Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

Columbia River White Sturgeon Management Plan

- **CLBMON-24 Mid Columbia River White Sturgeon Genetic Assessment**

February 2, 2021

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1.0 MONITORING PROGRAM RATIONALE

1.1 Background

1.1.1 Mid-Columbia River White Sturgeon Management Plan

The Columbia Water Use Plan Consultative Committee (WUP CC) and Fish Technical Subcommittee (FTSC) asked the Upper Columbia White Sturgeon Recovery Initiative Technical Working Group (UCWSRI TWG) to develop final recommendations related to treatment options and monitoring for white sturgeon recovery within a recommended funding period. The resulting recommendation involved a multi-phase management plan, extending over 10 years, aimed at better understanding habitat capabilities for juvenile white sturgeon in the mid Columbia River and the potential for Arrow Lakes Reservoir or Kinbasket Reservoir to become a sturgeon recovery or failsafe area with the help of conservation aquaculture. The plan was designed to inform on key hypotheses regarding potential habitat changes in the mid Columbia River that may have contributed to recruitment failure, and to focus on habitat capacity and early life history habitat requirements (spawning, incubation, and rearing), where bottlenecks to production are thought to be occurring. A seasonal minimum flow treatment was proposed as a possible means of improving spawning conditions and the survival of naturally spawned individuals during the egg and larval stages. An experimental aquaculture program was proposed to help address key uncertainties regarding the availability and suitability of juvenile rearing habitat in the mid Columbia River in the short term. Over the long term, a conservation aquaculture program in either Arrow Lakes or Kinbasket reservoirs would help to support the population until such a time as stock abundance, age structure, and habitat conditions can support a self-sustaining population.

The plan is designed in phases to allow the necessary flexibility in the allocation of annual funds for research, experimental treatments, and monitoring to ensure the program is responsive to future learnings and related changes in priorities. This objective will be facilitated through annual overview reviews and periodic comprehensive reviews of the program. For example, a decision to either implement flow tests in the mid Columbia River (if monitoring supports this decision) or to direct all or part of the conservation aquaculture effort to Kinbasket Reservoir were to be made once the initial phases of monitoring results are analyzed and reviewed.

The plan specifically addresses three key uncertainties related to white sturgeon recovery:

1) Can stocking of yearling (or younger) sturgeon provide for rebuilding of the Arrow sub-population and mitigate reservoir impacts?

2) Can stocking of yearling (or younger) sturgeon provide for either recovery of a self-sustaining sub-population or development of a failsafe (non-reproducing) population in the Arrow or Kinbasket reservoirs?

3) Can recruitment failure in the mid Columbia be addressed by operational changes?

The FTSC and UCWSRI TWG recognized that a substantial monitoring program would need to accompany the plan to address these key uncertainties. Research and monitoring programs, including studies to define sturgeon spawning and rearing habitat capability in the mid Columbia River and Kinbasket Reservoir, were considered essential for making decisions related to the need for seasonal minimum flow treatments, the magnitude and duration of flow treatments, and hatchery supplementation. The goal of these studies was to determine mechanisms contributing to recruitment failure and to serve as a baseline for evaluating the effectiveness of treatment options in eliciting a detectable recruitment signal and establishing sustainable recruitment.

Following an initial monitoring and evaluation period that included releases from the conservation aquaculture program and implementation of monitoring studies, technical reviews were held to determine next steps for the Mid Columbia white sturgeon management plan. Technical reviews that occurred in both 2012 (Harstone 2012) and 2018 (BC Hydro 2018) identified remaining uncertainties and next steps. A key outcome from those reviews was the recommendation to not consider Kinbasket for a recovery or failsafe population. This was a result of the considerable time required to determine if efforts in the Mid Columbia River and Arrow Reservoir have been adequately evaluated. Within the Mid Columbia River and Arrow Reservoir work, a key monitoring result was that the remaining wild adults in the population segment spawned more frequently than originally anticipated given the small estimated population size (program summary in Wood 2019). Notably, in addition to documenting successful spawning, progeny produced from those wild spawning events were successfully transferred to the conservation aquaculture program (FFSBC 2020), reared, and then released back into Arrow, preserving the genetic diversity of existing wild adults and aligning with approaches used for conservation aquaculture in the Lower Columbia white sturgeon management plan. Accordingly, recommendations were made to prioritize monitoring of spawning activity, collection of wild-origin progeny for conservation aquaculture, and monitoring the survival of juveniles released from the aquaculture program until the end of the Columbia WUP. Results from this work would be critical to addressing remaining uncertainties and informing next steps during the ordered review of the Columbia WUP.

This ToR is submitted in response to the *Water Act* Order issued by the Comptroller of Water Rights (CWR) on January 26, 2007, Schedule F, Clause 1(f). The Order requires a ToR for genetic assessment work for white sturgeon in Arrow Lakes Reservoir.

1.1.2 Mid Columbia River White Sturgeon Genetics

White sturgeon in the Canadian section of the Columbia River were listed as endangered under the Species at Risk Act (SARA) in 2006 (Fisheries and Oceans 2014). The majority of the population resides in the lower Columbia River downstream of the Hugh L. Keenleyside Dam (HLK), with a smaller segment of the population residing in the Arrow Lakes Reservoir and Mid Columbia River upstream to Revelstoke Dam (Hildebrand and Parsley 2013; Fisheries and Oceans 2014). This small population segment was estimated to be comprised of approximately 52 adult White Sturgeon (37 - 92 individuals at 95% confidence level; Golder 2006) that are older than the construction date of HLK Dam (1968). While spawning has been documented over a number of years (see Wood 2019), natural recruitment to this population has not been identified through juvenile monitoring. An assessment of the recovery potential of this segment of the population has been underway through the Columbia Water Use Plan since 2007.

The main recovery measure used to evaluate recovery potential, or the potential for a failsafe population, has been conservation aquaculture. A key objective of the conservation aquaculture program is to retain genetic diversity of the existing wild population in Arrow Reservoir and the Mid Columbia River. Releases from the aquaculture program into the Mid Columbia River have primarily been produced from either collection of broodstock or wild-origin progeny in the lower Columbia River below HLK Dam (details in FFSBC 2020). While no evidence of population structure within the Transboundary Reach (upper Columbia from Grand Coulee Dam to HLK Dam) was found using nuclear microsatellite markers (Schreier et al. 2013), Nelson and McAdam (2012) reported substructure among WS showing fidelity to high use zones using mitochondrial DNA (mtDNA) data. Regardless of genetic substructure, the remaining adults in the Mid Columbia River population segment represent a unique group of isolated individuals that have not been represented in progeny reared and released from the aquaculture program. Importantly, representing the genetic diversity from the remaining adults in the Mid Columbia has become the leading objective of the aquaculture program in recent years. This has been addressed by collection wild-origin progeny (embryos and larvae) from the spawning grounds near Revelstoke and rearing them at the hatchery until release. Collection of wild-origin progeny has become the main approach used in the lower Columbia River as well to maximize genetic diversity by representing increased numbers of spawning adults compared to directly spawning wild adults. This approach has been supported by prior work on the lower Columbia River population (Schreier and May 2012; Jay et al. 2014), other white sturgeon populations (e.g. Snake River, Thorstensen 2019), and other sturgeon species (e.g. lake sturgeon, Crossman et al. 2011).

Despite prior work (Schreier and May 2012; Jay et al. 2014), additional evaluation of the wild-origin approach is underway for the lower Columbia River aquaculture program to evaluate success in recent years (2014-2020). No work has been done to assess the genetic diversity for samples collected in the Mid Columbia and remains a critical uncertainty to inform both the aquaculture program as well as increase our understanding of the adult population (e.g.

number of unique adult spawners). As described above, the Order (Schedule F, Clause 1(f)) called for a genetic assessment to compare white sturgeon in Arrow Reservoir to the population in the lower Columbia River. At the time of the Columbia WUP development, a genetic study was already underway to further investigate stock differentiation of the Arrow Lakes Reservoir and Lower Columbia River white sturgeon. It was envisioned that a 1-year program to help finalize that work would be useful. Since the initiation of the Columbia WUP, population level genetic studies were completed using available samples (Nelson and McAdam 2012; Schreier et al. 2013) and no additional capture of wild adults in the Mid Columbia River has occurred to provide tissue samples for analyses. Given the limited number of remaining adults, low capture probability with sampling (e.g. Golder 2006), and the significant investment required to implement a capture program, it was recommended that the program focus on collecting tissue from progeny collected at the spawning sites for genetic analyses.

1.2 Management Questions

While no evidence of population structure within the Transboundary Reach (upper Columbia from Grand Coulee Dam to HLK Dam) was found using nuclear microsatellite markers (Schreier et al. 2013), Nelson and McAdam (2012) reported substructure among WS showing fidelity to high use zones using mtDNA data. Regardless of population genetic differences from fish downstream, limited upstream movement of white sturgeon from downstream of HLK Dam suggests any progeny produced near Revelstoke would be limited to the small number of remnant adults in the Mid Columbia/Arrow Lakes Reservoir. Accordingly, with conservation aquaculture efforts in the Mid Columbia reliant upon wild -origin progeny from the Revelstoke spawning area, it is critical for recovery to define the number of wild adults contributing to progeny produced. Results from this work will add further information on the Mid Columbia population (number of breeders), reproductive success of individual adults in more recent years, and inform critical recovery actions for the conservation aquaculture program.

The fundamental management questions to be addressed through this study are:

1. What is the level of genetic diversity present in progeny captured by early life stage monitoring at the white sturgeon spawning site below Revelstoke Dam?

2. How many wild adults are contributing to progeny collected at the white sturgeon spawning site below Revelstoke Dam and how do these estimates vary across years?

1.3 Management Hypotheses

This study is set up as a descriptive study using molecular approaches to address genetic uncertainties related to the spawning population of white sturgeon in the Mid Columbia and Arrow Reservoir. Accordingly, it is designed to provide baseline genetic information but is expected to inform future

management decisions regarding the conservation aquaculture program and the stated objective of maintaining genetic diversity of the wild population.

1.4 Key Water Use Decisions

During development of the Columbia River Water Use Plan (WUP), efforts were made to explore the relationship between white sturgeon spawning, incubation, and rearing habitat and operation of Revelstoke Dam and Arrow Lakes Reservoir, with the intent of recommending alternative operations within the constraints imposed by the WUP process. While results from this genetic work do not directly inform key water use decisions, they provide important insight into the reproductive dynamics of the spawning population of white sturgeon near Revelstoke. This information will be combined with results from other programs in the Mid Columbia River (e.g., CLBMON-23, CLBWORKS-25) to better understand the recovery potential for white sturgeon in the Mid Columbia River and Arrow reservoir going forward.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The primary objectives of this monitoring program are to:

1. Estimate the genetic diversity of progeny collected at the Revelstoke spawning site,

2. Describe the number of contributing wild adults to progeny collected at the Revelstoke spawning site,

3. Determine how both genetic diversity and the number of contributing adults vary between spawning events within a year and across years.

2.2 Approach

The program will analyze tissue samples collected from progeny produced at the Revelstoke spawning area since monitoring began in 1999. The number of samples available for analysis varies by year where spawning was detected, with more samples available in recent years. However, it is expected that the overall question of genetic diversity can be addressed by pooling all samples. Larger numbers of samples available in recent years will address interannual variability in the number of contributing adults. Additional information on spawning activity will be provided by CLBMON-23 (Middle Columbia River White Sturgeon Spawn Monitoring) as required.

2.3 Tasks

2.3.1 Task 1: Project Planning and Coordination

Project coordination involves the general administrative and technical oversight of the monitoring program, which will include, but not be limited to 1) budget

management, 2) study team selection, 3) logistic coordination, 4) technical oversight in analytical components, and 5) facilitation of data transfer among other investigations associated with the Columbia River White Sturgeon Management Plan.

2.3.2 Task 2: Laboratory analysis of genetic samples collected from embryos and larvae

The analysis is expected to follow the most current methods to address the objectives of the program. It is expected that following DNA extraction from available tissue samples, genetic markers (microsatellites and Single Nucleotide Polymorphisms (SNPs)) will be used to reconstruct family groups and estimate the number of spawners. Genetic diversity will be examined by sequencing up to 13 of the established octoploid microsatellite loci (Rodzen 2002, Bork et al. 2008) to obtain a genotype for each individual. Genotypic data will be used to describe overall genetic diversity by calculating the number of alleles detected across all 13 microsatellite loci for all individuals. The number of alleles present in groups of individuals from each spawning year should also be compared. SNP data will be collected following an unpublished protocol and analytical pipeline developed by the Columbia River Inter-Tribal Fish Commission (CRITFC). SNP data will add to the genetic diversity by estimating allelic richness and observed heterozygosity and allow for increased confidence for parentage assignment.

In order to estimate the number of contributing adults, it is expected that progeny arrays will be developed using Colony (Jones and Wang 2010), a program that uses a maximum likelihood approach to estimate and construct pedigrees from population genetic data. This approach has been successful for similar studies (Jay et al. 2014, Thorstensen 2019).

2.3.3 Task 3: Data Analysis and Reporting

The genotypic data will be analysed to assess genetic diversity and numbers of contributing adults. Methods should follow the most current approaches being employed for the species to allow for future analyses if required.

Project reporting will consist of one final report for the program at the conclusion of Year 2. The report should include a detailed description of methods, data analyzed, and the results. The final report will include:

(a) an executive summary;

(b) a detailed description of the methods employed;

(c) a detailed results section;

(d) a comparison of results with other populations (e.g. lower Columbia River);

(e) a discussion of how the results relate to the key management questions; and

(f) recommendations.

Reports will follow the standard format that is being developed for WUP monitoring programs. All reports will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files. Genotypic data will be provided in a suitable format for use in future projects.

2.4 Interpretation of Results

The results of this study will be used to confirm number of adults spawning in the Mid Columbia over a number of years. Further, results will help describe the effectiveness of the conservation aquaculture program for the Mid Columbia River in retaining genetic diversity in recent years where live progeny have been reared and released into Arrow Reservoir. Lastly, genetic diversity of the progeny assessed in this study can be compared to prior work done on samples from the Mid Columbia (Schreier et al. 2013) and to the diversity captured by the conservation aquaculture program for the lower Columbia River.

2.5 Schedule

This monitoring program is occurring at the end of implementation of the Columbia River Water Use Plan. It is expected that the work will take approximately 2 years to fully complete and be available prior to the WUP Order Review. The first year of the program will be implemented in 2021 the work is expected to be completed by 2023.

A proposed schedule is provided below.

i) Analysis of genetic samples to occur in 2021 and early 2022.

ii) Draft results to be presented and discussed at the Upper Columbia White Sturgeon Recovery Initiative Technical Working Group meeting in the fall of 2022.

iii) Report preparation from late 2022 to early 2023.

As highlighted in bullet ii, ongoing updates and results of the program will be presented at the UCWSRI TWG annual meetings. Updates will be required for meetings each spring and fall until the program is complete.

2.6 Budget

The estimated implementation budget for CLBMON-24 is $70,148 (see Table 1). It assumes the analysis and reporting will take up to 2 years and will be aligned with analyses ongoing for the lower Columbia River population for cost efficiencies and comparisons of results.

Table 1: Budget estimate for Implementation of CLBMON-24

The total revised budget for the project is $70,148.4

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