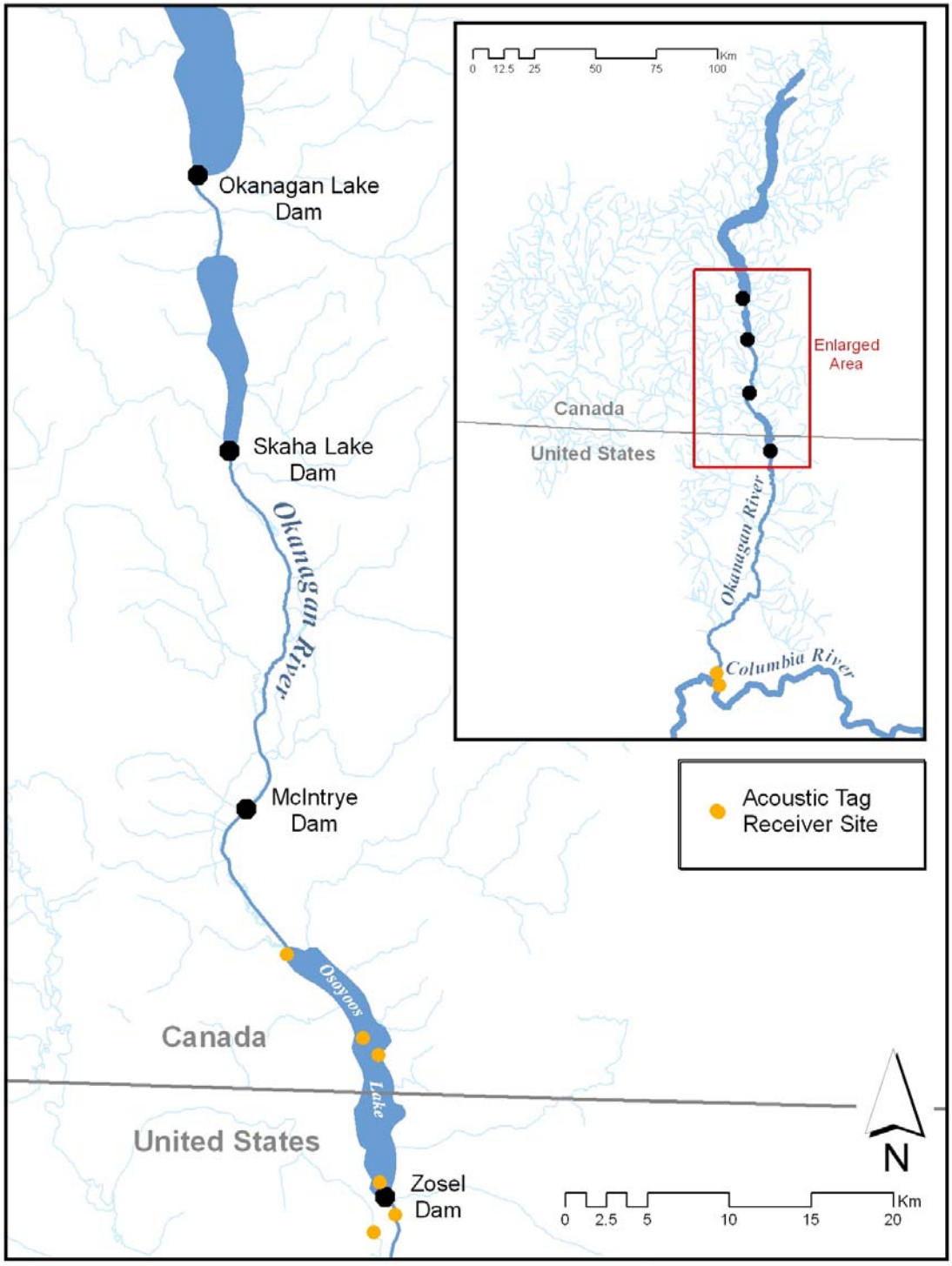

Figure 3. Map of the Okanagan Basin showing proposed acoustic tag receiver sites.

Given the relatively low summer water velocities in the lower Okanagan River, and especially through Osoyoos Lake, it is unlikely that carcasses drifting downstream would affect the results by generating detections at acoustic receivers.

The PIT tag network we develop as part of this project will also benefit other studies in the system by improve data on steelhead and Chinook use of the Canadian portion of the Okanagan 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 fish to be tracked through the hydrosystem, and their reaction to changing environmental factors (typically flow and temperature) 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 Okanagan 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 dams (the latter only available since 2006) 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 Okanagan Subbasin Plan goes on (Page 273) to call for "mark and recapture or radio tagging to determine where and why losses are taking place." This project will better determine where sockeye salmon are lost on the upstream migration, which we will correlate with temperature and oxygen levels to develop hypotheses as to conditions causing increased losses.

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 Okanagan 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. These estimates will be used to estimate egg-to-smolt and smolt-to-adult survival and also compared to estimates from existing Wenatchee River smolt traps

operated by Washington Department of Fish and Wildlife[4]. In addition, these estimates will be compared to those from the Osoyoos Lake. A plan for further Wenatchee research will also be developed as part of this project, however we believe that assessing smolt abundance will be critical to this research plan so plan to go ahead with the ATS while the plan is being developed.

D. Relationships to other projects

This project will run simultaneously with our Upstream Migration Timing (2008-518-00) as well as Pacific Salmon Commission (PSC)-funded Bonneville sockeye salmon sampling program. PSC funds the basic sampling and analysis, while the Upstream Migration Timing project will fund the tagging of sockeye (in addition to steelhead and Chinook) at the Bonneville Dam Adult Fish Facility. PIT tag data from this project will be uploaded to the PTAGIS system (www.ptagis.org) run by the Pacific States Marine Fisheries Commission (PSMFC).

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 Okanagan sockeye salmon from Wells Dam to a vertical diversion structure upstream of Osoyoos dam. (If PIT tag detection is installed at Zosel Dam, also estimate timing and survival through this site as well.) Also, estimate escapement over McIntyre Dam once it is modified to allow for adult passage.
2) Use acoustic tags to estimate survival through each of the three Osoyoos Lake subbasins and to determine sockeye salmon usage of selected Okanagan River tributaries. .
3) Standardize smolt abundance estimates between Osoyoos Lake and Lake Wenatchee by conducting an acoustic trawl survey in 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 Okanagan River Vertical Diversion structure as well as at McIntyre Dam (Figure 4). An acoustic tag network will also be installed in the Okanagan Basin (Figures 3 and 4) and sockeye salmon acoustically tagged at Wells Dam. In the second

[4] ATS estimates have been found to more accurately estimate sockeye smolt abundance in British Columbia than smolt trap estimates, especially for small populations such as the Wenatchee (Kim Hyatt, DFO, personal communication).

year PIT tag antenna installation is tentatively planned for Zosel Dam fish ladders[5] and the Okanagan Basin acoustic network will be expanded. The combined network will consist of the following:

1.) Acoustic receiver just upstream of the mouth of the Okanagan River.
2.) Acoustic receiver on the Columbia River upstream of the Okanagan River confluence.
3.) Acoustic receiver in the Similkameen River (entering the Okanagan River at km 119) just upstream from the mouth
4.) Acoustic receiver at Zosel Dam (Okanagan River km 125) tailrace
5.) Acoustic receiver at Zosel Dam forebay
6.) Acoustic receiver at channel between the central and southern basins of Osoyoos Lake (Okanagan River km 136)
7.) Channel between the central and northern basins of Osoyoos Lake (Okanagan River km 138)
8.) PIT tag detection at a lower vertical control structure. (The Okanagan River enters Osoyoos Lake at river km 145 and detection would be installed within the lower five kilometers.)
9.) Acoustic receiver Just upstream of whichever vertical control structure is chosen for PIT tag detection
10.) McIntyre Dam (Okanagan River km 170)

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. As part of this plan we will compile available data (Tumwater, Rocky Reach and Rock Island dam counts (DART 2008), spawning ground survey data [WDFW], smolt abundance estimates from smolt traps [WDFW], sockeye hatchery broodstock and release data [WDFW], age composition estimate [CRITFC], and any available water quality data. We also plan to hold a meeting in Wenatchee in late 2009 or early 2010 to gather Wenatchee sockeye salmon experts to present findings on trends in Wenatchee sockeye abundance, theories on the recent weakness of the Wenatchee sockeye run relative to the Okanagan, and possible studies to resolve key uncertainties. From this, we will develop a sockeye research plan to begin in late 2010.

It is likely that as part of this plan we will expand the sockeye acoustic network into the Wenatchee Basin and move acoustic tagging from Wells Dam to Priest Rapids dam which has a relatively new adult fish sampling facility.

This project will benefit from two other projects which sample and tag sockeye salmon at the Bonneville Dam adult fish trap. Sampling (including length measurement, and scale acquisition for aging as well as analysis) is funded by the Pacific Salmon Commission. Many of these sockeye salmon will be detected at the PIT tag detection

[5] The Colville Tribe has also been working towards installing PIT tag detection at Zosel Dam and it is possible that they will do so using other funding. If such funding does not come through, we hope to work with the Colville Tribe on this project.

systems planned at McIntyre Dam and a lower vertical diversion structure proposed by this project. Data acquired by these PIT tag detection systems will be uploaded and maintained by PTAGIS (www.ptagis.org) maintained by the Pacific States Marine Fisheries Commission (PSMFC). This data will then be available to anyone who registers at this site. Through PTAGIS, this project will likely benefit other Okanagan Basin PIT Chinook and steelhead tagging projects by providing data on PIT tagged fish movement in the Canadian portion of the Okanagan Basin.

Figure 4. 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 two 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. It is anticipated that data will be automatically uploaded via satellite to PTAGIS. This provides near real-time monitoring as well as providing quicker notification of any technical problems than does occasional downloading of data. However, if costs prove to be too high, data may be stored on site and downloaded periodically by technicians.

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)[6]. 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. This provides near real-time monitoring as well as providing quicker notification of any technical problems than does occasional downloading of data.

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 adult fish trap. Data from acoustic tags will be used to partition survival on the migration route into the following:

a.) Wells Dam to Okanagan River mouth
b.) Okanagan River mouth to Zosel Dam
c.) Through the southern basin of Osoyoos Lake
d.) Through the central basin of Osoyoos Lake

[6] If costs for this installation exceed our budget, installation may have to wait until 2010.

e.) Through the northern basin of Osoyoos Lake.

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 3): in the lower Okanagan River, Columbia River upstream of the Okanagan 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 Okanagan River to monitor migration passage as well as in the lower Methow River (where, in most years, sockeye salmon have been observed spawning), and Okanagan 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.

Although not part of this project, the Okanagan Nation Alliance (ONA) expects to use the Okanagan acoustic monitoring network portion of this project, likely supplemented with additional receivers, to assess downstream survival and migration timing. The ONA and Canadian Department of Fisheries and Oceans do not see PIT tagging juveniles as a viable option. This is due primarily to the difficulty in maintaining a smolt trap capable of capturing sufficient smolt downstream of Lake Osoyoos. During the spring outmigration, trap operations are often adversely affected by high flows from the Similkameen River, located just downstream, slowing Okanagan River flows which adversely affects trap efficiency. Another problem with PIT tagging juveniles is that first place where downstream migrating PIT tagged juvenile sockeye salmon can be detected is at McNary Dam. Large numbers of sockeye salmon would have to be tagged to get sufficient detections at McNary and downstream dams to obtain reasonably precise survival estimates over such a long distance. Even if that could be achieved, it still would be impossible to partition survival between Osoyoos Lake and McNary Dam. Acoustic tagging, combined with an acoustic network between Osoyoos Lake and Priest Rapids Dam, some of which may already be in place or which could be relatively inexpensively deployed (acoustic receivers for the network we are proposing are approximately $1500 each), would allow survival to be partitioned from Zosel Dam to the Columbia River and then through the different dam/reservoir systems.

Work Element 2.2 Disseminate Raw/Summary Data and Results

Data will be downloaded from the acoustic receivers every two weeks. Data will be uploaded to www.critfc.org. 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 Okanagan River, Zosel Dam, and through the three basins of Osoyoos Lake.

Acoustic and PIT tag detection results will allow detection of whether the apparent mortalities that take place between Wells Dam and the spawning grounds immediately below McIntyre Dam take place during: (1) the period of holding in Wells Pool, (2) the period of migration between the mouth of the Okanagan River and Zosel Dam, (3) the period involving passage from Zosel Dam through the South and Central Basin of Osoyoos Lake, (4) the period of pre-spawn holding in the North Basin of Osoyoos Lake or in the Okanagan River.

The general conceptual model that are testing is that various combinations of temperature, oxygen, and discharge interact within specific sub-habitats (Wells Pool, Okanagan River downstream of Zosel, Central and South Basins of Osoyoos Lake, North Basin of Osoyoos Lake) along the migration route of sockeye salmon such that one or more, sub-habitat specific survival "bottlenecks" may be identified. The statistics we'll use will likely be ANOVA comparisons for the existence of significant differences in mean survival by sub-habitat type and temporal interval.

Work Element 2.4 Disseminate Raw/Summary Data and Results

Summary acoustic data will be incorporated into an annual report. Raw data will be available upon request.

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

Beginning in winter 2009-10, ATS techniques will be applied at Lake Wenatchee to estimate sockeye salmon smolt abundance. The timing of this survey will be similar to that for the annual survey already conducted in Osoyoos Lake.

In the ATS, nighttime juvenile sockeye salmon densities will be estimated using a Simrad EYM 70-KHz sounder deployed over whole-lake transects and several depth strata using methods described in McQueen and Hyatt (2007b). Density estimates will be used to determine total numbers of juvenile sockeye salmon. Fish biosamples will be collected using a midwater trawl net (232-m mouth opening, 7.5-m length) to estimate lengths, weights, and ages as well as the proportion which are kokanee.

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 currently run by WDFW.

Work Element 4.1. Develop Wenatchee stock assessment plan. This plan will be developed in 2010. As part of developing this plan, we will sponsor a half- or full-day session in late 2009 or early 2010 to bring together scientists and managers

presently working on Wenatchee sockeye issues. The focus of this meeting will be to determine what research is currently being done, what data is being collected, and what needs to be done to determine why Wenatchee stock sockeye abundance is trending downwards in comparison to the Okanogan.

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 Pisces milestone reports

Work Element 6.3 Produce/Submit Scientific Findings Report- Submit annual reports.
Methods: Managing and administering this project, quarterly reports, and annual reports will be done by CRITFC staff.

G. Facilities and equipment

We expect to contract for PIT Tag array purchase and installation at a Vertical Diversion Structure and McIntyre Dam. Acoustic antennas and tags will be purchased for this project.

H. References

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I. Key personnel

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Dr. Kim Hyatt, Department of Fisheries and Oceans, Nanaimo, British Columbia.

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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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