TECHNICAL STUDY #2 (2023)

Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Proposed Implementation, Monitoring, and Evaluation

The Columbia River Salmon Reintroduction Initiative

BRINGING *the* SALMON HOME

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Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Proposed Implementation, Monitoring, and Evaluation

Technical Study #2: Salmon Reintroduction Experimental Design

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Cover photo by Eiko Jones

Citation: Richard Bussanich, David Robichaud, Steve Crawford, Wendell Challenger, Michael Zimmer, and Norm Johnson 2023. ***Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Proposed Implementation, Monitoring, and Evaluation.*** *Report prepared for Bringing the Salmon Home: the Columbia River Salmon Reintroduction Initiative, BC. 40 pp*. + Appendix.

Acknowledgements

The Okanagan Nation Alliance and partners, LGL Environmental Consultants, appreciate and recognize the contributions of the groups and individuals representing the: Ktunaxa Nation Council, Secwépemc Nation, Syilx Okanagan Nation Alliance, Fisheries and Oceans Canada, and Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Documentation and reporting supported by the following:

- ONA support staff – Courtenay Heetebrij, Tara Gleboff, Nicholas Yanniw, Skyeler Folks, Norm Johnson, and Howie Wright
- ONA Cultural Salmon Releases and FinS Program support – Dan Stefanovic, Herb Alex , Zeke Terbasket, Alfred Snow, and Shelley Hackett

This study and report were made possible through the collaboration of all five signatory governments of **Bringing the Salmon Home: The Columbia River Salmon Reintroduction Initiative (CRSRI),** especially the members of the Technical Working Group who provided guidance and expertise to inform all sections of this report. Our work was further generously guided by the Bringing the Salmon Home Initiative's Indigenous Knowledge Counsel and informed by the Indigenous Knowledge Statement.

The findings in this technical report represent the authors' understanding about the current state of knowledge based on input gathered through this research. The intent is that this work and related knowledge serves as a foundation for future salmon reintroduction efforts which will continue to evolve as future research and next phases of work are completed.

Bringing the Salmon Home: The Columbia River Salmon Reintroduction Initiative brings together five governments, the Syilx Okanagan, Ktunaxa, and Secwépemc Nations, with Canada and British Columbia, in an innovative Indigenous-led process to explore feasibility and options for salmon reintroduction to the Canadian portion of the upper Columbia River basin.

The Indigenous-led governance structure upholds the leadership of the three Nations, including as working group chairs. These tables include the Executive Working Group, Implementation Team, Indigenous Knowledge Counsel, Technical Working Group, and Communications Advisory Group.

This collaborative work is supported by the Indigenous Host Secretariat (Okanagan Nation Alliance) and the Management Team. Community engagement is facilitated by a team of three Nation-based Outreach & Engagement Organizers.

The shared long-term vision is to return fish stocks for Indigenous food, social and ceremonial needs, and to benefit all Columbia River residents and ecosystems as a whole.

For more information please see**: ColumbiaRiverSalmon.ca**

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Executive Summary

The purpose of the Phase 1 Reintroduction Plan (hereafter referred to as '*Pilot Plan*') is to define an initial 3-year near-term experimental effort (i.e., '*Pilot Program*') for determining the feasibility of reintroducing anadromous salmon to the Canadian Columbia River basin upstream of Grand Coulee Dam (WA, USA). The *Pilot Plan* is being developed around a Statement of Work developed by Bringing the Salmon Home: The Columbia River Salmon Reintroduction Initiative (CRSRI) with the purpose of identifying which reintroduction locations, donor stocks, and studies will best meet the Objectives set out by CRSRI. The evaluations are designed to answer key questions at each life stage as they relate to feasibility of reintroduction. The current document is the Phase 1 iteration of the *Pilot Plan* providing a conceptual overview and examples for each Objective. Phase 2 of the *Pilot Plan* is a separate document which will build on the groundwork laid out by this document providing detailed approaches to meeting each objective. If shown as feasible, lessons learned during these experimental studies will be applied to a long-term reintroduction program.

The *Pilot Plan* will focus on monitoring programs for reintroduction of fish using western science tools, while embedding themes heard from Indigenous Cultural leads. The *Pilot Plan* evaluated options for Spring Chinook Salmon (*Oncorhynchus tshawytscha*), Summer/Fall Chinook Salmon, and Sockeye Salmon (*O. nerka*), and identified management activities and monitoring programs that may be required for a successful salmon reintroduction. Investigations revealed no suitable available donor stock of Spring Chinook Salmon, and while other donor supply options are being investigated, these fish have for now been excluded from further consideration in Phase 2.

The Study Areas assessed are comprised of seven Salmon Planning Units (SPU) including four Units along the Columbia River and three Units located in tributary watersheds. Habitat for Summer/Fall Chinook has been identified in the Transboundary and Arrow Reservoir mainstem Units and in the Slocan River and Salmo River tributary Units. Sockeye Salmon habitat was identified in the Arrow Reservoir Unit of the Columbia River and the Slocan River tributary Unit. Additional locations may be identified through further investigation and synthesis of existing information.

Potential sources for Summer/Fall Chinook include the Okanagan-Methow-Wenatchee complex for tributary spawning populations and Hanford Reach and the Chief Joseph Dam tailrace for Columbia River mainstem spawning populations. The closest Sockeye Salmon that are available as a source is the Okanagan-Osoyoos population. Other potential Sockeye Salmon sources, located in the United States, include the Similkameen-Methow, and Wenatchee River populations.

Two approaches to reintroduction strategies are presented. The first is a "stepping stone" strategy that focuses on concentrating initial efforts in a smaller number of downstream locations. As those populations grow over time, they can be used as the brood source for expanding reintroduction efforts upstream into other locations. This allows for the population to evolve to the local environment over time, such that donor sources for subsequent SPUs are better adapted than the initial donors were. A risk associated with this strategy is the protracted time scale it entails (e.g., multiple generations may be necessary before the initial population is large enough to be used for the next "step") without guarantee that the initially introduced populations would ever grow large enough to provide donor stock for the next SPU. As such, we also present a second approach, a "diversified" strategy, which would involve multiple temporally spaced reintroductions of study fish of various life stages to a larger number of locations, to maximize the opportunity for success and the opportunity to gain information. This approach requires large numbers of seed fish to be available simultaneously from the donor stock, and minimizes opportunities to learn lessons from previous reintroductions.

To give guidance for some of the study design elements that will be described in the Phase 2 document, an overview of a Population Viability Assessment (PVA) model is presented. The PVA model considers key steps in the life cycle of released and naturally produced salmon, with life-history steps including rearing, emigration, ocean survival, return migration, and spawning, along with uncertainty or variation in those steps, so that the range of outcomes, including the likelihood of success of a program, may be assessed.

Table of Contents

List of Tables

List of Figures

1 Introduction

This report documents initial planning stages of a phased approach toward the eventual goal of maintaining a long-term self-sustaining population of anadromous salmon in the Canadian Columbia River. It was developed using the concepts and modeling tools inherent in the adaptive management methodology and the hatchery production guidelines developed through the Northwest Power Planning Council's Artificial Production Review and Evaluation (APRE) process and Fisheries and Ocean Canada (DFO) Wild Salmon recovery planning framework. The process was initiated in response to an Upper Columbia United Tribes (UCUT) request to the Northwest Power Planning Council in 2015. Building upon the principles and criteria provided by the Hatchery Science Review Group in the Scientific Framework for Artificial Propagation of Salmon and Steelhead (HSRG 2000), the plan identified hatchery operating procedures that maximize the benefits of artificial production programs while minimizing the risks to natural populations.

This work, *Pilot Implementation, Monitoring, and Evaluation Plan* (hereafter, the '*Pilot Plan*'), has been developed in response to the *Statement of Work* developed by the Bringing the Salmon Home: The Columbia River Salmon Reintroduction Initiative Technical Steering Committee (CRSRITSC) with direction from Indigenous Cultural Leads. Work on this *Pilot Plan* followed the issuance of a contract to Okanagan Nation Alliance (September 2021), and a review process with the Technical Working Group (TWG) represented by DFO, BC Ministry of Forests, Ktunaxa Nation Council (KNC), and SFC members. The *Pilot Plan*, itself a two phased product, is a critical part of the *Pilot Program*, a multi-step process to evaluate the potential for reintroduction of anadromous salmon, specifically Chinook and Sockeye salmon, into historical habitat above Grand Coulee Dam, and assess whether restoring these species to their historical habitat will provide a demographic benefit by increasing their spatial structure and abundance. This document represents the first phase of the *Pilot Plan,* the conceptual document.

Previous studies, conducted to assess the feasibility of salmon reintroduction upstream of Chief Joseph and Grand Coulee dams to the Canadian border (UCUT 2019), indicated that reintroduction is likely feasible for the Transboundary Reach and possibly further upstream. Previous research has concluded the following:

- Good donor stock options are available, particularly for Summer/Fall Chinook and Sockeye salmon;
- Disease risks are understood and are manageable;
- Large quantities of suitable spawning and rearing habitat are available;
- Passage technology exists and is being used at other high head dams (e.g., ladder, fishway, trap and haul, floating surface collectors, Whooshh);
- Life cycle models show potential to achieve reintroduction goals for the Transboundary Reach and identified critical uncertainties for subsequent testing (e.g., adequate flow cues for effective floating surface collector operation to pass juveniles); and
- Returning salmon to the upstream area will deliver cultural, ecological, and economic benefits for all.

Preliminary results from studies conducted to date for the Canadian Columbia River indicate the following:

- Summer/Fall Chinook Salmon were identified as potentially suitable donor stocks for salmon reintroduction in the mainstem of the Transboundary Reach (Warnock et al. 2016);
- Significant quantity of habitat available for spawning Summer/Fall and possibly Spring Chinook Salmon in the Transboundary and Mid-Columbia reaches (Golder 2016, 2017, Sheer et al. 2023), and life cycle modeling suggested the Transboundary Reach (including the Canadian portion) could support a reasonably abundant self-sustaining population (UCUT 2019);
- Chinook Salmon spawning and incubation habitat is available in the Mid-Columbia Reach through the current range of flows (Q10 to Q90; KNC *in prep*); and

- Seemingly high-quality spawning areas are available in the Mid-Columbia Reach with floodplain habitat downstream for emergent fry (Sheer et al. 2023).

While the previous work and preliminary results from current studies look favourable, conclusions were primarily derived from a Chinook Salmon life-cycle model that included many assumptions of salmon life history, survival, habitat, and passage interactions (UCUT 2019). In addition, reintroduction planning elements were also based on many assumptions of how salmon will fare once reintroduced, and uncertainties remain of how to maximize the efficacy of alternative reintroduction strategies (ISAB 2019).

The development of conceptual and detailed designs for salmon reintroduction using a phased approach is a critical next step for the reintroduction of salmon into the Canadian Columbia River, to plan phases of reintroduction activities, test assumptions, evaluate key uncertainties, and adaptively manage reintroduction efforts. To that end, the CRSRITSC issued a *Statement of Work* outlining a series of tasks to be addressed. The purpose was to develop broad (conceptual) and more focused (detailed) juvenile and adult salmon release/dispersal and monitoring designs that support learning and understanding of the feasibility of salmon reintroduction into the Canadian Columbia River. Specifically, the *Statement of Work* included six *Objectives*:

1) Develop a conceptual design that details the series of tasks required for successful Chinook and Sockeye salmon reintroduction into the Canadian Columbia basin, including identification of high-potential donor stocks and Salmon Planning Units (SPU) to be considered for detailed designs;
2) Determine juvenile downstream survival, migration rates, and timing through the Transboundary Reach, Roosevelt Reservoir, Grand Coulee Dam, and possibly farther downstream;
3) To the extent possible, determine the factors, such as physico-chemical habitat requirements, biological interaction requirements (e.g., food web dynamics, predation, competition), that influence juvenile survival, migration rates, and timing (including donor stock, size, and location/time of alternative release strategies);
4) Determine if initial releases can provide reasonable estimates of smolt survival to the Wells Reservoir (Pateros) and adult survival through the Roosevelt Reservoir that could be combined with existing US passage survival information in order to generate initial smolt-to-adult survival estimates and possible factors that influence these estimates.
5) Determine upstream survival, migration rates, and spawning habitat selection of adult Chinook Salmon captured downstream of Chief Joseph Dam, trucked and released upstream of Grand Coulee Dam; and
6) Determine the factors, such as physico-chemical habitat requirements (e.g., inputs of marine-derived nutrients) or biological interaction requirements (e.g., predation, competition) that influence adult survival, migration rates, and timing (including donor stock, size, and time/location of alternative release strategies).

The tasks outlined in the *Statement of Work* are addressed in two phases. Phase 1 (conceptual design; this document) includes consideration of potential donor stocks, release locations, release timing, size of released fish, hatchery development, and disease control. It lays the groundwork for a Population Viability Assessment (PVA) model that considers survival through rearing, migration, fish passage, and other life cycle elements. This initial phase describes potential knowledge gaps that could be answered during Phase 2 (detailed design). The Phase 2 document is focused on a subset of species, life history strategies, and/or SPUs based on a consideration of Indigenous Knowledge and results of Phase 1, including emphasis on an initial reintroduction that will maximize potential for successful reintroduction. Phases 1 and 2 are implemented in tandem, and results from Phase 1 provide input to Phase 2 tasks, with the goal of producing detailed reintroduction designs that can be implemented in 2023.

In addition to the tasks described in the *Statement of Work*, there were six other critical technical investigations being implemented simultaneously by the CRSRITSC. These include assessment of salmon habitat capacity, risk assessment of salmon reintroduction, identification of potential donor stocks for SPUs, fish passage assessments, salmon life cycle modeling, and assessment of knowledge and information gaps. The outcomes of these other investigations, particularly the risk assessment, will provide critical information and identify information gaps that will play an important role in the details of a reintroduction design. Effort has been made to ensure appropriate sequencing of activities among the technical investigations in order to maximize synergies among studies.

The approach taken to address the tasks outlined in the *Statement of Work* includes:

- Seeking guidance from the TWG and Indigenous Knowledge Counsel (IKC) early in the project on study design, particularly as related to cultural values, respect for All Living Things, ceremony, timing/locations of releases, and seek guidance later in the project to gather input on the proposed focus and approach to the detailed release design;
- Literature and data review to inform release and monitoring designs as they relate to critical uncertainties or assumptions for reintroducing salmon to the Canadian Columbia River basin;
- Design Phase 1 and 2 so early conceptual design results can inform detailed design and both Phases can be implemented concurrently. This required the development of a clear process and mechanisms for workflows from Phase 1 to 2 (e.g., setting of key triggers/criteria for work transfer; determining when consensus on triggers/criteria is achieved). Workflows were developed so that initial Phase 2 designs could be implemented in 2023;
- Collaboration with the CRSRI TWG to develop testable hypotheses that will address study questions;
- Designing release strategies that address the objectives and critical management uncertainties;
- Designing the release strategy (timing / location of release and size of fish at release) and monitoring plans with sufficient statistical rigour to address critical management uncertainties;
- Ensuring the release strategy and related monitoring plans consider the following:
    - Thermal barriers;
    - Survival and migration timing through reservoirs and dams;
    - Habitat use during each life cycle stage;
    - Juvenile life history pathway;
    - Behaviour near dams and potential locations for passage infrastructure;
    - Behaviour of translocated adult salmon (fallback, migration, spawning);
    - Options for rearing facilities, sources, and trap and truck facilities;
    - Testing of key assumptions
    - Leverage existing release, monitoring, and data coordination programs/approaches (e.g., PTAGIS) and innovative monitoring designs (e.g., parental-based tagging)
    - Design considerations to minimize disease and ecological risks based on results from the Risk/Benefits Assessment;
- Providing approximate cost estimates of release design alternatives;
- Where feasible, collaboration with US entities on release design and monitoring plans to ensure alignment and avoid redundancies (broader US engagement is initially being coordinated by the CRSRI Implementation Team and Communications Advisory Group that will include engagement with the TWG).

This report is the *conceptual design* document that comprises Phase 1 of the tasks outlined in the *Statement of Work*. The Phase 2 results are presented in a separate document (Bussanich et al. 2022).

1.1 Key Terminology

The following key terms were used in this document:

- "Upper Columbia Fish Passage Evaluation" is a study to evaluate the feasibility of reintroducing anadromous salmon to tributaries above Grand Coulee.

- "Pilot Plan" is the Pilot Implementation Plan describing the procedures and protocols for the Pilot Program. The *Pilot Plan* has been developed in two phases. The Phase 1 *Pilot Plan* provides a conceptual overview of the current knowledge base, examines potential donor stocks, release location, hatchery considerations, and identifies knowledge gaps that should be filled. It included a population viability assessment model that considered survival through rearing, migration, fish passage, and other life cycle elements. The Phase 2 *Pilot Plan* uses the information provided in Phase 1 to recommend specific Pilot Studies.
- "Pilot Program" is the implementation of the first phase of reintroduction of anadromous salmon above Grand Coulee Dam developed for the CRSRI and presented in the *Pilot Plan* as a 3-year (minimum) program. The Pilot Program addresses immediate uncertainties associated with initial regulatory and technical procedures and biological constraints that would preclude successful reintroduction; experiments with colonization strategies; assesses limiting factors that may affect whether or not salmon can recolonize and establish self-sustaining sub-populations, and assesses unintended risks to the recipient ecosystem and/or donor stock population.
- "Pilot Studies" are specific reintroduction colonization experiments and associated monitoring activities to provide data that help resolve uncertainties and data gaps such that the performance of the Pilot Program can be better evaluated.
- "Reintroduction Program" is the general term used to describe the Pilot Program and the long-term reintroduction.

1.2 Defining the Pilot Program and Pilot Plan

1.2.1 The *Pilot Project* from a Western Science Lens

The *Pilot Program* is designed to demonstrate the feasibility, or "proof of concept," for reintroduction of Summer/Fall Chinook and Sockeye salmon in the Upper Columbia River and key tributaries. It will use the scientific method to test many of the uncertainties related to the Experimental Reintroduction Program, including methods and tools needed for a successful reintroduction. This process involves obtaining critical data to allow CRSRI and resource agencies to balance the potential benefits against the risks and constraints. The results will inform best alternatives, and practicalities to implement a full-scale reintroduction in the Upper Columbia above Grand Coulee Dam. The *Pilot Program* is framed in an adaptive management structure and includes monitoring (or pilot) studies that will measure results keyed to criteria defining success. This is essential for learning and modifying the program, as required, to increase the likelihood of successful reintroduction. As the Pilot Program progresses, changes may be needed, and additional monitoring programs may be added.

Recovering salmon to the headwaters of the Canadian Columbia River is expected to be extremely complex. Within Canada, the Columbia River accounts for 801 km of the 2,040 km total length, with the full Columbia River encompassing multiple jurisdictions (US CDN, tribes-FNs, CRT), and a different landscape with additional access barriers than when salmon were last present. It is likely that prolonged recovery will involve large investment and long-term commitment. In the face of providing potential recovery in the present, climate change and land use changes pose uncertainty for the future of such a long-term program.

We recognize that substantial uncertainty exists in our understanding of factors influencing the potential success of the Upper Columbia River reintroduction efforts. Given this uncertainty, a framework was developed that will rely upon the principles of adaptive management. We will start by defining clearly formulated testable hypotheses, generally framed as predictions about how one or more important species will respond to management actions. The strength of this process is based on "learn and do"; it allows resource managers to take action in the face of scientific uncertainty. The adaptive management component is driven initially by hypotheses regarding the factors that will ultimately determine the effectiveness of the *Pilot Plan*. These hypotheses are developed by compiling relevant data, reviewing guidelines for artificial production programs, developing analytical models, and applying these tools to the Upper Columbia River.

The purpose of the *Pilot Plan* is to provide a framework for evaluating the potential to reintroduce anadromous salmon into their historical habitat above Coulee Dam. The *Pilot Plan* is a critical part and early step in an adaptive approach which aims to increase abundance, productivity, and spatial distribution, and to improve life history, health, and genetic diversity. The *Pilot Plan* describes how the first three to five years of the Pilot Program could be implemented and describes metrics and performance measures to be used to evaluate the success of the implementation techniques compared to the overall goal of the Pilot Program. It also provides a blueprint for obtaining additional critical information about the opportunity for successful reintroduction. This *Pilot Plan* is considered a living document and will be updated as new information is gained regarding feasibility of reintroduction, and to reflect any changes to the Pilot Program.

This Phase 1 *Pilot Plan* provides an overview of the current knowledge base as well as a variety of options available for meeting Project Objectives. This document provides information that may be useful for the other CRSRITSC technical investigations (e.g., risk assessment, salmon habitat capacity), and also discusses stock selection considerations, genetics, disease, and potential sources of donor stock for reintroduction. The Phase 2 *Pilot Plan* uses the information provided in Phase 1 to select the preferred alternatives and the rationale for the selections. Phase 2 will also provide more detail for the preferred alternatives than is present in this document.

1.2.2 The *Pilot Project* from an Indigenous Knowledge Learning Lens

Indigenous Nations believe they were placed in a sacred manner upon this earth and charged to care for and protect all of our relations within our homelands especially their most sacred relative, *water*. These responsibilities were given to us by the Creator, and they have been upheld since the beginning of time by their ancestors. They now pass to us and our children through our grandmothers and grandfathers. Water (the living beings such as Salmon) is recognized as an entity to be protected and shapes the norms of *Indigenous* people. The natural laws of the land have been passed down through *oral history, songs, and ceremonies.* It is through *the language and history* that learning about their responsibilities to the water and land occurs. *Indigenous* People have an intrinsic relationship with *Salmon.* The western paradigm has created a human-centric view of *Salmon* where humans are separate and superior to *Salmon*. From an Indigenous perspective, humans are not separate from *Salmon.* Maintaining the integrity of *a Salmon Landscape, Habitat and its living form* and respecting its relationship to all life is essential to identity and is entrenched in responsibility to the Land.

The *Reintroduction Strategy* is a call to action that outlines how the Nations intend to care for their territory and work to ensure that *Water and Salmon* is properly respected and available for all living things. This strategy is designed to protect and manage *Salmon* in Nations area of responsibility and is built on the understanding that the *Indigenous* People have inherent rights and responsibilities to care for *Salmon*. Current western *salmon* management regimes are missing the *Indigenous* worldview and *Salmon* is being disrespected. Extreme scarcity of salmon and other environmental disasters are increasing in frequency and magnitude in *the respective* Territory, underscoring the need for a cohesive approach toward reintroductions.

Through the use of Salmon Ceremonies, the reintroduction strategy shares a vision and responsibilities that include protecting and respecting *Water* and *Salmon* (all life forms on Earth). The release of living eggs, fry, and adults along with outplanting carcasses are all acts of calling the Salmon home and adding learning opportunities by "doing". In tandem with Ceremonies is a key Outreach element allowing two worlds to learn about the other. Via school programs such as FINS (Fish in the Classroom), the next generation are engaged in connecting to their environment and multiple perspectives. Both of these actions work toward seeking and achieving Truth and Reconciliation, in a good way.

1.3 Agreements

Cultural and Government to Government Agreements will need to be reviewed and provisions considered and agreed upon to achieve goals for fish passage and reintroduction of salmon to the Upper Columbia. The timelines for these agreements may be a long way off. Regardless, agreements needing consideration, but not limited to, include:

Downstream Fish Passage Agreement: Development of an implementation plan describing the proposed facilities and measures most likely to achieve a high Fish Passage Survival from the hatchery complex via the dam project site (FPS; e.g., "juvenile passage survival greater than 95%).

Upstream Fish Passage Agreement: Defining procedures and determining the criteria for implementing effective upstream passage in order to meet the needs for passing adults through volitional facilities. Three elements that need to be considered, include,

i) Adult fish are able to migrate to their natal tributary and survive transit at rates sufficient to achieve effective upstream passage as determined by CRSRI.

ii) A disease management plan will be implemented that defines an acceptable level of risk from Infectious Haematopoietic Necrosis (IHN), Bacterial Kidney Disease (BKD), and other diseases, and allows adult fish to be upstream of the barrier dam.

iii) Key donor stocks are identified and agreed with consensus to be used in the medium-term (over a few salmon generations) to determine if naturally recruiting, populations can be established and recruit in these basins.

*Fish Production and Hatchery Donor Stock Agreement for Introduction and Transfer of Salmon to the Upper Columbi*a. Total hatchery production for all stocks reared at the Penticton hatchery cannot exceed 30,000 kg (e.g., 6 million juveniles at 5 gm).

Fisheries and Hatchery Management Agreement. Require Dam operators to prepare, in collaboration with the CRSRI, a plan that identifies: i) the quantity and size of fish to be produced at the Upper Columbia Anadromous Hatchery Complex; ii) rearing and release strategies for each stock, including upward and downward production adjustments to accommodate recovery of indigenous stocks; iii) credit mechanisms for production of high quality natural stocks; iv) plans for Dam licence-funded on-going monitoring and evaluation; and v) a fisheries management strategy consistent with the priority objective of maximizing the natural production of wild indigenous fish stocks and species in the basin (which includes climate uncertainty).

1.4 Pilot Plan Goal & Future Management Objectives

The goal of the *Pilot Program* is to implement short-term (a few salmon generations or less) reintroduction actions and studies that will inform the planning for and feasibility of future reintroductions. We identified a list of specific steps in the Phase 2 *Pilot Plan*:

- Identify any operational requirements needed for the passage and reintroduction *Pilot Program*.
- Identify protocols for optimal handling, sorting, and release conditions for salmon collected by CRSRI and other partner-funded fish collection facilities when they are constructed.

- Identify the number, origin, and species of fish to be released into habitat upstream from key dams or weirs, incorporated into the hatchery broodstock, or taken to other destinations.
- Identify fish collection and transportation requirements (e.g., four-wheel drive vehicles, smooth-walled annular tanks, large vertical slide gates, provisions for tagging/marking) for moving fish from below project dams to habitats above reservoirs, avoiding the use of facilities or equipment dedicated for other purposes (e.g., existing transport trucks).
- Identify optimal release locations for fish, based on access, habitat suitability, disease concerns, and other factors (e.g., those which would minimize disease concerns, recreational fishery impacts, interbreeding with non-native salmonid strains, regulatory impacts, special authorities for studies/construction, and complications from upstream dams).
- Consider how to strengthen the Indigenous science and Traditional Ecological Knowledge so it is weighted appropriately relative to the western scientific data.
- Interweave western science and Indigenous science for learning and re-learning for adaptively managing allowing the fish to teach us.

The *Pilot Plan* should guide the development of *Management Objectives* by describing tangible outcomes the *Pilot Program* is trying to achieve. Within an adaptive management framework, management objectives are the basis for bounding the critical uncertainties. They must be consistent with the goals, providing greater specificity to what those goals actually mean, ensure these are measurable, demonstrate weight of evidence, practicality, and are timely. **The objectives of the reintroduction adaptive management plan need to inform the following:**

- Describe any issues that arise and identify solutions considered with most importance. Such as costs and resource estimates to implement a Pilot Program experiment;
- Provide an integrated monitoring plan and support the development of a life cycle model for a coordinated assessment of the hatchery program;
- Identify and describe studies that address the components of greatest uncertainty related to reintroduction, with cost estimates and resource needs for studies; and
- Describe the steps and processes for adaptive management in detail for the reintroduction program to remain durable with ongoing re-evaluation.

We suggest that the PVA overviewed in this document, and to be detailed in Phase 2, will inform feasibility of plans and reference endpoints as well as the impact of uncertainty on outcomes. Biological reference endpoints will be formally defined in Phase 2, but for the interim we suggest potential biological endpoints may include:

- Population abundance and distribution;
- Population age structure;
- Changes in abundance and structure over time; and
- Long-term population stability and/or likelihood of local extinction.

1.5 Key Limiting Factors of Successful Reintroduction

A reintroduction constraint is a factor limiting the ability of colonists to establish a population that is sustained by natural production. Anderson et al. (2014) divided reintroduction constraints into five main categories:

Barriers – The presence of Chief Joseph and Grand Coulee dams blocking migration is the most obvious constraint to recolonizing a natural population upstream into Canada while numerous dams within Canada provide further barriers to recolonization upstream of the Transboundary Reach. Therefore, some means for passage is necessary. Active colonization options, which include translocation and hatchery releases, can quickly place fish in the reintroduction site, but do not fully address altered biological processes and require ongoing human intervention. While hatchery releases can be used to initiate the reintroduction, a population that sustains itself through natural production will ultimately need to be established for the reintroduction to contribute to salmon recovery. As such, the long-term reintroduction will likely rely on dam passage. Short of dam removal, means of actively or passively moving adults from downstream to above a dam, as well as moving juveniles from upstream locations into downstream areas are critical to countering the reintroduction constraint posed by the presence of US and Canadian dams.

Habitat Quality – Poor habitat quality and/or limited habitat quantity will restrict recolonization success. There may or may not be limitations on spawning habitat and the quality of that habitat (e.g., how many eggs can the habitat support and what is the egg-to-fry survival). There is also the need to consider the quality and capacity of habitat to support juvenile rearing, since it is likely that both Sockeye and Chinook salmon will require a full year in freshwater prior to outmigrating. Habitat will also affect life history attributes such as residualization, or match-mismatch (i.e., the matching of the timing of smolts arriving into the estuary with conditions that favour survival). In some reintroduction programs, habitat restoration is needed before reintroducing fish to the area. Habitat reintroduction will need to be at a large (reach and landscape) scale to achieve measurable success, although small scale habitat restoration will be necessary to mitigate short term habitat impacts. Cold water refugia will be very important as climate change results in warmer and drier conditions during adult migration. It is important to note that there is abundant habitat in the system so the issue will be to get fish to those habitats, while we work on mitigating/restoring connectivity and other habitat that might be critical in the short term, to bridge us to the medium and long term goals.

Migratory and Ocean Survival – Survival along the migration corridor en-route through the Columbia and Tributary dams and during ocean residency will limit reintroduction success. Low survival of juvenile salmon migrating through the Lower Columbia River and out to the ocean is likely to be a constraint that requires mitigation. In 2018, hatchery yearling Chinook Salmon smolt had 81% survival from the Chelan River to McNary Dam while all Chinook smolts had 57% survival from McNary Dam downstream to Bonneville Dam (NMFS 2019). In 2020, Entiat and Methow River hatchery Chinook smolt had 67% and 16% survival to Bonneville Dam, respectively (NMFS 2021). Mean Sockeye smolt survival from Rock Island Dam to Bonneville Dam was 50% from 1996-2020 (NMFS 2021). As a result, significant attention is being placed on studying and increasing smolt survival. An acoustic tagging study or PIT tagging study to better understand the movement and survival of salmon smolts has been initiated for several of the dams downstream (e.g., Hatch et al. 2018). Similar studies focussed on project sites in the Upper Columbia should help direct recovery actions aimed at improving smolt survival.

Harvest – Harvest of adult Chinook Salmon in both marine and freshwater fisheries reduces the number of potential colonists, thus potentially limiting the chances for a successful reintroduction. Adult Sockeye harvest in the marine environment is assumed to be minimal (less than 0.5%), but recreational harvest fisheries occur throughout the Columbia River.

Interactions with Other Species and Populations – Interactions with existing/resident species in the ocean or in the Study Area could influence the likelihood of a successful reintroduction. Roosevelt, Arrow, and other reservoirs are home to populations of non-native fish such as Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*Micropterus dolomieu*), Northern Pike (*Esox lucius*), Walleye (*Sander vitreus*), and Lake Trout (*Salvelinus namaycush*), all of which may present predation and competition challenges for juvenile salmon. Competition and predation from native Bull Trout (*Salvelinus confluentus*) and Rainbow Trout (*Oncorhynchus mykiss*) in the Upper Columbia River and its tributaries also may constrain Chinook Salmon colonization. Ecological interactions between anadromous Sockeye, and other species such as mysids, or the existing fish community in lacustrine habitats (including kokanee) could limit Sockeye Salmon productivity.

1.6 Key Backgrounder Studies

Previous studies have been utilized in the creation of this document to provide information on topics such as habitats, donor stocks, hatcheries, passage technologies, and strategies available to fisheries managers. Many are cited directly throughout this report. Key background documents upon which the results of this report were built, are embedded in Appendix A, as an annotated bibliography.

2 Objective 1 – Development of a Conceptual Design and Identification of Salmon Planning Units and Donor Stocks

2.1 Pilot Release Strategies Big Picture Key Considerations

With many unknowns and questions regarding how salmon will respond to the new habitats there needs to be a balance between choosing the situations that are believed to be best suited for reintroduction and providing a wider variety of options so that the salmon may demonstrate what works best for them. With this idea in mind, a reintroduction plan will need to provide multiple avenues to success by utilizing a variety of options at each stage of the reintroduction process.

It is important to remember that the Pilot Plan is designed to guide the initial Pilot Program and that shorter term goals and objectives of the Pilot Program may differ from a longer-term reintroduction strategy but instead provide value in helping to define what direction longer-term reintroduction efforts take. Short-term restrictions in study designs may be balanced against completing additional combinations over a longer time scale. Prescriptions for study designs will be further detailed in Phase 2 with the understanding that issues such as annual variation in the availability of study fish may limit what can be undertaken in some years. Here we will provide descriptions of two potential approaches. Both approaches would involve Chinook and Sockeye salmon. Note that financial and resource constraints may play a large roll in determining the approach that is eventually used.

Stepping Stone Approach

One potential approach to Pilot Program reintroduction efforts would be a “stepping stone” strategy. This method focuses on concentrating initial efforts in a smaller number of locations and then as those populations grow, using them as the brood source for expanding reintroduction efforts into other locations. This could allow for the population to evolve to the local environment over time (e.g., Hendry et al. 2000) so that when used as a donor source for the next SPU the fish are better adapted than the initial donors were. For these populations that would be located so far from the Pacific Ocean, developing heritable traits such as migration timing could greatly enhance the success of future reintroduction efforts. For management, it allows for lessons learned from the initial population to be applied to upstream populations so that key issues and risks can be addressed sequentially rather than all at once. As it applies to the Pilot Program, this approach would likely entail limiting initial reintroduction studies to a single SPU for each of the species.

Short term benefits to this approach include the ability to concentrate efforts either in the highest quality habitats with the best likelihood of success, or in the most downstream areas with fewest movement barriers and shortest migration distances. Fewer study areas can also lower the number of study fish required and minimize risks associated with the potential availability of study fish. A smaller geographic footprint would lead to simpler logistics for fish transfer as well as allow for a more streamlined monitoring program. Re-establishment in the initial SPU’s will improve brood source capacity for expanding reintroduction efforts into other locations. Short term downsides to this approach include exposing study fish to a limited set of environmental conditions, and delaying the development of any heritable traits that are applicable to other SPU's.

Additional risks to this approach include the extended time scale it could entail. Multiple generations may be necessary before the initial population is large enough to be used for the next "step" and that same wait may be necessary at each successive "step." There is no guarantee that the initial populations will grow large enough to provide donor stock for the next SPU. Additionally, some SPUs may not have enough habitat to provide a population large enough for donating to the next "step."

Diversified Approach

From a conceptual design perspective, this means diversifying approaches along a number of dimensions to maximize the opportunity for success and the opportunity to gain information. Designs will consider diversified approaches under four key dimensions:

Minimum number of Salmon Planning Units
There are seven SPUs in the study being considered for reintroduction efforts. Descriptions of the various units can be found in the next section. We would aim to undertake initial reintroduction efforts for a number of these SPUs (e.g., a minimum of three Units could be targeted). Utilizing multiple Units allows us to study salmon across a wide variety of habitats and conditions as well as return the fish to many of the areas where they were traditionally harvested.

Minimum number of life stages (e.g., egg, fry, smolt, adults)
There are data gaps for all life stages of salmon in the Study Area. Time and resources (including availability of fish) will limit what studies can be undertaken during the *Pilot Program*. We would aim to study several life stages for each species (e.g., a minimum of two stages per species could be targeted). As many of the objectives relate to migrating smolt and adult salmon, those are two life stages that could be the focus of the studies.

Minimum number of replicates by space and time
Spatial and temporal replication is always critical in any ecological experiment. This speaks to our efforts to give the fish a variety of opportunities for success and to control for unknown factors that may impact success. Within each SPU we would ideally want to release fish in multiple distinct areas with multiple releases per year (e.g., we could target to have a minimum of three microsites with three releases per year). Distributing fish by both time and space can expose released fish to a wide range of conditions and provide information on what release strategies are the most effective which will guide future efforts. Releasing fish across multiple years (e.g., we could target three years of replicates) will provide valuable insight into inter-annual variations among the study groups. Release locations can be guided by the insight of the Nations and the locations they traditionally fished.

Alignment of Natural Laws, and respecting Salmon to teach and guide our path (Holism).
Full consideration of Indigenous Knowledge and cultural landmarks for place-based learning. Ceremonial releases provide an excellent opportunity for learning, developing strategies, and moving forward together with a meaningful process. For example: i) fish releases scheduled to a lunar cycle (New Moons), ii) releasing from Downstream to Upstream (Ceremonies, Songs; Oral Stories), and iii) emphasis on natural systems (live feed strategies, complex rearing environment; placement of carcass analogs and presence of juveniles to call and attract adults in relation to homing, or emphasis on spawning channels for adult mate selection and propagation).

In total this approach includes a large number of possible combinations which may need to be balanced against short-term goals and funding opportunities. Monitoring would be required to track the response of each release event. Types of monitoring projects are outlined in the Phase 2 document (Bussanich et al. 2022).

Path Forward

The main advantage of the Stepping Stone approach is that it allows us to focus efforts where the highest likelihood of success may exist, and subsequently build a larger program using from there. The main disadvantage is that there is no guarantee that reintroduction will work in that focused area, and even if it does it may not be able to support the next "step" in the model. On the contrary, a failure at the first ('best') location may suggest that subsequent steps may also not work, especially if the next step is farther, requires more elaborate solutions, requires more fish, or if the habitat appears to be of lesser quality.

The main advantage of the Diversified approach is that it broadens the sets of SPUs, release locations, and species (more of a 'try everything and see what works' approach). The main disadvantage of this approach is that it may not be possible with limited resourcing (funding, availability of brood/donor, etc.), and does not make use of trial and error lessons learned from smaller scale attempts.

Given that we will likely require large numbers of hatchery fish (see Phase 2 document, Bussanich et al. 2022), and there are limitations to broodstock availability, even if only one SPU is considered, the more focused Stepping Stone approach is that which appears more prudent. Later sections of this report (e.g., 2.2 and 2.3) review core areas and tributaries/SPUs to focus on. Indeed, in terms of reintroduction sequencing, it makes by far the most sense to proceed from a downstream to upstream direction. The reasons include:

- There is a limited supply of fish (i.e., appropriate donor brood) and resources to go around.
- Salmon mortality for both adults and juveniles is cumulative with increasing travel distance and mortality can be most heavily concentrated on dam passage, so will all else being equal, fish reintroduced to the most downstream locations are likely to have the highest survival rates.
- Survival/passage is a major constraint that must be solved lower in the basin for any further upstream stocks to also persist (i.e., passage through Hugh Keenleyside Dam, Roosevelt Reservoir, and Grand Coulee must be addressed before that through Revelstoke, and Mica dams).
- Fish passage is going to be extremely difficult and costly to solve at Revelstoke and Mica dams, but less so at Hugh Keenleyside and Brilliant dams.
- Arrow Lakes have the most evidence of suitability for Sockeye Salmon (Bussanich et al. 2017, Traditional Ecological Knowledge (TEK), kokanee abundance as a proxy), making it a good place to focus on initially.
- Far-inland migrating (> 1,000 km) stocks of Chinook Salmon are a poor selection for starting focal groups. We know that the historic Chinook Salmon stocks in the most upstream areas of the Columbia River (upstream from Revelstoke) were all Spring Chinook Salmon (Eigenmann 1895), and required special adaptations to deal with their longer migrations (e.g., higher lipid contents, more streamlined body shapes, later juvenile emigration, earlier spawn timing, earlier dates of river entry, immigrating when gonads are immature and then holding in thermal refuges to complete maturation, etc.; Healey 1991, Quinn 2005). Yet since most of the spring Chinook Salmon stocks at our latitude appear to be declining (many are listed), it may be unreasonable to expect that reintroduced upper Columbia stocks would do better, especially with more obvious hurdles in the way for passage survival. Regardless, there is no current access to broodstock for Spring Chinook Salmon at this time (see Section 2.4 below).

2.2 Phase 1 Study Area

The Study Area includes Canadian waters of the Columbia River drainage upstream of Chief Joseph and Grand Coulee dams (Figure 1). This includes a portion of the Kettle River drainage which enters the Columbia River within the United States. The Study Area is further broken up into seven SPUs which are described below.

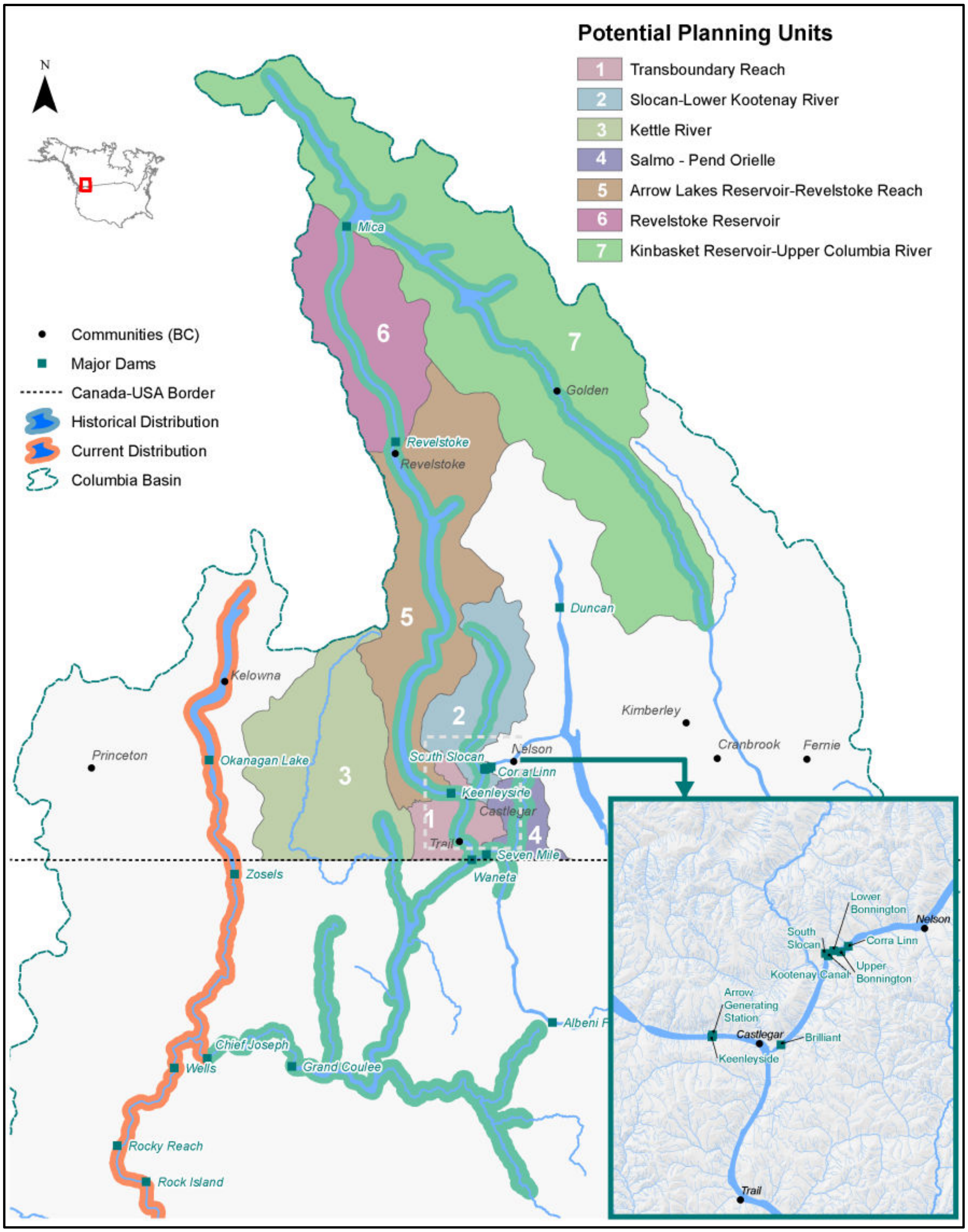

Figure 1. Distribution of the seven Salmon Planning Units that comprise the Study Area in the Columbia River drainage, BC.

Habitat assessment was conducted prior to the development of the *Pilot Plan* (Bussanich et al. 2017). The purpose of this study was to describe the perceived quantity and quality of habitat, and the habitat capacity of adult spawners for both Chinook and Sockeye salmon. This information is important for establishing the basis for selecting release and collection locations for adults and juveniles, spawning sites, and determining the potential to support viable populations of reintroduced Chinook and Sockeye salmon. Habitat attributes were scored by Bussanich et al (2017), including attributes such as channel morphometry and substrate.

In the following sections, we present for each SPU a brief overview of the potential habitat for use by Spring Chinook Salmon, Summer/Fall Chinook Salmon, and Sockeye Salmon, as assembled by the study team authors and based on the current knowledge base. For all potential populations, comments on limiting factors and passage barriers are confined to Canadian waters. This exercise provides value by highlighting SPUs that have high potential for reintroduction success in this initial stage of the process.

2.2.1 Planning Unit 1 - Transboundary Reach

The Transboundary Reach Unit is composed of the Columbia River and its tributaries from the Canada-United States border upstream to the Keenleyside Dam (Figure 1). The Kootenay River drainage, which flows into the Columbia River in this Unit, is not included.

2.2.1.1 Spring Chinook Salmon

This Unit contains nine tributaries with potential Spring Chinook Salmon habitat although the production potential in most of the identified streams is minimal (Bussanich et al. 2017). High water temperatures may be a limiting factor for pre-spawn and spawning adults. Bussanich et al. (2017) provides quantitative estimates of available habitat. It is unknown if there was historic spawning in this Unit.

2.2.1.2 Summer/Fall Chinook Salmon

This Unit contains a large amount of potential Summer/Fall Chinook Salmon habitat in the Columbia River for both juveniles and adults (Golder 2017, Warnock et al. 2016). This Unit was historically used by Summer/Fall Chinook Salmon for spawning and is a candidate for Pilot Program activities.

2.2.1.3 Sockeye Salmon

There is potential for Sockeye Salmon to spawn at creek mouths in this Unit although Roosevelt Reservoir kokanee do not use these habitats currently. Larger bodied Sockeye Salmon may be able to utilize spawning habitats that are not suitable for kokanee. Rearing for juvenile Sockeye Salmon from this Unit would likely occur in Roosevelt Reservoir. Historically there were no lakes in this area and this lack of rearing habitat meant that Sockeye Salmon did not spawn in this Unit.

2.2.1.4 Limiting factors

Water level fluctuations in the Columbia River due to dam operations could dewater spawning locations (e.g., Irvine et al. 2014) and provide inconsistent access to rearing habitats. Juvenile salmon could suffer predation from White Sturgeon (*Acipenser transmontanus*), Rainbow Trout, and Walleye. This unit benefits from having no Canadian dams downstream of it and is located at a shorter distance to the ocean than most Units which may provide higher survival during upstream and downstream migration. Therefore, it does not have the same large scale limiting factors other Units do.

2.2.2 Planning Unit 2 - Slocan-Lower Kootenay River

The Slocan-Lower Kootenay River Unit is comprised of the Kootenay River drainage from the Columbia River upstream to the South Slocan Dam including the Slocan River drainage (Figure 1).

2.2.2.1 Spring Chinook Salmon

There is potential spawning habitat for Spring Chinook Salmon in the Slocan and Little Slocan rivers, but these areas could potentially be at too low of an elevation and may present thermal issues (Bussanich et al. 2017). Higher elevation tributaries and the outlet of Slocan Lake may provide small areas of spawning habitat with cool enough water temperatures. This Unit was historically used for spawning by Spring Chinook Salmon.

2.2.2.2 Summer/Fall Chinook Salmon

There is a large amount of potential habitat for Summer/Fall Chinook Salmon in this Unit. The Slocan River as well as portions of the Little Slocan and Kootenay rivers all provide spawning habitat across a range of stream sizes. This Unit was historically used for spawning by Summer/Fall Chinook Salmon and is a candidate for reintroduction activities.

2.2.2.3 Sockeye Salmon

There is habitat available for Sockeye Salmon in this unit. In the vicinity of Slocan Lake, Bonanza Creek provides the best potential spawning habitat with the potential for more than 2000 adults (Bussanich et al. 2017). The potential for the seemingly high-quality spawning habitat in the Slocan River is reduced by virtue of being located more than 20 km downstream from rearing habitat in Slocan Lake. This Unit was historically used by Sockeye Salmon for spawning and is a candidate for reintroduction activities.

2.2.2.4 Limiting factors

The relative lack of identified spawning habitat located near Slocan Lake may limit Sockeye Salmon in the drainage. Brilliant Dam near the mouth of the Kootenay River and downstream of the Slocan River has no adult or juvenile passage facilities. The majority of the Slocan River drainage sits at a relatively low elevation and may be susceptible to warming from climate change.

2.2.3 Planning Unit 3 - Kettle River

The Kettle River Unit contains the Canadian portion of the Kettle River drainage (Figure 1). Due to Cascade Falls blocking access to the upper Kettle River, the majority of available habitat lies within the Christina Lake drainage. The majority of the available habitat in the Kettle River drainage is located within the United States and is not included in this Unit.

2.2.3.1 Spring Chinook Salmon

It is unknown if Spring Chinook Salmon utilized this Unit historically, but Bussanich et al. (2017) found limited Chinook Salmon habitat in tributaries to Christina Lake.

2.2.3.2 Summer/Fall Chinook Salmon

It is unknown if Summer/Fall Chinook utilized this Unit historically. There may potentially be some habitat available in the mainstem of the Kettle River and in Christina Creek from Christina Lake to the Kettle River (Bussanich et al. 2017).

2.2.3.3 Sockeye Salmon

It is unknown if Sockeye Salmon utilized this habitat historically. Sutherland and Sandner creeks were the only tributaries to Christina Lake which Bussanich et al. (2017) found contained Sockeye Salmon habitat although it was classified as low quality.

2.2.3.4 Limiting factors

The Kettle River Unit has little accessible habitat due to the presence of Cascade Falls. Warm water temperature may limit the potential for use of the mainstem of the Kettle River, as may the presence of piscivorous introduced species throughout the Unit. In the Christina Lake drainage, Bussanich et al. (2017) noted that increased urban development was reducing available habitat while introduced freshwater shrimp (*Mysis relicta*) competed with juvenile kokanee for food.

2.2.4 Planning Unit 4 - Salmo – Pend Oreille

This Unit is comprised of the Pend Oreille River drainage from the mouth at the Columbia River upstream (Figure 1). The Salmo River located upstream of Waneta and Seven Mile dams is the principal tributary in this Unit.

2.2.4.1 Spring Chinook Salmon

Historically, Spring Chinook Salmon used the waters of this Unit for spawning and rearing. The Salmo River drainage contains potential habitat in the mainstem as well as a number of tributaries. There is potential for some larger tributaries to provide cold water habitat.

2.2.4.2 Summer/Fall Chinook Salmon

Historically, Summer/Fall Chinook Salmon used the waters of this Unit for spawning and rearing. The Salmo River drainage contains potential habitat in the mainstem as well as the lower reaches of a number of tributaries (e.g., Green et al. 2006).

2.2.4.3 Sockeye Salmon

Sockeye Salmon did not historically use the waters in this Unit. Lacustrine habitats behind Waneta and Seven Mile dams are warm, run of river impoundments that do not support kokanee populations and would not be suitable for rearing Sockeye Salmon.

2.2.4.4 Limiting factors

Fish passage is needed at Waneta and Seven Mile dams which may be difficult due to their size. Mainstem habitats in the Pend Oreille River are limited due to the lack riverine conditions and warm water temperatures. Bull Trout are present (Baxter 2004) and may prey on salmon. Non-native piscivores in this Unit include Northern Pike, Walleye, and Smallmouth Bass.

2.2.5 Planning Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach

This Unit contains the Columbia River drainage from Keenleyside Dam upstream to Revelstoke Dam including Upper and Lower Arrow lakes (Figure 1).

2.2.5.1 Spring Chinook Salmon

Spring Chinook Salmon used this Unit historically. There are a number of large, cold tributaries in the Unit that could provide spawning and rearing habitat.

2.2.5.2 Summer/Fall Chinook Salmon

It is likely that Chinook that historically used the narrows between Upper and Lower Arrows lakes were Summer/Fall run. There is likely potential spawning habitat available in the mainstem Columbia River near Revelstoke (Alex et al. 2021) and in the lower reaches of some tributaries.

2.2.5.3 Sockeye Salmon

Historically the Arrow Lakes were among the largest Sockeye Salmon producing areas in the Columbia River drainage. Spawning assessments need to be completed but there is potential spawning habitat in a number of tributaries, near Revelstoke in the Columbia River, and along reservoir shorelines. Kokanee spawn in a number of locations in the Unit.

2.2.5.4 Limiting factors

Passage is needed past Keenleyside Dam. Distance to the Pacific Ocean could be problematic for upstream and downstream migrations. Summer/Fall Chinook and Sockeye salmon populations do not exist at this distance from the ocean in the Fraser River drainage and Sockeye populations in the headwaters of the Salmon/Snake River drainage are at critically low levels. Available brood stock for Sockeye Salmon may not be adapted for the energetic needs of migrating to this SPU. Inundation of low gradient streams may be caused by the raising of water levels by Hugh Keenleyside Dam (Thorley 2008).

2.2.6 Planning Unit 6 - Revelstoke Reservoir

This Unit contains the Columbia River drainage from Revelstoke Dam to Mica Dam and is principally comprised of Revelstoke Reservoir (Figure 1).

2.2.6.1 Spring Chinook Salmon

Spring Chinook Salmon likely spawned in this Unit historically. Spawning likely occurred in the mainstem of the Columbia and the lower reaches of tributaries all of which are now inundated under Revelstoke Reservoir. Remaining tributary habitat may have limited potential.

2.2.6.2 Summer/Fall Chinook Salmon

There is no historic record of Summer/Fall Chinook Salmon utilizing the waters in this Unit historically. This Unit is located farther from the Pacific Ocean than any known populations of Summer/Fall Chinook. Remaining tributary habitat may have limited potential.

2.2.6.3 Sockeye Salmon

There was historically no lake in this Unit and Sockeye Salmon were not present here. Currently kokanee production is limited within this Unit and it likely has little potential as Sockeye Salmon habitat. Were Sockeye Salmon to spawn in this Unit, juveniles entrained through Revelstoke Dam could rear in Arrow Lakes (Unit 5).

2.2.6.4 Limiting factors

Passage is needed past Keenleyside and Revelstoke dams. The distance from the Pacific Ocean has prohibited use of this area, prior to the building of dams, for all anadromous fish with the exception of Spring Chinook Salmon (but see Fulton 1970, who suggested that there were no barriers to Sockeye Salmon movement). Revelstoke Reservoir is ultraoligotrophic which may hamper juvenile rearing. The amount of riverine habitat may be limiting and needs to be more clearly defined. Dam operational impacts have been documented on kokanee (Bray et al. 2023) and may similarly impact anadromous Sockeye Salmon.

2.2.7 Planning Unit 7 - Kinbasket Reservoir – Upper Columbia River

This Unit includes the Columbia River drainage from Mica Dam upstream including Kinbasket Reservoir (Figure 1).

2.2.7.1 Spring Chinook Salmon

There is a large amount of potential spawning and rearing habitat in this Unit. High quality spawning locations include the outlets of Columbia and Windermere lakes and a large amount of rearing habitat is available in the Columbia wetlands.

2.2.7.2 Summer/Fall Chinook Salmon

There is no historic record of Summer/Fall Chinook Salmon utilizing the waters in this Unit historically. This Unit is located farther from the Pacific Ocean than any known populations of Summer/Fall Chinook.

2.2.7.3 Sockeye Salmon

It is unknown whether Sockeye Salmon historically spawned in this Unit. There is potential spawning habitat downstream of Columbia Lake and rearing habitat in Columbia and Windermere lakes as well as in Kinbasket Reservoir. This Unit is located further from the Pacific Ocean than any known populations of Sockeye Salmon.

2.2.7.4 Limiting factors

Passage past Keenleyside, Revelstoke, and Mica dams is required. It is unknown whether anadromous fish other than Spring Chinook Salmon used this area before the dams removed access. Dam operational impacts have been documented on kokanee (Bray et al. 2023) and may similarly impact anadromous Sockeye Salmon.

2.3 Phase 1 Tributary Selection Process for Experimental Releases

One core principle adopted by the Indigenous Nations was One River. Traditional knowledge and Historical Local knowledge of settlers to the region account for salmon accessing to the headwaters of the Columbia. Chinook navigated the Columbia mainstem to the headwaters, ascended the Kettle River proximate to Christina Lake, to the Slocan (enroute via the Kootenay River), and throughout the Salmo River on the Pend Oreille. Sockeye strongholds included the Arrow Lake and Slocan, with other candidate lakes needing additional TEK: Christina Lake (Kettle), Kinbasket, and the lake complex between Columbia and Windermere Lakes. A One River Approach for Releases will require outplants in each of the SPUs. For example, under the Diversified approach, salmon may be released in each of the Nations area of Responsibility as part of ceremonial calling the salmon to the headwaters from the Transboundary Reach to Columbia Lake, and include Slocan Lake. Nations may elect to outplant salmon where traditional fishing camps were located, as well as other key places of cultural and spiritual significance (the perimeters of each lake), or key headwater locations as per Salmon Stories. For this very reason, knowledge keepers advise Let the Salmon decide - this technique blended with science has provided a rich learning experience resulting in the success of Sockeye Salmon returning to the Okanagan River.

From a Western Science Lens, various approaches are used in identifying and prioritizing (but not to rule out) bodies of water in their current and future states, especially when making decisions on where to invest funding. Common approaches include any mix of Limiting Factors Analysis, Life Cycle Analysis, Intrinsic Habitat Potential modeling, etc. The complementary TWG studies for assessing Risk and Habitat Suitability utilized similar approaches to inform the prioritization of unoccupied habitats that historically supported anadromous salmon, deemed suitable for reintroduction in Phase 1. With limited funding, specific areas for experimental releases could be coded as either primary areas, candidate areas, or areas that have been ruled out for potential reintroduction at this stage.

For Spring Chinook, Summer/Fall Chinook, and Sockeye salmon, specific areas were chosen from initial screening as *primary* or *candidate areas* for reintroduction. A 'primary area' is defined as an area where there is a higher likelihood that reintroduction would be successful (assuming that passage to be provided), based on species-specific life history needs and available habitat quality and quantity). 'Candidate' reintroduction areas were defined as a possible – lower priority – areas for reintroduction. We cross-validated this with knowledge of traditional fishing camps, to develop a list of primary streams to support the critical freshwater life stages of Salmon:

- *Spring Chinook Salmon*: We identified the Illecillewaett River, Inncompleaux River, Halfway River, and Jordan River (Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach), Salmo River (Unit 4 – Salmo – Pend Oreille), and the Columbia River upstream of Kinbasket Reservoir (Unit 7 – Kinbasket Reservoir – Upper Columbia River) as candidate reintroduction areas. No primary areas were identified.
- *Summer/Fall Chinook Salmon*: We identified the Columbia River near Castlegar mainstem and Kootenay River confluence (Unit 1 - Transboundary), Columbia River near Revelstoke (Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach), and Slocan and Little Slocan River (Unit 2 – Slocan- Lower Kootenay River), as the primary areas for reintroduction. The Columbia mainstem at Genelle (Unit 1 – Transboundary), the Whatshan River (Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach), and Salmo River (Unit 4 – Salmo – Pend Oreille) were classified as candidate reintroduction areas.

- *Sockeye Salmon*: We classified the Caribou-Burton Rivers (Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach) as the primary area for reintroduction of Sockeye Salmon (these are known and well-established spawning tributaries). There is potential to add further tributaries in Unit 5 as primary areas for reintroduction with further investigation. Whatshan River and Inonoaklin Creek (Unit 5 – Arrow Lakes Reservoir – Revelstoke Reach) and Slocan River (Unit 2 – Slocan – Lower Kootenay River) are classified as candidate reintroduction areas due to historical populations of Sockeye Salmon.

For future evaluation in Phase 2 we identified four categories, each with multiple criteria, to help prioritize studies and study sites in the Pilot Program:

- *Ecological* – Holding habitat, spawning/incubation habitat, rearing habitat, conditions for juvenile migration, estimated spawner capacity, water temperature, water supply reliability, flow variability, predation, resource competition, disease, food, ability to foster life history diversity, and resilience to climate change.
- *Physical Implementation* – Transportation stress on fish, cost of fish collection and transportation, adult release sites, juvenile collection sites, and field studies.
- *Stakeholder/Landowner* – Public lands, recreation, watershed stewardship organizations capacity, landowner concerns, and heritage site concerns.
- *Regulatory Implementation* – Water Use Plans, Ecological Recovery Plans, Introductions and Transfers Committee regulations.

These criteria will be reviewed for each river, with scoring based on the place-based learning approach, habitat assessments, and with results weighted since the success of reintroduction depends on the socio-ecological conditions.

2.4 Donor Stock Selection and Hatchery Options

Initial reintroduction efforts will rely on outside sources of fish. Selection of donor fish is a balancing act between using populations that are most ideally suited for the Study Area as well as sources that have fish available for use.

2.4.1 Reintroduction Risks

Anderson et al. (2014) defined reintroduction risks as unintended or undesirable consequences for non-target species, non-target populations, spawning areas, or life history types of the reintroduced species. When considering biological reintroduction risks it is useful to categorize by: evolutionary, demographic, ecological, and disease risks. See Burke et al. (2023) for an assessment of risks of Summer-Fall Chinook and Sockeye reintroductions in SPUs 1 and 5, respectively.

2.4.1.1 Evolutionary Risk

Under evolutionary risk, salmon reintroductions have the potential to cause genetic homogenization, and/or reduced fitness (Anderson et al. 2014). If salmon originating from the reintroduction site return to adjacent populations as adults, the genetic distinctness among the adjacent populations may be altered (Table 1). We recognize that the genetic signatures of the extirpated salmon populations may be lost, and that the goal in some cases will be to reintroduce fish with 'as close to' the historic signatures as possible.

Warnock et al (2016) found for example that the Upper Columbia summer-fall ESU is the most appropriate donor for that specific reach and the use of out-of-basin stocks from other ESUs or the Fraser are not appropriate due to evolutionary risk and lack of ancestry matching.

There are specific concerns about Chinook Salmon life history pathway expression in the reintroduced populations. Outplanted adult Chinook Salmon will be from the Upper Columbia Summer-Fall Chinook ESU that can express a diversity of juvenile life history pathways but which is typically dominated by ocean-type juveniles. By contrast, far-inland Chinook

Salmon populations are dominated by stream-type life histories (Healey 1991, Quinn 2005). Thus there is interest in which strategies will be expressed *in situ* and whether the proportional expression of different strategies will change over time (Waples et al. 2004, Warnock et al. 2016).

Table 1. Characteristic comparison between the Desired Restored population,and populations that could be affected. Spring Chinook are omitted as a suitable donor stock is not currently available.

	Summer-Fall Chinook			Sockeye		
Genetics	**Okanagan River**	**Methow River**	**Wenatchee River**	**Okanagan River**	**Methow River**	**Wenatchee River**
Effective Population Size	Highest	Lowest	Moderate	High	Not applicable	High
Hatchery Influence	High (CAN) to Low (US)	Low to Moderate	Low to Moderate	High (Okanagan Lake) to Low (Osoyoos)	Not applicable	Low
Genetic Diversity	Low	Low	Low	Moderate	Not applicable	High
Natural Origin Spawners	Moderate	Moderate	Moderate	High	Not applicable	High
Population Viability Classification †	Independent	Independent	Independent	Moderate to High	Not applicable	Moderate to High
Risk of Extinction †	Data Deficient*	Low	Low- Moderate	Low to Moderate	Not applicable	Low to Moderate

Note: * Insufficient data is available to assess status (Lindley et al. 2007)
† see Lindley et al. (2004)

2.4.1.2 Demographic Risk

The main demographic risk associated with a reintroduction is the potential for reducing source population viability by removing individuals to support the reintroduction. This is a particularly important risk to consider for sockeye salmon because it is comprised of one genetic unit (higher homing rate compared to other species); whereas the current chinook stock is comprised of a meta-population (admixed). Taking individuals from the existing population to reintroduce salmon elsewhere could be risky unless it is clear the population has a demographic excess (i.e., it is a true “source” in meta-population source-sink dynamics) that can sustain removal for multiple successive years (Anderson et al. 2014).

A 2015 drought-related impact and lower adult spawner abundances raised questions on the availability of salmon stocks for future reintroductions. In order to protect the population, agencies have recommended Salvage Programs at downstream Dams to create a source population of salmon for drought mitigation. In the early stages of a reintroduction, there is a risk to the source population associated with taking fish and reintroducing them into habitat above dams. While there is a risk of reintroducing fish into new habitat, the reintroduction area, or Study Area, supported both Chinook and Sockeye before construction of the Grand Coulee Dam. If the *Pilot Program* can demonstrate that the reintroduction can produce a sustainable number of returning adults, then the risk to the SPUs will be reduced. Moreover, reintroducing anadromous salmon to the Study Area allows for a greater ratio of production (on a per-adult basis) due to expanded habitat. Thus, a successful CRSRI reintroduction program could increase the overall numbers of adult fish, thus producing an increased number of additional progeny relative to the extant salmon below the dams.

The preliminary or pilot phase of the reintroduction is the phase with the highest risk because there are unknowns (e.g., distribution in the Study Area and migration timing). To mitigate the risk associated with the early phases of the reintroduction, the Pilot Program will take a prudent approach to obtaining fish for the reintroduction including taking a small number of eggs or juveniles per crossed adults up to the total number desired, hold them separately, and minimize impacts on any one individual's fitness and survival. This approach would obtain as much diversity as possible from the donor stock and minimize risk to any one individual.

Before implementing the *Pilot Program*, source hatchery's genetic management policies should be audited for compliance, including assessment of environmental, regulatory, and biological risks.

2.4.1.3 Ecological Risk

Ecological risks from reintroductions are described by Anderson et al. (2014) as, "invasion by non-native species and suppression of pre-existing native species within the reintroduction site." See Burke et al. (2023) for an assessment of ecological risks in SPUs 1 and 5. The risk of non-native species invasions is more of a concern following barrier removal than with translocation reintroductions, where the species being transferred can be selected. In this case, salmon were once native to the area and other fishes co-evolved with them. Additionally, according to Pearsons and Temple (2007) and Buehrens (2011), the few empirical assessments of reintroduction impacts have found little effect on pre-existing native species.

The risks of residualized salmon c"n ma'Ifest in a variety of ways. Residualized Chinook Salmon may harm native fishes through predation as well as competing for shared food sources. Rearing Sockeye Salmon will compete with kokanee for shared food sources. For both Chinook and Sockeye, spawning of anadromous individuals with residualized fish may reduce fitness for anadromy.

2.4.1.4 Disease Risk

Reintroductions have the potential to spread harmful pathogens between the reintroduced species and other species. See Burke et al. (2023) for an assessment of disease risks in SPUs 1 and 5. Before implementing the *Pilot Program*, a Fish Health Study should be initiated that includes establishing a baseline of pathogen densities within the area to allow for better disease monitoring, and screening artificially-reared or transplanted fish before release that will minimize the risk of spreading disease (Anderson et al. 2014).

2.4.2 Donor Stock and Life Stage Approach

Selecting a source similar to the historical population that inhabited the reintroduction area should maximize the benefit and reduce the risks of a reintroduction. Reintroduced salmonid populations are expected to have a higher probability of success when they originate from donor populations that are most adapted to environmental conditions of the river systems to which they are being introduced (Nielsen and Powers 1995, Huntington et al. 2006). Understanding local environmental conditions of a reintroduction area is important for selecting stocks that have life histories and environmental tolerances most compatible with the existing habitat. Factors such as timing and magnitude of flows, locations and seasonality of migration barriers, water temperature, pool density and depth, cover, and spawning substrate quantity and quality are all key habitat attributes that influence the potential reintroduction success.

Donor stock selection is a critical element when monitoring and evaluating the evolutionary, demographic, ecological, and disease risks with reintroduction programs. Key donor stocks, by life stages, outlined in reports by UCUT (2019) and Warnock et al (2016), were the primary considerations for a Phase 1 Plan.

For Spring Chinook Salmon, UCUT found that "potentially-available Spring Chinook from upper Columbia River segregated hatchery programs pose a genetic risk to extant upper Columbia populations. Additionally, constraints associated with natural and hatchery origin ESA-listed stocks of Spring Chinook are expected to be burdensome and would likely constrain reintroduction efforts." As such Spring Chinook Salmon will be excluded from reintroduction field studies until the risks associated with those efforts are minimized.

For Summer/Fall Chinook Salmon, Warnock et al (2016) found that the Upper Columbia summer-fall ESU is the most appropriate donor for that specific reach and the use of out-of-basin stocks from other ESUs or the Fraser are not appropriate due to evolutionary risk and lack of ancestry matching. They also reported that Summer-Fall life histories are generally more appropriate for warmer, valley bottom mainstem, or large river habitats due to being pre-adapted to the thermal regime and early life stage habitats. Also, since Summer-Fall populations are not listed, there is more opportunity to source brood without posing demographic risk to donor populations.

UCUT elected to use the Okanagan-Methow-Wenatchee River population (i.e., where the remnant stocks from the Upper Columbia were released/salvaged before they were completely lost/blocked by Grand Coulee) as the adjacent population to consider when assessing the evolutionary risk of the reintroduction upstream from Grand Coulee Dam:

- *Summer Chinook Salmon for tributary habitats* – Okanagan-Methow-Wenatchee meta-population complex;
- *Summer/Fall Chinook Salmon for Columbia River mainstem habitats* – available access from
    a. Hanford Reach,
    b. possible small source downstream of tail race of Chief Joseph Dam.

For Sockeye Salmon, UCUT identified the Okanagan-Osoyoos population as the pilot stock as an adjacent population to consider when assessing the evolutionary risk of the reintroduction upstream from Grand Coulee Dam. Pending future information coming available from genomic investigations, the following may be candidate sources:

- Shingle Creek, which is a tributary to Penticton Channel (Skaha population), has 600+ adults, the majority of which are hatchery fish keying in on Penticton hatchery. This population could provide "proxy" fish for fish passage studies or any studies requiring low number releases to test survival (predator studies, stranding, etc.).

Additional alternatives include:

- Roosevelt Reservoir re-anadromized kokanee which are currently not available due to the depressed state of the population.
- Similkameen-Methow-Entiat Sockeye Salmon could be potential sources for tributary spawning populations utilizing a reservoir for rearing. PIT data indicates very low numbers of Sockeye Salmon observed in the Similkameen and Methow rivers with a higher likelihood of availability during extreme drought water years.
- Wenatchee River and Cle Elum Sockeye Salmon. These sources were not considered a high preference by UCUT, but potentially should be considered further.
- Fraser Sockeye Salmon were not considered due to their degree of genetic differentiation for Columbia River stocks.

The life stage of fish reintroduced into the study area will be dependent on a variety of factors including the availability of fish and goals of initial studies. For example, outplanting of adult salmon may provide valuable information on preferred spawning locations and spawning success but juveniles from an adult outplanting may not be abundant enough to be used for downstream passage studies. It is likely a combination of adult and juvenile outplants will be utilized during the Pilot Program.

Various options for the collection of study fish from donor populations are presented in the Fish Collection and Passage section later in the document.

2.5 Hatchery and Other Supplementary Translocation Options

This section outlines potential hatchery programs and facilities that can be utilized for rearing in the Pilot Program. Because of the current low-to-moderate numbers of salmon, the fish reared through the breeding program at the CJH and OKH may be needed to sustain the population. Therefore, information such as the run, numbers and life stages of fish that will be available for the pilot studies will be determined on a year-to-year basis. To minimize Demographic Risk, the Pilot Program should use fish from the broodstock program at Colville Chief Joe Fish Hatchery (Brewster, WA) and ONA kcpelkstim Hatchery (Penticton, BC).

2.5.1 Primary Facility – Chinook Salmon - Chief Joseph Hatchery

Chief Joseph Hatchery (CJH) has been operated by the Colville Tribes since 2013 for supplementation of Summer/Fall Chinook Salmon into the Okanogan River to mitigate the effects of Grand-Coulee Dam. The facility also serves to rear spring Chinook to supplement Okanogan and Methow River populations. The hatchery is operated on the left bank of the Columbia River within the forebay of Chief Joseph Dam near Brewster (N 48°00'053", W 199°38'51.8"). The hatchery is constructed on a 20-acre site and has an additional 5 acres available for development. The site has the potential to rear up to 2 million Summer/Fall Chinook and 900,000 Spring Chinook at full program. CJH has five wells capable of supplying up to 66,261 Lpm of variable temperature water ranging from 8.3°C to 14.4°C, and utilizes surface water from Rufus Woods Lake; supplying up to 101,941 Lpm of variable temperature water ranging from 3.9°C to 18.9°C. Both water sources undergo gas stabilization treatment, and surface water is filtrated and disinfected up to 5,606.7 Lpm.

The primary objective of the Chief Joseph Hatchery (CJH) program is to meet trust obligations to the Colville Confederated Tribes for ceremony, subsistence, health and cultural purposes in a manner consistent with conservation of the natural fish populations. The Summer/Fall Chinook components of the CJHP consist of two complementary programs:

1. An *integrated recovery program* designed to increase abundance, productivity, distribution, and diversity of naturally spawning Summer/Fall Chinook Salmon within their historical Okanogan sub-basin habitat; and
2. An *integrated harvest program* designed to support a tribal ceremonial and subsistence fishery, and to provide increased recreational fishing opportunities for local citizens. Before the CJHP was implemented, the Summer/Fall Chinook population in the Okanogan River supported natural production and a single hatchery program that produced up to 576,000 yearling smolts annually. The CJHP increased production of juvenile Summer/Fall Chinook for the Okanogan River by 400,000 early-arriving and 700,000 late-arriving Summer/Fall Chinook.

The Summer/Fall Chinook *integrated recovery program* is implemented through five conservation actions:

1. Development of a local Okanogan River broodstock;
2. Expansion of previous broodstock collection by two months, in order to propagate the full historical run of Summer/Fall Chinook;
3. Propagation of both the yearling and sub yearling life histories to achieve full, natural diversity and provide necessary programmatic flexibility;
4. Improved distribution of spawning throughout the historical Summer/Fall Chinook habitat; and

5. Control of the proportion of hatchery-origin fish spawning in the wild. The Summer/Fall integrated harvest program is designed to support a tribal ceremonial and subsistence fishery and to provide increased recreational fishing opportunities for local citizens. To support the integrated harvest objectives, 500,000 early-arriving, and 400,000 later-arriving Summer/Fall Chinook are released at Chief Joseph Hatchery on the Columbia River. Total new production for the conservation and harvest purposes is therefore 2,000,000 Summer/Fall Chinook.

At full program the facility (Table 2) rears up to 2 million Summer/Fall Chinook and 900,000 Spring Chinook. The Summer/Fall Chinook program has an integrated component for restoration and conservation purposes that meets high standards for natural origin fish composition on the spawning grounds. If the natural population cannot support the integrated hatchery program in a given year, then hatchery production will be reduced or eliminated to minimize effects to the natural origin spawners. The segregated program is a "stepping stone" program, striving to use only first generation returns from the integrated program and is targeted to provide increased harvest opportunity for all user groups. Research, monitoring and evaluation and data analysis is coupled with advanced hatchery fish culture, facilities and operational policies and are presented at the CJH Annual Program Review (March/April). This practice has been underway since 2012 and continues to guide the future actions and plans for the CJH program.

Table 2. Chief Joseph Program 2013-2020 (Integrated Summer Chinook Salmon) goals and performance.

Element	Goal	Performance Mean (Range)
Pre-spawn Survival	90 %	78% (62-96%)
Eggs Per Female	4600	4133 (3753-4550)
Green to eyed egg survival	90 %	83% (68-94%)
Eyed-egg to-fry survival	95 %	85% (54-99%)
Egg-to-smolt survival yearlings	86 %	79% (38-95%)
Egg-to-smolt survival sub-yearlings	84 %	84% (67-92%)
Released yearlings	800,000	495,929 (235,740-708,336)
Released fry	300,000	126,545 (0-216,804)

2.5.2 Primary Facility - Sockeye Salmon - k cpə'lk' stim' Hatchery, Penticton, BC, CA

The kł cp̓əlk̓ stim̓ Hatchery located on Penticton Indian Band, BC is operated by Okanagan Nation Alliance (ONA). The 25,000 square foot facility was built in 2013 and became fully operational in the summer of 2014. The hatchery has a capacity to hold up to 8 million eggs and is equipped to handle all fish culture aspects required for 5 million eggs from broodstock management until fry release. Water for the hatchery is supplied by three production wells that supply roughly 13,000 LPM with an ambient temperature range of 9-10°C. Also, the hatchery has the ability to chill incoming water by 2-10°C, allowing control over thermal marking and release strategies. The hatchery also consists of laboratories and associated programs for health and disease, plankton and mysid biometrics, and aging, which are necessary for the Sockeye Reintroduction program. This includes an administrative office, egg take station, fertilization room, incubation rooms, rearing facility, settling pond, full warehouse, and laboratory.

The Okanagan Sockeye HGMP requires the maintenance of genetic diversity in Osoyoos Lake. This is accomplished by using natural-origin fish as broodstock and limiting the number of hatchery-origin fish that spawn naturally. The program has been able to achieve a Proportion of Natural Influence (PNI) > 0.67 as recommended by the HSRG.

2.5.3 Secondary Facility - Chinook Salmon Eggs to presmolts or Sockeye Eggs to Fry Rearing Net Pens - Spokane Tribal Hatchery, Wellpinit, WA, USA

Spokane Tribal Hatchery (STH) has been operated by the Spokane Tribe of Indians since 1991 for supplementation of Roosevelt Reservoir and Banks Lake kokanee and Roosevelt Reservoir Rainbow Trout. This facility is located at Galbraith Springs on the Spokane Indian Reservation near Wellpinit (N 47°54'22.6", W 117°51'21.3"). The hatchery is constructed on 9 acres (estimate) with an additional 7 acres (estimate) available for development on an adjacent property. This site has the potential to produce up to 4.3 million kokanee fry, 475,000 kokanee yearlings from Kootenay Lake (Meadow Creek) and Lake Whatcom stocks, and 750,000 rainbow trout. STH has two wells capable of supplying up to 5,097 Lpm of variable temperature and utilizes surface water from a nearby spring capable of supplying up to 8,495 Lpm of variable temperature water. Water treatment includes aeration and direct injection of oxygen to compensate for unfavorable water conditions. Water is stored in a tower head box and is gravity fed to fish culturing areas. No negative impacts on eggs or fish from water quality are known. The STH contains: 44 indoor/outdoor raceways with 26,752 cubic feet of rearing space, self-fabricated upwelling units, transportation equipment, a laboratory, backup generator, and feed storage.

2.5.4 Secondary Facility - Chinook Salmon Eggs to Pre-smolts - Hanford Priest Rapids Hatchery, Desert Aire, WA, USA

Priest Rapids Hatchery (PRH) has been operated by the Washington State Department Fish and Wildlife since 1963 as a spawning channel and since 1981 as a full-scale hatchery for supplementation of fall chinook in the Columbia River and partial mitigation for the John Day Dam. The hatchery is operated on the left bank of the Columbia River adjacent to the Priest Rapids Dam near Desert Aire (N 46°38'50.2", W 119°53'55.8"). The hatchery is constructed on a 45-acre site (estimated) and has an additional 580 acres (estimated) available for development. The site has a potential for up to 17 million eggs and rearing 5 million 9-gram juvenile chinook from the Columbia River. PRH has a well field with six active pumps and one backup pump capable of supplying up to 27,184-30,582 Lpm of pathogen free variable temperature water ranging from 1.3°C – 16.0°C, and utilizes surface water from the Columbia River; supplying up to 203,881 Lpm of variable temperature water ranging from 0.3°C – 20.0°C. The water undergoes gas stabilization treatments and high surface waters temperatures during the Summer are mixed with well water to reduce temperatures.

2.5.5 Secondary Facility – Chinook Salmon Eggs to Pre-smolts – Wells Salmon Hatchery, Pateros, WA, USA

Wells Salmon Hatchery (WSH) has been operated by the WDFW and the Douglas PUD since 1967 as a spawning channel and upgraded to a hatchery in 1977 for supplementation of Summer Chinook above Wells Dam. The facility is operated on the right bank of the Columbia River directly beside Wells Dam near Pateros (N 47°56'48.2", W 199°52'14.1"). The Hatchery is constructed on a 35-acre (estimated) site and has an additional 10 acres (estimated) available for development. The site has the potential to rear up to 804,000 combined yearling and sub-yearling Summer Chinook from Columbia River stocks. WSH has one well capable of supplying 64,579 Lpm of variable temperature water ranging from 8°C - 14°C, and utilizes surface water from the Columbia River; supplying up to 240,851 Lpm of variable temperature water ranging from 2.2°C – 19.4°C. Known negative impacts on fish and eggs include an *Ichthyophthirius* outbreak which caused 50% mortality of the 2001 brood year Summer Chinook, and coagulated yolk in the sub-yearling program resulting up to 20 – 25% mortality. Effluent treatment is managed in accordance with the National Pollution Discharge Elimination System general permit. The WSH includes: a hatchery building, adult handling facility, raceways, two earthen sand ponds, and a boat launch.

2.6 Next Steps

Agreements should be put in place for cultivation and use of fish, with understanding on numbers of fish potentially available for planning purposes. Potential transportation options should be identified and assessed. Other considerations include potential for off-site rearing, potential for longer husbandry durations to grow fish to smolt size for using in acoustic tagging studies, and logistical considerations for additional staff, equipment, or infrastructure to support larger egg takes, rearing and tagging.

3 Objective 2 – Juvenile downstream survival, migration rates, and timing

Initial studies on the downstream movements of juvenile salmon will provide vital information guiding future activities. For example, extended rearing in some locations could necessitate further investigation of predation in those areas. Baseline survival through dams or reservoirs could advance or minimize the need for expanded trap and haul efforts or provide valuable information on locations where study fish congregate and would be more susceptible to trapping efforts. Studies concerning the survival of juvenile salmonids migrating through hydroelectric projects are common in the United States portion of the Columbia River. Data collected towards this Objective can help to update and refine the PVA model. Details of the potential initial studies are considered in the Phase 2 document (Bussanich et al. 2022).

3.1 Conceptual Study Design

A treatment group is tagged at the upstream area of concern, and a control group is tagged and released downstream of the area of concern. Together the data from the two groups is used to determine the impacts of the area of concern. Studies should account for any impacts of tagging related mortality. Taggers should be blind to release location to ensure objectivity. Monitoring arrays can be used to determine timing of movements as well as travel time between arrays. With high detection efficiency each array can also serve as a virtual release to then allow for studying areas of interest downstream.

3.2 Example Approach

An initial release of acoustic tagged fish would occur in the Slocan River drainage. A monitoring array at the mouth of the Slocan River could provide information on emigration from the Slocan River to the Kootenay River. Fish detected at this array would be the release group for travel through Brilliant Pool to Brilliant Dam. An array at Brilliant Dam would provide survival through Brilliant Pool and fish detected here would be the release group for detecting survival through Brilliant Dam. Below Brilliant Dam, fish from the Control Group would be released. An array, perhaps near Trail, would provide detections for the Test Fish (detected at Brilliant Dam) and the Control Group (released below Brilliant Dam) for calculating survival through the dam. Further arrays downstream through Roosevelt Reservoir could provide information on survival and migration through the reservoir. Small releases at the dam face could help account for post-release handling effects between the ‘virtual release’ treatment group (i.e., run-of-river), and the ‘physical release’ control group (e.g., ViPRE model, Skalski et al. 2010).

4 Objective 3 – Factors and requirements that influence juvenile survival, migration rates, and timing

Environmental and fish monitoring data are needed to:

- provide baseline conditions for pre-project and long-term monitoring,
- characterize conditions and variability effecting fish metrics,

- identify risk associated with the feasibility and performance of various study options and passage alternatives, and
- assess predation of reintroduced salmon by resident piscivorous fish

It may be of interest to monitor the change in size of juvenile salmon over rearing season and at outmigration (growth rate). Juvenile salmon should be healthy and achieve growth rates within the natural range of variability for natural populations. Length frequency statistics and trend analysis along with otolith analyses of daily growth rates for subsamples of fish collected periodically can be used for this metric. Additionally, length and weight measurements will be used to evaluate condition indices for comparison of intra- and inter-annual growth patterns and for comparison with other populations of Chinook and Sockeye salmon. As part of this Objective there may be value in assessing the impact of adult salmon carcass outplanting on the growth and survival of juvenile salmon.

Because anadromous salmon have not inhabited the Upper Columbia rivers since the 1940s, patterns of habitat use are unknown for these fish. Systematic surveys of the occurrence of juvenile salmon along the Study Area will be used to develop frequency of occurrence curves across key habitat parameters and compute habitat preference statistics. Distribution will be influenced by juvenile release and adult spawning locations so this information would be updated as more natural spawning and emergence occur in the river.

Consistently collecting data on fish as well as environmental conditions can give insight into juvenile salmon health and behavior in the short to medium term while also aiding long term planning and forecasting. Ideally monitoring programs should be designed and implemented prior to the reintroduction of salmon so as to provide baseline information that is collected in the same manner as data collected post-reintroduction.

Details of some potential initial studies are presented in the Phase 2 document (Bussanich et al. 2022).

4.1 Conceptual Study Design

Environmental data collection in study streams should include water temperature and stream discharge monitoring. Fisheries monitoring could include standardized sampling of Index sites and strategies that are repeatable in subsequent years. Sampling locations can be chosen with an eye towards assisting other objectives as well. This effort could be aided by identifying sites with historic data, current sampling, or are conducive for effectively collecting fish. Timing of movement through dams downstream of Chief Joseph Dam should utilize the existing PIT tag integration infrastructure in place.

4.2 Example Approach

The Slocan River currently has a hydrometric monitoring station which can be used for baseline historical flow data. A rotary screw trap or inclined plane trap could be operated in the lower Slocan River (other gear types may be more appropriate in rivers with greater flow) providing a collection point for resident and out- migrating fish. Catch rates paired with discharge and water temperature provide insight into migration timing. Collection of length and weight data can provide a proxy for fish health over time and paired with tagging could provide insight into survival of differing fish sizes. Collection should occur beyond the time period of expected out-migration in initial years to provide a clear view beyond the tails of the run. Sampling into the summer could provide insight into whether high water temperatures in the Kootenay River are problematic or if they occur after fish have left the system. Directed sampling for larger piscivorous fish could occur in Brilliant Pool with the goal of collecting diet samples to monitor predation in that stretch of the migration.

5 Objective 4 – Estimate sample sizes needed for juvenile survival to Wells Dam and adult survival through Roosevelt Reservoir

The details of some potential initial studies are considered in the Phase 2 document (Bussanich et al. 2022). Survival studies generally take the form of a series of replicated sets of paired release events, where each event includes a set of 'treatment' fish released above the area of interest, and a paired set of 'control' fish released downstream of the area of interest. In the case of survival of juveniles from the rearing location to Wells Dam, the 'treatment' fish would be released at the rearing location, and the 'control' fish would be released downstream of Wells Dam. All fish from both groups would be marked (e.g., PIT or acoustic tags) prior to release. The release of the control fish is delayed, relative to that of the treatment fish, in order that both release groups travel downstream (below the area of interest) simultaneously. Fish from both groups would be tracked as they continue to move downstream together. Since both groups are treated identically in every way – except for the fact that the treatment group had to pass through the area of interest before being tracked, whereas the control group did not – any differences in the survival of the two groups can be attributed to the passage through the area of interest. The sample sizes can be varied in two ways: the number of replicated paired-release events; and the number of fish released in each replicate. The numbers of fish released in the treatment groups tend to be larger than those in control group.

5.1 Example Approach

With the standard survival study design in mind, a power analysis will be conducted which will simulate survival of the treatment and control groups under a suite of assumed conditions, and output minimum samples sizes required to achieve precision goals. For example, sample sizes will need to be larger to achieve more precise survival estimates. The detection probabilities at the downstream tracking arrays will also impact sample sizes (more fish will need to be released if the detection probabilities are lower, as when using PIT tags; whereas fewer fish can be released if the detection probabilities are expected to be higher, as when using acoustic tags). Also, sample sizes will depend on the survival value itself (with fewer study fish needed when the survival approaches 100%). The power analysis will test a range of survival conditions (e.g., survival through area of interest of 25%, 50%, 75%, and 95%) detection probabilities at downstream arrays (e.g., 5%, 25%, 50%, 75%, and 95%) and sample sizes (e.g., treatment group sample sizes of 20, 200, and 2000; control group sample sizes of 15, 150, and 1500; replication ranging from 10, 15, or 20 groups) to estimate the precision of the resulting survival estimates.

The precisions that are outputted from the power analysis will be used to plan the Pilot Study. For example, the tag technology selected may be dictated by the number of study fish that can reasonably be acquired. Or, the precision goals may be tempered by the realities of budgetary limitations.

6 Objective 5 – Upstream survival, migration rates, and habitat selection of adult Chinook Salmon released upstream of Chief Joseph Dam

Tracking of adult Chinook Salmon upstream of Chief Joseph Dam will help formulate a plan for future reintroduction activities and guide where efforts are best utilized. Results from fish released in the lower reaches of Roosevelt Reservoir could point to a limited need to transfer fish further upstream before release, or may show that transfer of fish closer to the United States/Canadian border is necessary to get sufficient adult survival and access to spawning locations in a timely manner. Habitat selection by adult Chinook Salmon can identify which locations may need further study as potentially valuable habitat and show if preferred habitat outside of models is available. Data collected towards this Objective can help to update and refine the PVA while the initial PVA can provide guidance on the sample size needed to investigate this Objective. The details of some potential initial studies are considered in the Phase 2 document (Bussanich et al. 2022).

6.1 Example Approach

Multiple release locations of adult Chinook Salmon can be used to ensure sample sizes are large enough to answer questions of the migration to spawning areas upstream of Chief Joseph Dam. A release near Chief Joseph Dam can provide insight on travel and survival through Roosevelt Reservoir. This study group would consist of fish tagged with CART (Combined Acoustic/Radio Transmitters) tags, which have the capabilities of both tag types, allowing them to be tracked through Roosevelt Reservoir using the acoustic array (an array deployed in theory to monitor the juvenile migration), while also allowing for more detailed radio telemetry tracking in holding and spawning habitat upstream. A second study group, also CART tagged, could be released near the international border. A potential third study group could be released near expected spawning areas in the Columbia River to ensure that some fish are available to help evaluate the spawning potential. Additional adult fish could be released directly into tributary streams and their chosen habitats could be confirmed via radio telemetry or during stream walks.

7 Objective 6 - Factors and requirements that influence adult survival, migration rates and timing

Environmental and fish monitoring data are needed to:

- provide baseline conditions for pre-project and long-term monitoring,
- characterize conditions and variability affecting fish metrics, and
- identify risks associated with the feasibility and performance of various study options and passage alternatives.

Consistently collecting data on environmental conditions can give insight into adult salmon health and behaviour in the short to medium term while also aiding long term planning and forecasting. Ideally monitoring programs should be designed and implemented prior to the reintroduction of salmon so as to provide baseline information that is collected in the same manner as data collected post-reintroduction. The details of some potential initial studies are considered in the Phase 2 document (Bussanich et al. 2022).

7.1 Conceptual Study Design

PIT tagging of juvenile salmon allows for detection of those fish returning as adults as they transit up the Columbia River. PIT tracking infrastructure is operating at all of the hydroelectric projects from Wells Dam downstream. Hydroelectric facilities also provide monitoring for environmental factors such as discharge and water temperature. Upstream of Chief Joseph Dam similar environmental monitoring occurs, although there is limited opportunity to detect PIT tagged fish in either the reservoir or riverine environment. Pairing environmental data with migratory data collected under Objective 6 could help provide a clearer picture of the influence of environmental conditions upstream of Chief Joseph Dam. There is also potential to utilize tags (radio, acoustic, or CART) with sensors that monitor depth, temperature, or predation to give additional insight into the conditions an individual fish is experiencing and how that may be influencing their migration. See Bussanich et al. (2023) for further details.

8 Population Viability Analysis

To help quantify some of the study design elements that are described in the Phase 2 document, a PVA model is being developed. The PVA models key steps in the life cycle of released and naturally produced salmon, with life-history steps including rearing, emigration, ocean survival, return migration, and spawning (Figure 2). Release cohorts will be tracked over time within the PVA with outcomes of survival and key life history decisions determined at multiple points throughout the life cycle. Fish releases in both the Okanagan and SPU can be tracked simultaneously in order to provide a point of reference for success, as well as implications for differences in long-term viability over multiple generations. The PVA also includes an optional natural reproduction component within an SPU so that runs with and without the potential for natural reproduction can be considered.

To build the PVA model, literature reviews (details in the Phase 2 document; Bussanich et al. 2022) were conducted to generate possible values for parameters such as the rate of survival of juvenile fish from the release location to Wells Dam, or the rate of survival of adults through the Roosevelt Reservoir. The background research that was used to populate PVA parameter values will also be used for other quantitative elements in the Phase 2 document, for example, the power analyses associated with Objective 4.

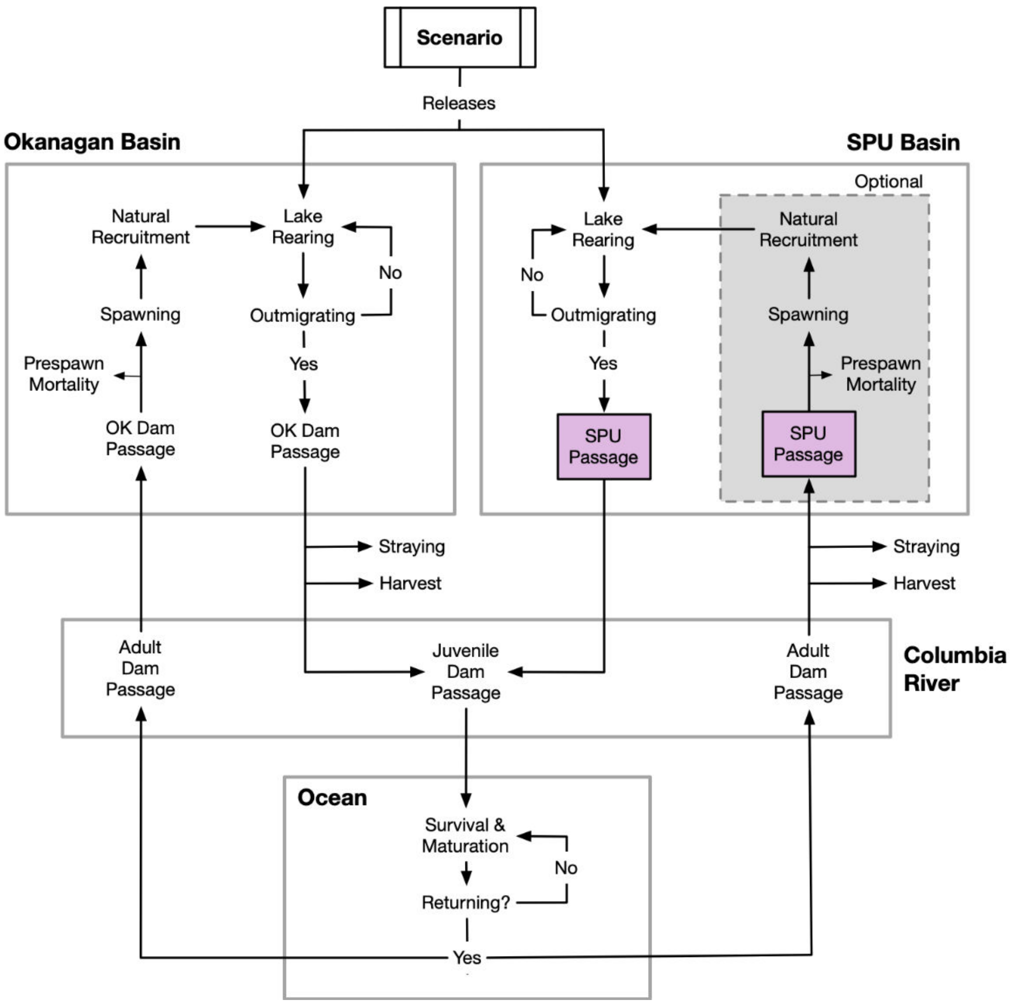

Figure 2. Schematic diagram indicating major life cycle components and decisions under considerations in the PVA.

One of the critical components of the PVA is the ability to formally consider natural variation and uncertainty and its potential impact on performance metrics under consideration. At its heart the PVA is a Monte Carlo computer simulation where the model is rerun multiple times (termed iterations) and life history steps have stochastic elements that can result in randomized outcomes (e.g., dam survival). This provides a mechanism to consider the impact of natural variation on performance metrics or performance thresholds. For example, surpassing a minimum threshold for number of spawners returning to a SPU may be performance metric of interest. By including key stochastic elements in the PVA, natural variability can be modelled and the PVA can provide estimates of how likely a lower threshold may be exceeded under a scenario of natural variation. In addition to natural variation, stochastic components can also be used to represent the impact of unknowns on the success of a reintroduction program. For example, environmental or climate uncertainty or a lack of knowledge in a particular life cycle step can be modelled using stochastic elements. In this context, stochasticity is being used to represent risk in whether or not a reintroduction may be successful. Sensitivity to any of these assumptions can also be tested by comparing runs with and without stochastic elements.

By including natural variation and uncertainty in the model a critical dimension for assessing SPU performance can be provided. For example, one or more SPUs could provide similar results metrics regarding average behaviours (e.g., average number of spawners), but differ in the likelihoods of surpassing a lower threshold (e.g., falling below the minimum threshold) due to either differences in natural variation or uncertainties associated with risk of a reintroduction program failing. In this case the SPUs with more consistent returns would likely rank higher in terms of priorities over an SPU with more variable returns, despite producing similar average returns. Similar to the parameter values used in the PVA, estimates of uncertainty or risk can be derived from biological studies as well as guided by expert opinion (i.e., scientific or TEK) which can provide insight into processes, such as expected year-to-year variation in environmental conditions during migration, that may not yet be available from scientific studies.

8.1 Metrics and Performance Informed by Population Viability Modeling

Measures to determine the Pilot Program success, metrics and performance measures need to be established before its implementation. Metrics and performance measures assist in developing expectations of the *Pilot Program*, and should be: **Specific - Measurable - Accurate - Reliable - Time-limited** (i.e., the time in which the objectives are to be achieved is specified and realistic) **- Scientifically-based and Informed by TEK.**

These metrics and performance measures are tied to the key questions based on the objectives identified by CRSRI. The key questions can then be evaluated based on how much the Pilot Studies can successfully contribute to the overall Pilot Program objective of obtaining sufficient surviving juveniles/smolts per female to contribute to an increasing population. This directly assesses the feasibility of a long-term reintroduction program.

At the end of each year, the Steering Committee can use the metrics to determine the level of success and to decide on the next steps of the Pilot Program or whether to move to the next phase of reintroduction.

9 Fish Collection, Release, and Passage Option Evaluations

The effective collection of fish is an important component of a successful *Pilot Program*. The initial collection of fish, both juvenile and adult, from donor stocks will provide the basis of the reintroduction field studies. Subsequent collection during field studies would permit the monitoring of fish health and growth, migratory timing, and provide fish for passage studies. The transport and passage of collected fish would constitute a large component of any potential long term reintroduction plan. This Phase 1 of the *Pilot Plan* provides general descriptions of fish collection and passage options that may be utilized for the *Pilot Program* while introducing potential longer-term options. More details are provided in the Phase 2 document (Bussanich et al. 2022).

9.1 Collection of Juvenile Salmon and Eggs

In Tables 3 and 4, we present a number of potential options for obtaining juvenile salmon with an understanding that every application of each gear type has strengths and weaknesses. Rotary screw traps, weirs, and electrofishing would all potentially capture target fish in tributary environments. Seine nets could be used to capture juvenile fish in larger riverine and reservoir settings although they are limited in how much of a body of water they can sample. Minnow traps can be used in a variety of habitats but have a lesser quantity of fish they can capture. Key constraints in the early parts of the program are going to be the scale of the study area and the capture efficiency of the sampling gears. There will be a relatively small number of fish of interest and large habitats from which to potentially sample. Indeed, some sampling methods are likely to be inviable as they would require unreasonable levels of effort to detect sufficient numbers of study fish.

Table 3. Advantages and risks of different methods for collecting juvenile salmon from donor populations.

Collection Method	Advantages	Risks	Mortality Risk
Seine	Samples large area in short time High catch rate for some size/age classes Effective in relatively shallow water	Damaged by debris Requires smooth substrate Low catch rates for other size/age classes	Low
Rotary screw traps	Reliable when properly deployed Common on salmon rivers Can continuously sample	High maintenance (monitored frequently) Expensive to build Challenging to use in high flows	Low
Minnow trap & Fyke net	Effective in most habitats (high debris) Low maintenance and cost Passively samples No permanent deployment	Low catch rates May require regular maintenance	Low
Electrofishing	High catch rate Samples diverse habitats No permanent deployment	Potential injury to fish (Snyder 2003) or modification of behaviour Safety hazard No continuous sampling	Moderate/High
Trawl	Samples large area in short time Higher catchability for different size/age classes	Constrained to deeper water Requires boat High cost and labor	Moderate/High
Salvage	Opportunistic Ease of capture Can continuously sample	Genetic uncertainty of stock Impacts to populations Low catch rates	Low
Hatchery	Ease of capture	Reduced fitness	Low

Table 4. Summary of preferred juvenile and egg collection methods.

Collection Method	Mortality Risk	Ease of Collection	Genetic Diversity
Seine	Low	High catch rate Effective in relatively shallow water	Can collect a few individuals from multiple locations Samples large area in short time
Minnow trap & Fyke net	Low	Effective in most habitats (high debris) Low catch rates	Can collect a few individuals from multiple locations
Rotary screw traps	Low	Reliable when properly deployed Common on salmon rivers High maintenance Must be monitored regularly	High likelihood of collecting siblings Continuous sampling
Obtain incubating eggs from in-river	Low/Moderate	Does not remove spawners from population	Most abundant life stage Multiple crosses can be collected Several spawning areas can be targeted for collection Can collect a few individuals from each redd
Electroshocking	Moderate/High	High catch rate No permanent deployment Safety hazard	Samples diverse habitats Can collect a few individuals from each habitat No continuous sampling
Adult egg takes in the wild-active spawners	Moderate/High	Requires coordination among field biologists, spawning crew, and hatchery personnel Difficult to target specific ripe fish Stresses non-target fish	Collect from known parents Collected individuals will be full siblings

9.2 Collection of Adult Salmon

There are several collection methods for adult salmon migrating upstream. Adults may voluntarily return to a hatchery at which point they can be loaded for transport upriver. Or, seining can be used to collect adults in areas or populations away from hatchery collection facilities. Other potential collection methods could involve angling and capture from fish ladder facilities at Columbia River dams in the US. Consideration for the goals of the captured fish, as well as the handling and potential husbandry involved, should be given when deciding whether to target pre-spawn or spawning adult salmon.

9.3 Release and Reintroduction of Study Fish

At each life stage that may be considered for reintroduction efforts there are a number of options as to how to release fish and the benefits and risks involved. In Tables 5 to 7 we provide overviews of options for releases involving eggs, juveniles, and adults, and Table 8 presents an overview of the various options.

Table 5. Pros and cons of egg reintroduction methods.

Introduction Method	Pros	Cons	Mortality Risk
Use eggs to eventually develop captive broodstock	Only requires take from individuals from donor population for three years	Requires larger hatchery facility to maintain a captive broodstock Limited sampling of donor populations could lead to fairly rapid inbreeding of captive broodstock	High
Streamside Incubators	Allows for experimental incubation using water from different areas of the river Opportunities for public outreach	Subject to tampering/vandalism Potential water temperature concerns Requires instream water intake to be maintained	High/Medium
Instream incubator box	Newly fertilized or eyed eggs can be used Sedimentation is limited Egg survival can be determined	Requires handling eggs in the outside environment when air temperature can be high	Medium
Egg planting	Allows for natural in-river incubation to occur Allows for evaluation of in-river egg to fry survival	Requires handling eggs in the outside environment when air temperature can be high	Low/Medium

Table 6. Pros and cons of juvenile reintroduction methods.

Methods	Pros	Cons
Direct Releases (Donor)	Reduced holding period Mimic natural timing	Logistically challenging Reduced release densities impact survival No time for imprinting
Direct Releases (Captive Reared)	Can grow to large size More control over release location/timing	Reduced Fitness Risk of cohort failure Risk of residualization
Holding Pens (Donor)	Allows time for imprinting and acclimation Allows for larger release groups to alleviate predation impacts	Increased exposure to vandalism Increased holding time/stress Increased risk of disease
Holding Pens (Captive)	More control over release location/timing Can be used for experimental purposes	No need for imprinting. Added expense with little benefit Increased risk of disease

Table 7. Pros and cons to adult reintroduction methods.

Methods	Pros	Cons
Holding Prespawn Adults	Fish are robust and healthy Allows acclimation to local conditions	Handling stress Risk of poaching Prespawn mortality
Spawning Adults		High risk of handling stress Prespawn mortality Premature loss of eggs/milt

Table 8. Pros and cons of reintroduction methods by life stage.

Life History Stage	Pros	Cons
Captive Broodstock (all stages)	Can control the relatedness of source stocks to achieve genetic goals Lower number of source populations needed to produce large numbers of individuals for reintroduction	Reduced fitness from hatchery practices
Eggs	Can collect from various sources All local selection pressure (none from natal watershed) High relatedness	Collection methods may damage donor redd integrity Typically low survival of egg-juvenile stage Methods relatively untested for release to river
Juveniles	Higher survival than eggs Potential for controlled experimental releases More tolerant to thermal stress Can be marked/tagged (CWT and PBT) prior to release Less likely to be sibling Less potential for holding mortality than adults	No information on egg survival gained Less imprinting opportunity than eggs Greater impact on donor stock population than the same number of eggs
Adults	Can accommodate natural spawning pairs All selection on gametes occurs in the Columbia River basin	High potential to holding/handling stress Large impact to donor population

9.4 Downstream Passage

For the *Pilot Program* juvenile fish may be transported downstream via truck or, if they are not collected, may attempt to migrate downstream using spill and turbine pathways to pass dams. Initial studies can be used to more clearly define the necessity for dedicated juvenile collection efforts at the various dams associated with the study.

9.4.1 Collection

There are a number of potential methods available to collect out-migrating juvenile salmon during the Pilot Program, although they are primarily small in scale. Rotary screw traps, weirs, and electrofishing are all used to capture juvenile salmon in stream environments. Seine nets could be used to capture juvenile fish in larger riverine and reservoir settings although they are limited in how much of a body of water they can sample. There may also be potential to utilize a small floating surface collector in the reservoir near the damface. When deciding among potential streams for initial reintroductions, attention should be paid to the ability to effectively collect juvenile fish from those locations.

In the long term there may be potential to utilize floating surface collectors on a larger scale or construct juvenile bypass pipes around certain dams.

9.5 Upstream Passage

For the Pilot Program adult salmon migrating upstream will be trucked around dams for release near potential spawning habitats or in locations where their migratory habitats can be studied to meet Program Objectives. In the future there may be additional options for passage at dams including Whooshh.

9.5.1 Collection

There are two collection methods for adult salmon migrating upstream. Adults may voluntarily return to a hatchery at which point they can be loaded for transport upriver. Additionally, seining can be used to collect adults in areas or populations away from hatchery collection facilities. Other potential collection methods could involve angling and capture from fish ladder facilities at Columbia River dams in the US.

10 Marking and Tagging Options

Marking and tagging of both juvenile and adult study fish will be an important component of the study. It is likely that different Objectives will require the use of different tags or marks to provide satisfactory results. Below we highlight some of the options available, their strengths and weaknesses, and possible uses for them within the Pilot Program.

10.1 Juvenile Marking

10.1.1 PIT

PIT tagging allows for the marking of fish, down to a small size, with a unique identifier that will operate for the life of the fish. Existing PIT detection infrastructure occurs throughout the Columbia River basin as does an integrated database for detections (PTAGIS). PIT tags allow for the in-field identification of individual fish and but can have relatively small detection ranges, depending on the tag type and physical environment. PIT tagging has been used with ceremonial releases of fish in Roosevelt Reservoir to provide some preliminary information on the outmigration timing of juvenile salmon.

10.1.2 Adipose Fin Clip

Adipose fin clipping can be used to mark large numbers of fish at a relatively low cost. Fin clips cannot be used to identify individual fish and for the purposes of this study could be best employed to identify juvenile fish of hatchery origin in a stream that may also have wild offspring as the result of outplanted adults. This method would require coordination with other programs that reply on adipose clips. Clipping is currently being done by some hatcheries, and could otherwise be an add-on to current operations. Detection of fin-clipped fish requires the capture and handling of the fish though a wide variety of means can be used to accomplish that.

10.1.3 Fin Clip (non-adipose)

Additional fin clipping can be done in field to support trap efficiency and mark-recapture calculations in tributaries. These efforts are low cost but have potential to lower the fish's fitness over the long term. Fin punches can also be used and may be more less harmful than the removal of a large portion of a fin.

10.1.4 Acoustic Tags

Acoustic tags are among the most expensive options for tagging study fish. Tags must be implanted surgically by a trained biologist and an array of detection equipment must be deployed and maintained to monitor the tagged fish. Acoustic tags battery life is finite, though it can be increased by transmitting less often (which impacts detectability) or by using larger tags (which may not be suitable for smaller size classes of fish given that we usually limit the size of the tag to about 2-5% of the total fish body weight). Benefits of using acoustic tags include a large detection range which lowers the sample sizes required for studies and does not require the recapture of study fish. Acoustic tags are best utilized in survival and migration studies where movements of individual fish between detection sites can be compared to environmental conditions at those times and locations. Acoustic tags can be paired with PIT tags in large enough fish to gain the benefit of existing PIT detection infrastructure throughout the Columbia River.

10.1.5 Coded Wire Tags

Coded wire tags can be used to mark large numbers of fish at relatively low cost. While equipment can be used to detect if a fish is carrying a coded wire tag, the recovery and reading of the tag can only occur after the fish has died. For this study a potential use would be the tagging of study fish as juveniles and then utilizing the presence of a coded wire tag to identify those fish as Upper Columbia origin when they return as adults, assuming other salmon are not being coded wire tagged near adult collection locations.

10.1.6 Thermal Marking

Thermal marking can be done to mark juvenile fish at hatcheries. Water temperatures can be raised and lowered for a set period of time to form an identifiable growth pattern on each fish's otoliths. Recovery and identification of this type of mark can only be done after a fish has died and its otoliths are recovered.

10.1.7 Parentage Based Tagging (PBT)

PBT is a large- scale, non-lethal tagging method for monitoring and evaluating salmonid hatchery stocks (Steele et al. 2013). Fin tissues are collected from all hatchery brood stock, which makes any progeny from that brood identifiable using genotyping. None of the juveniles in the hatchery need to be handled prior to release. To detect the marks, there are no issues with tag loss or tag detection, and 'detection' of the mark requires only a non-lethal tissue sample. The method is not good if marks need to be read *in situ*, but will accurately identify the broodstock from which a fish was reared.

10.2 Adult Marking

10.2.1 Acoustic Tags

Acoustic tags are among the most expensive tag options available. An array of detection equipment must be deployed and maintained to monitor the tagged fish. Acoustic tags have a finite battery life, and the smallest tags (designed for smaller size classes of fish) may not last long enough to be suitable in all study applications. Benefits of using acoustic tags include a large detection range which lowers the sample sizes required for studies and does not require the recapture of study fish. Acoustic tags are best utilized in survival and migration studies where movements of individual fish between detection sites can be compared to environmental conditions at those times and locations. Relative to radio tags, acoustic tags are better suited for detecting fish in deep water or in locations far from shore where radio telemetry stations may be located. Acoustic tags can be configured to include sensors for environmental conditions such as acceleration, depth and temperature.

10.2.2 Radio Tags

Radio tags can be tracked from shore-based fixed stations as well as mobile tracking platforms such as boats, aircraft, automobiles, or stream walks. Relative to acoustic tags, radio tags offer more potential to define a fish's location especially in smaller streams where acoustic equipment has limited range. Radio tags can be utilized in studies concerning proportional spawning tributary selection and identification of spawning areas. In most habitats radio tags have a large detection range but deep water can make tracking of radio tags ineffective relative to acoustic tags. Radio tags can be configured to include sensors for environmental conditions such as depth and temperature.

10.2.3 CART

CART tags are Combined Acoustic/Radio Transmitters which have the capabilities of both tag types. The benefit to this type of tag is it can be tracked in deep water locations with acoustic monitoring equipment as well as shallow tributary locations with radio telemetry equipment. This combination allows for a more complete picture of a fish's movements than either gear type alone. For this study CART tags would be helpful in locations where fish could potentially be moving from deep reservoir or Columbia River locations into shallow spawning areas on gravel bars or in tributaries. CART tags can be configured to include sensors for environmental conditions such as depth and temperature.

10.2.4 PIT - Passive Integrated Transponder

PIT tagging allows for the marking of fish with a unique identifier that will operate for the life of the fish. Existing PIT interrogation infrastructure occurs throughout the Columbia River basin as does an integrated database for detections (PTAGIS). PIT tags allow for the in-field identification of individual fish and have a small detection range that allows for unmanned detection arrays in some types of locations. These tags can be utilized on their own or used along with other types of tags.

10.2.5 Floy/External

Floy/External tags can be used in situations where adult fish may be observed or handled by members of the public. A unique number on the tag as well as contact information allows information on the distribution of fish to be reported with minimal cost and directed effort from the study beyond the initial transport and tagging. As an added value it provides an opportunity for the public to be involved in the study. The disadvantage is the injury caused to the fish when applying the tags (they are usually lodged in the flesh).

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12 Appendix A – Annotated Bibliography

Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Annotated Bibliography

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Citation: Gieboff, T. and R. Bussanich. 2023. ***Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Annotated Bibliography.*** *pp. 42 – 68 in R. Bussanich, D. Robichaud, S. Crawford, W. Challenger, M. Zimmer, and N. Johnson,* ***Phase 1. Plan for Experimental Reintroduction of Anadromous Salmon into Upper Columbia River: Proposed Implementation, Monitoring, and Evaluation.*** *Report for* Columbia River Salmon Reintroduction Initiative*, BC*.

Table of Contents

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