Proposed Study Plan
Sockeye Migration Study at OLAFT with
Transport via the Whooshh Fish Transport System

June 2016

Purpose

To conduct an investigative study to evaluate the effect of transport via the Whooshh Fish Transport System (WFTS), during passage up the Priest Rapid Dam ladder, on migration of Sockeye in the mid-Columbia River.

Background

It has been reported that dams impact anadromous fish species in a number of ways from inundating shoreline and spawning areas to changing the flow patterns of rivers, creating reservoirs and still water which can result in a rise in water temperatures with a domino of ecosystem impacts (Harrison, 2008). The most obvious impediment however is that dams block anadromous fish passage between spawning, juvenile habitats and the ocean. The spawning migrations of Pacific salmon are fueled by energy stores acquired during ocean residency prior to entering freshwater rivers and streams (Nadeau et al. 2010). Because salmon populations have genetic adaptations optimized for migration efficiency for specific river conditions, it is expected that the stresses encountered in travel through man-made passage facilities could have negative implications regarding spawning success. Man-made passage impediments often require additional energy expenditures of the fish. Traditional ladder passage typically cause fish to expend energy reserves as they are forced to swim through a series of high gradient cascades to pass the barrier. This output of energy can deplete a portion of the population inhibiting them from reaching the spawning grounds or having adequate energy remaining for spawning. In addition, there is growing evidence that dam-associated increases in water temperature, which often feed the upper section of ladders by gravity, is contributing to downstream fallback and represents a significant migration obstacle concern (Crozier, 2013 and Caudill, 2013).

In considering passage challenges to be addressed in the future, might there be a way to implement safe fish passage with minimal fish energy expenditure at a cost that is not prohibitive in terms of fish survival and reproduction, time, land and resources, and dollars? An innovative fish passage system developed by Whooshh Innovations, LLC (Whooshh) has been designed to decrease passage time with the benefit of requiring minimal energy expenditure during passage. The Whooshh fish transport system (WFTS) utilizes a novel differential pressure system that facilitates movement of individual fish through a soft tube structure in a matter of seconds. The tube is made of a flexible material which is highly adaptable to location needs and challenges, and provides the ability to direct entry and exit at desired locations (Whooshh,

2016). A number of successful studies and applications have been conducted employing 40 and 250 ft tubes to transfer fish from holding tanks and traps in rivers to haul trucks and raceways. In a comparative study conducted by PNNL, evaluating fish well-being of net capture and haul, to a 40 or 250 ft WFTS tube transfer yielded favorable results with the WFTS transported fish, (both 40 ft and 250 ft transport) demonstrating equal to or better outcomes in health, survival and reproduction measures compared to controls (PNNL, 2014). Proof of concept of the ability to utilize the Whooshh system to transport fish through a tube of 1100 ft has been demonstrated on live fish. The time to transport through a 1100 ft Whooshh tube ranged from 35-45 seconds. With the ability to alter the pressure, the system is designed such that deceleration at exit can be achieved to NMFS standards. The current study builds on these studies to address the question of WFTS transport effect on migration.

The Columbia River Inter-Tribal Fish Commission (CRITFC) has conducted yearly migration studies on the Columbia river to monitor the up-river migration extent and reach that various salmon populations achieve in seeking suitable spawning grounds (Narum and Fryer, Fryer et al, 2015, Fryer, et al., 2016, CRITFC 2016). CRITFC and Whooshh Innovations have put in place a study to evaluate the mid-Columbia migration of Sockeye PIT-tagged at the Off Ladder Adult Fish Trap (OLAFT) on the Priest Rapids Dam. In addition to migration assessment, the study offers potential benefits for the Columbia River Fish Accords Passage Project (CRITFC, 2016b). PIT tag data will be collected as the sockeye potentially pass through the PIT tag antennas at fish ladders at Priest Rapids, Rock Island, Rocky Reach, Wells, Zosel and Tumwater Dams as well as instream arrays in the Wenatchee and Okanogan basin. PIT tag data will be uploaded to PTAGIS and travel times and survival compared to sockeye tagged at Wells and Bonneville dams.

PIT detection efficiencies are generally high at Tumwater, Wells and Rocky Reach Dams (about 98-100%), and a bit lower at Rock Island Dam (about 94-96%). The Okanogan tributary arrays detection efficiency varies widely, depending on environmental conditions. In 2013, it was reported that 772 sockeye were tracked by PIT tag detection at Priest Rapids in the mid-Columbia. Of the total sockeye detected at Bonneville, 70%, entered the Okanogan Basin, 28% entered the Wenatchee Basin, and a combined 2.1% entered the Entiat, Yakima and Deschutes Basins (Fryer, 2013). Based on Fryer's data from 2013, if 500 Sockeye are tagged in 2016, it is likely that about 98% of these fish will be detected at some upstream array beyond the immediate site post tagging-expected 100% PIT detection, at Priest Rapids Dam. How far they are detected upstream into the tributaries will depend on how well these arrays are operating, but chances are very good that fish will be detected at one or more mainstem dams on the Columbia River.

Objectives

- *To insert a PIT tagging and Sockeye assessment step +/- a WFTS transport step of ~100 ft into the standard fish passage process at OLAFT.*
- *Sample a minimum of 700 but no more than 900 sockeye as they pass through the*

OLAFT facility across a timeframe of ~one month.

- *Monitor the upriver migration of the PIT-tagged sockeye collecting data via PIT tag antennas at upstream sites.*
- *Comparative migration analysis of the experimental WFTS transported study set relative to the control standard passage set of sockeye PIT tagged for this study at OLAFT.*
- *A secondary analysis may be conducted utilizing the mid-Columbia River PIT tag migration data of this study compared with Wells and Bonneville sockeye tagged data.*
- *Derive from the analysis a data-driven position with respect to the effect of WFTS transport on migration, homing and associated genetics, passage timing, in essence long term migration survival, and indirectly on passage safety and disease transmission.*
- *Produce a report on the effect of WFTS transport on Sockeye long term migration survival, homing, passage time, including indirect evidence related to passage safety and disease transmission.*

Methods

Over the past 10 years, sockeye runs have averaged over 285,000 fish at Bonneville Dam (Fish Passage Center, 2016). Their passage through various dams is well documented however migration tracking can be refined by employing PIT tagging to enable individual fish migration analysis. In encountering the Priest Rapids Dam (PRD) the fish enter the ladder and proceed up approximately half the distance to the forebay before being routed to the OLAFT. Once in the trap the fish can be sampled and returned to a recovery area from which they re-enter the ladder system and travel the second half up to the forebay, being detected by the PRD PIT antennas on the way.

An approximate sampling schedule has been created to distribute the sampling across the sockeye run. A minimum of 700 will be sampled across a one-month period.

Start Date		Based on 900 goal		Based on 700 goal	
Week	**Sample Dates**	**Weekly**	**Cumulative**	**Weekly**	**Cumulative**
26-Jun	June 29-July 1	242	242	188	188
3-Jul	July 6-8	340	580	264	452
10-Jul	July 12-14	215	796	167	619
17-Jul	19-Jul	104	900	81	700

Trained personnel will manage the process with sampling help provided by CRITFC, Whooshh and the Yakama Nation (YN). The Sockeye in the OLAFT will be routed into a tank containing Aqui-S to mildly anesthetize allowing fish handling for measurements and tagging. Measurement expectations include weight, fork length and circumference positioned just in front of the dorsal fin. In addition, scales will be taken to determine age and genetic samples collected. The fish will be scanned for other tags, PIT-tagged and placed in a recovery tank for a short time, allowing fish to partially recover from anesthetic treatment prior to loading into the WFTS or hand transporting to the ladder recovery area. The sample will be systematically divided into the two groups representing an equal number with alternating samples of sockeye

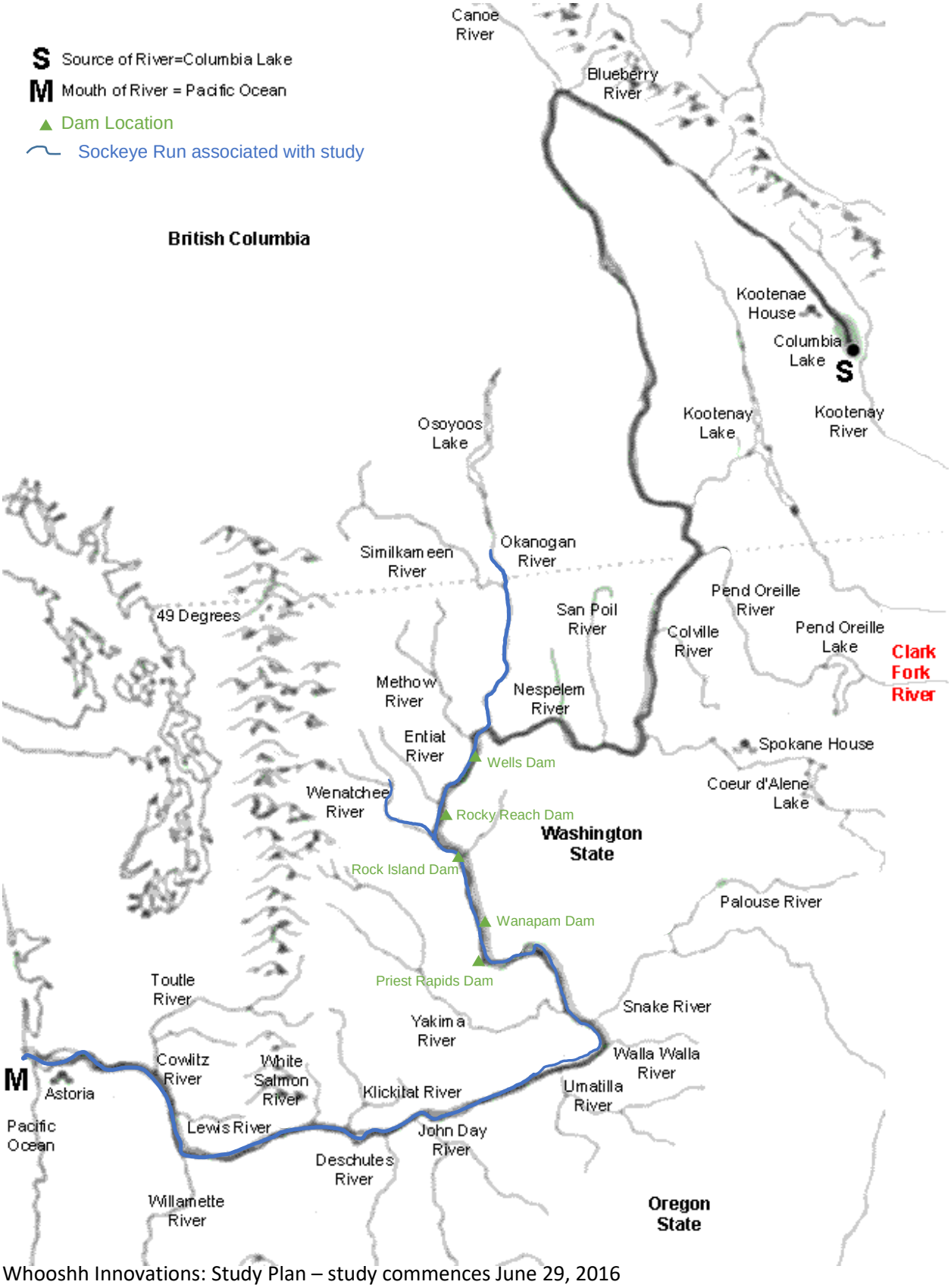
to be transported via WFTS or hand carriage. These shall be referred to as the WFTS group "WFTS set" and hand carriage group "OLAFT-control set". The WFTS will be approximately 100 ft in length and utilize a T123 conduit. General guidelines for this system cite a minimum circumference of 30.2 cm and a maximum of 38.4 cm, typically in the 1-3.7 kg range. Fish of the WFTS set are placed in the Whooshh tube, transported and exit the tube into the ladder recovery area wherein they are allowed to reenter the ladder system. Atypical behavior of any one fish or fish from any one transport group will be noted.

All collected data will be sent to CRITFC and PIT tag data uploaded to PTAGIS. CRITFC will provide copies of any data sheets or files to Whooshh. PIT tag detection data will be captured as the fish migrate upstream through fish ladders and over in-stream arrays, all of which send their data to PTAGIS in near real time. Some of these sites include Rock Island, Rocky Reach and Wells on the mainstem Columbia River, and Zosel, Oliver, McIntyre, Skaha and Lower Okanogon in the Okanogon Basin, and at Tumwater and other small tributaries in the Wenatchee System. Some of these sites work great all the time (near 100% detection), and others are dependent on river flow levels to get precise data. PIT tag data is uploaded in near real time for most of these sites however, data from a few of these challenged sites such as McIntyre and Skaha are typically not uploaded to PTAGIT in real time. The intermittent data collected from those sites will be deemed supplemental and supportive data but not critical to draw study conclusions. Table 1 is an example of Data Access in Real Time (DART) PIT tag data which is similar to that which will be generated from the PTAGIS data system and Figure 1 is a map of the sockeye migration run. Analysis of the PIT detection data will reveal a picture of sockeye long term migration survival up the mid-Columbia River.

PIT Detection Site	PIT Site Name	Location		Sockeye PIT counts			Fraction of Priest Rapids detections			Fraction detected from downstream dam			3 year average
		River	KM	2013	2014	2015	2013	2014	2015	2013	2014	2015	
Priest Rapids	PRA	Columbia	639.0	1062	1687	989	1.00	1.00	1.00				
Rock Island	RIA	Columbia	730.0	945	501	761	0.89	0.30	0.77	0.89	0.30	0.77	0.65
Wenatchee confluence	---	Columbia	753.8	---	---	---							
Tumwater	TUF	Wenatchee	49.7	328	322	207	0.31	0.19	0.21	0.31	0.19	0.21	0.24
Rocky Reach	RRF	Columbia	763.0	687	1251	631	0.65	0.74	0.64	0.96	0.93	0.85	0.91
Wells	WEA	Columbia	830.0	660	1230	587	0.62	0.73	0.59	0.96	0.98	0.93	0.96
Okanagon confluence	---	Columbia	858.6	---	---	---							
Lower Okanogan	OKL	Okanogan	24.9	1	612	474	0.00	0.36	0.48	0.00	0.50	0.81	0.44
Zosel	ZSL	Okanogan	132.0	184	1396	295	0.17	0.83	0.30	0.28	1.13	0.50	0.64

Table 1. PIT tag adult sockeye salmon data from 2013-2015 (DART website)

Figure 1. Study of PIT-tagged Sockeye Migration Run



Data Analysis

After migration is complete, data on PIT tagged sockeye will be retrieved from the PTAGIS website (http://www.ptagis.org/) by Dr. Jeff Fryer of CRITFC, Bryan Norland and scientists at Whooshh. A comparative analysis will be performed with respect to the migration behavior, travel time and survival to upstream dams, of the WFTS set and the OLAFT control set. Group demographics will be assessed within and across the study sample sets. Comparisons of this migration data set relative to the tagging data available from Bonneville and Wells dams will be a secondary analysis. It is a study expectation that demographic raw data will be available throughout the duration of the study and that the full data will be available within 30 days of the completion of sampling. PIT tag data will be available from PTAGIS in near real time. Analysis will require some time. Any known mortalities identified immediately upon transport of test or control fish will be recorded and discussed with NMFS, and a decision whether to include them in the final data set will be documented in the study report.

The null hypothesis will be that long term migration survival of WFTS transported fish and OLAFT passed fish are equivalent. We expect to prove the null hypothesis showing that the effect of transport passage of the WFTS set is not significantly different than the OLAFT control set in their long term migration survival. Diving deeper, analyses will consider questions of altered homing, passage time, passage safety and disease transmission relative to migration reach and arrival time at each detection site.

Deliverables

It has been agreed upon that a report will be generated by the analysists and vetted for review by CRITFC and Whooshh by Dec 5, 2016. After addressing edits and any other concerns the final report will be shared among CRITFC and Whooshh and other agencies. At that time, the study report may be made accessible on the websites of CRITFC and Whooshh Innovations. In addition, if warranted, a publication manuscript may be drafted as a collaborative effort between the study participants.

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