Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) – Year 2

Project No. 2003-036-00

Annual Report for FY 2005

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Submitted to

Tracy Yerxa
KEWB-4
Bonneville Power Administration
P. O. Box 3621
Portland, OR 97208-3621

Compiled by

Marc Porter, David R. Marmorek and Ian J. Parnell,
ESSA Technologies Ltd.
1765 West 8th Avenue, Suite 300
Vancouver, BC V6J 5C6 Canada

On behalf of the

Columbia Basin Fish and Wildlife Authority
851 SW Sixth Avenue, Suite 260
Portland, OR 97204

November 21, 2005

Contributors:

Chris Beasley (QC-NP)
Bill Bosch (YN)
Rick Carmichael (ODFW)
Evan Brown (IDFG)
Dave Fast (YN)
Stuart Ellis (CRITFC)
Jay Hesse (NP)
Annette Hoffman (WDFW)
Steve Katz (NOAA)
Phil Larsen (EPA)
Dave Marmorek (ESSA)
Dick OConnor (WDFW)
Charlie Petrosky (IDFG)
Marc Porter (ESSA)
Tom Rien (ODFW)
Kris Ryding (WDFW)
Sam Sharr (IDFG)
Chris Toole (NOAA)
Earl Weber (CRITFC)
Keith Wolf (KWA-Colville)
Tom Berggren (FPC)
Nick Bouwes (EcoLogical)
Cedric Cooney (ODFW)
Tim Copeland (IDFG)
Jeff Fryer (CRITFC)
Peter Galbraith (CRITFC)
Peter Hahn (WDFW)
Chris Jordan (NOAA)
Katheryn Kostow (ODFW)
Claire McGrath (IDFG)
Ian Parnell (ESSA)
Charlie Paulsen (PES-BPA)
Darcy Pickard (ESSA)
Craig Rabe (NP)
Phil Roger (CRITFC)
Bruce Schmidt (StreamNet)
Eric Tinus (ODFW)
Paul Wagner (KWA-Colville)
Paul Wilson (USFWS)
Frank Young (CBFWA)

Citation: **M. Porter, D.R. Marmorek and I.J. Parnell.** 2005. Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) – Year 2, Project No. 2003-036-00, Annual Report for FY 2005. Prepared by ESSA Technologies Ltd., Vancouver, B.C. on behalf of the Columbia Basin Fish and Wildlife Authority, Portland, OR. 18 pp. + appendices.

Executive Summary

The Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) is a coordinated effort to improve the quality, consistency, and focus of fish population and habitat data to answer key monitoring and evaluation questions relevant to major decisions in the Columbia Basin. CSMEP was initiated in 2003 and is chaired by the Columbia Basin Fish and Wildlife Authority (CBFWA), with the participation of several federal, state and tribal fish and wildlife agencies[1]. CSMEP is a major commitment of the Council towards regionally integrated M &E across the Columbia Basin, and is a critical element of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP). CSMEP's specific goals are to: 1) interact with federal, state and tribal programmatic and technical entities responsible for monitoring and evaluation of fish and wildlife, to ensure that work plans developed and executed under this project are well integrated with ongoing work by these entities, 2) document, integrate, and make available existing monitoring data on listed salmon, steelhead, bull trout and other fish species of concern, 3) critically assess strengths and weaknesses of these data for answering key monitoring questions, and 4) collaboratively design and implement improved monitoring and evaluation methods with other programmatic entities in the Pacific Northwest to fill information gaps and provide better input to key decisions in the Columbia Basin.

Progress in FY05

During FY2005 CSMEP made considerable progress on its inventory and assessment goals. CSMEP and StreamNet jointly completed inventories of fish data for the first set of selected pilot subbasins in Washington (Lewis and Yakima), Oregon (Imnaha and Lower Columbia) and Idaho (Clearwater – Selway; Salmon – South Fork Salmon River), as well as for a second set of selected subbasins (Washington - Okanagan, Methow, Kalama; Oregon – Deschutes, Grande Ronde; Idaho – Upper Fork Salmon, Middle Fork Salmon). CSMEP biologists continued with their reviews of the strengths and weaknesses of these subbasin data for addressing a structured set of monitoring questions about fish population status and trends at different spatial and temporal scales. The CSMEP web database developed in FY04 to store inventory metadata in a readily accessible format and location was further developed and populated with metadata from the pilot watersheds. The public website developed in FY04 for communication and coordination amongst CSMEP members and interested parties was restructured for greater ease of use.

Significant progress was also made on CSMEP's goals of collaborative design of improved M&E methods. Three multi-agency monitoring design workshops were held to explore how best to integrate the most robust features of existing monitoring programs with new approaches (e.g., Federal RME pilot studies, EPA EMAP). CSMEP began to build on this information and develop general 'design templates' for monitoring the status and trends of fish populations and the effectiveness of habitat, harvest, hatchery and hydrosystem recovery actions within the Columbia River Basin. As a pilot exercise, information from the CSMEP metadata inventories as well as from ongoing regional RME studies were used to develop design templates at the spatial scale of the Snake Basin ESUs. CSMEP's work on the Snake Basin pilot has fed into the NOAA-F /BPA Salmon River Basin pilot study, as well as the Lemhi Basin HCP. The draft design templates were discussed at the July 2005 CSMEP workshop with a subset of regional policy

[1] **Agencies**: NOAA Fisheries, US Fish and Wildlife Service (USFWS), Columbia Fish and Wildlife Authority (CBFWA), Columbia River Intertribal Fish Council (CRITFC), Bonneville Power Administration (BPA), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), Idaho Department of Fish and Game (IDGF), Fish Passage Center (FPC), StreamNet, Nez Perce Tribe, Confederated Tribes of the Colville Reservation, Yakama Indian Nation

Consultants: ESSA Technologies Ltd. (Facilitators), Eco Logical Research, Quantitative Consultants, Paulsen Environmental Research, KWA Ecological Sciences staff for initial feedback on whether the designs will be appropriate for addressing the information needs of decision-makers. Further information on CSMEP metadata inventories, strengths and weaknesses assessments and monitoring design products for FY05 are presented in the main text of this Annual Report and its appendices as well as on the CSMEP public website (www.cbfwa.org/Committees/CSMEP).

Plan for FY06

During FY2006, CSMEP will first complete an integrated M&E design for the Snake Basin, evaluating the multiple tradeoffs associated with different M&E designs. We will then build on lessons learned from the Snake River pilot exercise to develop general M&E 'design templates' for application to other parts of the Columbia River Basin. CSMEP will also identify situations where general "design templates" are not appropriate, and instead develop the consistent "design processes" that will lead to better monitoring designs (e.g., for watershed specific evaluations of habitat restoration action effectiveness). CSMEP will continue the metadata inventory process and strength and weaknesses assessments for additional subbasins in the Columbia Basin and use these results to help test the applicability of monitoring design templates and processes developed from the Snake Basin pilot. CSMEP design templates will be presented at relevant forums to decision-making entities for continuing feedback on whether they address regional information needs. CSMEP will increase its integration with PNAMP and other regional RME bodies to ensure that CSMEP analytical expertise is most efficiently utilized within the broader context of Columbia Basin monitoring programs.

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1. Introduction

The Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) is a collaborative effort led by the Columbia Basin Fish and Wildlife Authority (CBFWA). The project is co-sponsored by NOAA Fisheries (NOAAF), the U.S. Fish and Wildlife Service (USFWS), three state fish agencies (WDFW, ODFW, IDFG), StreamNet, the Fish Passage Center (FPC), the Columbia River Inter-Tribal Fish Commission (CRITFC; Nez Perce, Yakima, Umatilla, Warm Springs Tribes) and the Confederated Tribes of the Colville Reservation. It also involves other Columbia Basin entities, such as the Northwest Power and Conservation Council (NPCC). Close interaction occurs with the Pacific Northwest Aquatic Monitoring Partnership (PNAMP).

This three-year project focuses on the issue of systemwide monitoring and evaluation of fish status, addressing requirements of NMFS and USFWS Biological Opinions and Recovery Plans as well as the NPCC Fish and Wildlife Program. It involves an integrated, collaborative effort by fisheries scientists and biometricians to fulfill seven objectives:

1. *Interact with federal, state and tribal programmatic and technical entities* responsible for monitoring and evaluation of fish and wildlife, to ensure that quarterly work plans developed and executed under this project are well integrated with ongoing work by these entities.
2. *Collaboratively inventory existing monitoring data* that bear on the problem of evaluating the status and trend of salmon, steelhead, bull trout and other species of regional importance across the U.S. portion of the Columbia Basin, and for selected parts of the Columbia Basin in Canada which affect the status of key fish stocks in the U.S. Columbia Basin (e.g. Okanagan sockeye).
3. *Work with existing entities (e.g. StreamNet, NOAA Fisheries, NPCC) to make a subset of existing monitoring data available through the Internet*, recognizing the continuing evolution of data management in the Columbia Basin.
4. *Critically assess the strengths and weaknesses* of existing monitoring data and associated evaluation methods for answering key questions at various spatial scales concerning the state of ecosystems and fish habitat, as well as fish distributions, stock status and responses to management actions.
5. *Collaboratively design* improved monitoring and evaluation methods that will fill information gaps and provide better answers to these questions in the future, by providing state and tribal fish agency participation and work products for multi-agency development of regionally coordinated monitoring programs.
6. Coordinate state and tribal participation and work products for regionally coordinated, multi-agency *implementation* of pilot projects or large scale monitoring programs.
7. *Participate in regional forums* to evaluate new monitoring program results, assess new ability to answer key questions, propose revisions to monitoring approaches, and coordinate proposed changes with regional monitoring programs.

Since project initiation in October 2003, CSMEP participants have collaboratively developed work plans in close consultation with other programmatic and technical entities (Objective 1). For Objective 2 (data inventory), CSMEP began with a set of 16 specific monitoring and evaluation questions adapted from Jordan et al. (2002), and a set of 45 performance measures for viable salmonid populations, adapted from McElhany et al. (2000). This original set of questions has been expanded by CSMEP workgroups to more comprehensively cover the key M & E questions perceived of relevance to decision makers in Columbia fish and wildlife agencies (Appendix A). To evaluate the range of data quality that exists within the

Columbia Basin, CSMEP selected pilot subbasins that included both data rich and data poor areas. For each of these pilot subbasins, StreamNet staff and CSMEP biologists jointly completed an inventory of the information available for each of the key performance measures for each of the target fish species. An Internet-based database (Objective 3) has been developed by StreamNet and allows access to the metadata recorded from these CSMEP inventories. For Objective 4, CSMEP biologists reviewed the strengths and weaknesses of these data for addressing Tier 2 status and trend questions, and considered opportunities for using these data to answer Tier 3 action effectiveness questions (see Appendix A for definition of tiers). CSMEP workshops have provided continuing opportunities for biologists and biometricians from across the region to meet and discuss recent advances in M&E approaches (e.g. EMAP sampling frames, results from pilot projects, IMW strategies). CSMEP thus represents a unique forum for the cross-fertilization of M&E ideas among federal, state and tribal fish agency staff (Objective 7). Ideas expressed at these workshops are being incorporated into the developing CSMEP M&E designs.

CSMEP has made considerable progress in FY05 in the creation and evaluation of monitoring designs (Objective 5). CSMEP design work is intended to fulfill the following overall objectives:

- Collaboratively develop Tier 1, 2 and 3 designs in an integrated, cohesive manner to ensure that experimental designs and monitoring protocols integrate across tiers, spatial hierarchy levels and life cycles in a cost-effective manner, to address the information needs of decision makers.
- Apply the EPA's Data Quality Objectives process to work systematically from decisions to M&E designs
- Consider multiple objectives, observation error, natural spatial and temporal variability, future trends, and types of analytical methods to estimate parameters of interest, building upon existing work of the FCRPS RME Plan and other regional federal, state and tribal M&E efforts to date.
- Review existing pilot studies' design, and assess their applicability to other regions.
- Evaluate the success of existing pilot projects as results become available.
- Recommend the most cost effective M&E designs within available budget constraints for each sub-basin with well integrated M & E methods.

The conceptual approach for the collaborative design and evaluation process is captured in Figure 1.1. The specific work tasks and products associated with these objectives through FY05 and FY06 are to:

- Develop a draft design template and the general structure of a decision analysis to guide the evaluation of monitoring designs appropriate for different performance measures at various spatial and temporal scales (this report).
- Review and revise the design process, design template and evaluative framework.
- Adapt / build tools and perform quantitative evaluations of alternative monitoring designs, taking into consideration their statistical and cost properties.
- Present a preliminary evaluation of alternative monitoring designs for the Snake Basin to client agencies and reviewers.
- Test preferred options against the second set of pilot subbasins inventoried and evaluated by StreamNet and CSMEP staff.
- Revise the M&E designs and present the revised plans to clients and reviewers.

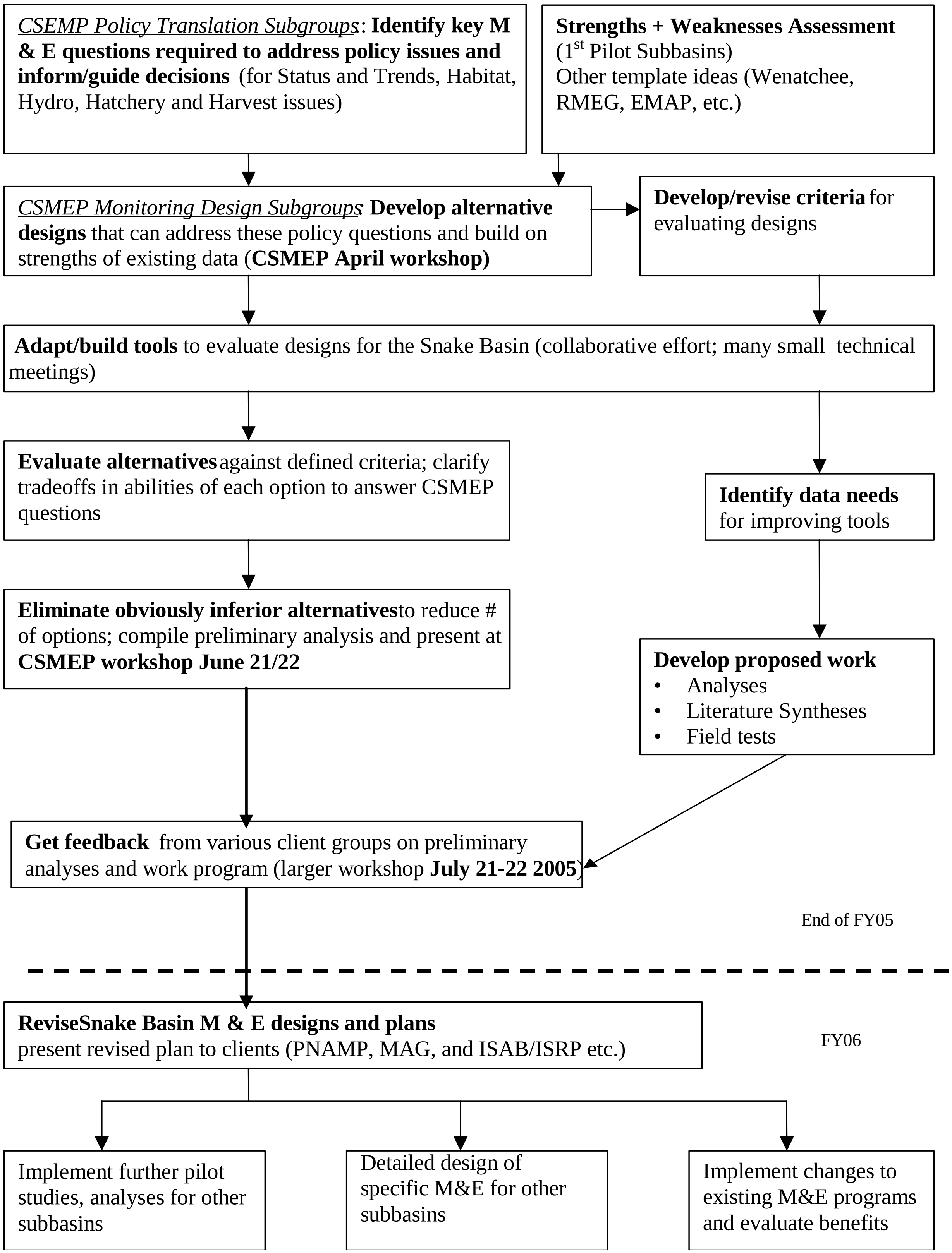


Figure 1.1. Process for CSMEP development of basin-wide M & E designs - FY 2005/2006.

2. Summary of Progress in FY05

2.1 Design and Evaluation

Three multi-agency monitoring design workshops were undertaken in FY2005 to further explore how best to integrate the strengths of existing monitoring, together with novel approaches that help to deal with their weaknesses. For example, one could use the strengths of the existing monitoring infrastructure (dams, weirs, rotary screw traps, etc.) and blend this with EMAP sampling designs for other areas not sampled by this infrastructure. CSMEP is exploring the ability of these approaches to answer the questions in Appendix A, and is attempting to lay out a structured approach to evaluating the costs, benefits and tradeoffs of different M&E strategies. The CSMEP design process is outlined in the Proposed Evaluation and Design of Preliminary Design Templates (Parnell et al. 2005) document available on the CSMEP website. As a pilot example of this design process CSMEP has focused their efforts to date principally on the Snake River Basin spring/summer chinook ESU; this pilot exercise is however intended to illustrate the steps that will be required for development of an integrated monitoring program across the Columbia Basin.

2.2 Data Quality Objectives (DQO) Design Process

CSMEP has been using the 7-step EPA Data Quality Objectives (DQO) process to rigorously connect policy decisions and the M&E designs that provide the input for these decisions (Table 2.1). The DQO process forces rigour: clarification of the critical management decisions to be made in the Columbia Basin, the alternative evaluation approaches to those decisions, the performance measures required to feed those evaluation approaches, and the sampling options available to generate data for the key performance measures. In FY05, five CSMEP subgroups (Status and Trends, Habitat, Harvest, Hydro and Hatcheries) have been applying the DQO process to develop a set of robust M&E designs for evaluating both the status and trends of fish populations and the effectiveness of habitat, harvest, hatchery and hydrosystem recovery actions. That is, what are the M&E alternatives for answering the questions laid out in Appendix A, how well can each option answer those questions, and at what cost? What are the risks of not answering certain questions well? The draft results of steps 1-5 of the DQO process for the spring/summer chinook ESU pilot exercise for each CSMEP subgroup are available on the CSMEP website (Marmorek et al. 2005). Participants in each of these CSMEP subgroups are listed in Table 2.2.

Major advances in M&E design (steps 6 & 7 of the DQO process) were made at a recent workshop in April 2005, held in Nampa ID. The preliminary M&E alternatives developed for the Snake Basin pilot were subsequently presented to a subset of fish and wildlife managers for feedback at a July 2005 workshop attended by both CBFWA and PNAMP representatives. Obtaining additional feedback from regional policy representatives is a current focus of CSMEP efforts. The preliminary M&E alternatives for the Snake Basin will subsequently be revised based on the feedback from managers. In FY06, CSMEP intends to work with PNAMP partners to expand our pilot DQO design efforts and develop integrated M&E guidance applicable to other subbasins, both within the Columbia Basin and potentially to other areas served by PNAMP.

Table 2.1. EPA Data Quality Objectives process for developing monitoring and evaluation designs. (Source: **United States Environmental Protection Agency**. 2000. Guidance for the Data Quality Objectives Process. EPA QA/G-4. www.epa.gov/swerust1/cat/epaqag4.pdf

1. State the problem
2. Identify the decision
3. Identify inputs to the decision
4. Define the study boundaries
5. Develop an "if-then" decision rule
6. Specify limits on decision errors (both directions)
7. Optimize the design for obtaining data

Table 2.2. Participants in each of the CSMEP design subgroups. Individuals with bold italicized names are the designated subgroup leaders.

I) **Status and Trends** of Listed Species/Stocks for Extinction Risks and Recovery Evaluations: ***Chris Jordan (NOAA), Sam Sharr (IDFG),*** Claire McGrath (IDFG), Frank Young (CBFWA), Charlie Petrosky (IDFG), Paul Wilson (USFWS), Jay Hesse (NP), Chris Beasley (NP-Quantitative Consultants), Eric Tinus (ODFW), Peter Hahn (WDFW), Jay Hesse (NP), Paul Wilson (USFWS), Charlie Paulsen (Paulsen Environmental Research), Nick Bouwes (Eco Logical Research), Dave Marmorek (ESSA), Marc Porter (ESSA), Darcy Pickard (ESSA)
II) Effects of **Habitat** Restoration Actions: ***Steve Katz (NOAA), Keith Wolf (KWA-Colville.),*** Chris Beasley (NP-Quantitative Consultants), Charlie Paulsen (Paulsen Environmental Research), Tim Copeland (IDFG), Nick Bouwes (Eco Logical Research), Ian Parnell (ESSA), Marc Porter (ESSA)
III) Effects of **Hydrosystem** Operations: ***Charlie Petrosky (IDFG), Earl Weber (CRITFC),*** Chris Toole (NOAA), Paul Wilson (USFWS), Charlie Paulsen (Paulsen Environmental Research), Nick Bouwes (Eco Logical Research), Tom Berggren (FPC), David Marmorek (ESSA),
IV) Effects of **Hatchery** Operations: ***Rich Carmichael (ODFW), Chris Beasley (NP-Quantitative Consultants),*** Craig Rabe (NP), Peter Galbraith (CRITFC), Dave Fast (YN), Bill Bosch (YN), Jay Hesse (NP), Katheryn Kostow (ODFW), Marc Porter (ESSA),
V) Effects of **Harvest** Management Decisions ***Annette Hoffman (WDFW), Tom Rien (ODFW),*** Eric Tinus (ODFW), Jeff Fryer (CRITFC), Sam Sharr (IDFG), Stuart Ellis (CRITFC), Ian Parnell (ESSA)

2.3 Status and Trends

CSMEP's Status and Trends subgroup has focused its DQO efforts on identifying monitoring design elements necessary to adequately address one of the most important management decisions in the Snake Basin: has there been sufficient improvement in population status of a listed Snake River S/S Chinook ESU to justify delisting and allow removal of ESA restrictions? This decision is based on the abundance, productivity and spatial structure & diversity of SRSS chinook salmon over the prior 10 years (IC-TRT 2005). Appendix B provides the subgroup's summary of the design elements (DQO steps 1-7) for Status and Trends monitoring that are required to answer this question. A full description of the S & T's subgroup's work on DQO steps 1-5 for the Snake pilot is presented as a chapter in Marmorek et al. 2005. A brief PowerPoint presentation describing the Status and Trends group's DQO steps 1-5 is also provided on the CSMEP website.

In FY05 as part of its work on DQO steps 6 and 7, the S &T subgroup began development of a simulation model that can be used for evaluating alternative designs for monitoring fish at the population, major population group and ESU scales; this tool will be further refined in FY06. These design alternatives are intended to describe: 1) the location and temporal pattern of measurements ("sampling design"); 2) the specific types of measurements that are to be made ("response design"); and 3) the analyses to be performed to make a decision ("evaluation design"). Alternative design templates will be compared in terms of cost ($/yr) and probability of error in decisions that are associated with individual templates. The immediate objective of this tool is to evaluate alternative design templates for determining the status of SRSS Chinook salmon. The ultimate objective is to develop a tool that can be adapted for monitoring designs in other basins and for other species. A draft document outlining the subgroup's DQO steps 6-7 modeling approach is provided on the CSMEP website, as is a preliminary version of the alternative design spreadsheet that will feed this model. PowerPoint presentations on the subgroup's approach to DQO steps 6-7 (Presentation1, Presentation2) are provided on the CSMEP website.

2.4 Hydrosystem

The existence and operation of the Federal Columbia River Power System (FCRPS) is one of the more important anthropogenic factors influencing mainstem survival of listed and proposed ESUs. Decisions on FCRPS actions can directly or indirectly affect survival of these stocks. Monitoring of the expected and actual effectiveness of these actions (e.g. juvenile collection, bypass, and transportation; water management; offsite mitigation) is essential for reliable decisions (Figure 2-1).

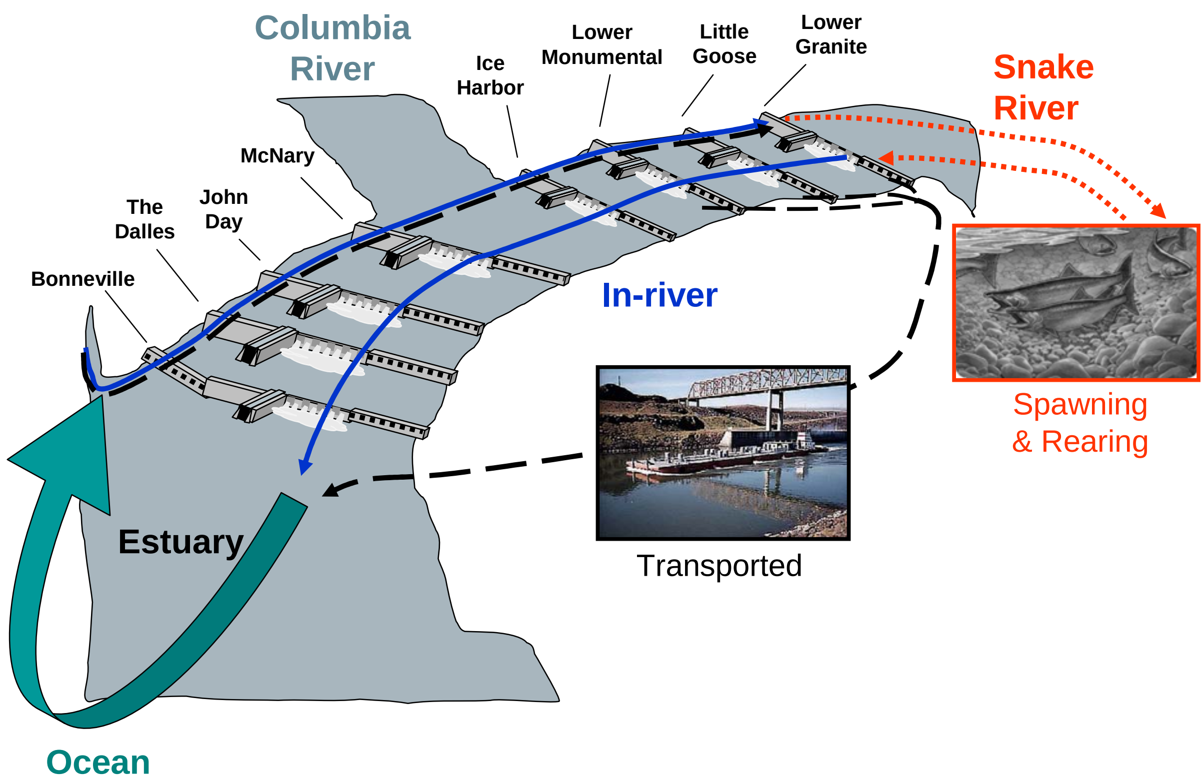


Figure 2.1 Illustration of the different scales of interest for monitoring the effects of the hydrosystem on salmon survival rates: survival at individual projects, survival by different passage routes through the entire hydrosystem, post-Bonneville survival of different groups of fish, smolt to adult return rates back to Lower Granite Dam, and overall life cycle survival back to the spawning ground. Moving from smaller to larger scales results in more confounding from other factors (ocean conditions, hatcheries, harvest), but also provides an assessment of indirect effects over a larger portion of the life cycle. The CSMEP hydro subgroup is integrating monitoring designs with other CSMEP subgroups, particularly related to PIT-tagging.

The Hydro subgroup took on a subset of hydro management questions across several scales: individual projects, survival by different passage routes through the hydrosystem, and overall life cycle survival. These different scales relate to a variety of decisions: operations at individual projects (e.g. spill, bypass, removable spillway weirs); overall operations (e.g. when to transport fish within season, compliance with hydrosystem Biological Opinions), longer term hydrosystem decisions (e.g. flow management, effectiveness of transportation over multiple years, system configuration); and adequacy of hydrosystem operations for stock recovery. Moving along these scales, the performance measures of interest change. Performance measures range from direct survival at and between dams, to smolt-to-adult survival rates (e.g. smolts leaving Lower Granite Dam to adults returning there 2-3 years later) to inferences about delayed mortality from contrasts in mortality patterns (contrasts in recruits/spawner or smolt-to-adult survival rates). At the largest scales, other factors come into play (estuary, ocean, harvest, etc.) which make it harder to isolate the signal from the hydrosystem.

The choices that are available to improve the quality of information for hydrosystem decisions, and reduce the risks of making incorrect decisions, include: the number of years of data collected, the magnitude of tagging effort, the number of stocks that are monitored, the ability to filter out year to year natural variation and isolate the signal of management actions, and implementation of deliberate manipulations of hydrosystem operations to reduce uncertainty in effectiveness evaluations. Our analyses indicate that for some questions, simply adding more tags won't improve the quality of information unless one can filter out the effects of year to year natural variation. CSMEP has developed, and is continuing to assess alternative methods of data analysis that filter out this variation. For many of these questions, CSMEP has developed low, medium and high alternative designs and explored the strengths and weaknesses of each approach.

Appendix C provides the subgroup's summary of the design elements (DQO steps 1-7) for Hydro monitoring. A full description of the Hydro subgroup's work on DQO steps 1-5 for the Snake pilot is presented as a chapter in Marmorek et al. 2005. A report on the Hydro subgroup's current progress on DQO steps 6-7 is provided on the CSMEP website (will be updated for final report) , as are PowerPoint presentations for Hydro DQO steps 1-5 and DQO steps 6-7 (Presentation1, Presentation2)

2.5 Habitat

Habitat actions are considered a cornerstone of recovery strategies for Columbia Basin fish stocks but there is a need to more clearly determine the effectiveness of these actions for increasing salmonid survival rates and production. Monitoring designs for evaluating the effectiveness of habitat actions must be able to reliably detect two linked responses :

1. the effect of habitat actions on fish habitat; and
2. the effect of changes in fish habitat on fish populations.

Appendix D1 provides the subgroup's summary of the general design elements (DQO steps 1-5) for Habitat monitoring that can help address these questions. A full description of the Habitat subgroup's current work on DQO steps 1-5 for the Snake pilot (at both intensive and extensive scales) is presented as a chapter in Marmorek et al. 2005.

The Habitat subgroup has recognized, however, that there are serious challenges to the development of a generic template for habitat effectiveness monitoring. These include:

1. Habitat conditions vary greatly across subbasins in terms of their natural biogeoclimatic regimes, the status of their fish populations, the degree of human impact and management, and the number and nature of restoration actions that have been implemented, or are being considered for implementation within them.
2. Habitat effectiveness questions encompass different scales of inquiry, which imply different scales of monitoring.

The subgroup is instead attempting to develop a consistent "process" that can be applied to development of individual monitoring designs dependent on the particular situation. They are piloting this approach within the Lemhi subbasin. Appendix D2 provides a summary of detailed DQO steps 1-7 for the Lemhi, while a full report (will be added for final report) on the Habitat subgroup's current progress on DQO steps 1-7 for the Lemhi is provided on the CSMEP website. PowerPoint presentations for Habitat DQO steps 1-5 and DQO steps 6-7 (Presentation1, Presentation2) are also available on the website.

2.6 Hatchery

Throughout the FY 2005 contract period, the hatchery subgroup identified a number of questions important to the evaluation of hatchery management, and has reviewed numerous existing and proposed hatchery Research, Monitoring, and Evaluation (RME) plans within the Columbia River Basin. Following this review, the subgroup has concluded that existing and proposed hatchery RME plans (if fully implemented) are likely to address the majority of the management questions identified by the subgroup. However, the subgroup has also concluded that a number of questions regarding the *effectiveness* of hatcheries as a class of actions are unlikely to be adequately addressed by existing and proposed hatchery RME. These hatchery effectiveness questions (identified in Appendix E) will likely be efficiently and comprehensively addressed only through the implementation of a stratified and representative study design that spans the entire Columbia River Basin. As such, the study designs to address these questions are best developed within a collaborative process that can rely on the expertise of the multiple tribal, state, and federal agencies with operational jurisdiction and familiarity with the facilities. This expertise exists within CSMEP and has been useful in understanding the high level of diversity represented by individual programs. With appropriate stratification, this diversity can be leveraged to identify the mechanistic linkages of individual programs to broader monitoring questions that evaluate the overall *effectiveness* of hatchery strategies at the regional scale. These broader-scale hatchery program effectiveness questions (as opposed to individual hatchery operation questions) will become the focus of CSMEP designs intended to address larger scale multi-hatchery questions that can be stratified across the region.

The subgroup has focused much of their initial efforts on developing alternative monitoring designs that could help answer two of these critical questions relating to hatchery effectiveness:

1. What is the magnitude and distribution of hatchery strays into natural populations? (for Harvest Augmentation Hatcheries), and
2. What is the relative reproductive success of natural spawning hatchery fish and natural origin fish? for both F1 and F2 generations) (for Supplementation Hatcheries)

Insights into approaches gained from the CSMEP analyses required to address these two questions will provide a foundation for tackling additional hatchery questions in a prioritized manner in FY06. Appendix E provides the subgroup's current summary of the design elements (DQO steps 1-7) for Hatchery monitoring that are required to answer these and other questions. A full description of the Hatchery subgroup's work on DQO steps 1-5 for the Snake pilot is presented as a chapter in Marmorek et al. 2005. A report on the Hatchery subgroup's current progress on DQO steps 6-7 is provided on the CSMEP website, as are PowerPoint presentations for Hatchery DQO steps 1-5 and DQO steps 6-7.

2.7 Harvest

Targeted fisheries on salmon are managed by setting allowable catch, catch allocations and open periods for each fishery prior to opening a fishery (considering escapement goals and preseason/updated run predictions) and then adjusting those regulations as runs develop. However, both mark-selective and non-selective fisheries can exert mortality on non-targeted stocks of anadromous, adfluvial, and resident species that are incidentally intercepted. Removal of fish in fisheries can potentially affect spawners, life history diversity and the spatial structure of populations. The Harvest subgroup has therefore been focused on developing alternative monitoring designs that can answer two general classes of Harvest questions:

1. What are the inseason estimates of run size and escapement for each stock management group (target and non-target) and how do they compare to preseason estimates?

2. What is the target and nontarget harvest and when is it projected to reach allowable levels?

Appendix F provides the Harvest subgroup's summary of the design elements (DQO steps 1-7) for harvest monitoring that are required to answer these questions. A full description of the Harvest subgroup's work on DQO steps 1-5 for the Snake pilot is presented as a chapter in Marmorek et al. 2005. A report on the Harvest subgroup's current progress on DQO steps 6-7 is provided on the CSMEP website, as are PowerPoint presentations for Harvest DQO steps 1-5 and DQO steps 6-7 (Presentation 1, Presentation2).

2.8 Monitoring Integration

A Monitoring Integration group, with representation from each of the five CSMEP subgroups, has been formed to explore the integration of the individual RME component parts within a larger monitoring framework (i.e., generate improved efficiencies through integrated designs). This group has begun to develop a comprehensive matrix of shared performance measures and data interdependencies across the different CSMEP subgroups. This evolving Looking Outward Matrix (LOM) is available on the CSMEP website. The matrix is providing a starting foundation for identifying the priority performance measures for monitoring and the relevant spatial scale(s) of these data for varied subgroup monitoring needs. This subgroup is also pursuing a simulation analysis to assess the cost/benefit of a large integrated PIT-tagging program designed to address a range of key monitoring questions across the subgroups. The ultimate intent is to evaluate what intensities of basin-wide PIT-tagging (and at what life-stages) would/would-not-be sufficient to achieve adequate statistical power and at reasonable cost to address the suite of subgroup questions at various spatial scales. Initial analyses for this exercise are presented as a draft report (PIT tag V2 10-17-05.doc) on the CSMEP website as well as within this report in Appendix J. The Integration subgroup will be working to further quantify this analysis in FY06 and intends to extend this approach into other sampling protocols that have the potential for integration across the monitoring subgroups.

2.9 Policy Input and RME Coordination

CSMEP is working to ensure that analyses and monitoring designs explored as part of the project are consistent with the overarching objectives of Columbia Basin monitoring agencies. Table 2.3 provides a summary of CSMEP interactions with agency representatives throughout FY05. CSMEP representatives have participated in a series of PNAMP meetings and workshops and a number of CSMEP participants are also PNAMP members. CSMEP/PNAMP have begun to plan a shared workshop early in FY06 among four of the key monitoring groups in the Basin: PNAMP, CSMEP, Federal RME program, and NED to further clarify M&E niches across the groups.

CSMEP gave a presentation at the NPCC Council meeting in June, 2005 and received feedback on CSMEP's ongoing process. CSMEP convened a workshop in Bonneville in July 2005 to present CSMEP's analytical results to date and solicit input from invited agency managers. A summary report of this July 2005 workshop is provided on the CSMEP website. CSMEP has developed a survey form that can be used to consistently identify the key monitoring questions (across species and spatial scales) of most relevance to different regulatory agencies This survey matrix, "Relevance of Monitoring Questions to Regulatory Agencies" is available on the CSMEP website. CSMEP was discussed at the August 30, 2005 MAG meeting and completion of this survey was assigned to group members as an agenda item. CSMEP has refined the questionnaire since that time and will be doggedly pursuing completion of this matrix by agency managers and PNAMP members as a key item in FY06. The results of this questionnaire will help reshape as necessary CSMPE inventory and design efforts over the coming year.

Table 2.3. CSMEP programmatic and technical interactions in FY 2005.

Entity	Purpose of Interaction
Pacific Northwest Aquatic Monitoring Partnership (PNAMP)	Explain CSMEP tasks, continue to refine project / program descriptions, harmonize PNAMP and CSMEP workplans. Use PNAMP as conduit to get programmatic support from above for various agencies' staff (e.g. BLM, USFS, DEQ, EPA) to assist StreamNet staff with Task 2
AREMP; PIBO; OWEB	Explain CSMEP tasks; more clearly define CSMEP's role in fish habitat monitoring; obtain information on habitat monitoring for integration with our Snake Basin pilot designs
EMAP (ODFW); EPA EMAP (Corvallis)	Explain CSMEP; clarify exactly what they're doing; get inventory and design documents (or URLs) regarding habitat / fish monitoring; initiate collaboration on EMAP designs for Snake Basin pilot
NOAA Fisheries Habitat Group	Explain CSMEP; clarify exactly what they're doing; get inventory and design documents (or URLs) regarding habitat monitoring; work collaboratively on DQO process
NOAA – Action Agency RME Group	Explain CSMEP; clarify current status (beyond RME plan); get inventory and design documents (or URLs) regarding habitat / fish monitoring; coordinate work plans and priority M&E questions
NOAA – Pilot Projects under 35019; Chris Jordan	Explain CSMEP; clarify exactly what they're doing; get inventory and design documents (or URLs) regarding habitat / fish monitoring pertaining to watersheds of interest:; obtain information on products from RME studies in John Day (OR), Wenatchee, Methow & Okanagan (WA) ,and Salmon (ID); contribute to pilot project design
Technical Recovery Teams (TRTs) for the Interior and Lower Columbia, Willamette	Explain CSMEP; get input on needs of decision-makers clarify exactly what they're doing; get inventory and design documents (or URLs) regarding approaches to monitoring and recovery evaluations; obtain TRT documents and GIS products for Snake Basin design work; get input from TRT to inform S & T designs
USFWS Bull Trout Recovery Monitoring and Evaluation Group (RMEG)	Explain CSMEP; clarify exactly what they're doing; get RMEG inventory and design documents regarding approaches to monitoring and recovery evaluations of bull trout

3. Subbasin Inventory and Evaluation

3.1 Subbasin Inventory Work

During FY2005, CSMEP biologists, with the assistance of StreamNet staff, conducted detailed inventories of fish data for seven new pilot subbasins selected in Washington (Okanagan, Methow, Kalama), Oregon (Deschutes, Grande Ronde) and Idaho (Middle Fork Salmon, Upper Fork Salmon),. These subbasin inventories describe, in a systematic manner, the kinds of information currently available on the abundance, productivity, spatial distribution and diversity of salmon, steelhead and bulltrout. This inventory process will continue in FY2006 for additional subbasins to be selected in the three states.

3.2 Strengths and Weaknesses Analyses

CSMEP biologists in FY05 continued their evaluations of the strengths and weaknesses of pilot subbasin fish inventory data for addressing the CSMEP Tier 1, 2 and 3 monitoring questions (Appendix A). The strengths and weaknesses reviews (Table 3.1) completed to date are identifying areas where fish monitoring is being done well, in addition to uncovering inferential weaknesses and data gaps that will be important to address in CSMEP's monitoring design work. Though excellent monitoring does exist in many subbasins, a common weakness is the fact that sampling sites were not typically chosen through a rigorous process that allows generalization to larger spatial scales. A preliminary synthesis framework for evaluating strengths and weaknesses across the pilot subbasins is presented in Appendix G. This synthesis will be further developed in FY06 (i.e., are there strengths and weaknesses in regards to monitoring of particular performance measures that are common *across* the subbasins?)

Table 3.1. Data strengths and weaknesses analyses completed in FY04/05 by subbasin and species (hyperlinked to the Table B2 summaries on the CSMEP website).

State	Subbasin	Species
Idaho	South Fork Salmon River	spring/summer chinook
	Clearwater, Selway River	chinook (spring, summer) steelhead (summer) bull trout
Oregon	Imhaha	chinook (spring) steelhead (summer)
	Lower Columbia	fall chinook
Washington	Lewis	chinook (spring, tule and bright fall) steelhead (summer, winter)
	Yakima	coho fall chinook spring chinook steelhead (summer)

State	Subbasin	Species
	Methow	Chinook (spring, summer) Steelhead (summer)

3.3 Web Data Application

CSMEP has created a centralized web-based data application (managed by ODFW StreamNet) to store and allow access to these inventory metadata and data assessments. [2] As of the end of FY05 there were over 1450 records on the CSMEP data server. There have been over 36,000 hits on the website to date, with the heaviest month being May, 2005 with 5,522 hits. A brief summary of the CSMEP data application and an screen capture of the website's front end is provided in Appendix H.

[2] **CSMEP Web Application Data Portal** https://nrimp.dfw.state.or.us/csmep/default.aspx?mod=15 (user name = csmep, password = csmep).

4. Habitat Monitoring

CSMEP efforts in FY05 were only indirectly focused on issues of habitat monitoring, leaving this principally to the purview of PNAMP. However CSMEP anticipates that as their fish population monitoring designs become further developed they will become closely linked with concurrent fish habitat monitoring programs. For the Snake Basin pilot CSMEP has endeavored to identify and map the spatial location of all habitat monitoring sites and current fish population monitoring sites within the Snake ESU. A PowerPoint presentation depicting these monitoring locations within the Snake ESU is provided on the CSMEP website. Identifying these ongoing monitoring locations can help to refine the spatial components of CSMEP designs by taking advantage of existing sampling programs. CSMEP anticipates that developing centralized spatial databases of habitat monitoring data and evaluating the quality of this data will become an important component of future inventory work. CSMEP has developed a format for assembling habitat inventory metadata and applied it as a pilot to the Okanogan subbasin. An example of this C1 table for Okanogan habitat metadata is provided on the CSMEP website. A PowerPoint presentation describing the Okanagan habitat data and a pilot exercise for evaluating the quality of the habit performance measures (analogous to CSMEP's existing B2 table for strengths and weaknesses assessments) is also provided on the CSMEP website.

5. Summary of FY06 Workplan

In FY06 CSMEP will carry forward the momentum built up during FY04/FY05 and continue to build on the products and methods developed over that period. The main objective of FY06 is to complete the design and evaluation monitoring templates and refine the processes suitable for addressing important questions of status and trend, and the effectiveness of hydrosystem, hatchery, habitat and harvest actions. The final PISCES FY06 SOW for the CSMEP project is provided on the CSMEP website. The list below provides a brief overview of the main CSMEP tasks identified for FY06. Tasks are those described in Section 1.

Task 1

- Continue frequent meetings to monitoring progress on tasks.
- Collaboratively prepare workplans and assign tasks.
- Conduct outreach and coordination with other entities involved in monitoring and evaluation initiatives

Task 2

- Complete metadata inventories for additional subbasins in Oregon, Washington and/or Idaho (these next subbasins to be selected in FY06)

Task 3

- Continue to update and maintain the CSMEP website to communicate CSMEP objectives, reports, inventory results, and analyses
- Continue to maintain and update the CSMEP database and web-based data entry system for CSMEP inventory data (developed by StreamNet staff). The system went live on Oct. 15/05 and now has 1450+ records entered from the inventory data collected during the first sets of pilot inventories.

Task 4

- Complete the strengths and weaknesses analyses for additional sets of subbasin data inventories.
- Complete a full synthesis overview of the strengths and weaknesses assessments.

Task 5

- CSMEP analysts will complete the design and evaluation of monitoring templates to address questions of Status and Trend and the effectiveness of Hydrosystem, Hatchery, Habitat, and Harvest actions for the Snake spring-summer chinook ESU pilot exercise, following the general process and workplan developed at the September 2003 CSMEP Design Workshop.
- CSMEP analysts will expand their pilot analyses to address larger questions of integrated fish monitoring designs across the Columbia Basin

- A design Workshop 5 will be held in Nov, 2005 in Portand, OR for an internal review of CSMEP monitoring design products and initial exploration of efficient monitoring integrations across the S & T and 4 H's subgroups

Task 6

- CSMEP will work with PNAMP to ensure that relevant CSMEP design products can be evaluated and implemented as necessary within regionally coordinated, multi-agency pilot projects or large scale monitoring programs.

Task 7

- CSMEP representatives will communicate their developing ideas and products to agency decision-makers through relevant forums (e.g. PNAMP) and associated workshops (e.g., PNAMP/CSMEP/Federal-RME/NED workshop, potential agency workshop on fall Chinook monitoring)
- CSMEP has developed a standardized matrix for regional managers to rank the relevance of the key monitoring questions for their respective agencies. CSMEP will use the results of this matrix to help adjust the focus of CSMEP design tasks as necessary to better address regional monitoring issues.

Appendix A: Summary of CSMEP Questions[3]

(used to guide both assessments of the strengths and weaknesses of existing data and the development of robust monitoring designs)

1. Broadscale Fish Distribution and Ecosystem Status

- What is the distribution of adult salmonid fishes across broad regions?
- What is the ecosystem status for Columbia River Basin (CRB) fish populations?

2. Fish Population and Habitat Status and Trends

- What is the size, annualized growth rate, freshwater productivity, age-structure of CRB fish populations?
- How frequently do resident fish spawn, and what life history types make up different populations?
- What is the fraction of potential natural spawners that are of hatchery origin?
- What are the physical habitat condition, biological condition and chemical water quality of CRB fish spawning and rearing habitat?
- Have listed CRB populations recovered sufficiently for delisting and removal of ESA restrictions?

3. Action Effectiveness of Specific Recovery Actions (habitat, hydro, hatchery, or harvest management)

HABITAT

- Have specific habitat projects affected habitat conditions and local fish population survival, abundance or condition?
- Did groups of habitat projects within a subpopulation or sub watershed on aggregate affect fish survival, abundance or condition in a larger demographic unit?
- Are particular classes of habitat projects effective?
- What are the mechanistic connections between habitat actions and fish population responses?
- Have habitat projects achieved the expected improvements in conditions?

HARVEST

- What are the inseason estimates of run size and escapement for each management group and how do they compare to preseason estimates?
- What is the target and nontarget harvest and when is it projected to reach allowable levels?

HATCHERIES

- To what extent can hatcheries be used to assist in meeting harvest management goals while keeping impacts to natural populations within acceptable limits?
- To what extent can hatcheries be used to enhance viability of natural populations while keeping impacts to non-target populations within acceptable limits?
- To what extent can hatcheries be used to conserve the genetic legacy of imperiled fish populations?

HYDROSYSTEM

- Are smolt-to-adult survival rates (SARs) sufficiently high to meet NPCC and recovery goals?
- Has hydrosystem complied with performance standards set out in 2000 FCRPS BiOp?
- What are the patterns in fish survival rates both within the mainstem and subsequent to it, for different species and groups of fish (e.g. transported vs. in-river, hatchery vs. wild, upstream vs. lower river)?
- What's the effect of different within-season transportation management and flow/spill management actions on various measures of fish survival rates?
- To what extent would Removable Spillway Weirs improve fish survival rates, at both the project scale and over the overall life cycle?

[3] CSMEP's central data inventory and analysis questions. The questions below span 3 tiers. The tiers are defined as follows: Tier 1 - broad-scale assessment of fish distributions at a sampling frequency of about 3 to 5 years, and a general assessment of ecosystem status at a sampling frequency of about 5 to 10 years. Tier 2 - statistically based sampling to determine the annual trends in the status of fish populations and their habitat. Tier 3 - research and monitoring to assess, in the form of explicitly posed experiments, the effectiveness of specific recovery actions.

For each of the above questions, CSMEP biologists are addressing the following five issues:

1. What are the spatial scales of interest for this question?
2. Has anyone attempted to answer this question before in this sub-basin, or for a larger spatial unit that contains this sub-basin? If Yes, who did this, and how? What methods were used? Provide reference citation. Was accuracy or precision of answer estimated?
3. If answer to #2 was no (or attempt failed), could question be answered with available data? (yes, no, maybe, don't know). Any ideas on how / method? At what level of accuracy AND precision, ideally with quantitative estimates, or if not available qualitative estimates (L, M, H).
4. On what spatial scale could answers be provided with existing information (e.g. tribs, individual pop, pop group, ESU) and over what temporal scale (e.g. last 20 years, last 5 years)?
5. Summarize the overall strengths and weaknesses of existing data for answering this question. What critical improvements are required to overcome weaknesses

Appendix B. Status and Trends DQO Summary

<table>
<tr><th>DQO STEPS</th><th>SNAKE RIVER BASIN PILOT</th><th>Policy Inputs[1] (✓)</th></tr>
<tr><td colspan="3">1. State the Problem</td></tr>
<tr><td>Problem:</td><td>Delisting of Snake River S/S Chinook ESU</td><td></td></tr>
<tr><td>Stakeholders:</td><td>States—Washington, Oregon, Idaho
Tribes—NPT, SBT, CTUIR, CTWSR, YIN
Federal—NOAA, USFWS, USFS, BPA, USACOE
Intergovernmental—Columbia River Compact, CBFWA, CRITFC, PFMC, PSC, NPCC
Other—Idaho Power, conservation groups, fishers (tribal, commercial, sport), landowners, upland land users (ranchers, farmers, municipalities, state and county governments), water users (agricultural, industrial, municipal)</td><td></td></tr>
<tr><td>Non-technical Issues:</td><td>Interagency coordination, fiscal constraints, legal constraints, land ownership and access</td><td></td></tr>
<tr><td>Conceptual Model:</td><td>Life history models</td><td></td></tr>
<tr><td colspan="3">2. Identify the Decision</td></tr>
<tr><td>Principal Questions:</td><td>What is the ESA listing status for Snake River S/S Chinook salmon?</td><td></td></tr>
<tr><td>Alternative Actions:</td><td>• If status is “listed,” then recovery strategies (i.e., more restrictive management strategies at one or more points in the life history model).
• If status is “delisted,” then recovery or sustainable harvest strategies.
• If status is “recovered,” then sustainable harvest strategies</td><td>✓</td></tr>
<tr><td>Decision Statements:</td><td>• Has there been sufficient improvement in population status of Snake River S/S Chinook ESU to justify delisting and allow removal of ESA restrictions?
• Are additional management actions required for regional, ESA recovery and NPCC SAR goals?</td><td>✓</td></tr>
<tr><td colspan="3">3. Identify the Inputs</td></tr>
<tr><td>Information Required:</td><td>
<table>
<tr><th>Information required</th><th>Abundance</th><th>Productivity</th><th>Spatial structure</th><th>Diversity</th></tr>
<tr><td>Abundance of spawners</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Abundance/distribution of redds</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Origin of spawners</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Age-structure of spawners</td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Sex ratio of spawners</td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Abundance/distribution of juveniles</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Juvenile survival</td><td></td><td></td><td></td><td>✓</td></tr>
</table>
</td><td></td></tr>
<tr><td>Sources of Data:</td><td>State, tribal, and federal programs and NGSs identified in CSMEP metadata inventories</td><td></td></tr>
</table>

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
Quality of Existing Data:	Data varies in level of precision and bias. Major issues: • Abundance of spawners: 10 of 31 populations have weirs in combination with redd counts, 21 of 31 populations rely on redd abundance as a surrogate for spawner abundance. Weir data provide precise information on abundance of spawners but no information on spawner distribution; redd data provide less precise information on abundance but also provide information on distribution of spawners. • Abundance/distribution of redds: populations vary in spatial and temporal extent and resolution. Fixed index sites are used instead of probabilistic methods for site selection. • Origin of spawners: mark quality is high, but sample sizes are low especially during years of low abundance. • Age-structure of spawners: because they are based on carcass recoveries estimates are imprecise and likely biased. As an alternative, application of a basin-wide estimate is also imprecise and likely biased at the population-level. • Sex ratio of spawners: same as for age-structure data • Abundance/distribution of juveniles: 15 of 31 have juvenile traps, 22 of 31 populations have snorkel . Trap data is more precise for abundance but give no information on distribution; snorkel data are imprecise for abundance but provide high quality information on distribution. • Survival of juveniles: PIT-tags can provide precise estimates but sample sizes are low in less productive populations.	
New Data Required:	• Probabilistic sampling strategies reduce bias and likely will improve information available for spatial structure and diversity. • Existing methods may require calibration and validation to improve their utility. • Analysis of available data may indicate performance measures for which higher quality data are needed to evaluate decisions	
Analytical Methods:	IC-TRT rules and criteria for combining measures of abundance, productivity, spatial structure, and diversity.	✓
4. Define the Boundaries		
Target Populations:	Snake River S/S Chinook Salmon	
Spatial Boundaries (study):	Population, MPG, and ESU levels for S/S Chinook salmon within Snake River basin.	✓
Temporal Boundaries (study):	Status data evaluated over generations from annual abundance data, generational productivity data, and spatial structure and diversity data collected at unspecified intervals. Data on historical distribution and productivity also are needed.	✓
Practical Constraints:	Legal and logistical issues with access, interagency coordination across jurisdictional boundaries.	✓
Spatial Boundaries (decisions):	Delisting decision made at level of ESU.	
Temporal Boundaries (decisions):	IC-TRT rules for abundance and productivity require historical data, and 10 year series of annual data. IC-TRT rules require spatial structure and diversity data collected at unspecified intervals.	
5. Decision Rules (IC-TRT Rules)		
Critical Components and Population Parameters:	Two metrics (A/P and SS/D) are used to assess the status of each population. A/P combines abundance and productivity VSP criteria using a viability curve. SS/D integrates 12 measures of spatial structure and diversity.	✓
Critical Action Levels (Effect Sizes):	Risk categories are assigned at the population level for A/P using a 5% risk criterion to define viable populations. Populations scored as moderate or high risk in A/P criteria cannot meet viable standards, while populations at high risk for the 12 SS/D measures cannot be considered viable.	✓

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
If-Then Decision Rules: IC-TRT Draft	**MPG-level Viability Criteria:** Low risk (viable) MPGs meet the following six criteria: 1. One-half of the populations historically within the MPG (with a minimum of two populations) must meet minimum viability standards (Section X). 2. All populations meeting viability standards within the ESU cannot be in the minimum viability category (Figure X); at least one population must be categorized as meeting more than minimum viability requirements. 3. The populations at high viability within an MPG must include proportional representation from populations classified as “Large” or “Intermediate” based on their intrinsic potential. 4. Populations not meeting viability standards should be maintained with sufficient productivity that the overall MPG productivity does not fall below replacement (i.e. these areas should not serve as significant population sinks). 5. Where possible, given other MPG viability requirements, some populations meeting viability standards should be contiguous AND some populations meeting viability standards should be disjunct from each other. 6. All major life history strategies (i.e. adult “races,” A-run/B-run, resident and anadromous) that were present historically within the MPG must be present and viable. **ESU-level Viability Criteria:** 1. All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU must be at low risk. 2. ESUs that contained only one MPG historically must meet the following criteria: a. Two-thirds or more of the populations within the MPG historically must meet minimum viability standards; AND b. Have at least two populations categorized as meeting more than minimum viability requirements.	✓
Consequences of Decision Errors:	Incorrectly concluding that delisting criteria have been achieved: • Decisions to relax ESA restrictions increase risks to the ESU Incorrectly concluding that delisting criteria have not been achieved: • Minimal biological impact given that decisions do not relax ESA restrictions • May over-invest in intensity of monitoring efforts • Unnecessary listing and restrictive measures • Loss of harvest opportunity	

[1]Policy Inputs - indicates with a check steps where group really needs policy feedback

Steps 6 and 7. Optimizing the Design *(examples)* Evaluation Design *(How data will be analyzed to answer a question)* Sampling Design *(Where and When data will be collected)* Response Design *(What and How data are collected)*
Refer to following matrices.

"Current" Design Template:

Data need	Method / Description		SF Salmon			Little	Cham	Middle Fork										Upper Mainstem Salmon								Grand Ronde-Imnaha							Low. Snake	
			SF Mainstem	Secesh	EFSF	Little Salmon	Chamberlain Creek	Big Creek	Lower MF Mainstem	Camas Creek	Loon Creek	Pistol Creek	Sulphur Creek	Bear Valley Creek	Marsh Creek	Upper MF Mainstem	North Fork	Lemhi	Pahsimeroi River	Up. Salmon Low. Mainstem	East Fork Salmon River	Yankee Fork	Valley Creek	Up. Salmon Up. Mainstem	Wenaha	Lostine	Minam	Catherine Creek	Up. Grande Ronde River	Imnaha Mainstem	Big Sheep Creek	Tucannon	Asotin
Abundance of fish	A1	Census weir		1																													
	A2	Weir with MR	1	1	1														1		1			1		1		1	1	1			
	A3	Weir without MR				1																										1	
	A4	MR survey, no weir																															
Abundance / spatial distribution of redds	B1	Cen-cen																															
	B2	Cen-multi																	1						1	1	1	1	1	1	1		
	B3	Cen-once																	1	1													
	B4	Stat-cen																															
	B5	Stat-multi																															
	B6	Stat-once																															
	B7	Fixed-cen																															
	B8	Fixed-multi	1	1	1	1		1	1		1	1			1	1	1	1			1	1	1	1									
	B9	Fixed-once					1			1			1	1			1	1			1	1	1	1								1	
Age structure of spawners	C1	Tags																															
	C2	Hard parts																								1		1	1	1			
	C3	Length at age	1	1	1	1									1				1	1	1			1	1	1	1	1	1	1	1	1	
	C4	Basinwide estimate	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Origin of spawners	D1	Hatchery marks, handle fish at weirs	1		1	1													1		1			1		1						1	
	D2	Hatchery marks, remotely sense																															
	D3	Hatchery marks on carcasses		1			1	1			1			1	1		1			1		1	1	1	1		1	1	1	1	1	1	
Sex ratio of spawners	E1	Carcass survey	1	1	1		1	1			1				1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	E2	Female per redd expansion				1													1													1	
Abundance / spatial distribution of smolts	F1	Juvenile trap	1	1	1										1			1	1		1	1		1		1	1	1	1	1		1	
	F2	Electrofishing	1	1																													
	F3	Snorkel survey	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										
Survival of juveniles	G1	Mark recapture	1	1	1										1			1	1		1	1		1		1	1	1	1	1			

"High" Design Template:

Data need	Method / Description		SF Salmon			Little	Cham	Middle Fork									Upper Mainstem Salmon								Grand Ronde-Imnaha							Low. Snake	
			SF Mainstem	Secesh	EFSF	Little Salmon	Chamberlain Creek	Big Creek	Lower MF Mainstem	Camas Creek	Loon Creek	Pistol Creek	Sulphur Creek	Bear Valley Creek	Marsh Creek	Upper MF Mainstem	North Fork	Lemhi	Pahsimeroi River	Up. Salmon Low. Mainstem	East Fork Salmon River	Yankee Fork	Valley Creek	Up. Salmon Up. Mainstem	Wenaha	Lostine	Minam	Catherine Creek	Up. Grande Ronde River	Imnaha Mainstem	Big Sheep Creek	Tucannon	Asotin
Abundance of fish	A1	Census weir		1																													
	A2	Weir with MR	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	A3	Weir without MR																															
	A4	MR survey, no weir																															
Abundance / spatial distribution of redds	B1	Cen-cen																															
	B2	Cen-multi	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	B3	Cen-once																															
	B4	Stat-cen																															
	B5	Stat-multi																															
	B6	Stat-once																															
	B7	Fixed-cen																															
	B8	Fixed-multi																															
	B9	Fixed-once																															
Age structure of spawners	C1	Tags	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	C2	Hard parts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	C3	Length at age																															
	C4	Basinwide estimate																															
Origin of spawners	D1	Hatchery marks, handle fish at weirs	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	D2	Hatchery marks, remotely sense																															
	D3	Hatchery marks on carcasses																															
Sex ratio of spawners	E1	Carcass survey	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	E2	Female per redd expansion																															
Abundance / spatial distribution of smolts	F1	Juvenile trap	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	F2	Electrofishing																															
	F3	Snorkel survey	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Survival of juveniles	G1	Mark recapture	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

"Medium" Design Template

Data need	Method / Description		SF Salmon			Little S	Cham	Middle Fork									Upper Mainstem Salmon								Grand Ronde-Imnaha							Low. Snake	
			SF Mainstem	Secesh	EFSF	Little Salmon	Chamberlain Creek	Big Creek	Lower MF Mainstem	Camas Creek	Loon Creek	Pistol Creek	Sulphur Creek	Bear Valley Creek	Marsh Creek	Upper MF Mainstem	North Fork	Lemhi	Pahsimeroi River	Up. Salmon Low. Mainstem	East Fork Salmon River	Yankee Fork	Valley Creek	Up. Salmon Up. Mainstem	Wenaha	Lostine	Minam	Catherine Creek	Up. Grande Ronde River	Imnaha Mainstem	Big Sheep Creek	Tucannon	Asotin
Abundance of fish	A1	Census weir																															
	A2	Weir with MR	1			1	1								1									1						1		1	
	A3	Weir without MR																															
	A4	MR survey, no weir																															
Abundance / spatial distribution of redds	B1	Cen-cen																															
	B2	Cen-multi																															
	B3	Cen-once																															
	B4	Stat-cen																															
	B5	Stat-multi	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	B6	Stat-once																															
	B7	Fixed-cen																															
	B8	Fixed-multi																															
	B9	Fixed-once																															
Age structure of spawners	C1	Tags																															
	C2	Hard parts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	C3	Length at age																															
	C4	Basinwide estimate																															
Origin of spawners	D1	Hatchery marks, handle fish at weirs	1			1	1								1									1						1		1	
	D2	Hatchery marks, remotely sense																															
	D3	Hatchery marks on carcasses	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sex ratio of spawners	E1	Carcass survey																															
	E2	Female per redd expansion																															
Abundance / spatial distribution of smolts	F1	Juvenile trap	1			1	1								1									1						1		1	
	F2	Electrofishing																															
	F3	Snorkel survey	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Survival of juveniles	G1	Mark recapture	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

"Low" Design Template:

Data need	Method / Description		SF Salmon			Little Salmon	Chamberlain	Middle Fork									Upper Mainstem Salmon								Grand Ronde-Imnaha							Low. Snake	
			SF Mainstem	Secesh	EFSF	Little Salmon	Chamberlain Creek	Big Creek	Lower MF Mainstem	Camas Creek	Loon Creek	Pistol Creek	Sulphur Creek	Bear Valley Creek	Marsh Creek	Upper MF Mainstem	North Fork	Lemhi	Pahsimeroi River	Up. Salmon Low. Mainstem	East Fork Salmon River	Yankee Fork	Valley Creek	Up. Salmon Up. Mainstem	Wenaha	Lostine	Minam	Catherine Creek	Up. Grande Ronde River	Imnaha Mainstem	Big Sheep Creek	Tucannon	Asotin
Abundance of fish	A1	Census weir																															
	A2	Weir with MR																															
	A3	Weir without MR																															
	A4	MR survey, no weir																															
Abundance / spatial distribution of redds	B1	Cen-cen																															
	B2	Cen-multi																															
	B3	Cen-once																															
	B4	Stat-cen																															
	B5	Stat-multi																															
	B6	Stat-once																															
	B7	Fixed-cen																															
	B8	Fixed-multi																															
	B9	Fixed-once	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Age structure of spawners	C1	Tags																															
	C2	Hard parts	1			1	1								1									1						1		1	
	C3	Length at age	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	C4	Basinwide estimate																															
Origin of spawners	D1	Hatchery marks, handle fish at weirs																															
	D2	Hatchery marks, remotely sense																															
	D3	Hatchery marks on carcasses	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Sex ratio of spawners	E1	Carcass survey																															
	E2	Female per redd expansion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Abundance / spatial distribution of smolts	F1	Juvenile trap																															
	F2	Electrofishing																															
	F3	Snorkel survey	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Survival of juveniles	G1	Mark recapture	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Appendix C. Hydrosystem DQO Summary

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Needed (✓)
1. State the Problem		
Problem:	The existence and operation of the Federal Columbia River Power System (FCRPS) is one of the more important anthropogenic factors influencing mainstem survival of three ESUs of concern to this Snake River [SR] pilot study: SR spring/summer chinook, SR fall chinook, and SR steelhead. ESA-listed bull trout are also affected, but are not considered in this pilot study. Decisions on FCRPS actions directly or indirectly affecting survival of these stocks are conducted under the authority of the ESA. Information on the expected and actual effectiveness of these actions (e.g. juvenile collection, bypass, and transportation; water management; offsite mitigation) is essential for reliable decisions. There is a need to assess what quality of data are required to: 1) reliably detect the effects of FCRPS actions on fish survival rates; and 2) reliably compare survival rates to pre-defined goals.	
Stakeholders:	NMFS makes FCRPS management decisions under the ESA for the three ESUs considered in this preliminary analysis. USFWS also assesses FCRPS effects on bull trout under ESA. Other stakeholders affected by these decisions: state agencies and tribes that co-manage the fisheries resource; federal fishery agencies that implement ESA and hydropower mitigation management; federal agencies that operate and market electricity from the FCRPS and fund mitigation activities; commercial, recreational and tribal fishers: power users.	
Non-technical Issues affecting M&E:	Funding, legal authority to handle and mark fish, legal authority to place detection structures in fishways, decisions on dam operations that affect detection rates and/or influence contrasts among different groups (e.g., volume of spill, bypass/barging operations); ongoing BiOp/Remand considerations.	
Conceptual Model:	Assessment of hydrosystem impacts involves a suite of four sets of indices: 1) direct survival (project pathway, reach, entire hydrosystem); 2) SAR overall; 3) SAR ratios (T/I, D, upriver / downriver stocks); and 4) recruits/spawner (spatial/temporal patterns). Moving from 1 to 4 results in more confounding from other factors (ocean conditions, hatcheries, harvest), but also provides an assessment of indirect effects over a larger portion of the life cycle.	
2. Identify the Decision		
Decisions / Alternative Actions	Hydro Action Effectiveness Questions [Section of Report on DQO steps 6-7; Status of Work to Date[4]] *[Example feedback required]*	
Are SARs, and important SAR ratios relating to effectiveness of transportation, meeting NPCC and BiOp targets?	Is SAR sufficient for 1) NPCC goal [5]& 2) recovery goals? [6.1; A] Is transportation more effective than in-river passage? [6.1; A] What is the relative survival of transported fish post-BONN, compared to in-river fish (D)? [6.1; A] {*no regulatory target*} Has hydrosystem complied with performance standards set out in 2000 FCRPS BiOp? [6.2; A] *{If targets not met (by how much?), then may need to consider changes in FCRPS operations (e.g. when, how much to transport) or configuration.}*	✓
Should FCRPS change timing of transportation of some species within season?	How does effectiveness of transportation change over the course of the season? [6.5; A] *{Are Snake R wild chinook equally important as wild steelhead? Are wild chinook more important than hatchery chinook?}*	✓

[4] Status of Work to Date: **A**: Have posed testable hypotheses; explored precision of alternative evaluation, sampling and response designs; still need to do more work and assess costs; **B**: Have clarified questions and described evaluation design; need to do more work on forming hypotheses, assessing precision of alternative sampling and response designs; **C**: Have only clarified questions

[5] Pg. 13 of NPCC mainstem amendments of 2003-2004. www.nwcouncil.org/library/2003/2003-11.pdf ; interim goals of 2-6% SAR

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Needed (✓)
Is the cumulative effect of hydrosystem actions and estuary-ocean conditions leading to stock recovery? *{No regulatory target}*	What's the incremental mortality of Snake R fish populations (passing 8 dams) as compared to lower Columbia stocks passing 1-3 dams? [6.3; B] What is the inferred delayed mortality of both in-river and transported fish? [6.4; B]	✓
Are current flow and spill management actions meeting survival targets? If not, should FCRPS change these actions?	What is the effect of different flow management actions in the hydrosystem on SAR and Sp/Sp ratios? [6.6; B] What is the effect of different flow and spill management actions on in-river survival? [6.7; A-B] *{Need to confirm targets}*	✓
Is offsite mitigation working? *{No regulatory target}*	Have freshwater habitat restoration actions been sufficient to compensate for hydrosystem direct and delayed mortality, as measured on the Snake R aggregate sp/sum chinook stock? [6.9; B]	✓
Are dam project operations maintaining desired targets for fish survival rates and condition? *{FCRPS Biological Opinion and other targets}*	What are the survival rates and condition of fish past turbines, spillway and bypass routes of passage? How would RSWs change SARs and Sp/Sp? Would RSWs be an effective alternative to transportation? Would the reduced spill associated with RSWs affect fish survival and condition? [6.8; C] *Review current operational targets for project survival, fish guidance, etc. with BPA, Army Corps*	✓
Decision Statements:	Decision rules are within purview of agency with statutory authority. Logically, decision rules should: • anticipate survival changes in the mainstem;, • address management measures for all the Hs, • incorporate adult and juvenile data (consider indirect effects); • project stock abundance over many decades; and • accommodate gradual improvements in habitat condition and habitat deterioration that could offset hydrosystem effects.	✓
3. Identify the Inputs		
Information Required:	Estimates of *direct survival rates and SARs* for a contrasting range of: mainstem passage timings and routes (transported vs. in-river; bypass vs. spillway vs. turbine); species (spring/summer chinook, fall chinook, steelhead, sockeye); stock origins (upstream vs. downstream; wild vs. hatchery). Estimates of *estuary/ocean survival rates* are required to assess delayed mortality; these are inferred from estimates of in-river survival, SARs, recruits / spawner, and the proportion of fish below Bonneville Dam that were transported. *Estimates of the feasibility of achieving survival improvements* across all H's need to be merged for evaluating the most promising suite of actions for recovering populations.	
Sources of Data:	*Direct survival estimates through the hydro system and estuary/ocean through tagging and recapture:* coded wire tags, PIT tags, balloon tags, radio tags, hydro acoustic technologies. *Other survival and recruitment estimates used to estimate estuary/ocean survival, climate/ocean effects and delayed mortality:* dam counts, redd counts, carcass counts, age analysis from scales.	

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Needed (✓)
Quality of Existing Data:	Data quality varies by the question of interest, species and stock origin: • Precision of survival estimates greatly improved since the use of PIT tags; • Precision of survival estimates varies with number of fish tagged: estimates for hatchery spring/summer chinook and steelhead more precise than for wild fish; estimates for entire year's migration more precise than for within-year groups; poor estimates for fall chinook • Tagging methods to determine the relative survival rates of fish through different dam passage routes have various weaknesses • Recruit/spawner estimates have various limitations but also have long time series; contrasts in SARs provide better signal of hydrosystem effects • Intensive studies of smolt health and estuary survival not yet linked to SAR data for various PIT-tagged groups, to understand mechanisms of delayed mortality	
New Data Required:	• Higher precision in SARs to improve reliability and speed of responses to key questions • PIT-tag based SAR data for fall chinook (hatchery) • Improved ability to assess differences in spring/summer chinook SARs across contrasts in passage route, timing, and stock origin • Better linkage of physiology studies below Bonneville with SAR data • See tables and charts at end of this handout	
Analytical Methods:	Methods for estimating precision of reach survival, SARs and SAR ratios (e.g. T:I, D) are well developed. Methods for inferring delayed mortality are indirect, involve many inputs, and are less precise. Challenge is to develop evaluation methods that filter out natural year to year variation (as well as other confounding factors) to isolate hydrosystem effects and answer key questions in an acceptable timeframe.	
4. Define the Boundaries		
Target Populations:	Snake River spring/summer chinook, fall chinook, steelhead and sockeye examined to date; bull trout also of interest	
Spatial Boundaries (study)	From entrance into hydrosystem at Lower Granite to various points beyond (reach survival, Bonneville Dam, estuary, return to Bonneville Dam, return to Lower Granite Dam, return to spawning ground)	
Temporal Boundaries (study)	Studies must be of a sufficient duration to detect the effect of contrasting actions. Thus the required duration of monitoring depends on the hydrosystem action being evaluated, and the effect size of interest (longer for more subtle effects). Time scales range from daily detections of PIT-tags, to seasonal contrasts of SARs, to annual SARs, to decadal-scale contrasts in spawner-recruit data.	
Practical Constraints:	Difficult or impossible to: determine causes of mortality after fish pass into ocean; disentangle effects of hatchery operations and # of dams passed on hatchery SARs (these factors covary); relate condition of PIT-tagged smolts in the estuary with their ultimate SAR. Not enough wild fish in some years to obtain reliable estimates of mainstem survival rates or SARs; year to year variation in survival means that 'average effects' may hide important information	
Spatial Boundaries (decisions):	Entire Columbia Basin. Decisions on hydrosystem operations and configuration have implications over the scale of the electricity grid to which generated power is distributed.	
Temporal Boundaries (decisions):	NOAA and USFWS Biological Opinions on FCRPS are released every 5 to 10 years. Analyses need to consider actions such as habitat restoration which may take decades to become fully effective.	
5. Decision Rules		
Critical Components, Population Parameters and Action Levels:	• Compare hydrosystem survival rates to NOAA FCRPS BiOp targets, • Compare SARs to NPCC interim targets of 2-6% and other recovery goals; Compare T:I ratios to assess transportation benefit (e.g. T/I > 1.0?); • Compare D to level indicative of substantial delayed mortality of transported fish (e.g. D < 0.7?) • Compare probability of extinction and probability of recovery to NOAA and USFWS targets	✓

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Needed (✓)
If-Then Decision Rules:	**If** juvenile survival rates through the hydrosystem, SARs **or** the probability of recovery are consistently below target levels, **and** this can be clearly shown to be related to the direct and indirect effects of the hydrosystem, **then** alternative mitigative actions will be considered (e.g., changes to hydrosystem operations, removal of predators from reservoirs, changes to hydrosystem project structure or configuration)	✓
Consequences of Decision Errors:	Failure to make required changes in hydrosystem operation or configuration may result in extinction of fish species, or failure to recover stocks. Making ineffective changes in operations or configuration may waste significant amounts of money.	
Steps 6 & 7. Summary of alternative M&E designs for assessing effectiveness of hydrosystem actions	CSMEP developed and evaluated several sets of alternative designs for the questions outlined in steps 1-5. This work is ongoing and is summarized in a detailed report on DQO steps 6-7. The following pages provide tables, graphs and charts to illustrate some alternative designs (low, medium and high intensity) developed by CSMEP for a subset of the questions described above under step 2. Increased levels of tagging would help to improve the precision of answers to all hydrosystem questions. Ultimately these low, medium and high designs need to be synthesized across all hydro questions, and then across the questions from all subgroups.	

Table C-1. Alternative designs for hydro questions related to SAR, T/I, and D. Current M&E efforts are shaded in grey. The low option is indicative of less M&E than current efforts, whereas the high option involves increased effort. Charts C-1 to C-4 (end of this Appendix) describe low, medium and high M&E options for spring/summer chinook and steelhead in greater detail.

M&E Level	Spring/summer Chinook	Fall Chinook	Steelhead	Sockeye
Low	Background level of PIT-tagging. Run reconstruction SARs: partition wild and hatchery smolts and adults at upper dam (e.g., Petrosky et al. 2001; Raymond 1988)	PIT tag hatchery group only as surrogate for wild SAR??	Run reconstruction SARs: partition wild and hatchery smolts and adults at upper dam (e.g., Marmorek et al 1998; Raymond 1988).	SARs: run reconstruction at Redfish Lake; T/I and D unsampled, assume response similar to or worse than spring/summer chinook??
Medium	PIT tag wild aggregate SARs from opportunistic tagging (current CSS); PIT tag SARs major production hatcheries. Estimate annual T/I and D for wild and hatchery groups (current CSS)	PIT tag wild fall Chinook above LGR, treat same as CSS fish; PIT tag SARs major production hatchery groups (USFWS/NPT proposal) (NOAA proposal)??	PIT tag wild aggregate SARs from opportunistic tagging (current CSS since 2002); PIT tag SARs major production hatcheries (proposed CSS-not funded)	SARs: PIT tagged migrants from Redfish Lake, treated same as CSS fish in FCRPS (beginning 2005); T/I and D not feasible because extremely limited potential sample sizes
High	PIT tag for wild SARs at level of Major Population Groups (MPG); all hatchery releases represented in SAR, T/I and D estimates	Same as medium??	PIT tag for wild SARs at level of Major Population Groups (MPG) (feasibility ??); all hatchery releases represented in SAR, T/I and D estimates	Not possible to go beyond Medium level.

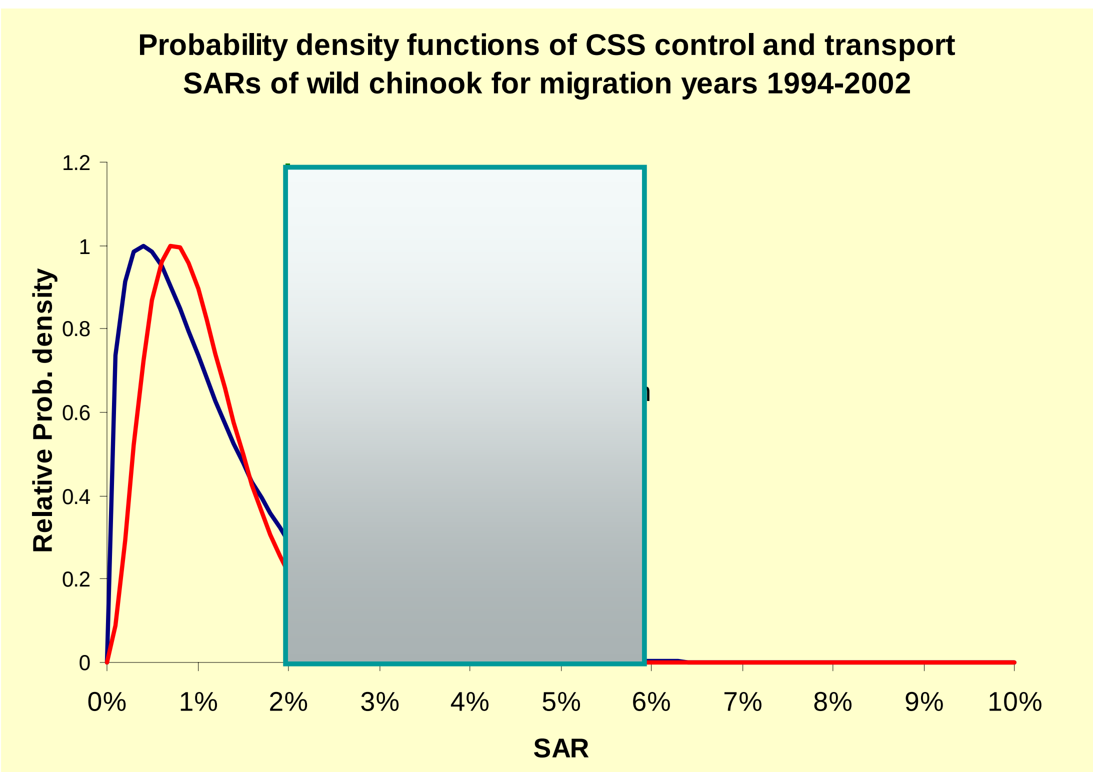


Figure C-1. Probability density functions of SARs for wild Chinook, for both control (**blue**) and transported (**red**) fish, between 1994 and 2002, compared to the NPCC interim goal of 2-6% (shaded rectangle with **green** perimeter). Most of the fish in both groups had an SAR lower than the 2-6% goal. REVISE THIS FIG WHEN NEW ONE RECEIVED FROM PAUL

Table C-2. Alternative designs to assess if the hydrosystem has complied with performance standards set out in 2000 FCRPS BiOp. More specifically, is inriver survival of wild Snake spring-summer chinook and steelhead at or above the 2000 BiOp 50% (approx.) standard?

Background: The BiOp standard is that survival should be only 9% greater than pre-BiOp estimates of survival from LGR to BON. There are four challenges in attempting to monitor for compliance with this standard: 1) smaller changes in survival are easier for managers to achieve and more "certain to occur", but also harder for biometricians to detect; 2) inter-annual variation is high and monitoring cannot change this fact; 3) estimated survival for any given year (1998-2004) has had high error bounds (generally +/- 10-15%); and 4) there are few data from before 2000 (Figure C-2).

M&E Level	Monitoring Activities
Low	Decrease tagging and detection efforts from current level (Medium option), wait 5-10 years for data to accumulate, and compute a new, multi-year average survival rate. However, years with exceptionally low or high flow, temperature, etc. (e.g., 1999, 2001, 2005) make it unlikely that the spread in the estimate will go down just because one has more years of data. On the other hand, lower tagging effort would obviously decrease costs. Decreased spill would increase fish detection and precision, but will also likely decrease survival rates.
Medium	Continue current tagging and detection efforts. With current tagging (e.g., 20,000 - 30,000 wild chinook tagged or detected at LGR each year), estimates of LGR to BON in-river survival have wide error bounds. If one pools estimates for 1998-2004, survival rate on average was about 47%, +/- 9%.
High	Increase tagging substantially (e.g. 2-10 fold), and increase below-Bonneville trawls significantly (e.g. 2-5 fold). Continue efforts to increase detection efficiency at the BONN corner collector, which diverts many fish away from turbines (good) but detects few if any tagged fish (bad). Preliminary results suggest that these steps in combination would reduce the spread in any given year's survival estimates quite substantially. However, inter-annual variation in survival rates is clearly a real phenomenon, and not just an artifact of sampling/tagging/detection efforts. This variation will of course continue into the future. Obviously, this would result in increased costs for both tagging and (trawl) detections in the estuary below BON.

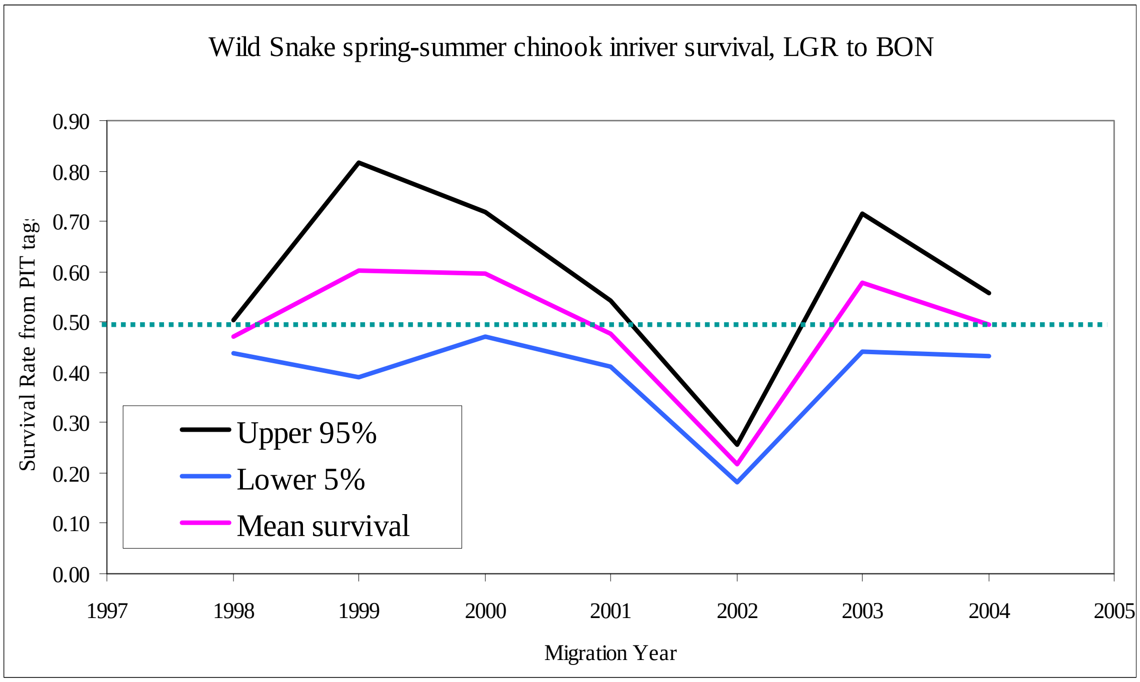
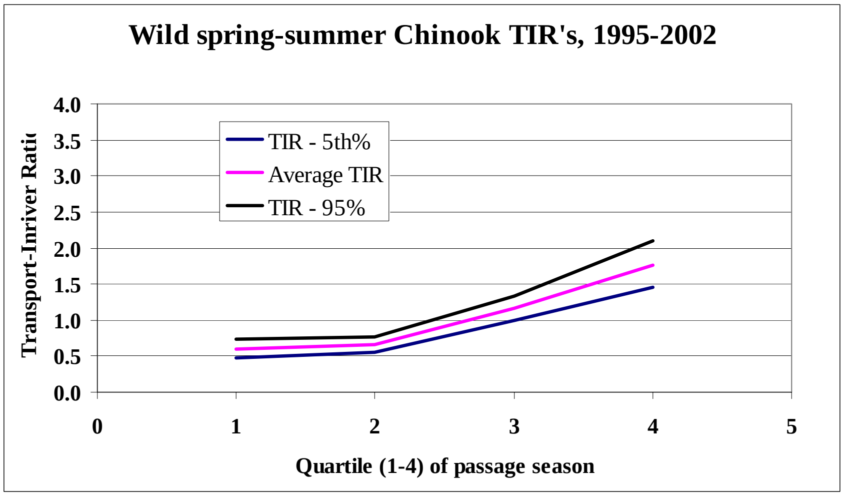


Figure C-2. The 95% confidence intervals about estimates of mean annual in-river survival rates of wild Snake spring-summer chinook generally bracket the 2000 FCRPS standard of ~50%.

Alternative Designs for the question "What's the effect of different in-season transportation management actions on Post-Bonneville survival of transported fish?" These designs are likely to be similar to those listed above in Table C-2 for compliance with BiOp survival targets.

Background: Preliminary NOAA and CSS work suggests that Transport/In-river SAR ratios may vary within a season. For Snake River **wild** spring-summer chinook – early migrants may do better in-river, but later migrants do better in barges. In addition, it appears that **hatchery** chinook, and both wild and hatchery steelhead, do not exhibit a strong seasonal pattern – transport is generally better, both early and later in the spring. Hence there are tradeoffs among species when making in-season transport decisions.



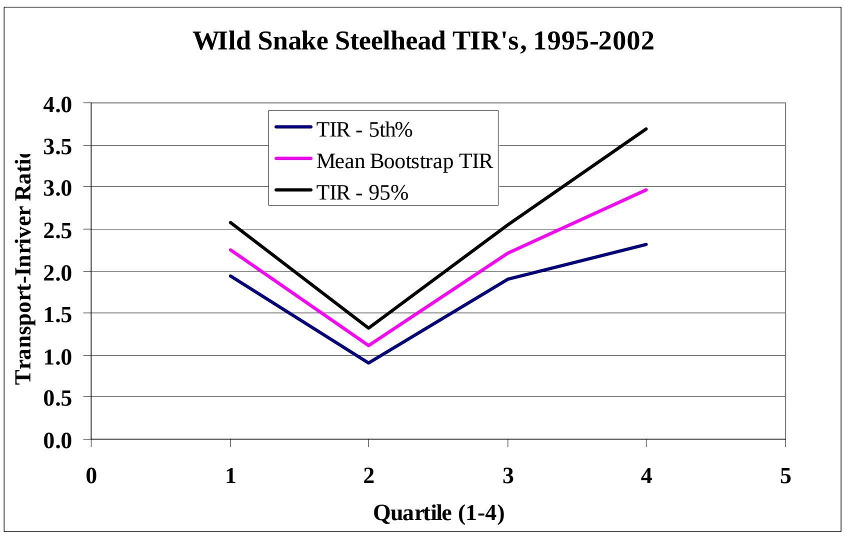


Figure C-3. Transport to Inriver SAR ratios (TIRs) for wild spring summer Snake River chinook (top graph, gradually improving ratio over the season) and wild Snake River steelhead (bottom graph, little pattern).

Table C-3. Alternative designs for estimating upstream-downstream differential mortality and SAR ratios. Current M&E efforts, or developed proposals, are highlighted in grey. SR=Spawner Recruit.

M&E Level	Spring/summer Chinook	Fall Chinook	Steelhead	Sockeye
Low	SR estimates for differential mortality, upstream-downstream incremental mortality, wild index stocks from Snake River and downriver regions (Deriso et al. 2001). No program for SARs.	No SAR data yet for either wild or hatchery; will be getting hatchery SAR data in 2005 with NOAA study. Snake R and Deschutes R SR data.	SR estimates only. No program for SARs.	n.a.
Medium	SR estimates for upstream-downstream incremental mortality, plus SARs from PIT-tag studies for Snake River and John Day wild stocks and SARs for Snake River and downriver hatchery stocks (Carson & Leavenworth) (Figure C-4).	SR estimates from Snake and downriver stocks, SARs for Snake and Deschutes wild fall chinook.	SR estimates from Snake and downriver stocks, SARs from PIT tag studies for Snake River wild stocks (current CSS) plus additional PIT-tag SARs from wild downriver stocks (John Day).	n.a.
High	Elements from medium level plus more representative wild stock composition for both SR and SAR estimates, both regions. (candidates: Warm Springs, Yakima, others – monitor Major Population Groups consistent with Status and Trends subgroup)	SR estimates from Snake and downriver stocks, SARs for Snake and multiple downriver wild and hatchery stocks. Candidate wild stocks: Deschutes, N Fk. Lewis, Hanford Reach	SR estimates from Snake and downriver stocks, SARs for Snake and multiple downriver wild and hatchery stocks. Candidate wild: John Day, Deschutes, Warm Springs	n.a. *

* There is no comparable downriver sockeye stock. One could include Wenatchee and Okanagan sockeye stocks to get a general comparison basin-wide.

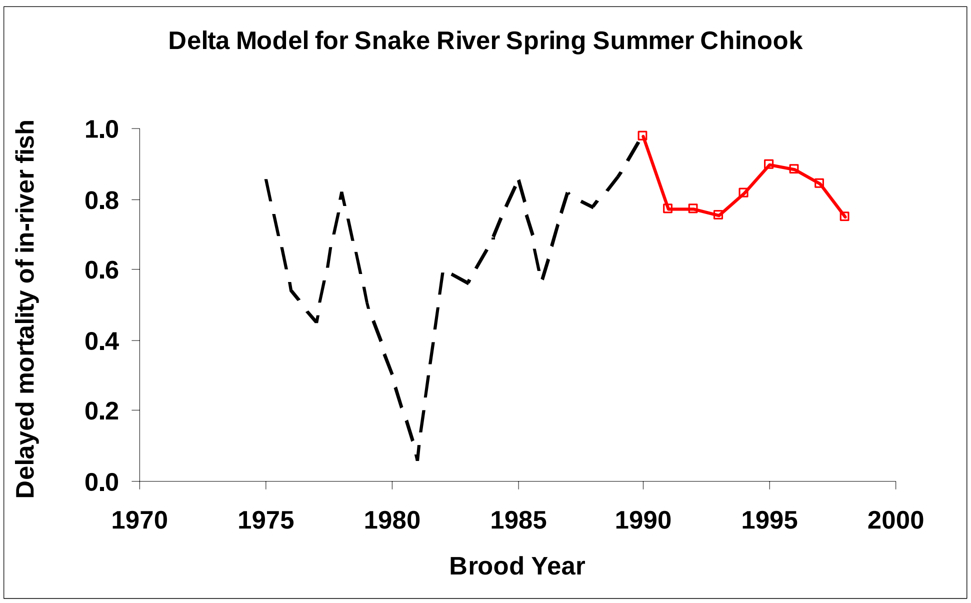


Figure C-4. Updated estimates suggest delayed mortality of in-river fish has remained high even as ocean conditions improved in the late 1990s.

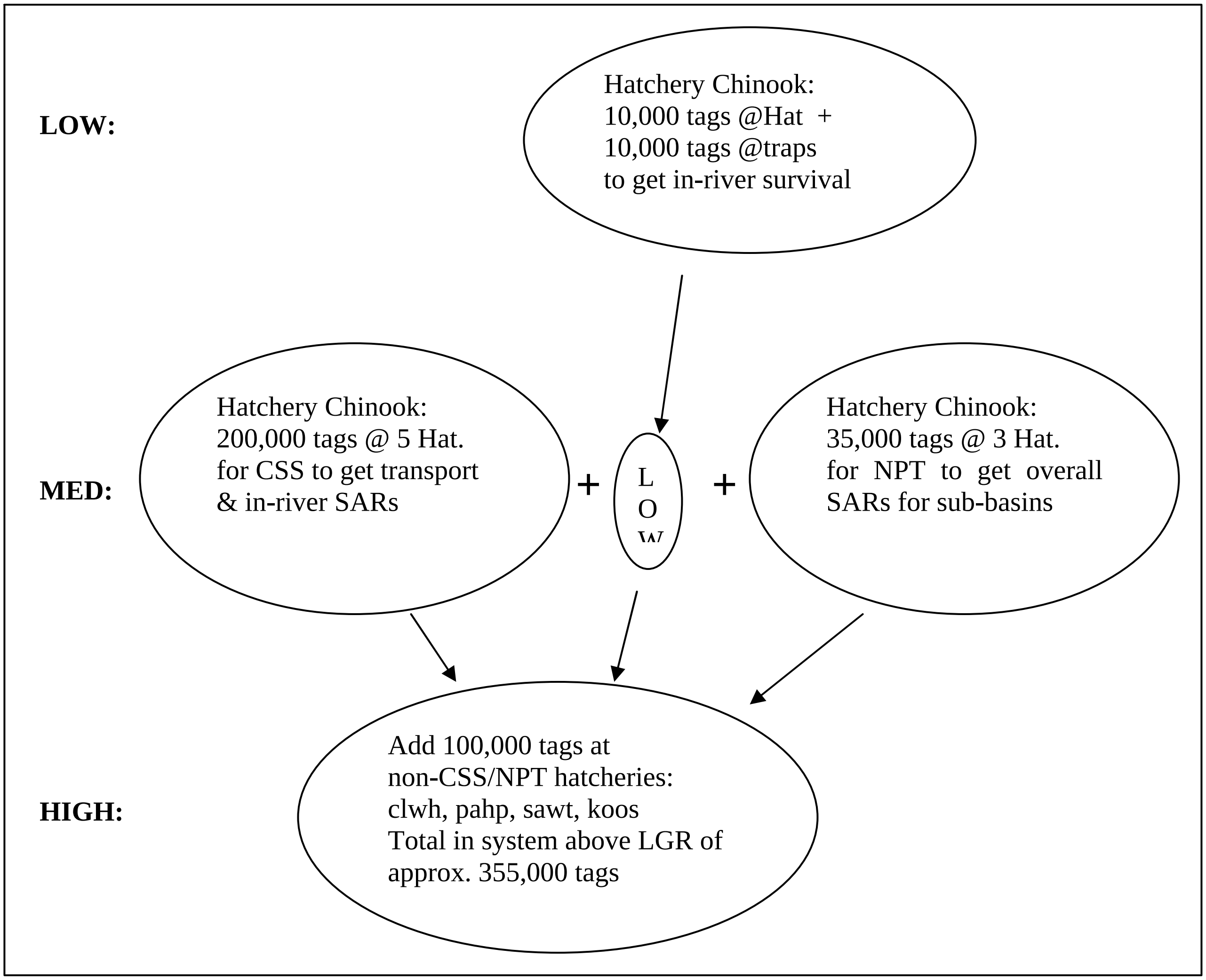


Chart C-1. Increase in PIT-tagging effort for **hatchery Chinook** from baseline (LOW level) with releases for in-river survival estimation purposes to current (MED level) with larger releases for SAR estimation with transport and in-river migrants. The HIGH level increases tagging effort at hatcheries not currently covered within MED level.

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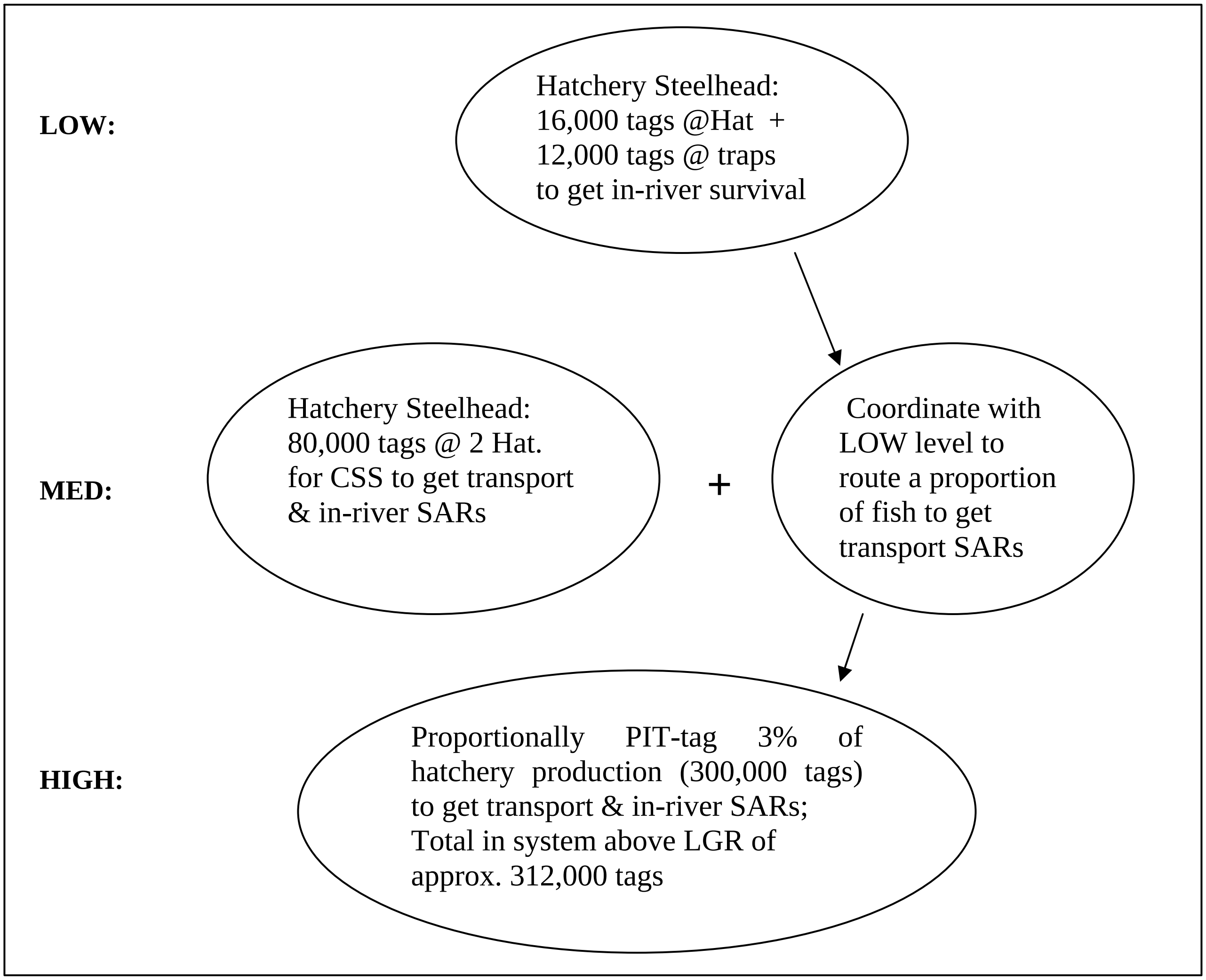


Chart C-2. Increase in PIT-tagging effort for hatchery steelhead from baseline (LOW level) with releases for in-river survival estimation purposes to MED level adding two hatchery releases for SAR estimation of transport and in-river migrants. The HIGH level increases tagging to cover 3% of overall production, proportional to individual hatchery releases number, across the basin.

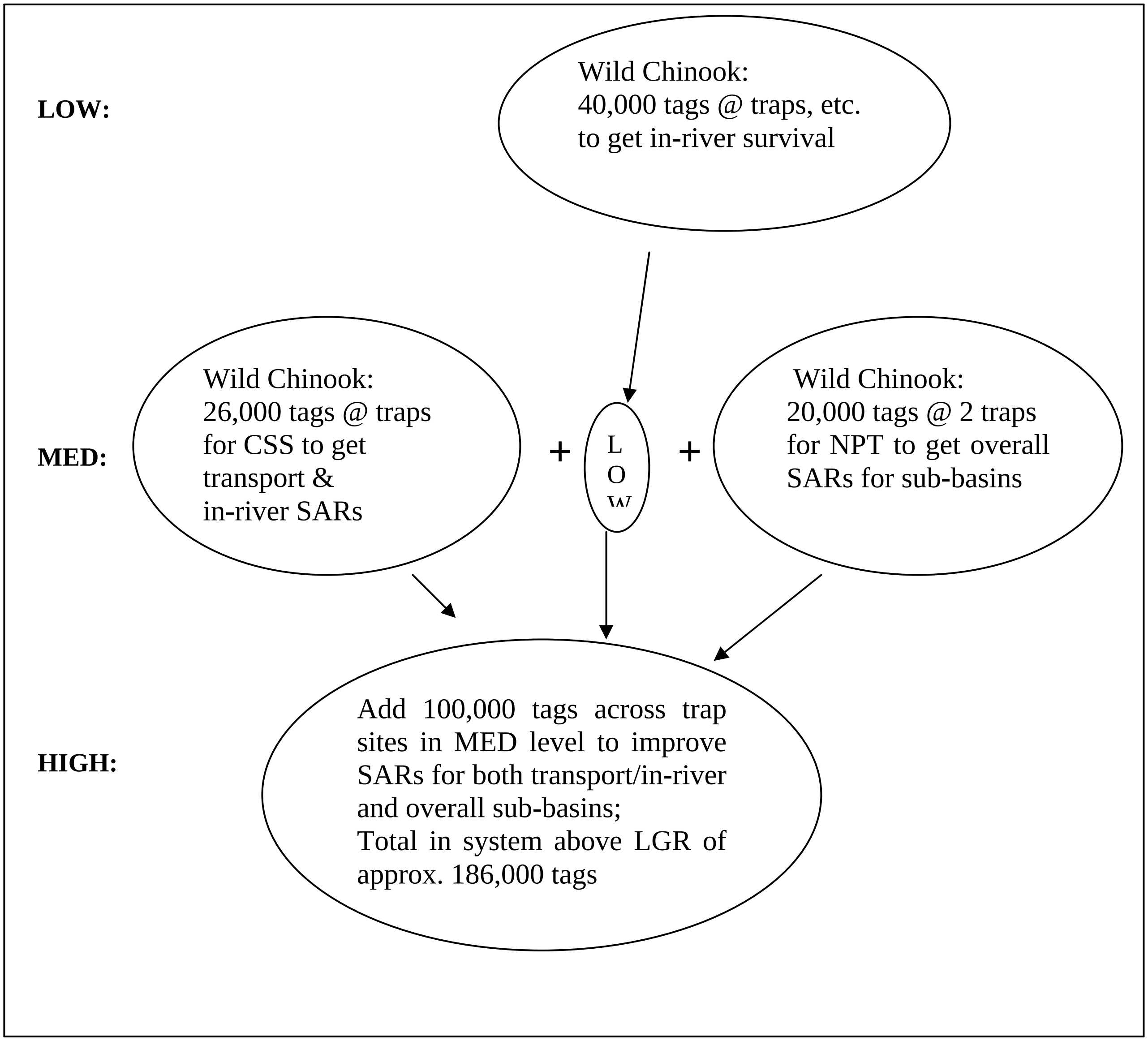


Chart C-3. Increase in PIT-tagging effort for wild Chinook from baseline (LOW level) with releases for in-river survival estimation purposes to current (MED level) with larger releases for SAR estimation with transport and in-river migrants. The HIGH level increases tagging effort at each trap covered within LOW and MED levels.

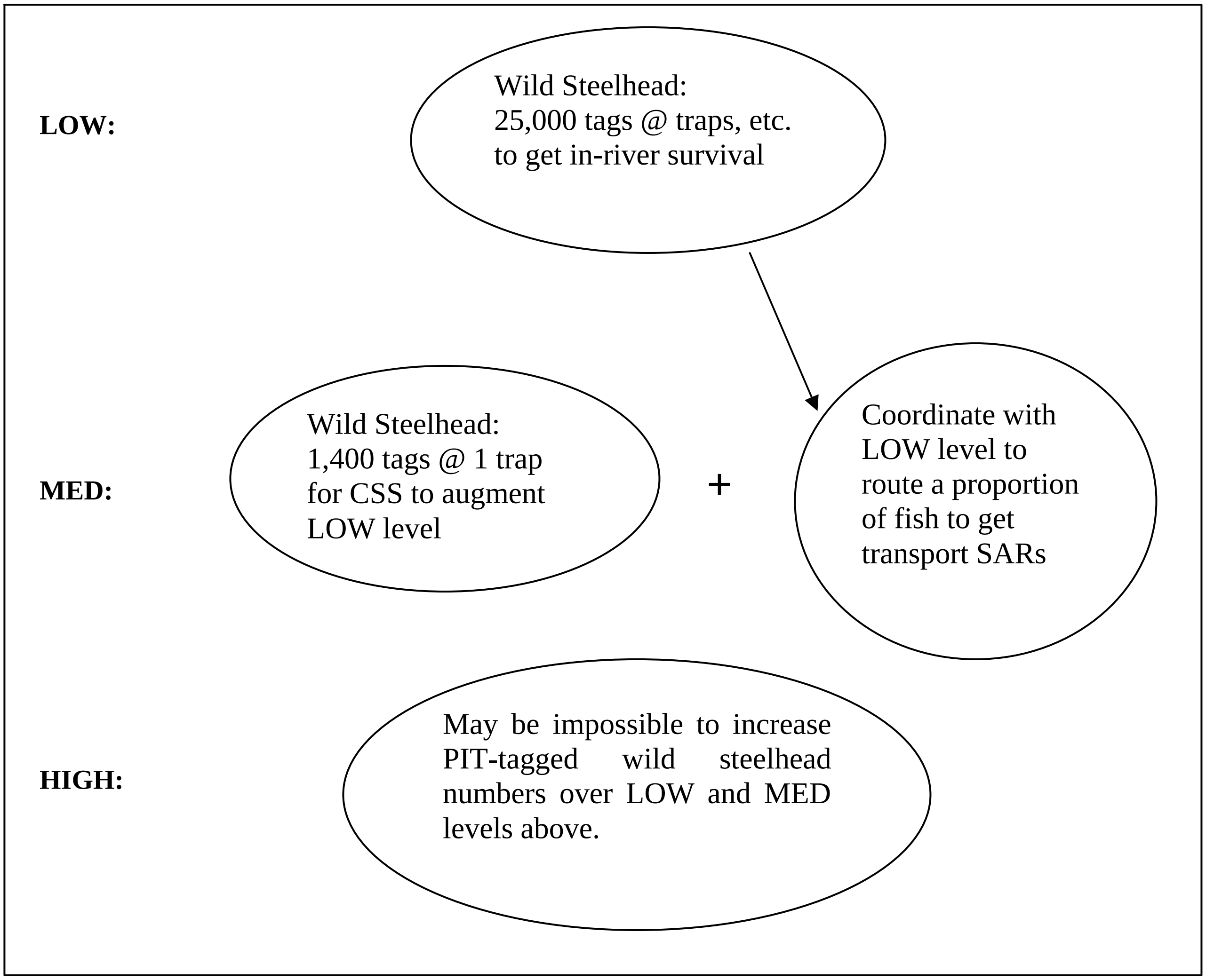


Chart C-4. Difficult to increase PIT-tagging effort for wild steelhead from baseline (LOW level) due to low numbers available for tagging, so emphasis in MED level has been a limited increase in tagging effort with coordination of the routing of more available tagged wild steelhead to transport for SAR estimation of transport and in-river migrants. A HIGH level may not be reachable in the near future from the basin above LGR.

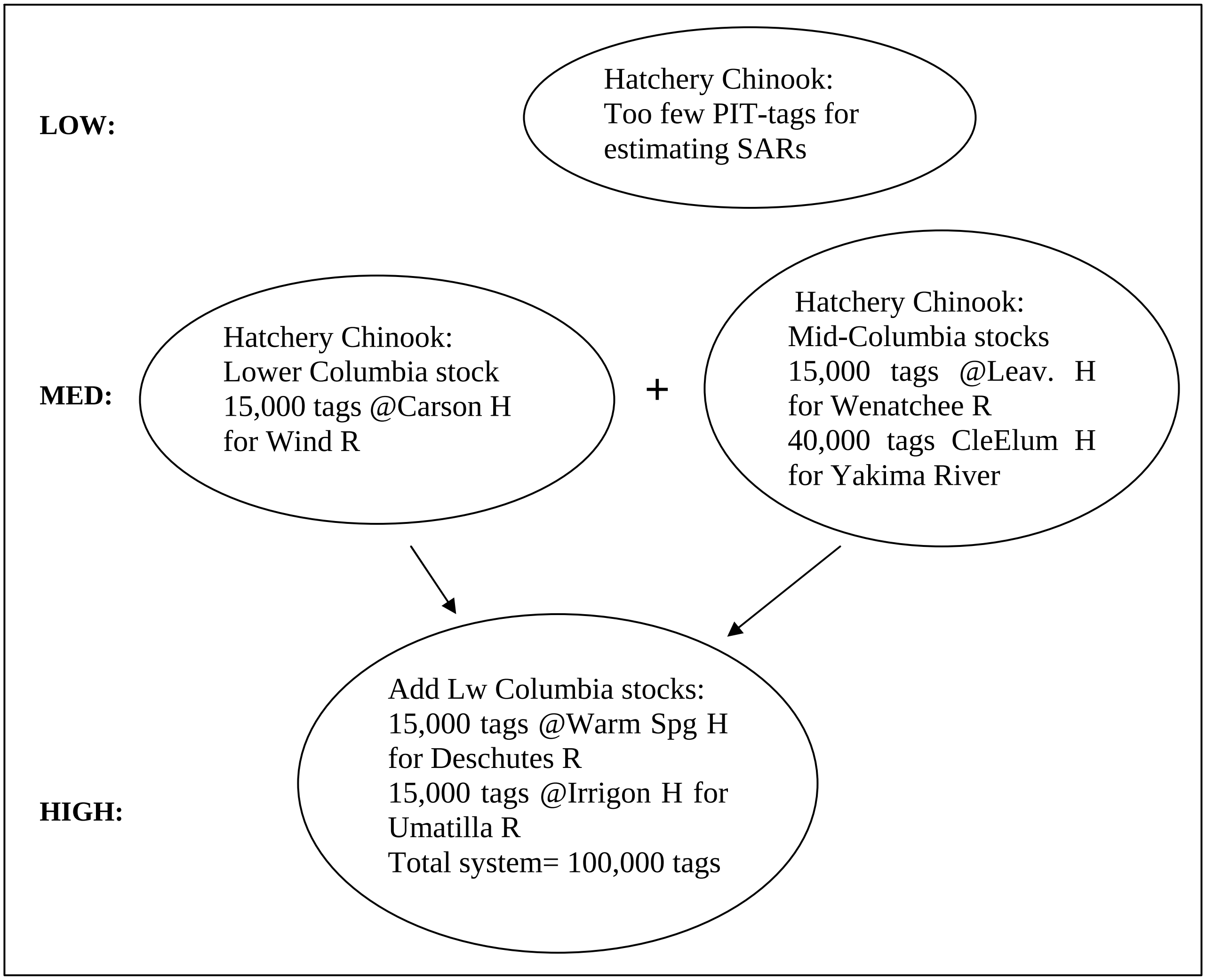


Chart C-5. Increase in PIT-tagging effort for hatchery Chinook from current (MED level) to HIGH level by increasing tagging effort at hatcheries not currently covered within MED level. MED and HIGH provide improved upstream-downstream contrasts.

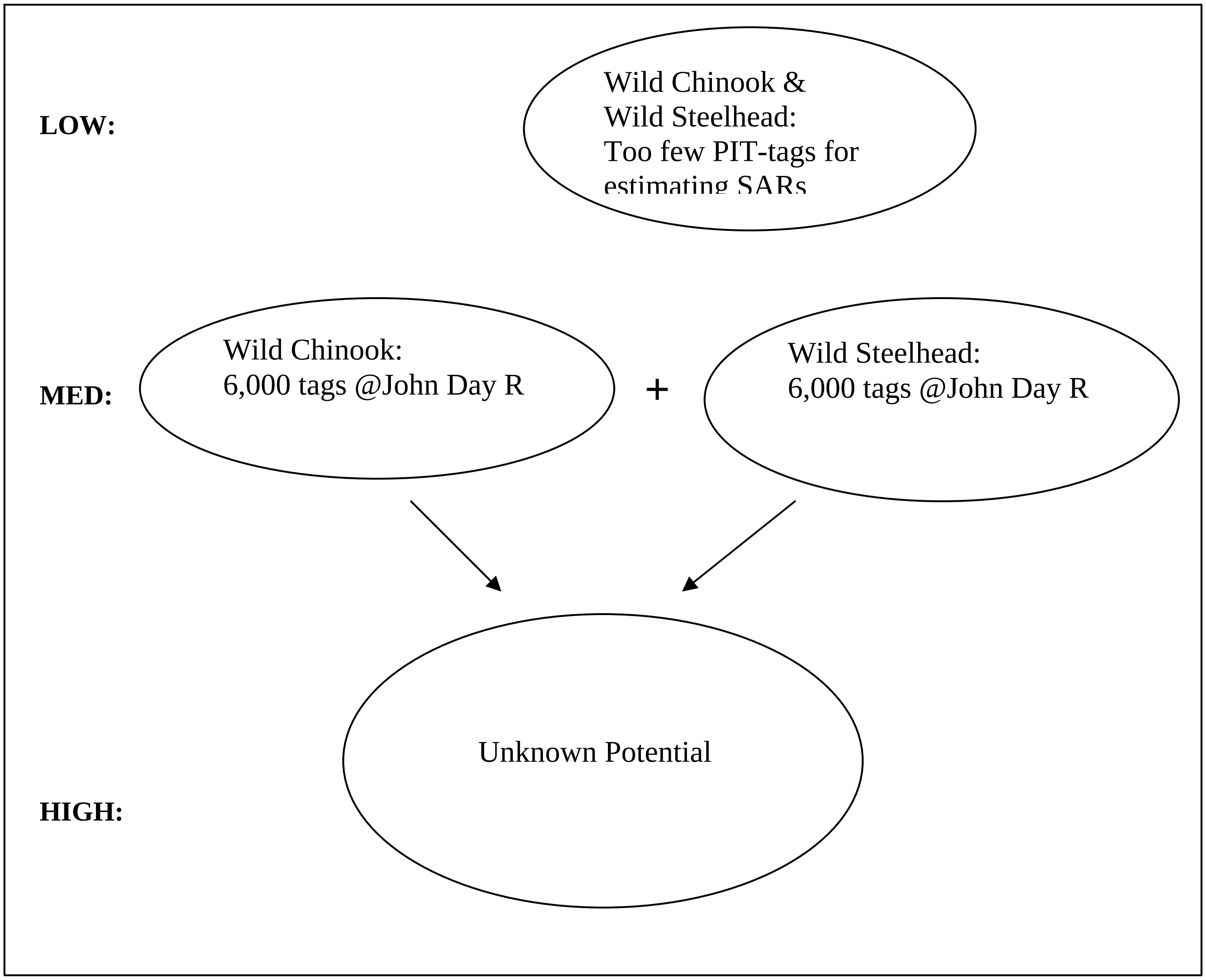


Chart C-6. Current PIT-tagging effort for wild Chinook and Steelhead in John Day River (MED level) may be difficult to reproduce in other Lower Columbia River tributaries, so potential for HIGH level is presently unknown. MED provides improved upstream-downstream contrasts.

Appendix D1. Habitat DQO Summary (General Assessment DQO Steps 1 – 5)

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
1. State the Problem		
Problem:	Habitat degradation and loss of connectivity are considered key factors in the decline of CRB anadromous and resident salmonid populations. Habitat actions are considered a cornerstone of recovery strategies but there is a need to more clearly determine the effectiveness of these actions for increasing salmonid survival rates and production.	
Stakeholders:	States—Washington, Oregon, Idaho Tribes—NPT, SBT, CTUIR, CTWIR, YIN. Colville Tribes Federal—NOAA, USFWS, BPA, USACOE Other—NPPC, CBFWA, conservation groups, Tribal, commercial, sport fishers, landowners & local soil conservation districts	
Non-technical Issues:	Lack of funding; Landowner Permission; Uncoordinated processes; Ill-defined scope and objectives; Jurisdictional overlap (e.g., state, tribal, federal, international boundaries, local regulations); Legal constraints and adjudication	
Conceptual Model:	Habitat actions will first increase habitat distributions and/or improve habitat conditions, and the improved conditions will lead to increased habitat use, improved fish condition, reach-scale abundance, and watershed scale fish survival and productivity. Thus the problem has three components: 1) detect the effect of habitat actions on habitat, 2) detect the effect of changes in habitat on fish populations, and 3) detect the overall effect of habitat actions on fish populations. The scale of effects of actions on habitat may vary, ranging from the local target action area up to the entire watershed. Effects of actions on fish populations could range from individual fish up to the larger population, the extent of which may be dependent on a species life history characteristics.	

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
2. Identify the Decision		
Principal Questions: Includes the key policy questions (numbered) and the clarification elements (bulleted) required for biologists to translate these questions into M & E in the field (e.g., Lemhi example)	1. Have specific habitat projects affected habitat conditions and local fish distribution, population survival, abundance or condition? • What are the species, down to life-history type and gender, of interest? • To what factors do you want to be able to attribute the observed population response? 2. Did groups of habitat projects within a subpopulation or sub watershed on aggregate affect fish survival, abundance or condition in a larger demographic unit? 3. Are particular classes of habitat projects effective? • Are there surrogate measures you can use to answer your questions? 4. What are the mechanistic connections between habitat actions and fish population responses? • What is the spatial boundary of the population for which inferences must be made? • Over what time period(s) do you want to describe this population response? 5. Have habitat projects achieved the expected improvements in conditions? • What is the population response variable you want to evaluate to determine whether a change has occurred? • What is the reference and final condition (i.e., the change to be defined in the population response variable)? • What size of change in population response do you want to be able to detect? • What tradeoffs between uncertainty, errors and costs are you willing to accept (DQO Steps 6 and 7)	✓
Alternative Actions:	Maintain current program and designs of habitat actions Make adaptive management changes to design of current habitat actions to improve performance and increase benefits to fish populations. Discontinue habitat actions as currently designed, adopt different strategy for restoring fish populations	✓
Decision Statement:	Is the current program of habitat actions achieving the objectives for improved fish habitat and fish population performance measures so that program modifications, expansions, or elimination are not required?	✓
3. Identify the Inputs		
Action Levels (critical effect sizes):	Quantitative performance standards need to be specified against which the results of monitoring can be compared. At this time there are few examples of such quantitative values available for the evaluation of habitat actions in the Columbia River basin. Without this guidance it will be necessary to calculate the ability of alternative designs to detect a range of effect sizes that bracket important action levels. These action levels will vary with the scale of the monitoring question (e.g., project level, subbasin, ESU). The minimum detectable effect at different scales will often not be known and may need to be guessed at by analysts until verified in the field.	✓
Information Required:	Data/inventories of past, ongoing, and planned habitat restoration activities (and their hypothesized effects and sequencing) Data/Inventories of past, ongoing, and planned fish and habitat monitoring.	
Sources of Data:	State, tribal and federal programs and NGOs identified in CSMEP meta-data inventories (which may include information from the following sources: AA & NOAA habitat action inventories; IAC/SRFB; IDQ; USFS (AREMP and PIBO); USFWS	
Quality of Existing Data:	Data available apply generally only to Snake spring-summer chinook, and only to actions affecting parr-to-smolt or parr-per-spawner life stages. Additionally, these data were collected through programs that were not designed to evaluate habitat project effectiveness. CSMEP data inventories found little information on programs that specifically collected data to assess the effectiveness of habitat actions in the Snake River (a situation likely common throughout the Columbia Basin)	
New Data Required:	New data and sampling approaches are required. There is a need for statistically valid sampling of both fish and habitat. Better spawner and smolt enumeration may be necessary to detect changes in these metrics due to habitat actions. It appears feasible to obtain this in many locations in the Snake (but not everywhere).	

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
Analytical Methods:	B-A, or BACI designs, where differences between before and after treatment values of performance measures may be compared to Action Levels using a t-test or confidence intervals. To account for important covariates and confounding factors, it may be necessary to apply more complex analytical models. Examples from recent work include linear regression models, non-linear neural networks, and multivariate models. However, because these applications are quite novel, with few published analyses completed to date, it is difficult to predict exactly what methods will be required, especially for detection of habitat action effects on fish survival and productivity.	
4. Define the Boundaries		
Target Populations:	Snake River Spring and Summer Chinook (current focus of Lemhi example) (with linkages to Upper Columbia summer Chinook due to lower river harvest) Redfish Lake Sockeye Snake River steelhead Bull Trout (also addressed in the Lemhi example)	
Spatial Boundaries (study):	Watersheds within the lower Snake River ESU (Lemhi subbasin as focal example)	
Temporal Boundaries (study):	Monitoring duration: Until actions shown to be effective or not Update schedule: example - beginning in year x at 3, 5, 7, 12, and 15 year intervals, and each 4 year period subsequent Time scale over which the data vary: 3-12 years	
Practical Constraints:	Funding Access to sample site, project locations, or data. Statistical constraints such as feasibility of acquiring required data	
Spatial Boundaries (decisions):	Watersheds/ESU within the lower Snake River	
Temporal Boundaries (decisions):	Federal Recovery Plan is scheduled to be completed in April 2006 Adaptive Management schedule (plan check ins are recurring intervals) 2004 FCRPS BiOp is a 15 (?) year plan with milestone and check-in State Recovery Plans have 25 year planning cycle Subbasin Plans have 15 year planning cycle HCP is a 30 year plan	
5. Decision Rules		
Critical Components and Population Parameters:	1) Changes in habitat quantity 2) Changes in habitat conditions (quality) 3) Change in smolts per spawner resulting from habitat actions 4) Changes in parr-to-smolt survival rates from actions	✓
Critical Action Levels (Effect Sizes): - these need to be clearly defined	1) Changes in habitat quantity - X% increase 2) Changes in habitat conditions – X% goes from poor to good? 3) Change in smolts per spawner must be at least X%? 4) Changes in parr-to-smolt survival rates must be at least X%?	✓
If-Then Decision Rules:	If the observed change in the critical population components between treatment (project) and control locations, before and after the implementation of the project is positive and greater than or equal to the critical action level then do more of these project types in similar locations. If an effect is not detected, then the process moves through the adaptive management sequence to assess whether the monitoring and evaluation program was sufficient to be able to detect such a change, or whether the management action, or Action Level criteria need to be changed.	✓

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
Consequences of Decision Errors:	May continue/expand actions that have little beneficial effect (Type I error); May discontinue actions that really do work (Type II error); Undue or increased cost; Continued loss of fisheries; Negative impacts to state and local economies; Federal trust responsibilities not met; Adjudicated requirements not met	✓

[1]Policy Inputs - indicates with a check steps where group needs greater policy level feedback, presentation will elaborate on what feedback is required

Appendix D2. Habitat DQO Summary Lemhi Basin Example

Specific Assessment DQO Steps 1 – 5 Detailed Monitoring Designs DQO Steps 6 - 7

DQO STEPS	LEMHI BASIN EXAMPLE	Policy Inputs[1] (✓)
1. State the Problem		
Problem:	As part of an extended Habitat Conservation Plan (HCP) to restore salmonid populations in the Lemhi a number of water conservation projects are to be implemented in the basin, primary of which are a series of approximately 10-16 actions to reconnect currently isolated tributaries to the mainstem Lemhi River in combination with reestablishment of the historical hydrograph. Evaluating the cumulative success of these actions across a range of fish performance measures is the focus of Lemhi M & E efforts.	
Stakeholders:	IDFG, Shoshone Bannock Tribes, Local landowners, Office of Species Conservation, Upper Salmon Basin Watershed Project, NOAA Fisheries, USFWS	
Non-technical Issues:	Landowner relationships, lack of funding, interagency coordination	
Conceptual Model:	The underlying assumption of the HCP is that as habitat conditions are improved, fish will respond and desired biological effects will be achieved. The conservation objectives are 1) to provide adequate flow to remove or reduce migration barriers, 2) maintain or enhance riparian conditions, and 3) improve instream conditions with respect to cover, temperature, flow, and sedimentation. The desired actions are: 1) reconnect tributaries to the Lemhi River, 2) alter channel morphology to address fish passage, 3) minimize fish entrainment, 4) enhance spawning and rearing habitat, 5) maintain minimum flows, 6) improve riparian corridors, 7) mimic the natural hydrograph. Some are these actions will be quite local, while others will address the entire Lemhi watershed.	
2. Identify the Decision		
Principal Questions	Have the actions implemented under the Lemhi HCP: • Expanded the distribution of rearing juvenile salmonids? • Increased the density of rearing juvenile salmonids? • Increased the number of chinook smolts leaving the Lemhi River? • Caused any changes in seasonal migration pulses and size distribution of Chinook smolts leaving the Lemhi River? • Increased abundance of bull trout in reconnected tributaries? • Increase parr-smolt survival of juvenile Chinook leaving the Lemhi? • Increased returns of adult Chinook salmon to the Lemhi basin?	✓
Alternative Actions:	Maintain current Lemhi HCP program of habitat actions Make adaptive management changes to design of current habitat actions to improve performance of HCP habitat actions and increase benefits to fish populations. Discontinue plans for HCP habitat actions as currently designed, adopt different strategy for restoring fish populations	✓
Decision Statement:	Is the current program of habitat actions achieving the objectives for improved fish habitat and fish population performance measures so that program modifications, reductions/expansions, or elimination are not required?	✓

DQO STEPS	LEMHI BASIN EXAMPLE	Policy Inputs[1] (✓)
3. Identify the Inputs		
Information Required:	*Habitat Performance Measures:* 1. Temperature – creation of summer refugia in reconnected tributaries & adjacent main stem 2. Flow – increased ease of passage & survival of adults & juveniles 3. Substrate & channel characteristics – increase amount of optimal spawning/rearing habitat *Fish Performance Measures:* 1. Spatial distribution (chinook parr, steelhead parr/smolts, all bull trout) 2. Parr density (chinook) 3. Smolts per redd (chinook) 4. Migratory timing & size (chinook) 5. Population abundance (bull trout) 6. Parr-to-smolt survival (chinook) 7. Redd counts (chinook) – to account for effect of seeding level and changes in spawning distribution. 8. Spawning adults (chinook) – weir counts, to account for effect of seeding level	
Sources of Data:	IDFG Chinook redd counts, IDFG snorkel surveys, IDFG juvenile screw traps, IDFG tributary surveys (bull trout redd counts, electrofishing surveys, tissue sampling), IDFG PIT tag detectors at diversion bypasses in Lower Lemhi, Idaho State University telemetry tracking of bull trout in upper Lemhi and Hayden Creek, IDWR flow and temperature gauges at several sites, USGS flow gauges, flow modeling by BoR and University of Idaho, IDEQ FLIR flight of Lemhi mainstem, IDFG water temperature monitoring at remote sites in mainstem and tributaries, baseline instream and riparian habitat inventory (1994) by multi-agency group, PIBO reach inventories.	
Quality of Existing Data:	• Long time series of consistently done single pass-pass chinook redd counts • Little hatchery influence on datasets (no hatcheries on Lemhi) • Estimates of outmigrating juveniles available from traps	
New Data Required:	• Adult weir is needed on Big Timber Creek tributary to evaluate movements of fluvial trout • Expanded telemetry tracking of trout in Upper Lemhi • Increased in the number and frequency of parr density surveys • Systematic steelhead abundance estimates • More information in general is required for other areas of the Lemhi watershed, particularly Hayden Creek and the lower mainstem	
Analytical Methods:	B-A, or BACI designs, where differences between before and after treatment values of performance measures may be compared to Action Levels using a t-test and confidence intervals. To account for important covariates and confounding factors, it may be necessary to apply more complex analytical models. Preliminary designs divide the Lemhi into three Sections: • Section A – mainstem Lemhi and tribs below Hayden Creek. Tentatively an additional control area. • Section B – mainstem Lemhi and tribs above Hayden Creek. Tentatively the Treatment area. • Section C – Hayden Creek and tribs. Tentatively the Control area.	

DQO STEPS	LEMHI BASIN EXAMPLE	Policy Inputs[1] (✓)
4. Define the Boundaries		
Target Populations:	Sp/Summer Chinook Bull Trout	
Spatial and Temporal Boundaries (study):	The sampling design (where, when, and for how long the protocols are activated) is dependent on the spatial contrast and protocol of interest. For example, if a snorkeling protocol were activated to address the effects of channel reconnection in the Lemhi watershed, randomly selected sites could be snorkeled in treatment and control areas of the Lemhi inter- and intra-annually for a period of 20 years. Five-year check-ins could be included for progress evaluation. Alternatively, if a snorkeling protocol were activated to address the effects of channel reconnection in tributary/mainstem junctions, snorkeling would occur at fixed and random sites only within the treatment areas on an inter- and intra-annual basis for a period of 20 years. For either question, sampling intensity (number and size of the sample units) will be determined based on desired statistical attributes (accuracy, precision, and power)	
Practical Constraints:	Funding Access to sample sites, project locations, or data. Statistical constraints such as feasibility of acquiring required data Inherent variability of the Lemhi system	
Spatial Boundaries (decisions):	Lemhi Basin	
Temporal Boundaries (decisions):	Habitat Conservation Plan (HCP) for Lemhi Basin is 30 years duration)	
5. Decision Rules		
Critical Components and Population Parameters (key examples):	Have the actions implemented under the Lemhi HCP **expanded the distribution** of rearing juvenile salmonids within the basin and **increased the density** of rearing juvenile salmonids relative to average mainstem densities by X% over 30 years (with some precision) when the number of spawners, natural disturbances, climate indicators, and habitat conditions not-impacted by the actions have been accounted for? Have the actions implemented under the Lemhi HCP produced at least a 100% **increase in the number** juvenile **spring Chinook** salmon leaving the Lemhi River in 30 years (+/- X%) when the number of spawners, natural disturbances, climate indicators, and habitat conditions not-impacted by the actions have been accounted for? Have the relative **magnitudes of the seasonal migration pulses** and **size distribution** of migrating **Chinook juveniles** leaving the Lemhi River **changed** over the life of the Lemhi HCP? Have the actions implemented under the Lemhi HCP **increased the abundance of bull trout** in reconnected tributaries relative to unconnected tributaries by X% over 30 years (with some precision)? Have the actions implemented under the Lemhi HCP **increased parr-smolt survival** (X% +/-specified precision) of juvenile **spring Chinook** salmon leaving the Lemhi River in 30 years when the number of spawners, natural disturbances, climate indicators, and habitat conditions not-impacted by the actions have been accounted for? Have the **returns of adult Chinook salmon to the Lemhi basin increased** X% (+/-specified precision, see VSP criteria developed by ICTRT) of the life of the Lemhi HCP?	✓
Critical Effect Sizes:	Have not been defined for the Lemhi HCP	✓
If –Then Decision Statements:	These have not yet been defined for the Lemhi HCP (i.e., what would be the appropriate response if the actions do/do not result in expected improvements in habitat/fish performance measures)	✓
Consequences of Decision Errors:	May continue/expand actions that have little beneficial effect (Type I error); May discontinue actions that really do work (Type II error); Undue or increased cost	✓

Steps 6 and 7. Optimizing the Design *(examples)*	Evaluation Design *(How data will be analyzed to answer a question)*	Sampling Design *(Where and When data will be collected)*	Response Design *(What and How data are collected)*
Question 1: Has the spatial distribution of juvenile chinook changed as a result of tributary reconnections?	L: ($ 285K/year; price includes snorkeling, seining, electroshocking, tagging efforts) Compare connected and unconnected tribs within each of sections A, B, C using BACI like design w/covariates	*Hayden Creek (section C)*, *Upper Lemhi (section B)*, and *lower Lemhi (section A)*, including tributaries – several times per year for each site.	Snorkel surveys to estimate parr numbers, several times per year for each site. Verify detection rates with multi-pass electro-shocking.
	M: ($354K/year; price includes snorkeling, seining, electroshocking, tagging efforts) Compare connected and unconnected tribs within each of sections A, B, C using BACI like design w/covariates	Add more sites to Hayden Creek (C), Upper Lemhi (B), and lower Lemhi (A), including tributaries – several times per year for each site	Snorkel surveys to estimate parr numbers, several times per year for each site. Verify detection rates with multi-pass electro-shocking
	H: ($421K/year; price includes snorkeling, seining, electroshocking, tagging efforts) Compare connected and unconnected tribs within each of sections A, B, C using BACI- like design w/covariates.	Same number of sites as M design but more effort towards tagging in Hayden Creek (C), Upper Lemhi (B), and lower Lemhi (A), including tributaries – several times per year for each site	Snorkel surveys to estimate parr numbers, several times per year for each site. Verify detection rates with multi-pass electro-shocking
Question 2: Have the actions implemented under the Lemhi HCP increased parr-smolt survival of juvenile spring Chinook salmon leaving the Lemhi River?	L: (60K/year; Cost assumes Question 1 work paid for PIT tagging of all fish captured + cost of screwtrap operation) Compare between sections A, B, & C using BACI-like design w/covariates.	Hayden Creek (Section C), Upper Lemhi (Section B), and lower Lemhi (Section A) once per year.	Collection and tagging of parr during parr surveys plus collection of parr in screwtraps and detection of tagged smolts at Lower Granite dam.
	M: ($60K/year; Cost assumes Question 1 is paid for tagging of all fish captured with PIT tags + cost of screwtrap operation) Compare between sections A, B, & C using BACI-like design w/covariates. This design provides more power than the low design because more fish are tagged at more sites. There are no additional tagging costs because these are included in work to address Question 1.	Hayden Creek (C), Upper Lemhi (B), and lower Lemhi (A) once per year.	Collection and tagging of parr during parr surveys plus collection of parr in screwtraps and detection of tagged smolts at Lower Granite dam.

Steps 6 and 7. Optimizing the Design *(examples)*	Evaluation Design *(How data will be analyzed to answer a question)*	Sampling Design *(Where and When data will be collected)*	Response Design *(What and How data are collected)*
	H: ($69-97K/year; Cost assumes all fish captured under Question 1 were tagged with PIT tags + cost of screwtrap operation+ cost of either 3 mainstem PIT tag detectors, 11 mainstem detectors, or mainstem and tributary detectors) Compare connected and unconnected tribs within each of sections A, B, C using BACI- like design w/covariates. This is the most powerful design. The addition of several PIT tag detectors, multiple treatment and control sites and more tagged fish will allow better estimation of large scale effects on fish survival and distribution as well as the development and testing of relationships between habitat changes and fish survival.	Hayden Creek (C), Upper Lemhi (B), and lower Lemhi (A) and tributaries multiple times a year.	Collection and tagging of parr during parr surveys plus collection of parr in screwtraps and detection of tagged parr and smolts in tributaries and mainstem Lemhi and at Lower Granite dam.

Appendix E. Hatchery DQO Summary

<table>
<tr><th>DQO STEPS</th><th>SNAKE RIVER BASIN PILOT</th><th>Policy Inputs[1] (✓)</th></tr>
<tr><td colspan="3">1. State the Problem</td></tr>
<tr><td>Problem:</td><td>Artificial propagation is used extensively as a management tool for Pacific salmon in the Snake River Basin. Hatchery programs are operated to contribute to three general management goals:
1. Harvest Augmentation: to provide fish for tribal, commercial, and recreational opportunity while keeping impacts to natural populations within acceptable limits.
2. Supplementation: the use of hatchery fish to enhance the viability of natural populations while keeping impacts to non-target populations within acceptable limits.
3. Genetic Conservation: maintain genetic resources of imperiled populations to allow for reintroduction of supplementation in the future.
Considerable uncertainty remains, however, regarding benefits and risk of supplementation and conservation hatchery programs, as well as, risks to natural populations for harvest augmentation programs.</td><td></td></tr>
<tr><td>Stakeholders:</td><td>States—Washington, Oregon, Idaho
Tribes—NPT, SBT, CTUIR, CTWIR, YIN
Federal—NOAA, USFWS, BPA, USACOE
Other—NPPC, CBFWA, conservation groups, Tribal, commercial, sport fishers</td><td></td></tr>
<tr><td>Non-technical Issues:</td><td>Appropriate people with enough time to assess ongoing M & E programs, develop integrated study plans, and assess if uncertainties are being adequately addressed.
Lack of adequate funding for data collection for supplementation program M & E projects</td><td></td></tr>
<tr><td colspan="3">2. Identify the Decision</td></tr>
<tr><td>Principal Questions:</td><td>There is a large suite of monitoring questions required in evaluation of hatchery programs (the group identified 11 questions for harvest augmentation, 25 for supplementation and 5 for conservation hatcheries) Examples of some principal questions include:
<u>Harvest Augmentation:</u>
• To what degree does the hatchery program meet harvest objectives?
• What is the magnitude and distribution of hatchery strays into natural populations
<u>Supplementation</u>
• What is the ratio of R/S for hatchery produced and naturally produced fish
• What is the relative reproductive success of natural spawning hatchery and natural fish?
<u>Conservation</u>
• Questions within this category are being deferred until later date
For the purpose of initial CSMEP design work we focused on only a smaller subset of key Harvest and Supplementation hatchery questions</td><td>✓</td></tr>
<tr><td>Alternative Actions:</td><td>Make adaptive management changes to hatchery programs to improve performance and reduce impacts on natural populations.
Reduce the magnitude of reliance on hatcheries, including elimination of some hatchery programs.
Modify existing hatchery facilities to improve effectiveness.</td><td>✓</td></tr>
</table>

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
Decision Statements:	Is the harvest augmentation hatchery program achieving harvest contribution objectives and keeping impacts to natural populations at acceptable levels so that program modifications, reductions, or elimination are not required? Is the supplementation hatchery program enhancing the viability of the target natural population and keeping the impacts to non-target populations at acceptable levels so that program modifications, reductions, or elimination are not required? Is the genetic conservation hatchery maintaining the genetic resources of the imperiled population so that program modifications, reductions, or elimination are not required?	✓
3. Identify the Inputs		
Action Levels (critical effect sizes)	The level of change that would trigger an adaptive management action varies considerably between each hatchery objective and the associated metrics. Unfortunately, the vast majority of hatchery programs do not identify quantitatively “acceptable limits”. It would be difficult to describe generic action levels for each metric that would trigger an adaptive change in a specific hatchery program or groups of programs. Instead, decisions must be framed around two general factors, the perceived value of the particular metric monitored as well as the variance or degree of confidence in this value.	✓
Information Required:	The range of information required to address the suite of hatchery questions is extensive. We identified a need for information from 65 performance measures across hatchery, supplementation and conservation hatcheries. Examples of some of the information needs include: Harvest Augmentation Hatcheries: • Commercial, recreational, and tribal harvest contributions by fishery • Smolt-to-adult survival • Progeny-to-parent ratios • Stray rates • Proportion of natural spawners that are hatchery strays Supplementation Hatcheries: • Recruits per spawner for hatchery/natural fish • Hatchery/Natural fish abundance • Hatchery/Natural fish harvest rates • Hatchery/Natural fish spawning distribution • Smolt to adult survival for natural/hatchery fish • Allelic richness	
Sources of Data:	Data resides in a variety of sources. Each hatchery program has some data for some metrics. No programs have data for all metrics. The temporal and spatial scales, as well as, the number of metrics for which there are data varies considerably among programs.	
Quality of Existing Data:	Harvest augmentation hatcheries: catch contribution, catch distribution, and smolt-to-adult survival data is available. In some cases, however, specific harvest objectives are not well defined. The data available for stray rates, and particularly for stray impacts to natural populations, is limited. Supplementation hatcheries: little data available because many programs are early in implementation and the data sets are for a limited number of years. In addition, most supplementation hatchery programs are not collecting data for all the important metrics, and there are no pre-treatment data in some cases. There is a lack of data from control or reference streams that can be used for comparisons.	
New Data Required:	There is a need to conduct an audit of each hatchery program to determine what objectives and metrics are being assessed and at what level of adequacy. There is a need for additional years of data from currently well designed hatchery M&E programs, and for greater sampling for programs which have inadequate monitoring designs (e.g., - more extensive juvenile tagging; more extensive spawning survey efforts; development of comprehensive genetics monitoring) This needs to be a large multi-basin and multi-generation effort.	

DQO STEPS	SNAKE RIVER BASIN PILOT	Policy Inputs[1] (✓)
Analytical Methods:	Given the wide range of hatchery objectives and associated metrics, a suite of analytical approaches are required, including: • Pre-post/control comparisons (BA, BACI) • Relative performance comparisons between hatchery/natural fish • Standard parametric and non-parametric tests • Genetic analyses • Time series analyses • Stock recruitment analyses • EMAP designs	
4. Define the Boundaries		
Target Populations:	Snake River Spring/Summer Chinook ESU - 33 natural populations Snake River Steelhead ESU - 25 natural populations Snake River Fall Chinook ESU - 1 natural population Snake River Sockeye ESU - 1 natural population	
Spatial Boundaries (study)	The focus areas are in the Snake River Basin. However, ocean and in-river harvest downstream from the Snake are included in the boundary, as are the locations of populations where Snake River fish stray.	
Temporal Boundaries (study)	There will be variable temporal boundaries dependent on the specific question and associated metrics. Temporal durations include life-stage specific, annual, generational, and multi-generational.	
Practical Constraints:	There are financial, logistical, and technical constraints. In addition, there is lack of pre-treatment or control system data available around which to frame analyses.	
Spatial Boundaries (decisions):	The first level of assessment is hatchery program-specific, the second level is the target natural population, the third level is at the major population grouping, the fourth level is at the ESU, and the fifth level will be outside the ESU.	
Temporal Boundaries (decisions):	Adaptive decisions can be made annually for each program; however, the temporal scale is linked to the timeframe for availability of adequate data. Adequate data, in some cases, is many salmon generations out in the future.	
5. Decision Rules		
Critical Components and Population Parameters; Critical Action Levels: If-Then Decision Statements;	While the group was successful at defining hatchery monitoring questions and associated information needs, they were less successful at defining appropriate "decision rules." Very few hatchery programs provide quantitative guidance for the use of data in an adaptive management framework. For example, many hatchery programs communicate their goals as "supplement natural populations while keeping impacts to non-target populations within acceptable limits." The vast majority of programs do not identify quantitatively what "acceptable limits" are or define what their response would be if these acceptable limits were exceeded. This is a complex issue, primarily for three reasons: 1) acceptable limits are not purely scientific, since hatcheries have legal mandates and a complex societal basis; 2) the long and short-term biological affects of impacts at various levels are largely unknown and are unlikely to manifest uniformly across all hatchery programs; and 3) decisions regarding hatchery management are typically made based on the interaction of multiple questions rather than the result of a single question, thus creating a difficult decision matrix.	✓
Consequences of Decision Errors	May continue/expand hatchery actions with little beneficial effect or even detrimental effects on fish populations; May discontinue hatchery actions that do have beneficial effects on fish populations; Unnecessary costs; Negative impacts to fisheries harvest; Continued loss of fisheries	

[1]Policy Inputs - indicates with a check steps where group needs greater policy level feedback, presentation will elaborate on what feedback is required

Steps 6 and 7. Optimizing the Design *(examples)*	Evaluation Design *(How data will be analyzed to answer a question)*	Sampling Design *(Where and When data will be collected)*	Response Design *(What and How data are collected)*
Harvest Augmentation Q: What is magnitude and distribution of hatchery strays into natural populations?	L ($ 1,330,000) 38 new sites @ 35 k - high tag rates (rotating); lower replication = longer study duration	- sampled across CRB at sites selected by stratified design (84 sites + 10 additional EMAP sites) - sampled annually and also opportunistically	- multiple pass carcass surveys for CWT or PIT tagged fish
	M ($2,070,000) 69 new sites @ 30K - high tag rates (rotating); mod replication = mod study duration	- sampled across CRB at sites selected by stratified design (176 sites + 10 additional EMAP sites) - sampled annually and also opportunistically	- multiple pass carcass surveys for CWT or PIT tagged fish
	H ($2,425,000) 97 new sites @ 25k - high tag rates (rotating); higher replication = shorter study duration	- sampled across CRB at sites selected by stratified design (231 sites + 20 additional EMAP sites) - sampled annually and also opportunistically	- multiple pass carcass surveys for CWT or PIT tagged fish
Supplementation Q: What is the relative reproductive success of natural spawning hatchery and natural origin fish?	L) ($3,000,000/year-approx.) ($250,000 x 12 sites) Inference via BACI design	Monitored at 3 strata x 2 replicates + reference = 12 sites, Minimum of 2-3 generations	Abundance of Progeny/adults, change in productivity (identical sampling infrastructure and tagging program as for high option)
	H ($1,800,000/year-approx.) ($300,000 x 6 sites) Genetic parentage analysis	Monitored at 3 strata X 2 replicates = 6 sites, Variable duration depending on the contrast	Genetic sampling of adults and progeny and assignment of juveniles/adults to parents

Principle CSMEP Hatchery Questions to be addressed:

Throughout the FY 2005 contract period, the hatchery subgroup identified a number of questions critical to the evaluation of hatchery management, and has reviewed numerous existing and proposed hatchery Research, Monitoring, and Evaluation (RME) plans within the Columbia River Basin. Following this review, the subgroup has concluded that existing and proposed hatchery RME plans (if fully implemented) are likely to address the majority of the management questions identified by the subgroup. However, the subgroup has also concluded that a number of questions regarding the *effectiveness* of hatcheries as a class of actions are unlikely to be adequately addressed by existing and proposed hatchery RME. These effectiveness questions (listed below) will likely be efficiently and comprehensively addressed only through the implementation of a stratified and representative study design that spans the entire Columbia River Basin. As such, the study designs to address these questions are best developed within a collaborative process that can rely on the expertise of the multiple tribal, state, and federal agencies with operational jurisdiction and familiarity with the facilities. This expertise exists within CSMEP and has been useful in understanding the high level of diversity represented by individual programs. With appropriate stratification, this diversity can be leveraged to identify the mechanistic linkages of individual programs to broader monitoring questions that evaluate the overall *effectiveness* of hatchery strategies at the regional scale. These broader-scale hatchery program effectiveness questions (as opposed to individual hatchery operation questions) will become the focus of CSMEP designs intended to address larger scale multi-hatchery questions (listed below) that can be stratified across the region.

Harvest Augmentation Hatcheries: *To what extent can hatcheries be used to assist in meeting harvest management goals while keeping impacts to natural populations within acceptable limits?*

Regional Question	Priority
What are annual harvest contributions and catch distribution of hatchery produced fish?	H
To what degree does the hatchery program meet harvest objectives?	H
What is the magnitude and distribution of hatchery strays into natural populations?	H
What are the proportions of natural spawning stray hatchery fish in non-target natural populations and their impact on the viability of natural populations?	H
What are the disease agents and pathogens in hatchery fish, to what degree are these agents transmitted to natural fish, and what are the impacts of such tranmissions?	H

Supplementation Hatcheries: *To what extent can hatcheries be used to enhance viability of natural populations while keeping impacts to non-target populations within acceptable limits?*

Regional Question	Priority
What is the relative reproductive success of natural spawning hatchery and natural fish?	H
What are the effects of hatchery supplementation on productivity and abundance of non-target natural and hatchery-influenced populations?	H
What are the relative effective population sizes of hatchery supplemented vs. unsupplemented populations?	H
What is the magnitude and distribution of hatchery strays into natural populations?	H
What are the proportions of natural spawning stray hatchery fish in non-target natural populations and their impact on the viability of natural populations?	H
What are the catch contribution and catch distribution of hatchery fish?	H
What are the effects of alternative hatchery production strategies on juvenile characteristics, survival rates, adult life history characteristics, and spawner distribution?	H

Regional Question	Priority
What are the disease agents and pathogens in hatchery fish, to what degree are these agents transmitted to natural fish, and what are the impacts of such tranmissions?	H
What are the effects of status and trends of habitat on supplemented populations?	H
What are the status and trends of naturally produced juvenile abundance of supplemented populations?	H
What are the effects of the hydrosystem on productivity and survival of supplemented populations?	H

Appendix F. Harvest DQO Summary

DQO STEPS	SNAKE RIVER BASIN PILOT (Snake River spring/summer chinook ESU)	Policy Inputs[1] (✓)
1. State the Problem		
Problem:	Targeted fisheries on Chinook, steelhead, coho, and (in some years) sockeye are managed by setting allowable catch and catch allocation limits and open periods for each fishery prior to opening a fishery (considering escapement goals and preseason and updated run predictions) and then adjusting those openings and limits as runs develop and catches are totaled. Both mark-selective and non-selective fisheries exert mortality on non-targeted stocks of anadromous, adfluvial, and resident species that are incidentally intercepted. Removal of fish in fisheries can potentially affect the number of mature adults that spawn in natural and artificial production areas on a seasonal basis and potentially affect diversity and spatial structure of population components on a longer term basis if removals are selective of phenotypes (e.g. size, sex or age). Fishing opportunity in areas with mixed stocks and species inevitably results in bycatch of non-targeted species or stocks. Because such bycatch counts towards the harvest of the bycaught species, it must be accounted for. If the bycatch in a particular non-targeting fishery exceeds allowable catch or impacts set for that fishery or some other pre-specified limit, then management actions will come into play. The type of action will depend on the fishery, on the bycaught species and on management agreements in place. Take includes direct harvest, indirect harvest (released fish that die or non-target landed fish). It may also be worth considering the impact on fitness of catch and released fish.	
Stakeholders:	State agencies and tribes that co-manage fisheries impacting anadromous fish populations: • Confederated Tribes of the Umatilla Indian Reservation • Confederated Tribes of the Warm Springs Reservation • Yakama Nation • Idaho Department of Fish & Game • National Oceanic and Atmospheric Administration Fisheries • Nez Perce Tribe of Idaho • Oregon Department of Fish & Wildlife • Shoshone-Bannock Tribes of Fort Hall • U.S. Fish & Wildlife Service • Washington Department of Fish and Wildlife	
Non-technical Issues:	Impacts to fish from other "H's" and changes to fish marking programs are both technical and policy issues; other non-technical issues are changes to artificial production schedules, consumer market demands and health concerns (toxins).	
Conceptual Model:	Track components of run size and the methods of estimating them through the Columbia River tribal, commercial and sport fisheries from the lower estuary to the tributaries of the Snake River basin for Snake River spring-summer chinook salmon. For example, natural origin Snake River spring Chinook salmon can be intercepted in mark-selective commercial and sport fisheries downstream of Bonneville Dam, selective sport fisheries between Bonneville and McNary dams, and in the lower Snake River; in traditional Treaty fisheries between Bonneville and McNary dams; and in terminal selective sport and Treaty fisheries in Snake Basin tributaries. Snake River natural spring /summer chinook are assumed by managers to have very low impact rates in ocean fisheries.	
2. Identify the Decision		
Principal Questions:	What are the inseason estimates of run size and escapement for each management group (target and non-target) and how do they compare to preseason estimates? What is the target and nontarget harvest and when is it projected to reach allowable levels?	✓
Alternative Actions:	Open or close various fisheries; Increased or decreased harvest opportunities for fishers.	✓

DQO STEPS	SNAKE RIVER BASIN PILOT (Snake River spring/summer chinook ESU)	Policy Inputs[1] (✓)
Decision Statements:	Open Fishery *X* during periods *a, b, and c* subject to the catch not exceeding *Y* for target species *M* and *Z* for non-target species *M*. Once the bycatch is projected to reach to quota, then the fishery would be halted, postponed, or reshaped.	✓
3. Identify the Inputs		
Information Required:	Catch, Effort, CPUE, stock identification (for mainstem spring season fisheries, the only stock identification used in season is for below Bonneville fisheries where separation between Willamette and Upriver stocks are made. Age-specific estimates of the numbers of each management unit (stock) in the escapement. Age specific data is only used in forecasting, not in in-season fishery management.	
Sources of Data:	Mainstem commercial, subsistence, ceremonial, and sport fisheries, Hatcheries, dams, previous fisheries, natural spawning estimates, and mark samples.	
Quality of Existing Data:	The main source of uncertainty is statistical sampling error and perhaps bias due to assumption violations, such as error in assumptions regarding release mortality rates. Decision making is typically based on point estimates of take and addresses the uncertainties by adopting conservative actions. (See Table at back of handout)	
New Data Required:	More data, more research on mortality rates resulting from interceptions with varying gears (e.g. hook and release, tangle net release, and others). There is considerable uncertainty in tangle net release mortality rates. There have also been wide ranging estimates made for hook and release mortality rates. There are debates about whether hook location, barbed vs. barbless or environmental (i.e. temperature) are the most important determinant of release mortality. There are no estimates currently in use for net dropout rates for Columbia River net fisheries. Expansion of Genetic Stock Identification (GSI) baseline sampling and in-season sampling of catch and escapement. There has been only limited GSI sampling of fish from harvest. (See Table at back of handout)	
Analytical Methods:	Stock-recruitment relationships have been used to set escapement goals for some Columbia Basin salmon populations. Cohort analyses have been used to develop pre-season expectations. There are no agreed to escapement goals for the entire Snake River spring/summer chinook ESU. There are some tributary return goals, but these have not been useful for mainstem fishery management. (See Table at back of handout)	
4. Define the Boundaries		
Target Populations:	ESA listed salmonids including Snake Basin Chinook, sockeye, and steelhead ESU's. It should be noted that the Snake River spring/summer ESU includes all naturally spawning spring/summer chinook populations in the Snake Basin except from the Clearwater. This fact complicates management below the Mouth of the Clearwater, because estimates of natural origin Snake River spring/summer chinook below the Clearwater are a mix of listed and non-listed fish. All anadromous populations impacted by mainstem and tributary fisheries during the time that Snake River spring Chinook are migrating upstream.	
Spatial Boundaries (study)	The Columbia River below Priest Rapids dam, Snake River to the WA, ID border, as well as terminal fisheries in Snake River tributaries.	
Temporal Boundaries (study)	Annual March through June for all mainstem fisheries May through July for Snake Basin tributary fisheries.	
Practical Constraints:	Budget; time required to analyze sample data in-season.	
Spatial Boundaries (decisions):	The Columbia River below the mouth of the Snake River, Snake River to the WA, ID border, as well as terminal fisheries in Snake River tributaries.	
Temporal Boundaries (decisions):	Annual and in-season when data are available.	

DQO STEPS	SNAKE RIVER BASIN PILOT (Snake River spring/summer chinook ESU)	Policy Inputs[1] (✓)
5. Decision Rules		
Critical Components and Population Parameters:	Harvest number, harvest rate, age and stock composition, escapement by stock.	✓
Critical Action Levels (Effect Sizes):	Varies by return size. Formulas set by compact and treaty requirements.	✓
If-Then Decision Rules:	1. *If* the catch of upriver spring chinook and Snake River spring or summer Chinook approaches X% of the total upriver spring chinook and Snake River spring summer chinook run size at the Columbia River Mouth in the mainstem Columbia River tribal spring management period Zone 6 fishery, *then* the fishery will be closed. X% depends on the allowed harvest rate in the management agreement that is based on the updated river mouth run size. There is a stepped harvest rate schedule in the current mainstem management agreement. 2. *If* the catch and/or handling mortality of wild upriver spring chinook and Snake River spring/summer Chinook approaches X% of the wild run size in the mainstem Columbia River non-tribal commercial or select area fishery, *then* the fishery will {decision type here – in-season adjustments to effort level, gear type, duration, etc.}. The decision will depend on if the sport/commercial allocation limit is being approached or if the overall wild impact limit is being approached. 3. *If* the catch and/or handling mortality of wild upriver spring chinook and Snake River spring /summer Chinook approaches X% of the cumulative run in the mainstem Columbia River recreational fishery, select area sport fishery, or Washington Lower Snake River sport fishery, *then* the fishery will {decision type here – in-season adjustments to effort level, gear type, duration, etc.}. The decision will depend on if the sport/commercial allocation limit is being approached or if the overall wild impact limit is being approached. 4. *If* the catch and/or handle of the Snake River spring or summer Chinook approaches X% of the cumulative run in the terminal area tribal fishery in any part of the Snake River Basin, *then* the fishery will {decision type here – in-season adjustments to effort level, gear type, duration, etc.}. The actual harvest limits in any terminal fishery depend both on the allowed ESA take if any and the state tribal allocation agreements and escapement objectives that may be in place in any year. 5. *If* the catch and/or handle of the Snake River spring or summer Chinook approaches X% of the cumulative run in the terminal area non-tribal fishery of the Columbia River, *then* the fishery will {decision type here – in-season adjustments to effort level, gear type, duration, etc.}. The actual harvest limits in any terminal fishery depend both on the allowed ESA take if any and the state tribal allocation agreements and escapement objectives that may be in place in any year.	✓
Consequences of Decision Errors:	Management is dependent on point estimates rather than on hypothesis testing so a discussion of precision is relevant as opposed to a discussion of Type I and Type II error. There is no defined precision criteria except that a 20% sample is the goal for species composition.	✓

[1]Policy Inputs - checked steps indicate where group really needs policy feedback

Steps 6 and 7. Optimizing the Design *(examples)* Evaluation Design *(How data will be analyzed to answer a question)* Sampling Design *(Where and When data will be collected)* Response Design *(What and How data are collected)*
Refer to following table

From Tables A1 and C1.									For each population:							
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessment of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisition	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
Stock composition	Visual Stock Identification	Biological sampling for phenotypic characteristics (light vs. dark faces).	Above Bonneville ESU's as a whole vs. Willamette	To Spring Chinook below Bonneville fisheries or other stock-selectivity based on run timing	quick, inexpensive, non-invasive,	low resolution; subjective, uncertain accuracy, limited applicability	L	Biosampling of catch								
	PIT tags	Tagging program and recovery program (with tag detectors).	Individual fish,	List of hatchery and wild PIT tagging programs (Jeff)		tagging expense, cannot tag all sizes, tagging mortality higher compared to CWT, tags lost if fish cleaned before sampling, detection requires investment in detectors (no visible mark); not enough wands in sampling programs to take advantage of the existing PIT tags.	H	Marks released by origin and recoveries from appropriately sampled catch					High	High	High	Low
	Coded-wire tags	Tagging program and recovery program. Need fin clip or wands to detect CWT presence so CWT can be removed for later analysis.	Tag group (typically 10,000-200,000 fish)	List of hatchery and wild CWT tagging programs. Willamette Springs (Jeff/Earl Trial, Tom OR Annette WA)		recovery relatively expensive, data not typically quickly available, batch mark, need external mark or detector to recover tag. Invasive recovery.	Marks released by origin and recoveries from appropriately sampled catch						High	High	High	Low
	Scale-Pattern Recognition	Laboratory analysis of scale growth patterns (either visual or measuring).	Generally hatchery/wild, has limited ability to identify specific origin	Typically used to distinguish H:W and is also used to differentiate the two primary Columbia basin sockeye stocks.		Limited application, visual scale analysis may be subjective, training for proper scale sampling and interpretation, scale preparation expense, usually a delay between sampling and analysis, need baseline dataset if scale analysis is conducted by measuring scales (and lab time for this process).	M/L	Scale growth patterns from appropriately sampled catch as well as known-stock samples.					High	Low	Dependent on degree of differences in growth characteristics. Method often works well for small numbers of stocks (2-3) but poorly for larger numbers of stocks (5 or more).	Low if correctly used

From Tables A1 and C1.									For each population:								
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessmen t of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisitio n	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
	Run reconstructio n															
	Otolith	Laboratory analysis of otolith growth patterns.	Can be used to differentiate properly marked hatchery stocks. Annette talk with Steve Schroeder; Tom talk with Curt Melcher	Hatchery rearing programs		Invasive recovery mark. No external features to distinguished marked fish. Sample preparation time. Need trained people to recover otoliths and to analyze patterns.	M/H									
Research Needed	Genetic Stock Identification	Micro-satellite technology; DNA analysis of frequencies in catch optimized against known frequencies of donor populations.	Annette talk with Sewall to describe status quo. No age information.	Depends on coverage of baseline information.	Samples cheap and simple to collect from every fish, non-invasive	Baseline needs development (? Talk with Sewell); data processing expensive	M	Lab work on appropriate tissue samples from sampled catch					High	High	High	Low
	Elemental analysis of hard body parts	Laboratory analysis of otoliths or scales for elemental composition	Can be used to differentiate properly marked hatchery stocks. Some potential (research required) to differentiate natural origin stocks using natural differences in composition.	Currently hatchery rearing programs, potential applicability for wild stocks.		No external features to distinguish marked fish. Sample preparation time. Need trained people to recover otoliths. Expensive (except for tetracycline marks which flouresce). FDA concerns with regards to adding elements to food/water for hatchery fish. Extensive research needed regarding applicability for wild fish.										

From Tables A1 and C1.									For each population:							
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessment of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisition	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
	Various batch marking methods	Apply mark or tag and recover by examining fish.	Identify fish group.	Currently used for small programs for research purposes		Limited number of marks available to distinguish groups of fish. Often poorly coordinated, difficult to find origin of batch marked fish.	M/H	Marks released by origin and recoveries from appropriately sampled catch								
Incidental mortality (post-release mortality of unharvested fish encountered in fisery).	Angler interviews/Run reconstruction	Interview anglers regarding release rates are used to estimate the number of fish released and run reconstruction is then used to divide the released fish into species/stock/age categories	Specific fisheries and resolution subject to same criteria as under run reconstruction with stock composition	Size and species selective fisheries		Release mortality rate is unknown and must be supplied from elsewhere subjecting these estimates to bias. Depends on voluntary reporting or reporting from memory on releases and angler ability to differentiate species and run reconstruction assumptions.										
	Test fishing	Test fishing for catch characteristics subject to same data considerations as stock composition	Specific fisheries and resolution subject to same criteria as under stock composition	Size and species selective fisheries subject to data (tagging programs) as under stock composition.		Release mortality rate is unknown and must be supplied from elsewhere subjecting these estimates to bias. Needs routine application during run, otherwise limited by time and geography.										
	Double Index Tag Program	Hatchery programs release companion marked/tagged fish and unmarked/tagged fish.	Specific fisheries and stocks represented by the DIT program	Mark-selective fisheries		Release mortality rate is unknown and must be supplied from elsewhere subjecting these estimates to bias. Foregone harvest on umarked DIT group, cost of doubling tagging program; electronic detection equipment, sampling expense (must sample all fish returning, not just marked fish)										

From Tables A1 and C1.									For each population:							
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessment of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisition	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
Bycatch to catch encounters (defining conversion rate)	Test fisheries		Time and general area.	Size and species selective												
	marked to unmarked ratio using double index tags.	rates from paired fisheries, release rates, or escapement rates.	To the related tag group.	Mark selective fisheries												
Post release mortality rates	Captive holding		To catch method and fishery.	All selective fisheries												
	Compare recovery rates of between test and control groups of fish.		Specific fisheries measured on.	Commercial fisheries, research needed to apply to recreational fisheries.												
Fishing Effort	Aerial surveys	Count and categorize nets or fishing boats	Daily to weekly	Limited to commercial net fisheries and recreational boat fisheries		Limited by geography, visibility, safety, and budget		Boat counts categorized by angler type								
	Recreational Angler interviews	Interview anglers regarding fishing effort	Daily to weekly	Currently used for recreational fisheries, could be used for other fisheries		Lots of staff time required, relies on honest answers, need accessible anglers, difficult to get a representative sample										
	Mandatory check station	Interview anglers at check point on fishing effort.	Daily to weekly	Generally applied to terminal fisheries in restricted access areas.		Depends on honest answers from anglers. Limited by geography.										

From Tables A1 and C1.									For each population:							
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessmen t of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisitio n	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
Catch (number of harvested fish)	Landing Tickets	Each commercial sale generates a receipt with species and weight.	By sale daily	Commercial fishery at a licensed buyer.		Not all fish are sold to commercial buyers. Numbers of fish generally not recorded.	H	Reported landings (pounds) by species.								
			Average weight during fishery period.	Commercial fishery at a licensed buyer.	difficult to apply a representative design.		Number of fish and total weigh of batch									
	Angler Harvest Record Cards	Voluntary return of angler harvest cards validated through followup survey	To zone and day up to sampling	Widely applicable, but restricted by participation		Participation (return of cards not enforced). High potential for bias by non-representative card return. Delay in processing; historical record rather than management tool.	L	Reported harvest by individual angler								
Catch per Effort																
	Angler interviews	Interviews of anglers stratified by angler type, weekday/weekend/holiday.	To zone and day up to sampling	Currently used for recreational fisheries, could be used for other fisheries												
		Mandatory check station														
	"Over the Bank" sales monitoring															
	"On-board" monitoring of fishing vessels															
Harvest Rate (estimated proportion of stock thatis harvested in specific fishery)	Marked fish exploitation estimate	Fishery recoveries of known marked fish population														

From Tables A1 and C1.									For each population:								
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessment of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisition	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
	Catch/run size	F/(Ncr-Fo) [Where: F = Estimated harvest-related mortality; Ncr = Estimated population abundance at Columbia River mouth; Fo = ocean harvest-related mortality]														
	Indicator stock monitoring	- Ocean fisheries assumed to have similar exploitation rates on fish from a group of stocks or rivers that mix fully.														
Age Composition of catch	PIT tags	Recapture of PIT tagged individuals. High precision in total age assignment for individuals. (May not provide a freshwater/saltwater age breakdown.) Requires recapture of fish tagged as known age juveniles.					H	Recovery of sufficiently large number of PIT tags from fish that adequately represent the catch.					High	Likely high as stocks comprising catch not PIT tagged proportionally	High, but may not be able to separate total age into freshwater and saltwater age	Likely high due to catch not PIT tagged proportionally

From Tables A1 and C1.									For each population:							
Performance Measure	General method to estimate PM	Specific method to estimate PM	Level of Resolution	Applicability	Strengths	Weaknesses	Qualitative assessment of relative precision	Dataset required	Cost per unit of data	# units per year (sites x replicates)	Additional cost (e.g., access, logistics, equipment needs, addl spls needed not covered in data already available)	Total cost for data acquisition	Accuracy and Precision of Input Data	Bias of Input Data	Accuracy and Precision of Method	Bias of Method
	Coded-wire tags	Recapture of CWT individuals. High precision in total age assignment for individuals. (May not provide a freshwater/saltwater age breakdown.) Requires recapture of fish tagged as known age juveniles.											High	Likely high as stocks comprising catch not tagged proportionally	High, but may not be able to separate total age into freshwater and saltwater age	Likely high due to catch not tagged proportionally
	Scale analysis	Interpret scale patterns					M	Scales collected from an appropriately sampled catch.					High	Low if properly sampled	Moderate, depends on reader, availability of known-age scale samples, scale condition, species, and run	Moderate

Appendix G. Draft Early Synthesis of Strengths and Weaknesses Assessments for Columbia Subbasins

Performance Measure: **Abundance, Spawners** **Species/race:** **Sockeye** [yellow=check]

	Okanogan River, Washington/British Columbia			Wenatchee River, Washington		
What is measured?	Fish (Historical)	Redds (Recent)	Fish (Historical/Recent)	Fish (Historical)	Redds (since 2003)	Fish (Historical/Recent)
What is (can be) estimated?	Single pass, "peak" count of number of spawners.		Escapement to Okanogan Basin	Single pass, "peak" count of number of spawners.	Multiple pass count of number of redds	Escapement to Lake Wenatchee
Total basin population estimated?	No not expandable		Yes	No not expandable	Yes	Yes
How measured?	Single pass, "peak" count most years; other techniques also tried		Counts at Wells Dam fish ladders by on-site counter or reviewer reviewing video	Single pass, "peak" count in most years	multiple pass (walk), ultimately hope to use Little Wenatchee counts to estimate White River in peak years	Fish ladder video counts
Where? Site selection:	Non-random "index"; preferred spawning areas; some gaps & variation across years		Wells/Rocky Reach dams	White and Little Wenatchee rivers and Napeequa Creek below natural barriers, other rarely used sites (e.g. Nason Creek) in some years.	White, Little Wenatchee, and Napeequa Creek in low escapement (<20000) years, ultimately just L. Wenatchee and Napeequa in high escapement years	Tumwater Dam
Approx. % PSA* surveyed	50% but probably representing 90% of spawning		100%	Nearly 100% of commonly used PSAs	30 to 100%	100%
When? (Time period) & comment	1947 to present,		Rocky Reach Dam 1961-1966; Wells Dam 1967-present	1947 to 1988	2003 to present	1989 to present
Statistical design & comment:	None		Census	None	None	Census
Precision	Unknown		Not tested, but likely high.	Unknown	Unknown	High in years tested (1992-1994), likely high other years as well

	Okanogan River, Washington/British Columbia			Wenatchee River, Washington		
Accuracy (bias)	Probably low		Low-highly variable mortality from Columbia River to spawning grounds. A small number of sockeye may spawn in the Methow	Probably low	Unknown	Reasonably high for estimating spawners
Constraints			Not accurate for measuring spawning escapement due to high mortality, gender of sockeye not identified		Difficulty in estimating White River redds in peak years due to mass spawning	Gender of sockeye not identified but is identified for sockeye sampled at trap or collected for broodstock
Key assumptions	1. All fish visible 2. True peak counted 3. Peak is constant proportion of total fish		1. Species correctly identified 2. Fallback is insignificant (which would result in fish being double-counted upon reascending the ladder). 3. Number of sockeye bound for locations other than the Okanogan (e.g. Methow, Similkameen, Lake Roosevelt [kokanee washouts]) is insignificant.	1. All fish visible 2. True peak counted 3. Peak is constant proportion of total fish	1. All redds visible 2. Potentially assuming constant relationship between portions spawning in L. Wenatchee and White.	1. Species correctly identified 2. Fallback is insignificant 3. Pre-spawn mort. is small (for comparison with redds) 4. Male/female ratio estimated from trap samples/broodstock is accurate 5. In years with a sport harvest, harvest estimates are accurate and M/F ratio is proportional to the run.
Key Reference	Stockwell, M.M., and K.D. Hyatt, 2003.					

* PSA = Potential Spawning Area: accessible and appropriate for that species. Estimated % may be subjective. "MR" = mark-recapture.

	Salmon River, Idaho			Hanford Reach, WA	
What is measured?	Redds (Historical)	Redds (Recent)	Fish (Historical/Recent)	Redds (Historical/Recent)	Fish (Historical/Recent)
What is (can be) estimated?			Escapement to Salmon Basin/Redfish lake	Index of successful female spawners	Escapement from dam counts (Priest Rapids Count-(McNary Count + Hatchery returns + Ice Harbor count + Yakama River Count + Hanford Reach/McNary Pool harvest))
Total basin population estimated?			Yes	No not expandable	Yes
How measured?			Counts at Redfish Lake weir and Snake River dam fish ladders	3-6 aerial flights, peak count for each of ten areas used	From fish ladder counts,spawning survey (Moran Creek) and harvest estimates
Where? Site selection:			Redfish Lake, Snake River dams	Entire reach from Priest Rapids Dam to McNary pool	McNary, Priest Rapids, Prosser Dam, Moran Creek, and Priest Rapids hatchery
Approx. % PSA* surveyed			100%	100% of commonly used PSAs	100%
When? (Time period) & comment			Redfish Lake weir (1954-64, 1992-present), Snake River dam counts (1962-1991)	1948 to present	1963 to present
Statistical design & comment:			Census	None (subjective)	Census
Precision			High for Redfish Lake weir, reasonably high for dam counts	Unknown	Unknown
Accuracy (bias)			High for Redfish Lake weir, low for Snake River dam counts	Unknown	Unknown
Constraints			Redfish weir does not account for sockeye that return to other lakes (though currently, none do)	Weather can interfere with aerial flights forcing cancellation or poor estimates	None
Key assumptions			1.	1. All redds visible 2. True peak counted	1. Pre-spawn mortality is constant (for trend) 2. Ladder counts are accurate 3. Pre-spawn mort. is small (for

	Salmon River, Idaho			Hanford Reach, WA	
					comparison with redds) 4. Male/Female ratio is constant (for comparison with redds)
Key Reference					

* PSA = Potential Spawning Area: accessible and appropriate for that species. Estimated % may be subjective. "MR" = mark-recapture.

Performance Measure: **Abundance, Spawners**
Species/race: **Spring (& summer) Chinook**
100% coverage in 1991, 1992, 1994, 1995 & 2000-2002

	Lewis, Washington (spring)	**Methow, Washington (spring)**		**Imnaha, Oregon**			
What is measured?	Fish (live + dead)	Redds (historical)	Redds (recent) visibility excellent				
What is estimated?	Post-spawner pop., M+F		Female spawner pop. Males by expansion				
Total basin population estimated?			Yes (census, ~females) Males by expansion				
How measured?			Weekly foot surveys entire season by WDFW (YIN frequency ?)				
Where? Site selection:			All known spawning areas (subareas arbitrary)				
Approx. % PSA* surveyed			100%				
When? (Time period & comment)			WDFW 2003 to present YIN '91,92,94,95,2000-02 ('96 & '98 = 0 spawners)				
Statistical design & comment:			Census (marked redds, WDFW=map/GPS)				
Precision			Census var(F) ~0 (some error likely) Poss. est. var(Males)				
Accuracy (bias)			Bias believed small				

			(F) (but not proven) M bias depends on broodstock sampling				
Constraints			(none? PUD funding?)				
Key assumptions	1. 2.	1. 2.	1. All redds visible 2. Species known 3. Each redd counted only once 4. Each redd life > 1 week 4. Redd=female that spawned	1. 2.	1. 2.	1. 2.	1. 2.

* PSA = Potential Spawning Area: accessible and appropriate for that species. Estimated % may be subjective. "MR" = mark-recapture.

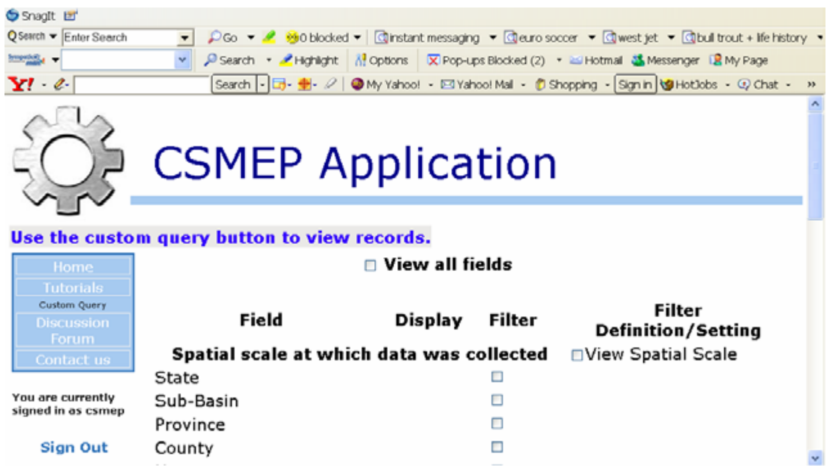
Performance Measure: **Abundance, Spawners**
Species/race: **Spring/summer Chinook**

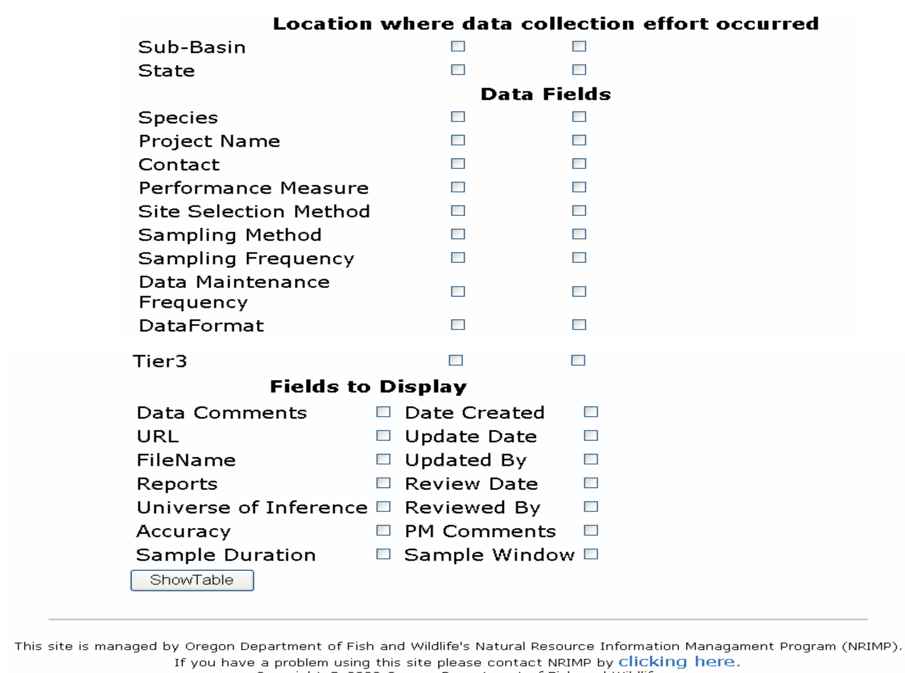
What is measured?							
What is estimated?							
Total basin population estimated?							
How measured?							
Where? Site selection:							
Approx. % PSA* surveyed							
When? (Time period & comment)							
Statistical design & comment:							
Precision							
Accuracy (bias)							
Key assumptions	1. 2.						

* PSA = Potential Spawning Area: accessible and appropriate for that species. Estimated % may be subjective. "MR" = mark-recapture.

Appendix H: CSMEP's web meta-database application

CSMEP (in conjunction with the ODFW) has developed an Internet accessible application for accessing the subbasin metadata described in the CSMEP C1 data inventory catalogues. This web application builds on the databases already available through existing data warehouses (e.g., Fish Passage Center, StreamNet), by providing pointers to this information within the CSMEP catalogues. The CSMEP web application is currently managed by Oregon Department of Fish and Wildlife's Natural Resource Information Management Program (NRIMP) and allows access to assembled metadata for fish monitoring datasets in the Columbia Basin. The screen captures below show the template of the CSMEP web application and the database metadata fields viewable/downloadable from the site. The URL for the site is https://nrimp.dfw.state.or.us/csmep/ and the generic logon/password is csmep/csmep for public viewing.





Appendix J. Integrated PIT-Tag Analysis