APPENDIX AD3

Comprehensive Aquatic Research, Monitoring and Evaluation Plan

NOTE: This is a formal draft submitted for technical review. Please see the executive summary for gaps and shortcomings of this current draft RM&E plan, schedules for revisions, and opportunities for further review.

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1. INTRODUCTION

Local and regional efforts have begun to achieve a coordinated approach in the Columbia River subbasins to recover depleted salmon and steelhead populations. A part of those efforts is the development of Research, Monitoring and Evaluation (RM&E) plans that will help direct limited funds to accomplishing the most critical work.

This document describes a RM&E plan for aquatic and fisheries restoration programs in the Walla Walla Subbasin. Programs include hatchery actions for steelhead, reintroduction of spring Chinook salmon and Pacific lamprey, harvest management, and habitat, flow, and passage improvement projects. The RM&E plan outlines a strategy for obtaining information needed to assess the performance and evaluate the direction of these restoration programs. The intent of this plan is to 1) clearly articulate the connection between management and RM&E, 2) present a sound scientific approach to gathering information on critical uncertainties inherent in the fish restoration programs, and 3) describe sampling protocols that are consistent with regional standards, comply with National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) mandates, and fill data gaps associated with stock status and management programs.

Many of the monitoring and evaluation activities described in this plan are in place. However, several currently unfunded activities are proposed in this plan to address key information gaps. These proposed activities include modification of ongoing monitoring, critical uncertainty research, and innovative study approaches. A process for prioritization of RM&E activities and funding will need to be undertaken by co-managers and funding agencies following ISRP review of Subbasin management and RM&E plans.

1.1 GUIDING DOCUMENTS AND PLANNING ENTITIES

This plan relied upon regional RM&E efforts such as the FCRPS Biop plan developed under the direction of NOAA, the Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery (CMS), the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), and other similar strategies and plans currently under development. Management uncertainties and RM&E objectives were derived from the Walla Walla Subbasin Plan, Ecosystem Diagnosis and Treatment Model, and from technical staff recommendations obtained during bi-annual Walla Walla Technical Work Group meetings. Methods were taken in part from {Jordan, 2003 #1816; NPPC, 2004 #6590; Hillman, 2003 #1818; Hillman, 2002 #6587}.

The RME plan that follows describes RM&E objectives to address critical management uncertainties in the Walla Walla Subbasin. This plan consists of introductory material describing the management context of RM&E planning, identifies critical uncertainties, presents RM&E objectives for addressing these uncertainties, and finishes with a proposed detailed methodology. The experimental design is discussed in sections (2) and in the context of RM&E objectives and methods.

1.2 MANAGEMENT OBJECTIVES

Section 7 of The Walla Walla Subbasin Plan identifies a vision for management of the Subbasin's natural resources.

> *The vision for the Walla Walla Subbasin is a healthy ecosystem with abundant, productive, and diverse populations of aquatic and terrestrial species that supports the social, cultural and economic well-being of the communities within the Subbasin and the Pacific Northwest.*

In addition to that qualitative vision statement, and the quantitative assessment of the Walla Walla Subbasin, the management plan goes on to describe a set of biological habitat restoration objectives, strategies for achieving those objectives, and working hypotheses for testing the relationships among objectives, strategies, and population status and trends. The objectives for each geographic area are summarized in Table 7-1. Each habitat restoration objective has inherent assumptions associated with project implementation and efficacy. Corresponding working hypotheses have inherent assumptions associated the ecological response of aquatic populations to habitat restoration actions under varying environmental and ecological conditions.

The purpose of this document is to describe a plan of action for addressing assumptions and critical management uncertainties associated with the biological objectives, working hypotheses, and limiting factors analysis outlined in the Subbasin Plan, and various BPA supported artificial production activities. The assumptions and hypotheses are listed below (1.3) in the form of management uncertainties. Each uncertainty is associated with a set of biological objectives and working hypotheses. These statements converge in the form of performance metrics (Table 1) and associated methodologies for calculating each metric.

Table 1 Aquatic Performance Measures and Corresponding Management Uncertainties for the Walla Walla Subbasin

Metric	Life Stage	Performance Measure	Critical Uncertainty
Abundance	Adult	Spawner abundance	How many adult salmon and steelhead return each year to the Walla Walla, Touchet and Mill Creek watersheds by species and stock, and to all watersheds combined? Are these stocks meeting established escapement and spawning goals?
			How many bull trout, mountain whitefish, freshwater mussels, and Pacific lamprey are present in each watershed? Are these populations sustainable?
			How many broodstock were collected for hatchery production, where, when and how, including sizes and condition? What is their age structure and origin?
		Return to mainstem dams	What is the run-timing and abundance to each Columbia Mainstem dam?
		Spawner composition	Are there any naturally produced adult spring Chinook spawners? How many? What is the composition of hatchery vs. naturally reared steelhead spawners?
		Spawner Escapement	What is the annual distribution and abundance of spawners and redds in each watershed for spring Chinook, steelhead and redband trout, bull trout, whitefish, freshwater mussels, and lamprey?
			What are the migratory patterns, distributions and maximum upstream ranges of spring Chinook, steelhead, and pacific lamprey migrants?
		Run Prediction	What is the predicted run-size to the Walla Walla River mouth for each species? Can the run size or spawning population of each species be predicted accurately prior to the adult returns or spawning?

Metric	Life Stage	Performance Measure	Critical Uncertainty
	Juvenile	Parr and pre-smolt Abundance	What are the summer densities of salmonids, by species, throughout the basin? What are the summer densities of non-salmonids by species that may affect salmonid abundance?
		Outmigrant Abundance	What is the total abundance of salmonid outmigrants, by species and stock?
		Residual Abundance	What is the total abundance and demographic composition of hatchery residuals?
Survival and Productivity	Adult	Broodstock Survival	How, where and when were adult broodstock held prior to spawning, including numbers, sizes and condition?
			How, where and when were broodstock artificial spawned, including numbers, sizes and condition?
			What is the survival and productivity of each broodstock cohort?
		Smolt-to-Adult Return	What are the smolt-to-adult return ratios for each species, stock and brood year?
		Smolt-to-Adult Survival	What are the smolt-to-adult survival rates for each species and brood year?
		Parent Progeny Ratio	What are the parent-to-progeny ratios for each species and brood year?
		Pre-spawn Mortality	What was the egg retention and proportion of pre-spawn mortalities by reach?
		Re-spawning	How much repeat spawning occurs for bull trout, steelhead and resident redband trout or whitefish?
		Recruit /spawner (adult to adult)	What are the limiting factors that influence adult to adult production and survival rates?
	Juvenile	Egg to Fry Survival	What are the egg to fry survival rates for each species and brood year, and what are the limiting factors that influence survival rates?
			How, where and when were hatchery eggs incubated?
		Fry to parr and parr to outmigrant survival	What are the fry to parr survival rates for each species and brood year, and what are the limiting factors that influence survival rates?
			How, where and when were hatchery fry and parr reared, including numbers, sizes and condition?
		Outmigrant Survival to McNary Dam	What is the survival of salmonid outmigrants to McNary Dam and the lower Columbia River, by species and stock?
			What are the passage times, injury rates and mortality rates at each passage facility and between facility reaches?
		Smolt Survival through Mainstem Columbia River	What are the smolt survival rates through the Columbia Mainstem and to the Columbia estuary?
Distribution and Movement	Adult	Spawner Spatial Distribution	What is the spawner disposition of adult steelhead, salmon, bull trout, whitefish, redband trout and lamprey in each watershed?

Metric	Life Stage	Performance Measure	Critical Uncertainty
			What are the origins and marks of all spawners??
		Stray Rate	What are the stray rates or contribution of Walla Walla Basin steelhead, bull trout and salmon into other basins?
			How many salmon and steelhead stray into the Walla Walla Basin each year from other basins, by species and stock?
	Juvenile	Rearing Distribution	What is the relative abundance and distribution of salmonids, by age and species, seasonally, throughout the basin? What is the rearing distribution of non-salmonids that may affect salmonids?
		Residual Distribution	What is the distribution and relative abundance of hatchery residuals?
Life History	Adult	Run Timing	What is the annual run timing of each species and stock?
			What is the average passage time for spring Chinook at each passage facility and between facility reaches?
			What is the average daily movement by species, month and reach for salmon, steelhead, and bull trout?
			How do flows, temperatures, seasons, facility operation and other factors affect adult migration of salmon, steelhead, bull trout, whitefish and lamprey?
		Age of spawners	What proportion of the steelhead/rainbow and bull trout spawners had resident, fluvial or anadromous life histories each year?
			What is the age of salmon, steelhead, bull trout, whitefish, lamprey and rainbow trout spawning naturally in the basin?
		Size of spawners	What are the length-age and length-weight frequency distributions of spawners?
		Sex Ratio of spawners	What is the sex ratio of spawners for each species and brood year?
		Fecundity	What is the number of eggs per female and the number retained or not viable?
		Spawn-timing	What is the spawn timing of each species?
	Juvenile	Size at Release	What is the size-frequency distribution of all hatchery releases?
		Release Location	How, where and when were parr and smolts acclimated and/or liberated, including numbers, sizes, and condition?
		Emigration Timing	What is the timing of parr and smolt outmigrations, by species and stock?
			What is the average daily downstream movement by species, month and reach?
			What is the arrival timing for parr and smolt outmigrants to McNary Dam and the lower Columbia River, by species and stock?
		Age at Emigration	What are the sizes, age and growth rates of salmonids, by species throughout the basin?
		Size at Emigration	What is the size of parr and smolt outmigrants, by species and stock?

Metric	Life Stage	Performance Measure	Critical Uncertainty
		Condition at Emigration	What is the condition of parr and smolt outmigrants, by species and stock?
			What are the marks and tags used to identify each release group?
			What was the disease and treatment history of each life history stage?
Fish Health	Adult and Juvenile	Disease Incidence	What are the vertical and horizontal transmission rates of dominant diseases in natural and supplemented populations?
		Disease Severity	What is the severity of diseases in natural populations?
		Disease Treatment	For each relevant disease, what is the best disease management practices for the prevention and treatment of each species, stock and life history stage?
Genetic	Adult and Juvenile	Genetic Diversity and Population Structure	What are the general genetic characteristics and geographic stock structures of steelhead, Chinook, bull trout, redband trout, lamprey and whitefish in the Walla Walla and surrounding subbasins?
			What is the contribution of resident redband trout to steelhead production in the Walla Walla?
			What is the rate of hybridization between endemic wild and out-of-basin hatchery reared stocks?
			What is the rate of hybridization between bull trout and introduced brown trout, if it occurs?
			What is the origin and ESU of lower Walla Walla coho and fall Chinook? Are these listed stocks?
			What is the rate of change in the genetic characteristics (drift and flow) in the various steelhead, redband, bull trout, whitefish, lamprey and Chinook stocks through time?
		Reproductive Success	Are there negative or deleterious changes (based on current genetic theory) to the population characteristics of Walla Walla steelhead, redband, bull trout, whitefish, lamprey and Chinook stocks through time?
			What is the long-term reproductive success of endemic hatchery reared steelhead or hatchery spring Chinook?
		Effective population size	What is the optimum adult escapement for natural production for each species? How many fish breed each year? Are these stocks meeting established spawning goals?
Fisheries	Adult	In-basin harvest	Are hatchery steelhead, redband trout, and spring Chinook achieving harvest mitigation goals?
			What and where? was the annual sport harvest of salmonids by species in the basin?
			What and where was the annual tribal harvest of salmonids by species in the basin?
			What are the cumulative affects of harvest management on wild steelhead, bull trout, naturally produced spring Chinook and mountain whitefish?

Metric	Life Stage	Performance Measure	Critical Uncertainty
			What are the most cost effective and statistically robust harvest monitoring strategies and protocols for the sport and tribal fishing seasons? What are the rates of redd bull trout or salmon redd disturbance by trout fishers?
		Out-of-basin harvest	What and where was the annual out-of basin harvest of Walla Walla Basin origin salmon and steelhead?
		Hooking rate	What are the hooking rates and capture rates for each species and race?
		Handling mortality	What is the morality rate of hook-and-released fish?
Hatchery Practices	All	Operations	What are the processes, standards and criteria needed to develop hatchery practices that balance the needs to be efficient, cost effective and minimize ecological and genetic risks to natural and hatchery stocks? What are the optimal breeding practices for each species and stock? What are the optimal incubation practices for each species and stock? What are the optimal rearing methods for each species, stock and life history stage? What are the optimal growth and feeding rates for each species, stock and life history stage? What are the optimal times, methods, and protocols for tagging hatchery reared fish for each species and stock? What are the optimal sizes, times, locations and conditions to release hatchery reared fish into the basin?
		Genetic Management	What are the best stocks to use for each species for the hatchery programs?
		Broodstock	What are the best strategies and methods to collect broodstock for hatchery programs for each species and stock? What are the best methods to hold and spawn broodstock for each species and stock?
		Hatchery Performance	What are the similarities and differences in the sex ratio, fecundity, run timing and spawning time of adult hatchery and natural steelhead and Chinook? What are the similarities and differences in size, age, migration timing, migration survival and smoltification of hatchery and natural steelhead and Chinook? Are hatchery stocks meeting survival or production standards? What are the similarities and differences in genetic characteristics of hatchery and natural steelhead and Chinook? What are the similarities and differences in the types, incidence and severity of diseases in hatchery and natural steelhead and Chinook?

Metric	Life Stage	Performance Measure	Critical Uncertainty
Habitat	Adult and Juvenile	In-stream flow	Are flow rates suitable to spawning and rearing for each reach and species? Are they limiting focal species? If so, where and when?
		Surface-ground water exchange	What is the nature and rate of groundwater exchange with fish bearing streams?
		Water temperature	What are the water temperatures in the basin from the mouth to the headwaters, May through October?
			What are the water temperatures in the basin during the winter?
			Are temperatures limiting focal species? If so, where and when?
			What are the interactions between flow and temperature associated with flow augmentation planning?
		Water quality	What are the seasonal and annual means and variances in water quality conditions by reach or watershed?
		Physical habitat conditions	What are the conditions, trends, quantities and connectivity of various salmonid habitat types in the basin? What is the connectivity with other subbasins?
			What EDT metrics are most easily measurable given local programmatic, social, and environmental constraints? What are the appropriate habitat inventory protocols for each stream type?
			How effective are various physical habitat management and restoration actions and strategies in improving survival, productivity, condition, abundance and distribution of each species and stock, by life history stage and reach?
			What restoration actions have occurred, where, when, and to what extent?
		Biological habitat conditions	Are fish habitat conditions improving or degrading for focal species, and what are the rates of change by stream and reach?
		Habitat Quantity	What are the natural production capacities for each sub-watershed in the basin?
			What habitats are the most important to rehabilitate, maintain and preserve?
			What and where are the landscape scale problems affecting fish habitat within and outside the subbasin?
			How does salmonid natural productivity and capacity in the basin compare to neighboring basins?
			Are Titus, Garrison, or other poorly studied creeks potential salmonid producers?
		Passage barriers and diversions	Are instream flows adequate by reach and species for fish productivity and passage?
			Are there delays at passage facilities for juveniles or spawners, and if so, how many, where, when and under what conditions?

Metric	Life Stage	Performance Measure	Critical Uncertainty
			How well do focal species negotiate the passage and flood control facilities, especially through the lower Mill Creek-Yellowhawk Creek complex?
			Is Yellowhawk Creek used as spawning habitat, or purely as a migration corridor?
			Were Nursery Bridge, Burlingame, Hofer, Bennington Dam, Gose St. or other passage restoration efforts successful?
			Is the Yellowhawk weir an effective monitoring facility?
			Does the Hofer irrigation diversion or other poorly studied sites provide sufficient downstream passage?
			Does Dry Creek provide adequate passage past Dixie during low flows?
			Are current flows and temperatures sufficient to provide adequate adult passage?
			How well do downstream migrants negotiate the passage facilities?
			How many fish are being diverted into the Bennington Lake Diversion?
			Are the newly placed screens effectively excluding salmonids?
		Habitat utilization	Is available habitat adequately seeded with spawners and juveniles? What are the preferred habitats by species, age, or size and season?
		Smolt production of habitat	What is the quantity of production of juveniles produced from each unit of habitat in each priority watershed by species?
Ecosystem	Juvenile and Adult	Trophic relationships	What are the aquatic focal species trophic relationships in pristine and disturbed watersheds?
		Competition	Are we effectively isolating the out-of-basin stock, and minimizing the ecological impacts on wild fish within and outside the Walla Walla Basin? What are non-salmonid and non-native species impacts on focal species?
			What are the competetive ecological and genetic interactions of wild and hatchery steelhead?
		Natural mortality	What are the primary physical, chemical, and climatic factors and relationships that influence survival, productivity, condition, abundance and distribution of each species, stock and life history stage?
		Marine ecology	What are the marine life-history and ecological interactions of Walla Walla salmon and lamprey?
		Redd impacts	Are the ecological benefits of salmonid and lamprey redds maximized under the current management regime?
		Carcass impacts	Are the ecological benefits of salmon carcass inputs maximized under the current management regime?
Whole System	Socioeconomic Indicators	Capital Accounts	What are the relationships between natural, social, and economic capital?

Metric	Life Stage	Performance Measure	Critical Uncertainty
		Wealth Creation	How do production modes, efficiencies, innovations, and investment contribute to an improved value chain of natural, social, and economic capital?
		Dividends	How do opportunities for growth, sustainable standards of living, and financial security relate to wealth creation and natural, social, and economic capital accounts?
		Cultural	What is the efficacy of policy, regulation, and values in contributing to natural, social, and economic dividends, wealth creation, and capital accounts?
		Waterscape/ Landscape	How do fish, wildlife, and people interact within the same landscape through time?

1.3 MANAGEMENT UNCERTAINTIES

Management information needs were developed in a collaborative setting by members of the Walla Walla Subbasin Technical Work Group (TWG). The following performance metrics and critical uncertainties were developed in 2003, and updated by TWG in March of 2004 for the Subbasin Plan and the comprehensive RM&E plan. The list has not been prioritized, and represents an exhaustive list of RM&E needs associated with the natural production biological objectives and working hypotheses identified in the WWSBP, plus additional uncertainties associated with ongoing and planned artificial production activities. Some tasks will be addressed directly by TWG membership under on-going monitoring. Other objectives will be addressed through collaborative endeavors using multiple funding sources. Some questions are currently being addressed by targeted research programs. See Table 2 for relationships between uncertainties, performance metrics, and institutional activities and responsibilities.

In developing this list of uncertainties, the Walla Walla Subbasin Planning Team and technical staff recognize the following RM&E needs as paramount to adaptive management in the subbasin:

1. Fill EDT data gaps and establish baseline habitat conditions
2. Verify habitat attribute values to validate EDT modeling runs
3. Establish firm baseline of habitat conditions to track change over time and to assess the watershed response to habitat improvement actions undertaken in the basin
4. Use systematic habitat characterization provided by EDT as basis for future validation monitoring.
5. Focus RME efforts on critical data needs for VSP attributes, ESA evaluation, and Power Act Implementation.
6. Conduct long-term monitoring and evaluation of population, environmental, and ecological conditions for all salmonid life stages and rearing types
7. Conduct effectiveness monitoring of restoration actions at the watershed scale

8. Address critical uncertainties in the relationships between habitat attributes, ecological conditions, stochastic variability, and salmonid production.

9. Coordinate with regional Tier 1 and Tier 2 protocols, data management, and coordination efforts

10. Coordinate with regional basic science efforts (Tier 3 studies)

11. Validate EDT model as a reliable measure of habitat and population response to recovery actions taken in the Walla Walla subbasin using regionally standardized survey and analysis methodologies.

2. RESEARCH, MONITORING, AND EVALUATION OBJECTIVES

2.1 RESEARCH, MONITORING, AND EVALUATION GOAL

The goals of the Walla Walla Aquatic RM&E program is to monitor the status and trends of natural and hatchery reared salmonids, lamprey, and mussel populations and ecosystems, to research the factors that influence aquatic population viability, to assess the effectiveness of management actions, and to provide information to resolve critical uncertainties using sound adaptive management application.

The following sections present the experimental approach, research objectives, and monitoring and evaluation objectives used to meet the requirements of the Walla Walla Aquatic RM&E program goals.

2.2 MONITORING AND EVALUATION CONTEXT

Critical uncertainties often serve as a pretext for inappropriate management actions. Uncertainty is a function not only of unpredictability and ecosystem randomness but also of our state of knowledge and scientific understanding. Therefore, monitoring and evaluation have long been recognized as necessary components of natural resource management. Monitoring and evaluation activities are intended to address uncertainty and to provide feedback for proper adaptive management (NPPC, 1990). Thus, the monitoring and evaluation plan serves as an adaptive management tool for assessing the effectiveness of habitat restoration, harvest management, and hatchery programs, and addressing gaps in our knowledge and understanding of natural resources.

The importance of monitoring natural resource status and assessing the impact of management actions is emphasized by several science groups (Botkin et al. 2000; Hesse and Cramer 2000; ISRP 2001; McElhany et al. 2000). Monitoring and evaluation activities should describe program status and provide feedback to managers (Steward 1996; NPPC 1999). This is accomplished through annual monitoring of population status and trends, small-scale studies, and replicated experiments with controls. Feedback consists of collecting information that describes the distribution, condition, status and trends of biological and environmental variables of interest with analytical and predictive power. Management then has current data on a continuous basis in which to properly evaluate program effectiveness. Moreover, well-coordinated management actions, when coupled with relevant monitoring and evaluation programs, can reduce uncertainty about the effect of those actions on target and non-target populations.

2.3 ARTIFICIAL PRODUCTION MONITORING

Hatchery production of anadromous salmonids may be capable of increasing natural production and harvest. The reintroduction of extirpated species may be capable of establishing locally adapted, self-sustaining populations. The goals of reintroduction of spring Chinook in the Walla Walla River are to restore natural production and to provide and enhance tribal and non-tribal subsistence and recreational fisheries throughout the basin. The management intent of WDFW's experimental endemic steelhead production program is harvest is just to minimize the effects of the harvest augmentation program on listed fish. There is clear evidence from radio-telemetry data, the inefficiency of the Dayton Weir, and the operational procedure at the Dayton Weir hatchery fish and naturally reared fish overlap in their spawning distribution. CTUIR supports an integrated hatchery program for steelhead in the Walla Walla. CTUIR is hopeful that the endemic portion of this program will result in supplementation of natural production to help rebuild this listed population. While there is a lack consensus by the co-managers on this issue, there is no ambiguity as to the need to understand existing hatchery-wild spawning interactions. The plan below includes RM&E objectives and methods dealing with these hatchery-wild steelhead interactions.

The benefits of hatchery augmentation and reintroduction to recovery are not universal and may be highly uncertain (ISAB 2003-3), and reintroduction of fish populations using non-local stocks is not without risk. Traditional hatchery programs have not always met success in the past. Hatchery smolts produced from localized stocks perform better that hatchery smolts from distant stocks (Reisenbichler 1988), successful outplanting of hatchery-origin fish depends on the ability to produce hatchery fish qualitatively similar to native fish (Lichatowich and McIntyre 1987), genetic fitness decreases as differences between hatchery and native fish increase (Chilcote et al. 1986), and the production of native stocks can be reduced after the introduction of poorly adapted fish (Vincent 1987). Therefore, monitoring and evaluation are integral in managing the risks associated with hatchery augmentation and reintroduction.

The plan below describes monitoring and evaluation activities associated with currently implemented artificial production programs: a spring Chinook adult outplanting program, a Lyon's Ferry steelhead harvest mitigation program, and an experimental endemic steelhead mitigation program. Additional RM&E efforts will be required if and when these programs change. For example, a master plan for spring Chinook hatchery production at the South Fork Walla Walla holding facility is currently being developed. The implementation of this program would require increased monitoring efforts, and possibly the installation of in-stream PIT-tag detectors or other outmigrant monitoring devices. These contingencies are not discussed below.

2.4 EXPERIMENTAL DESIGN

The research, monitoring and evaluation aspects of this plan are designed to assess the current status of stocks, proposed restoration efforts and test new strategies for the reintroduction, hatchery augmentation, and restoration of salmonids, lamprey, and freshwater mussels, and the establishment and enhancement of commercial and recreational fisheries. Due to the complex nature of salmonid restoration programs in the Walla Walla, this RM&E plan was designed to address six monitoring domains comprehensively. These domains are trend, status, implementation, effectiveness, validation, and compliance monitoring (Hillman and Giorgi 2002). This multifaceted approach will allow scientists to answer a breadth of management uncertainties associated with natural variability of the Walla Walla system and its fishes, the extent and effectiveness of management actions, the management paradigm and adaptive strategy, and various legal requirements associated with ESA listed species, state laws, and tribal treaty requirements.

The Independent Scientific Advisory Board (ISAB) recognizes a three-tiered approach to monitoring involving trend analysis (tier I), statistical inferences from appropriate performance measures (tier II), and experimental research (tier III). Trend monitoring requires repeated measurements within a consistent landscape to quantify change over time. Statistical monitoring can help provide conclusive information regarding management actions and experimental research can establish cause and effect (Hillman 2003). Key indicators or performance measures should be broad in nature and involve the entire life cycle of focal species. In addition, the Independent Science Review Panel (ISRP) recommended viewing artificial production projects as a large-scale manipulative experiment and testing the major hypotheses associated with artificial production as a rebuilding and recovery tool. Variables to be tested in a population and artificial production/supplementation assessment should include adult escapement, smolt yield, smolts per spawning adult, harvest, recruits per spawner, and trends in these statistics over time periods that define the productivity and capacity of the system (ISRP 2002). Other relevant focal species metrics are outlined above and below.

In addition to ongoing monitoring, the plan includes new descriptive studies to add additional baseline data and background information. These studies include basic information on interspecific ecological interactions between steelhead, bull trout and Chinook salmon as well as intraspecific interactions between hatchery and natural-origin salmonids. Additionally, genetic studies are proposed to provide the necessary data to address critical uncertainties on 1) the reproductive success of hatchery and natural origin steelhead and Chinook salmon spawning naturally in the Walla Walla Subbasin, and 2) the amount of reproductive isolation between hatchery and natural origin salmonids reproducing in the wild, 3) the connectivity among bull trout populations in the Columbia Plateau, and 4) the identification of different sub-populations or stocks within the subbasin.

To establish cause and effect relationships, tier III manipulative experiments are included in the plan to assess the efficacy of adult outplanting. Tier II manipulative experiments in the natural production project include flow enhancement and habitat improvement to improve migration corridors and spawning and rearing habitat. Before/after comparisons can be made to assess the success of habitat improvement projects, however these comparisons are confounded by inter-annual variation in environmental and climactic conditions. Instead a comparative performance approach will be used to determine the efficacy of various restoration actions.

2.5 STATUS MONITORING

Status monitoring is performed at some scale for all focal species in the Walla Walla Subbasin. Natural production status monitoring includes abundance indices for juveniles (parr and smolts), number of returning adults, estimated redd numbers, as well as flow, temperature and habitat data to assess the success of flow augmentation and stream restoration work. Hatchery and natural production evaluations include the monitoring of smolt-to-adult returns, smolt-to-adult survival, catch contribution, catch distribution and straying rates, and experimental releases of juveniles and spawners. Juvenile outmigration monitoring includes the number of outmigrating smolts, travel timing, and survival to downstream dams. In addition, the fishery is monitored using creel surveys and marine fishery observations to estimate the contribution of Walla Walla River fish to all commercial, subsistence and recreational fisheries.

The objectives of status monitoring are to describe existing habitat conditions and stock status, and to provide evidence of trends over time. The NOAA Fisheries RME Plan (NOAA 2003) calls for status monitoring to document progress toward recovery of listed populations. Controls are not required in status monitoring because cause-and-effect relationships are not sought. Repeated measurements (temporal replicates) are taken over time to quantify change. Existing population conditions are compared to performance standards as established in the appropriate recovery or master plans.

2.6 SPATIAL SCALE

The variability of physical and biological components of an ecosystem occurs at multiple spatial scales (Bisbal 2001). Management action and resource status reviews occur on multiple spatial scales that may be different from the important scales of physical or biological variability. Scales that are very fine may be too variable to provide meaningful results for some performance measures. Scales that are too course may lack sufficient sensitivity to detect change for other performance measures. Thus, the appropriate spatial scale for monitoring and evaluation is dependent on the performance measure of interest. Unfortunately, transferability across spatial scales is sometimes difficult, and so a multi-scale approach to monitoring the restoration of salmonids and their ecosystems is essential (NOAA 2003).

Subbasin-wide: Information from monitoring at this scale provides a basis for interpreting subbasin-level population data. At this spatial scale, the primary objective is to develop a general understanding of focal species abundance and demographics. The data collected by this type of monitoring will be used to assess population trends, assess the status of subbasin health, and associate subbasin condition with population status and processes (Jordan et al. 2002).

Several population and environmental metrics will be sampled at the subbasin scale. A number of other reach and watershed scale metrics will be aggregated at the subbasin scale. This will allow population performance criteria, such as total smolt-to-adult survival, to be evaluated for the entire Walla Walla Subbasin. In addition, we will measure a number of subbasin scale variables, such as the total adult escapement to the mouth of the Walla Walla River, allowing a regional comparison of relative performance with other subbasins.

Watershed: Some analyses will be performed on the watershed scale because of variability in the status of the riparian corridor and instream habitat among watersheds within the Walla Walla Subbasin. The more pristine, higher elevation watersheds in the Walla Walla Subbasin provide most of the spawning habitat for steelhead, spring Chinook salmon, and bull trout. Habitat restoration, spatial overlap between natural and hatchery origin spawning habitat, and the potential for spawning sanctuaries for native fish vary by watershed. A number of variables, including land-use characteristics, temperature, hatchery releases and discharge will be sampled at the watershed scale.

Reach: A number of attributes show tremendous variation at the reach scale. Instream and riparian conditions tend to vary across meters and kilometers, resulting in a patchwork of essential fish habitat. Individual fish in all life stages respond to these surroundings, make choices, and experience the environment accordingly. This interface of environment, behavior, and ecology defines the spatial scale for monitoring spawning success, juvenile populations, and their habitat. These variables will be measured by CTUIR using a modified Environmental Monitoring and Assessment Program (EMAP) approach. Sampling effort will be stratified throughout each watershed at the reach scale, and the results will be aggregated accordingly.

This multi-scale approach to monitoring and evaluation provides a broad but coherent context to approach the complex questions associated with sustainable salmonid restoration. In addition the multi-scale approach provides a framework within which small-scale or tier-3 research can be conducted simultaneous to longer-term monitoring work. The following section outlines the monitoring and research objectives of the Walla Walla Aquatic RM&E program, and provides some details regarding the multi-scale and multidisciplinary approach needed to address their corresponding uncertainties. These general descriptions are followed by a detailed technical methodology that includes power analyses and sampling protocols where appropriate.

2.7 RESEARCH AGENDA

Numerous efforts are presently ongoing within the Columbia Basin to recover salmonids, mussels, and lamprey. Research is underway to document population response to habitat, hatchery, harvest and hydro modifications. During these actions the general understanding of the biology and ecology of salmon and steelhead populations is increasing. There remain significant data gaps and critical uncertainties regarding recovery actions. Limited funds must be used wisely to help ensure ESA populations receive maximum benefit from actions, without sacrificing ongoing reintroduction programs for extirpated stocks. Many critical uncertainties remain throughout the region, and within the subbasin. These uncertainties must be answered if populations are to be rebuilt and delisted. Such uncertainties may include habitat/life history stage relationships, causal relationships for degraded habitat and depressed or extirpated populations, and understanding the relationship between resident and anadromous *O. mykiss* subpopulations. These critical uncertainties will be identified in forums such as: Regional salmon recovery planning; Region wide (Columbia Basin) critical needs lists developed by management agencies; NOAA's Comprehensive FCRPS BiOp RME plan; and Washington State's Comprehensive Monitoring Strategy; and the Walla Walla Subbasin Comprehensive RME Plan. Critical uncertainties for whitefish, mussels, lamprey, and redband trout will continue to be identified by subbasin managers and scientists.

The Walla Walla Subbasin research agenda was developed in response to specific cause-effect relationships in Walla Walla Subbasin salmonid production that cannot be extrapolated from previously published research or derived from prior Walla Walla RM&E. The critical uncertainties were selected in part due to their importance in the Walla Walla Subbasin in particular, but also due to their regional management applicability. The following research objectives and approaches are needed to address critical management uncertainties in the subbasin.

2.7.1 Test the EDT Working Hypotheses

Status: Partially funded (BPA)

Purpose and Scope

EDT was developed to provide a spring-board for quantitative decision making in the habitat and fisheries management arena. The model is theoretically well supported, and provides a set of working hypotheses for habitat restoration and off-site salmonid mitigation. Although EDT is populated using local habitat data, the response predicted for fish productivity, capacity, and abundance is generally theoretical and associative in nature and has little supporting documentation for the Walla Walla Subbasin. In addition much of the habitat data used for EDT was not all of the same quality and much of it was based on professional judgement. The fish population component of EDT does not consider the antagonistic, additive, or synergistic effects of restoring multiple species at once, and it does not consider the density dependent complications associated with restoring populations with relatively small numbers of individuals. Therefore EDT could over or underestimate the benefits of habitat restoration in the Walla Walla Subbasin.

Habitat data must be improved for sections of the Walla Walla Subbasin. Section 2.8.6 outlines the process for updating habitat data and incorporating it into a system-wide database. Within five years, habitat data for the Walla Walla will be dramatically improved, and a revised estimate of baseline conditions can be produced. In the five years that follow it will be feasible to 1) compare EDT estimates to data-derived estimates of focal species production, 2) begin to populate habitat scenarios in EDT using real data, and 3) test the ability of EDT to predict the biological response of focal populations to habitat changes. The purpose of this ten year project is to test the following null and alternative hypotheses:

> Ho: The restoration of habitat, as described in the EDT working hypotheses, will result in salmonid production that is equal to that predicted by EDT.
>
> Ha1: The restoration of habitat, as described in the EDT working hypotheses, will result in salmonid production that is more than that predicted by EDT.
>
> Ha2: The restoration of habitat, as described in the EDT working hypotheses, will result in salmonid production that is less than that predicted by EDT.

The federal management agencies are working closely together to improve Columbia mainstem passage conditions, and to reduce the impacts of out of basin harvest on ESA listed salmonids. If the habitat restoration actions described in the working hypotheses are achieved in the Walla Walla Subbasin, one might anticipate that Ha1 will be most strongly supported. However, as more and more people relocate to the region, and water resources become increasingly strained, the chances for recovery continue to diminish. Statistical support of the working hypothesis will help guide the nature and intensity of future habitat protection and restoration actions in the Walla Walla Subbasin.

Approach

Most of the work needed to address this critical uncertainty will take place in the context of long-term monitoring. The experimental approach is to conduct an observational study of the Walla Walla Subbasin using collaborative monitoring of fish and their environment; e.g. (Hillman 2003; ISAB and ISRP 2004; Jordan et al. 2003; USACOE et al. 2003). Collectively the Walla Walla Subbasin RM&E projects will:

- Conduct long-term monitoring and evaluation of stream, watershed, and aquatic conditions
- Conduct long-term monitoring and evaluation of population, environmental, and ecological conditions for all salmonid life stages and rearing types
- Conduct effectiveness monitoring of restoration actions at the watershed scale

These monitoring efforts will take place subbasin-wide for the next ten years. A holistic analysis of the relative impacts of habitat restoration, ecological interactions, stochasticity, climate, and out-of-basin effects will be conducted every three to five years using a modified EDT model. Strategy implementation will be assessed under regular Tier 1 monitoring. Action effectiveness will be evaluated using Tier 2 habitat, water quality, and fish population monitoring results. The interaction of project implementation and system response will be evaluated using EDT.

Currently EDT is not fully capable of incorporating the suite of forcing functions that drive salmonid production. There are limitations in the model in terms of regional habitat nuances and population responses (the biological rules) that must be addressed. CTUIR, WDFW, ODFW and WWBWC will work with Mobrand Biometrics and the University of Washington Columbia Basin Research Center to develop a version of EDT that addresses all sources of production and loss in Walla Walla salmonids. The biological rules will be updated every one to three years as new habitat and population response data becomes available.

Once the working hypothesis strategies have been implemented, the predicted (EDT) and realized (M&E) salmonid production levels will be compared. The quantity and rate of predicted and realized responses will be compared using univariate and multivariate statistics. The results of this analysis will be used to better inform EDT on a regional scale, and to better predict the average benefits of habitat restoration work in the Walla Walla and Columbia Basins.

2.7.2 Estimate Connectivity of Resident Walla Walla Salmonid Populations within the Subbasin, and among Neighboring Populations

Status: Partially funded (USFWS, USGS)

Purpose and Scope

The construction of McNary Dam and subsequent formation of Wallula Lake dramatically altered the routes and conditions resident salmonids must undertake to connect with neighboring populations. These hurdles are amplified by the acute and chronic stressors that resident and fluvial bull trout and mountain whitefish face within each subbasin. The culmination of these chronic stressors, coupled with direct mortality, have resulted in an ESA listing for bull trout, and increasing concern for the status of mountain whitefish.

Population connectivity is a measurement of interbreeding among arbitrary or allopatric populations. Connectivity can increase the average fitness of a population by increasing heterozygosity and genetic diversity. The mouth of the Walla Walla River is most directly juxtaposed to the John Day, Umatilla, Yakima, and Snake River basins. Connectivity between Walla Walla populations and these neighboring populations is unknown. An understanding of connectivity will help guide mainstem management, and will greatly inform the ESA delisting process. Increased connectivity generally results in decreased jeopardy, and is therefore a critical metric of species conservation. The purpose of this five year project will be to test the following null and alternative hypotheses:

> Ho: Gene flow (F) in Columbia Plateau bull trout and mountain whitefish populations is less than 0.1, and connectivity (Nm) is less than 10 immigrants per generation.
>
> Ha: Gene flow (F) in Columbia Plateau bull trout and mountain whitefish populations is greater than 0.1, and connectivity (Nm) is more than 10 immigrants per generation.

Approach

The Bull Trout Recovery Team advises critical uncertainties research on this species. A collaborative effort is underway to examine the current status and population trajectory of bull trout in the Walla Walla and Umatilla Subbasins. These efforts put personnel on the ground, and provide substantial opportunities for data collection. The co-managers will work with this collaboration and similar efforts in the John Day, Grande Ronde, Yakima, Umatilla, and Tucannon Subbasins to develop a regional program for resident fish genetic sampling. Fin clips will be selected from reproductively active male and female bull trout as well as juveniles and mountain whitefish in all these subbasins, and in all three major Walla Walla watersheds, during normal monitoring activities. These samples will be analyzed using micro-satellite markers to determine the number of immigrants to each subbasin per generation for both species.

2.7.3 Monitor and Assess the Ecological Characteristics of Walla Walla Essential Fish Habitat

Timeline: Seven year study

Status: Unfunded, not implemented, innovative research

The relationships between salmonids and the variables that limit production are complex, confounded by mortality and movement, and often masked by error in the sampling process (Williams 1999). Even in the case of hatchery releases or flow enhancement where direct control over the restoration treatment is possible; the impacts of actions may be masked by natural variance in the system, and the causes of these patterns may not be readily apparent. The watershed concept has been used to successfully address these complexities in tributaries (Moring and Lantz 1975; Ringler and Hall 1975; Hall 1977; Beschta and Taylor 1988; Hicks et al 1991; Stednick and Kern 1994; Nakamoto 1998; Tschaplinski 2000; Thompson and Lee 2002; Bilby et al. 2003; Regetz 2003). This body of work suggests that by aggregating several performance metrics to the watershed scale it is then possible to analyze and evaluate the impacts of management in the face of natural and anthropogenic stochasticity.

Ecosystem-based analysis of the factors that impact production at the watershed scale is quite different from more traditional comparative performance analysis or status monitoring. On a national level scientists have recognized the importance of more sophisticated ecological analysis and ecosystem-based monitoring to the success of restoration efforts (Heland 1987, Duncan et al. 1989, Poe et al. 1994, Kauffman et al. 1995, Espinosa et al. 1997, Reeves et al. 1997, Hill and Platts 1998, Cederholm et al. 1999, Collen and Gibson 2000, Epifanio 2000, McMichael et al. 2000, Cooney et al. 2001, Healey 2001, Willette et al. 2001, Chaloner et al. 2002, Klovatch 2003, NOAA 2003, Regetz 2003). If certain design criteria are met, ecosystem-based analysis and evaluation can be used to discern the impacts of subtle confounding factors from important forcing functions such as management actions (e.g. Carpenter and Kitchell 1993). The current conditions of the Walla Walla Subbasin have been assessed with considerable detail, and substantial "pre-treatment" information has been compiled (Contour 2003; CTUIR and ODFW 2004, Mendel et al. 1999, 2000, 2001, 2002, 2003, and 2004). Therefore the system is suitable for ecosystem-based association analysis at the watershed scale.

Ecological relationships have direct and indirect impacts on fish productivity through trophic, physiological, and behavioral interactions. Direct interactions are sometimes considered and managed for, but these may be dwarfed by indirect exchanges (Beamesderfer et al. 1996). There are numerous pathways of confounding relationships in a supplemented salmonid community that might impact egg to smolt survival (Vander Haegen et al. 1998), and in many systems in-stream mortality of smolts may have a far greater impact on production than spawner productivity (Fryer and Mundy 1993, Collis et al. 2001). Given this, it is difficult to discern in any one tributary system between the nominal importance of salmonid abundance and the impacts of ecological relationships on salmonid productivity.

In general there are two ways these relationships can manifest (Carpenter and Kitchell 1993). Top-down and density-dependent interactions can result in predator mortality or in changes in growth due to increased metabolic expenditures or decreased consumption rates. Bottom-up changes in trophic resources or metabolic conditions can result in direct starvation or in decreased growth associated with consumption rates or metabolic efficiency. When fish experience intense competition or limited prey resources, they reduce consumption rates and consume lower quality prey. This process, called "trophic shifting", can result in radical changes in growth and productivity (Zhang et al. 1997, Beauchamp and Van Tassell 2001, Cooney et al. 2001, Willette et al. 2001, Finlay et al. 2002). An understanding of trophic shifts and resulting growth alterations under various environmental and management conditions can be used to adaptively manage stocks for greater productivity.

The complexities of these factors and their importance to fisheries management has been described in detail (Kitchell et al. 1974). Although these principles have been accepted by the scientific community, they have been rarely incorporated in management. This is true for the Walla Walla Subbasin, despite the fact that ecological impacts may, under some conditions, be greater than physical or chemical impacts. A greater understanding of the ecological controls on salmonid productivity will have direct management implications. A quantification of predator mortality and competitive interactions will help guide future release strategies and juvenile production objectives. A detailed understanding of inter- and intra-specific competition will allow for the determination of optimal seeding strategies in a multi-species restoration framework. This information could inform multi-species management throughout the Columbia Plateau.

Approach

Three parallel lines of investigation will be followed to evaluate the ecological characteristics of Walla Walla fish habitat. 1) We will assess the structure of salmonid predator and prey communities during field surveys, 2) we will assess the nature of nutrient and energy flows throughout these communities using stable isotope analysis, and 3) we will quantify these flows using bioenergetics and mass-balance models. Fish communities will be sampled during regular juvenile surveys (Detailed Method 1). The density, distribution, and demographics of predator and prey fish will be determined during this regular monitoring activity.

Trophic interactions among hatchery and naturally reared salmonids and their ecosystems will be assessed using stable isotope monitoring and ecological inference (Detailed Method 7A). The relative ratios of stable isotopes in fish muscle tissues relates directly to a) the background levels of the isotope, and b) the biological processes that brought the element to the tissue. If some relative estimate of the background conditions can be made, the ratio of stable isotopes and the non-isotopic elements can be used to derive the magnitude, nature, and rate of trophic interactions. We will use aquatic snails and crayfish as estimators of background isotope ratios in watersheds in the Walla Walla Subbasin. These background values will be compared to those of salmonids, their predators, and their prey to develop an estimate of the average fractional trophic level by year class for rearing steelhead and Chinook.

This information will provide estimates of the sourcing of nutrients and energy, the magnitude and nature of piscivorous salmonid mortality, and any potential trophic shifts associated with artificial production, habitat degredation, or changes in community structure that might impact growth and productivity of the target species. In addition stable isotopes can serve as potential indicators of toxin exposure, habitat use, resource use, and the non-consumptive benefits of salmon restoration such as the nutrient inputs to the system. Hatchery reared fish will have a stable isotope signature that differs from those of naturally reared fish. Therefore, the non-consumptive impacts (i.e. feeding of non-target salmonids and the deposition of hatchery-derived nutrients) of smolt releases will be readily discernible using stable isotope analysis.

The ecological characteristics of essential salmonid habitat will be analyzed and evaluated using a multi-species spatially explicit model based on MBI's EDT, fish Bioenergetics 3.0 (Hanson et al. 1997), and Ecopath with Ecosim (www.ecopath.org; Detailed Method 7B) . Energy flow and metabolic productivity will be estimated for each watershed using a reach-based model, with results aggregated to the watershed and subbasin scale. Fish Bioenergetics 3.0 will be used to derive consumption and natural mortality of salmonids based on population demographic information and the thermodynamic models of fish energetics (Kitchell et al. 1974). EcoPath version 5.0 will be used to estimate flows to and from salmonid populations based on mass-balance theory (e.g., Larkin 1996, Mackinson et al. 1997, Perez-Espana and Arreguin-Sanchez 1999, Pitcher et al. 1999, Kitchell et al. 2000, Shannon et al. 2000, Zetina-Rejon et al. 2001, Morato and Pitcher 2002, Okey 2002, Zeller and Freire 2002). The model will be used to evaluate the current structure and function of Walla Walla salmonid ecosystems, to predict the direct impacts of different management regimes on natural salmonid production and productivity, and to predict the indirect affects of management actions on salmonid ecosystems and cohabitants.

2.7.4 Impacts of Spring Chinook Reintroduction on ESA Listed Salmonids

Status: Partially funded (BPA)

Purpose and Scope

After eighty years of extirpation CTUIR is sponsoring an experimental reintroduction of spring Chinook in the Walla Walla Subbasin. Adult spawners were out-planted during 2000-2004 in the Mill Creek and upper Walla Walla watersheds. Since 2002 out-planting was restricted to the upper Walla Walla watershed. Out-plants were released just prior to spawning, so the full behavioral and ecological impacts of their summer-time presence were not experienced by their cohabitants such as spawning bull trout.

The first adult progeny from those out-plants returned in the spring of 2004. Partial counts at traps were around 300 spawners, and total estimated spawners based on redd surveys were 200-400 females including the outplanting 250 additional Umatilla-origin adults. Fish entered the upper Walla Walla, Mill Creek, and Touchet watersheds in May to early July. Those fish held in cooler water through the summer in the upper Walla Walla River above Milton-Freewater and in Mill and Yellowhawk Creek from the city of Walla Walla up to the City Intake dam in the Mill Creek Headwaters Watershed and spawned in August and September. Due in part to passage constraints, Chinook returns to the Mill Creek watershed were limited compared to returns to the Walla Walla River.

Chinook, steelhead, and bull trout have co-existed in the Columbia Basin for thousands of years. Their life-history strategies do not limit competition or interspecific predation entirely, but they do spawn at slightly different times of the year and in different portions of the watershed with limited overlap. The deposition of marine nutrients from carcasses most definitely benefits salmonid habitat (Helfield, 2001; Chaloner, 2002; Chaloner, 2002), so one might predict a positive interaction between these species.

Conversely, the current population and ecosystem status in the Walla Walla may present specific challenges to the coexistence of these species. Chinook holding in deep pools during the summer may marginalize adult or juvenile bull trout and rearing steelhead. This spatial reordering may marginalize rearing ESA species to sub-optimal habitat. The resulting direct mortality and decreased productivity may impact population recovery rates of both species. Under healthy population conditions these interactions may have little affect or may be beneficial to salmonid communities, but in a depressed population they may be detrimental. These direct and indirect interactions are theoretical in nature, but are worth investigating due to the high stakes associated with ESA species recovery and spring Chinook salmon reintroduction. The purpose of this three year project is to test the following null and alternative hypotheses:

> Ho: The presence of spring Chinook will not impact juvenile bull trout and steelhead growth rates
>
> Ha1: The presence of spring Chinook will result in increased juvenile bull trout and steelhead growth rates
>
> Ha2: The presence of spring Chinook will result in decreased juvenile bull trout and steelhead growth rates

Approach

The experimental approach will be to assess the density, distribution, and growth rates of juvenile bull trout and steelhead at the mega-scale: e.g. in watersheds with and without spring Chinook spawners. Although EDT suggests that the overall capacities of the upper Mill Creek, upper Walla Walla, and upper Touchet watersheds are markedly different, these differences do not stem from variability in the headwater habitat qualities, but are more significantly related to passage and habitat variability in the middle and middle-upper watersheds. Since the headwaters of all three systems reside in the Umatilla National Forest, they receive somewhat similar, though subtly different, land use treatments. The Touchet system is more heavily roaded than either the Mill Creek or Walla Walla watersheds. Nonetheless, the current land management regimes for bull trout spawning habitat in those systems are relatively uniform. Anadromy is limited in the Mill Creek watershed due to limited passage on the Mill Creek mainstem. In addition, adult outplanting has ceased in the Mill Creek River, but continues on the South Fork Walla Walla River. This provides a unique opportunity for a partially controlled observational experiment.

The null hypotheses assumes that significant differences in growth rates in bull trout or steelhead from the three major watersheds will not correlate with micro-habitat variability, and will not be affected by Chinook outplants. The alternative hypotheses suggest that differences will be detectable and will be correlated with macro-habitat variability, the availability of habitat, the densities of each sub-population, and their ecological conditions (especially spring Chinook outplants). Spring Chinook reintroduction will likely be the most significant ecological treatment of the South Fork Walla Walla watershed aside from natural variability. The relative absence of spring Chinook in the Touchet system, and limited presence of spring Chinook in the Mill Creek system should be significant as well. By monitoring the extent of the spring Chinook treatment and the growth rates and condition of bull trout in the context of a comprehensive RM&E program it will be possible to make strong inference regarding these interacting and confounding variables.

The density and distribution of Chinook adults, and Chinook, steelhead, and bull trout juveniles will be assessed on the rearing grounds using snorkeling surveys, seines, and traps during regular juvenile fish surveys and as part of the USGS bull trout study based at Utah State University. Scale samples will be collected from each sub-population during juvenile abundance surveys. Scales will be analyzed using light-microscopy to elucidate daily growth rings. Growth curves will be developed for each of the three watersheds. The relationships between fish age, length, and weight will be estimated using non-linear regression, and compared between populations using univariate and discriminant analysis. The density and distribution of spawners and rearing juveniles will be compared among watersheds using geostatistical and multivariate models. The strength of species interactions will be assessed using interaction coefficients.

2.7.5 Monitor and Assess the Ecological Interactions of Naturally-Reared and Hatchery-Reared Chinook Salmon and Summer Steelhead

Timeline: Seven-year study

Performance Metrics: Trophic interactions of Chinook salmon

Status: Unfunded, not implemented

Trophic relationships affect the flow of energy to focal species, and their cascading impacts to their prey. Hatchery fish enter the Walla Walla River metabolically and physically different than their natural counterparts, and will have a unique stable isotopic signature. These differences may impact the competitive and predatory relationships of both stocks, and may also impact the condition and logistics of either stock's entry to the Columbia River or its estuary. The indirect effects of these differences are virtually unpredictable due to the complex nature of salmon food webs. Since trophic relationships ultimately control growth and fecundity in the wild, a quantification of potential differences among hatchery and naturally reared fish could prove invaluable. On one hand, artificial production puts prey into tributary systems, and may benefit larger salmonid and non-salmonid piscivores. On the other hand, out-migrating smolts are generalist predators, and they may negatively impact juvenile populations of naturally reared fish. However, it has yet to be determined that naturally- and hatchery-reared Chinook salmon behave ecologically different in a tributary setting. Without an understanding of these potential differences it is difficult or impossible to manage the ecological impacts of restoration programs.

Approach

Trophic differences between hatchery-reared and naturally-reared Chinook salmon will be surveyed using stable isotope analysis. Isotope samples will be collected during juvenile fish surveys, smolt outmigrant monitoring, adult monitoring, harvest surveys, and spawner carcass surveys. Comparative inferential statistics will be used to detect differences in isotope ratios among stocks and cohorts. The realized energetic consequences of these differences will be modeled using bioenergetic and mass-balance models.

2.7.6 Monitor and Assess the Relative Reproductive Success of Naturally-Spawning Hatchery- and Naturally-Reared Steelhead

Timeline: Ten year study

Performance Metrics: Relative reproductive success of natural and hatchery-reared steelhead

Status: Unfunded, not implemented

The reproductive success and genetic characteristics of hatchery-reared fish can be different from those of naturally reared individuals or populations (Reisenbichler and McIntyre 1977). These affects stem in part from the environmental conditioning of hatchery programs, and in part from the artificial selection associated with the hatchery environment. The problem can in theory impact population growth (productivity of the naturally-reared population) even when endemic stock is used and traditional stock domestication is avoided (Chilcote 2003, Reisenbichler et al. 2003).

The impacts can be elusive because of the short-term production gains associated with supplementing a diminished population, and could in theory limit the recovery of salmon fisheries in the Walla Walla Subbasin and elsewhere. Chilcote suggests that the problem is theoretical in nature, and is "not sensitive to likely levels of data error or confounded by extraneous habitat correlation with" production (our emphasis, Chilcote 2003, p1057).

Pedigree studies are being used in a variety of subbasins to answer a number of questions. These endeavors are costly and resource intensive, but may provide essential management information. Unless the utility of an ongoing pedigree analysis is established by one of the co-management entities, this study will terminate following a final report in December 2015. During each year of operations the project will be evaluated to determine if biologically or statistically significant patterns in fitness can be detected, to determine the likely importance of this information given the status of ongoing artificial and natural production, and to determine if new insight is being produced that can effectively inform the population or harvest recovery strategies.

Approach

Polymorphic microsatellite loci have been used in a variety of studies to determine parentage and population structure (O'Reilly et al. 1998, Bernatchez and Duchesne 2000, Letcher and King 2001, Eldridge et al. 2002). The technique and its application have been thoroughly reviewed (Wilson and Ferguson 2002). The complicated aspect of design for this study involves collecting a comprehensive sample of all spawners entering a system by stock origin, a representative sample of resident fish that contribute to the anadromous population, and a reasonable sample of outmigrants. Currently the Touchet system is the optimal target for a reproductive success study, however the Dayton fish weir is too inefficient to collect samples from all of the spawners entering the headwaters. In addition the headwaters are too large to collect a representative sample of redband trout. Several options are available for this type of study, but they require careful planning and research. The co-managers will work to develop a reproductive success project that answers critical uncertainties associated with the spawning of Lyons Ferry fish and any endemic hatchery releases in the subbasin. A formal proposal will be made to BPA once a comprehensive plan for this study has been completed.

2.7.7 Assess Socioeconomic Indicators of Ecological Performance in a Comprehensive Monitoring & Evaluation Program

Timeline: Long term

Status: Partially funded, proposed. Ready to evaluate sample site (project) level data; ready to evaluate subbasin level data. Reach and drainage level data in development. Evaluation and further development will occur in 2004, and become operational in 2005. The program will be refined through use, and by feedback from both the Basin Technical Working Group and the emerging Community Development

Working Group. Partially funded by Columbia Basin Water Transaction Program – as it pertains to CBWTP generated water transactions. In FY 2005, the Watershed Alliance will use the program as a "decision support tool" in the design of multiple-year performance-driven restoration plans in the following areas: Titus/Mill Creek; Yellowhawk Creek; Stone Creek; Old Lowden Ditch are of the Walla Walla River Mainstem.

Purpose and Scope

It is important to monitor and evaluate when and where humans are the source of ecosystem disturbanceand their general interactions with the system to understand how and why disturbance occurs. This knowledge will help inform the design, prioritization, implementation and monitoring of projects and plans to restore and sustain the human, fish, and wildlife components of the system.

This M&E Program will test the following hypotheses of the Watershed Alliance:

Ha1: It is possible to simultaneously restore and enhance the health of the Basin's culture, ecology, and economy (the "Triple Bottom Line")

Ha2: When the Triple Bottom Line is on an upward trend, humans will desire and work to restore the ecosystem because it is in their best interest to do so.

Performance Indicators

Capital Accounts: natural (landscape structure, ecosystem products and services, land supply), social (social structures, labor quantity and quality, health), economic (build infrastructure, financial capital).

Wealth Creation: production modes (industries, markets, products, technologies, methods), production efficiencies (resource utilization, productivity, losses to the system, extent of true-cost coverage), value chain (value being added to production, economic linkages, lost value & externalities), innovation (creation of new value, adaptation ot change), investment (net capital flow toward local value-chain).

Dividends: Opportunities for growth (diversity of employment, investment niches), returns on investment (returns to land, labor capital), material standards of living (affordability, consumption), faith in the future (financial security, predictability of outcomes, propensity to invest/give).

Cultural: various legal and policy indicators

Ecological: see Table 1

Hydrological: see Table 1

Approach

This monitoring and evaluation program will investigate how fish, wildlife, and people use the same landscape at the same time, and the complex set of interactions that ensue. It will expand the knowledge base and develop a toolset to enable managers to evaluate the impacts of human actions at varying scales in the freshwater ecosystem, to prioritize actions on the basis of their societal and ecological benefits, and to communicate those alternatives (scenarios) to decision makers.

This program will have a flexible interface to watershed and ecological data, and a scalable set of landscape and ecosystem indicators that fit local needs and facilitate understanding of system functioning.

It uses the Ecosystem Management Decision Support (EMDS) system (www.fsl.orst.edu/emds), developed and extensively tested by the USFS as a base modeling environment, along with NetWeaver (www.rules-of-thumb.com/NetWeaver) as a knowledge base. The program has adapted the “criteria” and “indicator” approach known as Local Unit Criteria and Indicators Development (LUCID), developed by the US Forest Service and based on the Montreal Process Criteria and Indicators (generated from the United Nations Conference on Environment and Development – Rio 1992).

2.8 MONITORING AND EVALUATION OBJECTIVES

2.8.1 Monitoring and Evaluation Framework

The EDT model was populated without extensive empirical data for the Walla Walla Subbasin. In all cases empirical data were used if available. However many habitat attributes were rated based on local knowledge and best scientific judgment. It is clear that such data may inadequately represent habitat and fish assemblage conditions. The predictive capacity of EDT to help direct recovery actions and assess their potential beneficial effect could be substantially limited by the data quality. Improved data quality can be achieved by collecting the following empirical data:

- Those attributes with the greatest leverage on EDT model outputs (e.g. max width, gradient, habitat type inventories, large wood, bed scour) (From: *Mobrand Biometrics Quick Guide to Developing the Stream Reach Editor*, 2003)
- Those that are within priority protection or restoration stream reaches
- Data that is limited for attributes that have a broad (subbasin wide) effect on population or habitat status (passage at obstructions, water quality, others)
- Data identified in the Hypotheses and Objectives within the subbasin plan
- Attributes identified in the context of Walla Walla management information requirements, and listed in table A1.

The general M&E framework for the Walla Walla Subbasin will be to fill EDT data gaps and establish a better understanding of the baseline habitat conditions including the characteristics of passage, flow, substrate, and ecological interactions that most directly impact the production of resident and anadromous salmonids. The overall goal of monitoring and evaluation efforts will be to address, at a minimum, those critical areas for Viable Salmonid Population Analysis as described by NOAA Fisheries. Presently an evaluation and rating system for populations within ESUs is being developed by the Interior Columbia TRT. Once the methodology is complete, completing a rating exercise for the basin will be necessary. Beyond that action, specific attribute requirements have been identified for each of the four areas of VSP:

Adult abundance: Run size to the basin (This can be greatly impacted by out-of-subbasin effects but is critical to monitoring population status). Estimates or enumeration of escapement to the spawning grounds, including hatchery interactions in natural spawning areas, is crucial. Harvest within the subbasin including hatchery harvest and incidental hooking mortality of wild fish. Out-of-basin harvest and mortality (up-river subbasins may be prevented from recovering if out-of-basin effects limit adult escapement.

Juvenile: Smolt production at the subpopulation level to reflect freshwater survival and production within the basin. It will be critical in modeling population response to habitat restoration actions.

Diversity: Genetic characterization, life history pathways (juvenile and adult), artificial propagation effects (hatcheries)

Spatial Structure: Distribution of juveniles and adults within the subbasin, habitat limiting factors by season.

Productivity: Population Growth rate or potential – juvenile and natural return ratio (NRR) for adults (should be above replacement or 1.0). Hatchery effects should not reduce NRR below 1.0

Monitoring of these VSP characteristics and the various performance metrics delineated in Table 1 is described in general in the RM&E objectives that follow. Detailed methods are defined where possible in section3.

2.8.2 Monitor and Assess the Status and Trends of Abundance and Productivity of Hatchery- and Naturally-Reared Salmon, Steelhead, Whitefish, Bull Trout, Lamprey, and Mussels

Timeline: Long-term monitoring

Performance metrics: Number of hatchery- and naturally-reared adults , run timing of hatchery- and naturally-reared adult returns, smolts-per-spawner, adult progeny-per-parent ratios, relative densities and abundance for resident fish and mussels.

Status: Partially funded, ongoing

Adult return to the Walla Walla River is a critical metric for monitoring the status and long-term trends of salmonid populations in the Walla Walla Subbasin. Monitoring trends in these productivity metrics will be critical to assessing the performance of the Walla Walla Subbasin fish restoration program. These measures will also be used in stock-recruitment models to estimate natural production capacity of the subbasin. Adult monitoring to the Walla Walla River is limited by the absence of a trap or ladder near the mouth of the river. Therefore, total returns to the Walla Walla River are virtually unknown. Traps exist in the middle-upper reaches of each drainage. Facilities at the Dayton weir and Bennington Dam fish ladder require improvements.

Approach

Numbers of adult hatchery- and naturally-reared returns will be enumerated by trap counts, as well as by visual redd surveys (see Section 2.8.3). Current traps/monitoring stations in the basin include Nursery Bridge, Bennington Dam ladder, Dayton adult trap, Copei Creek adult trap, and the Yellowhawk fish weir. A complete count of escapement past these location could be obtained, but several of the facilities require improvement. Counts of adult returns in combination with other metrics described in later M&E objectives (harvest, straying, spawner abundance, and smolt outmigrant abundance) will be used to estimate key metrics of survival (smolt-to-adult survival, pre-spawn mortality) and productivity (smolts-per-spawner, adult progeny-per-parent ratios). Mussel and lamprey densities will be monitored using visual in-situ surveys. Survey designs for these efforts are under development.

CTUIR will sponsor an design investigation to study the feasibility and technical requirements of placing a video-sonar adult monitoring system at or near the mouth of the Walla Walla. The study will cover design and maintenance requirements for a system, and will recommend best-available technology for such as system. If implemented the system would greatly aid management in understanding to total abundance of adult returns to the Walla Walla, run timing and environmental correlates of migration in the lower river, and the return of stocks, species (such as coho) and sub-populations of anadromous fish spawning in reaches below the middle-river traps at Dayton, Nursery Bridge, and Bennington Dam. In addition, CTUIR will work ACOE to improve fish monitoring equipment and protocols on Bennington

Dam as described by Tice (2004). Improvements may include the use of visual, sonar, and lasers to acquire a more complete count of fish passing the facility.

2.8.3 Monitor and Assess the Distribution and Density of Spawners on the Spawning Grounds and Juveniles on the Rearing Grounds

Timeline: Long-term monitoring

Performance metrics: Spawner escapement; spawner spatial distribution, spawn timing, pre-spawn mortality, rearing distribution, juvenile production and distribution

Status: Spawner monitoring is funded and ongoing, juvenile surveys are funded and implemented

The principle subbasin-scale performance measures for each brood year for anadromous fish are assessed from total outmigration of juveniles and adult returns to the Walla Walla River. However, this information is limited in its explanatory power due to the variability in factors influencing spawner abundance and juvenile production, and does not work for resident species. Spawners can escape differentially to each watershed due to habitat conditions, in-subbasin harvest, pre-spawn mortality, and stochasticity. Resident species can experience changes in their population status due to either mortality or production. The production of juveniles can vary among watersheds due to spawner abundance, spawner productivity, habitat quality, habitat quantity, egg mortality, fry mortality, or parr mortality. An understanding of spatial and temporal variance in both spawner and juvenile production and productivity is therefore necessary to estimate a variety of performance measures. Improved accounting of adults into the upper Mill Creek and upper Touchet systems (including Coppei Cr) is needed.

Approach

In-situ sampling will be conducted for each species within their spawning and rearing habitat (Detailed Method 3C). The sampling design will follow a ***modified*** EMAP protocol. Spawner and carcass surveys will be randomized by tributary and reach for randomly selected reaches. Index reaches have been established for most of the subbasin. Juvenile surveys will be randomized by watershed, or stratified where randomization is undesirable. Annual estimates of density will be produced for each life-history stage and watershed. A geostatistical analysis will be conducted using population and habitat data to estimate fish-habitat relationships and to produce a geostatistical stock assessment of spawners and juveniles. Associative and trend analyses will be used to monitor changes in spawner and juvenile populations.

2.8.4 Monitor and Assess the Abundance, Timing, Life History Characteristics, and In-stream Survival of Out-migrating Salmonids

Timeline: Long-term monitoring

Performance metrics: Migration parameters, abundance, survival, and life history characteristics (including age, size and condition) of emigrating smolts or migrants

Status: Partially funded, modify and expand ongoing activities

An estimate of smolt abundance for naturally-reared species in the lower Walla Walla River is essential to answering critical uncertainties surrounding natural production capacity and within-subbasin productivity. In addition, an understanding of migration success and survival is necessary to identify in and out-of-subbasin bottlenecks (including environmental conditions, flow, fish habitat, hatchery rearing and release strategies, predation, and passage difficulties) and estimate loss by life stage for hatchery- and naturally-reared species.

Approach

Total subbasin smolt abundance will be estimated for naturally-reared salmonids emigrating from the Walla Walla River using a rotary screw trap. Estimates of outmigrant abundance will be obtained for the upper Walla Walla and Mill Creek rivers using rotary screw traps. Depending on Adult trap/weir modifications at the Dayton adult trap, WDFW may install a rotary screw trap in the Touchet River as well. The Bootstrap method with 1,000 iterations will be used to derive a variance. Smolt survival and migration parameters (timing, duration and travel speed) will be monitored for hatchery- and naturally-reared species using PIT tags and remote interrogation at the lower screw trap and Columbia River dams. Survival estimates will be calculated using the Migrant Abundance Method (Burham et al. 1987 and Dauble et al. 1993) and the SURPH 2 model (http://www.cbr.washington.edu/). The binomial test will be used to test for significant differences in detection between comparable release groups of hatchery-reared fish. Environmental variables including water discharge, flow, temperature and water clarity in the lower river will be monitored and ties to smolt survival and/or migration success will be assessed using regression and correlation analyses. Juvenile life history characteristics including smolt emigration timing, length, age, health, condition and smolt status will be collected. Associative and trend analyses will be used to evaluate outmigration.

2.8.5 Monitor and Assess the Residualization of Hatchery- and Naturally-Reared Steelhead and Chinook Salmon

Timeline: Long-term monitoring

Performance metrics: Residualization rates

Status: Chinook - Unfunded; not-implemented. Steelhead work is funded and is currently being implemented.

Hatchery-reared fish are usually released at sizes and conditions that differ from their naturally-reared counterparts. Sexually mature residualized fish can compete with returning anadromous adults for mates, and can compete with resident fish or pre-migrant juveniles for ecological resources. Recent studies by the Yakima-Klickitat Fisheries Program suggest that hatchery practices can be modified to decrease residualization rates if problems are detected. The purpose of this work will be to determine the extent and impacts of residualism, whether hatchery practices produce greater-than-natural residualization rates, and if so some potential corrective measures.

Approach

The WDFW Snake River Lab and Fish Management have annually surveyed (electrofishing) the juvenile production areas of the Touchet River since 2001. Hatchery origin summer steelhead have been captured and identified (Lyons Ferry stock or Touchet Endemic stock), and residual population estimates have been derived to assess the overall impacts. Juvenile surveys will continue into the future to monitor the residualism rates and their distribution within the watersheds to describe interactions with natural salmonids. In the Walla Walla and Mill Creek system, residualized steelhead and Chinook salmon will be sampled during juvenile surveys. Residuals will be classified based on the presence of a fin clip or wire tag for hatchery fish, the length-frequency distribution for natural Chinook salmon, and using outlier analysis for the juvenile population. Resident redband trout populations will be similarly noted, but are recognized as part of the steelhead population (Currens and Schreck 1995, Kostow 2003).

2.8.6 Monitor and Assess the Distribution, Condition and Utilization of Essential Salmonid Habitat in the Walla Walla Subbasin

Timeline: Long-term monitoring

Performance metrics: Quantity, quality, and utilization of essential fish habitat

Status: Not funded, not implemented

Natural production of salmonids requires quality habitat. This pivotal assumption is the backbone of the working hypotheses developed in the subbasin plan, and the numerous off-site mitigation projects operating in the Walla Walla Subbasin. At the macro- and micro-scales land use and riparian conditions are strongly related to in-stream conditions (Crispin et al. 1993, Stednick and Kern 1994, Chen et al. 1998). These features directly impact water quality conditions, and can thereby alter salmonid production through behavioral, physiological, and ecological mechanisms (Torgersen et al. 1999, Ebersole 2002). These powerful in-subbasin impacts are detectable at multiple scales, and do result in decreased survival and production of juveniles (Paulsen and Fisher 2001) and decreased recruitment of spawners (Regetz 2003) at the subbasin scale.

Approach

The Walla Walla Subbasin Plan identifies a set of desired future conditions that may increase natural production and harvest opportunities in the Walla Walla Subbasin through habitat restoration and protection, flow augmentation, passage restoration, and hatchery supplementation. There are a number of habitat-based RM&E information needs that must be addressed if the benefits of these management actions are to be effectively detected with sufficient power. For example, the availability and distribution of quality essential fish habitat will be used to define the sampling universe of juvenile and spawner surveys. The adequacy of habitat representation in EDT will need to be evaluated. The condition and importance of several EDT habitat variables, especially bedscour and sediment load, needs to be investigated.

Spatial and numerical relationships among the habitat and salmonid variables will be used to estimate the degradation or restoration through time of essential fish habitat associated with both natural and anthropogenic disturbance; to estimate the absolute abundance and distribution of juveniles and spawners using geostatistical expansions; to estimate the effectiveness of habitat restoration and flow augmentation projects; and to estimate the quantitative relationship between habitat and production. Physical, biological, chemical, and ecological habitat conditions will be monitored throughout the subbasin using a variety of techniques.

2.8.7 Assess and Monitor Limiting Factors for Walla Walla Salmonids, Lamprey, and Mussels

Timeline: Long-term monitoring

Performance metrics: Mortality and survival at all life-stages

Status: Partially funded, partially implemented

Limiting factor analysis is the process by which population bottlenecks are determined for managed species. As conditions are improved through mitigation actions, and population bottlenecks are diminished or eliminated, it is essential to re-assess limiting factors to guide future mitigation actions.

Without this information it will not be possible to determine whether changes in adult and juvenile production are related to changes in habitat conditions, mainstem or marine survival, or stochasticity.

Approach

Limiting factors and the capacity of the Walla Walla Subbasin will be analyzed every five years as part of regular evaluation activities. A multi-species spatially explicit model of the Walla Walla Subbasin, such as EDT, will be used to estimate mortality in Walla Walla, Columbia, and marine life-history stages of all managed salmonids. CTUIR is currently supported to participate in evaluation using models and statistics. Agency involvement by other co-management entities is uncertain and dependent upon increased fiscal support.

2.8.8 Monitor Adult Spring Chinook Salmon Migration and Summer Holding in the Walla Walla Subbasin to Assess Spatial and Temporal Patterns of Migration, Holding and Pre-spawning Losses

Timeline: Five year study

Performance metrics: Spatial and temporal patterns of adult migration, adult passage, summer holding, and prespawn losses

Status: Unfunded, not implemented

Information on the spatial and temporal patterns of adult migration and summer holding and mortality might allow managers to increase harvest opportunities, reduce poaching, and better prioritize habitat enhancement projects. Estimates of migration timing provide additional information about the hydrology of the system a whole, and the behavior of particular brood years, species, or rearing types. This information can be used to quantify the production benefits of various management scenarios including increased or decreased artificial production or increased flow augmentation.

Approach

The approach would involve radio telemetry, trap counts and ground surveys. Radio tags would be implanted gastrically in adult fish collected from the lower Walla Walla River. Tagged fish would be recorded by aerial and ground mobile tracking and by maintaining the set of fixed monitoring stations already in place in the Walla Walla Subbasin. Fifty spring Chinook will be tagged each year. In addition, hatchery and wild fish would be counted when captured at the various traps in the upper Walla Walla, Touchet, and Mill and Yellowhawk Complex. And finally, visual counts of adults would be obtained while walking, boating, or snorkeling. Ideally, roving radio telemetry and visual surveys should cover all summer holding and spawning areas, but alternatively a stratified random sampling design could be used. Data collected during visual surveys would include numbers of adults by location and date including hatchery- and naturally-reared origin when possible, and a qualitative description of viewing conditions.

2.8.9 Assess the Impact of Habitat Improvement and Protection on Salmonid Production in the Walla Walla Subbasin

Timeline: Long-term monitoring

Performance metrics: Habitat conditions, egg, fry, juvenile, and smolt production and survival, and smolts per spawner or per female, etc. Comparison with information on survivals and smolts per spawner with other subbasins

Status: Evaluation is partially funded; habitat monitoring is not funded and not implemented

Considerable resources are invested in habitat improvement measures. Most habitat improvement projects conduct some monitoring and evaluation at the micro-scale to determine successful project implementation. However, for the most part only the cumulative impacts of watershed restoration can be tied directly to increased salmonid production. The connection between Tier 1 habitat project implementation monitoring and Tier 2 effectiveness monitoring must be addressed across the spatial hierarchy of reaches and watersheds.

Approach

Habitat status (Detailed Method 6) and juvenile production (Detailed Method 1) information will be collected during EMAP surveys at the reach scale. These data will be expanded to the watershed scale using associative and geostatistical analysis. Long term effectiveness will be evaluated using trend analysis, and comparative performance analysis of treatment/reference watersheds.

2.8.10 Monitor and Assess the Life History Characteristics of Naturally-produced and Hatchery-reared Steelhead

Timeline: Long-term monitoring

Performance metrics: Adult and juvenile migration timing, juvenile growth rates, age and size at emigration, adult sex ratios, parr, smolt, and adult age distribution.

Status: Partially funded, partially implemented

For animals with indeterminate growth the impacts of ecological and environmental conditions converge in the expression of the life-history characteristics that determine production and productivity (Kitchell et al. 1974, Heino and Kaitala 1999). Unlike animals with determinate growth who must meet metabolic requirements or die, salmonids can buffer the impacts of environmental or ecological changes by modifying energy allocation and behavioral regimes (Stockwell and Johnson 1997, Railsback and Rose 1999), but this results in changes to fecundity, egg size, spawner size and the like.

Approach

Fish size and condition are not managed for the WDFW Lyon's Ferry program, and it is unclear at this time if an endemic steelhead program will be developed in the Walla Walla Subbasin. If an endemic program is developed the following text will apply to both the hatchery and naturally reared fish. Three life history metrics will be monitored in the natural and hatchery-reared steelhead populations; survival, outmigration timing, and growth rates. A sub-sample of naturally reared juveniles will be PIT-tagged on the spawning grounds for outmigrant detection at the lower Walla Walla screw trap and Columbia Mainstem facilities. Scales of naturally reared juveniles will be sampled juvenile fish surveys and lower river trapping. Age and growth analysis will be conducted and associative models will be used to evaluate growth of hatchery- and naturally-reared fishes from each release site and watershed.

2.8.11 Monitor and Assess the Genetic Characteristics of Naturally and Hatchery Reared Steelhead

Timeline: Long-term monitoring

Performance metrics: Genetic diversity, genetic distance, effective population size

Status: Partially funded, partially implemented

The artificial propagation of fish and manipulation of breeding structures includes genetic risks that may compromise the goal of supplementation (Currens and Schreck 1995). It is important to monitor the genetic characteristics of natural and hatchery-produced fish to insure that adequate effective population sizes are maintained, to prevent catastrophic genetic drift, and that outbreeding depression does not reduce the reproductive success of the entire population.

Approach

Since 2000, WDFW Snake River Lab and Fish Management staffs have collected a number of genetic samples from Walla Walla Basin natural origin summer steelhead. In addition, samples have been collected from the Lyons Ferry stock summer steelhead for comparisons to the natural stocks. Analysis of these samples have been presented (Bumgarner et al 2003). Due to the development of the Touchet Endemic stock summer steelhead since 2000, WDFW will continue to monitor and collect genetic samples from adult summer steelhead trapped at the Dayton adult trap. These will include broodstock collected for the hatchery program and fish passed upstream for natural spawning. A maximum of 100 natural origin samples will be collected each year. Lyons Ferry stock summer steelhead genetic profile has been determined through sampling between 2003-2005. Periodic samples from the Lyons Ferry stock may be collected in the future for other comparisons

We will collect genetic samples from an additional 50 naturally-reared returning adults to maintain a genetic archive. Genetic samples will consist of fin clips, which will be immediately preserved in alcohol. These genetic samples will be analyzed using microsatellite and/or allozyme analysis on a periodic basis to determine the genetic diversity among returning wild and hatchery adults, the genetic distance between wild and hatchery adults, and the effective population size of the naturally reproducing adult spawning population within the Walla Walla Subbasin. Analysis will be initially conducted every five years to determine changes in the performance metrics over a generation and assess the periodicity of additional sampling.

2.8.12 Monitor and Assess the Natural Production and Productivity of Naturally Spawning Out-planted Chinook Salmon in the Walla Walla Subbasin

Timeline: Long-term monitoring

Performance metrics: Production and productivity of hatchery-reared Chinook

Status: Partially funded, partially implemented

Walla Walla Chinook salmon were reintroduced using Carson stock, and are currently supplemented using Umatilla-run Carson stock. In the short-term this artificial production-based restoration program appears to have been a success, resulting in significant returns to the Walla Walla and Mill Creek drainages for the first year of returns. However, questions remain regarding the long-term viability of this stock, the potential for domestication, and the overall ability of the current management regime to develop natural production of hatchery-reared adult returns. These questions will remain for some time because the Walla Walla Chinook salmon program is relatively unique and cannot be managed based on the performance of other subbasins; it is a management experiment that continues to unfold against a changing landscape and ecoscape. Therefore, the proposed approach is based on long-term monitoring strategies integrated with short-term studies of production and productivity.

Approach

Production and productivity of hatchery-reared Chinook salmon will be measured in terms of the production of redds, the production of eggs, the production of smolts, the return of first and second generation adults, and the genetic characteristics of the stock. Redd production will be monitored during spawner carcass surveys. Fecundity will be monitored using hatchery brood stock during egg-take enumeration and carcass surveys. The production of smolts by hatchery-reared Chinook salmon will be assessed using an elemental marker that is currently under development. Detailed methods for this study will be developed once the protocol for strontium marking of Chinook salmon spawners has been fully developed. The marker will allow for the elucidation of single-generation productivity of natural and hatchery-reared fish, and the smolt-to-adult survival of their progeny.

2.8.13 Monitor and Assess Whether Annual Broodstock Collection Targets are Met

Timeline: Long term monitoring

Performance metrics: Number of broodstock collected

Status: Funded, ongoing

Maintaining a hatchery program whether for mitigation production or supplementation depends highly on being able to meet annual broodstock needs. Clearly defined broodstock goals are needed for each program, with contingencies for varying sex ratios, pre-spawning mortality, and post-spawning disease incidence (IHNV for steelhead).

Approach

WDFW currently traps summer steelhead at Lyons Ferry Hatchery and the Dayton adult trap for the production of Lyons Ferry stock and Touchet Endemic stock steelhead. Lyons Ferry stock are released in the mainstem Walla Walla and from Dayton Acclimation Pond. For now, the Touchet Endemic stock is released into the North Fork of the Touchet River. Current broodstock collection goals are 1,650 Lyons Ferry Stock, and 36 Touchet Endemic stock. A total of 350 Lyons Ferry stock and 32 Touchet Endemic stock summer steelhead are needed to meet eggtake goals, respectively. In-season adjustments are made depending on sex ratios, pre-spawning mortality and post-spawning disease incidence. The excess collection of summer steelhead at Lyons Ferry Hatchery are to provide a large enough sample of coded-wire tags for program assessment. The WDFW Lyons Ferry Hatchery operates and maintains in-season trapping records for the Lyons Ferry stock summer steelhead, and the WDFW Snake River Lab operates and maintains the in-season trapping records for the Touchet Endemic stock. Final trapping records are submitted using standardized hatchery record forms and submitted to WDFW State Headquarters for archiving and program summary.

2.8.14 Monitor Broodstock Survival and Disease Incidence During Holding

Timeline: Long term monitoring

Performance metrics: Broodstock survival and disease incidence and severity for mortalities

Status: Funded, ongoing

In conjunction with 2.8.13, WDFW hatchery and evaluation staffs monitor broodstock survival during holding and spawning times. Daily mortalities are removed from the pond and processed as necessary for data needs and CWT recovery. Mortality rates that exceed 1% of the pond total are reported to the fish health specialist. After consultation with the fish health specialist, treatments may be applied to lessen the mortalities.

2.8.15 Monitor Smolt Production, Smolt-to-Adult Survival, Adult Production, Annual Returns, and Harvest and Spawning Contributions of Hatchery-reared steelhead and Chinook Salmon to Ensure a Full Accounting of All Hatchery Production Strategies

Timeline: Long term monitoring

Performance metrics*:* Broodstock survival and disease incidence and severity for mortalities

Status*:* Funded, ongoing

To successfully operate a mitigation or supplementation hatchery program, key elements need to be monitored and evaluated to determine program success. Factors such as in-hatchery survival, overall production, and returns of released production need to be evaluated and then changed to maximize the benefits of the program.

Approach

Hatchery and evaluation staffs will monitor in-hatchery survival rates for each stock of fish released into the Walla Walla Basin (survivals will begin at the egg stage and continue to smolt release). Smolts will be sampled prior to release for size and overall condition in relation to program goals. Return adults will be monitored through CWT recoveries from fisheries and traps, spawning ground surveys, and terminal adult trap locations where possible. Careful analysis of survival to various life stages can be compared to program goals and adjustments will be made as necessary.

2.8.16 Monitor and Compare Progeny-Per-Parent Productivity of Hatchery- and Naturally-Reared Steelhead and Chinook Salmon

Timeline: Long term monitoring

Performance metric: Progeny-per-parent ratio (P:P ratio)

Status: Funded, ongoing

Determination and long-term monitoring of the P:P ratio is critical for all ESA listed stocks in the Walla Walla basin. Whether or not a given stock is above (>1) or below (<1) the replacement level plays a critical role for the management and actions on the stock. Researches throughout the Columbia and Snake river basin have been able to determine this ratio for many of the salmon stocks because estimates of returns by stock can generally be accomplished through spawning ground surveys and adult traps, in combination with CWT recoveries from fisheries that might be present. Determination of R/S in steelhead populations have been more problematic due the difficulties in adult returns by brood year because of difficulties in conducting spawning ground surveys during the spring, maintaining adult traps in tributaries during the spring, and the more complex life history pattern of steelhead (repeat spawners).

Approach

Hatchery Stocks **–** Broodstock collection and the actual number of fish spawned (hatchery or natural origin) at the hatchery for each stock must be determined and recorded annually. The number of hatchery or natural fish in the broodstock may also be part of the equation to determine adult returns from a particular brood year. The number of fish by brood year will compiled. *Natural Stocks* **–** To determine R/S for natural stocks, it is imperative that accurate and precise spawning ground estimates area available. Surveys will be conducted to cover the entire range and period of spawning for the natural stock area. Survey techniques will be maximized to minimize the number of expansions that are required to derive the spawning estimates. In addition, all carcasses found will be sampled for determination of origin and age for brood year designation, so the final total spawning escapement can be proportioned by age class.

2.8.17 Monitor and Assess Whether Life History Characteristics of Hatchery-Reared Steelhead Mimic those of Naturally-Reared Steelhead

Timeline: Long term monitoring

Performance metrics: Smolt migration timing, adult migration timing, ocean residency age structure, and adult sex ratios

Status: Funded, ongoing

Performance metrics*:* Smolt migration timing, adult migration timing, ocean residency age structure, and adult sex ratios, spawn timing

Status*:* Funded, ongoing

Having hatchery reared salmonids mimic the life history patterns of the natural populations has often been a goal of managers, especially in the context of artificial production/supplementation programs. Changing the returning age structure, timing, spawning, and sex ratios has generally been viewed as negative traits that might be harming the natural stock. However, having complete mimicry of hatchery fish may be undesirable for mitigation programs. For example, it may be desirable to have an early spawning non-native hatchery steelhead stock so if these fish escape onto the spawning grounds they will have less chance of mixing with the native stock, and their progeny may not be successful if they spawn early. It might also be desirable to have a non-native hatchery stock with different run timing compared to the natural stock so fisheries could take place without severely impacting the natural fish. As such, each program should be carefully evaluated based on it's overall intent, and then decided which traits should be mimicked.

Approach

For each summer steelhead stock, the agencies will determine on an annual basis the following metrics to describe mimicry compared to the natural summer steelhead within the Walla Walla Basin: 1) Smolt migration timing, 2) adult migration timing, 3) ocean residency age structure, 4) adult sex ratios, and 5) spawn timing. Smolt migration timing of both hatchery and natural fish will be determined at the smolt trap on the lower Walla Walla River. Adult migration will be determined by temporary and adult traps located throughout the Walla Walla Basin. Scale samples sex ratios collected from adult fish at traps or recovered from carcasses on spawning ground surveys will be used to compare ocean age residence and sex ratio of hatchery and natural stocks. Spawn timing will be determined/extrapolated based on visual observations (if possible) during spawning ground surveys, and arrival at fish to adult traps.

2.8.18 Monitor the Health of Hatchery- and Naturally-Reared Steelhead and Chinook Salmon

Timeline: Long-term monitoring

Performance metrics: Pathogen prevalence and levels in hatchery- and naturally-reared steelhead and Chinook salmon

Status: Partially funded, partially implemented

The overall goal of the fish health program is to only release fish into the Walla Walla Subbasin that are known to be have a healthy disease history during rearing to minimize impacts on naturally- and other hatchery-reared fish.

Approach

The health of hatchery-reared fish will be monitored starting with broodstock and continue through rearing and release of juveniles. Natural fish health will be assessed on mortalities encountered during parr, smolt, and spawner monitoring activities. If possible, all sampling, diagnostic, and statistical analyses will conform with the Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection Committee guidelines. All monitoring will be consistent with the ODFW fish health policy and the native fish conservation policy. Fish health sampling and monitoring will be conducted under supervision of a fish health specialist, and processed at a qualified fish disease laboratory. Analysis of samples will follow standard protocols defined in the latest edition of the American Fisheries Society "Fish Health Blue Book" (Procedures for the Detection and Identification of Certain Fish Pathogens).

2.8.19 Monitor Straying of Adult Steelhead and Chinook Salmon from the Walla Walla Subbasin Hatchery Programs

Timeline: Long term monitoring

Performance metrics: For all hatchery production and release groups: number of hatchery-reared returns that stray, and percent of returns reaching the mouth of the Walla Walla River that stray into the Snake and upper Columbia River basins

Status: Funded, modify and enhance existing monitoring

WDFW monitors the returns of spring and fall chinook and summer steelhead throughout southeast Washington through adult trapping (Tucannon River, LFH, LGR, Touchet River, Cottonwood Creek), and spawning ground and creel surveys (sport harvest and CWT expansions can be used to estimate the number that would have returned to the project area); all of which provide CWT recoveries of marked fish for evaluation purposes. Trapped and/or spawned broodstock fish and carcasses provide data concerning origin, stray rates, sex ratios, age composition, and mean fecundity of each year's run. Spawning surveys provide numbers of redds, spawn timing, and distribution of fish in each of the rivers WDFW surveys. Precocial hatchery male spring chinook have been documented spawning in large numbers in other river basins. We believe that the incidence of precocial hatchery spawners is low in the Tucannon River but currently lack observational data. Snorkel surveys of spawning adults will allow us to determine the incidence and origin of precocial male spawning.

Straying of hatchery-reared fish has been identified as a potentially critical impact on ESA listed populations of salmon and steelhead in the Columbia Basin. Adult trapping and broodstock collection activities gather substantial data annually on stray fish entering southeast Washington streams and facilities.

Stray monitoring for spring Chinook will need to be expanded when spring Chinook production releases begin. Protocols, methods, and strategies for that work are under development with the hatchery master plan.

2.8.20 Monitor and Assess Flow and Passage Requirements for Adult Spring Chinook Salmon Homing, Survival, and Passage efficiency in the Walla Walla River

Timeline: Long term monitoring

Performance metrics: Delay or passage at ladders and dams during various flows; habitat access for spawners; homing, delay, and straying near the mouth of the Walla Walla River

Status: Funded. Modify and enhance existing work

The focus of this objective will be to identify flow requirements for spring Chinook salmon homing to the Walla Walla River and to provide critical information needed for the evaluation and adaptive management of the flow enhancement program. In addition the objective relates to section 2.8.8 in the evaluation of passage at structures under various flow regimes. It is unclear what levels of attraction water are needed to allow spring Chinook to locate the mouth of the Walla Walla River, and what flows are needed to allow fish to pass various structures. Without this information mangers may under or overestimate targets for the restoration of attraction water, and would have difficulty evaluating the success of passage restoration actions.

Since 2001, telemetry has provided critical information to managers and other interested parties regarding the effectiveness of the new passage facilities, potential migration barrriers, and the movement and use of space by adult steelhead and bull trout in the Walla Walla Subbasin. In spring 2004, telemetry shifted its monitoring focus from steelhead and bull trout to collecting baseline data on the inaugural return adult spring Chinook. Some 21 fish were trapped, radio-tagged and then monitored in the upper Walla Walla River and Mill and Yellowhawk Stream Complex.

Understanding delay at the recently constructed (BPA funded) fish passage facilities is a necessary and mandated component for determining the success of CTUIR's spring Chinook hatchery supplementation program and for evaluating the effects of these facility operations on ESA listed fish (e.g. Middle Columbia River Steelhead and bull trout).

Approach

Assessment of homing efficiency relative to environmental variables is logistically challenging, but can provide a wealth of information. Fish will be collected at McNary Dam based on PIT-tag detections that show they were produced in the Walla Walla River. Those fish will be radio tagged and monitored as they move up the Columbia mainstem and to the mouth of the Walla Walla River. Delay and movement rates will be monitored for each radio-tagged fish that approaches the mouth of the river, and will be compared to flow conditions. This will provide managers with some estimate of the relationship between flow and homing behavior, and may result in decreased straying and increased returns via water management actions. Passage efficiency and spawner migratory survival would continue to be monitored for spring

Chinook and steelhead for the distant future since passage improvements continue to be implemented in the subbasin. The approach for this work is described in 2.8.8.

Co-managers have identified a possible critical uncertainty associated with the impacts of flow and passage structures on the survival of outmigrants. Survival estimates for outmigrants will be developed as described above and below. If survival bottlenecks are identified, this telemetry objective may be expanded to studied passage efficiency for outmigrating juveniles at specific structures.

2.8.21 Monitor and Assess the Effect of Flow on the Availability of Spawning and Rearing Habitat in the Mainstem Walla Walla

Timeline: Long term monitoring

Performance metrics: Spawning and rearing habitat utilization, effectiveness of flow restoration programs

Status: Partially funded, partially implemented

Considerable effort and resources are put towards flow restoration in the Walla Walla. However, some of the direct benefits to fish have not been quantified. The relationships between flow restoration and trap-and-haul work is comparatively straightforward: proper flow through structures and reaches allows for easy passage and a reduction in the need to trap and haul fish. However, the relationship between increased flow and increased spawning and rearing habitat has rarely been directly studied. The Instream Flow Incremental Methodology (IFIM) was used to study optimal flow conditions for a number of reaches in the Walla Walla Subbasin, and these results are currently being used to guide flow restoration programs. Baseline effectiveness monitoring is needed to understand the added benefits to fish that these future flow programs would bring to the subbasin, and to determine the accuracy of IFIM in predicting habitat use under various flow conditions for priority reaches.

Approach

Juvenile habitat utilization will be monitored in the Walla Walla mainstem during annual juvenile fish surveys by CTUIR. Flow will be monitored in these mainstem reaches during fish surveys uses a hand-held flow meter. Habitat potential will be modeled using a spatially explicit model of habitat quality and quantity such as IFIM or life-cycle analysis, facilitating the evaluation of the relative impacts of various flow management regimes, including the implementation of flow exchange programs and climatological variability. The results of IFIM studies will be compared with results obtained in the field to evaluate the accuracy of the modeled flow recommendations and suggest changes when necessary.

2.8.22 Develop Models for Pre-season Estimation of Walla Walla River Returns to Facilitate Management of Subbasin Fisheries

Timeline: Long-term monitoring

Performance metrics: Run size forecast

Status: Funded; ongoing

Accurate run size predictions allow managers and program staff to plan appropriate broodstock collection, harvest, spawning escapement, and CWT recovery strategies in advance. In addition, models describing return timing can be used in the evaluation of flow management regimes in-season. These models are relatively simple to develop, but require datasets that cover several years or even many decades to be relatively accurate. In general the results of much of the long-term monitoring work will be used to produce these models.

Approach

Correlation models have been developed for preseason prediction of Chinook salmon and steelhead run size to the Columbia River. Local models must be constructed to predict the timing and size of anadromous runs to the Walla Walla. A variety of metrics (including marine conditions, flow conditions, outmigrant abundance, jack returns, etc.) are collected as part of regular status and trend monitoring or out-of-basin monitoring by governments, academia, and industry. These variables will be used to develop run predictors for all anadromous fishes including lamprey. Detailed methods for this exercise are under development, and are not discussed below.

2.8.23 Quantify Fishing Effort, Catch, and Harvest by Gear Type for Tribal and Non-tribal Fisheries in the Walla Walla River

Timeline: Long-term monitoring

Performance metrics: Fisher hours, catch, and harvest.

Status: Partly funded; modify and enhance existing monitoring. No spring Chinook fisheries yet.

Much of the impetus for the Walla Walla supplementation and reintroduction programs and the WDFW sponsored steelhead hatchery programs is tribal and non-tribal harvest mitigation. Creel or catch-card data are needed to provide information to determine whether steelhead and salmon harvest goals are achieved or exceeded, to enumerate fish removed from the run, and to assess how to optimize fishing opportunities through adaptive management. Creel data are needed for resident trout and non-salmonid fisheries in basin to determine harvest related mortality for those species.

Approach

WDFW utilizes catch cards and a limited creel to monitor harvest. The need to expand these efforts is currently being investigated. Tribal harvest is minimal and is currently not being monitored. The development of a spring Chinook hatchery will likely result in increased fisheries, and will demand increased monitoring efforts.

2.8.24 Quantify Harvest of Walla Walla Steelhead and Chinook Salmon in Out-of-Subbasin Fisheries

Timeline: Long-term monitoring

Performance metrics: Out-of-subbasin harvest

Status: Funded; ongoing

Harvest estimates for Walla Walla Subbasin origin fish in out-of-subbasin fisheries provide essential data that tracks status and trends of fish populations for comparing progeny-per-parent ratios of hatchery- and naturally-reared fish, and quantifying straying and movement in the Columbia mainstem.

Approach

Annual out-of-subbasin harvest will be reported for tribal and non-tribal ocean, and Columbia River fisheries.. In out-of-subbasin fisheries that are selective for hatchery-reared fish, harvest of hatchery-reared fish will be estimated from CWT recoveries reported on the Pacific States Marine Fisheries Commission CWT database. In out-of-subbasin fisheries that are not selective for hatchery-reared fish, harvest of naturally-reared fish will be estimated as the number of hatchery-reared fish harvested times the ratio of the naturally- to hatchery-reared run sizes (run sizes to the mouth of the Walla Walla River).

2.8.25 Conduct Collaborative Study Planning, Implementation, Synthesis of Results, and Results Dissemination

Timeline: Long-term

Performance metrics: Report production

Status: Ongoing

This Aquatic RM&E Plan has been developed collaboratively by a large number of collaborating entities. It will serve as a first step toward development of a Comprehensive RM&E Plan for all fish programs in the subbasin that will be incorporated in the Walla Walla Subbasin Plan. Additional time and resources are needed to effectively plan for coordinated and collaborative research in the subbasin. CTUIR will continue to facilitate coordination and collaboration via RM&E planning meetings, further development of this RM&E plan, and continued communication with the co-management agencies. Annual collaborative study planning will be achieved through review of Draft Work Statements and subsequent coordination meeting between RM&E project sponsors, managers, and operations staff to define priority of information needs and assist in the development of RM&E objectives, approaches, methods, and activities for future planning.

Annual reports will be developed with data and information exchanged between the RM&E projects to provide integrated summaries, analyses, and interpretations of data in relation to RM&E objectives. Annual reports will be one means of providing recommendations for adaptive management of the fisheries program. Integration of RM&E findings into program management and operations is an ongoing process facilitated primarily by regular meetings of the Walla Walla Technical Work Group (TWG). TWG meets biannually or as needed and is made up of RM&E staff, fisheries managers, and program operations staff working within the subbasin.

2.8.26 Adopt locally and regionally standardized protocols.

Timeline: Long-term

Performance metrics: Management performance and coordination

Status: Ongoing

We will participate in several regional processes to coordinate Walla Walla RM&E activities with regional information needs. These processes include independent reviews/audits of anadromous fish hatchery performance initiated by the Northwest Power and Conservation Council, using performance measures developed by Independent Hatchery Operations Team (IHOT) and Artificial Production Review and Evaluations (APRE). Currently, co-managers are coordinating with NOAA to assess the scope and status of information needs identified in the Biological Opinion and WA State Salmon Recovery Process.

The Walla Walla RM&E program will also be coordinated with the CBFWA, LSCRP, Cooperative Systemwide Monitoring and Evaluation Partnership (CSMEP) and NWPCC's Pacific Northwest Aquatic Monitoring Partnership (PNAMP). The ISRP Provincial Review process provides an additional means of identifying regional information needs.

We will incorporate regional sampling protocols into our RM&E activities to provide region-wide data compatibility as these standards are defined. Currently, RM&E activities incorporate regional protocols for PIT-tagging, coded wire tagging, and marking developed by the Pacific States Marine Fisheries Commission, and fish health monitoring developed by the Independent Hatchery Operations Team (IHOT). We propose in this RM&E to incorporate a stratified randomization sampling protocol into our fish habitat and population status monitoring, based in part on the EMAP protocol. We will adopt other regional protocols for data collection as they are developed thru the Artificial Production Review and Evaluations (APRE), IHOT, NOAA Biological Opinion, and CBFWA Regional Monitoring and Evaluation program processes.

We will utilize project specific and region-wide databases that have been developed to centralize data management and access. A CTUIR website will be maintained to house a standardized database for primary data and description of meta-data. WDFW may use Paladin and Streamnet or local WDFW servers to manage data. Appropriate components of program data and results will be provided to the Pacific States Marine Fisheries Commission (PSMFC) websites, including: StreamNet, PIT Tag Information System (PTAGIS), and the Regional Mark Information System (RMIS). Fish production and release summaries including mark applications will be provided to the Fish Passage Center for incorporation in their web based data. Run size information will be provided to the Columbia River Technical Advisory Committee.

2.8.27 Coordinate with Local and Regional Management and Research Groups, and Integrate Information from these Groups into Assessments of Walla Walla Subbasin Fisheries Program.

CTUIR will be partially responsible for RM&E coordination, and will participate in the operation of the Walla Walla Technical Work Group (TWG). CTUIR will obtain information from other basins to compare with Walla Walla Subbasin RM&E study findings. CTUIR will compare subbasin-to-subbasin status and trends of fish abundance, productivity, and habitat. In particular, we will compare trends in Walla Walla steelhead abundance and productivity with the unsupplemented steelhead population in the John Day Subbasin to evaluate the impacts of artificial production by WDFW. CTUIR will also compare Walla Walla spring Chinook salmon productivity with other naturally-reared populations in nearby basins to assess the status of the Walla Walla restoration program. Trends in abundance of Walla Walla steelhead and Chinook salmon will also be compared with the Columbia/Snake River Basin metapopulation to assess whether the Walla Walla populations are following regional trends. As regionally standardized protocols are expanded, we will integrate the regional-scale understanding of fish populations and habitat into the assessment of Walla Walla fish programs. Lack of uniformity in sampling protocols has confounded the validity and utility of some previous between-subbasin comparisons. Collection of comparable data may provide the ability to calibrate past data, thus increasing the validity of between-subbasin comparisons.

3. DETAILED METHODS

3.1 JUVENILE ABUNDANCE AND DISTRIBUTION MONITORING

The use of an EMAP sampling design is currently being studied by a number of research coordination groups including the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and the Columbia Systemwide Monitoring and Evaluation Partnership (CSMEP). The utility of these techniques to monitor Walla Walla focal species is currently unknown. Nonetheless, the current sampling design being used in the Walla Walla Subbasin by the co-management agencies does incorporate many of the basic components of an EMAP design. Collectively the co-managers sample at index sites that are visited annually, and at a variety of randomly or haphazardly selected sites that are visited less frequently. The sites are stratified at the reach and watershed level, and this stratification is dealt with via an aggregation of results during analysis. Hence the current sampling regime can be considered a "modified" EMAP design. If EMAP is accepted as a regionally standardized protocol for habitat, juvenile, or spawner surveys the co-managers will need to modify their sampling design to adhere to the statistical requirements of EMAP anlaysis. The cooperators are re-evaluating their sampling design, and will adjust it to more formally adopt EMAP as information becomes.

Electrofishing, seining, and trapping will be used to quantify the abundance of juvenile salmonids at the reach scale. The sampling universe for juvenile surveys will be the EDT reaches developed for subbasin planning and in-situ sampling designs (Figure 1). We will use these reaches and watershed delineations to allocate sampling across the subbasin. Sampling intensity will be increased in watersheds that are receiving supplementation, flow, or habitat treatments, or where specific uncertainties exist.

Previous work in the Walla Walla by CTUIR (Contor 2003) and WDFW (Mendel et al. 2003, Bumgarner et al. 2002) showed high variability in community structure and the density of juvenile salmonids based on two or three pass depletion electrofishing. This high variability suggests that significant between-reach differences in community structure and juvenile densities can be detected with as few as three sites per watershed (Figures 2-5).

The geographic variability in salmonid densities is juxtaposed by a relatively small temporal variability at index sites. Temporal variability of juvenile densities may be limited by a number of reasons including the ability of salmonids to migrate to the highest quality rearing habitat. Quality fish habitat tends to attract rearing juveniles from throughout a watershed, and will usually maintain high salmonid densities from year to year (Roper et al. 2003). This makes the detection of reach-scale changes in productivity extremely difficult in the absence of relatively large (>20 percent) changes in rearing densities. Therefore the number of samples needed to assess temporal changes in salmonid production based on traditional statistics exceeds the practical maximum of field activities. In addition, in some areas of the watershed seasonal sampling is possible, but not in the mainstem reaches. This makes it difficult to collect sufficient samples in the non-wadable reaches where focal species densities may be high.

Instead of attempting to populate traditional statistical models, we will use a geostatistical estimator of population variance to project juvenile stock assessments across watersheds based on annual juvenile fish surveys of 3-10 samples per tributary. This will reduce the number of samples needed to produce a reasonable estimate of density and abundance at the tributary level. This novel technique is under development by a number of research groups, has received considerable peer review, and is considered a viable alternative to traditional statistical estimators of juvenile populations. We will survey 3 to 5 permanent index sites in each target watershed using multiple pass depletion electrofishing, snorkeling, and seining between barrier nets. Habitat conditions of the index sites will be estimated every 3 to 10 years, and the wetted width and volume of each site will be determined annually. An additional 2-5 sites will be randomly selected using a spatially balanced algorithm (Stevens and Olsen 2003, 2004). Within each reach sampling sites will be distributed randomly where possible, but will conform to landowner requests and trespassing laws. Fish communities and habitat information will be sampled at each randomly selected site. A draft site selection is currently under development and review by EPA's EMAP laboratory for the Walla Walla Subbasin. Thirty permanent index sites and at least an additional thirty randomly selected sites will be sampled each year. This sample size approaches the practical maximum for field efforts, surpasses the sample size required to detect geographic patterns in community structure related to habitat variability, far exceeds the sample size needed to detect changes in each watershed (Roper et al. 2003), and should be sufficient to detect a 50% change in salmonid densities per annum at the watershed scale. Approximately five to ten percent of the catch will be PIT-tagged for survival and outmigration monitoring. This will provide a sample for the assessment and monitoring of within-subbasin survival of salmonids using detections at Columbia River PIT-tag detectors and the within-subbasin rotary screw traps.

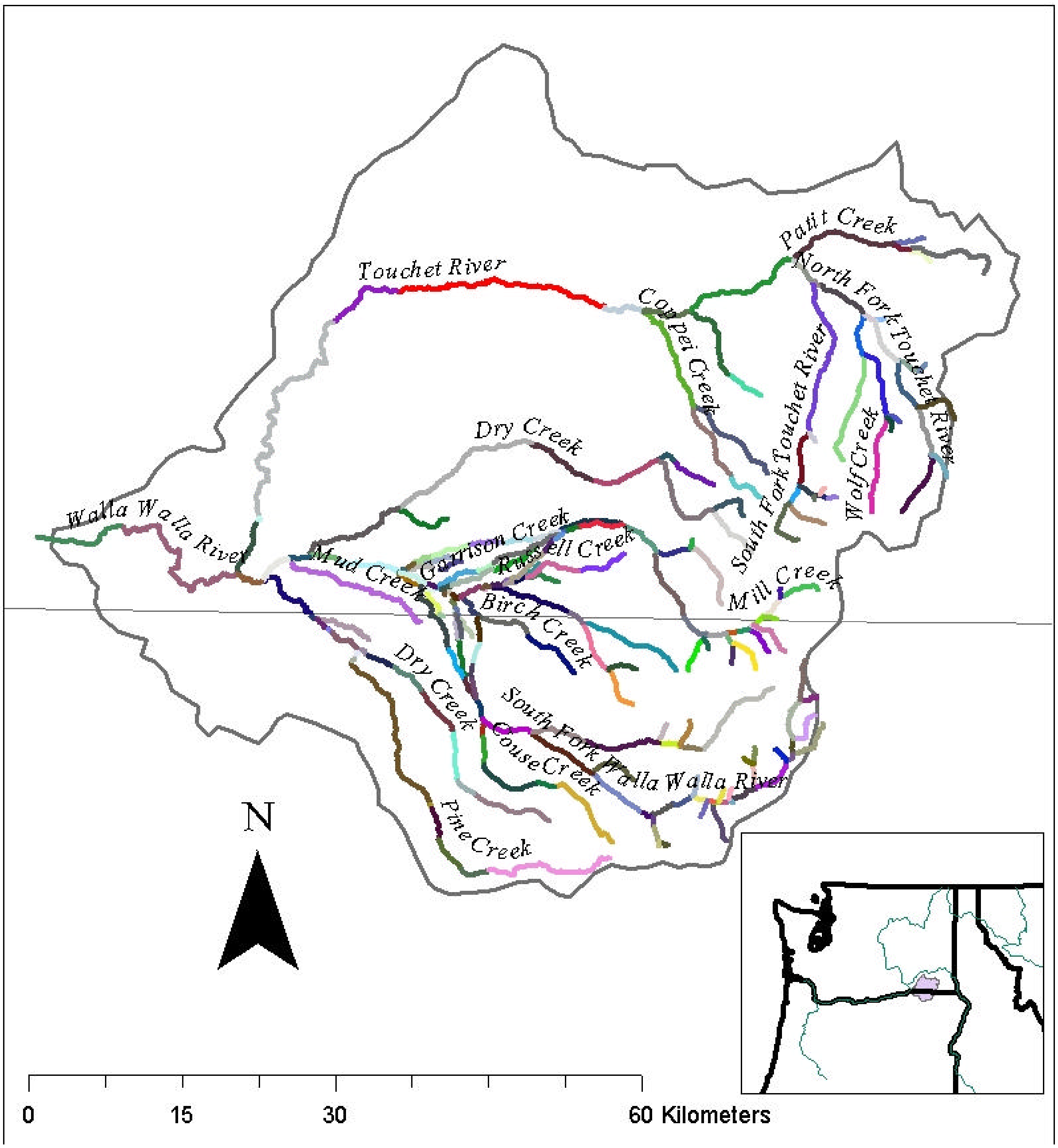

Figure 1 EDT Reach Distribution for the Walla Walla Subbasin

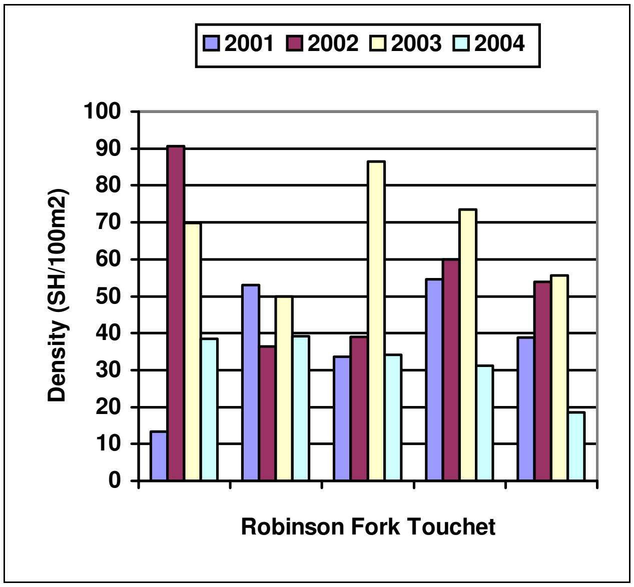

Figure 2 **Steelhead Densities at Index Sites Sampled in the Robinson Fork of the Touchet River (WDFW data).**

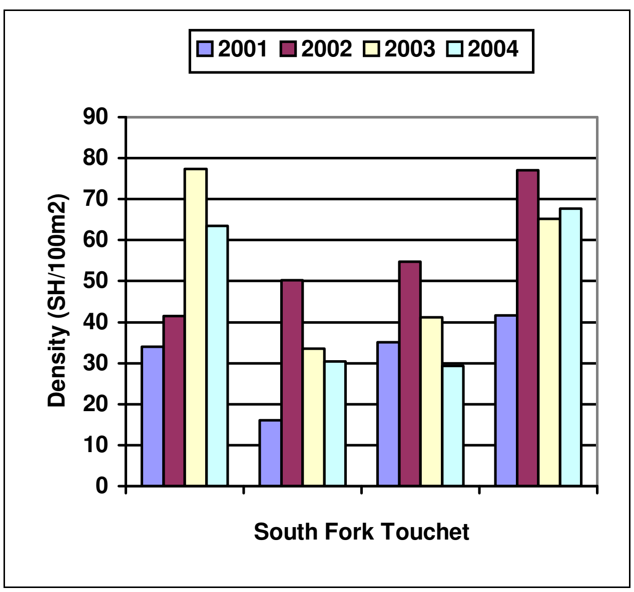

Figure 3 **Steelhead Densities at Index Sites Sampled in the South Fork of the Touchet River (WDFW data)**

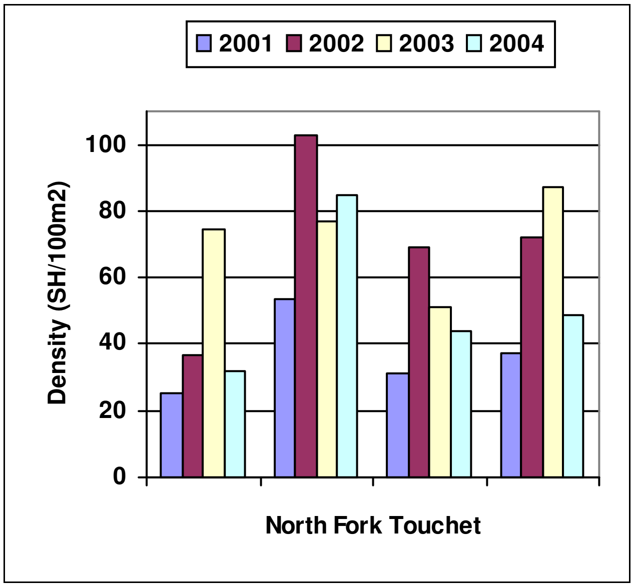

Figure 4 Steelhead Densities at Index Sites Sampled on the North Fork of the Touchet River (WDFW data)

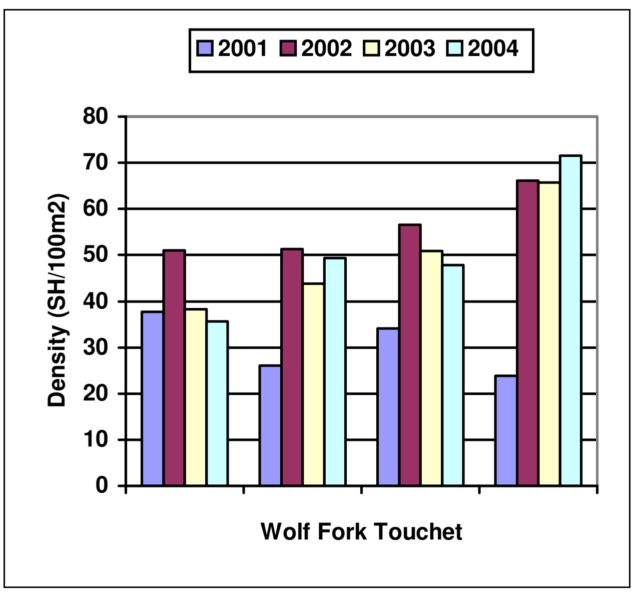

Figure 5 Steelhead Densities at Index Sites Sampled on the Wolf Fork of the Touchet River (WDFW data)

Analysis

The total abundance and CPUE by reach and sampling methodology for all fish species will be analyzed using associative, geostatistical, time series, and structural analysis. Associative analysis will be used to relate fish community parameters to habitat data as well as the various management treatments each watershed receives. Association analysis is the process of determining whether or not two or more measures relate to each other in an observational, before/after, or treatment/control experiment. Traditional inferential statistics including ANOVAs, t-tests, regression, and principle components analysis all utilize the associative paradigm. The general equations for associative analysis of any variable X are the probability functions:

Equation 1-1
$$\mu = \sum x \bullet P(x)$$

Equation 1-2
$$\sigma^2 = \sum [(x-\mu)^2 \bullet P(x)]$$

Equation 1-3
$$\sigma = \sqrt{[\sum x^2 \bullet P(x)] - \mu^2}$$

Where P is the probability of encountering any given value of x, μ is the mean of that probability function, σ is the variance, and σ^2 is its standard deviation. These general equations are the foundation of probabilistic and inferential statistics, and have general applicability in the assessment of any quantitative association. Juvenile fish population and community information will be compared to reach, watershed, and subbasin-scale measures of habitat, supplementation, environmental conditions, and management actions using inferential statistics to determine patterns of strong inference such as correlation, cross-correlation, and independence. These patterns will be used to infer cause-effect relationships between management actions and confounding factors where these are statistically plausible.

Annual variability at index sites, and of aggregated randomly selected sites, will be analyzed using time-series analysis. The trend analysis paradigm shares some features with associative analysis with one critical difference. Trend analysis recognizes the linear nature of time series; that no point in time can ever being experienced again, and that no co-occurrences in time can be fully independent of each other. Changes over time can result from the interactions of associated variables, but can also stem from serial dependency, seasonality, and temporal stochasticity. There are two major foci of time series analysis; to identify the correlates of a variable represented by a series of observations, and to predict the future values of that variable. The management intent of trend analysis is to quantify the deterministic components that underlie juvenile fish communities against the back-drop of spurious relationships. Trend analysis is generally conducted as an autocorrelative function; the serial correlation coefficients and standard errors of temporal lags in covariates for variable x:

Equation 1-4
$$x_t = \xi + \phi_1 * x_{(t-1)} + \phi_2 * x_{(t-2)} + \phi_3 * x_{(t-3)} + ... + \varepsilon$$

where:

ξ is a constant (intercept),

and

ϕ_1, ϕ_2, ϕ_3 are the autoregressive model parameters

Juvenile population and community information will be analyzed using trend analysis for all index sites, and for the aggregation of all index and randomly selected sites to the watershed and subbasin scale. The stability, resilience, and resistance of populations will be quantified. Detrending, filtering, transfer functions, and intervention analysis will be applied. For each spatial scale and set of performance metrics we will ask "Did the system change?" and if so "What were the most statistically plausible (or associative) factors?" In addition we will use autocorrelation to build potentially predictive models of change.

Juvenile population and community estimates will be expanded from the site and reach scale to the watershed scale using geostatistical stock assessment based on habitat data (Petitgas 2001). Geostatistical analysis is used to assess the spatial variability of a variable or variables, and then to utilize that variability and co-variability as an estimator or predictor of a covariate such as population density (Petitgas 2001). Geostatistical analysis recognizes the potential spatial co-variation of metrics that can be associative, confounding, or predictive. Changes across space can result from the spatial distribution of variables such as the extent of clustering, or it can result from underlying co-variation with habitat characteristics or inter-specific relationships. In a stream-network spatial variability can also result from contingency and dependency on up-stream or down-stream factors. Geostatistical analysis relies on the estimation of spatial means, called the zone mean, rather than the process mean used in inferential statistics. The mean (Z) is derived from for any variable x, and its covariate v.

Equation 1-5
$$Z_v = \frac{1}{V}\int_V z(x)dx$$

The calculation of the estimate and estimator variance is exponentially more complex, and depends on the realization of an expectation function, covariogram, and variogram. The use of these spatial means to develop geostatistical or geospatial estimates of random or deterministic functions is perhaps not more complex, but more complicated because the precise method (or kriging formula) depends on the realized variogram and covariogram functions. The reader is referred elsewhere for discussions regarding the kriging decision tree (Demyanov et al. 2001, Lloyd and Atkinson 2001) and the application of kriged results (Rendu 1980, Warren 1998, Barbaras et al. 2001).

Habitat, population, and environmental variables will be analyzed to determine their spatial co-variation. The relationship between juvenile populations and habitat metrics will be used to conduct a geostatistical expansion of fish observations throughout each watershed. This expansion will be used to generate geostatistical stock assessment estimates (Petitgas 2001). We will apply geostatistical analysis in parallel with associative and trend analysis to determine the spatial, temporal, and nominal co-variation of performance metrics, treatment actions, and confounding factors. Fish community data will be further analyzed from an ecological perspective using functional analysis.

3.2 OUTMIGRANT MONITORING

Smolt abundance, migration timing, and in-basin survival are all studied during outmigrant monitoring. Smolt yield is important for long-term monitoring of restoration actions and provides the foundation for developing relationships used to estimate in-basin capacity and productivity measures. Smolt abundance is collected at the subbasin scale and described in the outmigrant trapping section. An understanding of migration success and survival is also necessary to identify in and out-of-basin bottlenecks and to estimate loss by life stage for hatchery- and naturally-reared salmonids. Survival is estimated at both the subbasin and watershed scales. Methodologies are described in the PIT-tagging and detection section of this plan. Juvenile life history characteristics are key components used in assessing the performance of hatchery-origin fish relative to naturally-produced fish. In particular, they are used to assess whether management of hatchery operations (broodstock collection, spawning strategies and release timing) differ from those of naturally-reared populations to determine where differences in survival are detectable. Information is then used to depict trends over time and ultimately assist managers in making program management decisions.

Current methodologies applied to derive in and out-of-basin survival estimates include the use of mark-recapture techniques. Smolt abundance is derived from fish collection and expanded by the trap efficiency. We are currently investigating alternate methodologies to collect outmigrant data in order to improve project operations, estimates, and efficiency, and reduce potential error. Examples of these include moving towards the SURPH model for in-basin survival estimates, changing trap types and locations or applying in-basin survival estimates to upper river abundance to derive a total smolt outmigrant estimate.

3.2.1 Trapping

A rotary-screw trap is utilized to capture emigrating juvenile salmonids in the lower Walla Walla River. The trap is operated November through May to collect all out-migrating juveniles. The rotary-screw trap consists of a 5-ft diameter perforated cone and 12.8-ft2 livebox, supported between two 16-ft long aluminum pontoons. Fish enter the upstream end of the trap and are forced rearward into the livebox by rotation of the perforated cone, driven by the water current. Fish captured are held for a maximum of 24hrs prior to sampling. Smolt traps are also located in the Walla Walla River near Milton Freewater and in Mill Creek. A smolt trap is needed in the middle or lower Touchet River.

All salmonids captured are anesthetized with a stock solution of MS-222 (40 mg/l) prior to sampling. Fish are enumerated by species, race and rear type. Rear type is categorized as “natural” or “hatchery” based on the presence/absence of a fin clip, wire tag, and the appearance of wear on the dorsal and ventral fins. Scales are collected on a subsample of natural summer steelhead for age analysis and developmental (smoltification) stage for all species is assessed by visible brightness and the presence or absence of parr marks. Fork length (FL) is measured to the nearest millimeter (mm) and single character descriptor codes are used to describe descaling, injuries, parasites, and disease for all natural juvenile salmonids and a subsample of 60 hatchery salmonids per day.

All smolts captured during fish sampling are manually interrogated for PIT tags. All recaptured PIT tagged smolts are reported to the PTAGIS database. Data is recorded directly into the PITTag 3 program using a laptop computer.

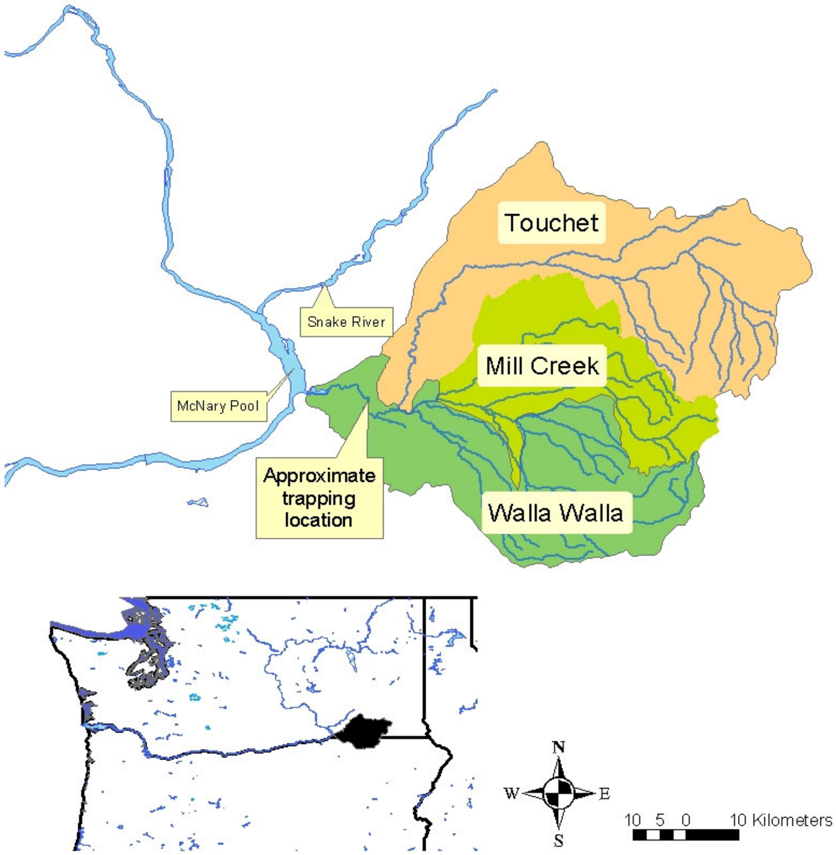

Figure 6 The Walla Walla Subbasin, Its Three Major Drainages, and the Approximate Location of the Rotary Screw Trap

3.2.2 Trap Efficiency

To calibrate the collection efficiency of the traps and estimate outmigrant abundance and survival, groups of 50 to 100 fish per species are collected, PIT-tagged and released upstream of the traps for recapture. Tests are generally conducted 2 times a week for each species while sufficient numbers of fish are being captured. Tagged fish are typically held for 24 hours prior to release, to assess latent mortality (tagging effect), tag loss and determine the probability of survival of individual release groups. The probability of survival and estimated survival of tagged fish released is calculated using the following equation:

Equation 2-1 $s = L/H$

Equation 2-2 $M = N(s)$

Where s = probability of survival, L = number of live tagged fish after holding, H = initial number of tagged fish held, M = estimated survival of tagged fish released, N = total number of tagged fish released. Tagged fish that die or drop their tags prior to release are removed from the test group. Tag retention and fish survival for all factors other than tagging are assumed to be 100% after release, and we assume that mortality due to tagging after release is equal to mortality during the holding period. Recaptured fish are enumerated by species/origin and trap efficiency estimates are computed using the following formula:

Equation 2-3 $TE = R/M$

Where, TE = estimated trap efficiency, R = number of recaptured tagged fish, and M = number of tagged fish released and adjusted for survival. Separate trap efficiency estimates within a species are compared using chi-squared analysis and pooled if the estimates are not significantly different ($P > 0.05$). If less than five tagged fish of a particular release group are recaptured, adjacent test groups are pooled until the number of recaptures is greater than five. Pooling is continued until a significant difference was determined. The final trap efficiency estimate is the weighted mean of the pooled estimates.

3.2.3 Smolt Emigrant Abundance

Smolt emigrant abundance is defined as the number of smolts leaving the Walla Walla River. Smolt abundance is derived based on the number of fish collected at lower river trap sites and the estimated trap efficiency. Abundance of fish sampled at the screw trap is estimated as:

Equation 2-6 $A = (C/TR)/TE$

Whereby, A = total number estimated outmigrants, C = the number of fish captured, TR = trap retention efficiency and TE = estimated trap efficiency. Sampling rate and time were not adjusted due to 24 hr a day trap operation.

Emigrant abundance is calculated on a monthly basis and then summed to derive a total number of outmigrants for the season. For months where trap efficiencies of natural species are not available or are sparse, trap efficiency estimates from hatchery conspecifics are substituted. If hatchery conspecifics are not available for a particular month, efficiency estimates from the month before or month after are used. The Bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994), with 1,000 iterations, is used to derive a variance and 95 percent CI for

All Chinook salmon $\geq$ 45 mm captured at RM 3.7 or 1.2 are considered outmigrants. Age-0 migrant steelhead are assumed not to be outmigrants based on the fact that a subyearling life history pattern has never been detected on scale samples collected from adult steelhead escaping to the Walla Walla River.

3.2.4 Smolt emigration timing

Emigration timing is a key performance measure used to test for life history divergence between hatchery and natural salmonids. Weekly frequency distributions will be compared using the Kolmogorov-Smirnov test. PIT tag detection data will also be used to compare smolt migration characteristics between hatchery and natural smolts. Methods are described in section 2B2 of this plan.

3.2.5 Age at Emigration

Age at emigration is characterized as the annual proportion of smolts in a particular age class emigrating from the Walla Walla River. Percent age composition analysis from a five year mean of adult returns is applied to annual smolt abundance estimates to derive the total estimated number of emigrants by freshwater age class for a particular year. Methods used to analyze adult scales are described in section 5 of this plan. Age at emigration is also accomplished through annual scale pattern analysis of juvenile summer steelhead collected at RM 3.7. Scales are mounted on mylar strips and examined under a microfiche at 24X or greater magnification to discern annuli patterns reflecting freshwater age.

3.2.6 Size at Emigration

Size at emigration is quantified annually from fish captured in traps for each species of salmonid. Length data is used to create monthly length-frequency distributions and summary statistics; including sample size, mean fork length, and minimum and maximum fork lengths. A one-way analysis of variance (ANOVA) is used to make interannual comparisons of mean fork length for each species of natural emigrants ($\alpha = 0.05$). When significant differences are found, further analysis will be performed using the Scheffé method for multiple comparisons among means ($\alpha = 0.05$). All PIT tagged fish encountered in hand samples are measured to assess growth from tag date to recapture date. The growth in length (mm/d) for individual tagged fish is calculated as length at recapture minus length at tagging divided by the number of days between tagging and recapture.

3.2.7 Condition at Emigration

Condition at emigration is characterized as the proportion of cumulative scale loss evident on the fish at the time of emigration. Condition of individual fish is categorized into one of three categories: good, partially descaled, and descaled, following criteria used by the Walla Walla Hatchery Monitoring and Evaluation project (Keefe et al. 1994). Condition is considered "good" if cumulative scale loss on either side of the fish was less than 3 percent. Fish are considered "partially descaled" if cumulative scale loss was greater than 3 percent but less than 20 percent. Fish with scale loss greater than 20 percent are considered "descaled".

Scale loss is expressed as the weekly proportion of descaled fish observed in the sample and the Spearman rank correlation test is used to analyze the possible relationship of scale loss with various independent variables. Independent variables included river discharge, water temperature, and secchi depth. This analysis ranks the variates and calculates a coefficient of rank correlation. A nonparametric test is used because scale loss data is not typically normally distributed.

3.2.8 Juvenile fish health

Juvenile fish health is monitored during emigration by using single character descriptor codes to describe body injuries, external parasites, bird marks, obvious fungal infections of the body surface, and signs of potential disease. The Spearman rank correlation test is used to analyze the possible association of fish health variables (weekly proportion of fish with body injuries, parasites, or bird marks) and three independent variables. The independent variables are river discharge, secchi depth, and water temperature. Fish mortalities are noted by species and identified as being from an unknown source or a direct result of sampling activities. Annual mortality rates are calculated for unknown, sampling, and combined mortalities. All natural fish that die from an unknown cause and some diseased and dead hatchery fish are forwarded to the ODFW Fish Pathology Lab. Sample, diagnostic and statistical analyses conform if possible with the Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection Committee guidelines. Analysis of samples follows standard protocols defined in the latest edition of the American Fisheries Society " Fish Health Blue Book" (Procedures for the Detection and Identification of Certain Fish Pathogens).

3.2.9 Environmental Variables

Environmental variables including river discharge, flow augmentation, water temperature and water clarity are monitored annually and analyzed using associative and time-series analysis to characterize conditions in the Walla Walla River and to assess their effects on emigration timing and fish passage. Daily river discharge, flow augmentation from McKay Reservoir, and water temperature data is obtained from the USBR Hydromet Archives. Weekly mean discharge and temperature from the Walla Walla gauging station is plotted against time. Weekly mean discharge and daily mean water temperature from McKay Reservoir is also plotted against time. Water clarity is measured to the nearest 0.05 m using a 7-in-diameter secchi disk. Weekly mean secchi depth is plotted against time.

The relationship between river discharge and the daily proportion of emigrants passing a trap site is tested using the Spearman rank correlation test. The Spearman rank correlation test is also used to test for a relationship between water temperature and the proportion of emigrants passing a trap site. The variable reflecting the river discharge or water temperature during the passage period is the average of the mean of the day before and the day of passage. The time period used for the analysis is between the day when the first and last emigrant was observed. Discharge and temperature variables from gauging stations are utilized for the analysis. Any missing discharge or temperature records are estimated by taking the average of the mean daily discharge or temperature three days prior and three days after the missing record. Linear regression is used to evaluate the possible relationship of environmental variables and smolt emigration timing by comparing the day of year of median emigration with average daily water temperature and river discharge from 1 February to 1 July.

3.2.10 PIT-tagging and Detection

3.2.10.1 In-Stream Smolt survival

Survival estimates for hatchery and natural salmonids are conducted to assess in-basin and out-of-basin loss by species and life-stage. Survival estimates are also generated to support hatchery production monitoring and evaluation of optimal release and rearing strategies. Mark-recapture methodology utilizing PIT tags and subsequent detections at the rotary screw trap and Columbia River dams is used to calculate survival. Hatchery fish are tagged at hatchery or acclimation facilities prior to release and natural fish are captured and tagged in the headwaters and the Walla Walla River mainstem during juvenile abundance surveys.

In-basin survival of hatchery salmonids is currently estimated using the Migrant Abundance Method (Burham et al. 1987 and Dauble et al. 1993), whereby:

Equation 2-7 $S = A/R$

Equation 2-8 $A = TD/TE$

S = survival, A = abundance (estimated total number of outmigrants passing RM 3.7), R = the number of tagged fish released at upriver sites (R), TD = number of tagged migrants recaptured in Walla Walla River traps, and TE = estimated trap efficiency. Since detections are date specific, efficiency estimates used encompass corresponding tag dates. If efficiency estimates do not correspond to the dates tags are detected, trap efficiency data is arbitrarily pooled using the closest daily estimates before and after the detection date. Confidence intervals (95 percent) for survival estimates are based on derived population confidence intervals. The binomial test is used to test for significant differences in detection between comparable hatchery release strategies (acclimated vs. direct released fish, different release locations).

Out-of-basin and in-basin survival of natural and hatchery salmonids will also be estimated using the CRiSP and SURPH models. Sample size requirements for determining survival rates to McNary (MCN) and John Day Dam (JDD) using these models was determined using the SURPH Sample Size program (v 1.2). Observed survival rates and detection probabilities from PIT tagged hatchery and natural salmonids released in the Walla Walla River in 2003-2004 were used to estimate minimum release group sizes needed to generate out-of-basin survival rates with various levels of precision (see below). Similar numbers were not available at this time for a power analysis to determine the sample size needed to estimate in-basin survival. Numbers from the Umatilla subbasin suggest an average pre-smolt to outmigrant survival rate of 60%. This preliminary estimate was used below to populate a power analysis including in-stream survival estimates. This analysis will be sufficient to estimate a reasonable PIT-tag sample size for 2006. The sample size requirements for in-stream survival monitoring will be re-evaluated in 2005 and 2006, and PIT-tag requests will be revised accordingly.

Testing for significant differences in survival rates will be conducted annually, and in detail over aggregated five-year periods. The SURPH model and other likelihood estimators will be used to estimate in-stream survival based on release sizes, trap efficiencies, and the number of recaptures. Smolt survival estimates generated by SURPH include a point estimate and associated variance. ANOVA testing with transformed data and trend analysis will be used to characterize trends over time.

3.2.10.2 Migration Parameters

Migration parameters are monitored using PIT tags and subsequent detections at McNary, John Day, and Bonneville Dams. Migration parameters will be summarized by the 10, 50, and 90 percent detection dates at McNary, John Day, and Bonneville Dams.

PIT tag detections at the rotary screw trap will be expanded by examining downstream detections at McNary and John Day Dams to generate day-by-day estimates of the proportion of PIT tagged fish detected vs. those not detected as they passed the rotary screw trap using the equation:

Equation 2-9 $f_e = N_{JD\text{-}TMF} / N_{TJD}$

Where f_e is the expansion factor, $N_{JD\text{-}TMF}$ is the number of PIT tagged fish detected at John Day Dam previously detected at NcNary dam, and N_{TJD} is the total number of Walla Walla PIT tagged fish detected at John Day Dam

Alternatively, if the sample size of PIT tagged fish passing John Day Dam is too small, we will use weekly trap efficiency estimates to estimate the number of PIT tagged fish passing the trap. A similar approach using Bonneville Dam detections will be used to expand PIT tags observed at John Day Dam.

The number of smolts passing Bonneville Dam daily will be estimated by expanding daily numbers of PIT tag detections according to the proportion of water passing through the powerhouse. Separate estimates will be made for each powerhouse and then summed to generate day-by-day totals. No adjustments will be made for fish guidance efficiency, horizontal, vertical, or temporal fish distribution.

Equation 2-10 $f_{P1} = (P1 + P2 + S) / P1$

Equation 2-11 $f_{P2} = (P1 + P2 + S) / P1$

Where f_{P1} and f_{P2} are the expansion factors for powerhouse 1 and 2, respectively, P1 and P2 are the flows through powerhouse 1 and 2, respectively, and S is the flow being spilled over the dam.

A Kruskal-Wallis test on the dates of detection, expressed as day of the year, will be performed to test for differences in the emigration timing of hatchery and natural summer steelhead smolts ($\alpha = 0.05$). The Kruskal-Wallis test ranks observations from lowest to highest and tests the null hypothesis that the medians of the two samples are equal.

Travel speed to the mouth of the Walla Walla River will be expressed in miles per day and calculated for each tagged fish detected at West Extension Canal using the following equation:

Equation 2-12 $$TS = (RM-3.7)/(D-R)$$

Where TS = travel speed, RM = river mile of release or tagging, D = date and time of detection at the rotary screw trap, and R = date and time of forced release or tagging. Travel speed of individual fish will be loge transformed to meet the assumption of normality. Within-year comparisons of hatchery release groups will be conducted using ANOVA ($\alpha. = 0.05$). The Scheffé test will be used to make pairwise comparisons when significant differences are found ($\alpha. = 0.05$). Negative travel speed estimates from volitional movement of hatchery fish are omitted from the analysis, along with tagged fish interrogated during trapping operations, because of the inability to assign an accurate date and time stamp of detection.

3.2.10.3 Out-of-basin survival

Out-of basin survival will be estimated using the CRiSP (www.cbr.washington.edu) and SURPH models. Sample Size v. 1.3 (Westhagen et al. 2003) was used to determine the relationship between sample size and power for detecting survival of each brood year of summer steelhead, spring Chinook salmon, and fall Chinook salmon using PIT-tags. Tables 1 and 2 show the average detection rates and survival estimates for the subbasin based on 2003-2004 tagging data. This preliminary sample size is relatively limited and predicts a large PIT-tag sample size is needed to estimate survival. Figures 7 and 8 show the sample size needed for outmigrant survival monitoring of summer steelhead and spring Chinook. Currently WDFW tags 10,000 steelhead in the Touchet system, and CTUIR tags 5000 spring Chinook and 1000 summer steelhead in the Mill Creek and Walla Walla drainages. These sampling efforts will need to be increased significantly in 2006 to include ~12,000 summer steelhead and ~17,000 spring Chinook. The 10,000 WDFW tags are allocated 100 percent to hatchery fish, so an additional 10-12,000 natural fish will need to be tagged. This large PIT-tagging effort will be implemented for three years to ensure sufficient power is achieved. As revised estimates and confidence intervals for mainstem survival are developed new power analyses will be performed. Reduced tagging regimes will be implemented when they are justified statistically.

Table 1 Jolly-Seber Survival Estimates for 2003-2004 Summer Steelhead and Spring Chinook Outmigrants from the Walla Walla Subbasin

Population	Headwaters to McNary Pool	Release to McNary Dam	McNary to John Day Dam	John Day to Bonneville Dam
Summer Steelhead	0.6*	0.24(0.02)	0.94(0.21)	Not available
Spring Chinook	0.6*	0.31(0.01)	0.88(0.08)	0.76(0.25)

*Derived from Umatilla River estimates.

Values are the mean with the 95% CI in parentheses.

Table 2 Capture (Detection) Probabilities for 2003-2004 Summer Steelhead and Spring Chinook Outmigrants from the Walla Walla Subbasin

Population	Rotary screw trap	McNary Dam	John Day Dam	Bonneville Dam (S*P)
Summer Steelhead	0.07*	0.25(0.03)	0.22(0.05)	0.12(0.03)
Spring Chinook	0.15*	0.48(0.02)	0.28(0.02)	0.15(0.05)

*Derived from Umatilla River estimates
Values are the mean with the 95% CI in parentheses.

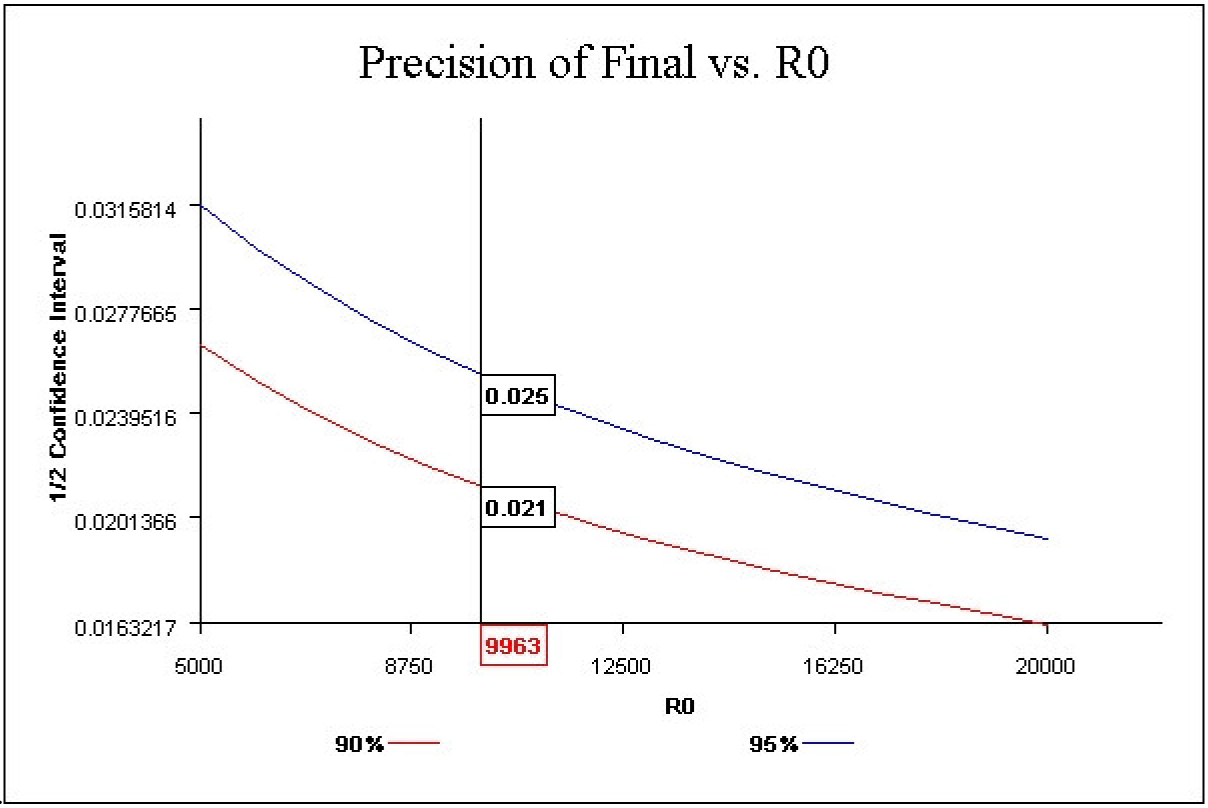

Figure 7 Sample Size (9963) Needed to Produce a 95% Confidence Interval of Outmigrant Survival for Walla Walla Subbasin Spring Chinook

Figure 7 was produced using Sample Size vs. 1.3 by the University of Washington Columbia Basin Research program, and assumes an additional 2500 fish are tagged at the lower river rotary screw trap.

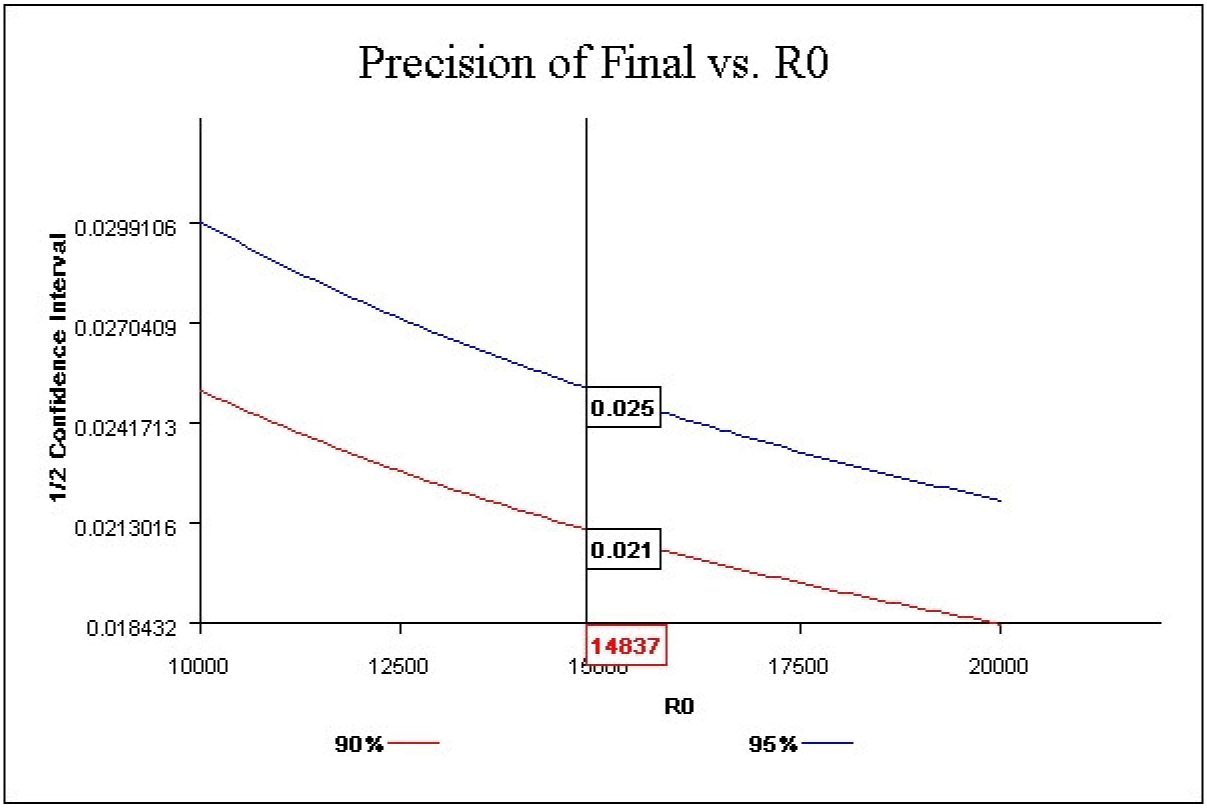

FIGURE 8 Sample Size (14837) Needed to Produce a 95% Confidence Interval of Outmigrant Survival for Walla Walla Subbasin Summer Steelhead

Figure 8 was produced using Sample Size vs. 1.3 by the University of Washington Columbia Basin Research program, and assumes an additional 1000 fish are tagged at the lower river rotary screw trap.

3.2.10.4 Migration Parameters

Migration parameters will be monitored using PIT tags and subsequent detections at the rotary screw trap. Parameters analyzed include emigration timing, duration, and travel speed and will be monitored to evaluate the migration success of hatchery-reared species compared with that naturally-reared counterparts. Smolt emigration timing will be expressed as the proportion of juvenile salmonids moving past the rotary screw trap during a particular period. Peak smolt movement will be defined as the date when the maximum number of tagged emigrants pass through the trap. Median emigration will be the date when 50 percent of the tag detections are observed. Diel movement will be determined by the percentage of fish detected within hourly blocks of time, and migration duration will be considered the period between the first and last date of tag detections.

Travel speed will be calculated for each tagged fish detected at the rotary screw trap and mainstem dams using equation 2-12. The median travel speed will be calculated for all naturally-reared fish and comparable release groups of hatchery-reared fish. Median rather than mean travel speeds will be computed because detection distributions are usually skewed. Negative travel speed estimates from volitional movement of hatchery-reared fish will be omitted from the analysis, along with tagged fish interrogated during trapping operations, because of the inability to assign an accurate date and time stamp of detection.

A fish passage index will be used to analyze the migration parameters of juvenile salmonids in years where insufficient numbers of hatchery- or naturally-reared fish are tagged. The fish passage index is the number of fish captured during a designated block of time expanded by the sampling rate. Designated blocks of time range from a few minutes to several hours and sample rates are between 1 and 100 percent. Past experience has resulted in similar migration parameters between the PIT tag analysis and fish passage index methods.

3.3 ADULT MONITORING

3.3.1 PIT-tagging and Detection

Adults are PIT-tagged regularly by mainstem monitoring programs under BPA, Lower Snake Compensation Program, or ESA mandated projects. In addition a number of juveniles tagged in the Walla Walla Subbasin will return with PIT-tags intact, and will produce adult detections. Adult PIT-tag returns will be monitored using PITAGIS, and will be utilized to inform run prediction models. Travel times and adult passage information in the Columbia mainstem are calculated by the Columbia Basin Research Center at the University of Washington (www.cbr.washington.edu).

3.3.2 Adult Trapping, Collection, and Enumeration

The WDFW Snake River Hatchery Evaluation staff operates and maintains the Dayton adult trap on the Touchet River. The primary objective is for capture and partial enumeration of summer steelhead into the upper Touchet River. Because of design, the trap/weir is not 100% efficient and does not allow for full run enumeration. A portion of the captured natural-origin summer steelhead are collected each spring and taken to Lyons Ferry Hatchery for spawning to develop a new hatchery stock for use in the Touchet River. The rest of the natural origin summer steelhead captured are passed upstream of the trap for natural spawning, as well as any returns from the natural broodstock program. Any Lyons Ferry stock summer steelhead are passed downstream of the trap, with the intent they might be captured in the fishery and removed from the system. Additional species captured at the Dayton adult trap include bull trout, whitefish, brown trout, spring Chinook, northern pike minnow, and bridgelip sucker. Each of these other species are sampled and passed upstream of the trap.

Upon capture, each species is netted from the holding area of the trap, and either counted or sampled depending on the species. Samples collected include sex (if possible from visual observation), length, any marks, scales, and fin clips for DNA analysis. In addition, all bull trout are scanned for PIT tags. The WDFW has been PIT tagging captured bull trout on an annual basis to obtain recapture and growth data between migration years.

In addition to the adult trap, WDFW also has incorporated a Logie Resistivity Fish Counter at the weir. The resistivity counter is able to determine upstream or downstream passage of fish over the counter ramp. A digital video recorder with two cameras have been incorporated in the counter for species determination. At the end of the season, all video records are scanned and species determined. These counts, together with the adult trap counts, are then added together for total enumeration at the trap. Summer steelhead trap counts are recorded on standard WDFW hatchery record forms. Counts of other species captured or counted by the resistivity counter are maintained on file with WDFW. The fish ladder and trap are currently being redesigned to improve fish passage, trapping, enumeration and fish handling abilities at the Dayton Dam. The proposed ladder may be constructed during 2006 or 2007.

WDFW is in the process of constructing a temporary adult steelhead trap that would be operated in Coppei Creek a short distance upstream of Waitsburg to enumerate the numbers of steelhead returning to Coppei Creek, and more importantly determining the composition (hatchery or wild) of the returning steelhead. This trapping effort is only partially funded. It hopefully will continue for 2-3 years.

Ben Tice (2004) of the U.S. Army Corps of Engineers (Walla Walla District) has been video monitoring fish passage at the fish ladder at the Mill Creek Diversion Dam beginning in 2003 to assess the suitability of the fish passage facilities at the dam. In 2004, Tice (2004) installed an underwater video camera linked to a time-lapse VCR directly upstream of the ladder exit where visibility was generally good and the upper two thirds of the ladder exit could be seen. For the winter and spring of 2005 Tice will use digital cameras which should further improve fish counts (Ben Tice, U.S ACE, Walla Walla District, personal communication).

During 2004, the VCR recorded four frames per second to enable 24 hours to be recorded on one standard 120 minute VHS tape. During the 2004 season, the standard VCR was replaced by a high-density unit. Tapes were changed and viewed daily. Periods of darkness were not viewed. Each fish was viewed twice and the time, direction and travel and species were recorded. Length estimates were made by comparing the fish images to the images of a ruler placed at various locations in the exit of the ladder. Any adipose fin clips or other markings were noted. Flow data from the USGS stream gage at Mill Creek (gage number 14015000) was obtained for the time when each fish was observed. Hourly water temperatures were recoded at the diversion dam. Therefore, most fish observations have associated flow and water temperature data. For ten days in April, 2004, a second camera was installed on the opposite side of the ladder exit to monitor the lower third of the fish ladder. The recording times of each fish were carefully documented and compared to minimize double counting of fish recorded by both cameras (Tice 2004).

Video monitoring at the Mill Creek Diversion Dam is meeting current passage evaluation objectives by recoding many of the fish using the fish ladder. Accurate fish counting at the dam is desired for long-term stock status and trend monitoring. Long term funding has not been formally secured, but it is likely the U.S. ACE will improve and continue their monitoring efforts and the Mill Creek Diversion Dam (Ben Tice, U.S ACE, Walla Walla District, personal communication).

CTUIR intermittently operates adult traps at the mouth of the Walla Walla River, and at Nursery Bridge Dam. These traps are sampled by RM&E staff to radio tag fish, and to monitor returns of salmon and steelhead. Protocols are similar to those used by WDFW.

Telemetry Monitoring

Radio telemetry will be used to collect information on the spatial and temporal patterns of adult migration, summer holding and mortality, straying, spawning and rearing habitat use, passage timing, delay patterns and fish ladder use for adult spring Chinook salmon and summer steelhead. Radio tags will be implanted gastrically in fish collected from the lower Walla Walla River. Fifty spring Chinook and 40 steelhead will be tagged each year. Roving radio telemetry surveys should cover all holding and spawning areas, but alternatively a stratified random sampling design could be used. Tagged fish will be georeferenced by aerial and ground tracking and by maintaining the set of fixed monitoring stations already in place in the Walla Walla Subbasin.

Fish will be captured in a Merwin Trap positioned near the mouth of the Walla Walla. The Merwin Trap is a relatively large, passive capture technique designed to be highly mobile and easily assembled. Essentially the trap consists of two parts, the pontoon boat frame and a large floating fyke net with a lead net (1 ¼ inch stretch mesh) that runs perpendicular to the stream bank. The trap funnels migrants into a flow through 15’ deep x 10’ wide x 10 long net-pen. The trap will be inspected and empted of fish each day. Fish are removed from the trap by dipnet, recorded by species, examined for injury and fin marks, coded-wire tags, Passive Integrated Transponder Tags (PIT tags) or other type of tags. Spring Chinook and steelhead will be measured to the nearest millimeter fork length, and sexed. Healthily spring Chinook salmon and summer steelhead will then be esophageally implanted with a radio transmitter, held for 24 hours within the net-pen to confirm tag retention and survival, and then released at the trap. The trap will be maintained for up to six months between October and December for steelhead and April to June for Chinook. These two periods corresponding to the peak return for both species to the Walla Walla River. The trap will not be fished when stream temperatures exceed 68° F nor during high flow events. Use of the trap will enhance and standardize capture, handling and tagging; and significantly reduce fish injury and handling stress. However, if the trap catch cannot meet project tagging goals, then additional fish may be captured by angling during concurrent sport fisheries or by setting small-mesh tangle nets in the lower Walla Walla River.

The transmitters used are Lotek 3-Volt Micro Coded Fish Transmitters (MCFT-3A) configured with the year 2000 code set. These tags weigh 16g in air, measure 46mm in length by 16mm wide, and are equipped with a 43cm long external whip antenna. Tags are programmed to emit a digital code every three seconds on a frequency of either 150.110 or 150.210 MHz for an operating life of 474 days. Code frequencies were regionally coordinated to avoid potential frequency overlap with any other telemetry.

A combination of ground, aerial and fixed-station tracking methods will be used to locate fish during surveys. Data logging telemetry receivers (Lotek SRX_400) will be used for both tracking fish and automated data logging past the fixed-site telemetry stations. Ground surveys will be conducted by boat, vehicle, trail bike, and on foot. Either a hand-held H-antenna or a 5-element Yaggi antenna mounted in the bed of the vehicle will be used during roving surveys. Fish location will be georeferenced using Meridian Magellan GPS linked to the telemetry receiver. Aerial surveys will be conducted in a Cessna 182 fixed-wing aircraft outfitted with two wing-mounted 4-element Yaggi antennas, one facing fore and one aft. The pilot and aircraft are contracted through, a local charter (Sky Runners Corp. Walla Walla, Washington) a company that specialized in fish and wildlife telemetry. Ground survey will be done each week and flights scheduled for every other week, weather permitting.

Telemetry station locations (Table 3 and Figure 9) were selected with regard to evaluating passage at the six major diversion dams (Hofer, Gose, Bennington, Burlingame, Nursery Bridge and Little Walla Walla) and documenting migration routes into the major tributaries (Touchet River, Mill Creek, and Yellowhawk Creek. Other stations in Figure X were used in the past, and are equipped for use in the future if and when management questions arise. Station components and antenna reception range will be checked each week. Frequent reception attenuation and equipment maintenance is necessary to adjust for constant changes in the listing environment, fish behavior, and equipment malfunction. Regular site maintenance and reception checking will produce more robust information on fish travel direction and location.

Estimates of tag loss due to study effect, harvest, natural and unknown causes are important components of study results. Fish disposition will be periodically assessed by visual confirmation, lack of movement, or tag recovery. When possible, snorkel divers will validate tag retention, observe fish behavior, confirmed mortality and recovered lost transmitters.

Table 3 Location of Fixed Automated Data Logger Stations in the Walla Walla Subbasin

Site	Agency	Dates	Location	Rive mile	GPS Coordinates (WGS84 Datum:Degrees.Degrees)	
FX_05	CTUIR	2001-2005	Gose Street Dam (Mill Creek)	4.8	46.06433° N	118.38884° N
FX_07	CTUIR	2001-2005	Burlingame Dam	36.7	46.02293° N	118.42386° N
FX_10	CTUIR/ OWEB	2001-2005	Nursery Bridge Dam	44.7	45.95558° N	118.38391° N
FX_11	CTUIR/ OWEB	2001-2005	Little Walla Walla River Dam	45.9	45.92855° N	118.37863° N
FX_17	CTUIR	2001-2005	Bennington Lake Dam (Mill Creek)	11.5	46.07933° N	118.25470° N
FX_18	CTUIR	2001-2005	Yellowhawk / Walla Walla R.	0.1	46.01736° N	118.39990° N
FX_19	CTUIR	2001-2005	Hofer Dam (Touchet River)	4.1	46.08490° N	118.65896° N
FX_20	CTUIR	2004-2005	Pierce's RV Park / CTUIR rotary trap site (lower WW River)	9.32	46.07215° N	118.78577° N

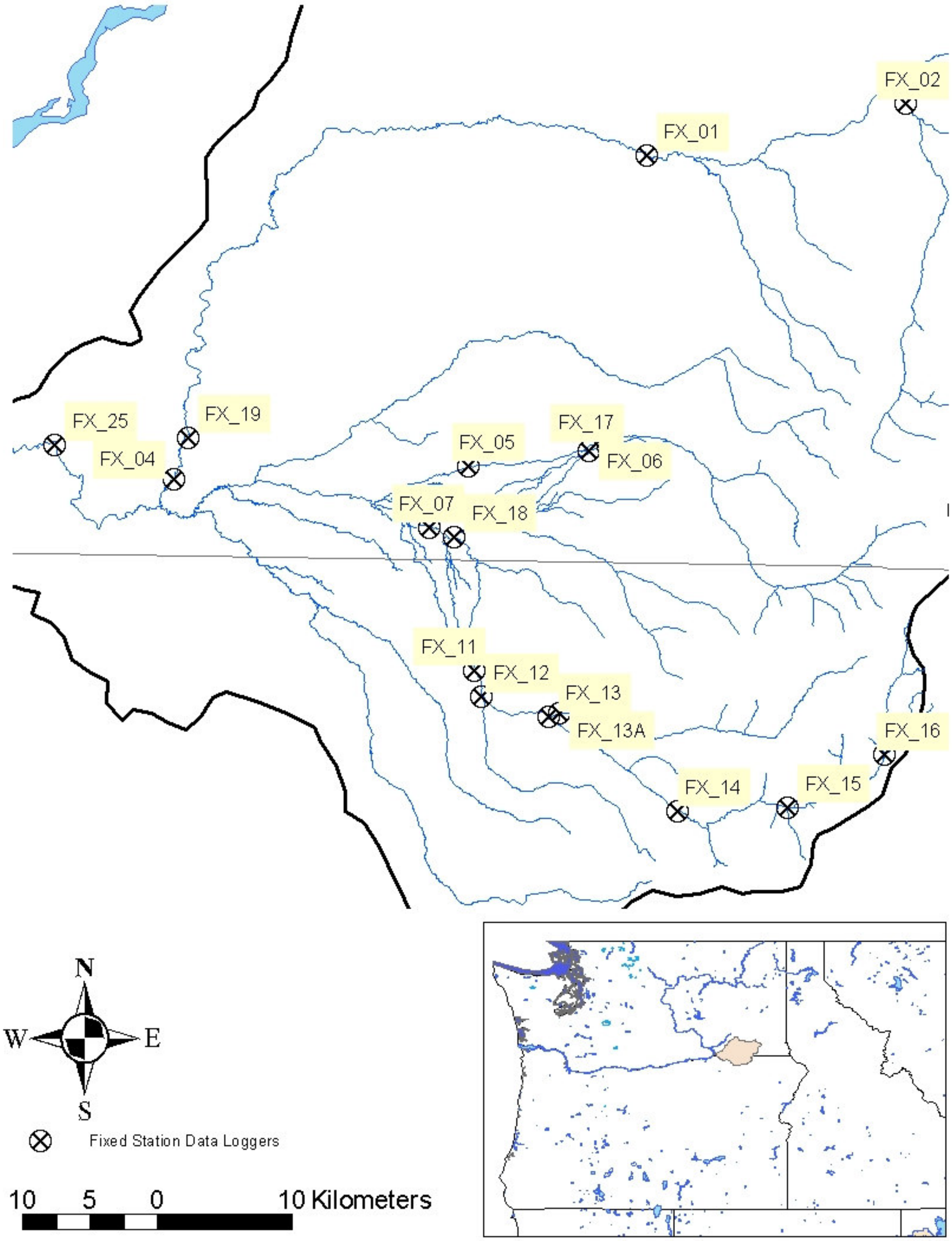

Figure 9 Location of Fixed-station Automated Radio Telemetry Data Loggers in the Walla Walla Subbasin

3.3.3 Spawning and Carcass Surveys

Spawner and carcass surveys will be conducted during the appropriate spawning and holding season for each species. Effort will be allocated using a stratified randomization of EDT reaches based on known and historic spawning habitat for each species. Redds and carcasses will be enumerated as an index of spawner abundance using multiple-pass visual surveys of the spawning grounds. The location of each redd and carcass will be georeferenced using OmniSTAR differential GPS. The condition of each redd and any observed spawner activity will be noted. Each observed redd will be flagged by marking tape on adjacent vegetation to avoid re-sampling.

Carcasses will be measured (fork length and/or MEHP) and weighed, and a scale sample may be collected for age, growth and origin analysis. Each carcass will be cut open to determine the spawning success of females. All external marks and tags will be noted. The snouts of adipose clipped fish will be removed for CWT analysis or the carcass will be scanned electronically for PIT tags and CWTs.

Steelhead survey efforts will be stratified using index sites that have five to ten-year datasets. Each site will be visited annually and receive at least three passes each year. An additional two to six randomly selected reaches will be surveyed annually using multiple-pass visual observations. The co-managers are currently working to develop a rolling panel or continuous survey methodology for summer steelhead and bull trout.

Spring Chinook salmon spawning surveys will be conducted differently due to the limited spawner range of spring Chinook salmon in the Walla Walla Subbasin. All known spawning grounds will receive at least three passes annually when reasonably numbers of fish are known to have returned to the watershed. Historic and marginal habitat will be surveyed during the spawning season to collect carcasses, and to watch for increased colonization of new spawning grounds

3.4 FISHERIES MONITORING

3.4.1 Non-Tribal Fisheries

Harvest of spring Chinook (when seasons are authorized) or steelhead will be estimated annually from WDFW angler catch record cards in Washington. Anglers are required to record all Chinook and steelhead retained on the catch record cards and submit the cards to WDFW in April each year. WDFW will continue to use a roving creel survey to evaluate angler and catch distribution and provide catch per effort estimates and recovery of CWTs. Specific, intensive creel surveys may be employed for anadromous or resident salmonid fisheries as funding and resources become available.

3.4.2 Out-of-Subbasin Harvest

CTUIR and WDFW are developing this section to describe a CWT evaluation program

3.5 AGE AND GROWTH MONITORING

Hard structures will be collected from juvenile and adult fishes during a variety of sampling activities. These hard structures will be analyzed to detect growth rings and other growth patterns including accelerated development of the nuclei (indicating hatchery-reared origin) and marine/freshwater transitional depositions (indicating years at sea and years in-river). A centralized age and growth lab is being developed at CTUIR facilities. The lab will be capable of detecting growth patterns from scale, otolith, vertebrae, and rays of fishes. The lab will use light-microscopy and computer digitalization to create a digital archive of all hard structures analyzed. The lab will be staffed with CTUIR and ODFW personnel who will share responsibility for age and growth determinations. Hard structures collected by CTUIR will be analyzed at this facility. Hard structures collected by WDFW will be sent to the WDFW age and growth lab in Olympia, Washington.

For CTUIR samples, scales will be mounted on gum cards and pressed in cellulose acetate. Hard structures will be sanded flat and mounted in CrystalBond © medium and sanded or section using a diamond saw. Adult scales will be examined under a stereo microscope at a magnification of 42x and/or 72x. Age designation utilized the European method; a fish returning in 2002 at age 1.2 was spawned in 1998, emerged from the gravel in January-March of 1999, migrated to the ocean in the spring of 2000, returned to freshwater in the spring 2002 and spawned in the late summer of 2002 at total age 4. Juvenile scales, otoliths, rays, and vertebrae will be examined under a compound scope at 100X or greater magnification. Daily, lunar, seasonal, and annual patterns will be discerned. Growth curves will be developed using von Bertalanffy equations (Bertalanffy 1934, Parker and Larkin 1959).

Equation 5-1 $$dl/dt = K(L_{inf} - l)$$

where:
L = length of fish in cm
L_{inf} = the asymptotic length of fish in cm
K = the rate at which length tends toward the asymptote
t =time (age of fish)

3.6 HABITAT AND ENVIRONMENTAL MONITORING

A variety of complementary habitat monitoring activities will be regularly conducted in the Walla Walla Subbasin to capture variance in physical, biological, and chemical conditions. The sampling regime of these activities will vary from continuous monitoring of flow and temperature, to decadal monitoring of riparian conditions. Monitoring will focus on factors that are not primarily controlled by upstream conditions so that measurable improvements can be detected in important elements of salmon habitat. Habitat recovery will be measured in terms of regrowth of the riparian vegetation, vegetation structure and cover. In addition, vegetative recovery is related to improvements in bank stability and channel morphology; therefore geomorphic characteristics will also be monitored. These broader parameters, though not useful for project specific monitoring, are more important when tracking comprehensive subbasin-wide recovery. The spatial coverage of these activities will vary as well. Protocols were developed using a variety of tools, and follow guidelines of the current regional and local protocols (Hankin and Reeves 1988, ODFW 1993, Johnson et al. 2001, Moore et al. 2002). The quantitative goal of the habitat monitoring program is to estimate the total abundance and distribution of essential fish habitat throughout the subbasin for each species every ten years.

3.6.1 In-Stream Features

Randomized sampling routines will be used to determine the order and magnitude of each reach that is surveyed annually. Reaches will be divided into contiguous quadrats based on linear habitat characteristics. In general CTUIR will follow ODFW habitat survey protocols (Moore et al. 2002) modified to include some EDT stream reach attributes, but will not include detailed riparian transects that are typically used to classify riparian canopy conditions. WDFW is also generally using a modified

ODFW sampling protocol (modified to include EDT variables and EDT large woody debris ratings, and a pool quality rating, etc.). The precise nature of stream habitat surveys is still under development due to advances by CSMEP and PNAMP, and the need to incorporate techniques used by USFS, the Watershed Alliance, WWBWC, and others. At a minimum, the following information will be collected for stream reaches surveyed by WDFW and CTUIR.

Valley form information will be recorded during surveys based on a visual estimate of geomorphology and artificial constraints (Moore et al. 2002). Valley width indices will be determined using digital elevation models and GIS software, rather than based on field estimates of valley metrics. Channel type and shade will be determined using ODFW techniques (Morre et al. 2002). The percent substrate composition will be estimated using the following categories;

1. Silt and fine organic matter
2. Sand
3. Gravel (pea to baseball; 2-64 mm)
4. Cobble (baseball to bowling ball; 64-256 mm)
5. Boulders
6. Bedrock

Relative embededness and approximate depth of annual bedscour will be recorded. A longitudinal and cross-sectional survey of conditions will be made to quantify wetted width, wetted depth, bank full width, and bank full (maximum) depth. The in-stream conditions of pools, glides, riffles, rapids, cascades and steps will be assessed using the following attributes.

POOLS

PP **Plunge Pool**: Formed by scour below a complete or nearly complete channel obstruction (logs, boulders, or bedrock). Substrate is highly variable. Frequently, but not always, shorter than the active channel width.

SP **Straight Scour Pool**: Formed by mid-channel scour. Generally with a broad scour hole and symmetrical cross section.

LP **Lateral Scour Pool**: Formed by flow impinging against one stream bank or partial obstruction (logs, rootwads, or bedrock). Asymmetrical cross section. Includes corner pools in meandering lowland or valley bottom streams.

TP **Trench Pool**: Slow flow with U or V-shaped cross section typically flanked by bedrock walls. Often very long and narrow.

DP **Dammed Pool**: Water impounded upstream of channel blockage (debris jams, rock landslides).

BP **Beaver Dam Pool**: Dammed pool formed by beaver activity.

AL **Alcove**: Most protected type of pool. Alcoves are laterally displaced from the general bounds of the active channel. Substrate is typically sand and organic matter. Formed during extreme flow events or by beaver activity; not scoured during typical high flows.

BW **Backwater Pool**: Found along channel margins; created by eddies around obstructions such as boulders, rootwads, or woody debris. Part of active channel at most flows; scoured at high flow. Substrate typically sand, gravel, and cobble.

IP **Isolated Pool**: Pools formed outside the primary wetted channel, but within the active channel. Isolated pools are usually associated with gravel bars and may dry up or be dependent on inter-gravel flow during late summer. Substrate is highly variable. Isolated pool units do not include pools of ponded or perched water found in bedrock depressions.

GLIDES

GL **Glide**: An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0 to 1 percent slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity.

RIFFLES

RI Riffle: Fast, turbulent, shallow flow over submerged or partially submerged substrate. Often with 5 to 15 percent of surface area with white water. Generally broad, uniform cross section. Low gradient; usually 0.5 to 2.0 percent slope.

RP Riffle with Pockets: Same flow and gradient as Riffle but with numerous sub-unit sized pools or pocket water created by scour associated with small boulders, wood, or streambed dunes and ridges.

RAPIDS

RB **Rapid with Protruding Boulders**: Swift, turbulent flow including chutes and some hydraulic jumps. Surface with 15 to 50 percent white water. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Moderate gradient; 2 to 4 percent slope.

RR **Rapid Over Bedrock**: Swift, turbulent, "sheeting" flow over smooth bedrock. Sometimes called chutes. Little or no exposed substrate, 15 to 50 percent white water. Moderate to steep gradient; 2 to 20 percent slope.

CASCADES

CB **Cascade Over Boulders**: Very fast, turbulent flow; many hydraulic jumps, strong chutes and eddies; 30 to 80 percent white water. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or step-pool sequences. High gradient; usually 3.5 to 10 percent slope, sometimes greater.

CR **Cascade Over Bedrock**: Same flow characteristics as Cascade over boulders but structure is derived from sequence of bedrock steps. Slope 3.5 percent or greater.

STEPS

Steps do not fit our general definition of channel units because they usually are much shorter than the channel width. However, they are important, discrete breaks in channel gradient with 10 to >100 percent slope. Steps are classified by the type of structure forming the step.

SR **Step over Bedrock (include hardpan and clay steps**

SB **Step over Boulders**

SC **Step over face of Cobble bar**

SL **Step over Logs(s), branches**

SS **Step created by Structure (culvert, weir, dam, beaver dam)**

SPECIAL CASES

DU **Dry Unit**: Dry section of stream separating wetted channel units. Typical examples are riffles with subsurface flow or portions of side channels separated by large isolated pools. Record the length, active channel width, and other variables for the dry areas.

PD **Puddled**: Nearly dry channel but with sequence of small isolated pools less than one channel width in length or width.

DC **Dry Channel**: Section of the main channel or side channel that is completely dry at time of survey. Record all unit data, use active channel width for width.

CC **Culvert Crossing**: Stream flowing through a culvert. The height from the culvert lip to the stream surface (drop), diameter, and shape of culvert will be recorded.

LARGE WOODY DEBRIS

Class 1 Woody debris absent or in very low abundance. No habitat complexity or cover created.

Class 2 Wood present, but contributes little to habitat complexity. Mostly small, single pieces, creating little cover or complex flow patterns. Ineffective at moderate to high discharge.

Class 3 Wood was present as combinations of single pieces and small accumulations. Providing cover and some complex habitat at low to moderate discharge, less effective at high discharge

Class 4 Wood present with medium and large pieces comprising accumulations and debris jams that incorporate smaller rootwads and branches. Good hiding cover for fish. Woody debris providing cover and complex habitat that persists over most stream discharge levels.

Class 5 Wood present as large single pieces, accumulations, and jams that trap large amounts of additional material and create a variety of cover and refuge habitats. Woody debris providing excellent persistent and complex habitat. Complex flow patterns will exist at all discharge levels.

3.6.2 Riparian Condition

Riparian conditions are excellent indicators of land use, and help describe the interface of water and watershed. For each in-stream contiguous quadrant we will estimate the primary, secondary, and tertiary structural components. Percent canopy cover will be visually estimated. Riparian and adjacent land use conditions will be categorized using the following attributes.

RIPARIAN VEGETATION

N No vegetation (bare soil, rock)

B Sagebrush (sagebrush, greasewood, rabbit brush, etc.)

G Annual grasses and herbs

P Perennial grasses, forbs, sedges and rushes

S Shrubs (willow, salmonberry, some alder)

D Deciduous dominated (canopy more than 70 percent alder, cottonwood, big leaf maple, or other deciduous species)

M Mixed conifer/deciduous (approximately a 50:50 distribution)

BANK STABALIZATION

NE **Non-Erodible**. Stable bedrock, hardpan, or boulder-lined bank

BC **Boulder Cobble**. Stable matrix dominated by boulders and cobble combined with soil, vegetation, and large roots.

VS **Vegetated-Stabilized**. Vegetated and/or overhanging bank, partly or wholly stabilized by root systems. Some exposed soils may be present, but with no evidence of recent bank failure.

AE **Actively Eroding**. Actively or recently eroding or collapsing banks. Exposed soils and inorganic material. Superficial vegetation may be present, but it does not contribute to bank stability.

3.6.3 Land Use Condition

AG **Agricultural crop land**

TH **Timber Harvest**. Active timber management including tree felling, logging, etc. Not yet replanted.

YT **Young forest Trees**. Can range from recently planted harvest units to stands with trees up to 15 cm dbh.

ST **Second growth Timber**. Trees 15-30 cm dbh in generally dense, rapidly growing, uniform stands.

LT **Large Timber** (30-90 cm dbh)

MT **Mature Timber** (50-90 cm dbh)

OG **Old Growth Forest**. Many trees with 90+ cm dbh and plant community with old growth characteristics.

PT **Partial cut Timber**. Selection cut or shelterwood cut with partial removal of large trees. Combination of stumps and standing timber. If only a few live trees or snags in the unit, describe in notes.

FF **Forest Fire**. Evidence of recent charring and tree mortality.

BK **Bug Kill**. Eastside forests with >60 percent mortality from pests and diseases. Enter bug kill as a comment in the notes when it is observed in small patches.

LG **Light Grazing Pressure**. Grasses, forbs and shrubs present, banks not broken down, animal presence obvious only at limited points such as water crossings. Cow pies evident.

HG **Heavy Grazing Pressure**. Broken banks, well established cow paths. Primarily bare earth or early successional stages of grasses and forbs present.

UR **Urban**

RR **Rural Residential**

IN **Industrial**

MI **Mining**

3.6.4 Biological Conditions

Biological habitat conditions will be sampled by CTUIR during juvenile fish and habitat surveys, and on a regular basis by WWBWC. The examination of aquatic macroinvertebrate communities is an important aspect of monitoring and evaluation programs because these communities are an integral component of aquatic and riparian ecosystems, and they can be used as an index of potential stream reach quality for salmonids and other cold-water fishes. One of the most important ecosystem functions of macroinvertebrates is the role they play in aquatic and riparian food webs. Macroinvertebrates are the main conduit of energy between basal resources (primary production and detritus) and fish (Allan 1995), and they are an important energy subsidy to surrounding riparian areas (Nakano and Murakami 2001).

The use of macroinvertebrate communities as an index of stream quality has a long history (Cairns and Pratt 1993), and indices of community structure exist that allow assessments of the types and degrees of various disturbances (Resh and Jackson 1993). Most species are affected by conditions at fairly small scales (e.g., a stream reach) because many species have small home range sizes (Platts et al. 1983). Thus, communities are likely to be influenced by local environmental conditions within a specific stream reach. This feature makes macroinvertebrates ideal for assessing the impact of restoration projects at the reach and watershed scales (Laasonen et al. 1998, Weigel et al. 2000).

Many species of aquatic invertebrates live for about one year (Wallace and Anderson 1996). This lifespan is long enough that individuals and populations integrate inherent variability in water quality that occurs on a daily and seasonal cycle. This is in contrast to many chemical and physical measures that are only snapshots of immediate conditions. However, this lifespan is short enough that impacts of environmental conditions on populations can be determined in just several years.

Quantitative samples of macroinvertebrate communities will be made at EMAP reaches following the standard USDA Forest Service methods (Platts et al. 1983). Invertebrates will be sampled at 5 points within each study reach using a Surber sampler, a device with a sampling quadrat of known size. Only riffle areas will be sampled for several reasons. Sampling riffles minimizes between-sample and between-site variability that results from habitat type and not habitat quality. In addition, riffles are known for their high invertebrate productivity (Allan 1995) and many of the invertebrates useful in biomonitoring are found primarily in riffles (Hilsenhoff 1987).

Four indices will be used to assess stream reach quality. Each of these metrics has potential biases, which can influence assessments based on only one metric. By measuring multiple indices, these biases can be at least partially taken into account (Karr and Chu 1999). The four metrics are: Simpson's Diversity Index, the number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, the number of disturbance-tolerant taxa, and the Hilsenhoff Biotic Index (HBI). Diversity is predicted to increase with decreasing human disturbance (Karr and Chu 1999). EPT taxa are sensitive to many anthropogenic disturbances and are most abundant in cold, clean-water reaches with little sediment (i.e., conditions good for salmonids) (Karr and Chu 1999). Their numbers are expected to decline with increasing human disturbance (Karr and Chu 1999). In contrast, the number of disturbance-tolerant taxa is expected to increase with increasing human disturbance. The HBI measures the dominance of taxa known to be insensitive to organic pollution (Hilsenhoff 1987).

3.6.5 Bed Scour

Bed scour was identified as an important limiting factor for Walla Walla Subbasin steelhead and spring Chinook. Currently there are no projects or programs that focus on the in-situ measurement of bedscour. The actual condition and importance of this stream attribute are extremely difficult to predict without field studies. Annual rates of bedscour will be monitored in pools, glides, riffles, cascades, and steps of low, medium, and high gradient reaches. One hundred bedscour chains will be placed around the subbasin during low flow conditions. Chains will be recovered after spring high flows, and the amount of scour or deposition will be estimated. Associative analysis will be used to relate reach conditions (gradient, sediment composition, etc.) to bedscour rates. This information will be used to repopulate EDT, and to evaluate habitat conditions and any apparent need for management actions.

3.6.6 Instream Flow

Instream flow is monitored continuously by BOR, NOAA, and USGS. These federal agencies are responsible for data management, data archiving, flow predictions, and flow analysis. The following web-sites describe flow monitoring programs in the Walla Walla Subbasin.

http://ahps.wrh.noaa.gov/cgi-bin/ahps.cgi?pdt&tchw1 (NOAA flow predictions and real time data)
http://waterdata.usgs.gov/or/nwis/uv?site_no=14020300 (Real time data for Meacham with archive data)
http://water.usgs.gov/waterwatch/ (Over view map of real time data for USGS)
http://waterdata.usgs.gov/or/nwis/current/?type=flow (Real time data index for Oregon)

In addition, flow is monitored using hand-held instruments be WDFW, CTUIR, WWBWC, WDOE, and OWRD. The locations of these monitoring activities were mapped in 2002 and have not been updated (Figure 10). It is believe that they subbasin is adequately covered by these entities. A gap analysis will be conducted in 2005 to coordinate spot measurements of stream flow.

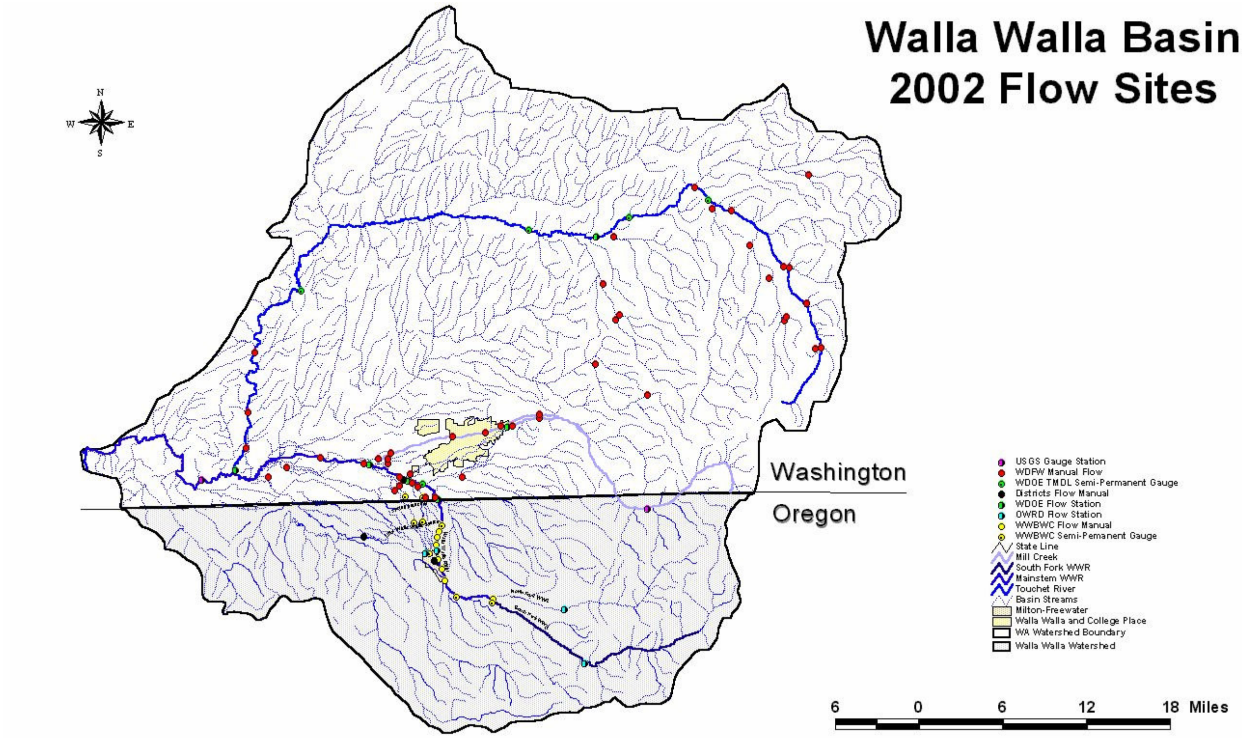

Figure 10 Locations of Flow Monitoring in the Walla Walla Subbasin.

3.6.7 Water Quality and Chemical Conditions

The Walla Walla River and its tributaries have been monitored for many years by natural resource agencies, tribes and local groups. The upper watershed is managed by the US Forest Service, where the greatest volume of stream water originates as groundwater or precipitation. Forest Service monitoring supports strategies for land management and drinking source-water protection. The Oregon Department of Environmental Quality and the Washington Department of Ecology are responsible for Subbasin-wide monitoring to evaluate whether water quality is sufficient to ensure that beneficial uses of public waters are fully supported. State and Federal fish and wildlife departments monitor stream habitat in the Basin. The Natural Resource Department of the Confederated Tribes of the Umatilla Indian Reservation is monitoring habitat and water quality in the subbasin as well. The Walla Walla Basin Watershed Council monitors water quality, flow and is evaluating groundwater and stream interaction.

Concerns have been identified for elevated temperature, fecal mammalian and/or avian bacteria, chlorinated pesticides, polychlorinated biphenyl compounds and pH. Ongoing temperature monitoring is being conducted by Tribes, WWBWC, WDFW, ODFW, WDOE and supported by ODEQ. Ongoing monitoring for the other constituents is still in the planning phase, and will likely be carried out as a collaborative inter-organizational effort. In general these monitoring activities are well coordinated, in great part due to the efforts of the WWBWC. Figure 11 shows the location of most water quality sampling efforts in the subbasin.

2002-2003 Walla Walla Subbasin Water Monitoring

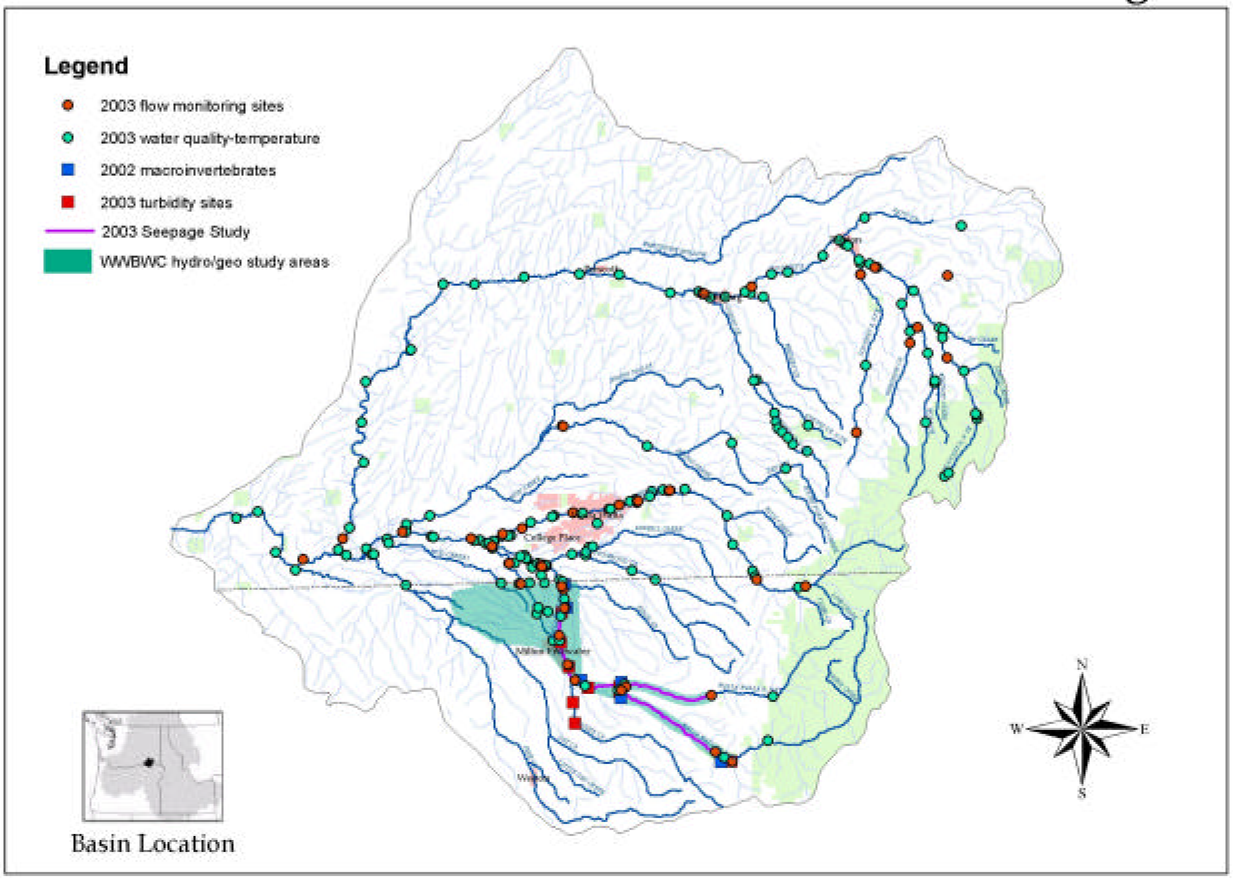

Figure 11 Location of Several Water Quality and Flow Monitoring Stations in the Walla Walla Subbasin in 2003

The WWBWC currently has more than 110 monitoring wells and flow-water-quality stations. The well network and flow stations are being used for numerous ongoing WWBWC projects including: a surface-groundwater interaction study, a field-verified water budget, a surface flow model for the Walla Walla River, and tracking water movement from the Hudson Bay Aquifer Recharge project. At gauge stations: flow, water quality (temperature, turbidity, conductivity, etc.) may be collected, depending on location. At wells sites: static level, temperature and conductivity are measured. At Little Walla Walla Spring-Creeks sites: flow, temperature and conductivity are measured. Springs were originally surveyed in 1933 by USGS (Piper). The WWBWC resurveyed the springs in 2003 and continues to monitor conditions.

The Hudson Bay Aquifer Recharge project was designed to test aquifer recharge as a tool to help stabilize and restore declining aquifer levels and spring flows in the Walla Walla River valley. This project has been developed as a collaborative effort between the Walla Walla Basin Watershed Council (WWBWC) and Hudson Bay District Improvement Company (HBDIC). Funding and technical support has been provided by the Oregon Watershed Enhancement Board (OWEB), Walla Walla Watershed Alliance (NRCS funds), Oregon Water Resources Department (OWRD), Oregon Department of Environmental Quality (ODEQ), HBDIC and the WWBWC. This report was generated in accordance to the outlined a HBDIC Recharge Project monitoring plan application to OWRD.

The Hudson Bay Aquifer Recharge Project was operated from April 8th until May 15th, 2004 under a Limited License Request (#758) from Oregon Water Resources Department. The conditions and limitation of the permit included: "The use of water from the Walla Walla River shall be limited to 50 cfs for the purpose of testing artificial ground water recharge during a testing season of November 1 through May 15. Water may only be diverted when there is adequate flow in the Walla Walla River to honor all existing water rights. When water is diverted under this limited license, the use if further limited to itmes when there is, at a minimum, the following stream flows in the Tum a lum reach of the Walla Walla River, between the Little Walla Walla River diversion and Nursery Bridge Dam and flowing past Nursery Bridge Dam: November – 64 cfs, December and January – 95 cfs, February to May 15 – 150 cfs."

3.6.8 Derived Habitat Metrics

A number of habitat metrics, including land use, total solar radiation, total chlorophyll and thermal irradiation will be derived from remotely sensed data. These watershed-scale metrics will be analyzed for their watershed-scale variability to develop associations between total land-use and waterscape use conditions and in-stream biological performance of managed species and their cohabitants. This analysis will be conducted cooperatively using GIS technologies as part of ongoing analysis and evaluation. Detailed methods for the derivation of remotely sensed data will be developed on an as needed basis.

3.6.9 Habitat and Environmental Analysis

The quantitative goals for habitat assessment and monitoring require ongoing monitoring subbasin wide. Therefore no power analysis is necessary. In-stream and riparian habitat features will be surveyed for every reach of stream every ten years, and annually where specific habitat restoration actions are implemented. Flow and temperature monitoring will be continuous. If funds are available, every five years CTUIR will work with the co-management entities and MBI to develop a revised ecosystem based model, and will estimate salmon survival rates in the Walla Walla Subbasin as a function of habitat condition (Cuenco and McCullough 1996). Habitat information will be used in combination with spawner and juvenile population information in trend, associative and geostatistical analyses as described below.

3.7 ECOLOGICAL MONITORING

3.7.1 Community Structure and Trophic Monitoring

Fish community information will be collected during juvenile fish surveys, and will be monitored throughout the subbasin using rotary, baited, and passive fish traps. Trapping effort will be distributed parallel to the juvenile fish survey site selection process. Additional fish community information will be derived from creel surveys of hook-and-line catch.

Predator, competitor, and prey relationships will be derived using stable isotope values, previously published research, and ecological inference (Gatz 1979). Stable isotopes will be used to validate estimates of fractional trophic levels, to monitor for trophic shifts associated with supplementation, community composition, and demographic variability, and to model bioaccumulation rates for persistent toxins. Stable isotope samples will be collected during juvenile fish surveys, outmigrant monitoring, and salvage efforts. Fish and macroinvertebrate tissue samples will be collected. Samples will be processed by Oregon State University, the University of Washington, Washington State University, or Northern Arizona University to determine the relative amounts of nitrogen and carbon, and the ratios of isotopic and non-isotopic atoms of nitrogen and carbon. This value, expressed as δX (where X is the element name), represents the difference between the sample isotopic percentage and a standard. For carbon δC is calculated as:

Equation 7-1 $$\delta^{13}C_{sample} = [(^{13}C/^{12}C \text{ sample}) / (^{13}C/^{12}C \text{ standard}) - 1] \times 1000$$

Within each watershed the isotopic signature of each fish specimen will be estimated as a relative deviation from the average herbivore and detritivore (snail and crayfish) signatures. Trophic shifts of hatchery and naturally reared salmonids will be determined using associative analysis based on the differences among watersheds of the relative deviation from the average herbivore and detritivore isotopic signatures. Size corrected fractional trophic levels will be estimated based on a simple correlation between isotopic value and inferred fractional trophic level (Equation 7-1). Relationships between toxin accumulation and stable isotope signature will be evaluated using associative, time series, and geostatistical analysis.

Dietary components will be calculated as simple dietary fractions for each 10mm cohort of juveniles, and 5cm cohort of resident fish. Fractional trophic levels will be derived from the dietary fractions, and standardized using stable isotope analysis, based on Mathews (1993), as:

Equation 7-2 $$\text{Trophic level} = 1 + \text{mean trophic level of the food items}$$

Bioenergetics models have been drafted for several Columbia Subbasin fishes (Hanson et al. 1997). We will refine bioenergetics models for spring Chinook salmon, bull trout, and steelhead based on observed age and growth data, locally adapted trophic relationships, and environmental correlates using perturbation protocols (Bartell et al. 1986, Stockwell and Johnson 1997). These local models will describe the consumption of prey by predators generally as:

Equation 7-3 $$Consumption = \mathrm{Re}\,spiration + Waste + Growth$$

The models will include a number of thermodynamic modifiers that can be applied to each 10mm cohort for juvenile salmonids, and 5cm cohort for resident fishes. The bioenergetics models will be used to produce absolute estimates of energy flow within and through each juvenile and spawner population. These interactions will be used to estimate the strength of community-wide interactions between fishes, their predators, and their prey (e.g., Rodriguez and Magnan 1995, Sala and Graham 2002).

Community and trophic metrics for each watershed will be analyzed structurally to monitor changes in the flow of resources to target and non-target species. Fish diversity, food web structure, connectivity, food web lengths, link densities, omnivory rates, cannibalism, and predator prey ratios will be evaluated. Undesirable structural changes in fish communities or their food webs will be described quantitatively and qualitatively as part of this seven-year study to understand the ecological conditions of Walla Walla River ecosystems.

3.7.2 Ecosystem Monitoring

The subbasin planning process has made imminently clear the benefits of an ecosystem perspective in on and off-site mitigation of Columbia Basin fish production. MBI's EDT model has been used with considerable success to describe ecological conditions where data is available. EDT provides a general estimate of carrying capacity, and presents a hypothetical increase in production associated with habitat, passage, and flow restoration.

Unfortunately EDT falls short of addressing three pit-falls that have been clearly pointed out by ecosystem modelers. First, EDT fails to address variability in individual behavior, growth, and physiology. This variance can contribute significantly to salmonid production and productivity (Kooijman et al. 1989, Werner 1992, Werner and Anholt 1993), and is relatively easy to address mathematically. Second, EDT is associative at several critical scales. Numerous subbasins have noted a need to "tune" EDT to regional stream and climatic conditions. This inaccuracy of the model stems from its lack of mechanistic detail that is essential to models with portable applicability (DeAngelis 1988). Last, EDT does not incorporate the density-dependent consequences a of age-structured or spatially-structured life history variability. This variance represents a critical compensatory response of most fish populations (McCauly et al. 1993, Walters et al. 1999), and should be mathematically represented in aquatic ecosystem models approaching carrying capacity (Christensen and Pauly 1998).

If funds are available, CTUIR will work with the co-management entities, MBI, and CBR to develop an individual-based version of EDT that is more portable to the diversity of ecosystems that is represented within and among Columbia River subbasins such as the Walla Walla. We will build upon EDT's "biological rules" using data derived from the WWBNPMEP comprehensive monitoring program, and parallel programs around the Columbia Subbasin. The revised EDT model will be developed from EDT core algorithms, and less proprietary models such as SURPH, CRiSP, Vitality, and egg-growth models (www.cbr.washington.edu). This product will be more mechanistic and explanatory, and less associative and empirical, in part because it will represent a combination of bottom-up and top down developmental forces. It will consist of a single software package in which every aspect of survival, production, productivity, emigration, and immigration can be evaluated and assessed under future conditions. The basic form of the model will be based on ECOPATH and ECOSIM (Larkin 1996, Pauly 1998, Pitcher et al. 1999)

Equation 7-4

$$\Pr oduction =$$
$$harvest + predation\_mortality + biomass\_accumulation + migration + other\_natural\_mortality$$

or the delay-difference version:

Equation 7-5

$$dB_i/dt = g_i \sum_j C_{ji} - \sum_j Cij + I_i - (M_i + F_i + e_i)B_i$$

Where the biomass (B) of pool i, equals the net growth efficiency (g), biomass immigration (I), non-predation mortality/metabolic rate (M), harvest mortality (F), and emigration (e) adjusting the biomass over time (C) for each species ji and ij interaction (Walters et al. 1999). That equation can be further expanded to represent life stages, and would need to be for salmonids.

The Walla Walla Ecosystem Model will produce estimates of the community, aggregate, and ecosystem metrics that describe ecological function. These include:

1. Single Species Metrics a. Abundance b. Distribution c. Habitat d. Growth Rates e. Length-Frequency Relationship f. Fecundity and Productivity g. Population Trajectories h. Genetics i. Harvest **2. Community Metrics** a. Diversity b. Multi-Species Interaction Rates c. Competitive Interaction Rates d. Natural Mortality	**3. Food Web Metrics** a. Food Web Structure b. Connectivity c. Food Chain Length d. Link Density e. Omnivory and Cannibalism f. Predator/Prey Ratios **4. Aggregate Metrics** a. Flux b. Ascendancy c. Capacity d. Efficiency e. Guild Composition f. Guild Production	**5. Systems Analysis Metrics** a. Exergy b. Emergy c. Ecosystem Production d. Ecosystem Mass e. Resilience f. Persistence g. Resistance h. Stability i. Free Energy j. Information Content

The single species and community metrics have all been discussed above. For discussions on Odum's Emergy, and the network metrics 3a through 5j see Christensen and Pauly (1992) and Christensen (1994). Food web structure (3a) refers to a graphical representation of the trophic network derived from equations 7-3 and 7-4. Connectivity (3b) is the number of linkages divided by the total number of possible links in the web. Food chain length (3c) is the number of discrete steps between primary production and terminal consumption for each complete chain. Link density (3d) is the average number of links per species. Metrics 3e and 3f refer to the direct estimate from equation 7-4 of the fraction of the community (in numbers and biomass) that is either an omnivore, predator, or prey species.

Flux (4a) is the quantity of biomass or energy that moves from one food web compartment to another in a given time period. Ascendancy (4b) is throughput times the information content of the food web flow. Capacity (4c) is the total capacity (in mass or joules) of each geographic area to support productivity. Efficiency (4d) is the ratio of the useful energy delivered by a dynamic compartment of the system to the energy supplied to it. Guild composition (4e) is the fraction of the community represented by each "Odum" guild (Odum 1957), and the guild production (4f) is the amount of mass or energy produced by each guild.

Exergy (5a) is the quality of the available free energy (5i), and thereby relates directly to the efficiency of the system. Emergy (5b) is the total throughput of the system, and relates directly to the production (5c) and mass (5d) of the ecosystem. Resilience, persistence, resistance, and stability (5e-h) are all measures of the state of the system through time that have particular and detailed importance. For a mathematical discussion of these sometimes controversial terms and their potential implications to fisheries management see Pimm 1980, Pimm and Lawton 1980, Pimm 1982, and Pimm and Hyman 1987.

Collectively these aggregate and system analysis metrics represent a step beyond traditional single species analysis towards NOAA's goal of "maintaining proper ecosystem function rather than on managing for specific habitat criteria. This focus requires a thorough understanding of the linkages between biological and physical processes within and across scales" (NOAA 2003, pg. 129). Ecosystem function has been poorly defined in the salmon recovery planning process, and requires sophisticated analysis. Whereas traditional monitoring represents the speedometer or tachometer of the management vehicle, these more sensitive metrics represent the diagnostic computer of engine performance. In an increasingly complex management scheme they are an essential component of sensitive and adaptive ecosystem management.

3.8 GENETIC SAMPLING

A number of RM&E objectives require genetic samples. Specifically, sections 2.7.2, 2.7.6, and 2.8.11 references critical uncertainties associated with salmonid genetics. Bull genetic sampling has been conducted during the past several years in much of the Walla Walla Basin. The intent of genetic sampling has been to characterize steelhead and bull trout populations by drainage (including comparison with populations outside the Walla Walla) and to evaluate the genetic interaction among the drainages.

WDFW's specific intent in genetic sampling is to genetically compare migratory adult bull trout captured in the Walla Walla River (in Oregon) with adult bull trout captured by ODFW and USFS in upper Mill Creek (City of Walla Walla intake dam) and by WDFW at the Dayton Dam on the Touchet River. This would allow a comparison of the migratory bull trout from the three major drainages in the Walla Walla Basin. WDFW has collected samples from juveniles in the tributaries of the Touchet River to try and determine if they are genetically similar or to try and determine whether they are reproductively isolated in the three major spawning areas in the upper Touchet (in the North Fork, South Fork/Burnt Fork, Wolf Fork). The USFS and ODFW also collected genetic samples from juveniles in the SF Walla Walla, upper Mill Creek and the North Fork Touchet in 1995 as part of a broader genetic study in the Columbia Basin. This study was previously published. They have recently collected genetic samples from Low Creek to examine the genetic characteristics of an apparently resident bull trout population and compare it with migratory bull trout captured at the Mill Creek Intake Dam. The USFWS and Utah State have also collected bull trout genetic samples recently in the SF and mainstem Walla Walla in Oregon.

The USGS/Utah State University bull trout project seeks to evaluate the across and within-stream (core area) genetic structure of bull trout and to evaluate potential genetic differences between residential and migratory life history forms in the South Fork Walla Walla (SFWWR) and North Fork Umatilla (NFUMAT) Rivers of NE Oregon. The project is analyzing mitochondrial DNA and 30 microsatellite loci developed for bull trout, along with four other general microsatellite loci that have been used in other bull trout genetics studies (Spruell et al. 2001). Previously, demographic and abundance data were collected in the SFWWR (from 2002-2004) and NFUMAT (2003-2004) which included tagging bull trout (> 120 mm) with 23mm PIT tags and external T-Bar anchor tags (Floy tags), and removing a 4mm-25mm2 anal fin clip from ~850 fish (preserved in 95% ETOH). In 2004, an additional 71 bull trout genetic samples (from untagged fish) were obtained from two main tributaries (Skiphorton Creek, and Reser Creek) to the SFWWR. The project will evaluate population structure within and across these streams based on gentic analysis of a subsample of our total collection of fin clips.

In addition, the USGS project is working to analyze samples for potential genetic differences in life history forms. In 2003, two passive PIT antennae arrays were constructed on the SFWWR, and in 2004 one array was constructed on the NFUMAT. These arrays detect the movement of tagged fish and will provide the data to determine which of our bull trout are migratory for genetic analysis and comparison. Tributary samples may reflect the residential life history form, but will be evaluated as an indeterminate mixed group based on an absence of movement data which would more concretely define their life history strategy. While it is not possible to have a known resident group, we have established a likely resident group based on tagged fish < 220mm that have not put-migrated over the time period of our study. After genetic analysis, all samples will be evaluated indepent of life history information and then cross referenced with their assumed life history strategies, to assess whether genetic variation reflects a difference in life history form.

These samples will be useful in developing estimates of gene flow among the bull trout populations in the Columbia Plateau. Steelhead samples will be collected to satisfy long-term monitoring requirements discussed in 2.8.11. Spring Chinook samples will be archived from a sub-sample of the outplanting broodstock held at the south fork Walla Walla fish facility. Spring Chinook genetic sampling will be expanded as needed as part of the hatchery master planning process. Sampling requirements for 2.7.6 will be developed in 2005 as part of the Washington State Salmon Recovery and BPA Provincial Review planning processes.

3.9 HATCHERY MONITORING

The WDFW Snake River Lab has been monitoring the Lyons Ferry Complex hatchery program since 1982 under funding from the Lower Snake River Compensation Plan (LSRCP). Evaluations within the hatchery have centered on broodstock collection, spawning techniques, size of smolts and time of release in relation to overall survival and being able to meet the goals of the LSRCP. As far as hatchery production in the Walla Walla Basin from WDFW's Lyons Ferry Hatchery, only summer steelhead (Lyons Ferry and Touchet Endemic stock summer steelhead) are described below. Techniques for Walla Walla spring Chinook outplant monitoring are similar except where otherwise noted. Additional hatchery RM&E protocols are being developed as part of the hatchery master plan. Techniques for endemic brood steelhead hatchery production monitoring will be developed further if and when the endemic brood program is adopted as a production program.

3.9.1 Holding

Lyons Ferry stock summer steelhead are trapped on-site. Touchet Endemic stock summer steelhead are trapped and hauled from the Dayton adult trap. All steelhead broodstock are held in three adult steelhead holding raceways. The holding raceways are 10'(w) x 80'(l) x 6'(d). A permanent building covers 1/3 of the adult raceways. Sorting and spawning of the broodstock occurs within the building. For the Lyons Ferry stock, an excess number of fish are trapped and held (CWT sample, IHNV contingency) than what is required to meet egg-take needs. Pre-spawning mortality ranges from 10-20% on an annual basis. Because of the excess fish, formalin treatment to control fungus in the broodstock is not required. For the Touchet Endemic stock, formalin treatments (1:600 ppm) are started immediately once fish have been taken to the hatchery for holding. Both hatchery and evaluation staff monitor the holding of broodstock. All dead fish in the pond are removed daily and enumerated as losses on standard WDFW hatchery records. Lyons Ferry stock fish are sampled for sex, length, fin clips, and presence of CWT (snout removed and bagged with ID tag). Touchet Endemic stock fish are removed from the pond and frozen. At a later date, these are sampled for sex, length, scales, and possible DNA collection by the evaluation staff.

Walla Walla spring Chinook holding monitoring is similar. Fish are collected from Three Mile Falls Dam and trucked to the South Fork Fish Facility. Fish are treated as necessary to control fungus, BKD, and other diseases. Fish are monitored continuously by on-site staff. Outplants are marked using an opercal punch prior to release in the Walla Walla and Mill Creek rivers.

3.9.2 Spawning

All males and females that have been kept for broodstock will be examined weekly during the spawning season to determine ripeness. For the Lyons Ferry stock, fish will be selected at random during the spawning process. The first 20 ripe females (Lyons Ferry stock only) selected for the day will comprise the egg collection for that week. The same will be true for the first 60 ripe males (if possible). For the Touchet Endemic stock, any ripe fish on the spawn day will be taken. For both stocks, all females are individually sampled for the presence of IHN virus. Samples are sent to WDFW virology lab for culturing that day, with results usually taking from 2-3 weeks. Each female lot is incubated separately. Eggs from individual females with positive results for the virus will be discarded (both stocks). In addition, eggs from any females that visually appear over-ripe (water hardened) will be immediately discarded and not incubated.

For the Lyons Ferry stock, mating crosses will occur in a 1x2 matrix (1 female to 2 males) to ensure the highest likelihood of fertilization, increase genetic diversity, and to increase the effective population size of the program. For the Touchet Endemic stock, attempts will be made to use two different males with each spawned female. However current broodstock size and extended spawn times of the endemic stock do not generally favor the 1x2 matrix cross. After fertilization, eggs are rinsed in a buffered iodine solution (100 ppm) to control viral and bacterial disease, and to remove unwanted organics from the fertilized eggs. They are then water hardened for one hour in the same solution. The volume of iodine solution to eggs should be at least 3:1.

3.9.3 Egg Take Enumeration

At Lyons Ferry hatchery, each summer steelhead egg take is initially enumerated by multiplying the number of females spawned by the average fecundity documented for each stock from past spawning. At the eye-up stage, each of the female egg lots are shocked and picked for loss. At this time, all dead eggs removed from the incubation basket by hand counting and recording the loss by each female. The total number of live eggs are then estimated by weight sampling. 100 live eggs (L_{w1}) are counted and weighed out to the nearest 0.1g. The entire live egg lot (L_{w2}) is then weighed to the nearest 0.1g. The number of live eggs are calculated from the formula (Lw2/Lw1*100), with this number adjusted down by 6% to account for water retention among the eggs during the weighing process. The total dead eggs counted and the estimated live eggs are then added to provide fecundity for each female. Egg take totals are obtained by adding the estimated fecundity of all females together. Spring Chinook egg production is monitored for pre-release mortalities only.

3.9.4 Growth and Production Monitoring

Lyons Ferry hatchery personnel track growth and production of each raceway/pond of each stock through bi-monthly sampling (weight samples) and mortality removals. Based on this sampling schedule, feeding frequency, diets, and percent body weight to feed each group/raceway can be adjusted accordingly to produce fish that meet program requirement at release. Fry/fingerling summer steelhead will be fed an appropriate commercial dry or moist steelhead/salmon diet. Fry feeding starts at ~8 times daily and is reduced as the fish increase in size. Range of feeding varies between 0.5 to 2.8% B.W./day. Feed conversion is expected to fall in a range of 1.1:1 (dry feed)– 1.4:1 (moist feed) pounds fed to pounds produced. A WDFW fish health specialist monitors fish health as least monthly. More frequent care is provided as needed if disease is noted. Treatment for disease is provided by Hatchery Specialists under the direction of the Fish Health Specialist. Program goal for the Lyons Ferry stock program for the Touchet (Dayton Acclimation Pond) and Walla Walla rivers release will be to release fish between near mid-April at 4.5 fish/lb.

3.9.5 Marking

State managers have endorsed mass-marking as an important tool for the management of both hatchery and listed natural populations. For the Lyons Ferry stock summer steelhead (harvest mitigation program), 100% of the production is marked with an adipose fin clip so they can be identified in the fishery as harvestable fish. For the Touchet Endemic stock summer steelhead, currently no fish are marked for harvest, so adipose and other fins are unclipped. However, for external identification, each smolt receives a Visual Implant Tag (elastomer) behind the eye, and 100% of the endemic group is CWT for the chance recovery with the lower Columbia River net fisheries.

WDFW monitors the returns of spring and fall chinook and summer steelhead throughout southeast Washington through adult trapping (Tucannon River, LFH, LGR, Touchet River, Cottonwood Creek), and spawning ground and creel surveys (sport harvest and CWT expansions can be used to estimate the number that would have returned to the project area); all of which provide CWT recoveries of marked fish for evaluation purposes. Trapped and/or spawned broodstock fish and carcasses provide data concerning origin, stray rates, sex ratios, age composition, and mean fecundity of each year's run. Spawning surveys provide numbers of redds, spawn timing, and distribution of fish in each of the rivers WDFW surveys. Precocial hatchery male spring chinook have been documented spawning in large numbers in other river basins. We believe that the incidence of precocial hatchery spawners is low in the Tucannon River but currently lack observational data. Snorkel surveys of spawning adults will allow us to determine the incidence and origin of precocial male spawning.

Straying of hatchery-reared fish has been identified as a potentially critical impact on ESA listed populations of salmon and steelhead in the Columbia Basin. Adult trapping and broodstock collection activities gather substantial data annually on stray fish entering southeast Washington streams and facilities. WDFW proposes summarizing and assessing stray information for all species using our sampling methods.

Coded-Wire Tag Data: The CWT data for analysis are gathered from two sources. First, the Regional Mark Information System (RMIS) Database maintained by the Pacific States Marine Fisheries Commission (PSMFC) for all WDFW Wallowa stock CWT's released from Cottonwood AP. Second, additional CWT recoveries from Lyons Ferry Hatchery, Cottonwood Creek Adult Trap, and fisheries in the Snake River Basin from WDFW prior to 1995 were obtained from WDFW LSRCP annual steelhead reports (Schuck et al 1986-1995). More recent CWT data from Snake River Basin fisheries (2000 to present) and Cottonwood or Lyons Ferry Hatchery have been compiled and expanded but have not been reported to RMIS at this time.

Freeze Brand Data: At Lower Granite Dam (LGD), NOAA Fisheries personnel operate the adult trapping facility to monitor the migration and passage of salmon and steelhead throughout the year (Jerry Harmon, NOAA Fisheries pers. comm. 2003). When the trap is being operated, fish containing CWT's or magnetized wire are diverted to a holding area where the fish are sampled. Tagged adult steelhead entering the LGD trap are sampled for fin clips and freeze brands, then released. Freeze brand readings have been provided to WDFW by NOAA Fisheries annually. Returns of freeze branded fish to LGD have been used to estimate return rates of WDFW steelhead release groups to the Snake River. Freeze brand observations provided by NOAA Fisheries for the release groups have been reported in WDFW LSRCP annual steelhead reports (Schuck et al. 1986-1998, Martin et al. 2000, Bumgarner et al. 2002, Bumgarner et al. 2003). For this analysis, we adjusted the freeze brand observations down by 5% to account for fall back and re-ascending rate at LGD based on radio tagging studies conducted by the University of Idaho (Keefer et al. 2002, Bjornn et al. 2003).

The number of freeze brands observed at LGD has always been greater than the number of fish we estimate were harvested in from fisheries above LGD and returns to Cottonwood Creek combined. The differences are likely caused by the inadequate adult trap capabilities at Cottonwood Creek, and poor fishery recovery rates above LGD in some years. As such, the numbers of freeze branded fish observed at LGD are likely a more accurate representation of returns of Cottonwood AP fish to the area above LGD.

To examine timing and location of recovery within the Deschutes River, the RMIS database will be queried for all fish by date. This data will be imported into an Excel spreadsheet or Access database for timing and location data extraction. All extracted CWT recoveries from RMIS, and CWT recoveries and freeze brand data from LSRCP annual reports will be included as well in an additional Excel spreadsheet.

Stray rates will be defined in two ways, 1) within the Snake River Basin, and 2) within each the release group.

1. Of the total stray fish estimated in the Snake River Basin what percent of those fish are from the Cottonwood AP releases? This analysis will be based solely on CWT recoveries reported in the RMIS database. Coded-wire tag recoveries will be grouped by run year and then fully expanded to include all possible fish from the release group based on the CWT mark rate documented at release.

2. Of the total fish recovered in and above the Snake River dams, what percent of those were recovered in the Tucannon, Grande Rhonde, or Snake River mainstem? To calculate the percent stray rate, we will use two different data sets. The first analysis will be based solely on CWT recoveries in the Columbia and Snake rivers and their tributaries. The second analysis will be based on CWT recoveries and freeze brand recoveries at LGD.

3.9.6 Release Monitoring

Pre-liberation samples (collected from Dayton Acclimation Pond, or rearing vessels at LFH) will note smolt development visually based on degree of silvering, presence/absence of parr marks, fin clarity and banding of the caudal fin. No gill ATPase activity or blood chemistry samples to determine degree of smoltification, or to guide fish release timing is anticipated. A range of 200-250 length/weight samples will be collected from each release location population. Samples are usually collected 1-2 days prior to full release.

3.10 PATHOLOGY MONITORING

The systematic fish health monitoring methods described here will allow for comparisons of fish health between rearing strategies or rearing facilities and provide a means to assess potential fish health impacts to fish in the natural environment.

3.10.1 Hatchery-Reared Juvenile Fish

All raceways of each species and stock at Walla Walla Hatchery will be monitored monthly for fish health. Monthly monitoring consists of examining one to five fresh-morbid or moribund fish from each raceway for systemic and gill bacteria on TYE-S agar. Kidneys of Chinook salmon are assayed for *Renibacterium salmoninarum* (Rs), the causative agent of BKD by the enzyme-linked immunosorbent assay (ELISA) as per methodology adopted from Pascho and Mulcahy (1987). Fish too small for the ELISA are examined for Rs by the direct fluorescent antibody (DFAT) method (Banner et al. 1982). In addition, monthly inspections include microscopy of gill tissue and body scrapings for parasites and gill condition from a minimum of five fish. Sixty fish will be tested annually for *Myxobolus cerebralis*, the causative agent of Whirling Disease. Diagnostic procedures will follow the Fish Health Section Bluebook (Fifth Edition, 2003). Within four weeks of transfer from the hatchery, tissues from grab-sampled fish are examined for virus on cell cultures from a minimum of 10 fish per raceway. Gill and body scrapings are examined by microscopy from a minimum of three fish per lower raceway at Walla Walla Hatchery. Thirty spring Chinook salmon per raceway are assayed for Rs by ELISA. Any statistical analysis of ELISA optical density values would involve log-transformation of these values (Ott 1977) and applying either a t-test (Triola 1992) or analysis of variance (ANOVA). In addition, prior to their liberation from acclimation facilities most groups of fish are examined from each acclimation pond as in the monthly monitoring protocols described above.

3.10.2 Broodstock

A minimum of 60 fish are examined for culturable viruses as per fish health section bluebook methods. This includes ovarian fluid and pyloric caeca/kidney/spleen samples from all broodstock for this program. All female spring and fall Chinook salmon spawners are assayed for Rs antigen by the ELISA. These results are tracked back to family group to allow for aggressive BKD management. Pathological brood screening protocol recommends culling eggs from parents with OD ELIZA values > 0.20 titres. This approach provides the means to cull eggs for BKD prevention control. All broodstock mortalities are examined for culturable systemic viruses using TYE-S agar. Chinook salmon broodstock mortalities are also examined for Rs by the ELISA. Other adult mortalities that may come from outplant programs are also examined; a minimum of 20 of these are examined annually if available.

3.10.3 Naturally-Reared Fish

Fish health personnel will examine naturally-reared fish that are submitted for analysis. This will primarily consist of mortalities from naturally-reared juveniles obtained from smolt traps and parr collected during juvenile fish sampling. The numbers will vary from year to year but analysis of naturally reared fish will provide valuable fish health information. These will be sampled for *M. cerebralis*, *R. salmoninarum* and infectious hematopoeitic necrosis virus (IHNV) and other culturalable viruses. Kidney samples collected from natural spawners during spawning ground surveys could provide additional fish health information. In the event of unusual fish loss, we will examine fish for pathogen levels by following diagnostic methods in the fish health bluebook.

3.11 DATA MANAGEMENT

A variety of agencies with diverse responsibilities are responsible for RM&E in the Walla Walla Subbasin. Due to the large number of people and projects in the subbasin, a centralized data management system has not been developed. At this point it is unclear if such a system is wanted or needed, and it is unclear what benefits would be derived from centralized data archiving.

However, the subbasin planning process made clear that there is a need for regular centralized data compilation and analysis, and that collaborative access to data is critical. The Walla Walla Watershed Planning activities support the development of some form of a centralized data management or data reference system. This sytem will support the implementation of the plan recommendations to allow Walla Walla County and other user groups to directly manage both their scientific and project information. The goal of the data management system is to provide a coordinated set of tools focused on providing field researchers, scientists, data managers and ecological modelers a set of tools to organize the wealth of ecological information available from a wide variety of sources. When completed, the EKO-System for Walla Walla will provide:

- A system that can be managed locally and be accessed by all key groups
- Centralized repository for any type of quantitative and qualitative information
- Intuitive web based data search / aggregation tool.
- Project management system that tracks not only project status, but full financial, goal, progress, and long term scientific impact for any project, funded by any source, using any protocol
- Publishing Portal providing a system and methodology to share information with other users of the system

The Data Repository will provide a place to store any type of qualitative and quantitative information that is not already being stored in some other data retrieval system. Using a unique universal data model, the repository can store self-describing information of any type, providing full search and retrieval capabilities. Data that is published at other sites can be spatially located and a link to the data storage site provided within the local data repository.

All information will be stored in an internal format that locates the data item, for example a measurement, observation, project step, or virtually any event at an intersection of time and space. By including temporal and spatial information along with protocol, quality control, and source references with each data element stored in the repository, the data can be searched and managed using a variety of techniques including relational, hierarchical and GIS techniques. By implementing embedded quality control, source, and protocol information, users can ensure they get the data of the quality they want, formatted the way they want it.

Implementation the Data Management System for the Walla Walla Watershed Plan will provide the following benefits:

- Provides a single data repository for the collection and management of all of the qualitative and quantitative data required for effective watershed management
- Provides a single consistent data mining tool for retrieving information from the system
- Is Web deployed, and usable from a variety of office and field sites
- Is operated by the Walla Walla County and other local groups eliminating the need to coordinate requests for information with outside organizations
- Security will be defined by the participants and managed by the Walla Walla County, enabling them to grant or restrict access as desired
- Dynamic design will allow the system to accommodate new information types without requiring programming changes.
- Repository for historical information and current study information.
- Project Management will allow the participants to have a for single system for tracking both financial and progress tracking for projects of all types and funding sources
- Project Management will enable a single scientific monitoring plan to support the goals of all projects – eliminating duplicated efforts across individual projects.
- Project Management can create reports required to be submitted to a variety of organizations automatically.

The co-managers will work to develop a hardware-software solution for regular compilation and analysis of Walla Walla RM&E data. The product will be developed as part of the Habitat Conservation Planning Process, Washington State Salmon Recovery planning, and local RM&E planning activities. The solution will consist of a relational database that links directly to project archives using Federal Geographic Data Committee (FGDC) ISO standards. The nexus will allow project managers and institutional representatives to maintain QA/QC, and will not place additional posting or QA/QC requirements upon individual projects. At the same time the FGDC standards will provide for meaningful comparisons of results, and for interactive modeling and evaluation of data from divergent projects or techniques. This nexus will operate at multiple spatial scales, and will incorporate data that is managed out of basin by state or federal agencies The centralized system will provide links to the CTUIR centralized database once the CTUIR server becomes operational..

The nexus will be updated regularly as new projects or collaborations are developed. Every five years the co-managers will re-engage in the context of testing the working hypothesis and conducting a subbasin review. This will provide an opportunity for comprehensive results reporting and evaluation, and will greatly facilitate the adaptive management process. The nexus will provide links or direct connections to locally applicable datasets that are centralized in off-site locations such as the Washington DOE, USFS, EPA, ODFW, StreamNet, CBR, and other databases.

3.12 EVALUATION

This comprehensive RM&E plan was developed to address management actions in the subbasin, as well as general critical management uncertainties. Information content associated with management actions and uncertainties is attained through research and monitoring. Evaluation is on-going and iterative, but somewhat distinct from research and monitoring activities. In general evaluation is the act of determining the significance, worth, or condition of things or actions within the subbasin. In order to maintain scientific integrity evaluation must take place within the context of hypothesis testing and statistical analysis.

RM&E objectives developed for this plan include hypotheses or statistical tests that allow for the determination of significance given the current state of scientific understanding. Due to the complex management landscape and eco-scape, and the large number of management questions being asked simultaneously, there are a number of requirements for a comprehensive evaluation program. These requirements fall into three basic categories: 1) evaluation of management actions, 2) evaluation of status, trends, critical uncertainty research, and 3) evaluation of RM&E program activities. In the Walla Walla Subbasin, evaluation must, at a minimum, meet the following information requirements:

1. Treatment evaluation
    - What hatchery, habitat, hydrosystem, and harvest projects were implemented according to plan?
    - What projects were effective (physically, biologically, or socio-economically) at the project level? Where possible: Why, or why not?
    - What projects were effective (physically, biologically, or socio-economically) at the reach, drainage, or subbasin level? Where possible: Why, or why not?
    - What are the mechanisms impacting the effectiveness of management actions? Which of these mechanisms are poorly understood vs. well understood? Which of these mechanisms are significant and poorly understood, and therefore require basic Tier 3 research?
    - What management projects require targeted monitoring vs. basin-wide monitoring?

- Based on technical evaluation, what are the design criteria for future management treatments?
- What treatment types and sequences should be funded in the future based on physical, biological, and socio-economic criteria?

2. Reach, Drainage, and Subbasin Evaluation
   - What are the status and trends in baseline habitat and ecological conditions?
   - What are the stock status and trends and recovery criteria (VSP or other) characteristics?
   - What are the status and trends in baseline socio-economic conditions?
   - What are the accuracy of EDT or other interpolated model inputs?
   - What are the accuracy, power and refinement of the EDT, life-cycle analysis, mass-balance and other models?
   - What are the limiting factors for each focal species by level of aggregation based on these models?
   - Based on this understanding, what are the current best-available predictions of future status and trends for populations, habitat, ecosystems, and socio-economic systems?
   - What mechanisms are forcing these predictions?
   - Which of these mechanisms are well understood, and which are poorly understood?
   - Which mechanisms are significant and poorly understood, and therefore require basic Tier 3 research?

3. Evaluation of the RM&E program
   - What RM&E activities are powerful and informative?
   - Has coordination and collaboration among entities been effective?
   - Have standardized RM&E criteria been achieved?
   - Can protocols be standardized to meet management uncertainties, or can disparate protocols be used in a collaborative data management system?
   - Has duplication been minimized?
   - Are the scale and resolution of RM&E activities appropriate for subbasin-wide management uncertainties?
   - Are basic science activities effectively informing management?
   - Are critical management uncertainties being addressed adequately from a technical perspecitve? From a management perspective?
   - Are results being effectively disseminated, and are they readily available for review or utilization?
   - Are RM&E results being incorporated into management decisions and planning?
   - Is the current RM&E plan adequate?
   - Is fiscal support for current RM&E requirements adequate?

The co-managers will conduct evaluation of management action effectiveness, status and trends, and the RM&E program. The efficacy of implementation (1a) will be monitored at the project level by appropriate staff. The extent of management treatments (i.e. number of smolts released, number of boulders placed, etc.) will be reported to the collaborative RM&E program. This information will evaluated as part of status and trend reporting in the short-term. The impacts of these actions will be evaluated in terms of their temporal, geospatial, and associative relationships to the physical, biological, and socio-economic responses of the system. In other words, for each level of aggregation (temporal, spatial, or system) the RM&E program will monitor and evaluate the status of the aggregate, the treatments it receives, and the trend it responds with.

The program will determine, to the extent possible, the worth or value of each management action within the context of natural variability of the system, and will provide recommendations for future actions. The impacts of actions on habitat conditions and limiting factors will be evaluated using EDT or other available models. The efficacy of some management actions may preclude the need for similar actions within a given geographic area if the action effectively minimized a given limiting factor. In this instance a similar action may be best placed in a geographic area where similar limiting factors have not been addressed. Other effective actions may significantly impact a limiting factor within a reach, but not across the entire geographic area. In this instance it may be difficult to determine the optimal placement of an action at the reach level, but the action may deserve repetition within the geographic area. The RM&E program will provide recommendations to the management community regarding action effectiveness, limiting factors, and optimal future actions.

The five year Subbasin Review process will provide an opportunity for scientists and managers to re-assemble and thoroughly re-evaluate progress in the subbasin. The goal of the Subbasin Review will be to evaluate progress in meeting the goals and objectives of the Subbasin Plan. The review will be conducted by the core participants that developed the Subbasin Plan. The evaluation component of the Subbasin Review will consist of a scientific, decision-making, and RM&E program evaluation.

The RM&E program will conduct scientific evaluation of the strengths and weaknesses of the current information status, and will produce a technical interpretation of the achieved progress towards the subbasin plan objectives. Progress towards strategy implementation will be evaluated in terms of changes in habitat quality and quantity, in-stream conditions, passage, etc.. The population response will be evaluated in terms of the total production in each geographic area, survival throughout the subbasin, and observed and projected returns of anadromous adults.

The quality of scientific information will be evaluated in terms of the ability of scientists to make technical evaluations with an appropriate level of statistical confidence, and to present that information to the management community. Progress towards strategy implementation will be evaluated in terms of programmatic effectiveness and action achievements: have the subbasin objectives been achieved? Did these produce the desired ecological and socio-economic results? Responses to scientific evaluation will be evaluated in terms of the perceived effectiveness of the current management actions, and the potential utility and attainability of revised actions. The program will, on an ongoing basis, evaluate its ability to address these questions in each system given current RM&E resources, and will request additional or differing resources as needed.

The public will conduct evaluation of the program as a whole, and the perceived and observed effectiveness of particular and total actions in the subbasin. The achievement of harvest opportunities, restoration of water quality and quantity, and recovery of diminished stocks will be addressed. The ability of the co-managers to work and communicate effectively with the public will be evaluated. Community knowledge and participation in management decisions and action implementation, including volunteerism and activism, will be considered. This public evaluation will take place in the context of town, city, and county meetings with political and management authorities.

4. RM&E CONCLUSIONS AND RECOMMENDATIONS

The Walla Walla Subbasin managers and stakeholders have begun to coordinate recovery and RME actions within the subbasin. Included in these efforts was an initial assessment of ongoing and needed RME actions as reflected in this document. The managers attempted to identify the current level of effort, and a subjective assessment that effort's progress toward meeting data needs within the subbasin. A complete assessment of current or needed RM&E actions or prioritization of actions within the table has not yet been accomplished. However, all involved parties have committed to completing an RME plan that would, eventually coordinate and address all current and needed RM&E actions and priorities. Following are broad preliminary conclusions and recommendations based on guiding principles and priorities. These will serve as generalized high priority (in principle) actions that should be pursued while the more comprehensive RME plan is completed.

1. Conclusion: The quality of data used within the EDT attributes and modeling exercise is inadequate. Empirical data of known accuracy and precision is needed for priority areas (habitat inventory using standardized protocols from region that will fit EDT) of the subbasin. These data will be used to evaluate the efficacy of EDT in modeling habitat and population response to actions taken within the subbasin, and to evaluate the hypotheses and objectives presented in the subbasin plan.

Recommendation: Fund habitat inventories to collect data necessary to fill data gaps *for habitat inventory information and especially* for attributes with high EDT model leverage and evaluation of progress toward subbasin plan objectives.

2. Conclusion: Population status monitoring must occur in a systematic manner that will allow managers to evaluate their progress toward delisting from ESA. Criteria established by NOAA and the TRTs under VSP will be used within the subbasin as well as attributes (from USFWS) necessary for bull trout recovery planning. These metrics will be useful within EDT, and provide a direct relationship between the habitat and population monitoring efforts, through model outputs.

Recommendation: Continue to fund existing monitoring and evaluation actions within the subbasin that fulfill critical VSP data needs.

Recommendation: Fund additional actions to complete basic population status monitoring needs for the subbasin (e.g. Monitor adult escapement into the three major basins of the Walla Walla (Touchet River, Mill Creek and Walla Walla above Mill Creek), and the smolt emigration from those basins)

To fulfill this example, the specific actions or improvements listed below may be needed.

1. Adult counting or trap at Bennington Dam
2. Improved passage and counting or trap at Dayton
3. Fix trap/ladder/passage at Nursery Bridge
4. Smolt trap in the middle or upper Touchet River
5. Adult counting at Coppei creek
6. Remote sensing or removable fish weir in lower Walla Walla River for adult counts

Additional VSP related action may be required/recommended as the full RME plan is completed.

3. Conclusion: Basic monitoring of restoration actions undertaken within the subbasin needs to occur to ensure that they were completed in accordance with expectations (Implementation monitoring). However, the effects of those actions on the habitat and salmonid populations (Effectiveness monitoring) is costly and should be done on only a portion of completed projects.

Recommendation: Accountability for restoration actions needs to occur for each project. Basic documentation should be completed in a cost efficient manner. A systematic approach to documenting effectiveness is required that provides sufficient accountability without unnecessary redundancy. (e.g. classes of actions my be represented by monitoring a small portion of similar projects)

4. Conclusion: Critical uncertainties will be identified in the Comprehensive RME plan and coordinated with other regional forums. Uncertainties must be understood and answered if population recovery is to occur. ESU wide uncertainties may be addressed in the subbasin as part of a regional RME effort. Subbasin specific factors may need localized RME efforts to answer.

Recommendation: Fund research on critical uncertainties unique to the Walla Walla as a priority for recovery actions in the subbasin. (direct need)

Recommendation: Fund research on critical uncertainties represented in the Walla Walla for a broader ESU relevance if not being funded or conducted in other subbasins. (opportunity for coordinated regional effort)

5. Conclusion: The managers have not established comprehensive population abundance goals for the subbasin. Interim escapement and spawning goals are inconsistent in definition and basis. The subbasin plan and its RME section as well as the WA State Salmon Recovery Plan can provide critical data for establishing these goals in a coordinated and scientifically defensible fashion.

Recommendation: Fund and implement RME that shows a clear link to resolving uncertainty regarding population abundance and management goals.

Table 4 Aquatic Performance Measures, Institutional Involvement, and Data Gaps in the Walla Walla Subbasin, 2004

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
Abundance					
Adult	Adult returns to Walla Walla River	WDFW, ODFW, CTUIR, USFS, USACOE, TSS	Counts are made at ladders and weirs throughout the subbasin. Some passive detection stations have been established	Direct observations should be replaced with passive detections throughout the subbasin. A passive detection system should be established at the confluence with the Columbia.	BPA, LSRCP, volunteers & cost-share
	Run to mainstem dams	USACOE and Columbia River compact	Passive detections and radio detections are made at all mainstem dams and the estuary.	The current effort is sufficient.	BPA, LSRCP
	CHS Broodstock Collection	CTUIR	Collected from Umatilla River Run CHS[1]	Broodstock should come from locally adapted naturally producing CHS run	BPA and US v Oregon
	STS Broodstock Collection	WDFW	Collected from Lyon's Ferry and Dayton ladder	If experimental hatchery program is deemed sustainable, broodstock should be collected from endemic run to Dayton and Nursery Bridge ladders.	LSRCP
	Spawner Escapement	CTUIR, USFS, USFWS, ODFW, WDFW	Standardized spawner surveys are divided across geographical boundaries, and conducted with low intensity.	Stratified randomized georeferenced surveys.	BPA, USFWS, LSRCP, ODFW
	Run Prediction	CTUIR	none	Run prediction models should be developed for CHS and STS[2]	none
Juvenile	Parr and pre-smolt Abundance	USFWS (BT), CTUIR (STS, CHS), WDFW (Touchet STS, CHS)	Electrofishing, seines, snorkel, and baited trap surveys are conducted by multiple agencies with some coordination.	Stratified randomized georeferenced survey design with increased collaboration and coordination.	BPA, USFS, USFWS, LSRCP, ODFW
	Smolt Abundance	USFWS (BT), CTUIR (STS, CHS)	Screw-trap collections for upper Mill Creek and Walla Walla systems, plus two Walla Walla mainstem traps.	Additional screw-trap or PIT-tagging effort in the Touchet system, plus increased effort in the mainstem to develop total outmigration estimate.	USACOE, USFWS, BPA, LSRCP

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
	Residual Abundance	WDFW, CTUIR	Limited coverage using hook and line and electrofishing.	Stratified randomized georeferenced assessment using hook and line and baited traps.	LSRCP, BPA
Survival and Productivity					
Adult	Broodstock Survival	WDFW, CTUIR	Monitored in-hatchery.	The current effort is sufficient.	LSRCP, BPA
	Smolt-to-Adult Return	USFWS, CTUIR, ODFW, WDFW, TSS, USFS	Metric derived from independent assessments of smolt survival, age at return, adult mortality, and spawner densities.	Increased PIT-tagging effort for hatchery and wild fish to develop SURPH and CRiSP models.	USFWS, BPA, ODFW, WDFW, PSMFC, volunteers
	Smolt-to-Adult Survival	USFWS, CTUIR, ODFW, WDFW, TSS, USFS	Metric derived from independent assessments of smolt survival, age at return, adult mortality, and spawner densities.	Increased PIT-tagging effort for hatchery and wild fish to develop SURPH and CRiSP models.	USFWS, BPA, ODFW, WDFW, PSMFC, volunteers
	Parent Progeny Ratio	USFWS, CTUIR, ODFW, WDFW, TSS, USFS	Metric derived from independent assessments of smolt survival, age at return, adult mortality, and spawner densities.	Increased PIT-tagging effort for hatchery and wild fish to develop SURPH and CRiSP models.	USFWS, BPA, ODFW, WDFW, PSMFC, volunteers
	Pre-spawn Mortality	CTUIR, WDFW, USFWS, TSS, WWBWC	Expanded from carcass surveys and telemetry study.	Stratified, randomized, georeferenced carcass surveys with increased coverage.	BPA, USFWS, OWEB
	Recruit /spawner (adult to adult)	USFWS, CTUIR, ODFW, WDFW, TSS, USFS	Metric derived from independent assessments of smolt survival, age at return, adult mortality, and spawner densities.	Increased PIT-tagging effort for hatchery and wild fish to develop SURPH and CRiSP models.	USFWS, BPA, ODFW, WDFW, PSMFC, OWEB, volunteers
Juvenile	Egg to Fry Survival	not assessed	not assessed	Should be derived from higher resolution studies of spawners, parr, and smolts.	unfunded
	Fry to parr and parr to smolt survival	not assessed	not assessed	Derived from higher resolution studies of spawners, parr, and smolts.	unfunded
	Smolt Survival to McNary Dam	CTUIR, WDFW, USFWS, USACOE	Derived from PIT-tag detections	Increased PIT-tagging effort to develop SURPH and CRiSP models, plus increased screw-trap effort to estimate total smolt outmigration from WWR.	LSRCP, BPA

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
	Smolt Survival through Mainstem Columbia River	CTUIR, WDFW, USFWS, USACOE	Derived from PIT-tag detections	Increased PIT-tagging effort to develop SURPH and CRiSP models, plus increased screw-trap effort to estimate total smolt outmigration from WWR.	LSRCP, BPA
Distribution and Movement					
Adult	Spawner Spatial Distribution	CTUIR, WDFW, ODFW, USFS, USFWS	Standardized spawner surveys are divided across geographical boundaries, and conducted with low intensity.	Stratified randomized georeferenced surveys.	BPA, USFWS, LSRCP, ODFW, OWEB
	Stray Rate	WDFW, PSMFC, CTUIR, U of I	Passive detections and radio detections are made at all mainstem dams and the estuary, plus CWT recoveries from creel, volunteers, and carcass surveys, and scale analysis.	The current effort is sufficient.	LSRCP, BPA, OWEB
Juvenile	Rearing Distribution	USFWS (BT), CTUIR (STS, CHS), WDFW (Touchet STS, CHS)	Electrofishing, seines, snorkel, and baited trap surveys are conducted by multiple agencies with some coordination.	Stratified randomized georeferenced survey design with increased collaboration and coordination.	BPA, USFS, USFWS, LSRCP, ODFW
	Residual Distribution	WDFW, CTUIR	Limited coverage using hook and line and electrofishing.	Stratified randomized georeferenced assessment using hook and line and baited traps.	LSRCP, BPA
Life History					
Adult	Run Timing	WDFW, CTUIR, ODFW, PSMFC, USACOE	PIT-tag detections, ladder counts, creel surveys, radio telemetry, and spawning surveys.	The current effort is sufficient.	BPA, LSRCP, OWEB, USACOE
	Passage efficiency	CTUIR, WWBWC, WDFW, ODFW, TSS, USACOE, UI	Telemetry, ladder counts, PIT-tag detections, and spawner surveys.	The current effort is sufficient.	BPA, USACOE, OWEB, ODFW, WDFW
	Age of spawners	ODFW, WDFW,CTUIR, USFWS	PIT-tag detections, CWT recoveries, scale and otolith analysis.	Increased PIT-tagging efforts and scale and otolith analysis with greater coverage and coordination.	BPA, LSRCP, USFWS

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
	Size of spawners	WDFW, ODFW, CTUIR, USACOE, USFS, TSS, USFWS	PIT-tag detections, CWT recoveries, ladder counts, creel surveys, and carcass surveys.	The current effort is sufficient.	BPA, LSRCP, ODFW, WDFW, USFS, volunteers, USFWS
	Sex Ratio of spawners	WDFW, ODFW, CTUIR, USACOE, USFS, TSS, USFWS	PIT-tag detections, CWT recoveries, ladder counts, creel surveys, and carcass surveys.	The current effort is sufficient.	BPA, LSRCP, ODFW, WDFW, USFS, volunteers, USFWS
	Fecundity	USFS, ODFW, USFWS, WDFW, CTUIR	Fecundity is measured in the hatchery and by ultrasound at the Walla Walla city water intake.	Fecundity estimates should be linked directly with age and growth estimates for all species.	LSRCP, BPA, USFS
	Spawn-timing	CTUIR, ODFW, WDFW, WWBWC, USFWS, USFS, UI	Telemetry, spawner surveys, and carcass surveys.	The current effort is sufficient.	BPA, LSRCP, USFS, USACOE, OWEB
Juvenile	Size at Release	CTUIR, WDFW	Monitored in-hatchery.	The current effort is sufficient.	BPA, LSRCP
	Release Location	CTUIR, WDFW	Monitored in-hatchery.	The current effort is sufficient.	BPA, LSRCP
	Emigration Timing	USFWS (BT), CTUIR (STS, CHS)	PIT-tag detections and screw-trap collections for upper Mill Creek and Walla Walla systems, plus two Walla Walla mainstem traps.	Additional screw-trap or PIT-tagging effort in the Touchet system, plus increased effort in the mainstem to develop total outmigration estimate.	USACOE, USFWS, BPA, LSRCP
	Age at Emigration	CTUIR, USACOE, WDFW, Batelle, USFWS	PIT-tag detections and screw-trap collections for upper Mill Creek and Walla Walla systems, plus two Walla Walla mainstem traps.	Additional screw-trap or PIT-tagging effort in the Touchet system, plus increased effort in the mainstem to develop total outmigration estimate.	BPA, LSRCP, UACOE, USFWS
	Size at Emigration	CTUIR, USACOE, WDFW, Batelle, USFWS	PIT-tag detections and screw-trap collections for upper Mill Creek and Walla Walla systems, plus two Walla Walla mainstem traps.	Additional screw-trap or PIT-tagging effort in the Touchet system, plus increased effort in the mainstem to develop total outmigration estimate.	BPA, LSRCP, UACOE, USFWS
	Condition at Emigration	CTUIR, USACOE, WDFW, Batelle, USFWS	PIT-tag detections and screw-trap collections for upper Mill Creek and Walla Walla systems, plus two Walla Walla mainstem traps.	Additional screw-trap or PIT-tagging effort in the Touchet system, plus increased effort in the mainstem to develop total outmigration estimate.	BPA, LSRCP, UACOE, USFWS

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
Fish Health					
Adult and Juvenile	Disease Incidence	WDFW, ODFW, CTUIR, USFWS	Monthly disease checks in hatchery. No coverage in natural populations and no assessment of hatchery-to-natural transmission.	Coordinated surveys of mortalities and carcasses, plus small sub-sample of "healthy" wild fish.	BPA, LSRCP, USFWS
	Disease Severity	WDFW, ODFW, CTUIR, USFWS	Monthly disease checks in hatchery. No coverage in natural populations and no assessment of hatchery-to-natural transmission.	Coordinated surveys of mortalities and carcasses, plus small sub-sample of "healthy" wild fish.	BPA, LSRCP, USFWS
Genetic					
Adult and Juvenile	Genetic Diversity and Integrity	CTUIR, ODFW, WDFW, USFWS	not assessed	Coordinated assessment of genetic characteristics for all supplemented, reintroduced, and listed species.	unfunded
	Reproductive Success	CTUIR, ODFW, WDFW, USFWS	not assessed	Experimental assessment of reproductive success of BT, STS, and CHS at Nursery Bridge Dam.	unfunded
	Effective population size	CTUIR, ODFW, WDFW, USFWS	Assessment of BT connectivity and spatial heterogeneity.	Standardized monitoring of effective population size measured as the rate of decline in genetic heterozygosity	USFWS
Fisheries					
Adult	In-basin harvest	WDFW, ODFW	Limited coverage using creel surveys plus catch records from volunteers.	Stratified randomized creel surveys of entire subbasin plus increased volunteer involvement.	WDFW, ODFW
	Out-of-basin harvest	LSRCP, PSMFC	Randomized creel surveys plus CWT and PIT-tag estimates of harvest.	Increased spatial and temporal coverage and consistency in survey methodologies.	LSRCP, NOAA
	Hooking rate	WDFW, ODFW	Limited coverage using creel surveys plus catch records from volunteers.	Stratified randomized creel surveys of entire subbasin plus increased volunteer involvement.	WDFW, ODFW
	Handling mortality	CTUIR, WDFW, USACOE, WWBWC	Derived from telemetry mortalities.	The current effort is sufficient.	BPA, LSRCP, OWEB, USACOE

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
Habitat					
Adult and Juvenile	Instream flow	WWBWC, OWRD, WDOE, Steelheaders, WDFW, USGS	Gauge stations, manual msmt	Increase spatial and temporal coverage	OWEB, OWRD, WDOE, WDFW, USGS, BPA
	Water temperature	WDOE, USFS, WWBWC, WDFW, CTUIR,	Temp loggers with traceable thermometer field audits. FLIR flights up to N.F. Touchet.	Increase spatial and temporal coverage. FLIR flights throughout subbasin.	OWEB, WDFW, WDOE, USFS, EPA
	Water quality	WDOE, WWBWC, WDFW	Grab samples using calibrated equipment	Increase spatial and temporal coverage	WDOE, EPA, OWEB
	Physical habitat conditions	USFS, WDFW, ODFW, WWBWC, USFWS	Modified Hankin & Reeves or Rosgen surveys, TMDL morphology, sinuosity analysis.	Addition of EDT-derived metrics such as bed-scour and embeddedness, plus georeferenced survey design.	BPA, LSRCP, USFS, USFWS, WWBWC, EPA, OWEB
	Biological habitat conditions	USFS, WDFW, ODFW, WWBWC, USFWS, OSU	For riparian conditions, modified Hankin & Reeves or Rosgen surveys. South fork and mainstem Walla Walla Oregon reaches have ongoing macroinvertebrate sampling and analysis every third year.	Increase spatial and temporal intensity benthic macroinvertebrate sampling and analysis	BPA, LSRCP, USFS, USFWS, EPA, OWEB
	Habitat Quantity	USFS, WDFW, ODFW, WWBWC, USFWS	Modified Hankin & Reeves or Rosgen surveys.	Addition of EDT-derived habitat types, plus georeferenced survey design.	BPA, LSRCP, USFS, USFWS, WWBWC
	Passage barriers and diversions	CTUIR, WWBWC, WDFW, ODFW, TSS, USACOE, UI	Telemetry, ladder counts, PIT-tag detections, and spawner surveys.	The current effort is nearly sufficient. Habitat surveys should be expanded to include geolocation of waterfalls and natural barriers.	BPA, USACOE, OWEB, ODFW, WDFW
	Habitat utilization	CTUIR, WDFW, ODFW, USFS, USFWS	Derived from juvenile and adult abundance and distribution surveys.	Georefenced survey design for fish population studies	BPA, LSRCP, USFS, USFWS
	Smolt production of habitat	CTUIR, WDFW, ODFW, USFS, USFWS	Derived from juvenile and adult abundance and distribution surveys.	Georefenced survey design for fish population studies	BPA, LSRCP, USFS, USFWS

Life Stage	Performance Measure	Collaboration	Current Effort	Desired Future Effort	Current Funding
Ecosystem					
Juvenile and Adult	Trophic relationships	CTUIR, WDFW, ODFW, USFS, OSU, USFWS	not assessed	Stable isotope assessments plus mass-balance models	unfunded
	Competition	CTUIR, WDFW, ODFW, USFS, OSU, USFWS	not assessed	Stable isotope assessments plus mass-balance models	unfunded
	Natural mortality	CTUIR	not assessed	Stable isotope assessments plus mass-balance models	unfunded
	Marine ecology	CTUIR, CRITFC, OSU	not assessed	Archival tag studies	unfunded
	Redd impacts	CTUIR, WDFW, ODFW, USFS, OSU, USFWS	not assessed	Stable isotope assessments plus mass-balance models	unfunded
	Carcass impacts	CTUIR, WDFW, ODFW, USFS, OSU, USFWS	not assessed	Stable isotope assessments plus mass-balance models	unfunded

[1] Spring Chinook
[2] Summer Steelhead

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