Proposed Study Plan
1100 ft Whooshh Fish Transport System

June 2016

Purpose

To conduct a feasibility/viability study to evaluate the efficacy of employing a Whooshh Fish Transport System (WFTS) to safely transport live fish across a distance and elevation that models a high head dam passage distance from a sited location of attraction flow to dam forebay.

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).

Might there be a way to implement safe fish passage with minimal fish energy expenditure across a dam 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 4F0 ft and 250 ft transport) demonstrating equal to or better outcomes in health, survival and reproduction measures (PNNL, 2014). Proof of concept of the ability to utilize the Whooshh system to transport a fish through a tube of a 500 ft length has been demonstrated on non-live fish. The time to transport through a 500 ft Whooshh tube ranged from 20-22 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 has modeled the distance from a sited location of attraction flow to dam forebay of the Cle Elum dam which encompasses an approximate 1100 ft distance and an elevation increase of approximately 100 ft.

The Cle Elum Supplementation and Research Facility (CESRF) in the Yakima River basin, Washington, is an integrated spring Chinook Salmon hatchery program designed to increase natural production. The program has been in place since the late 1990's and has been successful at increasing salmon returns to the basin and reducing the risks of conventional salmon hatcheries from genetic effects The program involves a long-term comprehensive monitoring program tied together with the hatchery propagation program which are l controlled and designed to accommodate additional arms of research investigation (Fast et al, 2015). The proposed plan is designed to be conducted in partnership with the Yakama Nation operations at Roza and CESRF. Fish travel up the ladder at the Roza dam into the Roza Adult Monitoring Facility (RAMF) holding tank. The fish are then monitored, measured and tagged per CESRF protocol. Fish designated for the hatchery are trucked to the Cle Elum hatchery where they are held in raceways until they are ready to spawn in September and October. At spawning 3 x 3 crosses are conducted to maintain genetic diversity. Data relative to adult salmon survival/mortality, spawning and egg viability are collected and can be compared to historical data.

Objectives

- *Design and construct an 1100 ft WFTS (WFTS 1100) with an elevation rise of ~100 ft*

- Optimize the WFTS 1100 with respect to tube misting (water pumping rate and misting locations) and transport time (pump controlled flow rate) to achieve successful, continuous transport in 40-55 seconds.

- Employ an adaptive experimental design and real-time immediate assessment of fish survival and response post WFTS 1100 transport. Observe fish behavior after transport. Atypical behavior will be noted and evidence of consistent atypical behavior considered a transport-associated result that may require transport adjustment.

- Transport a minimum of 90 S spring Chinook through the WFTS 1100.

- Compare the adult survival, spawning and egg viability of spring Chinook transported to

the Cle Elum hatchery per CESRF protocols via the hand carriage, WFTS 40 and WFTS 1100 methods. Note any gender or wild verses hatchery fish differences.

- Demonstrate non-inferiority measures of adult survival, production spawning and egg survival of WFTS 1100 transported fish relative to hand carriage and WFTS 40 fish.

Methods

Typically, a total of ~400-600 adult spring Chinook salmon are transported from the RAMF via CESRF protocols as conducted by trained Yakama Nation (YN) personnel (Fast et al., 2015). In the past two years, after measurements and tagging a percentage of fish have been hand carried to a haul truck and the remaining WFTS 40 transported directly into the truck. The fish are randomly selected for hand carriage verse WFTS 40 transport and together compose the necessary population required for the CESRF program. Once optimized and operational the WFTS 1100 will receive fish for transport in a randomized manner divided between the hand carriage, WFTS 40 and WFTS 1100 transport groups. The fish designated for WFTS 1100 will constitute an excess of the CESRF program needs, as they are considered an additional research investigative arm of the operation.

Trained YN personnel will manage the fish trafficking monitoring, measuring, tagging and either hand carriage or loading of the fish into a WFTS. For measuring and tagging the fish are mildly anesthetized in a MS-222 solution. Hand carriage fish will be carried while in this state as the calm state helps to prevent dropping or damaging the fish. WFTS selected fish will be allowed to partially recover from anesthetic treatment prior to loading into the system. The safety of the fish at exit of WFTS is greatly benefitted by non-anesthetized freedom to move its tail, to turn and swim. The behavior of the fish after they enter the haul truck tanks will be visually observed. Standard behavior of swimming in a righted position, collecting near the bottom of the tank, typical fish to fish interactions will be considered.

Atypical behavior of any one fish or fish from any one transport group will be noted. Consistent atypical behavior among a group will be deemed a transport-associated behavior. The nature of the behavior will be discussed among the YN fish handling experts, biologists and Whooshh personnel on site and considered in terms of fish safety with respect to possible effects of the behavior related to fish reproductive survivability. If warranted, adjustments may be recommended, and may include, but are not limited to, altering the misting sequence, altering the acceleration or deceleration rate, altering the fish load or fractioning the transport tube into two shorter 500 and 600 ft transports with a rest in a holding tank between the two.

Once fish are in the hauling truck, provided they demonstrate normal behavior, all fish regardless of group will be treated the same. They will be hauled to the Cle Elum hatchery in the chilled, oxygenated tanks where the fish will be moved into holding raceways until spawning. Standard

feeding, water flow etc. hatchery practices will be employed. At spawning 3x3 crosses will be performed to allow for viability assessment without single pairing incompatibility confounders. The fertilized eggs will be handled per CESRF protocol which typically yields >90% survival.

All collected data is routed to the Yakama Nation data management group. It is a study expectation that mortality data can be requested within the duration of the study and that full mortality, spawning and egg viability data will be available for analysis within 30 days of the expected egg viability gathering date.

Due to the limitations of the Yakima river spring Chinook run and CESRF sampling protocols which provide fish for hatchery and ensure adequate numbers of fish remain in the river to naturally spawn, convenience sampling (the method of utilizing sampling subjects that are available) is the method that must be utilized to supply the additional samples of the WFTS 1100 experimental test arm. Based on historical spring Chinook run numbers as recorded by the YN and the CESRF program, a minimum of 90 S Chinook can be accommodated for the WFTS 1100 experimental transport study arm. If the spring Chinook run proves to be larger than expected, then proportionally additional numbers may be placed in the WFTS 1100 group. End of study analysis will acknowledge the necessary convenience sampling numbers in the statistical analysis and the potential power there-of.

All tests will utilize the ambient water temperatures that occur during the migration and pre-spawning period and be performed when air temperatures are 70^{o} F or below. The entire process will be photographed and/or videotaped as representative of the process and for future reference and reporting. It is expected that fish will be collected and transported over a 6 to 8-week period. Daily photography is not expected.

Deliverables

A preliminary study group composition report will be compiled by Whooshh in conjunction with YN and distributed in October 2016 from data provided by YN data management within 30 days of completion of total 2016 spring Chinook CESRF program plus WFTS 1100 arm transport of fish to the Cle Elum hatchery (expected data availability by end of September). This report will be distributed as a study progress report to the USBR, YN and Whooshh. Contained in the report will be a description of the refined and final methods, sample sizes, key observation and adjustments, photographs and raw data collected on the WFTS 1100 experimental arm fish prior to transport. A final report will be compiled by Whooshh in conjunction with YN and submitted within 60 days of final data collection on the viability of the eggs. Said report may be published online by Whooshh Innovations and considered for publication in a peer review journal as a collaborative product from Yakama Nation and Whooshh Innovations. For transparency, all data and reports will be made available to USBR, Yakama Nation, and Whooshh Innovations. The data and reports will be available on the YKFP.org web site. In addition, a supplemental addendum and/or publication may be prepared by Whooshh Innovations to address the operational and engineering recommendations resulting from the feasibility study.

References

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