Grant County
PUBLIC UTILITY DISTRICT
Excellence in Service and Leadership

June 30, 2009

Kris Petersen
National Marine Fisheries Service
1201 NE Lloyd Blvd., #1100
Portland, OR 97232

Dear Ms. Petersen,

The Public Utility District No. 2 of Grant County (Grant PUD) is providing its Monitoring and Evaluation Plan (M&E) for hatchery activities associated with operating multiple artificial propagation programs that contribute to the conservation, reintroduction, and harvest of salmon and steelhead. This action is a requirement of Grant PUD's license to operate the Priest Rapids Project issued by the Federal Energy Regulatory Commission (FERC) on April 17, 2008[1] and has the potential to take species listed under the Endangered Species Act. Grant PUD, in consultation with the Priest Rapids Coordinating Committee's Hatchery Sub-committee (HSC), has developed an M&E plan that encompasses all of its hatchery programs. Brief descriptions of each of the monitoring plans are presented in Hatchery and Genetic Monitoring Plans (HGMPs) and Artificial Propagation Plans (APP), but more detail about M&E is provided in this plan. Draft versions of this plan were provided to the HSC with adequate time for review. Comments were received from several HSC members and efforts to address those comments are reflected in this plan.

As part of the HGMP submission, Grant PUD requests a permit for the monitoring and evaluation of the hatchery programs that it funds except for those programs that are already covered under another permit. It has not yet been determined which organization will conduct the monitoring and evaluation described in this plan. However, it is likely to be one of the following: Washington Department of Fish and Wildlife, the Yakama Nation, the United States Fish and Wildlife Service, Battelle, Grant PUD, Chelan PUD, other contractors, or a combination of the aforementioned. Regardless of who does the work, the contractor will be required to meet specific standards that are approved by the HSC. The primary action area of the request is the upper Columbia River between McNary and Wells Dam, the Wenatchee River, and the Methow River. Other M&E activities that Grant PUD funds will be covered under other Section 10 permits (e.g., programs in the Okanogan River, coho program). A separate M&E plan for the Priest Rapids Hatchery will also be submitted because it is different in a number of important aspects from the tributary based M&E. However, this plan describes the overall M&E activities

[1] (123 FERC¶ 61,049)

of Grant PUD and includes the Priest Rapids Hatchery. This action will continue for the duration of Grant PUD's 44-year FERC license, unless modified by the HSC and approved by FERC through a license amendment.

Grant PUD recognizes that this is a time sensitive process and is eager to work with all of the parties to allow mitigation to proceed with ample time to meet deadlines. Grant PUD's deadline to submit M&E plans to FERC is July 1, 2010.

Thank you for your consideration,

Tom Dresser
Fish, Wildlife, and Water Quality Manager
Public Utility District No. 2 of Grant County

cc: Elizabeth McManus, Ross & Associates
Jessica Gonzales, USFWS
Julie Pyper, Chelan PUD
Tom Kahler, Douglas PUD
Priest Rapids Coordinating Committee
Priest Rapids Coordinating Committee Hatchery Subcommittee

Monitoring and Evaluation Plan for Grant County PUDs Salmon and Steelhead Supplementation Programs

By

Todd N. Pearsons

And

Russell B. Langshaw

Grant Public Utility District
PO Box 878
Ephrata WA 98823

In Consultation with the Hatchery Sub-Committee of the Priest Rapids Coordinating Committee

June 30, 2009

Introduction

The purpose of this document is to present the monitoring and evaluation (M&E) plan for the Public Utility District No. 2 of Grant County (Grant PUD) hatchery mitigation program. The M&E program will be funded in part or total by Grant PUD as part of its mitigation requirements for the operation of Priest Rapids and Wanapum dams. A brief description of this plan is also presented in Hatchery and Genetic Management Plans (HGMP) that will be submitted to the National Marine Fisheries Service (NMFS) for the issuing of a section 10 Permit and in Artificial Propagation Plans.

As part of its mitigation requirements Grant PUD will annually produce approximately 10 million salmon and steelhead that will be released into areas of the upper Columbia River and its tributaries. A description of the mitigation programs is presented in Table 1. Hatchery programs will be coupled with comprehensive monitoring and evaluation (M&E) plans that are intended to provide the information necessary for adaptive management and assess compliance with mitigation requirements. The guiding principles for the development of M&E plans are presented in Table 2 and were developed from the Salmon and Steelhead Settlement Agreement (2006), NMFS 2008 Biological Opinion, and the Federal Energy Regulatory Commission's (FERC) proposed license for the operation of the Priest Rapids Hydroelectric Project (FERC No. 2114).

Coordination of project planning and implementation will occur by the Priest Rapids Coordinating Committee Hatchery Subcommittee (HSC) as stated in the 2008 NMFS Biological Opinion term and condition 1.24.

"This committee shall be the primary forum for implementing and directing supplementation measures for the Project's anadromous fish program. The HSC is comprised of NMFS, USFWS, WDFW, Confederated Tribes of the Colville Reservation, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Reservation and Grant PUD."

The HSC also coordinates activities and plans that affect land and water resources with relevant local planning and permitting entities, such as the Upper Columbia Salmon Recovery Board. The HSC has been meeting monthly since January 2005.

Grant PUD meets and coordinates monthly with Chelan and Douglas PUDs to discuss potential for cooperation with fish evaluations and resource issues as part of coordination with the PUD's and their Habitat Conservation Plan (HCP) Habitat and the HCP Hatchery subcommittees. Grant PUD also attends regional meetings and forums to promote technical consistency and compatibility with other entities throughout the Columbia River Basin. This interaction and consultation is consistent with requirements by FERC:

"FERC shall require that Grant PUD coordinate the design of its Performance Evaluation Program with the development of relevant parallel monitoring or evaluation systems by other hydropower operators in the Columbia Basin and the Northwest Power Planning Council. The purpose of such coordination shall be to contribute to a comprehensive evaluation of stock performances throughout the Columbia Basin." (2008 NMFS BIOP Terms and Conditions 1.34).

This document is intended to be a living document and is subject to change as new information becomes available. This document will be reviewed as needed by the HSC.

Table 1. Grant PUD's annual mitigation requirements and hatchery program characteristics. All programs will release yearling smolts unless indicated.

Hatchery Program (supporting document)	Mitigation Requirement	Goal	Strategy	Status
White River spring Chinook salmon (HGMP)	150,000	Conservation	Integrated (Captive brood and supplementation)	Endangered
Nason Creek spring Chinook salmon (HGMP)	250,000	Conservation	Integrated	Endangered
Methow spring Chinook salmon (APP)	200,000	Conservation	Integrated	Endangered
Okanogan spring Chinook salmon (APP)	110,000	Reintroduction	Integrated	Extirpated
Wenatchee Summer Chinook salmon (HGMP)	277,667	Harvest/conservation	Integrated	Healthy
Methow Summer Chinook salmon (HGMP)	277,667	Conservation/Harvest	Integrated	Healthy
Okanogan Summer Chinook salmon (APP)	277,667	Conservation/Harvest	Integrated	Healthy
Fall Chinook salmon (HGMP)	6,000,000 subyearlings 1,000,000 fry	Harvest	Integrated	Healthy
Sockeye salmon (HGMP)	Up to 1,143,000 fry	Reintroduction	Integrated	Extirpated
Coho salmon (APP)	373,296[1]	Restoration/Conservation	Integrated	Reintroduced
Steelhead trout (APP)	100,000	Conservation/Harvest	Integrated	Endangered
Total	10,149,296			

[1] This number is based on 7% mortality per hydro-electric project

Table 2. Principles of the Grant PUD M&E plan and the supporting documentation of the principles.

#	M&E Principle	Supporting Documentation
1	**Comprehensive**	Comprehensive monitoring and evaluation that includes monitoring in the natural environment and investigating the impacts of the hatchery program on the naturally produced population (2008 NMFS Biological Opinion Terms and Conditions 1.25, 1.26; UCR spring Chinook and steelhead) "This Agreement is intended to constitute a comprehensive and long-term adaptive management program for the protection, mitigation, and enhancement of Covered Species which pass or may be affected by the Project." (SSA 2006 section 2.1; see also SSA 2006 section 4.3).
2	**Ability to evaluate program objectives and contribute to adaptive management of program**	"Grant PUD shall, in consultation with the PRCC Hatchery subcommittee, develop a monitoring and evaluation plan to assess the effectiveness of the fall Chinook [summer Chinook, sockeye] propagation program at meeting the objectives developed by the Parties and consistent with the monitoring and evaluation plan described below in Section 13.1.4." (SSA 2006, Page 15, section 9.5, fall Chinook; section 10.4 for summer Chinook; section 11.4 for sockeye). "Where appropriate, the Performance Evaluation Program shall measure and evaluate individual actions within each category, assess the contribution of the action to the desired objective, and provide a basis for identifying new options and priorities among those options for further progress in meeting objectives (2008 NMFS BIOP Terms and Conditions 1.33). "The purpose of this program is to provide a measurable, reliable and technical basis to assess;…. (3) supplementation for the non-listed Covered Species affected by the Project as described in Sections IX-XV." (SSA 2006, section 4.5)
3	**Consistent with other programs**	"FERC shall require that Grant PUD coordinate the design of its Performance Evaluation Program with the development of relevant parallel monitoring or evaluation systems by other hydropower operators in the Columbia Basin and the Northwest Power Planning Council. The purpose of such coordination shall be to contribute to a comprehensive evaluation of stock performances throughout the Columbia Basin." (2008 NMFS BIOP Terms and Conditions 1.34).
4	**Update every 5 years and adapt plan as appropriate**	"Grant PUD shall, in consultation with the PRCC Hatchery subcommittee, develop a monitoring and evaluation plan for the propagation programs that is updated every five years. The first monitoring and evaluation plan shall be completed within one year of the Effective Date of this Agreement. The Parties agree that over the duration of this Agreement, new information and technologies that are developed will be considered and utilized in the monitoring and evaluation of the propagation programs.

		Grant PUD shall fund propagation program monitoring and evaluation programs required by this Agreement." "Adjustments [to production levels] will be made if necessary based on changes in average adult returns, adult-to-smolt survival rate and smolt-to-adult survival rates from the hatcheries relative to the survival rate and smolt-to-adult survival rates from the hatcheries relative to the survival rates utilized to establish the initial production levels via the BAMP." (SSA 2006 section 13.1.2)
5	**Use a high standard of care**	"The Parties agree that Grant PUD and the other Parties shall use the most current and best available scientific information and analysis as the standard of care for implementing this Agreement. … including the research, monitoring and evaluation activities" (SSA 2006 section 4.2)
6	**Evaluate alternatives using approved standards**	"In the event that the Parties advocate two or more alternatives to a study methodology, or measure or action, the Parties agree that Grant PUD and the other Parties shall evaluate and select the course of action based on the following criteria: 1) likelihood of biological success; 2) time required to implement; and 3) cost-effectiveness of solutions, but only where the Parties agree that two or more alternatives are comparable in their biological effectiveness." (SSA 2006 section 4.2).
7	**Develop and implement plans in consultation with the HSC**	Plans will be done "in consultation with the PRCC Hatchery Subcommittee and subject to NMFS approval." (2008 NMFS BIOP Terms and Conditions 1.25, 1.26)

The M&E plan presented in this document was designed to be consistent with other M&E activities that Grant PUD funds; such as those in Nason Creek, the Methow River, and Priest Rapids Hatchery. This plan was also designed to be consistent with M&E plans that were designed and are currently being implemented by Chelan and Douglas PUDs (e.g., Murdoch and Peven 2005; Cates et al. 2007, Hays et al. 2007, Murdoch et al. 2008, Hillman et al. 2008). Much of the conceptual framework presented in this plan was taken from Murdoch and Peven (2005) and Hays et al. (2007). The initial five-year M&E Plan proposed for the program identifies ten objectives, listed below. It is the intention of Grant PUD to coordinate and share the costs to implement this plan with other organizations that are implementing and monitoring hatchery programs such as Chelan PUD, Douglas PUD, Bonneville Power Administration, Colville Tribes, Yakama Nation, Okanogan Nation Alliance, and the Washington Department of Fish and Wildlife.

Objectives and Outline

The Regional Assessment of Supplementation (RASP 1992) identified the core variables of supplementation that should serve as the basis for designing and monitoring supplementation programs. These variables include an increase or maintenance of natural production and harvest, no decrease in the long-term fitness of the target population, and keeping the "ecological and genetic impacts on non-target populations within specified limits." Two other expert scientific groups identified three performance indicators that are required to evaluate whether standards of supplementation are being met (ISRP & ISAB 2005). These performance indicators are:

1. target population abundance, productivity, and capacity;
2. target population long-term fitness, and;
3. non-target population impacts.

This monitoring plan is structured to address the performance indicators identified by these three expert groups.

The objectives of a hatchery M&E plan should be consistent with addressing the objectives of a hatchery program. Therefore, hatchery program objectives are presented in this document. The HSC has developed quantitative objectives for many, but not all of the programs. Those programs without HSC approved quantitative objectives are the salmon reintroduction programs (Okanogan spring Chinook salmon, sockeye salmon, and coho salmon). The metrics for the Objectives are defined in Table 3 and the Objectives for many of the programs are presented in Tables 4 and 5. The objectives, hypotheses, variables, and methods for the M&E plan are presented in an outline form. This outline will be the main component of the M&E plan that will be contained in an HGMP and APP. Furthermore the outline serves as a point of reference that links the overall components of the M&E plan together.

Table 3. Metrics for quantitative objectives of hatchery supplementation programs. Specific objectives are found in Table 4 and 5.

Metric	Definition or calculation	Why important
Release number and size	Total number and weight of juveniles released	Necessary to assess whether or not the program is meeting mitigation production levels consistent with the Settlement Agreement. Life-stage specific survivals will also be measured to determine if each component is meeting expected survival standards.
Proportion of natural influence (PNI)	Proportion of total selection (hatchery and natural) that is due to natural selection. Calculated as pNOB/(pNOB + pHOS) pNOB=proportion of natural origin brood in the hatchery pHOS=proportion of hatchery origin spawners in the natural environment	Considered in management of hatchery broodstock, and management of fish of different origins on the spawning grounds
Hatchery SAR	Smolt-adult return rate by brood year	Necessary monitoring to assess overall hatchery smolt survival. Essential for run-forecasting and out-year mitigation requirements.
Within hatchery survival	Survival by life stage	Necessary monitoring to assess/maximize the efficacy of hatchery rearing and will guide future hatchery rearing strategies.
Escapement	Number of adults that spawn in the natural environment	Under escapement can harm the viability of the population and over escapement can result in lost harvest opportunity and potentially reduced productivity
Stray rate	Three metrics for evaluating straying: Stray 1=percentage of hatchery release that strays to non-target spawning areas, Stray 2=percentage of a non-target spawning population that contains hatchery strays, Stray 3=percentage of non-target populations that stray into targeted population	Straying into non-target populations has the potential to reduce productivity of non-target populations and reduce between population diversity. Strays from other programs could impact the target population.
Relative productivity	Productivity of hatchery and natural origin fish in the hatchery and the natural	Critical factor in evaluating whether a hatchery is contributing to or reducing natural production. Evaluating productivity

	environment across generations. This includes: freshwater productivity (e.g., The number of juveniles / redd or juveniles / spawner. Juveniles may be measured at different life-stages such as parr, emigrants, or smolts), Hatchery and natural origin adult recruits/spawner and hatchery smolt-to-adult recruitment (SAR).	at different life-stages also helps assess the time and place of achievement of objectives (i.e. assess potential mining of adults).
Genetic Diversity	Allele frequency Effective population size	Genetic diversity within and between populations is associated with increased productivity and long-term fitness.
Biological characteristics of adult hatchery and natural origin offspring.	Size at age, age at maturation, return and spawn timing, sex ratio, fecundity, egg size, spawn location	Manifestations of genetic and environmental differences which could impact long-term fitness, viability and productivity. Utilized as a monitoring indicator to support management decisions based on assessment of biological significance.
Harvest	Number of fish to be harvested in all fisheries	Contributes value to commercial, subsistence, and recreational fisheries, and is important for spiritual reasons
Non-target taxa of concern (NTTOC)	% impact to a taxon baseline abundance, size, or distribution A risk assessment will be conducted that will identify which NTTOC, if any, will be monitored and will help inform the frequency and intensity of monitoring. The containment objectives need to be consistent with HCP objectives.	Allows for a proper balancing of target and non-target taxa benefits and costs

Table 4. Draft biological goals for integrated hatchery programs that will be used for evaluation of different hatchery strategies and presentation in HGMPs. PNI=proportion of natural influence, EN= spawning escapement of natural origin fish, K=the minimum number of spawners to produce the asymptotic number of recruits, R=recruitment productivity in recruits per spawner, A=number of adults, H= hatchery, E=spawning escapement (hatchery and natural origin fish combined), N=natural origin recruits, D= donor population, Ne=effective population size, RH=recruitment of hatchery fish, RHN=recruitment of hatchery fish in the natural environment, RN =recruitment of natural origin fish in the natural environment, B = hatchery broodstock, P = prespawn mortalities.

HGMP	Release # and size (see table 5)	PNI[1], (E relative to K)	E[2]	Genetic Diversity	Stray Rate	Relative Productivity	Biological characteristics	Harvest[3]
Spring Chinook White River Nason Creek Methow River	White River (150,000 @ 10-15 fish/pound) Nason Creek (250,000 @ 10-15 fish /pound) Methow (200,000@ 10-15 fish/pound)	Needs to be determined by policy co-managers on a program basis [1]	K	Allele freq. H = N = D Sub-population genetic distance $_{year\ x}$ = distance $_{year\ y}$ $(Ne/E)_{year\ x} = (Ne/E)_{year\ y}$	<5% Between populations, <10% within population	RH*RHN*RN> RN*RN*RN (more great grandchildren if a fish is taken into hatchery than left to spawn in the natural environment).	H=W (see table 3)	≤A-K-B-P
Summer Chinook	833,000 @ 13-17 fish/pound	1, (EN≥K)[1] 0.67, (E ≥K)[1] 0-1 (E<K)[1]	K	Allele freq. H = N = D $(Ne/E)_{year\ x} = (Ne/E)_{year\ y}$	<5% Between populations, <10% within population	RH*RHN*RN> RN*RN*RN	H=W (see table 3)	≤A-K-B-P
Fall Chinook Hanford Reach	6 million + fry equivalence @ 50 fish/pound	1, (EN≥K)[1] 0.67, (E ≥K)[1] 0-1 (E<K)[1]	K	Allele freq. H = N = D $(Ne/E)_{year\ x} = (Ne/E)_{year\ y}$	<5% Between populations, <10% within population	RH*RHN*RN> RN*RN*RN	H=W (see table 3)	≤A-K-B-P
Steelhead Methow/ Okanogan	100,000 @ 5-8 fish/pound	1, (EN≥K)[1] 0.67, (E ≥K)[1] 0-1 (E<K)[1]	K	Allele freq. H = N = D $(Ne/E)_{year\ x} = (Ne/E)_{year\ y}$	<5% Between populations, <10% within population	RH*RHN*RN> RN*RN*RN (more great grandchildren if a fish is taken into hatchery)	H=W (see table 3)	≤A-K-B-P

[1] PNI values given in the table are initial estimates only and need to be defined on a program specific basis. The focus will be to maximize PNI while still fully seeding available habitat. The development of final PNI goals will require co-managers to evaluate what PNI values are realistically achievable in both the short and long-term using existing and future management tools. Ongoing discussion for management of spring Chinook salmon to be resolved in forthcoming 'implementation plan'.
[2] An initial estimate of K was presented by HSRG
[3] Prioritize harvest of hatchery origin fish to meet PNI objectives

Program Survival Standards

Program survival standards are a component of the quantitative objectives. In order to evaluate various life-history stages of artificially propagated salmonids, survival standards were determined (HSC 2009). By providing survival standards at different life stages, poor survival can be identified and improvements can be recommended. The survival standards to be used for steelhead and summer and spring Chinook salmon are found in Table 5.

Table 5. Hatchery salmonid survival standards by life-history stage, expressed in percentages, for Grant PUD supplementation programs. The fall Chinook survival standard was to achieve the recent Priest Rapids hatchery 10-year average survival for all life stages identified in this table.

	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Standard for Steelhead, summer and spring Chinook	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0

Conceptual Framework of the Monitoring and Evaluation Plan

It is important that the M&E Plan has obtainable goals, and that the objectives and strategies are clearly linked to those goals. Figure 1 depicts the generalized conceptual model that this M&E Plan will follow. The hypotheses focused on the primary indicators that will be tested under the objectives will be based on previous monitoring and evaluation information (i.e., key findings), and from the Biological Assessment and Management Plan (BAMP 1998). Strategies and the subsequent research, monitoring, and evaluation will clearly link to and provide feedback for the objectives.

As required by the SSA, the M & E Plan will be reevaluated, and revised if necessary every five years. It is important that information is collected through the evaluation plan that will enable the HSC to make changes if needed.

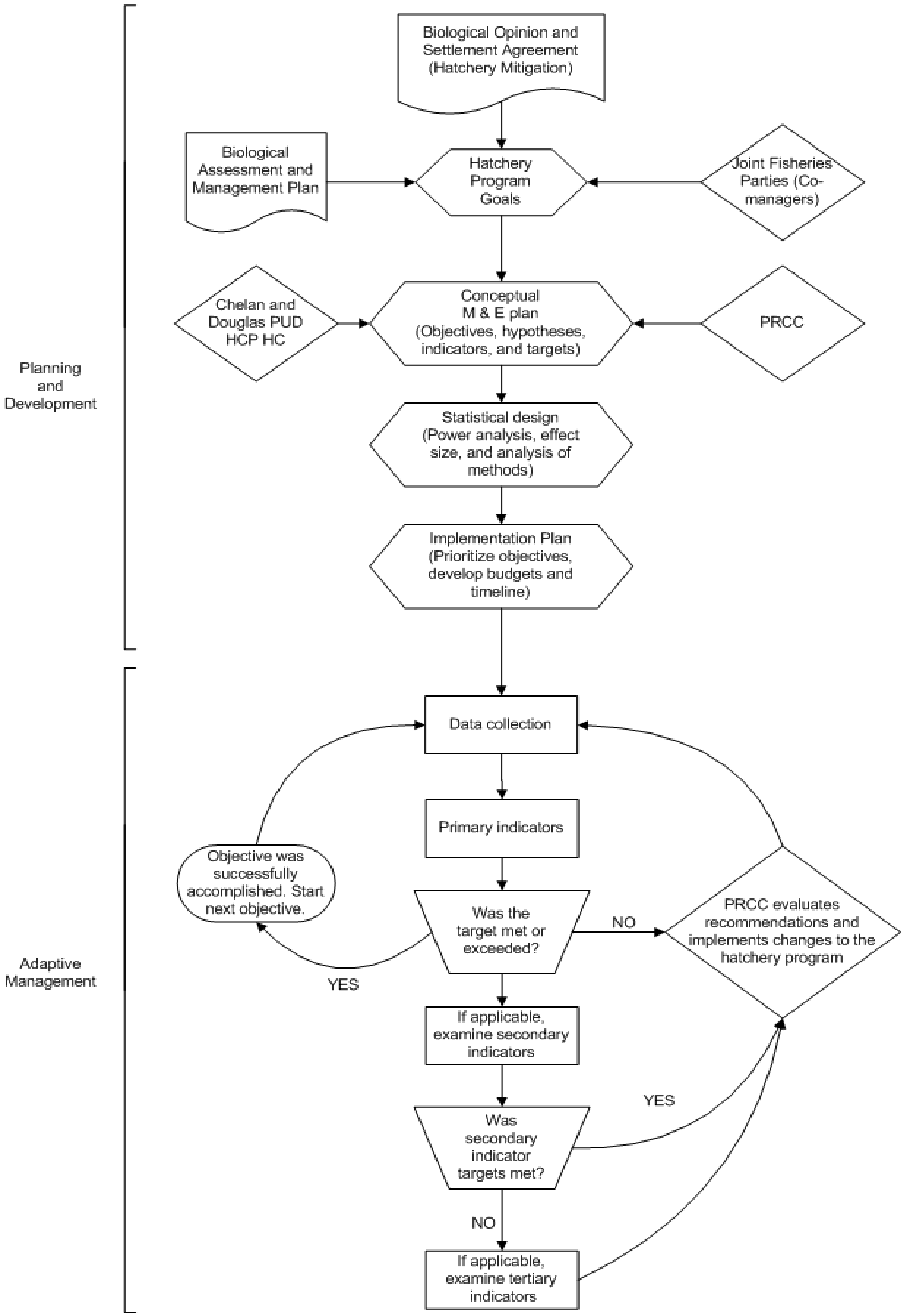

Figure 1. Conceptual framework of the M&E Plan.

Monitoring and Evaluation Plan Objectives and Hypotheses

The M&E objectives are intended to monitor the progress of the program toward achieving the programs objectives in Tables 4 and 5. The term supplementation refers to both adult-based and juvenile-based (i.e., captive broodstock) unless specifically stated.

Objective 1: Determine if programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference stream or condition) and the changes in the natural replacement rate (NRR) of the supplemented population are similar to that of the non-supplemented population.

Hypotheses:

- Ho: Number of HOR[2] $_{\text{Supplemented population}} \geq$ Expected value per BAMP
- Ho: Δ NOR[3] $_{\text{Supplemented population}} \geq \Delta$ NOR $_{\text{Non-supplemented population}}$
- Ho: Δ NRR $_{\text{Supplemented population}} \geq \Delta$ NRR $_{\text{Non-supplemented population}}$

Objective 2: Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

Hypotheses:

- Ho: Migration timing $_{\text{Hatchery}}$ = Migration timing $_{\text{Naturally produced}}$
- Ho: Spawn timing $_{\text{Hatchery}}$ = Spawn timing $_{\text{Naturally produced}}$
- Ho: Redd distribution $_{\text{Hatchery}}$ = Redd distribution $_{\text{Naturally produced}}$

Objective 3: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Hypotheses:

- Ho: Allele frequency $_{\text{Donor}}$ = Allele frequency $_{\text{Naturally produced}}$ = Allele frequency $_{\text{Hatchery}}$
- Ho: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations Structure $_{\text{Year y}}$

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[2] Hatchery Origin Recruits
[3] Natural Origin Recruits

- Ho: Δ Spawning Population = Δ Effective Spawning Population
- Ho: Age at Maturity $_{Hatchery}$ = Age at Maturity $_{Naturally\ produced}$
- Ho: Size at Maturity $_{Hatchery}$ = Size at Maturity $_{Naturally\ produced}$

Objective 4: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HHR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and equal to or greater than the program specific HRR expected value (BAMP 1998).

Hypotheses:

- Ho: HRR $_{Year\ x} \geq$ NRR $_{Year\ x}$
- Ho: HRR ≥ Expected value per assumptions in BAMP

Objective 5: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

Hypotheses:

- Ho: Stray rate $_{Hatchery\ fish}$ < 5% total brood return
- Ho: Stray hatchery fish < 5% of spawning escapement of other independent populations [4]
- Ho: Stray rate $_{Hatchery\ fish}$ < 10% total within independent populations [5]

Objective 6: Determine if hatchery fish were released at the programmed size and number.

Hypotheses:

- Ho: Hatchery fish $_{Size}$ = Programmed $_{Size}$
- Ho: Hatchery fish $_{Number}$ = Programmed $_{Number}$

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[4] This stray rate is suggested based on a literature review and recommendations by the ICTRT. It can be re-evaluated as more information on naturally produced Upper Columbia salmonids becomes available. This will be evaluated on a species and program specific basis and decisions made by the PRCC. It is important to understand the actual spawner composition of the population to determine the potential effect of straying.

[5] This stray rate is suggested based upon a literature review. It can be re-evaluated as more information on naturally produced Upper Columbia salmonids becomes available. The selected values will be evaluated on a species and program specific basis and decision.

Objective 7: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of smolts per redd) of supplemented streams when compared to non-supplemented streams.

Hypotheses:

- Ho: Δ smolts/redd $_{\text{Supplemented population}} \geq \Delta$ smolts/redd $_{\text{Non-supplemented population}}$

Objective 8: Determine if harvest opportunities have been provided using hatchery returning adults where appropriate.

Hypotheses:

- Ho: Harvest rate ≤ Maximum level to meet program goals

Regional Objectives

Two additional objectives will be included within the total framework of this plan because they are related to the goals of other hatchery programs throughout the region. These regional objectives will be implemented at various levels into all M&E plans in the upper Columbia Basin region (Douglas PUD, Chelan PUD, Grant PUD, USFWS, YN, and CCT). These objectives may be more suitable for a specific hatchery or subbasin, the results of which could be transferred to other locations. As such, the PRCC should ensure that these efforts are coordinated throughout the region so resources are used efficiently. Other objectives that are deemed more regional in nature could also be included in the section.

Objective 9: Determine if the incidence of disease has increased in the natural and hatchery populations.

Hypotheses:

- Ho: Disease supplemented pop. $_{\text{Year x}}$ = Disease non-supplemented pop. $_{\text{Year x}}$
- Ho: Naturally produced disease $_{\text{Year x}}$ = Naturally produced disease $_{\text{Year y}}$
- Ho: Hatchery disease $_{\text{Year x}}$ = Hatchery disease $_{\text{Year y}}$
- Ho: Supplementation Stream Upstream $_{\text{Year x}}$ = Hatchery Effluent $_{\text{Year X}}$ = Supplementation Stream Downstream $_{\text{Year X}}$

Objective 10: Determine if the release of hatchery fish impact non-target taxa of concern (NTTOC) within acceptable limits.

Hypotheses:

- Ho: NTTOC abundance $_{\text{Year x}}$ = NTTOC abundance $_{\text{Year y}}$
- Ho: NTTOC distribution $_{\text{Year x}}$ = NTTOC distribution $_{\text{Year y}}$
- Ho: NTTOC size $_{\text{Year x}}$ = NTTOC size $_{\text{Year y}}$

Details about Objectives and their Importance

Below we detail the ten objectives, generate hypotheses, and describe the importance of each objective in accomplishing goals of the plan. The term supplementation refers to both adult-based and juvenile-based (i.e., captive broodstock) unless specifically stated.

Objective 1: Determine if supplementation programs have increased the number of naturally spawning adults of the target population relative to a non-supplemented population

At the core of either captive broodstock or supplementation programs is the objective of increasing the number of spawning adults (both naturally produced and hatchery fish) in order to affect a subsequent increase in the number of returning naturally produced fish or natural origin recruits (NOR). This is measured as the Natural Replacement Rate (NRR). All other objectives of the M&E Plan either directly support this objective or minimize impacts of the supplementation program to non-supplemented population. Specific hypotheses tested under this objective are:

Ho: Number of HOR[6] $_{\text{Supplemented population}} \geq$ Expected value per BAMP

Ho: Δ NOR $_{\text{Supplemented population}} \geq \Delta$ NOR $_{\text{Non-supplemented population}}$

Ho: Δ NRR $_{\text{Supplemented population}} \geq \Delta$ NRR $_{\text{Non-supplemented population}}$

The supplementation program should in all cases increase the number of spawning adults (i.e., natural and hatchery origin) in the population. If the supplementation program does not increase the number of spawners, the subsequent increase in naturally produced fish cannot occur. Under this scenario, poor survival or high stray rates of the hatchery fish will prevent the objectives and goals of the hatchery program from being met.

When an increase in the spawning population has been observed, the subsequent increase in naturally produced returning adults is determined by comparing the natural replacement rate of the treatment population to a reference population (i.e., non-supplementation fish). If supplementation fish have similar reproductive success as naturally produced fish, then the trend of the NRR of both populations should not differ over time. Should divergence of the NRRs occur and the treatment population NRR does decline over time, the level or strategy of supplementation will be reevaluated by the HSC and appropriate adjustments to the program would be recommended.

[6] Hatchery Origin Recruits

If reference streams are not available for all hatchery programs or are not suitable due to 1) effects of other hatchery programs or 2) biotic or abiotic conditions are different from the treatment stream, an alternate experimental design needs to be considered to examine this important aspect of the M&E Plan. Relative productivity of hatchery and naturally produced fish can be empirically measured using a DNA pedigree approach study design. This approach may not be logistically feasible for all programs (i.e., too many fish to sample or poor trap efficiency). Alternatively, a temporal rather than a spatial reference stream can be used. This approach would involve not releasing hatchery fish in a specific stream for at least one generation and determine if a change in the NNR is observed without hatchery fish present on the spawning grounds. Regardless of the approach or experimental design used, this component of the M&E Plan is crucial and must be examined in order to determine if supplementation will result in an increased number of naturally produced adults.

Another important comparison, with or without reference streams, can be made by looking at different parental crosses (treatments) and what affects these crosses may have on NRR and HRR. Furthermore, the deviations in residuals from a parent to progeny model can be examined to determine if they are correlated with the percentage of hatchery origin fish on the spawning grounds.

Objective 2: Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

Supplementation is also termed "integrated" because the fish are intended to be managed as a single population. Hatchery and naturally produced fish are intended to spawn together and in similar locations. Run timing, spawn timing, and spawning distribution may be affected by the hatchery environment (i.e., domestication) or be related to the hatchery program (i.e., location of hatchery facilities with respect to the target population). If supplemented fish are not fully integrated into the naturally produced spawning population, the goals of supplementation may not be achieved. Hatchery adults that migrate at different times than naturally produced fish may experience differences in survival. Hatchery adults that spawn at different times or locations than naturally produced fish would not be integrated into the naturally produced spawning population (i.e., segregated stock). Specific hypotheses tested under this objective are:

Ho: $\text{Migration timing}_{\text{Hatchery}} = \text{Migration timing}_{\text{Naturally produced}}$

Ho: $\text{Spawn timing}_{\text{Hatchery}} = \text{Spawn timing}_{\text{Naturally produced}}$

Ho: $\text{Redd distribution}_{\text{Hatchery}} = \text{Redd distribution}_{\text{Naturally produced}}$

Broodstock collection and spawning protocols should ensure appropriate run timing and spawn timing of the supplemented fish, respectively. Observed differences in these indicators would suggest that protocols be reevaluated. Differences in redd distributions will be evaluated based upon the location that carcasses were recovered during spawning ground surveys. However, freshets or fall floods may limit the utility of these data. If the accuracy of carcass recovery locations is questionable (i.e., floods), a more precise, although more labor intensive, indicator for redd distribution would involve determining the origin of actively spawning fish.

<u>Objective 3</u>: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

The genetic component of the M&E Plan specifically addresses the long-term fitness of supplemented populations. Fitness, or the ability of individuals to survive and pass on their genes to the next generation in a given environment, includes genetic, physiological, and behavioral components. Maintaining the long-term fitness of supplemented populations requires a comprehensive evaluation of genetic and phenotypic characteristics. Evaluation of some phenotypic traits (i.e., run timing, spawn timing, spawning location and stray rates) is already addressed under other objectives.

Theoretically, a supplementation program should maintain genetic variation present in the original donor population, and as a program proceeds; genetic variability in hatchery- and naturally-produced fish in the supplemented population should be similar. Loss of within-population variation is a genetic risk of artificial production programs, and genetic divergence between hatchery and natural components of a supplemented population may lead to a loss of long-term fitness.

Differences in genetic variation among neighboring populations maintain the genetic population structure of drainages, basins, and regions. Mixing of populations in the hatchery (e.g., improper broodstock collection) or in the natural environment (e.g., excessive straying of hatchery fish) may lead to outbreeding depression and a loss of long-term fitness. Loss of between-population variation is also a genetic risk of artificial production programs, and can lead to long-term fitness loss at a scale larger than the population targeted for supplementation. Specific hypotheses tested under this objective for these issues are:

H_o: Allele frequency $_{\text{Hatchery}}$ = Allele frequency $_{\text{Natural}}$ = Allele frequency $_{\text{Donor}}$

H_o: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations $_{\text{Year y}}$

Supplementation should increase spawning population abundance as a result of high juvenile survival in the hatchery. Associated with an increase in returning spawner abundance should be an increase in effective population size (i.e., the number of actual breeders that produce successful offspring; N_e). The relative proportion of hatchery-origin spawners that participate in natural spawning is an important factor in realizing improvements in N_e. A disproportionate number of hatchery spawners may cause inbreeding depression if their level of relatedness is relatively high due to expected high juvenile survival. A decrease in reproductive success and thus lowered N_e is an expected result of inbreeding. Lowered genetic variability is also expected. Achieving a larger N_e in a supplemented population should improve long-term fitness. The specific hypothesis tested under this objective for this issue is:

H_o: Spawning Population Size Change = Effective Population Size Change

Results of domestication selection may be expressed through changes in life history patterns. Changes in phenotypic traits can result from inadvertent selection during artificial propagation and rearing. Persistence of selection effects will be influenced by the genetic basis of a trait. Age and size at maturity are two important phenotypic traits that have not been already addressed in the Plan. Should domestication selection be found, changes in broodstock collection protocols and hatchery operations should be considered by the HSC. Specific hypotheses tested under this objective for this issue are:

H_o: Age at Maturity $_{\text{Hatchery}}$ = Age at Maturity $_{\text{Naturally produced}}$

H_o: Size at Maturity $_{\text{Hatchery}}$ = Size at Maturity $_{\text{Naturally produced}}$

<u>Objective 4:</u> Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate) is greater than the natural adult-to-adult survival (i.e., natural replacement rate) and equal to or greater than the program specific expected value (BAMP 1998).

The survival advantage from the hatchery (i.e., egg-to-smolt) must be sufficient to overcome the survival disadvantage after release (i.e., smolt-to-adult) in order to produce a greater number of returning adults than if broodstock were left to spawn naturally. If a hatchery program cannot produce a greater number of adults than naturally spawning fish the program should be modified or discontinued. Production levels were initially developed using historical run sizes and smolt-to-adult survival rates (BAMP 1998). Using the stock specific NRR and the values listed in the BAMP, comparisons to actual survival rates will be made to ensure the expected level of survival has been achieved. Specific hypotheses for this objective are:

Ho: $HRR_{\text{year x}} \geq NRR_{\text{year x}}$

Ho: HRR ≥ Expected value per assumptions in BAMP

Using five-year mean and determining trends in survival of specific programs would address interannual variability in survival. Although annual differences among programs would still be analyzed to detect within year differences, which could explain some of the variability among programs. Specific recommendations to increase survival would be provided for programs in which the HRR do not exceed the NRR or the expected values.

<u>Objective 5:</u> Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks

Maintaining locally adapted traits of fish populations requires that returning hatchery fish have a high rate of site fidelity to the target stream. Hatchery practices (e.g., acclimation, release methodology and location) are the main variables that affect stray rates. Regardless of the adult returns, if adult hatchery fish do not contribute to the donor population the program will not meet the basic condition of a supplementation program. Fish that do stray to other independent populations should not comprise greater than 5% of the spawning population. Likewise, fish that stray within an independent population should not comprise greater that 10% of the spawning population. Specific hypotheses for this objective are:

Ho: Stray rate $_{\text{Hatchery fish}} < 5\%$ total brood.

Ho: Stray rate $_{\text{Hatchery fish}} < 10\%$ within independent populations

Stray rates should be calculated using the estimated number of hatchery fish that spawned in a stream using any recoverable tags. Recovery of CWTs from hatchery traps or broodstock may include "wandering fish" and may not include actual fish that spawned. Special consideration should be given to fish recovered from non-target streams in which the sample rate was very low (i.e., sample rate < 10%). Expansion of strays from spawning ground surveys with low sample rates may overestimate the number of strays (i.e., random encounter).

The rate and trend in strays from hatchery programs will be used to provide recommendations that would lead to a reduction in strays. Depending on the severity, hatchery programs with fish straying out of basin will be given high priority, followed by strays among independent populations, and finally strays within an independent population.

Objective 6: Determine if hatchery fish were released at the programmed size and number.

The HSC determined the number and size of fish that are to be released to meet NNI compensation levels. Although many factors can influence both the size and number of fish released, past experience should assist in minimizing impacts to the program. Specific hypotheses for this objective are:

Ho: Hatchery fish $_{\text{Size}}$ = Programmed $_{\text{Size}}$

Ho: Hatchery fish $_{\text{Number}}$ = Programmed $_{\text{Number}}$

Understanding causes of not meeting programmed release size or goal is important for the continued success of the program. Systematic problems should be identified and managed properly to achieve the objective(s) and goal of the program. Annual and some stock specific issues may be addressed via changes in hatchery operations.

A review of broodstock collection protocols should occur every five years concurrently with an evaluation of the number of fish released from each hatchery. In addition, the assumptions under pinning the size at release goals should be evaluated and if necessary should be adjusted based upon the best scientifically based conclusions. In the absence of such studies, the size at release goal should be the target for each hatchery program.

Objective 7: Determine if the proportion of hatchery fish on the spawning grounds affect the freshwater productivity (i.e., number of smolts per redd) of supplemented streams when compared to non-supplemented streams or references.

Out of basin effects (e.g., smolt passage and ocean productivity) have a strong influence on survival of smolts after they migrate from the tributaries. These effects introduce substantial variability into the adult-to-adult survival rates (NRR and HRR), which may mask in-basin effects (e.g., habitat quality, density related mortality, and differential reproductive success of hatchery and naturally produced fish). The objective of smolt monitoring programs in the Upper Columbia ESU is to determine the egg-to-smolt survival of target stocks. Smolt production models generated from the information obtained through these programs will provide a level of predictability with greater sensitivity to in-basin effects than spawner-recruitment models that take into account all effects.

A critical uncertainty with the theory of supplementation is the reproductive success of hatchery fish. Given the dependence of hatchery fish to assist in achieving program and recovery goals, monitoring smolt production with respect to the proportion of hatchery fish on the spawning grounds is critical in understanding subsequent adult-to-adult survival. While some factors that affect freshwater production require years or decades to detect change in productivity (e.g., habitat quality and quantity), other factors (e.g., spawner density and number of hatchery fish) can vary annually in most tributaries.

The number of smolts per redd (i.e., smolt production estimate divided by total number of redds) will be used as an index of freshwater productivity. While compensatory mortality in salmonid populations cause survival rates to decrease as the population size increases, inferences regarding the reproductive success of hatchery fish may be possible by carefully examining and understanding this relationship. Inherent differences in productivity are expected among tributaries (spatial). Changes in relative differences among years (temporal) would suggest differences in spawner productivity. Negative effects could then be minimized through actions taken by the management agencies. Specific hypothesis for this objective is:

Ho: Δ smolts/redd $_{\text{Supplemented pop.}} \geq \Delta$ smolts/redd $_{\text{Non-supplemented pop.}}$

<u>Objective 8:</u> Determine if harvest opportunities have been provided using hatchery returning adults where appropriate.

In years when the expected returns of hatchery adults are above the level required to meet program goals (i.e., supplementation of spawning populations and/or broodstock requirements), surplus fish are available for harvest (i.e., target population). Harvest or removal of surplus hatchery fish from the spawning grounds would also assist in reducing genetic impacts to naturally produced populations (loss of genetic variation within and between populations) and increase PNI. A specific hypothesis for this objective is:

Ho: Harvest rate ≤ Maximum level to meet program goals

A robust creel and tag recovery program on any fishery would provide the precision needed to ensure program goals are met. In addition, creel surveys would be used to assess impacts to non-target stocks.

<u>Regional Objectives</u>

<u>Objective 9:</u> Determine if the incidence of disease has increased in the natural and hatchery populations.

The hatchery environment has the potential to amplify diseases that are typically found at low levels in the natural environment. Amplification could occur within the hatchery population (i.e., vertical and horizontal transmission) or indirectly from the hatchery effluent or co-mingling between infected and non-infected fish (i.e., horizontal transmission). Impacts to natural populations have not been extensively studied and must be considered if recovery of listed species is an objective. While various diseases are common in hatchery populations, the most important and frequently occurring disease for Chinook is BKD. Specific hypotheses for this objective are:

Ho: Disease supplemented stream $_{\text{Year x}}$ = Disease non-supplemented stream $_{\text{Year x}}$

Ho: Naturally produced disease $_{\text{Year x}}$ = Naturally produced disease $_{\text{Year y}}$

Ho: Hatchery disease $_{\text{Year x}}$ = Hatchery disease $_{\text{Year y}}$

Ho: Supplementation Stream Upstream $_{\text{Year x}}$ = Hatchery Effluent $_{\text{Year X}}$ = Supplementation Stream Downstream $_{\text{Year X}}$

<u>Objective 10:</u> Determine if the release of hatchery fish impact non-target taxa of concern (NTTOC) within acceptable limits.

Supplementation of any stock or species will increase demand for resources and the potential of species interactions (Pearsons 2008). The benefits gained from supplementation must be balanced with the ecological costs of releasing hatchery fish into the ecosystem. Resource managers should be informed of and monitor potential impacts of supplementation related activities to non-target taxa. This is more important when supplementation activities involving more than one taxon are occurring simultaneously. For example, within the Methow Basin supplementation programs (i.e., spring Chinook, summer/fall Chinook, and steelhead), a spring Chinook harvest augmentation program and a coho reintroduction program release fish annually. At full program, the number of hatchery fish released into the Methow Basin would be approximately 2.4 million. Theoretical or realized benefits from supplementation activities may be at a cost to other taxa that are too great for the program to be deemed successful. In extreme cases, the costs of such activities may negate benefits of similar activities within the same subbasin.

Monitoring and evaluation plans concentrate efforts on the target species with little effort devoted to the direct or indirect impacts to non-target species. In the Upper Columbia River ESU, a target species in one program is likely a non-target species in another program. There are also some stocks and species in which no artificial propagation programs have been initiated and as a result are non-target for all existing hatchery programs. While impacts to non-target taxa are often preconceived to be negative (e.g., competition, predation, behavioral, and pathogenic), positive impacts may also occur (e.g., nutrient enhancement and prey). Monitoring efforts will be concentrated on those interactions that pose the highest risk of limiting the success of the programs and deemed important for ecological reasons. An ecological risk assessment will be conducted to determine the need and scope of NTTOC monitoring. Specific hypotheses for this objective are:

Ho: NTTOC abundance $_{\text{Year x}}$ = NTTOC abundance $_{\text{Year y}}$

Ho: NTTOC distribution $_{\text{Year x}}$ = NTTOC distribution $_{\text{Year y}}$

Ho: NTTOC size $_{\text{Year x}}$ = NTTOC size $_{\text{Year y}}$

If changes in abundance, distribution, and size of NTTOC occur, other information will need to be considered before attributing the changes to the hatchery program.

Strategies

The hypotheses and strategies that have been created in this plan were developed from the objectives of the hatchery program (Figure 1). As such, it is important to consider the goals and how they relate to the overall vision of the hatchery program, which is to meet NNI. The strategies outlined in this plan form the basis for how information will be collected and analyzed.

Commonalities among certain strategies and hypotheses will provide efficiencies in data collection and analysis. A detailed explanation of each strategy employed in the Plan is provided in the appendices to ensure repeatability in protocols, data collection, and analysis. Other strategies and potential hypotheses may be developed after information is collected and analyzed through the five-year review process.

Indicators

An important function of the Plan is to define the indicators and methods used to measure the effect of hatchery fish on naturally spawning populations, guide hatchery operations, and subsequent M&E activities. The indicators in the M&E Plan describe the biological data of interest. The protocols describe the strategy or methodologies used to measure or calculate the indicator. These are found in the appendices. The M&E Plan will also enable the hatchery committee to assess the progress toward meeting the goals and objectives of the hatchery program. The plan will be used to assure that the proper information is collected, and can be used to reevaluate hatchery production levels in future years. In order to do this, each objective must have a:

- **Indicator**: A description of the biological data of interest. Each indicator must have a standardized methodology or protocol to ensure accuracy and precision are consistent spatially and temporally.

- **Baseline condition**: Each indicator must have a measurement or range of measurements (spatially and temporally) against which future conditions will be compared.

- **Target**: A scientifically defendable value that when obtained would lead to meeting the objective(s).

- **Performance Gap**: The difference in the baseline condition of an indicator and the target.

In order to refine the monitoring and evaluation plan with appropriate detail, indicators are distributed into three categories: 1) the primary indicators will be used initially to quantitatively assess if the objectives of the programs are being achieved (i.e., was the target reached or exceeded); 2) secondary indicators will be used to collect information annually and may be used to calculate the primary indicator or assess whether the objectives are being reached in conjunction with the primary indicators; and 3) tertiary indicators will be used when secondary indicators fail to explain some critical uncertainties in reaching the target. Primary indicators may reflect performance on a longer (temporal) or larger (spatial) scale where secondary and tertiary indicators are often used to drive smaller scale adjustments and refinements in operations to improve the likelihood of meeting the target.

To the extent possible, the objectives of this Plan must be quantifiable. To assess this, indicators need to be developed that have targets associated with them that enable the PRCC to determine if the hatchery program is meeting objectives.

Due to variability in survival, monitoring and reporting will be conducted annually but evaluation of most objectives will be conducted over a five-year period. Measurements will center on the established indicators and whether the targets are being met. Trends in the primary indicators rather than simply the five-year mean will be important in determining if objectives are being achieved. Primary and secondary indicators will be calculated when needed (as dictated by the information obtained). However, in the event that these indicators fall below the agreed to target values, tertiary indicators may be required to explain the differences observed (uncertainty) and also a possible course of action.

Realistic targets for indicators need to be identified. Targets set too low may lead to a perceived short-term success, but may ultimately result in the long-term failure of the hatchery program. Conversely, targets that are too high may lead to an unnecessary use of resources and a low cost-benefit ratio. The proposed initial targets for indicators appear in Table 6.

Supplementation, either juvenile or adult based, is a strategy chosen by the JFP and PRCC. A critical uncertainty associated with supplementation is that naturally spawning hatchery fish possess a similar reproductive potential as naturally produced fish. This critical uncertainty associated with the theory of supplementation is a primary focus of the M&E Plan and logically a majority of the primary indicators in this plan are related to testing this uncertainty. Thus, the targets of many of the indicators are based on measurements taken from naturally produced populations, both temporally and spatially (i.e., Before-After-Control-Impact Design or BACI). Under this statistical design, inferences can be made regarding the effectiveness of supplementation in achieving the goals of the hatchery program. Without the use of a control or reference population, changes in the indicators over time may not be attributable to the supplementation fish. Due to potential multiple treatment effects, a direct comparison of the indicators may be invalid. Instead, a comparison in the change of the indicators over time may be more appropriate. For example, if indicator A showed a 15% increase in the reference population in the first five years, a similar 15% increase in the treatment population would also be expected. Thus, any change of the treatment population relative to the reference population could be attributed to the presence or abundance of supplementation fish.

All primary and a proportion of the secondary indicators have a target. Those indicators that are influenced by out of basin causes (e.g., ocean productivity) or density dependent factors (e.g., egg-to-smolt survival) do not have a target identified in this Plan because the ability to change these indicators fall outside the control of the HSC.

All primary and secondary indicators will be calculated on an annual basis. Tertiary indicators would only be measured or calculated when required. Most primary indicators will be analyzed at the five-year scale. However, conditions may exist which require certain primary indicators to be analyzed more frequently. All secondary and tertiary indicators would be analyzed on an annual basis.

Table 6. A list of primary indicators and targets used in the M & E Plan (S=supplementation; C1=captive brood 1st generation; C2=captive brood 2nd generation). Data will be collected annually and analyzed when required (minimum every 5 years).

Obj.	Program	Indicator	Target
1	S/C2	Natural replacement rate	≥ Non-supplemented pop.
2	S/C2	Run timing	= Naturally produced run timing
2	S/C2	Spawn timing	= Naturally produced spawn timing
2	S/C2	Redd distribution	= Naturally produced spawning distribution
3	S/C2	Genetic variation	= Donor population
3	S/C2	Genetic structure	= Baseline condition
3	S/C2	Effective pop. Size	Δ Spawning population size
3	S/C2	Size and age at maturity	≥ Naturally produced fish
4	S/C1/C2	Hatch. replacement rate	≥ Expected value[1]
5	S/C2	Stray rate	< 5% of adult returns
6	S/C1/C2	Number and size of fish	± 10% of production level
7	S/C2	Smolts/redd	≥ Non-supplemented pop.
8	S/C2	Harvest	≤ Maximum level
9	S/C2	*Rs* concentration	< Baseline values
10	S/C2	NTTOC	Various (e.g., 0-40%)

Table 7. Field sampling for the **White River and Nason Creek** spring Chinook salmon hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Tumwater Dam	May-September	Daily	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag
Adult spawning ground surveys	Walking surveys (redds and carcasses)	White River Nason Creek Little Wenatchee	August-September	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia R. Wenatchee R. Icicle	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Nason Creek Hatchery or Little White Salmon NFH	August-September	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant sampling	Rotary screw trap	White River Nason Creek	March-November	Daily	Date Species Count Length Weight Record mark and tag

					Apply mark or tag Take scales Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	White (Little White Salmon NFH, McComas) Nason (Nason Creek Hatchery)	All year	Generally monthly	Count Length Weight Fish health Tag or mark

Table 8. Field sampling for the **Methow River spring Chinook salmon** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Wells Dam Twisp Weir Methow Hatchery	May-September	Systematic daily sampling	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag
Adult spawning ground surveys	Walking surveys (redds and carcasses)	Methow River Twisp River Chewuch River	August-September	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia R. Methow R.	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock	Methow Hatchery	August-September	Weekly	Date Count

	at time of spawning				Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant sampling	Rotary screw trap	Methow River Twisp River	March-November	Daily	Date Species Count Length Weight Record mark and tag Apply mark or tag Take scales Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Methow Hatchery Twisp pond Chewuch pond	All year	Generally monthly	Count Length Weight Fish health Tag or mark

Table 9. Field sampling for the **Wenatchee, Methow, and Okanogan River summer Chinook salmon** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Dryden Dam Tumwater Dam Wells Dam Okanogan Weir	August-October	Systematic daily sampling	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag
Adult spawning ground surveys	Walking surveys (redds and carcasses) and floating surveys	Wenatchee River Methow River Okanogan River	October-November	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia Tributaries	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Gloyd Springs Hatchery Chief Joseph Hatchery	October-November	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant sampling	Rotary screw trap	Wenatchee River Methow River Okanogan	March-July	Daily	Date Species Count Length Weight Record mark and tag Apply mark or tag

		River			Take scales Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Gloyd springs Hatchery Dryden pond Carlton pond Chief Joseph Hatchery Okanogan Acc.	All year	Generally monthly	Count Length Weight Fish health Tag or mark

Table 10. Field sampling for the **Hanford Reach fall Chinook salmon** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Priest Rapids Dam Priest Hatchery weir	September-November	Systematic daily sampling	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag
Adult spawning ground surveys	Walking, raft, and aerial, surveys (redds and carcasses)	Columbia River	October-December	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Priest Rapids Hatchery	October-December	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant tagging	Seining	Columbia River	May-June	Daily	Date Species Count Length Weight Record mark and tag Apply mark or tag Take scales

					Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Priest Rapids Hatchery	September-May	Generally monthly	Count Length Weight Fish health Tag or mark

Table 11. Field sampling for the **steelhead trout** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Wells Dam Okanogan River Basin Other potential sites	July-April	Systematic daily sampling	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag
Adult spawning ground surveys	Walking surveys (redds) and floating surveys	Okanogan River Basin	March-May	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia Tributaries	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Cassimer Bar Hatchery Wells Hatchery	March-May	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant sampling	Rotary screw trap Snorkel surveys	Okanogan River Basin	September-November, March-June	Daily	Date Species Count Length Weight Record mark and tag Apply mark or tag Take scales

					Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Cassimer Bar Hatchery Acclimation sites	All year	Generally monthly	Count Length Weight Fish health Tag or mark

Table 12. Field sampling for the **Sockeye salmon** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult spawning ground surveys	Rafting surveys, (redds and carcasses)	Okanagan River	October-November	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Carcass tag (CWT, PIT) Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia Tributaries	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Shuswap Hatchery Penticton Sockeye Hatchery	October-November	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Shuswap Hatchery Penticton Sockeye Hatchery	October-May	Generally monthly	Count Length Weight Fish health Tag or mark

Table 13. Field sampling for the **Coho salmon** hatchery program M&E.

Task	Method	Location	Time	Sampling frequency	Data Collected
Adult migrant sampling	Adult trapping	Dryden Dam Tumwater Dam Wells Dam	September-November	Systematic daily sampling	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Apply tag * data collected at hatchery
Adult spawning ground surveys	Walking surveys (redds and carcasses)	Wenatchee and tributaries Methow	October-December	Weekly	Redd count Redd date Redd location Carcass count Carcass date Carcass location Carcass gender Carcass length Carcass egg retention Record carcass mark and tag Carcass origin
Estimates of Adult harvest	Commercial, Tribal, and sport harvest surveys	Ocean Columbia Tributaries	All year	Daily	Count Record mark and tag Location Scale
Broodstock sampling	Sampling broodstock at time of spawning	Cascade FH Willard NFH Winthrop NFH	October-December	Weekly	Date Count Length Origin Gender Scale sample Tissue sample Record mark and tag Fish health Egg weight
Juvenile migrant sampling	Rotary screw trap	Wenatchee and tributaries Methow	March-October	Daily	Date Species Count Length Weight

					Record mark and tag Apply mark or tag Take scales Origin
In-Hatchery performance	Subsampling of abundance and size, Disease screening, tagging	Cascade FH Willard NFH Winthrop NFH	All year	Generally monthly	Count Length Weight Fish health Tag or mark

Data entry, proofing, and management

Data will be recorded on PDAs (Personal Data Assistant), laptops, or paper data sheets. Error checking routines will be programmed into PDAs and laptops to prevent recording errors (Johnson et al. 2009). Data will then be imported or entered into Microsoft Excel or a database program. Further, error checking analyses will be performed to produce the final data set. Data will be stored on computers and backed up on a network hard drive or external hard drive. Backups of the data will be stored in a location that is different from the computer.

Data analysis and testing

Data will be analyzed and evaluated consistent with the analytical framework described in Hays et al. 2007 and with analyses that are being developed by the Hatchery Evaluation Technical Team (HETT). Most tests will examine hatchery or natural origin variables vs. a standard. Standards can include reference populations, performance of natural origin fish, mitigation requirements, quantitative objectives of the program, BAMP values, or other standards. Specific hypotheses to be tested are presented in previous portions of this document. In cases where statistical tests are equivocal or lack statistical power, weight-of-evidence approaches will be used to evaluate the data further.

Statistical difference

It is difficult to specify the exact statistical test that will be used for each comparison because data must be examined prior to testing to determine if assumptions of statistical tests are met (e.g. normality, homogeneity of variance). Priority will be given to parametric tests (e.g., ANOVA, paired t-test, GLM, permutation tests) because they generally have the highest statistical power. When assumptions of parametric tests cannot be met then non-parametric tests will be used (e.g., sign test, Wilcoxon matched pairs test). When significant annual variation exists in the data, paired analyses will be prioritized (e.g., test differences). P-values for statistical significance will be set at alpha = 0.05 unless other justifications are provided (e.g., low statistical power). Where appropriate and possible, statistical power will also be calculated. Similar types of analyses that will be used in this work are provided in Hays et al. (2006), Knudsen et al. (2006), and Knudsen et al. (2008).

Magnitude difference

Differences will be evaluated relative to the magnitude of difference. Some tests that result in significant statistical tests may not be biologically important. In contrast, some comparisons that do not exceed threshold P-values may be very important. Magnitude differences will often be recorded as percentages.

Implementation

Similar to HCP hatchery programs, specific details about the field methods of the M&E plan will be described in implementation plans, statements of work, and annual reports. A statement of work based on this document will be developed annually that outlines and prioritizes proposed M&E activities for the upcoming field season. This implementation plan will be reviewed by the HSC for approval before being finalized prior to the field season. The draft statement of work should be completed no later than July 1 and approved by the HSC no later than September 1, unless otherwise agreed to by the HSC.

The annual plan will serve two purposes; 1) allows the HSC to determine whether the monitoring efforts are prioritized correctly and 2) to determine costs of the program for budgeting.

Reporting

Findings will be presented annually in a technical report submitted to the HSC. This report will include an introduction, methods, results, and discussion. The HSC will have up to 30 days to review the report and provide comments to Grant PUD. When findings are sufficiently important to the scientific community and/or to resolve scientific disputes, attempts will be made to publish results in peer-reviewed scientific journals. A synthesis report will be written every 5 years, similar to that done for the HCP programs, that will provide the HSC opportunity to adaptively manage the project at regular intervals.

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Glossary

The following is a definition of terms used throughout the M&E Plan:

<u>Age at maturity</u>: the age of fish at the time of spawning (hatchery or naturally)

<u>Augmentation</u>: a hatchery strategy where fish are released for the sole purpose of providing harvest opportunities.

<u>Adult-to-Adult survival (Ratio)</u>: the number of parent broodstock relative to the number of returning adults.

<u>Broodstock</u>: adult salmon and steelhead collected for hatchery fish egg harvest and fertilization.

<u>Donor population</u>: the source population for supplementation programs before hatchery fish spawned naturally.

<u>Effective population size (N*e*)</u>: the number of reproducing individuals in an ideal population (i.e., N*e* = N) that would lose genetic variation due to genetic drift or inbreeding at the same rate as the number of reproducing adults in the real population under consideration (Hallerman 2003).

<u>ESA:</u> Endangered Species Act passed in 1973. The ESA-listed species refers to fish species added to the ESA list of endangered or threatened species and are covered by the ESA.

<u>Expected value</u>: a number of smolts or adults derived from survival rates agreed to in the Biological Assessment and Management Plan (BAMP 1998).

<u>Extraction rate</u>: the proportion of the spawning population collected for broodstock.

<u>Genetic Diversity:</u> all the genetic variation within a species of interest, including both within and between population components (Hallerman 2003).

Genetic variation: all the variation due to different alleles and genes in an individual, population, or species (Hallerman 2003).

Genetic stock structure: a type of assortative mating, in which the gene pool of a species is composed of a group of subpopulations, or stocks, that mate panmictically within themselves (Hallerman 2003).

HCP: Habitat Conservation Plan is a plan that enables an individual or organization to obtain a Section 10 Permit which outlines what will be done to "minimize and mitigate" the impact of the permitted take on a listed species.

HCP-HC: Habitat Conservation Plan Hatchery Committee is the committee that directs actions under the hatchery program section of the HCP's for Chelan and Douglas PUDs.

HRR: Hatchery Replacement Rate is the ratio of the number of returning hatchery adults relative to the number of adults taken as broodstock, both hatchery and naturally produced fish (i.e., adult-to-adult replacement rate).

Long-term fitness: Long-term fitness is the ability of a population to self-perpetuate over successive generation.

Naturally produced: progeny of fish that spawned in the natural environment, regardless of the origin of the parents.

NRR: Natural replacement rate is the ratio of the number of returning naturally produced adults relative to the number of adults that naturally spawned, both hatchery and naturally produced.

(NTTOC) Non-target taxa of concern: species, stocks, or components of a stock with high value (e.g., stewardship or utilization) that may suffer negative impacts as a result of a hatchery program.

Productivity: the capacity in which juvenile fish or adults can be produced.

Reference population: a population in which no directed artificial propagation is currently directed, although may have occurred in the past. Reference populations are used to monitor the natural variability in survival rates and out of basin impacts on survival.

Segregated: a type of hatchery program in which returning adults are spatially or temporally isolated from other populations.

(SAR) Smolt-to-adult survival rate: smolt-to-adult survival rate is a measure of the number of adults that return from a given smolt population.

Size-at-maturity: the length or weight of a fish at a point in time during the year in which spawning will occur.

Smolts per redd: the total number of smolts produced from a stream divided by the total number of redds from which they were produced.

Spawning Escapement: the number of adult fish that survive to spawn.

Stray rate: the rate at which fish spawn outside of natal rivers or the stream in which they were released.

Supplementation: a hatchery strategy where the main purpose is to increase the relative abundance of natural spawning fish without reducing the long-term fitness of the population.

Target population: a specific population in which management actions are directed (e.g., artificial propagation, harvest, or conservation).