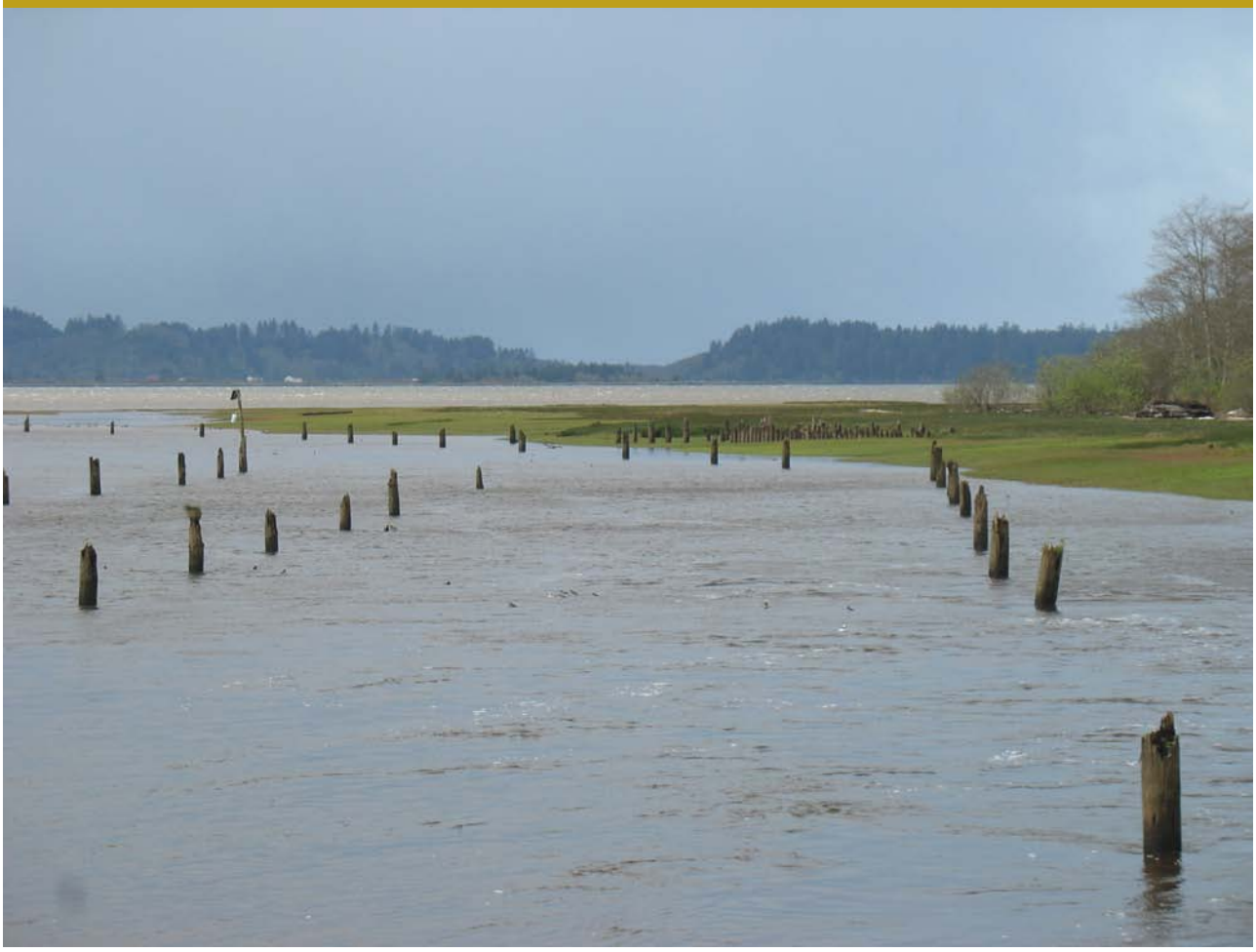
Research, Monitoring & Evaluation Program for Lower Columbia Salmon & Steelhead



Lower Columbia Fish Recovery Board
June 2010
Final

Preface

This comprehensive research, monitoring, and evaluation program for lower Columbia River salmon and steelhead was developed under the leadership of the Washington Lower Columbia Fish Recovery Board (LCFRB). The Board was established by state statute (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydropower project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington state agencies, regional organizations, local governments, and members of the public participated in the planning process. Participation was achieved through a steering committee, work groups, watershed planning units, and public meetings, workshops, and comment periods.

Program development was funded through grants furnished by the Washington Department of Ecology and the Salmon Recovery Funding Board. The program was developed under the direction of Jeff Breckel, Steve Manlow, Bernadette Graham Hudson, and Melody Tereski of the LCFRB with assistance from R. Beamesderfer, J. Brauner Lando, K. Arendt, and C. Ackerman of Cramer Fish Sciences. Oversight was provided by a steering group of representatives from implementing agencies and organizations including: Clark County, Clark Public Utilities, Columbia Land Trust, Cowlitz Indian Tribe, DNR, Ecology, GSRO, LCREP, NMFS, PacifiCorp, USACE, USFS, USFWS, and WDFW.

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1. Overview

This document details the monitoring, research, and evaluation (RM&E) elements of a coordinated regional program supporting Lower Columbia salmon and steelhead recovery and watershed plan implementation efforts. The RM&E program described herein integrates and complements other state and regional planning and RM&E efforts for salmon and steelhead recovery and watershed restoration. The area addressed by this plan includes Washington Columbia River subbasins from the Chinook River near the ocean, upstream to and including the Little White Salmon River in the gorge. The goal of this program is to provide a template for action and overall guidance to an extensive group of participants involved in implementation of the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (Recovery Plan), the WRIA 27/28 Salmon-Washougal and Lewis Watershed Management Plan, and the WRIA 25/26 Grays-Elochoman and Cowlitz Watershed Management Plan (Watershed Plans). Preliminary RM&E guidance was provided in the Recovery and Watershed Plans and the program presented herein is consistent with those overall objectives and actions. This RM&E program strives to provide a flexible and collaborative structure, developed with stakeholder involvement, for tracking, evaluating and responding to new information. Implementation of this RM&E Program will be achieved through a regional partnership of local, state, federal and tribal interests. This program does not serve as a regulatory document, nor does it obligate any party; however, it does establish specific responsibilities for actions that have been identified as important to fish recovery.

This program details the full spectrum of information needed for monitoring and evaluation of salmon and watershed recovery in Washington lower Columbia River subbasins, inventories what information and data are available from existing sources, and identifies critical information needs and priorities. The program includes six key elements: 1) biological status and trend monitoring, 2) habitat status and trend monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. Program elements were designed to address salmon status and threats consistent with ESA listing and recovery planning criteria and goals. Risk status is addressed through a combination of biological and habitat monitoring related to the Viable Salmonid Population concept (McElhany et al. 2000). Threats are evaluated based on habitat status, implementation/compliance, and action effectiveness monitoring. For the purposes of this program, action effectiveness refers to salmonid life-cycle based effects of habitat, harvest, habitat, hatchery, and ecological actions on biological status.

For each program element, we identify: A) objectives, B) indicators, C) sampling and analytical design, D) information gaps and priorities in available information, and E) implementation actions. Implementation actions identify specific projects or programs that will address the RM&E needs and priorities in this program.

2. Introduction

2.1 Program Goals

This document describes the coordinated regional research, monitoring, and evaluation (RM&E) program supporting salmon and steelhead recovery and watershed plan implementation efforts for the Lower Columbia region. The goal is to provide a template for action and overall guidance to an extensive group of participants involved in implementation of the Lower Columbia Salmon Recovery & Fish and Wildlife Subbasin Plan (Recovery Plan), the WRIA 27/28 Salmon-Washougal and Lewis Watershed Management Plan, and the WRIA 25/26 Grays-Elochoman and Cowlitz Watershed Management Plan (Watershed Plans). Preliminary RM&E guidance was provided in the Recovery and Watershed Plans and the program presented herein is consistent with those overall objectives and actions as well as the listing status decision framework identified by NMFS (Figure 1). The best available science outlined in the Recovery and Watershed Plans identify a reasonable course of action. Although the Plans provide clear direction and purpose, uncertainties persist and course corrections are inevitable. Existing information is not adequate to predict with precise certainty whether a prescribed set of actions will be sufficient to meet objectives. The RM&E program is an explicit acknowledgement of uncertainties and the likely need for course adjustments along the way.

This RM&E program strives to provide a flexible and collaborative structure, developed with stakeholder involvement and capable of tracking, for evaluating and responding to new information. This program is the product of a collaboration facilitated by the LCFRB and involving federal and state agencies, tribes, local governments, and the public. Recognizing that recovery of fish and wildlife and watershed health is a shared responsibility; it can only be achieved through the cooperative and combined efforts of federal, tribal, state, and local interests. Implementation of this RM&E Program will be achieved through a regional partnership of local, state, federal and tribal interests. This program does not serve as a regulatory document, nor does it obligate any party; however, it does establish specific responsibilities for actions that have been identified as important to fish recovery. It focuses on achieving outcomes and allows implementing agencies and other entities the flexibility to craft innovative, yet scientifically sound, approaches that best fit local conditions and values.

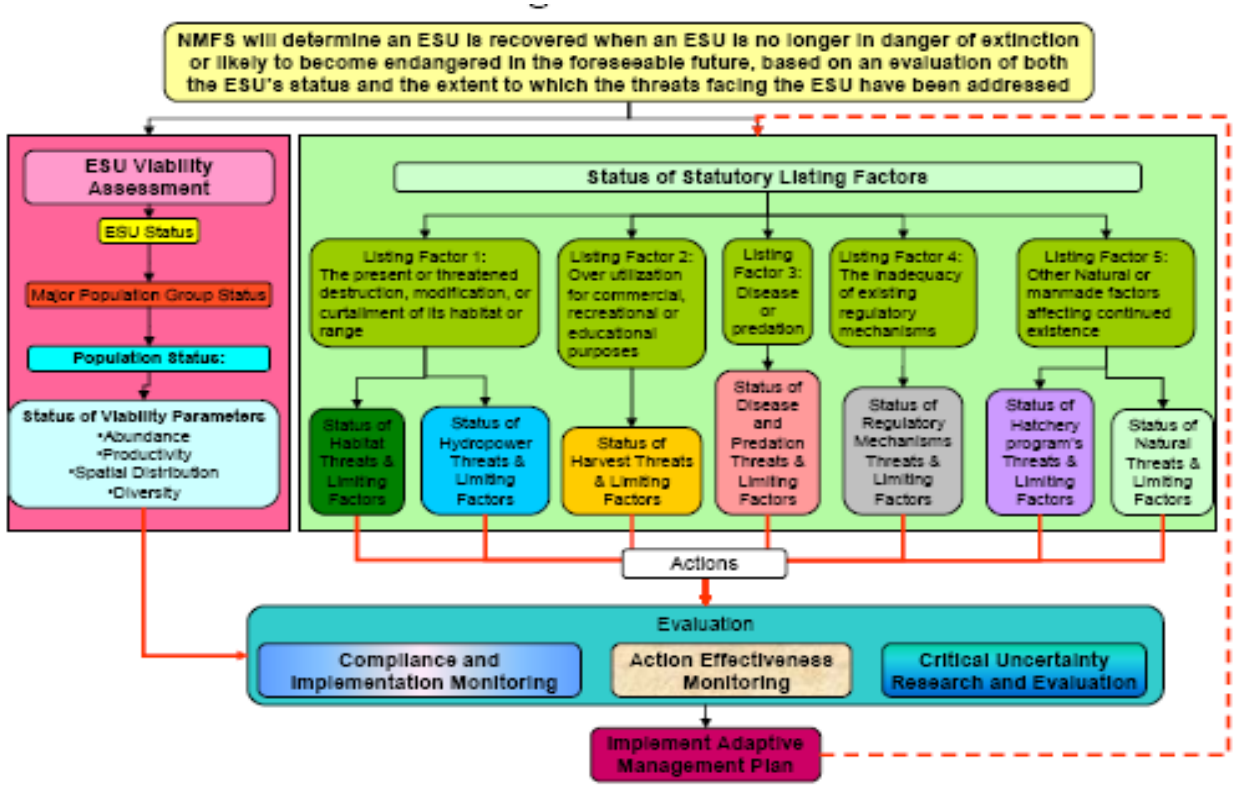

Figure 1. NMFS Listing Status Decision Framework.

2.2 Program Scope

The area addressed by this program includes Washington Columbia River subbasins from the Chinook River near the ocean to and including the Little White Salmon River in the gorge (Figure 2), which encompasses the WRIA 25/26 and 27/28 watershed planning areas. A Willamette/Lower Columbia Technical Recovery Team (TRT) convened by NMFS has divided this area into three ecoregions (Coast, Cascade, and Gorge) for recovery planning purposes. Species addressed by this RM&E program include Chinook salmon, chum salmon, coho salmon, and steelhead (Table 1). Listed bull trout also occur in a few areas of this region but are addressed in detail by a separate plan (USFWS 2002). Estuary monitoring, research, and evaluation is also the subject of a separate RM&E plan (LCREP 2004).

Table 1. Federally listed salmonid species endemic to Washington lower Columbia River subbasins.

Species	ESU	Status	Initial listing date
Chinook salmon	Lower Columbia	Threatened	March 24, 1999
Chum salmon	Lower Columbia	Threatened	March 25, 1999
Steelhead	Lower Columbia[1]	Threatened	March 19, 1998
Coho	Lower Columbia	Threatened	June 28, 2005
Bull trout	Columbia Basin	Threatened	June 10, 1998

[1] *Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany populations are in the Southwest Washington ESU and are not listed under the ESA but are addressed within the Lower Columbia RM&E program.*

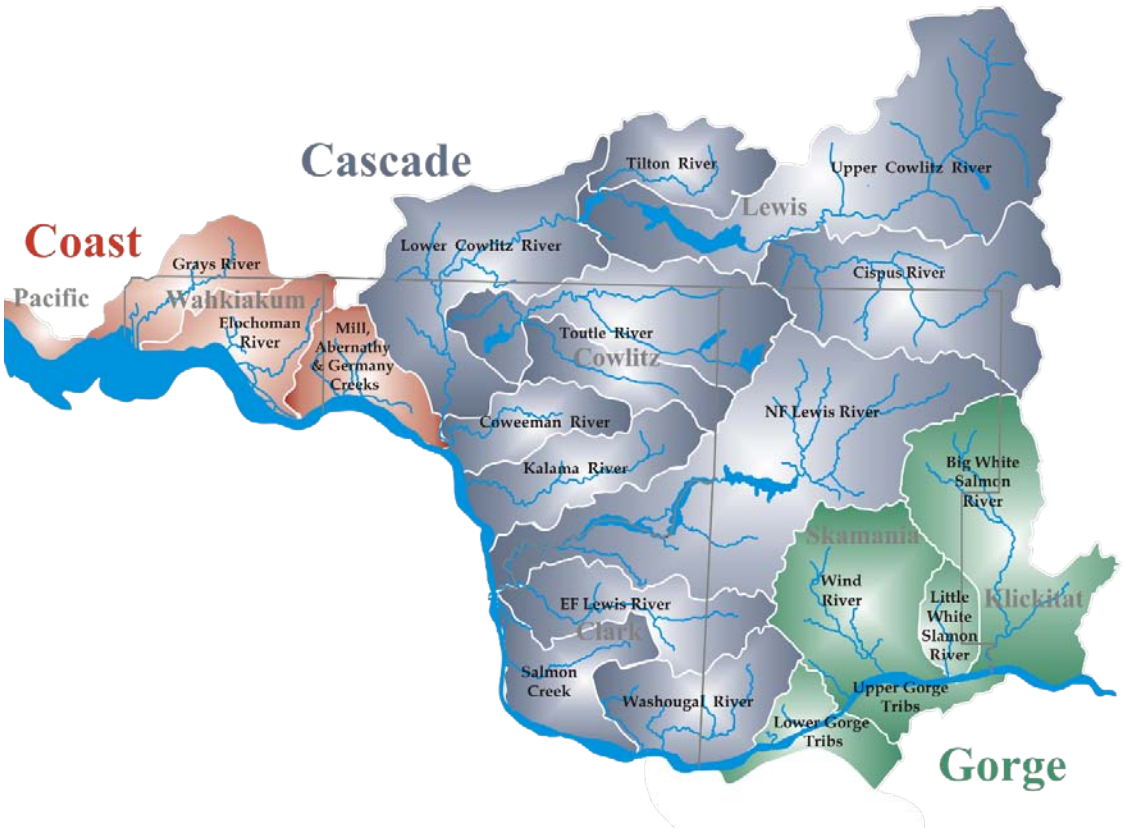

Figure 2. Map of basins in the Lower Columbia region and Coast, Cascade, and Gorge strata designations identified by the Technical Recovery Team.

2.3 Relation to Other Recovery Planning Efforts

The Recovery Planning process has integrated four interrelated initiatives to produce a single Recovery/Subbasin Plan for the lower Columbia:

- U.S. Endangered Species Act recovery planning for listed salmon, steelhead and trout is overseen by NOAA's National Marine Fisheries Service (NMFS).
- Northwest Power and Conservation Council (NPCC) subbasin planning for eight full and three partial subbasins which guide Bonneville Power Administration's funding of projects to implement the fish and wildlife program.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90.82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach promotes consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement actions.

The program presented herein directly reflects objectives, actions and priorities set forth in the Recovery Plan, individual subbasin plans, WRIA-based watershed plans, and subbasin habitat work schedules. Integrated recovery and subbasin plans were completed by the LCFRB in 2004

and subsequently adopted by NMFS on December 15, 2004 and NPCC in 2005. The Recovery Plan was subsequently revised and approved by the LCFRB in 2010 and will be combined with the Oregon Recovery Plan and Estuary Module to develop an ESU-wide Recovery Plan. The Recovery Plan set forth a 25-year target in which to reverse long term declining trends and establish a trajectory leading to recovery with course adjustments made as needed. Watershed Management Plans, including detailed assessments of water resource conditions, with a wide-ranging set of policies and recommendations, were completed for WRIAs 25/26 (Grays-Elochoman and Cowlitz) and 27/28 (Salmon-Washougal and Lewis) in 2006 (LCFRB 2006b, 2006c). Habitat Work Schedules, compiled pursuant to the Washington Salmon Recovery Act, have been completed for each of the major subbasins in the lower Columbia region (LCFRB 2006a). These schedules augment information found in the Recovery Plan and focus implementation efforts by identifying and ranking salmon and steelhead habitat protection and restoration priorities and potential activities to be accomplished during the next six years.

2.4 Relation to Other RM&E Programs

A variety of regional RM&E reviews and programs have been implemented by various parties with many interrelated objectives. For instance NMFS, working with the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, has developed a detailed research, monitoring, and evaluation plan for implementing the Federal Columbia River Power System (FCRPS) Biological Opinion (NOAA 2003). In addition, an estuary monitoring plan entitled Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program (Johnson et al. 2008) was developed in response to the 2000 and 2004 FCRPS Biological Opinions, and is aimed at coordinating and facilitating monitoring efforts in the estuary. A Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) has also been implemented by the Columbia Basin Fish and Wildlife Authority to answer key monitoring and evaluation questions relevant to major fish and hydropower management decisions in the Columbia Basin. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP 2004) has reviewed existing plans to provide strategic guidance for subbasin planners on monitoring objectives, monitoring indicators, data reporting, coordination and management. Guidance documents have also been developed by the Washington Governor's Forum on Monitoring Salmon Recovery and Watershed Health (Crawford 2007), Washington Salmon Recovery Funding Board (SRFB 2002), the Northwest Power and Conservation Council's Independent Scientific Advisory Board (ISAB 2003), and the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). More extensive descriptions of regional monitoring-related programs can be found in Appendix A.

In addition, many agencies conduct local monitoring programs focused on their specific areas of responsibility. For instance, the Washington Department of Fish and Wildlife (WDFW) conducts extensive annual surveys of fish status. Similarly, habitat conditions on State and National forest lands are monitored by the Washington Department of Natural Resources (DNR) and the U.S. Forest Service (USFS), respectively. Streamflow and temperature at selected sites are monitored by the U. S. Geological Survey (USGS) and Washington Department of Ecology (Ecology). Information on habitat and water quality conditions is also collected by some Counties, conservation districts, and utility companies. The Lower Columbia River Estuary Partnership (LCREP) also funds and conducts monitoring, research, and evaluation work related

to the Columbia River Estuary, in accordance with a separate RM&E plan (LCREP 2004). Numerous other local, state and federal programs also exist.

Appendix B provides a summary of existing biological and habitat status monitoring efforts currently underway within the area addressed by this program. However, it should be noted that biological and habitat status monitoring efforts vary over time given regulatory, budgetary and logistical constraints, as well as changes in management emphasis.

The RM&E program described herein integrates and complements other state and regional planning efforts for salmon. It details the full spectrum of information needed for monitoring and evaluation of salmon recovery in Washington lower Columbia River subbasins, inventories information and data available from existing sources, identifies necessary information that is not currently being collected, and describes an approach to filling informational and data gaps. Some or much of the needed information is currently being collected at various scales or purposes. In many or most cases, information being applied to other applications also has direct application to salmon recovery applications. The program identified in this plan is intended to integrate the application of available information to salmon recovery questions, and to fill in key gaps as needed to support successful implementation of the Recovery and Watershed Plans.

Successful implementation of this RM&E program will require the coordination and integration of efforts by implementation partners throughout the lower Columbia region. This program recognizes that RM&E efforts are often constrained by logistical and budgetary considerations. This program is intended to guide, prioritize and focus the efforts of implementation partners to achieve recovery objectives and goals, in light of these constraints.

2.5 Implementation Strategy

This RM&E Program is based on Recovery and Watershed Plan guidance in the form of A) strategies that provide overarching approaches for achieving plan objectives and B) working hypotheses or assumptions that underlie selection and definition of strategies.

Working hypotheses outlined in the Recovery and Watershed Plans include:

1. Successful implementation of this recovery/subbasin plan is predicated on an effective monitoring, research, and evaluation plan. Working hypotheses upon which the Recovery Plan is based provide clear direction but many hypotheses are uncertain. Future course corrections will be required based on RM&E.
2. Programmatic “top-down” and project “bottom up” monitoring, research, and evaluation approaches each provide useful guidance and an effective plan will incorporate elements of both approaches.
3. Existing programs meet many but not all RM&E needs of this plan.
4. There are direct tradeoffs in time and resource costs between RM&E and recovery actions that more directly affect species of interest.
5. It is not feasible to fund and implement projects to monitor, research, or evaluate every focal fish population, uncertainty or action.

RM&E strategies include:

1. Develop a programmatic regional framework for monitoring, research and evaluation to address ecosystem and ESU-wide concerns of fish recovery.
2. Define monitoring, research, and evaluation elements necessary to address both status and threats as identified by the National Marine Fisheries Service for listing considerations.
3. Recognize different spatial and temporal scales appropriate to a variety of programmatic and project-specific applications of RM&E with a framework that incorporates routine and statistical status monitoring, action effectiveness monitoring, implementation monitoring, and critical uncertainty research.
4. Optimize efficiencies by incorporating and adapting existing monitoring, research, and evaluation activities into the plan.
5. Utilize other Columbia Basin ecosystem and oceanographic monitoring, research, and evaluation efforts.
6. Identify information gaps that need to be addressed with new monitoring and evaluation activities while also balancing a recognition that the available resources limit implementation to the highest priorities and that tradeoffs exist between RM&E activities and measures that more directly contribute to fish recovery.
7. Focus selected monitoring and research activities in intensively monitored watersheds (IWAs) to optimize opportunities for identifying cause and effect relationships while also providing cost efficiencies.
8. Focus research on the effective implementation of recovery measures rather than detailed mechanistic studies of relationships between fish and limiting factors.
9. Incorporate provisions for regional coordination and data distribution to maximize accessibility and applicability.
10. Incorporate an adaptive evaluation framework with clear decisions points and direction to guide future actions.

2.6 Program Elements

Monitoring evaluations of Recovery and Watershed Plan implementation and effects revolve around a series of fundamental questions that address watershed health and salmon and steelhead status and threats (Figure 3). This document includes six fundamental elements of a comprehensive monitoring, research, and evaluation program organized around these questions. Elements include: 1) biological status and trend monitoring, 2) habitat status and trend monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. For each of these elements, this program identifies: A) objectives, B) indicators, C) available information, D) sampling and analytical design, E) information gaps and priorities, and F) implementation measures.

Biological status and trend monitoring - Characterizes the existing salmon and trout populations for evaluation of progress toward ESU recovery goals and objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Reflects temporal and spatial variability of the resource.

Habitat status and trend monitoring - Characterizes the physical, chemical and water quality conditions to evaluate the cumulative effect of human activity trends and recovery measures on critical limiting factors. Reflects temporal and spatial variability of the resource. Provides information on status of salmonid habitat factors and threats as well as cumulative effects of habitat protection and restoration actions. Habitat status and trends monitoring is focused on subbasin conditions. Monitoring of out-of-subbasin natural factors is being conducted on a system-wide scale and will be incorporated into evaluations of data provided by this regional program.

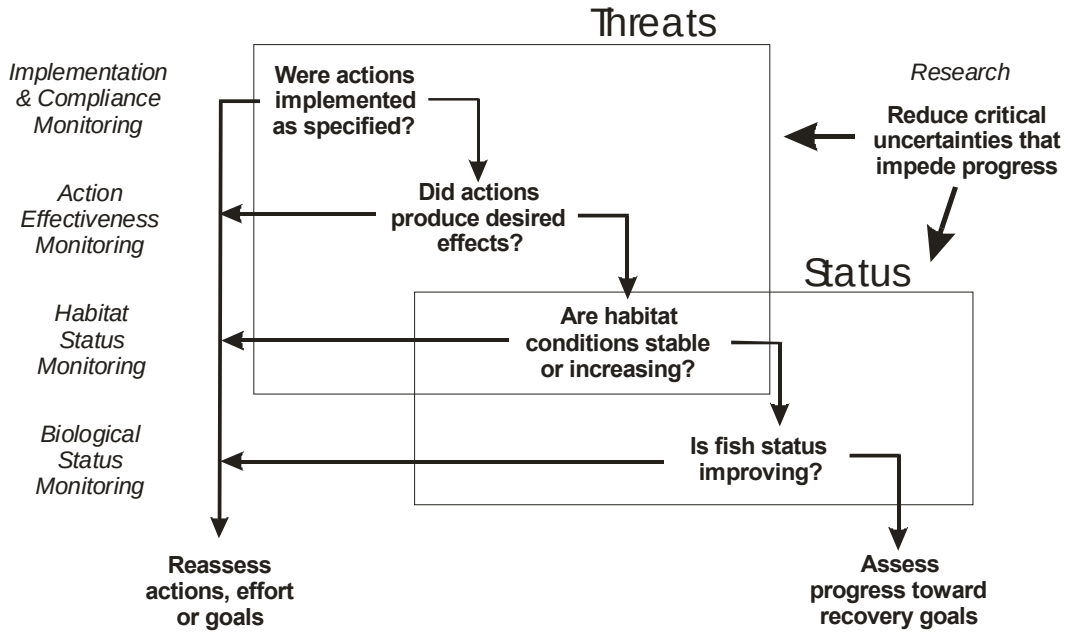

Figure 3. Monitoring, research and evaluation program elements.

Implementation/Compliance Monitoring - Determines if Recovery and Watershed Plan actions were implemented as planned.

Action Effectiveness Monitoring - Determines if actions had the desired functional effects (i.e. site-specific conditions or physical watershed processes). This program defines action effectiveness monitoring to include measurements of specific habitat, hydropower, hatchery, harvest, and ecological interaction effects. A key element is the evaluation of status and trends in threats. Monitoring and evaluation plans in other regions have sometimes adopted a more narrow definition of action effectiveness monitoring specifically focused on research on cause and effect relationships.

Uncertainty, Effectiveness, and Validation Research - Characterizes unknown ecological relationships and evaluates whether the hypothesized cause and effect relationships between restoration action and response (physical or biological) were correct. Research identified in this program targets specific issues that constrain effective Recovery Plan implementation including evaluations of cause and effect relationships between fish, limiting factors, and actions that address specific threats related to limiting factors.

Programmatic Evaluation - Evaluation includes interpretation of monitoring and research results, assessing the deviation from particular target goals or anticipated results, and recommending appropriate modifications to recovery strategies, measures, and actions. For the purposes of this plan, evaluation also includes gathering of diverse information available from a wide range of sources, processing and synthesis into common scales and formats required for analysis, and reporting of results and findings.

RM&E program elements are designed specifically to address NMFS's listing/delisting criteria based on an evaluation of both an ESU's viability and the extent to which the threats facing the ESU have been addressed. Delisting or downlisting of threatened or endangered species will ultimately depend on achievement of biological and threat-related criteria. Viability is assessed through a combination of biological and habitat status monitoring. Threats are addressed through a combination of habitat status monitoring, implementation/compliance and action effectiveness monitoring. Research provides guidance for evaluations of both status and threats. Note that habitat status monitoring can help assess both biological status and habitat threats. Inferences from habitat conditions are useful in biological status monitoring because comprehensive biological assessments of every population are not feasible. Habitat status also reflects the cumulative effectiveness of all habitat actions and impacts in aggregate.

The objective for habitat monitoring is to fully characterize, directly and inferentially, the baseline and changing habitat conditions over time. The distinction in monitoring biological populations versus habitat conditions is an important and purposeful strategy that supports the long-term assessment of viability. It allows the RM&E program to focus biological monitoring on listed populations, but simultaneously recognize possible changes in habitat use over time. For example, if currently impassible barriers are removed, additional spawning and rearing habitat may be colonized. In such a situation, habitat status data would be available and likely incorporated into the restoration planning process. As such the Lower Columbia monitoring program has chosen to characterize all habitat types, rather than focus on those currently associated with threatened fish populations. Sections 3.0 and 4.0 of this report detail the biological and habitat monitoring design strategies. Both forms of monitoring are subject to the adaptive management process and time tables. Habitat conditions, rated relative to properly functioning conditions (PFC) criteria, will be incorporated into the ESU's viability assessments.

Definitions in this plan are generally consistent with, but not always exactly equivalent to, those similar elements in other regional RM&E plans. For instance, we define action effectiveness monitoring to include status and trends of threats whereas other plans sometimes define effectiveness monitoring in terms of a specific research on cause and effect relationships. Although definitions may vary from plan to plan, each regional plan typically includes the same fundamental categories and elements.

3. Biological Status Monitoring

3.1 Objectives

Biological status monitoring is intended to characterize the likelihood of long term persistence (and conversely the risk of extinction) relative to the baseline condition at listing, periodic checkpoints in Recovery Plan implementation, and recovery goals. In addition to describing progress toward ESU recovery objectives, biological status monitoring also provides data necessary for action effectiveness monitoring and research to resolve critical uncertainties.

Null hypothesis:	**Fish status is unchanged or has continued to decline since listing.**
Alternative:	**Fish status has improved since listing.**

3.2 Strategy

This monitoring program identifies target sample numbers for strata by sampling intensity level based on the following guidelines:

M.S10. [1] ***Biological monitoring needs to address both ESU and population level viability recovery criteria and population parameters related to viability (abundance, productivity, spatial structure, and diversity).***

Evaluations of biological status are based on a series of indicators that are measured or derived variables defined at different hierarchical scales. Status and trends are evaluated at ESU, strata, and population levels. Each ESU is comprised of multiple geographical strata delineated to consider ecological differences among different geophysical regions within an ESU. Each stratum includes one or more populations. Recovery criteria defined by the Technical Recovery Team are detailed in the Recovery Plan.

M.S11. Status of every population needs to be assessed but all populations don't need to be monitored.

Assessments of progress toward recovery require information on the status of each population. Recovery Plan goals developed based on Technical Recovery Team criteria prescribe population levels consistent with ESU viability. Goals are based on average viability levels exceeding moderate for each strata as well as at least two populations per strata at high levels of viability. Ideally every population would be independently monitored. A combination of indicator, inventory, and intensive monitoring will provide an appropriate basis for inferring the status of every population. More comprehensive analysis for a representative subset of population will provide a valid basis for inference. However, status of some populations might be inferred from monitoring of other like-populations or habitat conditions, particularly for small unproductive populations targeted only for stabilization by the recovery strategy.

[1] *Monitoring Strategy (M.S#) codes correspond to those assigned in the WA Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (LCFRB 2010).*

M.S12. Highest priorities for monitoring are assigned to populations targeted in recovery strategies for high viability or large improvements.

A fundamental recovery strategy involves protection and restoration of key populations to high levels of viability. These populations also provide the best opportunities for effective implementation of an intensive monitoring program which represents a full suite of population dynamics information. Ideally, monitoring programs would be allocated across a representative range of population types but resource limitations will constrain the feasibility of conducting comprehensive monitoring programs for multiple populations within a species. Because only a subset of populations will ultimately drive recovery, the monitoring program is focused on identifying the status of that subset rather than of all populations in the ESU. The Recovery Plan identifies population priorities based on Primary, Contributing, and Stabilizing categories. Primary populations are those targeted for restoration to high or very high levels of viability. Contributing populations are those for which significant restorations will be needed to achieve a strata wide average of medium viability. Stabilizing populations are those that would be maintained at current levels.

M.S13. Representative samples are needed for Primary and Contributing populations for every species/life history type and strata (major population group) based on intensive or inventory monitoring.

Recovery will depend on improvements in both strong and weak populations. Status varies significantly among populations within a stratum. Different populations are subject to different limitations and can be expected to respond in varying ways to recovery actions. Not every Primary or Contributing population needs to be monitored at an intensive or inventory level but those that are rigorously monitored must be representative of those that are monitored at a lesser intensity.

M.S14. Intensive monitoring of juveniles and adults should occur for at least one population of every species/life history type and strata (major population group).

It is not realistic to expect to intensively monitor every population to assess status of each at the highest levels of precision and accuracy. A full suite of abundance, productivity, distribution, and diversity information based in intensive monitoring will provide a basis for analysis of fundamental relationships and assumptions of the monitoring program. This monitoring should include intensive monitoring of both adults (fish in) and juveniles (fish out) to provide life stage-specific information on production and factors affecting production. High levels of monitoring will include one intensively monitored population per species. Very high levels of monitoring occur when one population per strata is intensively monitored. Target monitoring levels will be determined based on funding availability.

M.S15. Higher priority is assigned to additional coverage of populations at intensive or inventory sampling intensity than coverage of multiple populations within a species/life history (major population group) at an intensive sampling level.

There is a tradeoff between the intensity of monitoring of a limited number of populations and the depth of monitoring of a greater number of populations. This plan prioritizes monitoring more populations at an intensive or inventory levels rather than monitoring fewer populations at in intensive level.

3.3 Indicators

3.3.1 Attributes & Metrics

We have categorized indicators as attributes, metrics, and statistics. Attributes of biological status include viability and Viable Salmonid Population (VSP) characteristics including abundance, productivity, distribution, and diversity (Figure 4). Box 1 describes the general approach to monitoring of each attribute. Table 2 details specific metrics that can be statistically quantified for each attribute. For instance, mathematical persistence probabilities (and conversely extinction risks) can be estimated using population trend or life cycle models parameterized with attribute data on abundance and productivity. In addition, the TRT has identified a categorical scoring approach that infers biological viability levels from quantitative and qualitative information for each VSP attribute. Figure 4 illustrates examples of VSP metrics with fish data.

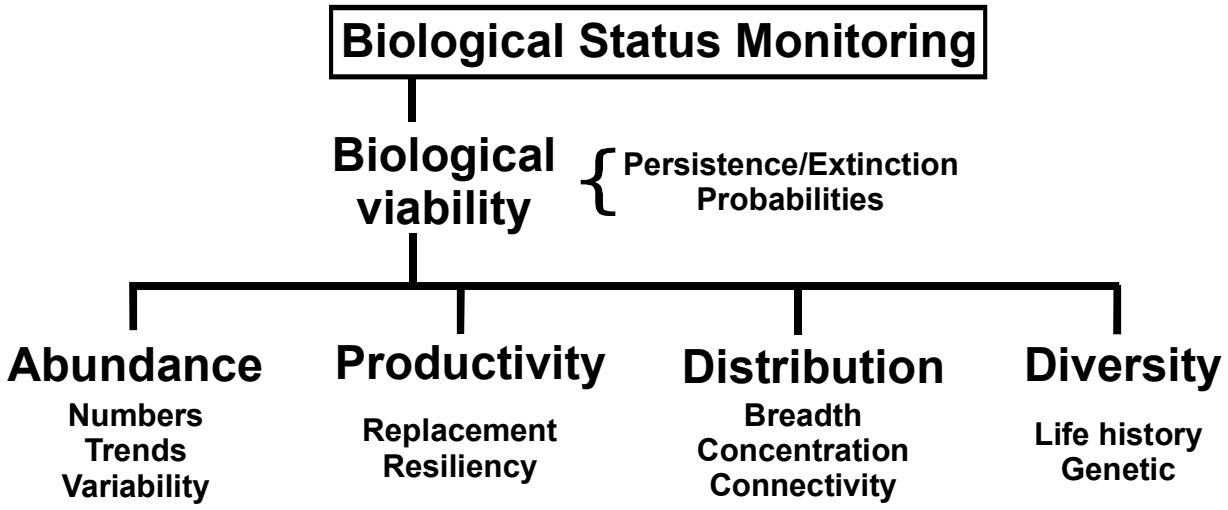

Figure 4. Elements for biological status monitoring of salmon recovery.

Box 1. Generalized description of biological monitoring approach for viable salmonid population attributes.

1. ***Monitor adult spawning abundance of representative populations of Chinook, chum, coho, and steelhead.***

   Questions: What is the current population size and trend relative to the recovery objective?

   Data: Estimates of absolute or relative abundance from counts of live fish, carcasses, or redds

   Sampling: Representative long term index sites (dams, weirs, snorkel, ground or aerial surveys)

   Analysis: Geometric mean number of spawners and annualized population growth rate.

2. ***Monitor juvenile abundance of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: What is current juvenile abundance and trend relative to the recovery objective?

   Data: Juvenile migrant population estimates or indices of abundance, size, age, migration dates.

   Sampling: Collection of migrating juveniles at representative index sites (traps, mark-recapture, catch per unit effort).

   Analysis: Annualized population growth rate, juveniles per spawner.

3. ***Monitor productivity of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: What is current productivity and trend in productivity relative to the recovery objective?

   Data: Numbers, ages, hatchery/wild origin.

   Sampling: Annual size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data.

   Analysis: Natural juvenile and/or adult recruits per spawner based on cohort run reconstructions.

4. ***Monitor distribution/spatial structure of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: How many reaches are used for spawning and how has distribution of spawners among reaches varied in relation to abundance, accessibility and historical use?

   Data: Indices of relative abundance of adults from counts of live fish, carcasses or redds and/or juveniles based on snorkel, electrofishing, or seining surveys.

   Sampling: Replicate random samples stratified by time period and area in one or more years, repeated at periodic intervals.

   Analysis: Relative abundance, range, patchiness, used vs. available area, representation of index sites identified in routine sampling.

5. ***Monitor trends and variation in diversity of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.***

   Questions: Do all life history patterns continue to be represented and are traits changing relative to objective descriptions?

   Data: Sex, size, fecundity, migration timing, hatchery influence, genetic characteristics.

   Sampling: Representative individual samples from adult or juvenile fish or carcasses in conjunction with adult or juvenile abundance and distribution sampling.

   Analysis: Averages and frequency distributions of data over time.

Table 2. Attributes, metrics, and example statistics for use as indicators of biological status. (Every statistic not expected to be available for every population.)

Attributes	Metrics	Example statistics
Biological viability	Persistence probability	Extinction risk
		Categorical scores based on criteria
Abundance (adults or juveniles)	Numbers	Geometric mean (4-, 12-, 20-yr)
		Median (4-, 12-, 20-yr)
		Stock-recruitment equilibrium abundance
	Trends	Time series slope (4-, 12-, 20-year)
		Median annual population growth rate (λ)
	Variability	Range (4-, 12-, 20-year)
		Variance (4-, 12-, 20-year)
		Coefficient of variation
Productivity	(Adult spawners)	
	Replacement	Spawner recruits per spawner (averages)
	Resiliency	Geometric mean recruits per spawner at low spawner nos.
		Stock-recruit function intercept parameter
	(Juveniles)	
	Replacement	Smolts per spawner (averages)
	Resiliency	Juvenile production function intercept
Distribution	(Spawning & rearing habitat)	
	Breadth	Miles accessible
	Concentration	Spawners per mile
	Connectivity	Miles occupied, % of historical usage
Diversity	Life History	% hatchery origin spawners & origin (pHOS),
		% natural origin broodstock (pNOB)
		% natural influence (PNI)
		Age at migration (frequency distribution)
		Age at maturation (frequency distribution)
		Run timing (mean & range)
		Fecundity (by size)
	Genetic	Frequency of population bottlenecks (generational geometric mean < threshold)
		Heterozygosity
		Frequency of rare types

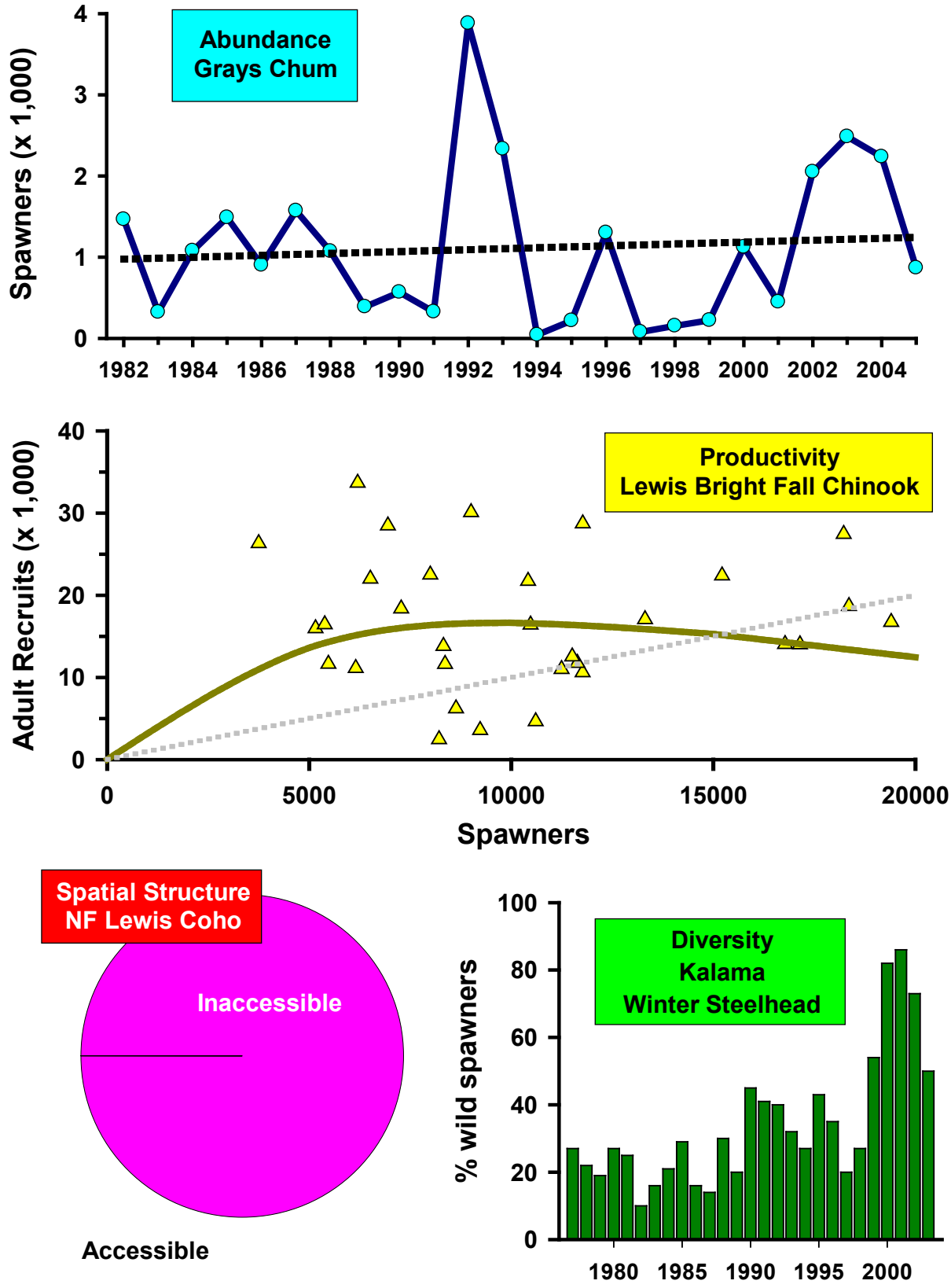

Figure 5. **Examples of Viable Salmonid Population data and metrics as applied to several lower Columbia River populations.**

3.3.2 Status Criteria

Assessments of progress toward biological viability goals will rely on quantitative and qualitative interpretations of attribute metrics and statistics. Interpretations will be based on changes in indicators over time as well as comparisons with criteria values. Criteria do not represent goals but are goal-related reference points or standards against which to compare performance achievements. Many different combinations of attribute conditions might satisfy recovery goals. Criteria provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level.

The Recovery Plan identifies goals based on ESU and population-specific criteria. ESU scale criteria (Table 3) were developed by the TRT. For instance, the TRT describes a high persistence probability for an ESU strata where the average population persistence probability is significantly greater than moderate and at least two populations are at high levels of persistence (e.g. <5% risk of extinction). All strata must achieve high persistence levels to meet recovery goals. Population-scale criteria (Table 4) were developed by the LCFRB and WDFW to address criteria developed by the TRT. Population-scale criteria identify attribute values generally corresponding with population persistence levels. The current TRT approach to rating status calculates persistence category for a population based on a weighted average of the attribute scores (TRT 2003).

Table 3. ESU strata-level criteria for evaluating fish status relative to recovery criteria guidelines (TRT 2003).

Strata-level Persistence probability	Average of population persistence	Populations at high persistence
Low (<75%)	Less than moderate (<2.0)	none
Moderate (75-95%)	Moderate (2.0 – 2.25)	at least 2
High (>95%)	Above moderate (>2.25)	at least 2

Based on a qualitative population score where persistence probability is 0 = very low (≤40%), 1 =low (40 -75%), 2 = moderate (75-95%), 3 = high (95-99%), and 4 = very high (>99%).

Table 4. Population-level criteria for evaluating fish status relative to recovery criteria guidelines.

Category	Description	Values[1]
	Population Persistence	
0	Either extinct or very high risk of extinction	Very low (0-40%) probability of persistence for 100 years
1	Relatively high risk of extinction	Low (40-75%) probability of persistence for 100 years
2	Moderate risk of extinction	Medium (75-95%) probability of persistence for 100 years
3	Low (negligible) risk of extinction	High (95-99%) probability of persistence for 100 years
4	Very low risk of extinction	Very High (>99%) probability of persistence for 100 years
	Adult Abundance and Productivity	
0	Numbers and productivity consistent with either functional extinction or very high risk of extinction	Extinction risk analysis estimates 0-40% persistence probability.
1	Numbers and productivity consistent with relatively high risk of extinction	Extinction risk analysis estimates 40-75% persistence probability.
2	Numbers and productivity consistent with moderate risk of extinction	Extinction risk analysis estimates 75-95% persistence probability.
3	Numbers and productivity consistent with low (negligible) risk of extinction	Extinction risk analysis estimates 95-99% persistence probability.
4	Numbers and productivity consistent with very low risk of extinction	Extinction risk analysis estimates >99% persistence probability.
	Juvenile Out-Emigrants	Evaluated based on the *occurrence* of natural production, whether natural production was *self sustaining* or supplemented by hatchery fish*, trends* in numbers, and *variability* in numbers.
0	Consistent with either functional extinction or very high risk of extinction[3]	No significant juvenile production either because no natural spawning occurs or because natural spawning by wild or hatchery fish occurs but is unproductive.
1	Consistent with relatively high risk of extinction[3]	Long term trend in wild natural production is strongly negative. Also includes the case where significant natural production occurs in many years but originates primarily from hatchery fish.
2	Consistent with moderate risk of extinction[3]	Sample data indicates that significant natural production occurs in most years and originates primarily from naturally-produced fish. No trend in numbers may be apparent but numbers are highly variable with only a small portion of the variability related to spawning escapement.
3	Consistent with low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. No long term decreasing trend in numbers is apparent. Juvenile numbers may be variable but at least some of this variability is related to fluctuations in spawning escapement.

Category	Description	Values[1]
4	Consistent with very low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. Trend is stable or increasing over extended time period. Variability in juvenile production is low or a large share of the observed variability is correlated with spawning escapement.
	Within-Population Spatial Structure	
0	Spatial structure is inadequate in quantity, quality[2], and connectivity to support a population at all.	*Quantity* was based on whether all areas that were historically used remain accessible. *Connectivity* based on whether all accessible areas of historical use remain in use. *Catastrophic risk* based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.
1	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population far below viable size	The majority of the historical range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.
2	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population of moderate but less than viable size.	The majority of the historical range is accessible but fish are currently concentrated in a small portion of the accessible area.
3	Spatial structure is adequate in quantity, quality[2], and connectivity to support population of viable size, but subcriteria for dynamics and/or catastrophic risk are not met	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.
4	Spatial structure is adequate to quantity, quality, connectivity, dynamics, and catastrophic risk to support viable population.	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.
	Within-Population Diversity	
0	All four diversity elements (life history diversity, gene flow and genetic diversity, utilization of diverse habitats, and resilience and adaptation to environmental fluctuations) are well below predicted historical levels, extirpated populations, or remnant populations of unknown lineage	*Life history diversity* was based on comparison of adult and juvenile migration timing and age composition. *Genetic diversity* was based on the occurrence of small population bottlenecks in historical spawning escapement and degree of hatchery influence especially by non local stocks. *Resiliency* was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.
1	At least two diversity elements are well below historical levels. Population may not have adequate diversity to buffer the population against relatively minor environmental changes or utilize diverse habitats. Loss of major presumed life history phenotypes is evident; genetic estimates indicate major loss in genetic variation and/or small effective population size. Factors that severely limit the potential for local adaptation are present.	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.

Category	Description	Values[1]
2	At least one diversity element is well below predicted historical levels; population diversity may not be adequate to buffer strong environmental variation and/or utilize available diverse habitats. Loss of life history phenotypes, especially among important life history traits, and/or reduction in genetic variation is evident. Factors that limit the potential for local adaptation are present.	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.
3	Diversity elements are not at predicted historical levels, but are at levels able to maintain a population. Minor shifts in proportions of historical life-history variants, and/or genetic estimates, indicate some loss in variation (e.g. number of alleles and heterozygosity), and conditions for local adaptation processes are present.	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.
4	All four diversity elements are similar to predicted historical levels. A suite of life-history variants, appropriate levels of genetic variation, and conditions for local adaptation processes are present.	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.
	Habitat	
0	Habitat is incapable of supporting fish or is likely to be incapable of supporting fish in the foreseeable future	*Unsuitable habitat.* Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historical range are addressed by spatial structure criteria[2].
1	Habitat exhibits a combination of impairment and likely future conditions such that population is at high risk of extinction	*Highly impaired habitat.* Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur in only in favorable years.
2	Habitat exhibits a combination of current impairment and likely future condition such that the population is at moderate risk of extinction	*Moderately impaired habitat.* Significant degradation in habitat quality associated with reduced population productivity.
3	Habitat in unimpaired and likely future conditions will support a viable salmon population	*Intact habitat.* Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)
4	Habitat conditions and likely future conditions support a population with an extinction risk lower than that defined by a viable salmon population. Habitat conditions consistent with this category are likely comparable to those that historically existed.	*Favorable habitat.* Quality is near or at optimums for salmon. Includes properly functioning through pristine historical conditions.

[1] *Rules were derived by the LCFRB and WDFW staff for attribute descriptions from McElhany et al. 2003. Application rules do not represent assessment by the TRT which is currently in the process of refining criteria.*

[2] *Because recovery criteria are closely related, draft category descriptions developed by the TRT often incorporate similar metrics among multiple criteria. For instance, habitat-based factors have been defined for diversity, spatial structure, and habitat standards. To avoid double counting the same information, streamline the scoring process, and provide for a systematic and repeatable scoring system this application of the criteria used specific metrics only in the criteria where most applicable. This footnote denotes these items.*

[3] *This is a modification of the interim criteria identified by the TRT for consistency with other criteria.*

3.3.3 Sample Summary Reports

Example reporting templates for biological status data are depicted in Table 5. Examples were included to illustrate how biological status data might begin to be organized and used. Many alternative depictions might ultimately be developed.

Table 5. Sample reporting templates.

Population viability data

Species		Washington	Current viability (No. of pop.)				Viability goal (No. of pop.)			
Type	Strata	Populations	Low	Med	High	Avg.	Low	Med	High	Avg.
Chinook										
Spring	Cascade Gorge	6	6	0	0	Low	1	3	2	Med+
Fall	Coast Cascade Gorge									
Late Fall	Cascade									

Abundance data

Species			Numbers (avg.)					Trends (avg.)			Viability
Type	Strata	Population	Goal	Base	4-yr	10-yr	25-yr	4-yr	10-yr	25-yr	category
Chinook											
Spring	Cascade	U. Cowlitz Cispus									

Productivity data

Species			Observed spawner/spawner				Normalized values					Viability
Type	Strata	Population	Base	4-yr	10-yr	25-yr	Goal	Base	4-yr	10-yr	25-yr	category
…												

Distribution data

Species			Accessibility			Occupancy				Viability
Type	Strata	Population	Hist. (Miles)	Base (%)	Current (%)	Base	4-yr	10-yr	25-yr	category
…										

Diversity data

Species			Hatchery fraction (avg.)					Bottleneck freq.			Viability
Type	Strata	Population	Goal	Base	4-yr	10-yr	25-yr	4-yr	10-yr	25-yr	category
…											

3.4 Sampling & Analytical Design

3.4.1 Framework

This program identifies a stratified, representative, multi-level sampling framework for monitoring the biological status at a population unit scale. It is simply not realistic to monitor every VSP parameter for every population in every year at a high level of precision due to costs of intensive biological monitoring, other monitoring and research needs, and tradeoffs in funding priorities between monitoring and other recovery actions. Instead, this plan identifies a biological sampling program that provides information on every population, but samples different populations at different intensities, and employs a stratified subsampling distribution of effort among populations to ensure representative coverage of all ESUs. The design incorporates existing activities and identifies priorities for additional biological monitoring efforts necessary to address identified gaps. This program is designed to provide the information necessary to assess progress toward achieving recovery goals and objectives. The stratified, representative, multi-level sampling design addresses the following four elements:

1) Major population group (strata) (Species, Stock & Region)
2) Intensity (Intensive, Inventory, Indicator)
3) Life stage (Juveniles, Adults)
4) Frequency (Annual, Periodic)

Sample strata are major population groups described by the TRT based on species, life history characteristics, and geographical proximity. A total of 102 populations of four species and seven species/life history types have been delineated by the TRT for this region (Table 6). Of these, 72 (71%) occur wholly or partly in Washington. Geographical strata reflect common spatial and ecological influences. The Coast stratum includes Columbia tributary subbasins downstream from the Cowlitz River. These subbasins are comprised of small rain-driven systems draining forestlands of the southern Willapa Hills. The Cascade stratum includes Cowlitz, Lewis, and Washougal subbasins, draining the West slope of the Cascades. These are typically larger rainfall and snow-driven systems in a mixture of forest and developed lands. The Gorge stratum includes systems from upstream of the Washougal River, to the White Salmon River. Gorge subbasins are typically small to moderate-sized, steep, forested Cascade systems.

Table 6. Numbers of Washington and Oregon Lower Columbia populations occurring in sample strata consisting of geographical/ecological regions and species/life history types (Washington populations are in parentheses).

	Chinook				Steelhead		
Strata	**Spring**	**Fall (tule)**	**Late Fall (bright)**	**Chum**	**Winter**	**Summer**	**Coho**
Coast	**0 (0)**	**7 (3)**	**0 (0)**	**7 (3)**	**7 (3)** [1]	**0 (0)**	**7 (3)**
Cascade	**7 (6)**	**10 (8)**	**2 (1)**	**7 (5)**	**14 (12)**	**4 (4)**	**14 (12)**
Gorge	**2 (1)**	**4 (3)**	**0 (0)**	**2 (2)**	**3 (2)**	**2 (1)**	**4 (3)**
Total	***9 (7)***	***21 (14)***	***2 (1)***	***16 (10)***	***24 (17)***	***6 (5)***	***25 (18)***

[1] *Not listed*

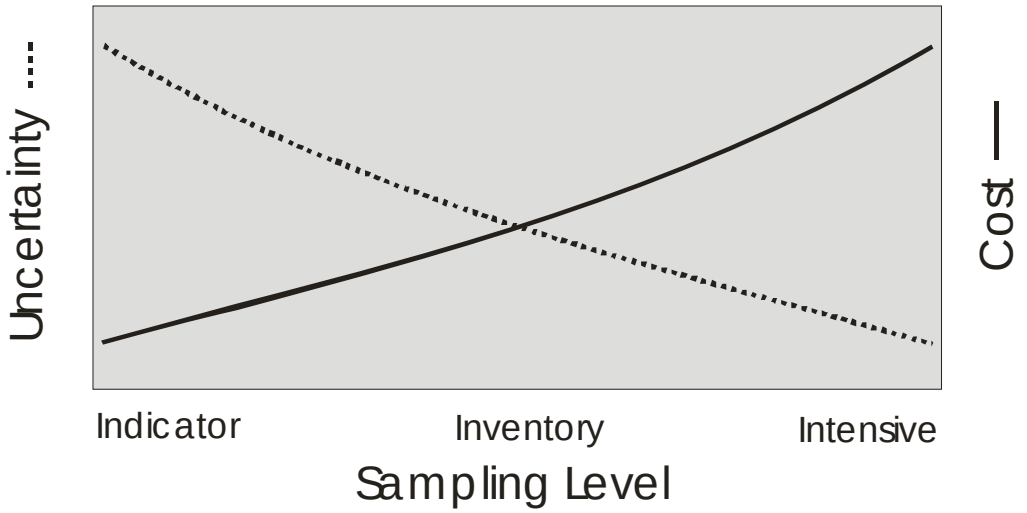

Figure 6. Tradeoffs in benefits among sampling protocols of varying intensity.

Three levels of sampling intensity are identified, reflecting tradeoffs between the precision provided and effort required for implementation (Figure 6). Levels are distinguished by the depth and breadth of adult and juvenile sampling activities. Any given sampling activity typically addresses multiple VSP parameters. Therefore sampling activities intended to estimate VSP parameters are bundled for the purposes of this program. Rather than repeating descriptions of the sampling activities needed to address each individual VSP parameter, this program identifies integrated suites of activities that address complementary VSP elements at a given level of accuracy and precision.

The ***Intensive*** sampling level provides the most comprehensive and detailed information on abundance, distribution, productivity, and diversity based on adult or juvenile direct census, marking or tagging, and individual fish sampling. Intensive sampling is distinguished by direct empirical measurements of attribute metrics and critical assumptions of the sampling method. For instance, intensive sampling would include comprehensive time and area surveys or mark-recapture programs to determine census accuracy. The high depth, accuracy, and precision of an intensive sampling program can be costly and has most effectively been implemented as part of a large-scale research program. Intensive sampling efforts have not been widely implemented in the lower Columbia.

The ***Inventory*** sampling level provides similar information on VSP attributes but with less rigorous testing of assumptions and greater uncertainty. For instance, expansions of adult index counts into estimates of absolute abundance might rely on historical or periodic rather than annual estimates of the proportional representation of index areas and periods. Similarly, spawner surveys might include index and extensive reaches that account for the large majority of the spawning distribution, but might be limited in occasional use areas. Tradeoffs in detailed assessments of assumptions can allow a much broader coverage of populations using inventory sampling than could be accomplished for the same cost and effort with intensive sampling. Faced with limited resources, the choice is between more detailed information for a few populations with intensive sampling or coverage of more populations at a lesser depth using an

inventory protocol. Inventory sampling has been widely implemented in the lower Columbia, particularly for Chinook and steelhead.

Indicator sampling is the least rigorous of the proposed sampling levels but provides key information on relative abundance and distribution at a population scale for a modest cost. It provides a means for status assessment of many populations where the available resources are not adequate to support intensive or inventory sampling. In the lower Columbia, limited sampling is commonly used to assess steelhead, coho and chum populations.

Intensive, inventory, and indicator sampling may be focused on adult and juvenile samples. Intensive sampling protocols typically involve both adult and juveniles sampling. Comparisons of adult and juvenile numbers provide very powerful information for interpreting patterns of variation in abundance as well as driving factors. Adult and juvenile sample levels are allocated independently. For instance, an inventory juvenile sampling program might be implemented for the same population as an intensive adult sampling program.

Sampling may be either annual (every year) or periodic (multi-year intervals). Annual sampling is generally intended to provide a detailed time series of status information to assess trends and variability. Periodic samples are primarily intended to evaluate status of less-intensively monitored populations relative to more-intensively monitored populations. Intervals for periodic sampling depend on the information objective.

3.4.2 Methods

Sampling methods associated with different sampling intensities for adult and juvenile salmonids are summarized below and in (Table 7). The table also describes how the sampling relates to the VSP parameters.

Intensive Sampling - Adults

Intensive adult sampling typically estimates absolute annual numbers of fish based on counts of fish at dams or weirs, or counts of live fish, carcasses, or redds in spawning or staging areas by ground, aerial, or snorkel surveys. Effective sampling methods are determined by the species and habitat type circumstances. In some cases, particularly at dams or weirs, counts may represent a near-absolute census of the population. However, in many cases, counts represent a subsample of the total population. An intensive sampling protocol estimates total annual numbers of fish from subsample data using expansion factors calculated from comprehensive time and area sample surveys, or mark-recapture data. Intensive surveys generally include multiple samples throughout the spawning period to accommodate temporal differences in abundance as well as individual fish that are present at different times. Intensive surveys also include all spawning areas or a stratified random approach including major spawning areas with subsamples of areas of limited use. In some cases, annual sampling is based on a subsample of representative index sites and times, while periodic sampling is conducted to develop expansion factors.

Intensive adult sampling provides detailed information on abundance, productivity, and diversity. Detailed information is also provided on distribution where based on spawning

ground surveys. Census data from adult abundance sampling generally provides the most accurate and precise data available for estimating annual patterns and trends in spawner numbers. Adult abundance sampling also provides detailed information on distribution, productivity, and diversity in addition to abundance. Costs of adult abundance sampling can be significant, particularly when coupled with collection of data on ages or size, hatchery fractions, and tag recovery.

Inventory Sampling - Adults

Inventory sampling of adults involves estimates of annual patterns and trends based on counts of live fish, carcasses, or redds made by ground, aerial, or snorkel surveys for a representative subsample of the available spatial and temporal distribution. Total population size might be estimated from index counts expanded for time and area by the assumed proportion of the total represented by the index area and period. The approach may be similar to intensive sampling except that expansions of index samples are based on more limited data (assumed values or non-replicated estimates).

Index sample sites are standardized from year to year to eliminate site effects on fish density that might confound interpretations of annual trends. The tradeoff is that differences in distribution between sampled and unsampled areas can affect annual patterns. For this reason, sampling areas are often selected to represent core production areas. Index sampling provides a systematic means of monitoring fish status at a moderate cost, accuracy, and precision.

Adult inventory sampling is designed to provide information on trends in abundance. Unlike intensive adult abundance sampling programs, inventory sampling programs typically provide limited information on distribution and diversity. Relative productivity data may be developed from index samples where coupled with age and mark sampling.

Indicator Sampling - Adults

Indicator sampling of adults describes annual patterns and trends based on unexpanded or partially-expanded relative numbers. Indicator sites typically include a subset of potential spawning areas. Counts might be made only once per year on historic peak spawning activity dates. Data is often represented on a unit basis (e.g. counts per mile). Representative sites and times are ideally selected during program development based on an initial survey of all potential spawning areas. Indicator samples might be made every year or in periodic years.

Indicator sampling may also involve adult presence/absence sampling involving low intensity reconnaissance grade surveys to determine if significant numbers of spawners may be present in any given area or time. They may be based on ground, aerial, or snorkel counts and are often periodic in nature. The primary purpose of the reconnaissance sampling is to track sporadic patterns of occurrence and distribution in cases where more formal rigorous sampling programs are not in place. Presence/absence sampling provides limited information on distribution but little or no statistical information on abundance, productivity or diversity.

Table 7. Description of representative multi-level sampling design components of biological status monitoring.

Level, Life stage	Attribute	Information type	Sampling activities[1]	Frequency
1. Intensive				
Adults	Abundance	Spawner census (total abundance)	Weir/dam counts, mark-recapture, or comprehensive time & area spawner surveys	Annual
	Distribution	Core & dispersed production areas	Spawner surveys of index & extensive reaches (e.g. EMAP style design)	Annual
	Productivity	Spawner recruits per spawner	Hatchery origin & age samples for brood year reconstructions	Annual
	Diversity	Hatchery fraction, age composition	Individual fish or carcass sampling for marks, CWTs, and scales	Annual
Juveniles	Abundance	Migrant census (total numbers)	Migrant trap counts, trap efficiencies from mark-recapture	Annual
	Distribution	Mainstem & ocean occurrence, timing	CWT of juveniles, ocean fishery recoveries	Periodic
	Productivity	Parr or smolts per spawner	Brood year comparisons with adult data	Annual
	Diversity	Run timing, size/age distribution	Seasonal trap catch rates, individual fish subsampling at traps	Annual
2. Inventory				
Adults	Abundance	Spawner no. (estimated abundance)	Spawner index surveys (standardized expansions for time & area)	Annual
	Distribution	Core & dispersed production areas	Spawner surveys of extensive reaches	Periodic
	Productivity	Spawner recruits per spawner	Hatchery origin & age samples for brood year reconstructions	Annual
	Diversity	Hatchery fraction, age composition	Individual fish or carcass sampling for marks, CWTs, and scales	Annual
Juveniles	Abundance	Migrant index (relative numbers)	Migrant trap, seine, or electrofishing catch per unit effort	Annual
	Distribution	Core & dispersed production areas	Surveys of index & extensive reaches (e.g. EMAP style design)	Periodic
	Productivity	Index migrants per spawner	Brood year comparisons with adult data	Annual
	Diversity	Run timing or seasonal abundance	Seasonal catch rates	Periodic
3. Indicator				
Adults	Abundance	Spawner index (relative abundance)	Index area fish, carcass, or redd peak surveys (ground, aerial or snorkel)	Annual
	Distribution	Adult presence/absence	Reconnaissance surveys of non-index areas	Periodic
	Productivity	NA	NA	
	Diversity	NA	NA	
Juveniles	Abundance	Parr presence/absence	Snorkel or electrofishing surveys in rearing areas	Periodic
	Distribution	Parr presence/absence	Distributed sampling regime	Periodic
	Productivity	NA	NA	
	Diversity	NA	NA	

[1] *Representative activities. Variations can result from different cases.*

NA = not available.


Figure 7. Salmon redd and carcass surveys are often the basis for inventory or intensive sampling of adults.

Intensive Sampling - Juveniles

Intensive juvenile sampling provides estimates of absolute juvenile numbers, typically smolt or pre-smolt migrants. Absolute estimates are generally based on subsamples from the total population collected in migrant traps or dam fish passage facilities. Subsample numbers are then expanded based on sample rates that are best estimated from recovery rates of marked fish released upstream from the sample site. Juvenile abundance sampling is useful for estimating capacity and productivity of freshwater habitats, relationships between spawner and juvenile numbers, and annual population status. Juvenile surveys are particularly useful for population status assessments where spawner surveys are difficult. Juvenile sampling programs often provide information on size, age, and timing of outmigration. Juvenile sampling programs are often conducted in conjunction with other programs such as migration and survival studies. Juvenile abundance sampling is labor intensive and costly. As a result, juvenile sampling programs in streams are not widespread. Juvenile census sampling can provide extensive information on abundance and productivity, and more limited information on distribution and diversity.

Figure 8. Intensive sampling of juveniles often relies on migrant trapping with a rotary screw trap. Where coupled with releases of mark groups to estimate trap efficiency, smolt trapping can provide estimates of absolute abundance of juveniles.

Coded wire tagging is a component of some intensive juvenile sampling programs. Coded wire tags are typically implanted in juveniles and provide critical information on fish origins when recovered in fishery, hatchery, or spawning samples. CWTs are a critical element of fishery index stock programs designed to monitor catch distribution patterns and to limit fishery harvest and impacts of specific stocks to desired levels. CWTs also important in hatchery evaluations of fishery contributions and relative survival rates of different hatchery treatments. CWTs are batch marks that are implanted in large numbers for representative subsamples of most hatchery stocks. Lesser numbers of wild fish are marked with CWTs owing to the cost and difficulty of capturing and marking a large enough sample to provide useful information from the typically small fraction of marked fish that reach adulthood and are sampled. As a result, hatchery samples have often been used as surrogates for wild stocks in the past.

Inventory Sampling - Juveniles

Inventory juvenile sampling provides information on relative rather than absolute abundance. It is typically based on index counts per unit of sampling effort from catches in juvenile migrant traps, catches in seine or electrofishing samples, or numbers observed in snorkel surveys. Inventory sampling is often similar to abundance sampling but without the time, area, or sample rate expansions for a total census. Inventory sampling can be useful for estimating relative capacity and productivity of freshwater habitats, relationships between spawner and juvenile numbers, changes in population status, distribution, or size, age and timing of outmigration.

Indicator Sampling - Juveniles

Indicator sampling of juveniles involves presence/absence consisting of low intensity reconnaissance grade surveys typically intended to determine if significant numbers of juveniles may be present in any given area or time. They may be based on catches in juvenile migrant traps, catches in seine or electrofishing samples, or numbers observed in snorkel surveys, and are often periodic in nature. Presence/absence information is most valuable for identifying gross patterns of distribution and has limited utility for monitoring temporal abundance patterns. However, presence/absence surveys can provide valuable information for addressing the TRT's spatial distribution criterion.

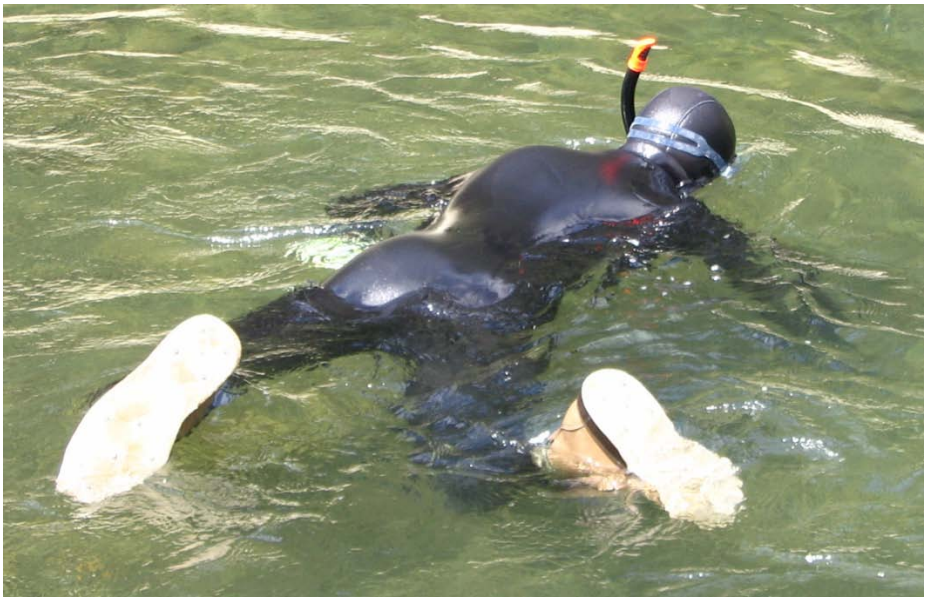

Figure 9. Snorkel surveys are often utilized for indicator or inventory surveys of juveniles or adults,

3.4.3 Sampling Criteria

Based on these guidelines, critera were established for evaluation of the adequacy of current efforts, information gaps, and priorities to fill gaps in biological status monitoring. Criteria are based on general statistical principles rather than prescribed statistical power analyses. Criteria are most useful as descriptive reference points to highlight differences in relative effort of biological monitoring programs for different species and strata. Criteria include both Oregon and Washington populations.

Criteria were established at major population group (MPG) and population levels. MPG-level critera were identified based on numbers of populations at low, moderate, and high sampling coverages corresponding to the relative degree of certainty in the biological status assessment (Table 8). The MPG criteria involve: 1) sampling depth based on intensive sampling of adults and juveniles of the same population for explicit estimates of life stage productivity and survival, 2) sampling breadth based on sampling of multiple populations to provide minimum levels of replication within an MPG, and 3) sampling coverage based on representative fractions of populations in each MPG that are monitored.

Table 8. Major Population Group-level sampling guidelines at low, moderate, and high levels of relative certainty for biological monitoring (number of populations monitored by sampling intensity).

Relative certainty	Sampling depth Intensive	Sampling breadth Inventory or Intensive	Sampling coverage Indicator or Inventory or Intensive
Low	<1 per species/life history (juveniles & adults)	<2 per species/life stage & strata (adults or juveniles)	<33% of populations (adults or juveniles)
Moderate	1 per species/life history (juveniles & adults)	2 per species/life stage & strata (adults or juveniles) [1]	≥33% of populations (adults or juveniles)
High	>1 per species/life history & strata (juveniles & adults)	>2 per species/life stage & strata (adults or juveniles)[2]	>50% of populations (adults or juveniles)

[1] *Or two populations if only two in the strata.*
[2] *Or two or three populations in strata with only two or three, respectively.*

Population-level criteria were identified for sampling levels consistent with population priorities for recovery (Primary, Contributing, Stabilizing categories). The sampling strategy directs that populations slated for recovery to high viability or large improvements will require significant sampling efforts to determine with some certainty whether goals are met. Thus, primary populations will require more intensive sampling than contributing populations, and contributing populations will require more intensive sampling than stabilizing populations. Population priority criteria are based on a relative data quality scale related to the depth and breadth of sampling efforts for each population (Table 9). This plan targets sampling of Primary populations at an A or B data quality standard, and contributing populations at a data quality standard of C or above. A description of current data quality relative to population-level sampling criteria can be found in Appendix D.

Table 9. Population-level data quality criteria for Primary and Contributing populations based on adult and juvenile sampling intensity. Quality ratings as based on a subjective relative scale (A to D).

Data quality	Adult sampling		Juvenile sampling	Adequate for primary?	Adequate for contributing?
A	Intensive	and	Intensive	Yes	Yes
	Intensive	and	Inventory	Yes	Yes
B	Intensive	or	Intensive	Yes	Yes
	Inventory	and	Inventory	Yes	Yes
C	Inventory	or	Inventory	No	Yes
D	Indicator	or	Indicator	No	No
--	none		none	No	No

The LCFRB has partnered with the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) to develop an integrated sampling design framework for collecting data and information to address biological (fish) status and trends questions described in this monitoring program. The resulting Integrated Status and Trend Monitoring (ISTM) project involves development of an integrated design framework that will use a variety of sampling methods, including a "master sample" concept to selection of sampling locations. This master sample design incorporates statistical randomization, is spatially balanced, and creates an ordered list of monitoring sites

for collection of data. By coordinating this effort with a similar ongoing project for habitat status and trends, efficiencies can be gained by sampling the same monitoring sites. The resulting sample design is intended to incorporate the LCFRB's sampling priorities, and allows selection of sites to meet particular needs in such a way that data sharing meets key design requirements to achieve status and trends monitoring goals. In other words, in using the master sample to identify sites for sampling, the resulting information can be aggregated and effectively integrated with other similarly obtained data to address key status and trends questions. The goal is to facilitate integration and "roll-up" of information from similar monitoring efforts throughout the Lower Columbia region, including those conducted by the ODFW, WDFW, and others monitoring fish populations.

3.5 Current Monitoring Activities

Biological status of salmon populations is currently being monitored for a subsample of populations and attributes. Some level of monitoring is currently being conducted in a majority of watersheds for most species. Activities as of a baseline period around 2004 are detailed in Appendix D. Intensive adult monitoring is currently conducted for all significant spring Chinook and summer steelhead populations and many winter steelhead populations. Adult fall Chinook are widely monitored at an inventory level. An inventory program including many chum populations has been initiated in recent years. Adult abundance sampling for coho in Washington has been largely been limited to reintroduction efforts above Cowlitz dams. Oregon has recently implemented an intensive coho monitoring program in lower Columbia streams to supplement long term intensive coho monitoring activities in the Clackamas and Sandy rivers.

Intensive juvenile monitoring includes hydro-related studies in Upper Cowlitz, a research program in the Kalama, the intensive watershed monitoring program in Mill, Abernathy, and Germany Creeks, and a restoration program in the Hood River. Juvenile inventory sampling programs involving migrant traps have recently been conducted or are currently underway for multiple species in Mill, Abernathy, and Germany creeks (Coast strata) as part of the intensively monitored watershed program funded by the State of Washington, Coweeman River (Cowlitz tributary, Cascade Strata), Cedar Creek (N. Lewis tributary, Cascade strata), Wind River (Gorge strata), and Hood River (Gorge strata). Juvenile inventory sampling also occurs at Cowlitz and Clackamas hydropower facilities. Juvenile indicator programs include presence/absence surveys conducted under the Forest and Fish Rules for stream typing purposes, project-related surveys conducted under local ordinances (e.g., critical areas, wetlands protection, etc), and surveys associated with research projects.

Monitoring of tributary populations is primarily conducted by WDFW and ODFW. Mainstem population monitoring activities are conducted by WDFW, ODFW, NMFS, and the USFWS. Monitored populations and attributes reflect a variety of needs and are also closely related to funding sources. For instance, inventory fall Chinook escapement information is collected to support inter-jurisdictional fishery management activities. Similarly, adult and juvenile data is collected in the upper Cowlitz as part of hydropower mitigation activities. The current program was not specifically designed to provide representative samples for the purposes of salmon recovery assessments. Note that the same information collected for the analysis of biological

status can have a variety of applications in action effectiveness monitoring as well as uncertainty, effectiveness, and validation research.

3.6 Information Gaps

Population-level monitoring gaps were identified where sampling intensity and corresponding data quality were inconsistent with population recovery priorities. Details of this gap analysis are described in Appendix D. Based on the sampling strategy, this analysis assumed that populations targeted for high levels of viability or significant improvements would require significant sampling efforts to confirm status. Significant discrepancies between recovery targets and current sampling efforts were identified for multiple populations of tule fall Chinook, chum, and coho. Shortcomings were particularly pronounced for chum and coho. Tule fall Chinook concerns were generally limited to the need for more intensive monitoring of several primary populations, particularly where hatchery influence was significant. Sampling efforts for bright fall Chinook and summer steelhead met population-level criteria for all populations. Sampling efforts for spring Chinook and winter steelhead met population-level criteria except for the contributing Toutle River spring Chinook population and the primary lower gorge winter steelhead population.

3.7 Implementation Measures

M.M1. Maintain current biological sampling efforts for representative priority populations of all species and strata.

Lead: WDFW, ODFW

Funding source: WA Salmon Recovery Funding Board, NMFS/Mitchell Act, Tacoma Public Utility District, Northwest Power and Conservation Council/Bonneville Power Administration, OR Watershed Enhancement Board, Portland General Electric

Rationale: Current biological monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments, recovery plans, and ongoing harvest management. Current programs are adequate for some Recovery Plan applications but fall short in other areas. Thus, effective monitoring and evaluation will require more funding, not less. This RM&E program seeks a balance in commitments between monitoring, protection, and restoration activities. This plan does not prescribe intensive monitoring of every parameter in all populations of every stratum. However, this approach places a premium value on information and data provided by existing programs. The long-term nature of many programs provides particularly valuable information for distinguishing real trends from sampling noise or normal variation. Current monitoring activities have been implemented with a mixture of hard and soft funds. In many cases, long term funding of key programs is not assured. Loss of significant components of current biological monitoring programs would significantly reduce the accuracy and precision of evaluations of progress or lack thereof to recovery goals. Appendix Table D- 3 identifies priorities for maintaining current biological sampling efforts for representative populations in each stratum.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.

b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M2. Implement additional intensive biological monitoring for juveniles and/or adults in all strata to meet representative monitoring needs of multiple species.

Lead: WDFW

Funding source: State of Washington, PacifiCorp

Rationale: Intensive biological monitoring activities of adults and juveniles in one subbasin can provide critical information for multiple species with significant economy. For instance, juvenile migrant trapping during spring can provide abundance, productivity, and diversity information on both coho and steelhead. Fall spawner surveys can index overlapping distributions and timing of chum, fall Chinook, and coho in different portions of a subbasin. Current Intensive Watershed Monitoring efforts in Mill, Abernathy, and Germany subbasins are an example of a comprehensive intensive monitoring program that meets numerous biological sampling moderate sampling level needs for species in the Coast strata while also providing valuable information on habitat action effectiveness and uncertain linkages in fish and habitat relationships. Intensive biological monitoring activities in the Cascade strata are primarily associated with spring Chinook, coho, and steelhead reintroduction efforts above tributary hydropower facilities. This is critical information for both basic biological status assessment and hydropower action effectiveness monitoring. However, these intensive reintroduction monitoring efforts do not adequately represent other species and subbasin types in the Cascade strata. Intensive monitoring of tule fall Chinook, chum, and coho is currently inadequate to reach moderate certainty major population group criteria in the Cascade strata. Intensive monitoring in all strata does not meet high certainty major population group criteria. East Fork Lewis and Coweeman subbasins are recommended candidates for an intensive biological sampling program of adult and juveniles in the Cascade strata to include fall Chinook, chum, coho, winter steelhead and summer steelhead. Grays and Elochoman/Skamokawa subbasins are recommended candidates for additional intensive sampling in the Coast strata.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M3. Implement a comprehensive natural coho sampling program in Washington in all strata.

Lead: WDFW

Funding source: NPCC/BPA.

Rationale: Adult and juvenile coho monitoring efforts in all watersheds are currently insufficient to adequately assess population status and viability parameters. A comprehensive coho monitoring program consisting of a combination of intensive, inventory, and indicator adult and juvenile sampling is among the highest of priorities for recovery monitoring in the lower Columbia River domain. A cost effective program can be implemented in conjunction with additional monitoring of winter steelhead. Appendix Table D- 3 identifies priority coho populations for inclusion in a comprehensive sampling effort.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate funding sources
b. Develop, submit, and support a detailed sampling proposal, work plan[2], and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M4. Expand current chum salmon sampling efforts to include more intensive and inventory monitoring of adults and juveniles.

Lead: WDFW

Funding source: NPCC/BPA.

Rationale Chum adult spawning and juvenile surveys are currently funded with "soft funds" and continued funding will need to be solidified. Moreover, the current funding provides the minimum resources needed to count fish and redds and does not include monies to conduct a thorough investigation of the accuracy of the methods used to estimate total adult spawning escapement, adult or juvenile productivity, or diversity, in all watersheds. Priority populations for expanded chum sampling efforts are identified in Appendix Table D- 3.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M5. Augment current sampling programs for fall Chinook and winter steelhead with more intensive adult and juvenile sampling levels in selected areas.

Lead: WDFW

Funding source: To be determined.

Rationale: Although existing monitoring programs for fall Chinook and winter steelhead provide significant data on a majority of populations of all strata, much of this

[2] WDFW has proposed this work for funding by the Bonneville Power Administration's Fish and Wildlife Program.

information is based on intensive or inventory surveys which do not adequately evaluate critical assumptions of current sampling and evaluation. Supplemental sampling is needed to validate the accuracy of the existing approach.

6-Year Implementation Work Schedule Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

4. Habitat Status Monitoring

Habitat monitoring provides critical information for salmon and watershed-related decision making at a variety of institutional levels and scales. Adaptive plan implementation, in the face of uncertainties in future trends and recovery and watershed restoration efforts, mandates regular check points on habitat conditions relative to recovery benchmarks in order to identify the need for course corrections. Without effective habitat protection and a means to distinguish long-term habitat trends, benefits of investments in recovery activities will not be realized or recognized. Without demonstrable improvements in critical habitat conditions, recovery and watershed restoration goals will not be achieved.

Habitat information addresses a multitude of critical questions including long-term cumulative effects of recovery measures and other human activities, inferences of fish potential where biological data is incomplete, identification of key limiting factors and functional relationships, and site-specific effects of specific recovery measures. This chapter focuses primarily on habitat status monitoring of cumulative effects of recovery and watershed restoration measures and human activities in order to assess related listing factors identified by NMFS. However, much of this same information will have application to biological status monitoring, effectiveness monitoring of specific habitat measures, and uncertainty or validation research. These linkages are highlighted in this chapter.

Habitat monitoring, more than any other element of this program, is complicated by issues of multiple and overlapping objectives, scales, information needs, and jurisdictional responsibilities. Each of these elements implies a specific set of information needs and sampling regimens. This program identifies a comprehensive set of habitat monitoring activities designed to address this hierarchy of needs. The program identifies sampling components at three habitat scales: 1) stream, riparian, and floodplain characteristics which are referred to in this plan as “stream corridor”, 2) watershed, hillslope/upland, and wetland conditions which are referred to in this plan as “landscape”, and 3) water quality and quantity. Monitoring components are identified for each of the three habitat scales.

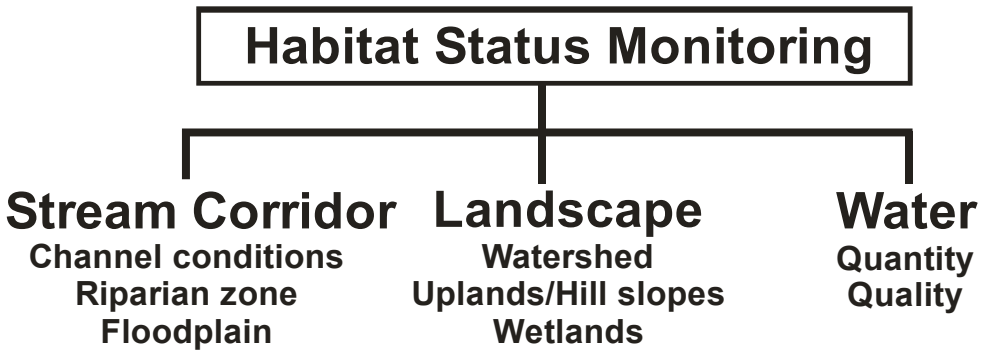

Figure 10. Elements for habitat status monitoring of fish recovery.

4.1 Stream Corridor – Channel, Riparian & Floodplain Conditions

4.1.1 Objectives

Habitat status monitoring at the stream scale is primarily intended to characterize conditions for fish relative to a baseline at listing and improvements consistent with recovery. Stream habitat conditions serve as an evolving record of aquatic ecosystem health that in turn affects the viability of fish populations. Stream conditions reflect the direct effects of actions at the stream habitat scale as well as watershed-scale actions and conditions that influence stream habitat forming processes. Monitoring of stream conditions will identify long-term trends and cumulative effects of recovery measures and other human activities at the stream and watershed scale (Box 2).

Stream habitat information has a variety of applications critical to effective salmon recovery. A primary application will be to evaluate the status of habitat-related statutory listing factors identified by the NMFS listing status decision framework (NOAA 2007). Stream habitat information is also useful for comparisons of observed and benchmark habitat conditions based on favorable values for salmon to identify critical limiting factors and help focus actions for maximum effect and efficiency. Comparisons of habitat suitability and potential for fish among stream reaches and subbasins guide prioritization of areas for preservation and restoration. Stream habitat information may be used to infer fish status in areas where biological data is incomplete. Stream habitat information is also used to evaluate the effectiveness of site-specific habitat actions. Finally, comparisons of landscape, stream, water, and biological information are the basis for uncertainty and validation research designed to identify key functional relationships and to reduce fundamental uncertainties which might constrain effective Recovery and Watershed Plan implementation.

Figure 11. Typical habitat conditions in a west Cascade headwater stream.

Box 2. Questions and hypotheses addressed by stream habitat monitoring.

Question #1. Are habitat conditions stable or changing as a result of fish protection and restoration actions, and other factors?

Null hypothesis: Stream habitat conditions are unchanged since listing.
Alternative: Stream habitat conditions have changed since listing.

Question #2. How are fish limiting factors affected by stream habitat status and trends?

Null hypothesis: Stream habitat limitations for fish are unchanged.
Alternative: Changes in stream habitat have affected critical fish limiting factors such that improvements in fish status are likely.

Question #3. Which streams and stream reaches are most important to fish protection and/or restoration?

Null hypothesis: All streams and stream reaches are of equal importance to fish.
Alternative: Some streams and stream reaches are more important than others.

Question #4. What is the fish production and abundance capacity of the stream habitat and how has it changed?

Null hypothesis: There are no significant differences in habitat productivity and capacity for fish among areas or trends over time.
Alternative: There are significant differences in habitat productivity and capacity for fish among areas and/or trends over time.

Question #5. Have specific stream habitat improvement actions achieved the desired physical and biological effects? (see action effectiveness monitoring section)

Null hypothesis: Actions resulted in no change in physical or biological conditions.
Alternative: Physical or biological conditions changes as a result of the action.

Question #6. How is fish status related to stream conditions and how are stream conditions affected by landscape/watershed factors and stream flow patterns? (see uncertainty and validation research section)

Null hypothesis: Stream conditions do not affect fish status and are unaffected landscape/watershed factors or stream flow patterns.
Alternative: Stream conditions affect fish status and are affected landscape/watershed factors or stream flow patterns.

4.1.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For stream habitat monitoring, these include:

M.S16. Complete comprehensive assessments of stream habitat status and significance to salmon at 12 year intervals as prescribed by the Recovery Plan.

A 12 year assessment interval is identified by the Recovery Plan for the assessment of stream habitat status relative to baseline conditions and benchmarks. The assessment will require a rotating panel of habitat samples to be repeated in a 12-year cycle. The relatively long interval

between assessments provides the opportunity to distribute sampling efforts in the region across multiple years so that a massive effort does not need to be completed within a short time period. The interval also recognizes the gradual or episodic nature of change at the habitat scale and provides enough time for potential changes to accrue before reassessment.

M.S17. Utilize a multi-level stream habitat sampling approach to address the multitude of objectives and applications of this information.

Stream habitat information is needed for a wide variety of purposes including characterizing conditions across the region, detecting trends, identifying problems and restoration opportunities, evaluating action effectiveness, and characterizing linkages with fish. No single stream habitat sampling design, level, or protocol is adequate for all of these purposes.

M.S18. Assess stream habitat status of every subbasin in a representative fashion (although every subbasin doesn't need to be monitored at the same sampling level).

Listing factor criteria identified by NMFS are evaluated at the population scale. Therefore, stream habitat monitoring must occur at the subbasin scale. Stream habitat sampling meets a variety of needs including providing some indication of changes in habitat suitability or potential for salmon populations where biological data is sparse. Habitat assessments can be a much more cost-effective alternative to evaluating the freshwater production potential, particularly for populations existing at very low levels in degraded habitats. Habitat information also provides a systematic means of inferring relative status of less intensively-monitored populations from more intensively-monitored populations.

M.S19. Stratify habitat monitoring in order to represent the full range of conditions and to maximize sampling power to detect changes.

Statistical power of tests for differences over time is increased by a spatial stratification scheme which reduces the error variation among samples by removing between-strata differences. Given the geographic extent of the Lower Columbia and the complexity of habitat conditions, acquiring habitat data for all locations in the region is unrealistic. Given the very large habitat variation across the region among strata, lack of a stratified design would greatly inflate the number of samples needed to characterize conditions throughout the basin and to detect even moderate-sized changes in habitat conditions.

M.S20. Replicate samples within each stratum in order to provide a statistical basis for evaluating differences.

There can be substantial variation in stream habitat conditions among streams and among reaches in a stream within any given strata. Replication (collecting data from more than one reach or site) is needed for statistical analysis of differences and trends. Differences among strata or within strata over time can only be demonstrated by comparison to differences within strata (Green 1979).

M.S21. Employ both a probabilistic sampling scheme designed to representatively survey conditions across the landscape and an index site sampling scheme designed for sensitivity to detect significant changes in salmon habitat threats over time.

The two primary habitat sampling objectives require fundamentally different approaches to sample site selection. Survey sampling to describe the average and range of conditions within a stratum requires random (probabilistic) sampling in order to provide representative coverage.

Index sampling for characterizing long term trends is most efficient where sample sites are selected based on sensitivity to likely changes and value to fish.

M.S22. Employ a range of sampling intensities consistent with the multiple objectives.

A multi-level habitat monitoring approach is the best avenue for providing adequate coverage of stream habitat information. Inventory sampling provides a big picture context for evaluating habitat patterns across the region. Indicator monitoring will provide representative breadth across the region and also representative index sites for periodic resampling. Intensive monitoring of selected reaches that are significant to fish recovery will provide more sensitive indications of temporal changes. Reconnaissance sampling provides a means of rapidly assessing problems not reflected in habitat subsampling sites as well as restoration or preservation opportunities.

M.S23. Monitor subbasins that are a higher priority for recovery at a greater intensity.

This habitat monitoring program is specifically designed to address salmon recovery needs. A fundamental recovery strategy involves protection and restoration of key populations to high levels of viability. These populations will be the focus of the most intensive stream habitat monitoring efforts. Ideally, monitoring programs would be allocated across a representative range of population types but resource limitations will constrain the feasibility of conducting comprehensive monitoring programs for multiple populations within a species.

M.S24. Design stream habitat monitoring for salmon recovery evaluations to make maximum use of other regional monitoring where consistent.

The scale of habitat monitoring required for salmon recovery applications is very large. Information collected for specific purposes is often useful for a variety of applications and opportunities to utilize this information should not be overlooked. An economical habitat monitoring program takes advantage of all potential sources of information even where they were not specifically intended for the desired application. Stream habitat assessments should make optimum use of all available information rather than relying on completely new and dedicated sampling efforts. The design will also need to be flexible in order to recognize and qualify potential limitations in other sampling. The key is understanding the limitations and applicability of each type of information.

M.S25. Adopt habitat monitoring protocols for dedicated salmon recovery habitat monitoring that are compatible with other regional monitoring efforts.

Most of the current baseline habitat information has been collected with relative standard protocols in wide use for salmon habitat monitoring. Unless existing protocols fall significantly short of monitoring needs for salmon recovery or a critical mass of standard methodology has not been applied, any new work undertaken should attempt to emulate past protocols as much as possible. It is also likely that regular protocols will have to be supplemented with additional methods or metrics in order to meet all information needs.

4.1.3 Indicators

4.1.3.1 Attributes & Metrics

Stream habitat conditions are characterized through a set of habitat indicators including attributes, metrics, and statistics that reflect the suite of conditions that are relevant to

salmonid protection and recovery (Table 10). Channel morphology and complexity, riparian condition and function, and habitat access are included as stream habitat attributes for the purposes of this monitoring program. Metrics include attributes such as channel morphology, substrate, woody debris, riparian cover, and bank stability.

The program recognizes the subjectivity of defining a boundary between stream and watershed attributes due to the complexity of connectivity and functional relationships. These attributes were grouped under the stream habitat category because they lend themselves to common sampling and analysis protocols. Specific metrics and example statistics are also identified for each attribute. Indicators are consistent with those identified in NMFS's listing status decision framework for the habitat category and with other diagnostic methods implemented in the region including the Ecosystem Diagnosis and Treatment model (EDT) (LCFRB 2010).

4.1.3.2 Criteria

Assessments of habitat suitability for fish and the effects of habitat changes will rely on quantitative and qualitative interpretations of indicators. Interpretations will be based on changes in indicators over time as well as comparisons with benchmark values. Criteria do not represent goals but are goal-related reference points or standards against which to compare performance achievements.

Given the inherent variability and complexity of natural systems, it is impractical to establish broadly-applicable goals for habitat conditions. A more effective approach for stream and watershed characteristics is to develop relative measures of trends over time. Many different combinations of attribute conditions might satisfy recovery goals. Criteria provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level. The Recovery Plan identifies habitat criteria based on Properly Functioning Conditions (PFCs) identified by NMFS to reflect freshwater habitat conditions generally favorable for salmonids' spawning and rearing (NMFS 1996b) (Table 11). PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes.

Table 10 Attributes, metrics, and example statistics for use as indicators of stream habitat status.

Attribute	Metric	Example statistics	Relevance to Fish
Channel conditions	Channel cross-section form	Width-to-Depth ratio, entrenchment, artificial confinement	Quality of physical habitat
	Channel gradient & channel form	Channel gradient, length & sinuosity	Suitable hydraulics and channel dynamics for habitat formation and maintenance
	Erosion and sedimentation	Percent fines, embeddedness, bed-material composition	Adequate substrate for spawning, egg incubation, and early rearing
	Habitat types	Percent & frequency pools, riffles, glides, off-channel areas, etc...	Spawning and rearing habitat availability
	Large Woody Debris	Abundance, size, and distribution	Availability of cover and complexity
Riparian zone	Vegetative Cover	Percent cover by vegetation type	Food source production, nutrient exchange, LWD recruitment, bank stability
	Shade	Percent shade	Stream temperature moderation
	Invasive Species	Presence/Absence and mapping	Natural riparian function
	LWD recruitment potential	Buffer width, tree size, stand density	Large woody debris recruitment
	Stream bank stability	Stream bank stability indices	Stream bank stability and sedimentation
Floodplain and channel migration processes	Channel migration zone encroachment Floodplain connectivity	Width of channel migration zone Extent of connected floodplains	In-channel habitat formation and maintenance, Off-channel habitat creation, Nutrient exchange, Flood abatement, Flood refuge, Temperature moderation
Accessibility	Anthropogenic & Natural Barriers	Miles/acreage of blocked habitat by type Barrier characteristics - location (GPS), type, width, length, gradient, drop, bedload, % passability etc.)	Fish Passage, Spawning habitat, Juvenile rearing, Outmigrant survival, Adult migration timing

Table 11. Salmonid freshwater criteria for stream habitat based on the Matrix of Pathways and Indicators (NMFS 1996b).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Stream channel & habitat units:	Pool Frequency	meets pool frequency standards (below) and large woody debris recruitment standards for properly functioning habitat (above) channel width (ft): pools/mi[1] (5:164, 10:96,15: 70, 20: 56, 25: 47, 50: 26, 75: 23, 100: 18)	meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	does not meet pool frequency standards
	Pool Quality	pools >1 meter deep (holding pools) with good cover and cool water[3], minor reduction of pool volume by fine sediment	few deeper pools (>1 meter) present or inadequate cover/ temperature[3], moderate reduction of pool volume by fine sediment	no deep pools (<1 meter) and inadequate cover/ temperature[3], major reduction of pool volume by fine sediment
	Substrate	dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20%[3]	gravel and cobble is subdominant, or if dominant, embeddedness 20-30%[3]	bedrock, sand, silt or small gravel dominant, or if gravel and cobble dominant, embeddedness >30%[2]
	Sediment	< 12% fines (<0.85mm) in gravel[1]	12-l7% (west-side)[1], 12-20% (east-side)[1]	>17% (west-side)[1], >20% (east side)[1] fines at surface or depth in spawning habitat[2]
	Large Woody Debris	>80 pieces/mile >24”diameter >50ft. length[1]; and adequate sources of woody debris recruitment in riparian areas	currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	does not meet standards for properly functioning and lacks potential large woody debris recruitment
	Off-channel Habitat	backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.) [3]	some backwaters and high energy side channels[3]	few or no backwaters, no off-channel ponds[3]
	Refugia (important remnant habitat)	habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations[1]	habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations[1]	adequate habitat refugia do not exist[1]
	Width/Depth Ratio	<10[2,4]	10-12 (we are unaware of any criteria to reference)	>12 (we are unaware of any criteria to reference)
	Streambank Condition	>90% stable; i.e. on average, less than 10% of banks are actively eroding[1]	80-90% stable	<80% stable
	Floodplain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/ succession	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/ succession altered significantly

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Riparian Zone	Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%[12]	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (≈70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[12]	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition <25%[12]
Habitat Access:	Physical Barriers	any man-made barriers present in watershed allow upstream and downstream fish passage at all flows and life stages	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows

[1] *Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.*

[2] *Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.*

[3] *Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.*

[4] *Biological Opinion on Implementation of Interim Strategies for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). National Marine Fisheries Service, Northwest Region, January 23, 1995.*

[5] *A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.*

[6] *USDA Forest Service, 1994. Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.*

[7] *Frissell, C.A., Liss, W.J., and David Bayles, 1993. An Integrated Biophysical Strategy for Ecological Restoration of Large Watersheds. Proceedings from the Symposium on Changing Roles in Water Resources Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.*

[8] *Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.*

[9] *e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.*

[10] *Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional Species and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management.*

[11] *USDA Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.*

[12] *Winward, A.H., 1989. Ecological Status of Vegetation as a Base for Multiple Product Management. Abstracts 42nd Annual Meeting, Society for Range Management, Billings MT, Denver, CO: Society for Range Management: p. 277*

4.1.3.3 Example Information

Example reporting templates for stream habitat data are depicted below. This data may be represented in terms of site or reach-specific physical conditions or can be represented relative to benchmark fish values. Spatial stream habitat data is well suited to presentation in a map format and this application is facilitated by use of Geographical Information Systems. Examples are included to illustrate how stream habitat data can be organized and used. The data included in examples also represents baseline conditions for comparison with results of future monitoring. Many alternative depictions might ultimately be developed.

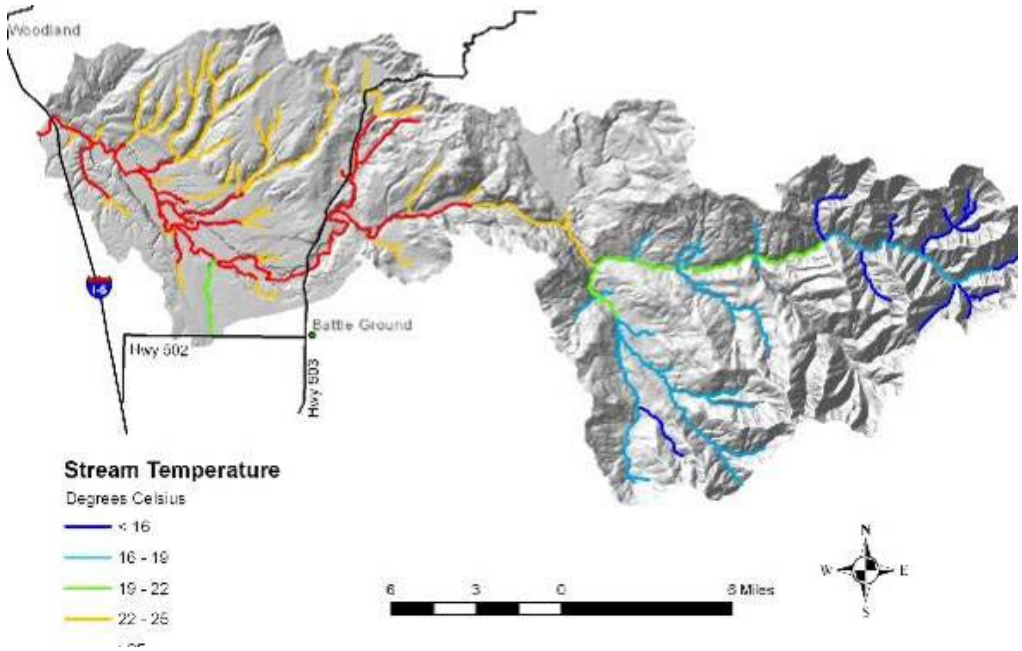

Figure 12. Map example depicting stream habitat data.

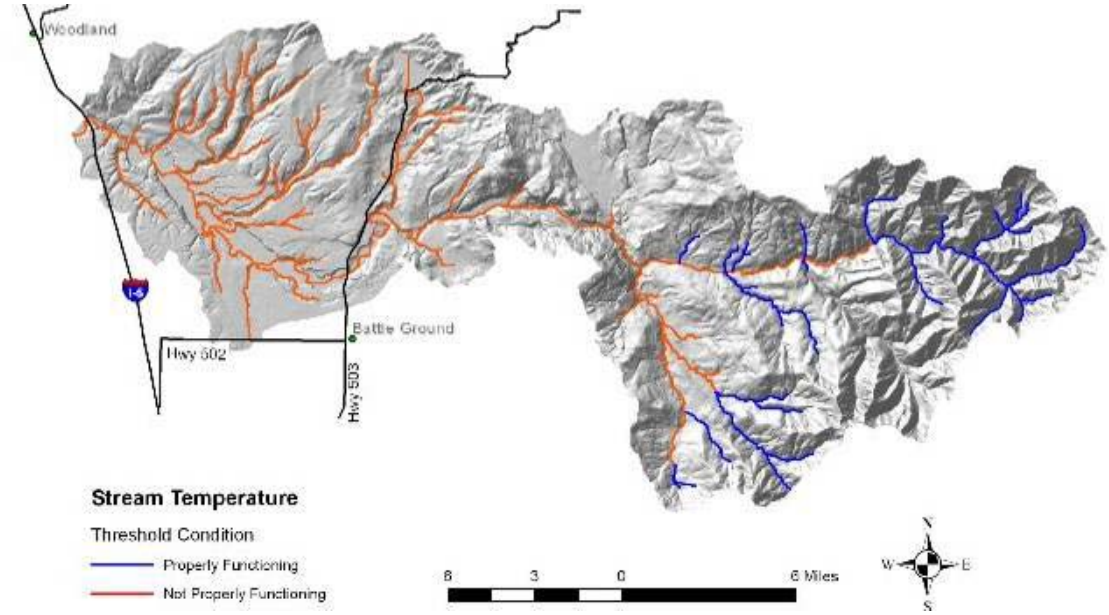

Figure 13. Map example illustrating stream habitat data relative to the Properly Functioning Condition criteria.

4.1.4 Sampling and Analytical Design

4.1.4.1 Framework

This program identifies a stratified, representative, multi-level sampling framework for monitoring stream habitat to meet multiple needs including characterization of habitat status, habitat trends, habitat action effectiveness, and fish status inferences. Elements of the design framework are identified in Figure 14.

Element	Definition	Categories
Goals	Purpose of the specific monitoring component	Status Trends Problems Effects
Spatial Strata	Hierarchy of areas and subareas by which sampling is organized in order to ensure adequate representation of the full range of conditions that occur within the region	Ecoregion WRIA Subbasin Physiographic zone Stream Size
Salmon Recovery Priority	Significance of an area or site to salmon (sample strata pertinent to some objective applications)	Stream reach tiers
Units, Replicates, Frequency	Units are the subbasins, reaches or sites sampled. Replicates are the number of units sampled per strata. Frequency refers to resampling interval.	Dependent on subsample type
Sampling Levels	Scope and intensity of sampling at any given site	Indicator Reconnaissance Index Intensive
Sampling Protocols	Data collection methods for sampling at any given level	Dependent on sampling level
Indicators	Attributes to be measured & criteria describing reference conditions	Statistics (see Table 10)

Figure 14. Elements of a systematic stream habitat sampling framework.

Objectives: Stream habitat monitoring addresses a variety of goals needed to evaluate salmon recovery. Each goal requires slightly different but overlapping sampling strategies and protocols. These goals can be classified into four categories:

Status is a characterization of conditions across the region within and among sampling strata at any given point in time.

Trends are changes in status over time.

Problems are specific habitat features or sites potentially targeted for action (e.g. hydromodifications, habitat impairments, or fish barriers.)

Effects refers to specific habitat information needs for action effectiveness evaluation or research into linkages between habitat and fish.

Sample Type: Sample type is categorized by site selection protocols dictated by the corresponding objective application. Different applications require fundamentally different site selection protocols.

Conditions across the landscape are evaluated using ***Survey Samples***. Survey samples are collected in a randomly-distributed (probabilistic) manner within a sampling stratum in order to represent average conditions and variation in conditions within that stratum. The principle characteristics of a probabilistic design are 1) the population being sampled is clearly described; 2) every element in the population has the opportunity to be sampled with a known probability; and 3) sample selection is carried out by a random process. Following these guidelines allows statistical confidence levels to be placed on the estimates. Washington's Watershed Health and Salmon Recovery Quality Assurance Monitoring Plan (WDOE) and EPA's EMAP program are examples of a probabilistic sampling approach in a stratified random sampling design intended to describe spatial patterns in conditions.

Trends over time are evaluated using ***Index Samples***. Index samples involve periodic resampling of specific sites. Index samples may be randomly selected from a stratum in order to describe conditions representative of that strata or they can be specifically selected to represent a specific set of conditions. Sampling power to detect modest incremental habitat changes is maximized when among-site variability is controlled by concentrated periodic sampling of the same index sites. Small incremental changes in stream conditions that result from long term trends in habitat-forming processes can be difficult to distinguish from randomly selected sites. Thus, index sampling will be most effective where it is focused on sites that are most sensitive to change. Examples might include reaches in areas where development is expected to occur or critical areas that are in limited supply. These non-randomly selected sites are not expected to be indicative of average conditions throughout a subbasin or larger area. Therefore, index sampling must be complemented with survey samples in order to characterize the relationship between sensitive index and representative survey sites. Index sites are also selected to facilitate access which improves sampling efficiency and to include areas of particular significance to fish in order to maximize applicability to biological analyses.

Diagnostic samples are typically used to evaluate the distribution and significance of specific conditions or problems. Examples of diagnostic sampling might include a roving survey of selected stream reaches to identify hydromodifications, habitat impairments, fish accessibility or potential restoration project opportunities. Diagnostic samples are typically focused on a few key metrics intended to guide implementation or evaluate effectiveness of specific actions or regulations. Diagnostic sampling programs may also involve specific agencies or jurisdictions and limited areas.

Focus samples are collected for other specific purposes such as project site planning, action effectiveness monitoring, and uncertainty and validation research. Efforts are often limited in

scale and can involve tests of specific hypotheses or project-level planning and monitoring. They include attempts to define cause-effect linkages between land use and habitat. Monitoring intensity can be frequent. The cause-effect processes discovered in these studies can also be used to relate watershed condition trends to stream habitat trends. Focal sampling methods depend on the specific objectives. Paired treatment-control or before-and-after evaluations are examples of focused sampling. These activities can involve intensive habitat sampling which can also have survey or index applications.

Spatial Strata: Stream habitat monitoring is organized by a nested series of regions and watersheds including ecoregions, WRIAs, subbasins, and physiographic zones.

Ecoregions are areas of similar geographical, climate, and habitat conditions used by NMFS to identify major population groups of salmon which together comprise an ESU. Three ecoregions (Coast, Cascade, and Gorge) have been identified in the lower Columbia Region (Figure 15).

Watershed Resource Inventory Areas (WRIAs) are major watershed basins identified by Washington for administrative and planning purposes. The lower Columbia Region includes 5 WRIAs including the Grays-Elochoman, Cowlitz, Lewis, Salmon-Washougal, and Wind-White Salmon basins.

Subbasins are smaller watershed areas within each WRIA, generally corresponding to salmon populations identified by the TRT.

Physiographic zones reflect topographic, watershed condition, and land use patterns of significance to fish habitat (Figure 15). Boundaries of the physiographic zones do not align with watershed boundaries but do distinguish different areas within each watershed subject to different activities and watershed processes which translate into fish habitat effects. Four physiographic zones are defined (Table 12). Physiographic zones are also related to land use and management patterns and authorities.

Stream size varies throughout the region from small headwater tributaries to large river mainstems. This monitoring program includes representative sampling and analysis across the available range of stream sizes. Stream size is often categorized by stream order which is a systematic number scheme ranging from headwater streams (1st order) though large mainstems (4th order or above).

An example stratification scheme is shown in Table 13.

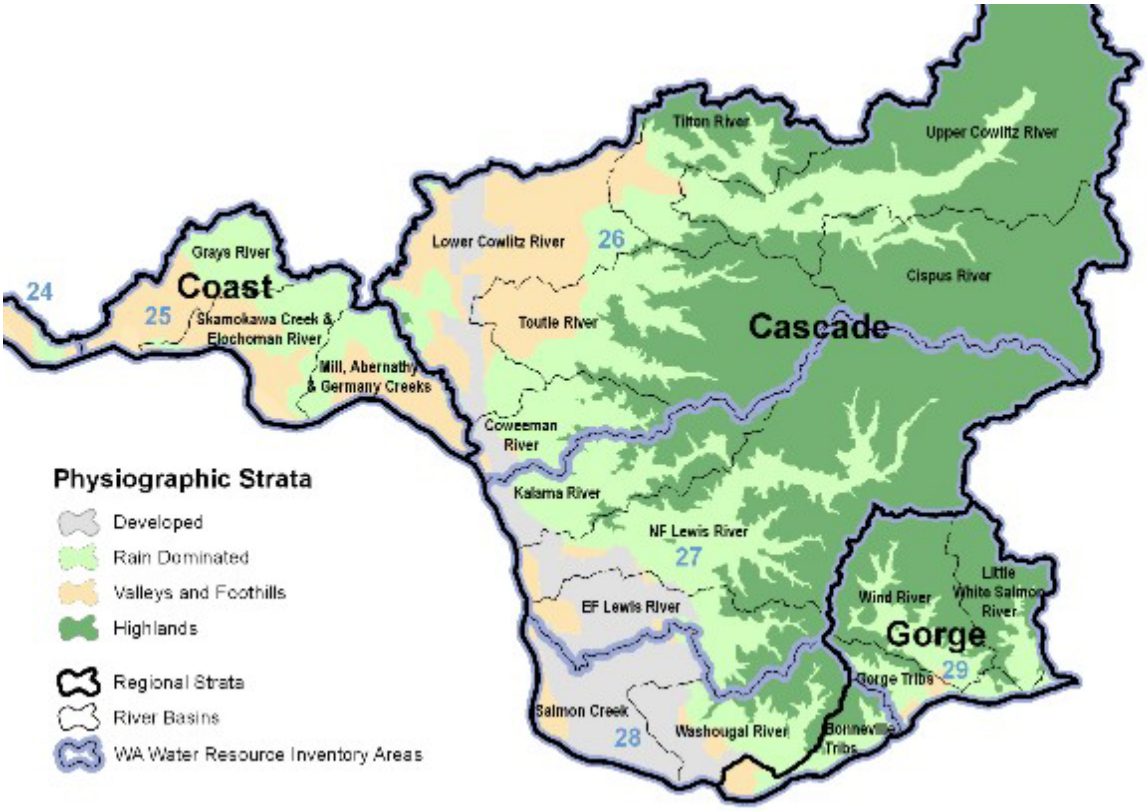

Figure 15 Spatial and physiographic strata within the Lower Columbia Basin.

Table 12. Definitions of physiographic zones used to in stream habitat sampling strata.

Zone	Definition
Developed	Large urban and residential zones in lower elevation valley floor areas along the Columbia River and I-5 corridor from Vancouver to Longview. Developed areas were distinguished based on population densities of greater than 100 persons per square mile using 2004 census data. (Small developed areas were eliminated from the Coast and Gorge ecoregions and were incorporated into other classifications.) Fish habitat in these areas, typically including river mainstems and small low gradient streams has been severely impacted by development.
Valley and Foothill	Undeveloped low elevation areas, typically in rural, agricultural, managed forest, or mixed use. This zone was derived from the lowland classification in the Washington Department of Natural Resources rain-on-snow GIS layer, with the exception of small developed areas as described above. These areas are expected to absorb much of the future population growth expected in the region. These areas include most of the historically-productive habitat for fall Chinook and chum salmon.
Rain Dominated	Low to mid elevation areas, typically in mixed or managed forest use. The zone was identified from the WDNR Rain Dominated area classification, with the exception of small developed areas as described above. These areas historically produced significant numbers of coho, spring Chinook, and winter steelhead.
Highland	Higher elevation areas, typically forest lands. This zone was derived from WDNR rain-on-snow area classifications (highlands, snow dominated, and peak rain-on-snow). Small areas of highlands in the Coast Strata were lumped into the Rain Zone. Highlands areas, where still accessible to fish, are among the most productive or potentially-productive salmon habitats in the region, particularly for summer steelhead and coho.

Table 13. Sample stratification scheme for representative surveys of stream habitat conditions at an inventory sampling level across the Washington lower Columbia River salmon recovery area.

Ecoregion (n=3)	WRIA (n=5)	Subbasin (n=18)	Physiographic zone (n=4) [3]	Stream order (n=4) [3]
Coast	25 Grays – Elochoman	Grays/ Chinook[1]	Developed Valley & Foothills Rain dominated Highlands	1, 2, 3, 4 or higher
		Elochoman/Skamokawa	“”	“”
		Mill/Abernathy/Germany	“”	“”
Cascades	26 Cowlitz	Lower Cowlitz	“”	“”
		Upper Cowlitz	“”	“”
		Tilton	“”	“”
		Cispus	“”	“”
		Toutle NF	“”	“”
		Toutle SF	“”	“”
		Coweeman	“”	“”
	27 Lewis	Kalama	“”	“”
		Lewis NF	“”	“”
		Lewis EF	“”	“”
	28 Salmon – Washougal	Salmon	“”	“”
		Washougal	“”	“”
Gorge	29 Wind – White Salmon	Bonneville tributaries[2]	“”	“”
		Gorge tributaries	“”	“”
		Wind River	“”	“”

[1] *Chinook River is part of WRIA 24 (Willapa) but is included for salmon habitat monitoring purposes with the Grays River*

[2] *Part of WRIA 28 (Salmon-Washougal) but included for salmon habitat monitoring purposes in the gorge strata.*

[3] *Not every physiographic zone or stream order may be represented in every strata.*

Salmon Recovery Priority: The Salmon Recovery Plan categorized stream reach in each subbasin into one of four reach tiers based on the number of fish populations that utilize habitat in that reach, the importance of each fish population relative to regional recovery objectives, and the significance of the reach to the specific fish populations (Figure 16).

Tier 1 includes reaches with significant production or restoration potential for one or more primary populations. Primary populations are those targeted for restoration to high or very high levels of viability.

Tier 2 has reaches not included in Tier 1 that are of medium priority for one or more primary species and/or high priority reaches for one or more contributing populations. Contributing populations are those for which significant restoration will be needed to achieve a strata wide average of medium viability.

Tier 3 includes other reaches which are medium priority for Contributing populations and/or high priority reaches for Stabilizing populations.

Tier 4 includes medium priority reaches for Stabilizing populations and/or low priority reaches for all populations.

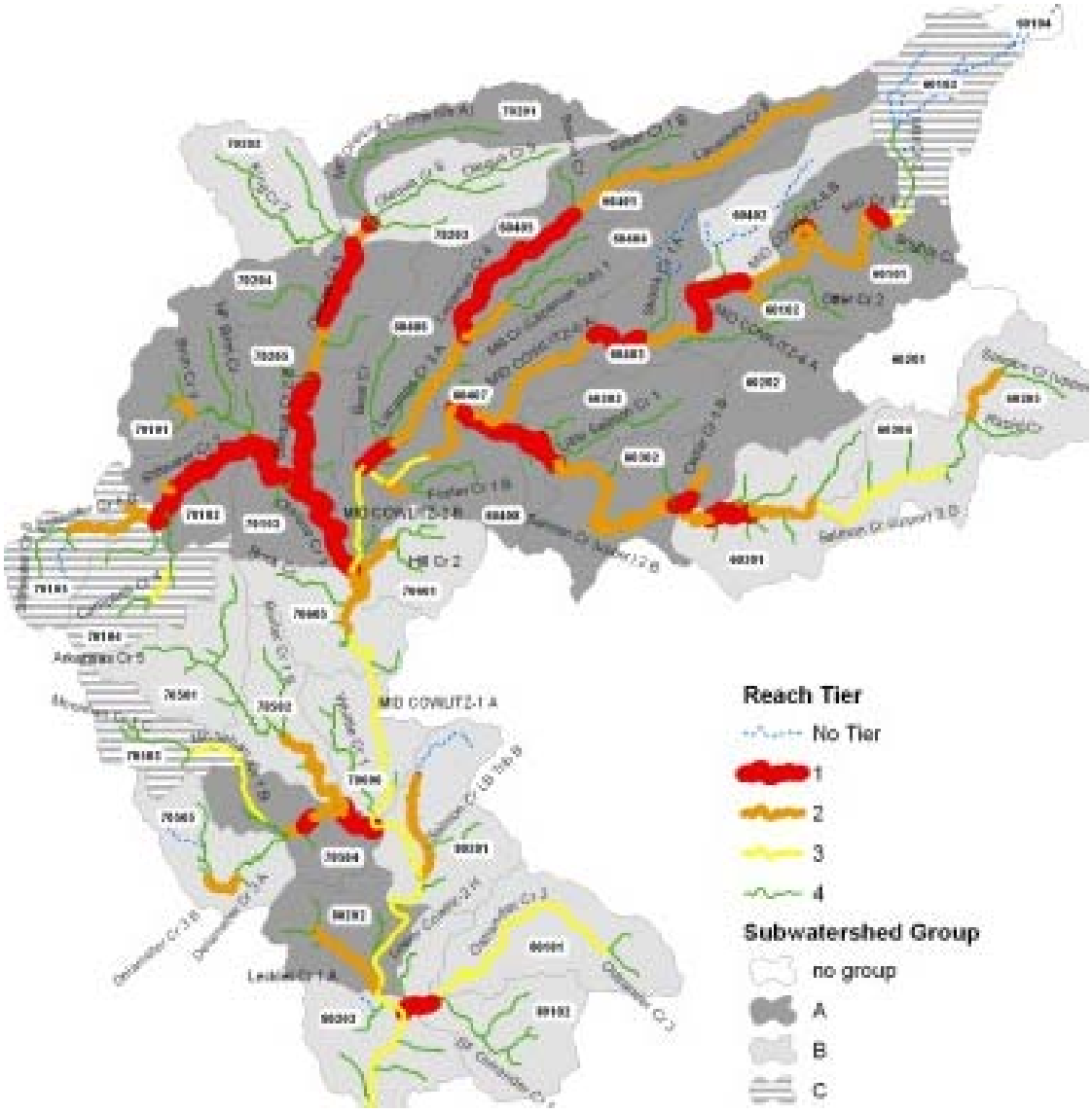

Figure 16. Examples of reach tiers representing the areas where recovery actions would yield the greatest benefits with respect to species recovery objectives. Example also includes subwatershed groups are based on Reach Tiers.

Units, Replicates and Frequency: Samples might be collected at multi-year, annual, seasonal, or even daily intervals depending on the scale of examination, the intended application, and the variability in the conditions being characterized. Longer sampling intervals are appropriate for large-scale landscape level features where changes are gradual or periodic and changes tend to be persistent. Thus, indicator level sampling based on remote sensing information is effectively applied at multi-year or even decadal intervals. In contrast, local site-specific conditions are more likely to display discernable changes at shorter time intervals which may warrant more frequent sampling.

4.1.4.2 Sampling Level

This program describes four sampling levels of varying scope and intensity (Table 14). Sampling level is generally related to certainty of results with more intensive sampling expected to provide more precise and accurate information but typically at a greater cost. Any level might be applied to any given sampling goal or involve a variety of stratification, site selection, or sampling protocols.

Indicator level sampling identifies standard attributes of a stream based on a synthesis or analysis of available remote sensing and GIS information. Indicator level sampling generally involves summary and interpretation of existing information while sitting in an office at a computer. Indicator sampling does not require on-the-ground sampling but can provide broad coverage of selected indicators at a modest cost. Indicator level sampling is readily applicable across the region or can be concentrated on a particular focal area. Remote sampling is best suited to provide broad-scale geographic coverage and reflect large-scale patterns in space and over time. Satellite imagery provides low cost answers to large scale habitat questions and also avoids intrusion onto private property (Crawford 2007). Measurement protocols depend on the metrics of interest and the information available.

Reconnaissance level sampling typically involves walking or floating sections of stream to quickly obtain qualitative information. This level of sampling effort is most effective for providing general descriptions of stream habitat conditions across broad areas. It is also particularly effective for identifying problem sites such as potential fish migration barriers, restoration opportunities, and the upstream extent of suitable fish habitat.

Inventory level sampling involves field sampling of stream and riparian characteristics at the stream reach and the habitat unit scale. It can also involve detailed analysis of remote sensing information (e.g. aerial photos) for some metrics. This level involves a systematic sampling regime and measurements or estimates of habitat metrics at multiple subsample sites within a reach at the habitat unit scale.

Intensive sampling is typically based on ground surveys of stream habitat conditions at the site scale to collect detailed quantitative measurements at specified points or transects. It is distinguished from inventory sampling by more rigorous sampling protocols and use of quantitative rather than qualitative metrics. It can incorporate all of the elements of indicator and inventory sampling as well as additional rigor specific to its intended purpose.

4.1.4.3 Sampling Protocols

A variety of sampling protocols have been developed to standardize methods used to collect stream habitat data (Figure 17). Standardized protocols are essential for quality assurance/quality control (QA/QC), for consistent implementation by disparate entities, and for the integration of independently sampled data. Sampling and reporting methods provide a transparent and defensible source of information that can be accessed by interested parties. Protocols and sampling levels are typically closely related but a given protocol may be used for a variety of sampling levels.

Several recent publications address the importance of protocols. The *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest Directory and Synthesis of Protocols for Management/Research and Volunteers* (Johnson et al. 2001) provides detailed recommendations of specific sample protocols for habitat metrics. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is also currently finishing an initial side by side test of different protocols (www.pnamp.org). A result of the PNAMP work is that the Washington Governor's Forum on Monitoring endorsed four sampling methods in their 2007 Salmon and Watershed Monitoring Guidance; these included: the USFS AREMP and PIBO programs, the USEPA EMAP protocols, and the 2007 Upper Columbia Monitoring Strategy by Tracy Hillman.

Table 14. Features of different stream habitat sampling levels.

Feature	Sampling Level			
	Indicator	**Reconnaissance**	**Inventory**	**Intensive**
Metrics	Limited	Limited	Moderate to Many	Typically Many
Activity	Remote / office	On-the-ground	On-the-ground	On-the-ground
Focus	Stream, reach or site	Stream or reach	Reach & habitat unit	Site-specific
Data type	Quantitative or Qualitative	Typically Qualitative	Quantitative or Qualitative	Typically Quantitative
Repeatability	Moderate	Low	Moderate	High
Cost per area sampled	Very Low	Low	Moderate	High
Example protocols	USFS Level I Remote sensing	USFS Visual Assessment EPA Rapid Assessment LCFRB Watershed Assessments	USFS Level II LCFRB Restoration Strategies Oregon Stream Inventories	USFS Level III EPA EMAP
Example application	Survey, Index, Focal	Diagnostic, Survey	Survey, Index	Survey, Index, Focal

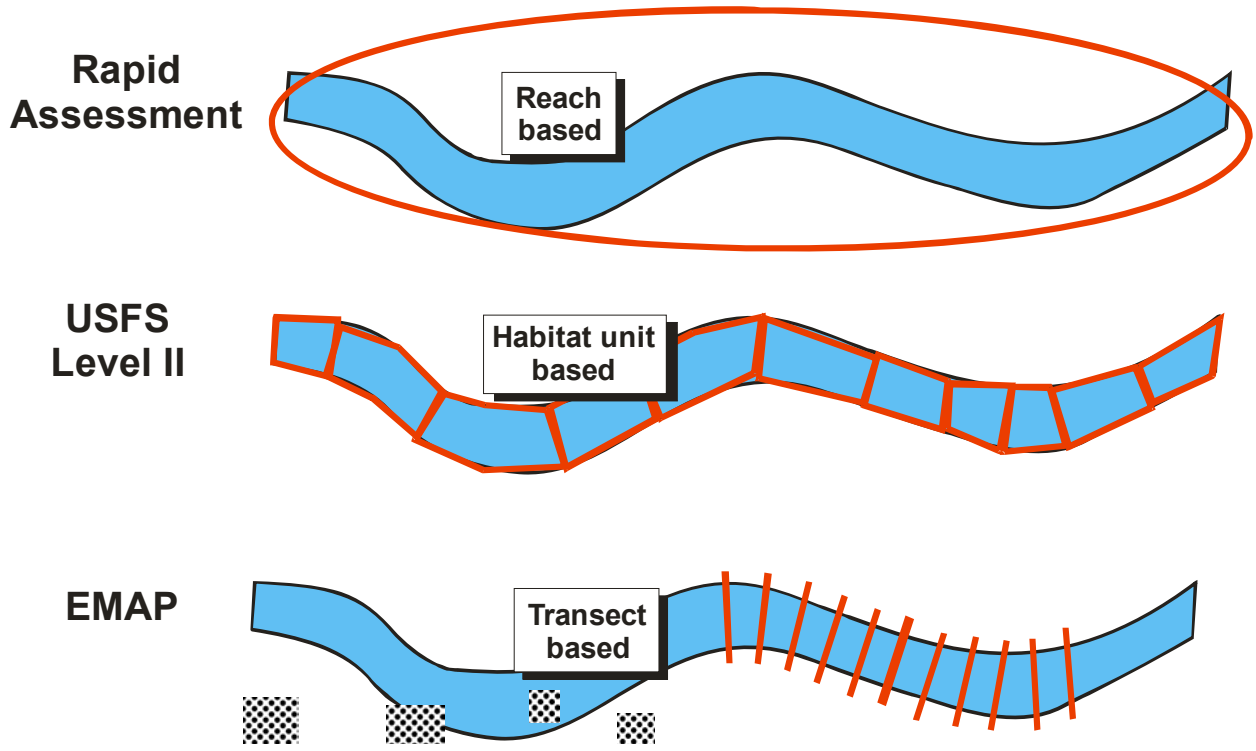

Figure 17. Examples of stream habitat measurement protocols.

4.1.4.4 Sampling Targets

Sampling targets outline the requirements necessary to carry out the monitoring program and will be used to measure progress toward accomplishing program goals. Targets are based on minimum requirements or criteria necessary to address all monitoring objectives consistent with the prescribed strategy. Targets are based on a systematic multi-tiered stratified statistical sampling design to address survey, trends, problems, and effects (Table 15). It is expected that some of these targets will be met by existing monitoring programs and some will require additional sampling effort. Minimum sampling targets could be met using other combinations of status and trend sampling.

Status sampling is intended to represent conditions at the subbasin level across the region. Minimum targets for status sampling are based on a 12-year sample rotation, probabilistic design, indicator and inventory level surveys, sample strata including subbasins, physiographic zones, and stream sizes, replicates of 3 sites per strata combination (Table 15). A total of 648 reaches would be sampled using the combination of a modified USFS level II and remote sensing data collection protocol would meet this benchmark. Distribution of these samples over a 12 year period would require a sample rate of 54 reaches per year. Sample sites would initially be selected at random from each strata but repeat sampling of the same sites in the second 12-year rotation would also provide for an evaluation of average habitat changes across the region.

Trends sampling is intended to detect trends in sensitive indicator stream reaches. Indicator sites are specifically selected to include areas that are particularly sensitive to habitat changes as well as significant to fish. These sites are selected independently from survey sample sites. Specified index sites will be repeat sampled at a three year interval in order to provide temporal replication needed to distinguish annual variation from long term trends and to characterize effects of periodic disturbances which are critical habitat forming processes. Minimum targets for index sampling involve one reach per physiographic zone in each subbasin. The 18 subbasins typically include 3 zones each for a total of 54 sample sites. Where distributed throughout the three-year rotation, this would require 18 sites to be sampled per year. Index sampling would be based on an intensive indicator measurement protocol (e.g. EMAP) in order to minimize measurement error in qualitative metrics due to potentially subjective surveyor judgment. Measurement transects in each reach would be fixed and repeat sampled during each sample replicate.

Problems sampling is intended to identify significant habitat and passage problem sites and potential protection and restoration opportunities. Problem sampling is concentrated on stream reaches of high priority for salmon protection or restoration as identified by reach tiers defined in the Recovery Plan. Minimum benchmarks for diagnostic sampling include 90% of tier 1 reaches and 50% of tier 2 reaches. Sample numbers are based on desired benchmark coverage levels and the numbers of Tier 1 and Tier 2 reaches in the region. Numbers vary from subbasin to subbasin depending on the number and priority of fish populations in each as well as basin size and fish distribution. Diagnostic sampling is conducted using rapid/visual assessment methods targeting the features of interest.

Effects sampling is designed for a variety of specific evaluation including site specific projects, action effectiveness, and landscape, stream, and fish linkages. Sampling elements are specific to each evaluation and are identified as appropriate. Benchmarks also identify the relative time and effort expected to be expended for each of the four sampling types. Effort allocation is approximate and based on benchmark sample sizes and protocols for each type.

The LCFRB has partnered with the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) to develop an integrated sampling design framework for collecting data and information to address habitat status and trends questions described in this monitoring program. The resulting Integrated Status and Trend Monitoring (ISTM) project involves development of an integrated design framework that applies a “master sample” concept to selection of sampling locations. This master sample design incorporates statistical randomization, is spatially balanced, and creates an ordered list of monitoring sites for collection of data and information for physical, chemical and biological attributes. The master sample is designed to incorporate the LCFRB’s sampling priorities, and allows selection of sites to meet particular needs in such a way that data sharing meets key design requirements to achieve status and trends monitoring goals. In other words, in using the master sample to identify sites for sampling, the resulting information can be aggregated and effectively integrated with other similarly obtained data to address key status and trends questions. The goal is to facilitate integration and “roll-up” of information from similar monitoring efforts throughout the Lower Columbia region, including those conducted by the U.S. Forest Service lands (e.g., AREMP), Washington State Department of Ecology, State of Oregon, and other local, state and federal agencies.

Table 15. Sampling targets for stream habitat monitoring by objective application and sampling type.

	Status	Trends	Problems	Effects
Objective	Represent conditions at the subbasin level	Detect trends in sensitive indicator sites	Identify significant habitat and passage problem sites & restoration opportunities	Design and evaluate site specific projects, action effectiveness, and fish linkages
Site selection criteria	Stratified Probabilistic	Non-random based on fish values & expected impacts	All high priority salmon habitat reaches	Action-specific
Sampling level	Indicator + Inventory	Indicator + Intensive	Indicator + Reconnaissance	As appropriate
Sample unit	Reach	Site	Reach	As appropriate
Subsample stratification	Subbasin x Zone x Order	Subbasin x Zone	Subbasin	As appropriate
Total # strata	18 x 3 x 4 = 216	18 x 3 = 54	18	As appropriate
Replicates / strata	3	1	variable	As appropriate
Samples total	648	54	360 (approx.)	As appropriate
Samples / subbasin	36		20 (approx.)	As appropriate
Sampling frequency	12-year rotation	3-year rotation	12-year rotation	As appropriate
Samples / year	54	18	30 (approx.)	As appropriate
Representation	>10% of available 1:100,000 scale reaches	not applicable	90% of tier 1 reaches 50% of tier 2 reaches	As appropriate
Example method	USFS level II or equivalent	EMAP or equivalent	Rapid / Visual Assessment	As appropriate
Approx allocation of total sampling effort	50%	20%	20%	10%

4.1.5 Current Monitoring Activities

There is currently no systematic and comprehensive stream habitat monitoring program in the Lower Columbia Region adequate for evaluations of status and trends necessary to inform the public and meet federal ESA recovery purposes (Crawford 2007). However, fish-related stream habitat survey information is available from a diverse mix of local, state, and federal entities and with various objectives (Table 16). Significant stream habitat sampling efforts in recent years are summarized by subbasin in Table 17. A detailed inventory of habitat-related monitoring activities is also presented in an Appendix.

Baseline stream and reach-level habitat conditions on the lower Columbia have been assessed and characterized using the Ecosystem Diagnosis and Treatment (EDT) methodology (MBI 1999). EDT is a database and mechanistic model that relates fish performance to aquatic habitat characteristics. Physical habitat conditions were described for each individual stream reach in the form of qualitative scores for 46 indicators, known as level 2 habitat attributes. These model inputs were then related through a set of rules to life stage specific survival in order to model fish potential and limiting factors for the current (patient), historical (template) and "Properly Functioning" conditions. This evaluation considered information from local experts, observations from reconnaissance-level stream habitat surveys conducted by several Conservation Districts in the late 1990s, and inventory-level surveys conducted periodically by the U.S. Forest Service on National Forest lands. WDFW also conducted supplemental indicator and reconnaissance-level assessments to support this effort. The EDT analysis was completed in 2004 for recovery and subbasin planning purposes and updated in 2007 with a more comprehensive dataset for small first order streams not included in the initial assessment.

A variety of stream habitat data on specific areas or selected metrics have also been collected by various parties in relation to project planning or evaluation, as well as for regulatory purposes. Examples include surveys in the Lewis River subbasin by PacifiCorp as part of hydropower evaluations and relicensing activities and on private timberlands in the Coweeman subbasin by Weyerhaeuser as part of forest practice evaluations.

More detailed stream habitat assessments were conducted by the LCFRB in the Kalama, Lewis, Salmon, and Washougal subbasins during 2004 (R2 Resource Consultants 2004; SPCA 2005). These surveys subsampled reaches stratified by stream size and significance to fish recovery, followed a modified USFS Level II sampling protocol, collected data on stream habitat conditions, riparian conditions, sediment sources, and also inventoried hydromodifications and potential habitat restoration opportunities. The intent of these projects was to help fill data gaps, identify potential enhancement, restoration, or protection projects, and to evaluate previous EDT results.

More detailed stream habitat assessments have also been undertaken as part of Washington's Intensively Monitored Watershed (IMW) Project (Bilby et al. 2004). This project is a joint effort of the Washington Departments of Fish and Wildlife and Ecology, NMFS, EPA, Lower Elwha Klallam Tribe and Weyerhaeuser Company and is funded by the Washington Salmon Recovery Funding Board and NMFS (http://wdfw.wa.gov/hab/imw/index.htm). The IMW project focuses intensive fish and habitat monitoring efforts on a few locations in order to identify the complex relationships controlling salmon response to habitat conditions and restoration treatments. The

IMW project includes Mill, Abernathy, and Germany creeks in the Coast strata of the lower Columbia Region, and cooperators have begun collecting a comprehensive suite of data in 2005 on water quantity, water quality, habitat, summer juvenile fish abundance, and smolt production. Stream habitat surveys in the IMW are based on EMAP protocols.

At the subbasin scale, significant habitat data has been collected from inventory or intensive level sampling efforts during the last 10-15 years in almost all of the Cascade and Gorge strata subbasins, with the exception of the lower Cowlitz subbasin. Intensive-level stream habitat sampling data is also available from the Mill, Abernathy, and Germany subbasin in the Coast strata and from the Wind subbasin in the Gorge strata. However, systematic ongoing monitoring efforts of a comprehensive suite of stream habitat conditions is currently limited to the IMW project in the Coast strata.

Table 16. Key entities involved in significant habitat monitoring in the lower Columbia region.

Entity	Information type	Location
Federal		
U.S. Forest Service	Riparian condition and function, channel morphology and complexity, temperature, water quality, watershed conditions and hillslope processes, fish passage	Kalama, Wind, Cowlitz, Lewis, Washougal, Bonneville Tribs, Gorge Tribs, Little White Salmon
Bureau of Land Management	Water quality, stream/riparian surveys, channel morphology and complexity	Lower Columbia
U.S. Geological Survey	Stream flow, water quality, limited habitat complexity and cover	Throughout the region
U.S. Fish and Wildlife Service	Channel morphology and complexity, Stream flows	Gee Creek, Hamilton Creek, Gibbons Creek, Lewis River
U.S. Army Corps of Engineers	Water quality	Lower Columbia Mainstem
NMFS	Habitat conditions	Lower Columbia Mainstem
State		
WA Departments of Ecology and Fish and Wildlife	Stream/riparian surveys, temperature, channel morphology and complexity	Lower Columbia
WA Department of Natural Resources	Water quality, watershed conditions and hillslope processes, fish passage	Lower Columbia
Washington Department of Ecology	Extensive water quality in a limited number of basins, instream flows, floodplain and wetland function; channel migration processes	Lower Columbia
State Parks	Stream/riparian surveys, blocked habitat, channel morphology and complexity	Lower Columbia
WA Department of Health	Drinking water quality	Statewide
Local		
Clark PUD	Temperature, stream and riparian surveys	Salmon, East Fork Lewis, Washougal
Clark Conservation District	Water quality, fish passage, habitat conditions, fish barriers	Lewis, Salmon Creek, Washougal
Wahkiakum Conservation District	Instream, floodplain, riparian conditions, Water quality, temperature, fish passage	Grays, Skamokawa, Elochoman, Mill
Cowlitz Conservation District	Channel complexity and morphology, water quality, fish passage, riparian conditions	Lower Cowlitz, Coweeman, Toutle, Kalama, Lower NF Lewis, Mill, Abernathy, Germany
Clark County	Water quality (temp/flow/quality) channel morphology and complexity, stormwater	EF Lewis, Lake River, Salmon Creek, Lower NF Lewis, Washougal
LCFRB	all limiting factors	Lower Columbia region
Lower Columbia Fish Enhancement Group (LCFEG)	Water quality, habitat conditions, fish/habitat associations	Lower Columbia & tributaries
Lower Columbia Estuary Partnership (LCREP)	Water quality, habitat conditions, fish/habitat associations	Lower Columbia & tributaries
Columbia River Estuary Study Task Force	Project effectiveness, restoration feasibility	Lower Columbia
PacifiCorp	Temperature, stream flow, instream habitat conditions	NF Lewis Basin
Underwood Conservation District	Water Quality	Wind Basin, White Salmon Basin
Fish First	Channel morphology and complexity, temperature	Cedar Creek, East Fork Lewis

Table 17. Summary of significant fish-related habitat survey efforts in Washington Lower Columbia subbasins.

			Sampling level		
	Basin	Indicator	Reconnaissance	Inventory	Intensive
Coast Strata	Grays	WDFW (2004-2006) [1]	WCD (1996)[3]	--	--
	Grays Bay Tribs		WCD (1996-1997)[3] WDFW (2002-2003)[2]	--	--
	Skamokawa	WDFW (2004-2006) [1]	WCD (1996-1997)[3] WDFW (2002-2003) [2]	--	--
	Elochoman	WDFW (2004-2006) [1]	CCD (1996)[3] WDFW (2002-2003) [2]	--	--
	Mill	WDFW (2004-2006) [1]	CCD (1996-1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
	Abernathy	WDFW (2004-2006) [1]	CCD (1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
	Germany	WDFW (2004-2006) [1]	CCD (1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
Cascade strata	Lower Cowlitz	WDFW (2004-2006) [1]	CCD (1996-1999)[3] LCCD (2000)[3]	--	--
	Coweeman	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	Weyerhaeuser (1995-1996)	--
	Toutle	WDFW (2004-2006) [1]	--	USFS (1993)	--
	Upper Cowlitz	WDFW (2004-2006)[1]	--	USFS (1987-2001)	--
	Cispus	WDFW (2004-2006)[1]	--	USFS (1987-2001)	--
	Tilton	WDFW (2004-2006)[1]	--	USFS (1993)	--
	Kalama	WDFW (2004-2006)[1]	--	USFS (1990) LCFRB (2004)	--
	Lower NF Lewis	PacifiCorp (2003)[1]	WDFW (2002-2003) [2]	PacifiCorp (1999-2000) LCFRB (2004)	--
	Upper Lewis	PacifiCorp (2003)[1]	PacifiCorp (1999-2000)	USFS (1989-2000) LCFRB (2004)	--
	EF Lewis	WDFW (2004-2006) [1]	WDFW (2003) [2]	USFS (1991-2001) LCFRB (2004)	--
	Salmon	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	LCFRB (2004)	--
	Washougal	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	LCFRB (2004)	--
	Lower Gorge	WDFW (2004-2006) [1]	--		--
Gorge strata	Upper Gorge	--	--	USFS (1997)	--
	Wind	WDFW (2004-2006) [1]	--	USFS (1988-2001)	--
	Little White Salmon	--	WDFW (2002-2003) [2]	USFS (1988-2001)	--

1 Part of EDT analysis
2 Subsampling for selected EDT Analysis inputs.
3 Qualitative surveys by stream reach for limiting factor assessments
4 Intensively monitored watershed program

WCD = Wahkiakum Conservation District
CCD = Cowlitz Conservation District
WDFW = Washington Department of Fish & Wildlife
USFS = US Forest Service
LCCD = Lewis County Conservation District
LCFRB = Lower Columbia Fish Recovery Board

4.1.6 Information Gaps

Current sampling efforts were evaluated based on sampling criteria to identify where information needed for salmon habitat recovery monitoring is lacking (Table 18). Significant information gaps were identified in almost all subbasins at every level.

Survey samples to describe current habitat status meet sampling criteria in the Intensively Monitored Watershed project area including Mill, Abernathy, and Germany creeks. Status survey criteria are partially met in most Cascade and Gorge subbasins by the combination of LCFRB inventory surveys during 2004, periodic USFS surveys on federal lands, and other efforts (Weyerhaeuser, PacifiCorp) in selected watersheds. However, survey sample coverage appears to fall short of criteria in some strata of Cascade and Gorge subbasins, particularly in representative small, low elevation streams on nonfederal lands. Survey sample data is limited for non IMW Coast subbasins, the lower Cowlitz, and the lower Gorge tributaries.

Table 18. Summary of current availability of stream habitat information relative to sampling criteria by objective application and sampling type.

		Status / Survey	Trends / Index	Problems / Diagnostic	Effects / Focal
	Criteria:	3 inventory samples per subbasin, zone & order	1 Intensive sample per subbasin & zone	Reconnaissance samples of 90% of Tier 1 & 50% of Tier 2	Not specified
	Basin				
Coast	Grays	**Low**	**Low**	**Moderate**	**Moderate**
	Grays Bay Tribs	**Low**	**Low**	**Moderate**	**Moderate**
	Skamokawa	**Low**	**Low**	**Moderate**	**Moderate**
	Elochoman	**Low**	**Low**	**Moderate**	**Moderate**
	Mill	**Very High**	**Very High**	**High**	**High**
	Abernathy	**Very High**	**Very High**	**High**	**High**
	Germany	**Very High**	**Very High**	**High**	**High**
Cascade	Lower Cowlitz	**Low**	**Low**	**Low**	**Moderate**
	Coweeman	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Toutle	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Upper Cowlitz	**Moderate**	**Low**	**Moderate**	**Moderate**
	Cispus	**Moderate**	**Low**	**Moderate**	**Moderate**
	Tilton	**Moderate**	**Low**	**Moderate**	**Moderate**
	Kalama	**Moderate**	**Low**	**Moderate**	**Moderate**
	Lower NF Lewis	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Upper Lewis	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	EF Lewis	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Salmon	**Moderate**	**Low**	**Moderate**	**Moderate**
	Washougal	**Moderate**	**Low**	**Moderate**	**Moderate**
	Lower Gorge	**Low**	**Low**	**Low**	**Moderate**
Gorge	Upper Gorge	**Moderate**	**Low**	**Moderate**	**Moderate**
	Wind	**Moderate**	**Moderate**	**Moderate**	**Moderate**
	Little White Salmon	**Moderate**	**Moderate**	**Moderate**	**Moderate**

Low: Criteria addressed primarily through Indicator level sampling.
Moderate: Criteria partially met by reconnaissance, inventory or intensive sampling within the prescribed period.
High: All Criteria met by sampling within a period correspond to the prescribed sampling frequency (3 or 12 years)
Very High: Sampling exceeds all criteria
Effects / Focal monitoring assessed based on degree of miscellaneous habitat assessments associated with action-specific or regulatory activities by various parties.

Index samples needed to provide a solid baseline for evaluating habitat trends are available only from Mill, Abernathy, and Germany creeks which are part of the Intensively Monitored

Watershed (IMW) project area. Trend index criteria might be partially addressed in some Cascade and Gorge subbasins by LCFRB inventory surveys during 2004, periodic USFS surveys on federal lands, and other efforts (Weyerhaeuser, PacifiCorp, Washington DNR) in selected watersheds. However, existing inventory data in these areas may be suitable only for detecting large changes in habitat conditions and may not be adequate for characterizing smaller incremental changes over time or distinguishing trends from periodic disturbances. Nor are all physiographic zones or stream sizes represented. Sampling criteria generally identify the need for more intensive sampling levels in sensitive areas in order to identify trends. Suitable trend index data is not available for several subbasins in each ecozone.

Diagnostic reconnaissance has been completed at some level in most subbasins but existing samples fall short of criteria levels either for level of sampling or coverage of the majority of reaches identified by the Recovery Plan as significant or potentially significant to fish production. Reconnaissance level surveys in coastal and lower Cowlitz subbasins by the conservation districts provided broad coverage to identify limiting factors at a gross scale but did not provide adequate information on site-specific problems and opportunities to guide habitat protection and restoration efforts. Assessments by the LCFRB and Forest Service in many Cascade or Gorge subbasins provided detailed information but did not include a complete coverage of significant fish reaches.

In addition, a variety of project or action related habitat monitoring efforts are underway across the region. These can be expected to provide some useful habitat information on some metrics in some areas. In particular, the Mill, Abernathy and Germany IMW project is expected to provide excellent data on habitat effects on fish. However, existing efforts fall short of needs for focal monitoring related to action effectiveness monitoring throughout the region. Further discussion of effectiveness monitoring for habitat actions may be found in a subsequent section.

While a patchwork of stream habitat information has been provided by a variety of activities, few of these are part of a long-term systematic effort that can be expected to answer habitat monitoring needs for salmon recovery. Most continuing habitat monitoring efforts are project or action related. These can be expected to provide some useful information but will likewise fall short of the information needed to evaluate progress or lack thereof of recovery efforts to address habitat-related threats that contributed to listing of salmon and steelhead throughout the region.

4.1.7 Implementation Measures

M.M6. Maintain current habitat monitoring efforts for representative priority areas.

Priority: Very High

Lead: USFS, WDFW, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Current habitat monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments and Recovery Plans. Current programs are adequate for some Recovery Plan applications but fall short in other areas. Thus, effective monitoring and evaluation will require more funding, not less. This RM&E plan seeks a balance in commitments between monitoring, protection, and restoration activities. Current monitoring activities have been implemented with a mixture of hard and soft funds. In many cases, long term funding of key programs is not assured. Many previous habitat sampling efforts are not part of any ongoing program. Loss of significant components of current habitat monitoring programs would significantly reduce the accuracy and precision of evaluations of progress, or lack thereof, with respect to recovery goals.

6-Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M7. Establish a baseline habitat characterization and database of current stream conditions in the lower Columbia region based on existing data for use as a reference point in future analysis as well as specific guidance for additional sampling needed to fill information gaps.

Priority: High

Lead: USFS, WDFW, WDNR, WDOE, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Significant habitat information exists from current and past sampling programs by a wide variety of parties for a multitude of purposes. This information is identified in this plan and used to identify significant information gaps. Much of this information was also utilized in the recovery and subbasin plan to generally characterize existing conditions and to identify priorities for protection and restoration actions. A considerable amount of data has already been collected by federal, state, tribal, and local entities; however, a comprehensive baseline, extending down to the stream scale, has yet to be established. The existing information has not been synthesized and summarized for the purposes of clearly identifying baseline conditions for future reference. Existing information has been compiled from a variety of sources but source protocols and references have not always been effectively captured in metadata. Recovery planning analyses using Ecosystem Diagnosis and Treatment and Integrated

Watershed Assessment methodologies relied primarily on readily available and easily summarized data sources and did not incorporate the full scope of the available data needed to characterize the baseline. More intensive synthesis, analysis, and documentation are needed than was required for recovery and subbasin planning purposes. Without this upfront work, future habitat monitoring evaluations will have difficulty discerning the baseline conditions, some current information may be lost, and gaps in current status information will be overlooked. The baseline habitat characterization will also provide an explicit template to guide future habitat evaluations at Recovery Plan implementation checkpoints.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate funding sources and implementation partners.
b. Develop and implement an appropriate plan of work.
c. Obtain existing data from regional entities, build a data library including documentation where available, and incorporate appropriate information into a georeferenced relational database suitable for use in future status, trend, and problem analyses.
d. Collectively analyze data to characterize baseline stream habitat conditions. Process and summarize data to produce regionally representative information (including extraction of level II information from the EDT analysis). This includes spatially locating data, and translation of diverse metrics, scales, and protocols to a common representation to the extent possible. Graphically and statistically characterize results.
e. Incorporate data quality assessments.
f. Identify specific sample data needs to fill information gaps in baseline conditions relative to sampling criteria.

M.M8. Develop and implement an empirical sampling program to fill specific data gaps in the habitat baseline relative to sampling criteria identified by this program.

Priority: High

Lead: LCFRB with support from USFS, WDFW, PNAMP, NMFS, conservation districts and counties

Rationale: Existing data is not adequate to clearly establish baseline habitat conditions. Lack of a clear description of baseline habitat status will preclude future determination of trends. Without clear evidence for trends, it will be impossible to determine the cumulative effect of recovery activities and other influences on habitat conditions, whether further actions are needed or whether past actions have achieved objectives. Even where actions produce significant benefits, due credit for results could not be given. In order to track progress with respect to the Recovery Plan goals for threat reduction and delisting criteria, existing data must be supplemented with additional sampling and analysis. Attempts to establish a current habitat status baseline will identify significant data gaps for specific areas and conditions that will require inferences from other sites or related information. An accurate baseline will require a sample set representative of the larger population at both the reach and watershed scale within each physiographic strata of the region. Targeted sampling will be required.

6-Year Implementation Work Schedule Activities**:**

a. Develop appropriate funding sources and implementation partners.
b. Develop and implement an appropriate plan of work.
c. Design and implement targeted surveys. Select specific measures and protocols consistent with objectives and needs identified in this program. Select sample sites according to sampling plan and data availability

M.M9. Develop and implement a sampling program to address long-term watershed, stream, and water quality monitoring needs not currently being addressed by other parties.

Priority: High

Lead: LCFRB with support from USFS, WDFW, conservation districts and counties

Rationale: No systematic stream habitat monitoring program currently exists for the Washington Lower Columbia Salmon Recovery Region. Habitat monitoring is currently conducted by a variety of parties for a variety of purposes, but activities and results are not coordinated or captured for application to salmon recovery monitoring and evaluation purposes. A dedicated sampling program is necessary to meet salmon recovery needs. This monitoring needs to incorporate a mixture of existing programs, new programs implemented by parties to address various needs, and new sampling of representative long term index sites.

6-Year Implementation Work Schedule Activities:

a. Develop appropriate funding sources and implementation partners.
b. Develop and implement an appropriate plan of work.
c. Design and implement a systematic annual stream habitat survey program as per the objectives, strategies and criteria detailed in this program.

4.2 Landscape – Watersheds, Uplands/Hill slopes, Wetlands

4.2.1 Objectives

Habitat status monitoring at the landscape scale is primarily intended to characterize watershed upland/hill slope and wetland conditions that affect stream habitat for salmon relative to a baseline at listing and improvements consistent with recovery. The objective at this scale is to detect broad changes in watershed conditions and processes that affect stream habitat forming processes. Stream conditions reflect the direct effects of actions at the stream habitat scale as well as watershed-scale actions and conditions that influence stream habitat forming processes. Monitoring of watershed conditions will identify long-term trends and cumulative effects of recovery measures and other human activities (Box 3).

Landscape-scale habitat information has a variety of applications critical to salmon recovery. A primary application will be to evaluate the status of habitat-related statutory listing factors identified by the NMFS listing status decision framework (NOAA 2007). Comparisons of observed and benchmark watershed and floodplain conditions with salmon habitat distribution also help to identify problem areas and focus actions for maximum effect and efficiency. Landscape scale information is also used to evaluate the effectiveness of actions at that scale. Finally, comparisons of landscape, stream, water, and biological information are the basis for uncertainty and validation research designed to identify key functional relationships and to reduce fundamental uncertainties which might constrain effective Recovery Plan implementation.

Box 3. Questions and hypotheses addressed by salmon-related landscape monitoring.

Question #1. ***Are landscape conditions stable or changing as a result of fish protection and restoration actions, and other factors?***

Null hypothesis: Watershed, upland/hill slope and wetland conditions are unchanged since listing.
Alternative: Watershed, upland/hill slope and wetland conditions have changed since listing.

Question #2. ***Which landscape-level areas and factors are most important to stream habitat conditions in key fish production areas?***

Null hypothesis: All watershed, upland/hill slope and wetland areas and factors are of equal importance to fish.
Alternative: Some watersheds, upland/hill slope and wetland areas and factors are more important than others.

Question #3. ***Have specific landscape-level actions achieved the desired physical effects? (see action effectiveness monitoring section)***

Null hypothesis: Actions resulted in no change in watershed, upland/hill slope and wetland conditions.
Alternative: Changes in watershed, upland/hill slope and wetland conditions are a result of the action.

Question #4. ***How are stream conditions affected by landscape/watershed factors? (see uncertainty and validation research section***

Null hypothesis: Stream conditions are unaffected landscape factors or stream flow patterns.
Alternative: Stream conditions are affected by landscape factors or stream flow patterns.

4.2.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For landscape-scale monitoring, these include:

M.S26. Complete comprehensive assessments of landscape conditions status and trends at 12 year intervals as prescribed by the Recovery Plan.

A 12 year assessment interval is identified by the Recovery Plan for the assessment of stream habitat status relative to baseline conditions and benchmarks. Landscape-scale information will be compiled uniformly across the entire study area at 12-year intervals corresponding with habitat assessment checkpoints identified in the Recovery Plan.

M.S27. Derive landscape-scale data for status and trends monitoring primarily from existing datasets or other regional activities.

This monitoring program does not anticipate intensive development or derivation of landscape-scale information across the region for the dedicated salmon recovery applications other than for watershed action effectiveness monitoring or research on watershed-stream habitat linkages. Rather, this monitoring program focuses on stream habitat conditions which are the more proximate driving factor in fish status and trends.

4.2.3 Indicators

4.2.3.1 Attributes & Metrics

Landscape scale conditions are characterized through a set of indicators including attributes, metrics, and statistics that reflect the suite of conditions that are relevant to salmonid protection and recovery (Table 19). The program recognizes the subjectivity of defining a boundary between watershed, floodplain, riparian zone and stream attributes due to the complexity of connectivity and functional relationships. Watershed indicators include geomorphology, land use, vegetation cover, road density, and landslides. Floodplain indicators include channel migration zones, connectivity, and wetlands. Indicators are consistent with those identified in NMFS's listing status decision framework for the habitat category and with other diagnostic methods implemented in the region including the Integrated Watershed Assessment (IWA) (LCFRB 2004).

Table 19. Attributes, metrics, and example statistics for use as indicators of watershed and floodplain status.

Attribute	Metric	Example statistics	Relevance to Fish
Watershed conditions & hillslope processes	-Road Density & stream crossing frequency -Mass Wasting -Impervious Surfaces -Land Use / Land Cover	Density and type of road & stream crossing Number and size/scale of events Percent impervious surfaces Area of land use and cover class	Habitat access Supply of spawning substrate Fine sediment supply Landslides and debris flows Flood magnitude and timing Summer low flow availability Pollutant runoff
Floodplain and wetland function; channel migration processes	-Channel migration zone encroachment -Wetland availability -Floodplain connectivity	Width of channel migration zone Acres of wetlands Extent of connected floodplains	In-channel habitat formation and maintenance Off-channel habitat creation Nutrient exchange Flood abatement Flood refuge Temperature moderation

4.2.3.2 Criteria

Assessments of habitat suitability for fish and the effects of habitat changes will rely on quantitative and qualitative interpretations of landscape indicators. Interpretations will be based on changes in indicators over time as well as comparisons with criteria values (Table 20). Criteria do not represent goals but are goal-related reference points or standards against which to compare performance achievements.

Given the inherent variability and complexity of natural systems, it is impractical to establish broadly applicable goals for habitat conditions, particularly at the watershed level. A more effective approach for habitat characteristics is to develop relative measures of trends over time. Many different combinations of attribute conditions might satisfy recovery goals. Criteria provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level. The Recovery Plan identifies habitat criteria based on Properly Functioning Conditions (PFCs) identified by NMFS to reflect freshwater habitat conditions generally favorable for salmonids spawning and rearing (NMFS 1996b). NMFS defines PFCs as "the sustained presence of natural habitat-forming processes in a watershed (*e.g.*, riparian community succession, bedload transport, precipitation runoff pattern, channel migration) that are necessary for the long-term survival of the species through the full range of environmental variation." PFC, then, constitutes the habitat component of a species' biological requirements. The indicators of PFC vary between different landscapes based on unique physiographic and geologic features. For example, aquatic habitats on timberlands in glacial mountain valleys are controlled by natural processes operating at different scales and rates than are habitats on low-elevation coastal rivers. PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes.

Table 20. Salmonid watershed criteria based on "Properly Functioning Conditions" Matrix of Pathways and Indicators (NMFS 1996b) and Northwest Forest Plan (1994).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Watershed Conditions:	Road Density & Location	<2 mi/mi² [11], no valley bottom roads	2-3 mi/mi², some valley bottom roads	>3 mi/mi², many valley bottom roads
	Disturbance History	NMFS <15% ECA (equivalent clearcut area; entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area;	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area;	>15% ECA (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area;
		NWFP-area (except adaptive Management Areas (AMA)), ≥15% retention of Late Successional/Old Growth (LSOG) in watershed[10]	NWFP area (except AMAs), ≥15% retention of LSOG in watershed[10]	does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%[12]	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (≈70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[12]	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition <25%[12]

[10] *Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional Species and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management.*

[11] *USDA Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.*

[12] *Winward, A.H., 1989. Ecological Status of Vegetation as a Base for Multiple Product Management. Abstracts 42nd Annual Meeting, Society for Range Management, Billings MT, Denver, CO: Society for Range Management: p. 277*

4.2.3.3 Example Information

Example reporting templates for landscape scale data are depicted below. This data may be represented in terms of area-specific physical conditions or can be represented relative to criteria values. Spatial landscape data is well suited to presentation in a map format and this application is facilitated by use of Geographical Information Systems. Examples were included to illustrate how data might begin to be organized and used. The data included in examples also represents baseline conditions for comparison with results of future monitoring. Many alternative depictions might ultimately be developed.

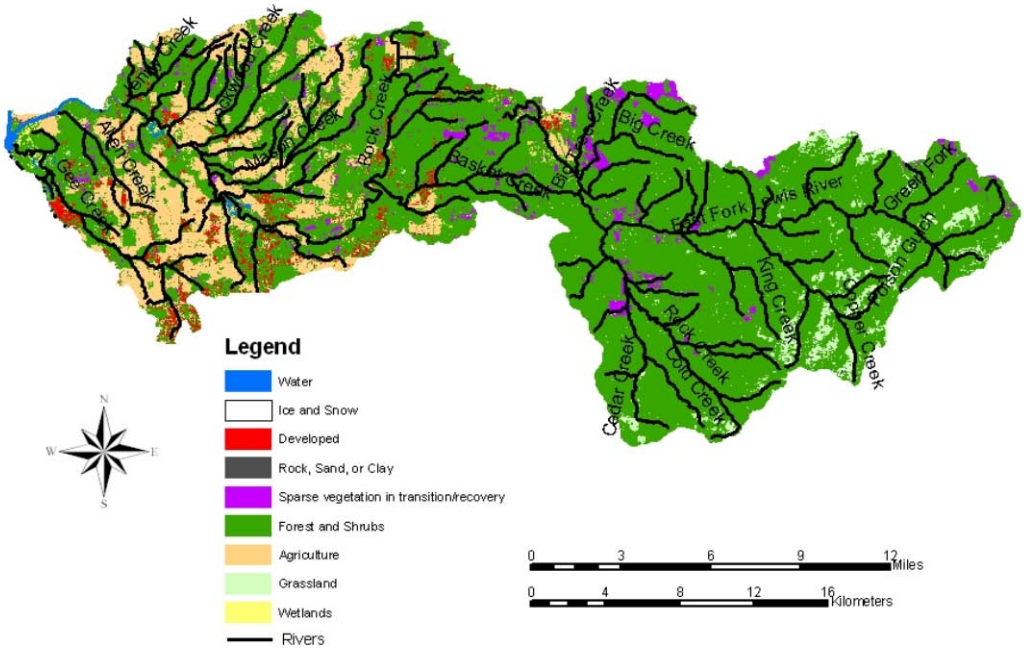

Figure 18. Map example depicting landscape-level data.

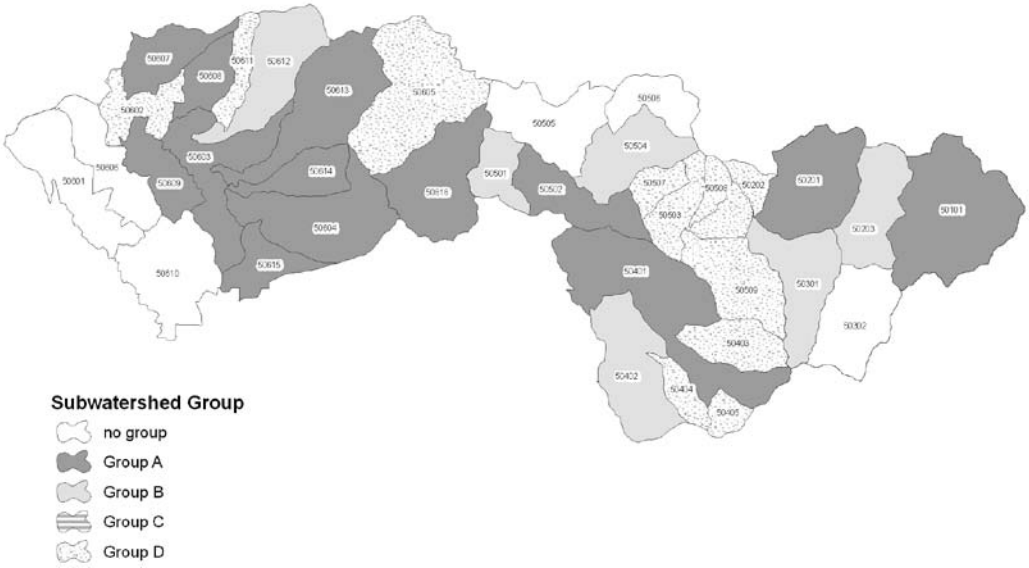

Figure 19. Examples of subwatershed categories based on significance to important salmon habitats.

4.2.4 Sampling & Analytical Design

Landscape-scale analyses will rely on region-wide land use and land cover metrics, as well as impairment ratings related to hydrology, fine sediment supply, and riparian function. Watershed-scale attributes are typically broad-scale and slow to change, and monitoring is therefore relatively infrequent and covers a wide spatial-scale. An exception might be rapidly developing areas where land cover may change dramatically within a period of years; these areas can warrant a more intensive monitoring focus. More intensive studies in developing areas will be identified but will also rely on existing GIS data sources compiled by cooperating agencies. Intensive watershed-scale studies will be driven by land use trends and data availability.

4.2.5 Current Monitoring Activities

Current monitoring activities at the watershed scale are primarily focused on regulatory, action effectiveness, or research applications. The depth and breadth of this activity varies considerably from place to place. Land management agencies such as the U.S. Forest Service that maintain detailed current information on activities and conditions on Federal forest lands. Ongoing USFS activities include the Aquatic Resource Effectiveness Monitoring Program (AREMP) and the Pacific Intermountain Biological Opinion (PIBO) sampling programs, both of which are using satellite imagery to characterize changes in forest seral stages and roads. Various Washington State agencies monitor and maintain landscape level information related to their responsibilities and authorities. For instance, landscape scale information is collected and maintained by the Department of Natural Resources for land use and conditions on state lands, the Department of Transportation on roads, and so on. Other local agencies and entities collect and maintain specific information within areas of their jurisdiction or interest (e.g. Counties, Utility Districts, etc.). At a more global landscape scale, detailed aerial and satellite imagery is widely available.

Baseline watershed conditions within the Lower Columbia Region have been characterized using a GIS-based approach referred to as the Integrated Watershed Assessment. The IWA explicitly considered three processes known to affect the quantity and quality of fish habitat: hydrology, sediment delivery, and large woody debris recruitment potential. IWA was used characterize existing and probable future conditions in 545 subwatersheds throughout the Washington Lower Columbia Region. IWA results provide a “top down” view of factors affecting instream habitat conditions.

4.2.6 Information Gaps

The primary gap identified in this monitoring program for landscape scale information is for a systematic regional effort to assemble, synthesize, and evaluate existing information at periodic intervals. The Recovery Plan identifies a 12-year interval for habitat status checkpoints. This is primarily a data mining exercise. Landscape-level analyses of watershed and floodplain conditions in the Integrated Watershed Analysis completed as part of the Recovery Plan captured the current landscape information readily available for the region and will serve as an effective baseline for future analyses.

No significant new data collection efforts at the landscape scale are identified in this monitoring program at this time independent of other watershed and floodplain information needs for regulatory, action effectiveness, or research applications. These needs are detailed in a subsequent section. Note that some landscape-level analysis of remote sensing information is identified as a need in support of stream habitat evaluations in specific reaches – that need is addressed in the stream habitat status and trends monitoring section.

4.2.7 Implementation Measures

M.M10. Maintain current landscape scale habitat monitoring efforts for application as available in periodic status and trend assessments.

Priority: High

Lead: USFS, WDFW, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Current habitat monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments and Recovery Plans. Habitat status and trend evaluations identified in this program are focused on monitoring at the stream habitat rather than landscape scale but landscape information for other sources will be incorporated into evaluations. Because dedicated landscape scale data collection efforts are not a focus of this monitoring program, future assessments will rely on other sources for information needed to provide a context for evaluation of habitat patterns at the stream scale.

6-Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules
d. Identify constraints and uncertainties
e. Identify coordination considerations.

M.M11. Seek and utilize opportunities to supplement existing landscape scale information collection, synthesis, and reporting activities appropriate.

Priority: Moderate

Lead: LCFRB, USFS, WDFW, WDNR, WDOE, local conservation districts (Clark, Cowlitz, Lewis, Underwood, and Wahkiakum), and counties (Clark, Cowlitz, Lewis, Skamania and Wahkiakum)

Rationale: Ongoing activities are expected to provide most of the landscape-level information needed to provide a watershed and floodplain context for stream habitat condition status and trends that are the focus of habitat monitoring in this plan. Opportunities may occasionally arise to augment existing efforts by other parties to increase depth and breadth of coverage of various landscape attributes. In this case, existing efforts might be substantially leveraged with very cost effective contributions.

6-Year Implementation Work Schedule Activities**:**

a. Identify opportunities as available.
b. Identify appropriate funding sources and implementation partners.
c. Develop and implement appropriate plans of work.

4.3 Water – Quantity & Quality

4.3.1 Objectives

Water quantity and quality are key components of this salmon recovery monitoring program. Water quantity and quality either reflect or affect virtually every other habitat characteristic in the watershed and stream habitat feature. These factors can have broad ranging effects on fish populations (e.g. temperature changes alter species distribution and persistence) as well as discrete point source impacts (e.g. chemical discharge at lethal toxicity levels). As with other habitat monitoring, the primary focus is to characterize conditions for salmon and watershed health relative to a baseline at listing and improvements in statutory listing factors consistent with recovery. This information will also meet other objectives as identified in Box 2, including identification of limiting factors to focus actions; determination of habitat suitability and potential to guide prioritization of areas for preservation and restoration; fish status inferences where biological data is incomplete; action effectiveness evaluations; and research on fundamental linkages among fish, watersheds, and streams.

This program describes monitoring needs specific to Salmon Recovery and comprehensive Watershed Plans completed for Washington lower Columbia subbasins in 2006 (LCFRB 2006b, 2006c). It also considers stream flow and water quality monitoring needs for a full spectrum of human and fish concerns (Box 4). The habitat monitoring program described herein incorporates elements of Watershed Plan monitoring pertinent to fish. The Watershed Plans are designed to address the salmon-related monitoring needs for water quantity or quality data. Water quantity and quality monitoring is also conducted in association with hydropower operations – these elements are addressed in the Action Effectiveness section later in this document.

Box 4. Water quantity and quality monitoring needs identified in Washington lower Columbia Watershed Plans (LCFRB 2006b, 2006c).

Flow

- Provide basic data needed to assess current status and long-term trends in stream flow.
- Provide basic data to determine how various components of the watershed contribute to flow.
- Assess how short-term or long-term changes in watershed conditions affect flows.
- Evaluate the effectiveness of specific management actions designed to improve the flow regime.

Water quality

- Determine the effects on human health for drinking water systems relying on surface water.
- Determine the effects on human health through contact recreation.
- Determine the effects on fish species listed under the Endangered Species Act and other aquatic life.

4.3.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For water quality and quantity monitoring, these include:

M.S28. Complete comprehensive assessments of water quality and quantity status and trends at 12 year intervals as prescribed by the Recovery Plan.

A 12 year assessment interval is identified by the Recovery Plan for the assessment of stream habitat status relative to baseline conditions and benchmarks.

M.S29. Monitor water quality and quantity as prescribed in the WRIA 25/26 and 27/28 Watershed Management Plans.

The Watershed Management Plans identify a water flow and quality monitoring strategy program designed to address the multiple objectives of this information (LCFRB 2006b, 2006c). Strategies and priorities identified in this comprehensive monitoring program were adopted directly from the Watershed Management Plans.

4.3.3 Indicators

4.3.3.1 Attributes & Metrics

Water quantity and quality are characterized through a set of indicators including attributes, metrics, and statistics relevant to salmonid protection and recovery (Table 21). Instream flow measurements of water quantity are calculated in cubic feet per second and expressed in terms of average low flows during summer or early flow, or in terms of peak flows. Low-flow levels during late summer and early fall can be defined at the 90th percentile, 50th percentile (median), and 10th percentile (flows expected on average in 1, 5, or 9 years out of ten, respectively). Peak flows are similarly expressed based on frequency of occurrence. For instance a 2-year flood has a 50% chance of occurring in any single year while a 10-year flood has a 10% chance of occurring in any single year. Frequency statistics generally require historical flow records at stream-gaging sites. Water quality indicators of particular interest to fish include temperature and dissolved oxygen. Other water quality parameters addressed by watershed plans include pH, conductivity, turbidity, nutrients, and indicator bacteria.

4.3.3.2 Criteria

Assessments status and trends in water quantity and quality relative to habitat suitability for fish will be evaluated based on changes in indicators over time as well as comparisons with criteria values. Criteria for water quantity are based on broad guidance identified in Properly Functioning Conditions (PFCs) for salmon and on target flows identified in the watershed plans. Criteria for water quality were based on PFCs and state water quality criteria.

PFCs were identified by NMFS to reflect freshwater habitat conditions generally favorable for salmonids spawning and rearing (NMFS 1996b) (Table 22). PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes. PFCs for water quality and quantity are broadly described in terms of functions rather than specific parameter values. The exception is water temperature where specific ranges were identified for salmonids by life stage.

Target flows are intended to reflect a realistic flow regime that could be achieved in most years by following sound management techniques over a long period of time (LCFRB 2006b, 2006c). Targets include both low flows and high flows and their frequency of occurrence over a period of years. These statistics are developed from historical flow conditions, current and projected water uses, and fish habitat needs. Target flows have not been developed for all streams in the region at this time, but could be developed in the future in additional areas where significant flow data has been collected over a long period of time (or where acceptable simulated flow data has been generated). Target flows should not be confused with "minimum instream flows" which are stream-specific seasonal or annual low flow rates specifically defined in state law for allocation limitations on the issuance of new water rights.

State surface water quality standards are criteria to ensure that water may be beneficially used for multiple purposes such as fishing, swimming, drinking, and fish habitat (WDOE 2006) (Table 23). Specific standards have been designated for aquatic life based on the presence of, or intent to provide protection for uses identified by species and life stage. Applications of specific criteria also include considerations of naturally-occurring conditions. Failure to meet criteria with no expectation of improvement within 4 years results in an "impaired" designation under section 303(d) of the federal Clean Water Act. The primary vehicle for achieving compliance with state criteria for surface water quality is Ecology's program for Total Maximum Daily Loads (TMDLs), also known as Water Cleanup Plans (LCFRB 2006b, 2006c).

Table 21. Attributes, metrics, and example statistics for use as indicators of stream habitat status.

Attribute	Metric	Example statistics	Relevance to Fish
Instream flows	Normal hydrograph Low flow Peak flow	Seasonal pattern Annual average & minimum Flood size and frequency (2-year, 10-year, 100-year) Exceedence levels for low flow target regime	Summer flow availability for juvenile rearing Juvenile/adult migration timing & access Spawning /rearing habitat availability & quality
Water quality	Temperature Dissolved Oxygen Turbidity & Suspended Sediments pH Conductivity Nutrients Contaminants - metals & pollutants	Seasonal average & range (º C) mg/L NTUs Unit measure µS/cm Nitrogen, Phosphorus Concentration and extent relative to threshold	Cool, clean water for adult, egg and juvenile survival Access to suitable habitat

Table 22. Salmonid freshwater habitat criteria for water quantity and quality based on "Properly Functioning Conditions" Matrix of Pathways and Indicators (NMFS 1996b).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Flow/Hydrology:	Change in Peak/ Base Flows	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	zero or minimum increases in drainage network density due to roads[8,9]	moderate increases in drainage network density due to roads (e.g. ≈5%)[8,9]	increases in drainage network density due to roads (e.g. ≈20-25%)[8,9]
Water Quality:	Temperature	50-57° F[1]	57-60° (spawning), 57-64° (migration & rearing)[2]	> 60° (spawning), > 64° (migration & rearing)[2]
	Turbidity	turbidity low	turbidity moderate	turbidity high
	Chemical Contamination & Nutrients	low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches[5]	moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one CWA 303d designated reach[5]	high levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one CWA 303d designated reach[5]

[1] *Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.*
[2] *Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.*
[5] *A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.*
Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.
[8] *Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.*
[9] *e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.*

Table 23. Examples of Washington State water quality standards for surface waters related to aquatic life uses of listed lower Columbia River salmonids (WDOE 2006).

	Temperature[1]	Dissolved oxygen[2]	Turbidity[3]	Dissolved gas[4]	pH[5]
Char spawning	9°C (48.2°F)	--	--	≤110%	--
Char spawning and rearing	12°C (53.6°F)	9.5 mg/l	5 NTU or 10% increase	--	6.5-8.5 (0.2 units)
Salmon and trout spawning	13°C (55.4°F)	8.0 mg/l	--	--	--
Core summer salmonid habitat (June 15-September 15)	16°C (60.8°F)	9.5 mg/l	5 NTU or 10% increase	≤110%	6.5-8.5 (0.2 units)
Salmonid spawning, rearing & migration (September 16 – June 14)	17.5°C (63.5°F)	8.0 mg/l	5 NTU or 10% increase	≤110%	6.5-8.5 (0.5 units)
Salmonid rearing and migration only	17.5°C (63.5°F)	6.5 mg/l	20 NTU or 20% increase	≤110%	6.5-8.5 (0.5 units)

[1] *Highest 7-day average of the daily maximum temperatures. Criteria also include 1 day maxima.*
[2] *Lowest 1-day minimum*
[3] *Based on background below or above 50 NTU.*
[4] *Percent saturation.*
[5] *Range and allowable human-caused variation.*

4.3.4 Sampling and Analytical Design

Water quantity monitoring requires continuous, long term data on flows. The monitoring design recognizes that installation and operation of gages requires funding, and it may be impossible to fund gages in every location desired. Therefore the Watershed Management Plans identify the following considerations for focusing funding resources on selected subbasins:

- Presence of existing gages that should be maintained permanently;
- Past record of discontinued stream gages, which provide data that can be leveraged if new gages are installed;
- Degree to which flow is impaired now, with potential harm to aquatic habitat;
- Size of subbasin and associated extent of habitat for aquatic life;
- Priority of streams in LCFRB Recovery Plan;
- Expected future changes in land use or water withdrawals, that will cause impairment of flow;
- Extent of existing urbanization, and associated feasibility of protecting or enhancing flow (e.g. consider highly urbanized subbasins less feasible); and
- Consideration should also be given to whether existing weather stations for measuring precipitation and other weather variables are adequate to meet stream management needs.

Based on these criteria, subbasins were prioritized within the Watershed Plans for installation and maintenance of permanent, continuously-recording stream gages. Six pilot subbasins in WRIAs 25-28 were designated for more intensive flow monitoring to explore the applicability of stream flow management approaches. More intensive flow monitoring in pilot subbasins can involve lower mainstem and upper basin gages, for instance, to monitor flows from forested headwaters, measure changes due to forest practices, and predict peak flows at downstream locations.

The water quality monitoring strategy incorporated two elements. First, data are needed to characterize water quality conditions in surface waters. Second, it is valuable to gather information on point and non-point sources of water quality impairment to provide a basis for actions to improve water quality. Full documentation of this strategy is presented in a Technical Memorandum (Barber 2004a, 2004b). The Watershed Management Plans designed monitoring to address human health concerns and fish and other aquatic life issues. Collecting information for improved fisheries management (particularly those listed under ESA) was an essential driver. Many of the proposed sites pose little to no threat to drinking water supplies even under projected population growth estimates. Many of the monitoring sites and parameters would be unnecessary and the frequency of sampling would be different if only human health problems were considered.

Note that this strategy does not entail intensive monitoring of flows and water quality in every subbasin. In order to provide representative data on all subbasins and salmon populations throughout the region, this program also incorporates sampling of specific water quantity and quality samples into normal stream habitat assessment protocols described previously.

4.3.5 Current Monitoring Activities

Long term flow data are available from a number of stream gages operated by the US Geological Survey (USGS) throughout the region (Table 24). Gages are funded by the U.S. Geological Survey and other Federal, State, Tribal, and local agencies, and some industries and utilities. Numerous historical stream gages have been discontinued or converted to stage-only stations, primarily due to lack of funding. In WRIAs 15 and 26, at this time there are several stream gages on the Cowlitz River, its tributaries in the upper part of the Cowlitz Basin, and on the Toutle River. The only long-term, continuously-recording flow gages in WRIAs 27 and 28 are in the Lewis River Basin. More recent gages have by installed by CPU and Clark County on Vancouver area streams. Little or no current flow data are available in most Coast or Gorge subbasins.

Table 24. Significant stream gage locations and record summary (LCFRB 2006b, 2006c). Sites in current operation are in bold type. (Some sites with limited time series data are not included.)

Subbasin	USGS Station No.	Name/Location	Drainage Area (mi^2)	Period of Record
Grays	14249000	Above S. Fork	40	1956-1976
"	14250500	West Fork		1949-1969
Elochoman	14247500	Elochoman R. near Cathlamet	66	1940-1971
Skamokawa				
Mill, Abernathy,	14246500	Mill Cr. near Cathlamet		1949-1956
Germany	14246000	Abernathy Cr. near Longview	20	1949-1958
Lower Cowlitz	**14243000**	**Castle Rock**	**2,238**	**1926-present**
"	**14238000**	**Below Mayfield Dam**	**1,400**	**1934-present**
"	**14231000**	**Randle**	**541**	**1910-1911, 1993-present**
"	14239000	Salmon Cr. near Toledo		
Upper Cowlitz	**14226500**	**Packwood**	**287**	**1911-present**
Tilton	**14236200**	**Above Bear Cr. Canyon Cr.**	**141**	**1956-present**
Cispus	**14231900**	**Above Yellow Jacket Cr.**	**250**	**1996-present**
"	14232500	Randle	321	1910-1996
Toutle	**14242580**	**Tower Rd.**	**496**	**1981-present**
"	**14241500**	**South Fork**	**120**	**1939-1957, 1996-present**
Coweeman	14245000	Kelso (RM 7.0)	119	1951-1982
Kalama	14223500	Below Italian Cr. near Kalama	198	1947-1975
Lewis NF	**14220500**	**Ariel**	**731**	**1922-Present**
	14219800	**Speelyai Creek near Cougar**		**1959-2006**
	14216500	**Muddy R. near Cougar**		**1928-2006**
"	14218000	Near Cougar	481	1924-1958
"	**14216000**	**Above Muddy River near Cougar**	**227**	**1927-1935, 1955-1970, 2006-Present**
"	14213200	Near Trout Lake	127	1959-1972
Lewis EF	**14222500**	**Near Heisson**	**125**	**1930-Present**
Salmon	**14212000**	**Near Battle Ground**	**18.3**	**1944-1975, 1988-1990, 1992-Present**
"	**14211895**	**Burnt Bridge Cr. at 112th Ave**	**8**	**1999-Present**
"	**14211898**	**Burnt Bridge Cr. at 19th St**	**18**	**1999-Present**
Washougal	14143500	Washougal	108	1945-1981
"	14144000	Little Washougal R. near Washougal	23	1951-1956
Bonneville tribs	--	--	--	--
Gorge tribs	**14123500**	**White Salmon**	**386**	**1912--present**
"	14125000	Little White Salmon near Cook		1957-1978
"	14125000	Little White Salmon above Lapham Cr.		1949-1964
Wind	14128500	Near Carson		1935-1981

A variety of water quality monitoring occurs throughout the basin under the auspices of various local, State, and federal programs and regulations. Washington's Watershed Management Plans (LCFRB 2006b, 2006c) describe these monitoring programs in the study area in detail. Significant water quality monitoring activities currently include:

- U.S. Forest Service, under the Northwest Forest Plan, is monitoring water temperature at 23 stations in the headwaters of the North Fork Lewis and East Fork Lewis Rivers every 30 minutes from June through September.
- U.S. Geological Survey collects some information on water quality (e.g. sediment discharge) at selected stream gage sites.
- Washington Department of Ecology, through their Statewide and regional water quality assessment program, is monitoring five stations in the study area on a monthly basis.
- Clark County is monitoring water quality at ten long-term index stations on tributaries to Lake River, Salmon Creek, Cedar Creek, Lacamas Creek, Little Washougal River, and East Fork Lewis River.
- Clark County is also monitoring water quality in the Salmon Creek subbasin, a program that was started in 1995 by Clark Public Utilities.
- PacifiCorp is monitoring water quality at each of its project tailraces on the Lewis River.

Water quality monitoring frequencies, protocols and parameters sampled vary among programs, locations, or even within subbasins due to factors such as the perception of ambient water quality conditions, permit requirements for wastewater discharges, limitation of resources, technical capabilities, and sampling location accessibility (LCFRB 2006b, 2006c). Waterbody segments or subbasins that are thought to be impaired are typically monitored more intensively than those thought to be unimpaired by pollution. However, the list of 303(d) impaired waterbody segments is also driven by the availability of quality-assured water quality monitoring programs and the ambient water quality data they generate. Thus, the 303(d) list of impaired waterbody segments may not represent a complete inventory of water quality impaired segments or conditions where standards are in violation of water quality criteria.

4.3.6 Information Gaps

Existing water quantity and quality information is not adequate to address the objectives and strategies identified in the Watershed Plans or salmon Recovery Plans. Priorities for installation and maintenance of permanent, continuously-recording stream gages for water quantity monitoring were identified by the Watershed Plans and are summarized in Table 25. Pilot subbasins identified for more intensive stream flow monitoring included the Grays River, Elochoman River, Coweeman River, Lower Cowlitz River tributaries, East Fork Lewis River, and Washougal River. Former and new monitoring sites were identified with priority to former sites to take advantage of previous data collected. As temperature is also a concern for anadromous fish, all monitoring sites would be equipped with temperature loggers.

Table 25. Subbasin priorities for stream gage installation and maintenance identified in Watershed Plans (LCFRB 2006b, 2006c).

Subbasin	Name/Location	Status	High	Medium	Low
Grays	Above S. Fork	Former	X		
	West Fork	Former		X	
	Middle mainstem, South Fork	New		X	
Elochoman	Elochoman R. near Cathlamet	Former	X		
	Elochoman R. upper mainstem	New		X	
Skamokawa	Lower mainstem	New		X	
Mill, Abernathy, Germany	Lower mainstem	New		X	
Lower Cowlitz	Below Mayfield Dam	Current	X		
	Olequa Creek	New	X		
	Salmon Cr. near Toledo	New	X		
	Other tributaries (Lacamas, Leckler, Mill, Delameter, Arkansas Creeks)	New	X		
	Coal Creek/Longview Slough	New			X
Upper Cowlitz	At Packwood	Current	X		
Tilton	Above Bear Creek Canyon Cr.	Current	X		
Cispus	Near Randle	Current	X		
Toutle	At Tower Rd.	Current	X		
Coweeman	Near Kelso	Former	X		
	Upper mainstem	New		X	
Kalama	Below Italian Creek near Kalama	Current		X	
Lewis NF	Ariel	Current	X		
	Speelyai Creek near Cougar	Current	X		
	Muddy R. near Cougar	Current	X		
	Lewis R. Above Muddy R.	New			
Lewis EF	Near Heisson	Current	X		
Salmon	Near Battle Ground	Current		X	
	Burnt Bridge Creek at 112th Ave	Current			X
	Burnt Bridge Creek at 19th St	Current			X
Washougal	Near Washougal	Former	X		
	Little Washougal River near Washougal	Former	X		
Bonneville tribs	Hamilton, Hardy, Duncan	Former			X
Gorge tribs	Little White Salmon R.	Former	--[1]	--	--
	White Salmon R.	Current	--	--	--
Wind	Near Carson	Former	--	--	--

[1]Watershed planning for WRIA 29 is not yet complete.

As part of its assessment of water quality information, the Watershed Planning Unit reviewed existing water quality monitoring activities being conducted by local, State, and federal agencies. From this review, it was apparent that water quality monitoring activities currently in place are designed to meet specific needs of various programs but are not comprehensive in terms of either the network of streams or the types of parameters monitored. In the absence of a comprehensive monitoring framework at the regional scale, it is difficult to identify impaired water bodies, characterize status and trends in surface water quality, or develop effective approaches to improving water quality.

The Watershed Plans proposed a Water Quality Analysis Plan (WQAP) for monitoring core water quality information related to flow, temperature, nutrients, and several other parameters at as many as 28 different stream segments (not all parameters measured at each segment). The monitoring plan for field sampled parameters of particular concern to fish is shown in Table 26 and Table 27. Details of core laboratory parameters identified in the WQAP may be found in LCFRB (2006b, 2006c) and Barber (2004a, 2004b).

The WQAP is particularly focused on monitoring for 1) identifying specific existing or emerging water quality problems and 2) characterizing waters and identifying changes or trends in water quality over time. The types of monitoring objectives that the WQAP would address are those concerned with baseline information and background information for identifying long-term trends. A range of options was discussed with the Planning Unit members in order to determine the practical scope of the monitoring plan in terms of what could be expected given funding limitations. It became apparent that given the size of the watersheds in WRIAs 27 and 28, sampling each waterbody for parameters such as macroinvertebrates, pesticides, and heavy metals would be too expensive.

Table 26. Summary of Core Water Quality Parameters in WRIA 25/26 (Table 5.3 in LCFRB 2006b).

Waterbody Segment	Field Sites (locations-frequency)				
	Flow[1]	Dissolved Oxygen	pH	Specific Conductance	Temperature[2]
Abernathy/Germany Creek Subbasin					
Abernathy Creek	1-Q	1-M	1-M	1-M	1-M
Germany Creek	1-Q	1-M	1-M	1-M	1-M
Coal Creek Subbasin					
Coal Creek	1-Q	1-M	1-M	1-M	1-M
Coweeman River Subbasin					
Coweeman River		1-M	1-M	1-M	1-M
Goble Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Mulholland Creek		1-Q	1-Q	1-Q	1-Q
Cowlitz River Subbasin					
Lower					
Cowlitz River		2-M	2-M	2-M	2-M
Olequa Creek		1-M	1-M	1-M	1-M
Ostrander Creek	1-Q	1-M	1-M	1-M	1-M
Upper Cowlitz River		1-M	1-M	1-M	1-M
Elochoman River Subbasin					
Elochoman River	1-Q	2-M	2-M	2-M	2-M
West Fork		1-T	1-T	1-T	1-T
Grays River Subbasins					
Grays River	1-Q	1-M	1-M	1-M	1-M
Hull Creek		1-M	1-M	1-M	1-M
South Fork Grays River	1-Q	1-T	1-T	1-T	1-T
West Fork Grays River	1-Q	1-M	1-M	1-M	1-M
Toutle River Subbasin					
Green River		1-M	1-M	1-M	1-M
North Fork Toutle River	1-Q	2-M	2-M	2-M	2-M
South Fork Toutle River	1-Q	2-M	2-M	2-M	2-M
Toutle River	1-Q	1-M	1-M	1-M	1-M

A – annually, C – continuously, M – monthly, T – two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled
[1] Download of continuous stage recorder and rating curve development
[2] Verification of continuous temperature loggers

Table 27. Summary of Core Water Quality Parameters (WRIA 27/28)

Waterbody Segment	Field Sites (locations-frequency)				
	Flow[1]	Dissolved Oxygen	pH	Specific Conductance	Temperature[2]
Burnt Bridge Creek Subbasin					
Burnt Bridge Creek	3-Q	3-M	3-M	3-M	3-M
Columbia River Tributaries					
Gibbons Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Greenleaf Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Kalama Subbasin					
Kalama River	1-Q	1-T	1-T	1-T	1-T
Little Kalama River	1-Q	1-T	1-T	1-T	1-T
Lacamas Creek Subbasin					
China Ditch		1-T	1-T	1-T	1-T
China Lateral		1-T	1-T	1-T	1-T
Fifth Plain Creek	1-Q	1-M	1-M	1-M	1-M
Lacamas Creek	2-Q	2-M	2-M	2-M	2-M
Mill Ditch	1-Q	1-M	1-M	1-M	1-M
Shanghai Creek		1-M	1-M	1-M	1-M
Lake River Subbasin					
Lake River		2-M	2-M	2-M	2-M
Lewis River Subbasin					
Lewis River		2-T	2-T	2-T	2-T
Burris Creek		1-Q	1-Q	1-Q	1-Q
Salmon Creek Subbasin					
Mill Creek	1-Q	1-M	1-M	1-M	1-M
Morgan Creek	2-Q	1-T	1-T	1-T	1-T
Salmon Creek	1-Q	2-M	2-M	2-M	2-M
Weaver Creek		1-M	1-M	1-M	1-M
Washougal Subbasin					
Washougal River Site 1	1-Q	1-T	1-T	1-T	1-T
Washougal River Site 2		1-T	1-T	1-T	1-T
Little Washougal River	1-Q	1-T	1-T	1-T	1-T
West Fork Washougal		1-T	1-T	1-T	1-T

A – annually, C – continuously, M – monthly, T – two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled
[1] Download of continuous stage recorder and rating curve development
[2] Verification of continuous temperature loggers
Note: Monitoring shown here is in addition to active, ongoing monitoring activities (see Appendix K)

4.3.7 Implementation Measures

M.M12. Maintain existing stream flow gages over the long term and install additional permanent gages as per recommendations and priorities identified in Watershed Plans.

Priority: Very High

Lead: USGS

Rationale: For purposes of improving stream flow management in the region, it is important that existing stream gages be maintained over the long term and that additional, permanent stream gages are installed. Recommendations for stream gaging at specific sites are provided in the Watershed Plans (LCFRB 2006b, 2006c).

6-Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.

M.M13. Implement a systematic water quality monitoring program based on existing and enhanced activities as per recommendations and priorities identified in Watershed Management Plans.

Priority: Very High

Lead: WDOE

Rationale: Water quality monitoring activities currently in place are designed to meet specific needs of various programs but are not comprehensive in terms of either the network of streams or the types of parameters monitored (LCFRB 2006b, 2006c). In the absence of a comprehensive monitoring framework at the regional scale, it is difficult to identify impaired water bodies, characterize status and trends in surface water quality, or develop effective approaches to improving water quality.

6-Year Implementation Work Schedule Activities**:**

c. Inventory current funding levels and sources.
d. Solidify long-term commitments to maintain adequate funding.
e. Identify data reporting schedules.
f. Identify constraints and uncertainties.
g. Identify coordination considerations.

M.M14. Incorporate selected water quantity and quality metrics into systematic stream habitat survey protocols identified in section 4.1.4 of this program in order to provide broad regional coverage of key limiting factors.

Priority: Very High

Lead: WDFW

Rationale: Monitoring activities identified in the Watershed Plans provide detailed information on selected sites and are also concentrated in subbasins where water management issues are intensive. Additional information is needed in other areas in order to provide broad regional representation of parameters that limit fish

(temperature, dissolved oxygen) or are related to limiting factors (conductivity). These parameters can be easily and inexpensively incorporated into standard stream habitat sampling protocols.

6-Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

4.4 Estuary/Mainstem Habitat

While this RME program does not provide specific information for status and trends monitoring of the estuary and Columbia River mainstem, other monitoring programs in the region provide guidance on this topic. The Research Monitoring and Evaluation for the Federal Columbia River Estuary Program (Estuary RME Program) (Johnson et al. 2008) is recognized as the appropriate monitoring plan to complement the estuary recovery plan module (NOAA 2007b). While the Estuary RME Program links the estuary module to the Federal Columbia River Power System biological opinions, it is critical that estuary monitoring efforts also be coordinated with recovery plan RME efforts in the Oregon and Washington tributaries.

The Estuary RME Program describes the following four objectives for estuary/mainstem status and trends monitoring:

- STM1. Map bathymetry and topography of the estuary as needed for RME.
- STM2. Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.
- STM3. Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.
- STM4. Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, conductivity, and primary and secondary production at representative locations in the estuary and plume.

In designing a specific status and trends monitoring program for the estuary and mainstem, the following recommendations should be considered:

- Monitoring efforts should be complementary and compatible with those in the tributaries in order to compare data relative to conditions affecting Lower Columbia ESU/DPS populations.
- An integrated status and trends monitoring (ISTM) process should be considered, similar to the ISTM process currently being undertaken in the Washington and Oregon tributaries for habitat status and trends.

- Fish status and trends monitoring in the estuary should be developed to focus on migration survival, distribution, and habitat use in conjunction with effectiveness monitoring of habitat and hydropower actions.
- Indicators identified for status and trends monitoring should correspond to those identified in the Mainstem/Estuary Action Effectiveness section of this RME Program (section 6.6)
- Estuary/mainstem monitoring efforts should incorporate components related to channel, riparian, and floodplain conditions; watershed, upland/hill slopes, and wetland conditions; and water quantity and water quality.
- Estuary/mainstem monitoring efforts should address, but not be limited to, actions called for in the FCRPS Biological Opinion (NMFS 2008) and Supplemental Biological Opinion (NMFS 2010).

5. Implementation/Compliance Monitoring

Implementation and compliance monitoring determines whether actions were implemented as planned or meet established laws, rules, and benchmarks. Salmon Recovery and Watershed Plans for the lower Columbia Region identify over 350 specific actions for implementation by approximately 65 partners. Partners include a broad spectrum of federal, state, and local governmental agencies, as well as a variety of nongovernmental organizations (Table 28). Neither of these plans has the authority to mandate implementation of these actions. Objective success will thus depend on voluntary implementation of actions. Implementation & compliance monitoring is one of the simplest and most direct measures of whether the plan is being implemented as designed.

The Salmon Recovery and Watershed Plans were developed with the assumption based on the best available scientific information that completion of the recommended implementation actions and strategies will lead to the desired goals and objectives. However, given uncertainties relating to the significance of limiting factors and variation in management responses, the implementation of all actions may or may not achieve the desired goals and objectives. NOAA (2007) notes that implementation/compliance monitoring cannot directly link restoration actions to response as physical, chemical or biological parameters are not measured. However, failure to implement significant actions identified in these plans is likely to result in failure to achieve the desired outcomes.

5.1 Objectives

The objectives of implementation/compliance monitoring are to:

1. Determine whether actions identified in the Salmon Recovery and Watershed Plans were implemented as planned.
2. Determine whether actions meet established laws, rules, and benchmarks specific to each action.

5.2 Strategy

M.S30. Complete comprehensive assessments of action implementation and compliance at 2-year intervals for the purpose of evaluating Salmon Recovery and Watershed Plan progress.

A 2-year assessment interval is identified by the Recovery Plan for implementation & compliance monitoring. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 2-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

M.S31. Rely on implementing partners to identify, evaluate and report on progress in the implementation and compliance of specific actions identified by the Plan.

Implementing partners are identified in the Plan for every action. Partners are expected to implement these actions by maintaining current programs where adequate, revising existing programs where necessary, and developing new programs where missing. As outlined in both the Recovery and Watershed Plans, partners are expected to document their approach for

implementing their actions through development of 6-Year Implementation Work Schedules (IWS). Tracking and reporting progress for actions under their responsibility is part and parcel to their accountability for plan implementation.

M.S32. Develop and maintain a centralized clearinghouse and database to track and summarize action implementation.

Periodic evaluations of plan progress and appropriate course corrections will be based on a summary and review of action implementation and compliance. This evaluation will be facilitated through use of a centralized clearing house and database, Salmon PORT.

Table 28. Numbers of implementation actions identified in Washington Lower Columbia River Salmon Recovery (LCFRB 2010) and Watershed Plans (LCFRB 2006b and 2006c) by implementation partner.

	Recovery Plan Categories										Watershed Plan Categories[1]				
Partner	Habitat	Hydro	Ecological	Estuary	Harvest	Hatchery	Implementation	Monitoring	Climate and Ocean	Other Species	Stream Flow Management	Surface Water Quality	Watershed Planning - Habitat	Water Supply	No. of actions
Battle Ground	6	--	--	--	--	--	--	--	--	--	--	--	--	--	**6**
BPA	3	3	5	8	--	--	--	--	--	4	--	--	--	--	**23**
Camas	8	--	--	5	--	--	--	--	--	--	--	--	--	--	**13**
Castle Rock	5	--	--	--	--	--	--	--	--	--	--	--	--	--	**5**
Cathlamet	6	--	--	5	--	--	--	--	--	--	--	--	--	--	**11**
Clark CD	6	--	1	2	--	--	--	--	--	15	--	--	--	--	**24**
Clark Co	9	--	1	6	--	--	--	--	--	15	--	--	--	--	**31**
Co. Noxious Weed Control Board	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
Cowlitz Co	11	--	1	6	--	--	--	--	--	15	--	--	--	--	**33**
Cowlitz PUD	3	1	--	--	--	3	--	--	--	--	--	--	--	--	**7**
Cowlitz/Wahkiakum CD	5	--	--	--	--	--	--	--	--	15	--	--	--	--	**20**
CPU	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
CREST	--	--	--	4	--	--	--	--	--	--	--	--	--	--	**4**
Ecology	5	--	--	8	--	--	--	--	--	--	--	--	--	--	**13**
EPA	--	--	--	5	--	--	--	--	--	--	--	--	--	--	**5**
FERC	2	1	--	--	--	--	--	--	--	--	--	--	--	--	**3**
Implementing Partners	--	--	--	--	--	--	--	54	--	--	--	--	--	--	**54**
Kalama	7	--	--	5	--	--	--	--	--	--	--	--	--	--	**12**
Kelso	9	--	--	5	--	--	--	--	--	--	--	--	--	--	**14**
LCFRB	4	--	--	3	--	--	24	--	--	--	--	--	--	--	**31**
LCREP	--	--	1	7	--	--	--	--	--	14	--	--	--	--	**22**
Lewis CD	5	--	--	--	--	--	--	--	--	15	--	--	--	--	**20**
Lewis Co	8	--	--	--	--	--	--	--	--	--	--	--	--	--	**8**
Longview	7	--	--	5	--	--	--	--	--	--	--	--	--	--	**12**
Morton	5	--	--	--	--	--	--	--	--	--	--	--	--	--	**5**
Mossyrock	5	--	--	--	--	--	--	--	--	--	--	--	--	--	**5**
NGOs	8	--	--	4	--	1	--	--	--	15	--	--	--	--	**28**
NMFS	1	3	3	1	20	--	6	--	2	18	--	--	--	--	**54**
North Bonneville	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**

	Recovery Plan Categories										Watershed Plan Categories[1]				
Partner	Habitat	Hydro	Ecological	Estuary	Harvest	Hatchery	Implementation	Monitoring	Climate and Ocean	Other Species	Stream Flow Management	Surface Water Quality	Watershed Planning - Habitat	Water Supply	No. of actions
NPCC	1	3	2	3	--	--	--	--	--	--	--	--	--	--	**9**
NRCS	2	--	--	1	--	--	--	--	--	--	--	--	--	--	**3**
Pacific CD	4	--	--	2	--	--	--	--	--	15	--	--	--	--	**21**
Pacific Co	6	--	1	6	--	--	--	--	--	15	--	--	--	--	**28**
Pacificorp	3	3	--	--	--	3	--	--	--	1	--	--	--	--	**10**
Port of Camas/Washougal	1	--	1	6	--	--	--	--	--	--	--	--	--	--	**8**
Port of Kalama	2	--	1	6	--	--	--	--	--	--	--	--	--	--	**9**
Port of Longview	1	--	1	6	--	--	--	--	--	--	--	--	--	--	**8**
Port of Vancouver	3	--	1	6	--	--	--	--	--	--	--	--	--	--	**10**
RPIC	--	--	--	--	--	--	1	--	--	--	--	--	--	--	**1**
Skamania Co	8	--	1	6	--	--	--	--	--	15	--	--	--	--	**30**
SRFB	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
State Noxious Weed Control Board	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
State Parks	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
Tacoma Power	2	3	--	--	--	3	--	--	--	1	--	--	--	--	**9**
Toledo	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
Tribes	4	--	1	3	5	--	--	--	--	17	--	--	--	--	**30**
Tribes	5	--	1	3	5	--	--	--	--	17	--	--	--	--	**31**
Underwood CD	5	--	1	--	--	--	--	--	--	15	--	--	--	--	**21**
USACE	3	3	6	10	--	--	--	--	--	5	--	--	--	--	**27**
USFS	2	--	--	--	--	--	--	--	--	--	--	--	--	--	**2**
USFWS	4	--	9	--	5	31	--	--	--	28	--	--	--	--	**77**
USGS	--	--	3	1	--	--	--	--	--	--	--	--	--	--	**4**
Vader	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
Vancouver	8	--	--	5	--	--	--	--	--	--	--	--	--	--	**13**
WACC	1	--	--	--	--	--	--	--	--	--	--	--	--	--	**1**
Wahkiakum Co	7	--	1	6	--	--	--	--	--	15	--	--	--	--	**29**
Washougal	6	--	--	5	--	--	--	--	--	--	--	--	--	--	**11**
WDFW	13	2	16	6	31	40	--	--	--	36	--	--	--	--	**144**
WDNR	6	--	--	5	--	--	--	--	--	--	--	--	--	--	**11**
Winlock	5	--	--	--	--	--	--	--	--	--	--	--	--	--	**5**
Woodland	8	--	--	5	--	--	--	--	--	--	--	--	--	--	**13**
WRIA 25/26 Planning Unit	1	--	--	--	--	--	--	--	--	--	14	2	8	7	**32**
WRIA 27/28 Planning Unit	1	--	--	--	--	--	--	--	--	--	17	10	12	9	**49**
WSDA	2	--	1	1	--	--	--	--	--	--	--	--	--	--	**4**
WSDOT	2	--	--	--	--	--	--	--	--	1	--	--	--	--	**3**
Totals:	**252**	**22**	**59**	**171**	**66**	**81**	**31**	**54**	**2**	**307**	**31**	**12**	**20**	**16**	**1124**
Discrete actions in category:	**53**	**6**	**16**	**16**	**31**	**40**	**27**	**54**	**2**	**41**	**31**	**12**	**20**	**16**	**365**

[1] *Watershed plan actions are listed by WRIA. Partner responsibilities are identified in each Planning Unit's Detailed Implementation Plan (LCFRB 2008 and LCFRB 2008a).*

5.3 Indicators

Action implementation and compliance is evaluated based on identification and completion of activities and tasks specific to each action. Activities and tasks are identified by the implementing agent, during development of the 6-Year Implementation Work Schedule (IWS). Evaluations are based on partner and action assessments. Partner assessments describe progress in the implementation of all actions, activities, and tasks under the responsibility of each implementing partner (Table 29). Action assessments describe progress in the implementation of all activities and tasks across partners (Table 30).

Table 29. Example data for action implementation/compliance monitoring at the partner assessment level.

		Total No. of	No. of activities			
Partner	**Type/Threat**	**Activities**	**Identified**	**Completed**	**Pending**	**Overdue**
WDFW	Habitat					
	Mainstem/Estuary					
	Hydropower					
	Harvest					
	Hatchery					
	Ecological					
	Implementation					
	Monitoring					
	Water Quality					
	Water Supply					
	Stream Flow					

Table 30. Example data for action implementation/compliance monitoring at the action assessment level.

		No. of	No. of activities			
Type/Threat	**Action**	**partners**	**Identified**	**Completed**	**Pending**	**Overdue**
Habitat	101 Floodplain protection					
	102 Native plant restoration					
Mainstem/Estuary						
Hydropower						
Harvest						
Hatchery						
Ecological						
Implementation						
Monitoring						
Water Quality						
Water Supply						
Stream Flow						

5.4 SalmonPORT

SalmonPORT (Salmon Partners Ongoing Recovery Tracking) is a web-tool designed to track actions and activities identified in the Plan in an efficient and effective manner. Salmon PORT is

an interactive system that allows users to add, review, and edit 6-Year IWS elements, including activities (Table 31) and tasks (Table 32). Salmon PORT is designed to answer basic questions regarding how and when recovery actions are completed, and at what cost. This system will help to establish tasks, benchmarks and milestones, and identify impediments to implementation such as budgetary and logistical constraints. It will also allow users, agencies and the public to access information and view a variety of reports related to implementation of salmon recovery efforts.

Figure 20. Salmon PORT interface page at http://www.lowercolumbiasalmonrecovery.org/.

SalmonPORT provides partnering agencies, local governments, organizations, and the public in the lower Columbia with the ability to track their activities and progress in managing their watersheds. Users of SalmonPORT and involved entities can enter and maintain information on salmon recovery and watershed management actions for their program or for the specific unit within an agency or organization. This interactive website is intended for use in updating and changing information as needed, coordinating efforts among the partners, and monitoring progress and deadlines. Users and the interested public can query information and create reports through this database to obtain information about progress and agencies or organizations that are responsible. A multitude of queries can be applied; including searches by action, subbasin, partners, and others. Salmon PORT also provides added levels of functionality to participating entities/users pertaining to its own progress and tasks.

Table 31. Salmon PORT worksheet for database entry of implementation partner work schedule activity.

<table>
<tr><td>Activity: Please provide a short title of the activity (50 char. Limit)</td><td>Objective: Provide a paragraph describing the goals and objectives of the activity as it relates to the action(s). Goals should be a general statement of what a program hopes to achieve. Objectives should focus more specifically on how the goals will be achieved. Please provide clear and specific expectations. (2000 char. Limit)</td><td>Explanation: This is intended to be a description of the key steps or tasks that must be completed to implement and sustain the recovery actions over the six year period and their anticipated outcomes or results. (2000 char. limit)</td></tr>
<tr><td>[type activity here]</td><td rowspan="5">[type objective here]</td><td rowspan="5">Information in bold was obtained from your website.
Information in italics provides suggestive activities used by other partners.
[type explanation here]</td></tr>
<tr><td>Relationship to Listings: Please use one of the following: New, Revised or Existing. This is based on the ESA listings.</td></tr>
<tr><td>[type relationship here]</td></tr>
<tr><td>Affected Actions: List all of the Actions this Activity addresses.</td></tr>
<tr><td>[type actions here]</td></tr>
<tr><td colspan="2">Has this activity been fully funded? Please explain whether you have the full staffing and resource needs met to fully implement the program. This should be related to the costs fields on the task worksheets</td></tr>
<tr><td colspan="2">[type explanation here]</td></tr>
<tr><td colspan="3">What tasks have not been fully funded and to what extent? Explain, if any, the funding gaps.</td></tr>
<tr><td colspan="3">[type unfunded tasks here]</td></tr>
<tr><td colspan="3">What are the key cost drivers to implement the activity? If the activity is ongoing and maintained regardless of the salmon listings, no costs will be reported. If the activity is new or revised, report only the incremental costs incurred due to the listings.</td></tr>
<tr><td colspan="3">[type cost drivers here]</td></tr>
</table>

Table 32. Salmon PORT worksheet for database entry of implementation partner work schedule tasks.

Tasks	
Task 1: Please provide a short title of your task *(50 char. limit)*	**Expected Outcomes:** What will be accomplished by this task? Task outcomes can be considered as key milestones for implementing the activity. For example, if the task is to perform an assessment, the outcome or milestone would be to published findings. Please also provide a brief description of the task. *(2000 character limit)*
[type title here]	**Information in bold is specific to your entity** *Information in italics represents examples from other entities* [type description here]
Start Date: When will this task be undertaken?	
[type date here]	
Proposed Completion Date: Provide the best estimate of the time when the task will be completed?	
[type date here]	
Coordination: In some instances the implementation of an action may be dependent on activities by other partners. In other instances several partners may share the responsibility of implementation of an action. This section describes the relationships and inter-dependencies necessary to fully address an action. (It is **not** intended to identify intra-agency coordinate between divisions or departments.)	
Partner: Identify one of the other 81 partners noted in the plan. *For each partner include a dependent task and/or a coordination task.	[type partner here]
Dependent Task: If the implementation of a recovery action is dependent on tasks by another partner, identify the partners task(s)/activity and explain what steps will be taken to coordinate with them.	[type dependent task here]
Coordination: If responsibility for implementing a task is shared with another partner, identify the partner involved and explain the steps that will be taken to coordinate efforts to achieve implementation.	[type coordination activities here]
Tasks (Continued)	
Challenges: Describe the constraints and uncertainties in accomplishing this task and how they will be addressed. Challenges may include political, legal, social, cultural and economic considerations.	
Description:	[type description here]
Response:	[type response here]
Costs: Report only those costs due to implementing ESA actions. For example, some tasks may be required by federal or state mandates even if the salmon were not listed, such as CAO updates; these costs should not be included. This section is intended to report costs added due to the ESA listings. **It is optional to report the costs outside of the scope of the six-year IWS.**	
Year	**Amount**
1998 - 2006	$ (optional)
2006	$
2007	$
2008	$
2009	$
2010	$
2011	$
Post 2011 costs	$ (optional)

5.5 Implementation Measures

M.M15. Maintain a coordinated database of federal, tribal, state, local, and non-governmental programs and projects implemented throughout the recovery region.

Lead: LCFRB

Funding source: To be determined

Rationale: The LCFRB has been specifically charged with development and oversight of Recovery Plan implementation throughout the Washington lower Columbia River region. In order to determine if recovery actions are being conducted and objectives met, implementation and compliance monitoring will be spearheaded using the newly developed SalmonPORT database.

6-year Implementation Work Schedule Activities**:**

a. Identify tasks and related outcomes, milestones, and schedules.
b. Identify current funding levels and sources.
c. Solidify long-term commitments to maintain adequate funding.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M16. Periodically summarize and report action implementation progress at the task level using the LCFRB Salmon PORT database system.

Lead: All implementing partners

Funding source: To be determined

Rationale: Reporting will occur at biennial intervals.

6-year Implementation Work Schedule Activities**:**

a. Identify tasks and related outcomes, milestones and schedules.
b. Identify current funding levels and sources.
c. Solidify long-term commitments to maintain adequate funding.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M17. Prepare biennial reports of progress in implementation and compliance of recovery actions.

Lead: LCFRB

Funding source: To be determined

Rationale: The LCFRB has been specifically charged with development and oversight of Recovery Plan implementation throughout the Washington lower Columbia River region.

6-year Implementation Work Schedule Activities**:**

a. Identify tasks and related outcomes, milestones and schedules.
b. Identify current funding levels and sources.
c. Solidify long-term commitments to maintain adequate funding.

d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6. Action Effectiveness Monitoring

Action effectiveness monitoring is defined in this program to evaluate the significance and status of threats to listed salmon and steelhead status, and changes in threat levels associated with specific types of recovery actions. This monitoring is specifically intended to evaluate the status and trends in statutory listing factors identified by NMFS (NOAA 2007) (Figure 1).

In this focused monitoring effort, functional effectiveness has been purposefully distinguished from biological effectiveness. Although biological effectiveness is the ultimate goal in recovery planning, population trends take many years to appear and are frequently confounded by the effects of environmental variability and uncertainty. As such, functional effectiveness serves as a more proximate and tractable measure of progress. Where species and habitat status and trend monitoring weighs the aggregate effect of a full complement of protection and restoration actions, action effectiveness monitoring considers the incremental effects of specific actions or suites of actions that affect habitat, hydropower, hatchery, fishery, and ecological interaction threats. Action effectiveness monitoring ultimately helps determine which actions work the best and what level of contribution toward recovery is contributed by an action or suite of actions.

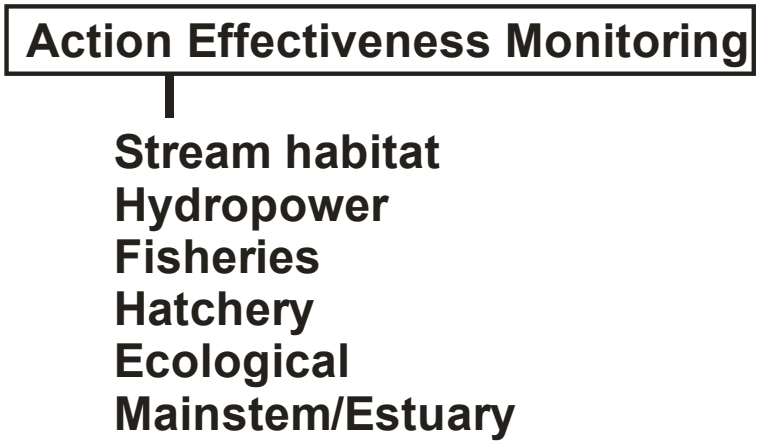

Figure 21. Categories of action effectiveness monitoring addressed by this plan.

Effects of actions may be estimated directly based on estimates of fish population attributes (e.g., abundance, productivity, spatial structure, diversity) or watershed health indicators (e.g., stream flows, water quality, etc), or indirectly based on effects on limiting factors or causative mechanisms. Formal experiments and rigorous statistical analysis involving both test and control populations may be required. In most cases, action effectiveness monitoring complements and utilizes the same types of information needed for status and trend monitoring of fish and habitat.

Monitoring and evaluation plans in other regions have sometimes adopted an alternative definition of action effectiveness monitoring specifically focused on research of cause and effect relationships and population or subpopulation scale biological responses to one or more actions. This plan considers evaluations of such cause and effects relationships and

mechanisms as research, An example of habitat action effectiveness monitoring under our definition might involve monitoring the numbers and types of shrubs and trees in the riparian zone following fence construction or estimating the effect on pool frequency and size or substrate composition following the addition of instream structure.

6.1 Habitat

6.1.1 Objectives

Habitat action effectiveness monitoring is intended to determine if specific protection and restoration projects function as planned. Where the baseline habitat status and trend monitoring generally provides a more global picture of the net effects of all activities and programs on conditions for fish, habitat action effectiveness monitoring is focused on the specific proximate effect of a particular action. Where habitat action implementation/compliance monitoring evaluates whether actions were implemented as planned, action effectiveness monitoring evaluates whether they function as intended. Habitat action effectiveness monitoring addresses stream habitat, water quality and flow, and watershed actions

Stream habitat action effectiveness monitoring has many elements in common with habitat status and trend monitoring but generally addresses a much narrower set of objectives. For instance, where habitat status and trend monitoring might quantify the number of stream miles accessible to anadromous salmonids, action effectiveness monitoring might evaluate whether culvert replacement has effectively increased access to a given amount of suitable habitat.

Box 5. Questions addressed by habitat action effectiveness monitoring.

1. **Have passage improvement actions increased access to significant amounts of suitable habitat for salmonids?**
2. **Have channel structure and bank stability improvement actions increased habitat quantity and quality for salmonids?**
3. **Have off-channel and side-channel improvement actions increased habitat quantity and quality for salmonids?**
4. **Have floodplain restoration actions increased habitat quantity and quality for salmonids?**
5. **Have water quality improvement actions increased habitat quantity and quality for salmonids?**
6. **Have water flow-related actions increased habitat quantity and quality for salmonids?**
7. **Have watershed actions increased watershed functions deemed beneficial to stream salmonid habitats?**

6.1.2 Strategy

M.S33. Complete comprehensive assessments of habitat action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.

A 6-year assessment interval is identified by the Recovery Plan for the effectiveness of actions relative to baseline conditions and benchmarks. The assessment may involve annual collection

and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

M.S34. Monitor the effectiveness of habitat-related actions affecting the stream, water quantity and quality, and watershed conditions.

The Recovery Plan identifies actions specific to each of these factors. Stream habitat related actions that address access to habitat blocked by artificial barriers, stream channel habitat structure and bank stability, off-channel and side-channel habitat, floodplain function and channel migration processes, and riparian conditions and functions. Water quantity and quality measures address limiting factors such as temperature, the adequacy of instream flows during critical periods, and the effects of regulated stream flows on critical habitat functions. Watershed measures address watershed conditions and hillslope processes (e.g. runoff and sediments) that affect stream habitats.

M.S35. Develop and maintain a comprehensive up-to-date inventory of habitat-related actions across the region.

A comprehensive project inventory is a basic first step in accurately evaluating the significance of habitat actions intended to improve fish status and ameliorate habitat-related threats. Projects are being implemented by a tremendous variety of parties which makes it difficult to characterize the nature and extent of these activities. An inventory is one simple measure of the significance of the effort expended.

M.S36. Intensively monitor the effectiveness of a subset of representative habitat actions using a formal statistical research design.

It is neither necessary nor feasible to conduct intensive scientific evaluations of the effectiveness of every habitat action. Resources are limited and benefits of monitoring to assure that actions are beneficial must be balanced with the costs of monitoring. Intensive effectiveness monitoring activities should be focused on a representative subset of actions. Effects of other similar actions may then be judged based on inference.

M.S37. Estimate and report the physical and biological effects and functional lifespan of every habitat-related project or program implemented in the region based on site-specific evaluations or by inference from similar project types elsewhere.

While every habitat project need not be evaluated with a formal statistically-designed research project, every project should describe or estimate expected benefits as a required step in the proposal, design or implementation stage. This information will formalize considerations of assumed or expected benefits, highlight situations where basic effectiveness monitoring information is lacking and provide basic data to the regional habitat action inventory. This will force implementers to ask and answer what they intend to accomplish with any given project.

M.S38. Conduct habitat action effectiveness monitoring in close and complementary association with habitat status and trend monitoring.

Habitat status and trend monitoring has many common elements with habitat action effectiveness monitoring. Wherever possible action effectiveness monitoring should capitalize on information that is useful for multiple applications. Action effectiveness monitoring should also adopt comparable metrics and protocols where appropriate. It is not likely, however, that habitat status and trend monitoring will provide the fine scale habitat data needed to evaluate

site-specific changes. Nor is it likely that action effectiveness habitat monitoring will always provide habitat data suitable that is representative of a broader region.

6.1.3 Indicators

Habitat action effectiveness indicators are identified for stream, water, and watershed characteristics in Table 33. Statistics describe the action, response, and functional lifespan of each project. Action descriptions may be qualitative or quantitative. Response descriptions may include physical or biological parameters. Lifespan of effect is of particular importance in evaluating short term vs. long term benefits. Response indicators for habitat action effectiveness monitoring have been categorized into three levels by the WSMOC (2003). Level 1 involves continued physical function as designed (e.g. did it survive high water?). Level 2 involves a physical response (e.g. did it provide the desired fish habitat condition?). Level 3 involves a biological response (e.g. were fish use and density affected as expected?)

6.1.4 Sampling and Analytical Design

This plan generally adopts habitat action effectiveness monitoring designs and protocols developed by the Washington Salmon Recovery Funding Board. An overarching approach to habitat action effectiveness monitoring was described in Washington's comprehensive monitoring strategy and action plan for watershed health and salmon recovery (WSMOC 2002). Results of reach scale effectiveness monitoring activities are reported annually by the Salmon Recovery Funding Board (WSSRFB 2007). Protocols for intensive habitat action effectiveness monitoring study designs have been developed by the WSSRFB for a variety of project types (Table 33).

This plan identifies two levels of habitat action effectiveness evaluation design.

Intensive: Intensive habitat action effectiveness monitoring involves a carefully designed and controlled scientific research design to describe physical and/or biological changes associated with a given project. It often employs a robust Before-and-After-Control-Impact (BACI) design. A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred (WSSRFB 2004). This design tests for changes at the area of impact relative to changes observed in a comparable control site where no impact occurs. This type of design is required when effects of external factors can confound before and after comparisons at the project site. An intensive sampling design for habitat action effectiveness typically involves repeated sampling over a period of years following project implementation. An intensive sampling regimen may also involve evaluations of project function as design (a level I response), physical effects of the project (a level II response), and biological effects (a level III response). Drawbacks of this design are the costs and years of data required. As a result, it is not feasible or desirable to implement an intensive action effectiveness monitoring effort for every project.

Extensive: This plan defines extensive habitat action effectiveness monitoring based simply on level I indicators that describe whether a project continues to function as designed for a specified period. Continued function along with assumed physical and biological benefits provide a sound basis for assuming project effectiveness where more intensive monitoring has demonstrated effectiveness of comparable projects. Extensive monitoring can provide basic data on a large number of projects in a cost effective manner.

Table 33. Example statistics describing habitat actions for use in effectiveness monitoring.

				Response Indicators			
Feature	**Factor**	**Example Project types**	**Descriptive statistics**	**Level I**	**Level II**	**Level III**	**Protocol[1]**
Stream	Access	Culverts, bridges, fishways, logjams, dam removal, debris removal	Number & type of improvements Affected stream length	Continued function as designed or placed	--	Species affected Fish use/density	MC-1
	Instream structure	Reconfiguration, deflectors, log & rock control structures, roughened channels, spawning gravel	Number & type of improvements Miles treated	Continued function as designed or placed	Pool frequency, stream width, substrate	Species affected Fish use/density	MC-2, MC-7
	Off-channel & side channel	Channel connectivity, channel or alcove construction	Number & type of improvements Effective area	Continued function as designed	Physical stream measurements	Species affected Fish use/density	MC-5
	Floodplain	Dike removal/setback, riprap removal, road removal/setback, landfill removal, wetland restoration	Number & type of improvements Effective area	Continued function as designed	Channel profile & capacity Pool frequency & depth	Species affected	MC-6
	Riparian	Planting, invasive plant removal or control, livestock exclusion	Number & type of improvements Stream length, width of zone Acres affected	Plant survival, plant reinvasion, fencing intact	Bank shading or erosion Canopy complexity	Species affected	MC-3, MC-4
Water	Quality	Point & non-point sources	Number & type of improvements	Continued function as designed	Temperature Contaminants	Species affected Fish use/density	
	Nutrients	Stream fertilization, carcasses or analogs	Area treated Volume of treatment	Continued function as designed		Species affected Fish use/density	
	Flow	Water lease or purchase, irrigation practice	Number & type of improvements Amount of flow (cfs) by time of year, water volume (acre ft.)	Continued function as designed	Stream flow	Species affected	
	Flow Regulation	Irrigation diversion dams, water treatment plants, pipes, ditches, head gates	Number & type of improvements	Continued function as designed	Stream flow	--	MC-8

Watershed	Condition	Sediment reduction, upland agriculture, upland vegetation	Number & type of improvements Miles of affected road Acres affected	Continued function as designed	Stream, riparian, upland characteristics	Species affected Fish use/density	MC-10
	Protection		Affected area	Continued function as designed	Stream, riparian, upland characteristics	Fish & macro invertebrates	MC-10

1 Report number reference for Washington Salmon Recovery Funding Board action effectiveness monitoring protocols (http://www.rco.wa.gov/srfb/docs.htm#strategy).

6.1.5 Current Monitoring Activities

A comprehensive list of all habitat action-related monitoring programs and activities may be found in Appendices A and B (information collected between 2004 and 2008). In addition, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) has initiated an effort to inventory current effectiveness monitoring programs in the Pacific Northwest (http://www.pnamp.org/).

6.1.6 Information Gaps

A comprehensive assessment of information gaps will require analysis of specific datasets relative to the information needs identified above. This work is identified in implementation actions.

6.1.7 Implementation Measures

M.M18. Maintain current habitat effectiveness monitoring activities of all significant habitat protection and restoration programs.

Lead: All habitat agencies

Funding source: Various

Rationale: Current action effectiveness monitoring programs provide critical information regarding adequacy to address statutory listing factors.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M19. Develop and maintain a comprehensive up-to-date database inventory of habitat-related actions across the region.

Lead: LCFRB

Funding source: To be determined

Rationale: Actions are distributed among a wide spectrum of parties. Data is needed to provide basic information on the scale of habitat-related recovery action. The LCFRB is uniquely situated to implement this action.

6-Year Implementation Work Schedule Activities**:**

e. Identify appropriate opportunities and funding sources.
f. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules.
g. Identify constraints and uncertainties.
h. Identify coordination considerations.

M.M20. Formalize effectiveness monitoring activities for habitat-related actions by every implementing party by identifying expected benefits, describing criteria by which effectiveness will be monitored, and referencing the basis for estimated benefits.

Lead: All habitat agencies

Funding source: Various

Rationale: Some consideration of action effectiveness needs to be incorporated into every habitat protection and restoration action although every action does not require an intensive controlled pre and post project evaluation. Tasks and activities that address effectiveness monitoring should be a design element of every habitat-related project or program.

6-Year Implementation Work Schedule Activities**:**

i. Identify appropriate opportunities and funding sources.
j. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules.
k. Identify constraints and uncertainties.
l. Identify coordination considerations.

M.M21. Implement focused investigations of critical assumptions and uncertainties related to the effectiveness of representative types of habitat protection and restoration actions.

Lead: All habitat agencies

Funding source: To be determined.

Rationale: Current assessments rely on a series of critical assumptions which affect the accuracy of those estimates. Intensive evaluations of representative actions will provide a basis for inference of similar actions throughout the basin.

6-Year Implementation Work Schedule Activities**:**

m. Identify appropriate funding sources.
n. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
o. Identify constraints and uncertainties.
p. Identify coordination considerations.

6.2 Hydropower

6.2.1 Objectives

Hydropower action effectiveness monitoring is intended to determine if related fish protection, restoration, and mitigation actions reduce or limit effects on wild fish to levels consistent with the conservation and recovery of listed fish species while also achieving desired fish production benefits. Construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control have fundamentally altered habitat conditions for fish and particularly anadromous fish throughout the Columbia River basin. Lower Columbia salmon, steelhead and trout are threatened by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage; and ecological changes in impoundments. Dams in the Lewis, Cowlitz, and White Salmon subbasins have blocked access by anadromous fishes to large areas of productive habitat.

Box 6. Questions and hypotheses addressed by hydropower action effectiveness monitoring.

Question #1.	**Are the target levels for juvenile and adult passage and survival through hydropower facilities consistent with recovery?**
Null hypothesis:	Juvenile and adult passage and survival through hydropower facilities are not effectively limited to target levels for each program consistent with recovery.
Alternative:	Juvenile and adult passage and survival through hydropower facilities are effectively limited to target levels for each program consistent with recovery.
Question #2.	**Are upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities consistent with recovery?**
Null hypothesis:	Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are not effectively limited to target levels for each program consistent with recovery.
Alternative:	Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are effectively limited to target levels for each program consistent with recovery.
Question #3.	**Are fish reintroduction efforts into previously-blocked tributaries meeting population viability objectives identified in the Recovery Plan?**
Null hypothesis:	Fish reintroduction efforts in tributaries are not meeting population viability objectives identified in the Recovery Plan.
Alternative:	Fish reintroduction efforts in tributaries are meeting population viability objectives identified in the Recovery Plan.
Question #4.	**Are hydropower mitigation benefits for fish adequately meeting prescribed program objectives?**
Null hypothesis:	Mitigation benefits are not meeting program objectives.
Alternative:	Mitigation benefits are meeting program objectives.

6.2.2 Strategy

M.S39. Complete comprehensive assessments of hydropower action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.

A 6-year assessment interval is identified by the Recovery Plan for the effectiveness of hydropower actions relative to baseline conditions and benchmarks. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

M.S40. Evaluate hydropower action effectiveness for passage, habitat protection and restoration, reintroduction, and mitigation-related impacts on salmon and steelhead at all significant mainstem and tributary facilities that currently limit the viability of listed lower Columbia River populations.

Hydropower facilities that affect Washington populations of lower Columbia River salmon and steelhead include Bonneville Dam on the mainstem Columbia River, multi-dam complexes blocking the upper portions of the Cowlitz and Lewis systems to anadromous fish, and Condit Dam on the White Salmon River which also blocks anadromous passage. The Recovery Plan

identifies significant actions for the benefit of listed populations involving each of these facilities.

M.S41. Monitor facility operations that potentially affect fish or fish habitat.

This includes normal operations data on inflow, outflow, spill, turbine operations, bypass and fishway operations.

M.S42. Conduct intensive annual monitoring and evaluation of juvenile and adult passage.

Annual monitoring of fish passage is necessary to evaluate the effectiveness of current facilities. Both adult and juvenile passage need to be monitored.

M.S43. Monitor and evaluate effectiveness of hydro-related habitat measures based on downstream effects on stream habitat characteristics, water quantity, and water quality.

Downstream habitat effects of hydropower operations can significantly affect fish migration, spawning and rearing conditions either directly or indirectly via influences on habitat forming processes.

M.S44. Monitor effectiveness of adaptively-implemented reintroduction efforts above tributary facilities in the Cowlitz, Lewis, and White Salmon rivers based on net productivity.

Recovery of several lower Columbia River species to meet criteria identified by the Technical Recovery Team cannot be achieved without restoring viable populations in several areas currently blocked to anadromous fish by hydropower facilities. The success of these reintroduction efforts will depend on achieving a net productivity measured in terms of net replacement rates.

M.S45. Monitor effectiveness of additional actions designed to mitigate hydropower impacts, where appropriate.

In some cases, hydropower actions involve mitigation for impacts through the implementation of other beneficial measures rather than direct remedies for the effects of facilities. The monitoring and evaluation program needs to include considerations of mitigation action effectiveness.

M.S46. Implement hydropower monitoring programs consistent with requirements of Federal Energy Regulatory Commission licenses, Biological Opinions, and other plans and agreements.

Monitoring and evaluation activities related to hydropower facilities are described, directed and governed by a variety of existing licenses, opinions, and agreements. The monitoring and evaluation strategy for hydropower action effectiveness relative to salmon recovery must be implemented in the context of the existing programs. It is expected that existing programs have fully addressed needs identified in the Recovery Plan or are in the process of revision to ensure the adequacy of existing programs relative to recovery needs.

6.2.3 Indicators

6.2.3.1 Attributes & Metrics

Hydropower indicators are identified for operations, passage, habitat, and reintroduction metrics (Table 34). Operations are simply project activities with the potential to affect fish. Passage includes both juveniles and adults. Habitat effects related to hydropower include water flow patterns, water quality, physical habitat features affected by flow, and material recruitment processes. Reintroduction involves the rebuilding of viable populations in areas currently blocked from anadromous production. Mitigation refers to other activities designed to improve fish status affected by hydropower facilities.

Table 34. Attributes, metrics, and example statistics for potential use as indicators of hydropower effects.

Attribute	Related Metrics	Example
Operations	--	Facility activities that potentially affect fish
	Project-specific	Discharge, spill, turbine operations, gate/weir openings, bypass and operations, fishway operations
Passage	--	Effective movement through hydropower facilities
	Collection efficiency	Proportion of t juvenile population that passes a facility
	Fish guidance efficiency	Proportion of juveniles entering turbine intakes that are guided into a bypass
	Fish passage efficiency	Proportion of juvenile migrants that pass a dam via non-turbine routes
	Passage survival	Proportion of the adult or juvenile population that survives passage of dam (may be net or route-related)
	Conversion rate	Proportion of adult population that passes a facility and associated reservoir
	Fallback rate	Proportion of adults that pass a dam but subsequently fall back downstream typically over the spillway
	Delay/travel time	Additional time required to negotiate artificial passage structures and other habitat impact. For juveniles can include reservoir passage due to discharge regulation
Habitat	--	Physical and environmental factors that limit fish
	Structure	Stream channel morphology, substrate, large woody debris
	Water quantity	Seasonal & annual discharge patterns & flood flows, seasonal minimum flows
	Water quality	Temperature, dissolved gas levels (seasonal averages, exceedence frequency)
Reintroduction	--	Restoration of viable populations upstream from facilities that currently block passage
	Productivity	Net production or replacement rate on a per adult basis (in part a function of passage)
	Viability	Abundance, productivity, spatial structure, diversity (see biological monitoring)
Mitigation	--	Beneficial actions implemented to indirectly address project effects
	Various	Project-specific including habitat protection & restoration, hatchery production, predator management, monitoring and research, information & education, etc.

6.2.3.2 Criteria

Hydropower related monitoring criteria are detailed for each facility in operating documents including Federal Energy Regulatory Commission licenses, Biological Opinions, and Settlement Agreements. The reader is referred to these documents for more details on project-specific criteria pertinent to salmon recovery.

6.2.3.3 Example Data Types

Example reporting templates for hydropower effectiveness monitoring data are included below to illustrate how this information might be organized (Table 35 and Table 36). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 35. Example data for dam passage and passage-related operations of potential use in action effectiveness monitoring (river run facility such as Bonneville Dam).

				Recent years					Recent
Species	**Metric**	**Goal**	**Base**	**2000**	**2001**	**2002**	**2003**	**2005**	**avg.**
Operations	Downstream flows minimum[1]								
	Annual maximums								
	Spill days & volumes								
Passage (by species)	Guidance efficiency (juv.)								
	Passage efficiency (juv.)								
	Passage survival (juv.)								
	Conversion rate (ad.)								
	Fallback rate (ad.)								
	Passage delay (ad.)								
Habitat	Tailrace dissolved gas levels[2]								

[1] *Seasonal frequency of falling below target levels during winter for instance.*
[2] *Days exceeding standards during juvenile migration periods for instance.*

Table 36. Example data for dam passage and passage-related operations of potential use in action effectiveness monitoring (terminal facilities subject to upstream reintroduction efforts as in the Cowlitz and Lewis rivers).

				Recent years					Recent
Species	Metric	Goal	Base	2000	2001	2002	2003	2005	avg.
Operations	Downstream flows minimum								
	Annual maximums								
Passage (by species)	Collection efficiency (juv.)								
	Passage survival (juv.)								
	Collection efficiency (ad.)								
	Passage survival (ad.)								
Reintroduction	Adult returns								
	Juvenile abundance								
	Productivity/replacement rate								
Habitat	Downstream temperature[1]								
	Habitat complexity[1]								
Mitigation	Hatchery production & return[2]								
	Habitat								

[1] *See habitat monitoring.*
[2] *See hatchery action effectiveness monitoring.*

6.2.4 Sampling and Analytical Design

6.2.4.1 Framework

The hydropower sampling design incorporates the following sampling and analytical design elements:

1. Routine monitoring and description of project operations on an hourly or daily basis as per current practice.
2. Systematic annual monitoring of juvenile and adult passage success based on mark-recapture and/or telemetry studies.
3. Systematic annual sampling of the abundance, productivity, distribution, and diversity of experimental reintroduced populations (see biological status and trend monitoring).
4. Focused empirical analyses of the efficacy of habitat actions (see habitat action effectiveness monitoring)
5. Hatchery and habitat monitoring programs consistent with mitigation objectives for each facility (see hatchery and habitat action effectiveness monitoring).
6. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.2.4.2 Methods

Many hydropower action effectiveness monitoring and evaluation methods are similar to those described for other factors. However, passage efficiency and survival evaluations are of particular importance to hydropower evaluations and are discussed briefly below.

Passage efficiency: Passage or collection efficiencies are typically estimated based on the proportion of a known population sampled in a specific collection point. Known populations are typically estimated based on recaptures of marked fish in a single release design. For instance, passage efficiency of juveniles in a collection facility often involves release of a known number of marked fish immediately upstream of the facility. Adult collection efficiencies are typically estimated based on detections of radio, acoustic, or PIT tagged fish released downstream of a facility. Estimates can be complicated where multiple routes of passage are possible.

Survival: Survival studies to estimate passage success typically involve mark-recapture studies of paired releases of tagged groups of fish. Differences in recapture rates of fish released above and below a facility describe mortality associated with the facility. Extensive PIT tag studies involving system-wide tagging of juvenile hatchery and wild fish are being used to estimate project and reach survival rates throughout the mainstem Columbia River. Juvenile and adult PIT tag detectors have been placed in many mainstem dam bypass systems in the basin including Bonneville Dam. A towed detection system is also being used in the estuary to collect recapture information on PIT tagged fish.

6.2.4.3 Program Targets

Hydro-related monitoring levels are detailed for each facility in operating documents including Federal Energy Regulatory Commission licenses, Biological Opinions, and Settlement Agreements. The reader is referred to these documents for more details on project-specific targets pertinent to salmon recovery.

6.2.5 Current Monitoring Activities

Current hydropower monitoring programs and monitoring responsibilities are summarized in Table 37.

Table 37. Significant hydropower facilities and dams in the Washington lower Columbia River recovery area and project monitoring responsibilities.

Location	Facility	Responsibilities
Cowlitz River	Mayfield & Mossyrock Dams	Tacoma Power
Cowlitz River	Cowlitz Falls Dam	Lewis County Public Utility District
Toutle River	Sediment Control Structure	U.S. Army Corps of Engineers/WDFW
Lewis River	Merwin, Yale & Swift Dams	PacifiCorp
Columbia River	Bonneville Dam	U.S. Army Corps of Engineers, Bonneville Power Administration
White Salmon River	Condit Dam	PacifiCorp

6.2.6 Information Gaps

- Reintroduction monitoring and evaluation in the Lewis River contingent on direction and agreements in the renewed license.
- Systematic monitoring and evaluation of downstream habitat and water quality effects of the sediment retention structure in the Toutle River.

6.2.7 Implementation Measures

M.M22. Maintain current monitoring and evaluation of adult and juvenile collection, passage, and survival rates at Bonneville Dam.

Lead: USACE, BPA, Fish Passage Center

Funding source: BPA

Rationale: Extensive monitoring programs are currently being implemented for Federal Columbia River Power System Facilities including Bonneville Dam. These programs are critical to limiting and improving passage success that limits the viability of upstream populations.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M23. Maintain current monitoring and evaluation of the relative abundance, distribution and dewatering of chum (and fall Chinook redds from the unlisted Middle Columbia River population) in the Bonneville Dam tailrace.

Lead: USACE, BPA, USFWS, WDFW

Funding source: BPA

Rationale: Bonneville Dam operations significantly affect habitat suitability downstream for populations of chum and fall Chinook of significant importance to salmon recovery. The importance of the chum population in particular is elevated by the limited scope for improvement of the chum population affected by Bonneville Dam.

6-year Implementation Work Schedule Activities**:**

e. Identify current funding levels and sources.
f. Solidify long-term commitments to maintain adequate funding.
g. Identify constraints and uncertainties.
h. Identify coordination considerations.

M.M24. Continue to implement intensive monitoring and evaluation of reintroduction efforts for coho, spring Chinook and steelhead in the upper Cowlitz and Cispus Rivers.

Lead: Tacoma Power, Lewis County PUD, WDFW

Funding source: Tacoma Power, Lewis County PUD

Rationale: These significant populations for recovery and effective reintroduction will depend on continuing facility refinements guided by monitoring and evaluation result.

6-Year Implementation Work Schedule Activities**:**

i. Identify appropriate opportunities and funding sources.
j. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules.
k. Identify constraints and uncertainties.
l. Identify coordination considerations.

M.M25. Implement intensive monitoring and evaluation of reintroduction efforts for coho, spring Chinook and steelhead in the upper Lewis River as per license direction and agreements.

Lead: PacifiCorp, WDFW

Funding source: PacifiCorp

Rationale: These significant populations for recovery and effective reintroduction will depend on continuing facility refinements guided by monitoring and evaluation result.

6-Year Implementation Work Schedule Activities**:**

m. Complete inventory of specific limitations of existing approach.
n. Identify appropriate funding sources.
o. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
p. Identify constraints and uncertainties.
q. Identify coordination considerations.

M.M26. Monitor the downstream channels of Mayfield (Cowlitz), the Sediment Retention Structure (Toutle), and Merwin (Lewis) dams for changes in flow, substrate, stream morphology, and water quality.

Lead: Tacoma Power, Lewis County PUD, PacifiCorp, U.S. Army Corps of Engineers

Funding source: Tacoma Power, Lewis County PUD, PacifiCorp, U.S. Army Corps of Engineers

Rationale: Downstream habitat impacts of impoundment and operation can have significant long term effects on habitat suitability for salmonids due to changes in sediment and flow conditions.

6-Year Implementation Work Schedule Activities**:**

r. Complete inventory of specific limitations of existing approach.
s. Identify appropriate funding sources.
t. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
u. Identify constraints and uncertainties.
v. Identify coordination considerations.

M.M27. Implement focused investigations of critical assumptions and uncertainties in current hydro-related monitoring and evaluation efforts.

Lead: WDFW, USFWS, NMFS

Funding source: To be determined.

Rationale: Current assessments rely on a series of critical assumptions which affect the accuracy of those estimates.

6-Year Implementation Work Schedule Activities**:**

w. Identify appropriate funding sources.
x. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
y. Identify constraints and uncertainties.
z. Identify coordination considerations.

6.3 Fisheries

6.3.1 Objectives

Harvest action effectiveness monitoring is intended to determine if fishery management regulatory processes and actions reduce or limit fishery-related mortality to levels consistent with the conservation and recovery of listed fish species while also providing significant and sustainable fishery opportunity and harvest (Box 7).

Fisheries that affect lower Columbia River salmon and steelhead are managed to optimize current and future fishing opportunity and harvest within the limitations and constraints of impact limits specified to protect weak, listed stock components. Fisheries do not target listed species but listed fish are incidentally caught in fisheries for hatchery and strong wild stocks. Incidental take of lower Columbia salmon and steelhead occurs in commercial, recreational, and tribal fisheries in the ocean from Alaska to northern California and in the mainstem Columbia and tributaries.

Fishery action effectiveness evaluations are complicated because harvest is identified as both a threat and a goal in the Washington lower Columbia Recovery Plan. Harvest acts as a threat through direct mortality of adult fish which decreases abundance and productivity, and can increase risks of extinction when the fishery impact is excessive. However, restoration of wild salmonids to sustainable, harvestable levels is also a recovery goal. Healthy, viable salmonid populations produce regular harvestable surpluses in excess of escapement needs for population sustainability. This program therefore includes monitoring and evaluation of both fishery impacts and benefits.

Box 7. Questions and hypotheses addressed by fishery action effectiveness monitoring.

Question #1.	**Are fishery impacts on sensitive stocks effectively limited to prescribed levels?**
Null hypothesis:	Fishery management systems and actions do not limit impact rates to prescribed levels.
Alternative:	Fishery management systems and actions limit impact rates to prescribed levels.
Question #2.	**Are prescribed fishing levels consistent with long term viability of listed stocks?**
Null hypothesis:	Prescribed fishery impact rates do not pose significant jeopardy to the long term viability of listed species.
Alternative:	Prescribed fishery impact rates pose significant jeopardy to the long term viability of listed species.
Question #3.	**Are significant fishery opportunity and harvest being sustained by existing populations and management?**
Null hypothesis:	Fishery opportunity and harvest is not being sustained at levels adequate to meet broad sense goals.
Alternative:	Fishery opportunity and harvest is being sustained at levels adequate to meet broad sense goals.

6.3.2 Strategy

M.S47. Complete comprehensive assessments of fishery action effectiveness at 6 year intervals as prescribed by the Recovery Plan.

A 6 year assessment interval is identified by the Recovery Plan for evaluating the effectiveness of fishery actions relative to baseline conditions and benchmarks.

M.S48. Monitor annual impacts relative to prescribed limits for significant ocean and Columbia River sport and commercial fisheries on representative index groups for all species based on in-season data on fish numbers and fishery mortality collected using systematic statistical surveys of catch, catch composition, and harvest.

Annual in-season monitoring is necessary to regulate direct and incidental fishing impacts within prescribed limits for each fishery while also optimizing fishery benefits in any given year. Fishery opportunity and effort is adjusted based on real time data on fish run strength, stock composition, and fishery success. Fisheries are managed based on index stocks representing sensitive species, life stage, and population groups.

M.S49. Periodically re-evaluate effects of prescribed fishery impact levels and strategies on long term viability of listed stocks based on risk assessments that consider recent stock abundance and productivity.

Prescribed fishery impact limits are based on prior assessments of the effects of fishery-related mortality on spawning escapements of weak stock groups. Limits are ideally based on risk assessments that calculate the marginal change in low run size probability due to fishing. Risks are sensitive to fishing rates, variance in fishing rates, relationships between fishing rate and abundance, and stock abundance and productivity patterns. Periodic reassessments are needed to consider whether prescribed fishery limits remain consistent with long term viability based on current abundance and productivity information.

M.S50. Monitor annual fishery opportunity based on effort, harvest, and value in significant ocean, Columbia River, and tributary sport and commercial fisheries for all species.

Monitoring of fishery statistics provides a basis for meeting sustainable use and value goals as well as the variety of escapement and allocation objectives consistent with optimum management of the fishable stocks and the fishery. These evaluations must consider the interaction in effects of protection measures for Columbia River stocks on fisheries directed on mixed stocks including fish originating in the upper Columbia and Snake rivers as well as Washington, Oregon, and Canadian systems outside the basin.

M.S51. Conduct annual evaluations of fishery assessment and management processes and tools based on post-season run reconstruction and analysis of forecast, in-season and actual information on fishery impacts and opportunities in order to optimize efficacy.

Fishery assessment and management processes and tools are continually evolving based on recent experience and new data. Annual reporting of numbers is a long-standing practice although the depth and breadth of corresponding evaluations varies among fisheries. This strategy highlights the need to conduct systematic formal post season evaluations on an annual basis. These evaluations also provide the basis for adaptive preseason planning of the next year's fisheries.

M.S52. Systematically implement improvements in assessment methods, processes, and tools based on annual efficacy evaluations and directed investigations of critical uncertainties in current assessments and systems.

This strategy includes focused effort on significant uncertainties in current assessment methods, processes, and tools. Specific examples are detailed under information gaps.

6.3.3 Indicators

6.3.3.1 Attributes & Metrics

Fishery indicators are identified for impact, effect, and benefit metrics (Table 38). Impact is defined as fishery-related mortality rate and is calculated as total harvest plus total indirect mortality divided by number of fish available. Indirect mortality includes catch-release mortality of fish that die following release due to the effects of handling in the fishery. In some fisheries, indirect mortality can also include drop-off mortality of fish that succumb prior to landing due to encounter with the fishing gear. Catch-release mortality is typically estimated as a fraction of the released component of the catch where the fraction has been based on directed studies. Catch composition apportions the catch in any mixed stock fishery among stocks of origin typically based on visual differences, recaptures of tagged fish or genetic information.

We define fishery effect in terms of the significance of fishing level to long term viability of the stock of interest. Significance to listed stocks is evaluated based on effects of fishing on extinction risk. This risk considers abundance and productivity of the limiting stocks as well as normal stock variation (process "error") and variance in fishery impacts due to fishing strategy and fishery implementation uncertainty (measurement "error").

We define fishery benefit based on effort, harvest, and value. Recreational fishery opportunities are typically assessed based on angler participation and success rates.

Commercial opportunities are typically assessed based on harvested numbers or weight of fish and the economic value of that harvest.

6.3.3.2 Criteria

Criteria for fishery action effectiveness monitoring are identified in this program based on historical fishery impacts and current impact limits. Historical rates about the time of listing are a useful reference point for measuring decreases in impacts implemented to reduce near term extinction risks of listed stocks until sustainability is restored by a comprehensive suite of recovery actions. Current ESA impact limits have been adopted by Federal, State, and Tribal fishery managers to protect long term viability of listed stocks in the interim. Aggregate fishery impact rate allowances for wild salmon populations currently vary from 5% for lower Columbia River chum to 49% for lower Columbia River tule fall Chinook based on species-specific differences in productivity (Table 39).

Table 38. Attributes, metrics, and example statistics for use as indicators of fishery effects.

Attribute	Related Metrics	Example
Impact	--	Proportion of available population that is subject to fishery-related mortality. Typically includes harvest and release mortality.
	Catch	Number of fish landed including those reduced to possession or released.
	Harvest	Number of fish harvested (a portion of the total catch).
	Releases	Number of fish caught or encountered but not harvested. Can include releases of non-target species or stocks as well as fish that are encountered but not landed where the encounter is deemed significant (e.g. drop-off mortality).
	Catch composition	Species and stock of origin of fish caught, harvested, released, or encountered.
	Run size	Number of fish available to fishery. Typically defined in terms of ocean recruits or Columbia River return.
	Encounter rate	Proportion of available fish that are caught (includes harvested and released fish).
	Harvest mortality rate	Proportion of available fish that are harvested directly.
	Non-harvest mortality rate	Proportion of available fish taken by catch and release or other encounter mortality.
Effect	--	Significance of fishing level to long term viability of listed stocks.
	Implementation uncertainty	Direction and variance in differences between planned and actual fishery impact rates due to forecast and in-season assessed uncertainties (affects risk).
	Risk	Marginal reduction in extinction risk due to fishery impacts on current and future spawner numbers (as propagated through the life cycle).
Benefit	--	Significance of fishery opportunity and harvest.
	Effort	Measure of angler participation typically in terms of angler trips (recreational fishery) or fishery days, net days, number of participants (commercial).
	Harvest	Fish numbers or weight.
	Value	Catch-per-unit-effort, ex-vessel value.

Table 39. Significant benchmarks for fishery impact rates and the current distribution of harvest among fisheries for lower Columbia River salmon and steelhead.

	Fishery wild impact rates				Harvest distribution (total to 100%)[1]			
	Historic highs[1]	Pre-listing[1]	ESA limit	Recent avg.[1]	AK/BC ocean	OR/WA ocean	Col. R.	Trib
Coho	85%	51%	25%[2]	18%	<1%	50%	44%	6%
Spring Chinook	65%	53%	25%[3]	22%	59%	23%	9%	9%
Fall Chinook (tule)	80%	65%	49%[4]	45%	33%	33%	22%	11%
Fall Chinook (bright)	65%	50%	49%	40%	48%	8%	20%	25%
Chum	60%	5%	5%	2.5%	0%	0%	60%	40%
Steelhead	75%	10%	10%[5]	8.5%	0%	<1%	41%	59%

[1] *Reported by LCFRB 2004 (Table 6 on Pg. 3-67). Averages reflect 2001-2003 fishing period.*
[2] *Future ESA rate to be determined. Rates of 15% and 20% were established for 2006 and 2007 fisheries.*
[3] *Freshwater fishery limit for Willamette spring Chinook is 15%. Ocean fisheries typically take an additional 10%.*
[4] *NMFS has recommended consideration of lowering of this limit from 49% to 42% (NMFS 2007).*
[5] *Limitation for summer steelhead populations above Bonneville is 17%.*

6.3.3.3 Example Data Types

Example reporting templates for fishery effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation of the impacts on listed stocks (Table 40) and fishery opportunity and value (Table 41). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 40. Example reporting template for net annual fishery impacts on listed wild lower Columbia River salmon and steelhead.

Species	Return Year	Fishery	Run size	Harvest rate	Indirect rate	Net Impact	Vs. Limit
Spring Chinook	2005	AK/BC ocean					
		OR/WA ocean					
		Col. R mainstem					
		Tributary					
		Total					
…	…	…					

Table 41. Example reporting template for fishery effort, harvest, catch rate, and value statistics including the relative significance of wild lower Columbia River stocks in the catch.

Species	Fishery	Year	Effort	Total harvest	Catch per effort	Value	% LCR wild in catch
Coho	AK ocean (all)	2005 2006 2007 2008 2009 2010					
	BC ocean (all) OR/WA ocean sport OR/WA ocean comm. Col. R. sport Col. R. commercial Tributary	…					
Spring Chinook . . .							

Note: units vary with type of fishery (sport vs. commercial)

6.3.4 Sampling and Analytical Design

6.3.4.1 Framework

This design framework addresses freshwater and marine salmon fisheries in Oregon and Washington to which lower Columbia River salmon and steelhead are subject. These fisheries are already subject to a comprehensive monitoring framework designed and implemented by State, Federal, and Tribal fishery management partners operating under a series of interconnected jurisdictional and programmatic structures including the Pacific Fishery Management Council; State Fish and Wildlife Commissions in Washington, Oregon, and Idaho; the Columbia River Compact between Oregon and Washington; U.S. v. Oregon jurisdictions, and Treaty Tribal Councils and Fishery Commission. Canadian and Alaska fishery impacts on Columbia River stocks are regulated and monitored under the auspices of the U.S.-Canada Treaty and the Pacific Salmon Commission. Most of these processes also include annual reporting elements.

Key sampling and analytical design elements of existing programs include:

1. Comprehensive accounting of effort, harvest, and impacts on listed stocks in all fisheries.
2. Stratified statistical random sampling of major ocean and Columbia River sport, commercial, and Tribal ceremonial, subsistence, and commercial fisheries.
3. Intensive effort, catch, and biological subsampling programs of significant commercial and sport fisheries.
4. Intensive in-season monitoring to estimate and regulate fisheries within prescribed limits.

5. Comprehensive annual pre- and post-season analysis and reporting of monitoring information.
6. Regular validation research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools.

6.3.4.2 Methods

Fishery monitoring activities include a number of common elements as described below.

Effort Surveys (Recreational Anglers): Fishing effort by recreational anglers is typically based on roving counts of boats, boat trailers, or anglers made either by airplane, boat, or vehicle (e.g. Columbia River mainstem fisheries). Effort may also be estimated based on access point surveys are useful where access is limited (e.g. ocean salmon fisheries). Effort can be highly variable by time and area. Counts generally involve a systematic stratified sampling scheme at prescribed days, times and areas. Counts provide index numbers for effort that are then expanded to provide total effort based on documented relationships between index and total numbers. Relationships between index and total numbers require very intensive surveys which are periodically recalibrated. Effort data is typically combined with angler survey data to estimate total harvest.

Angler surveys (Recreational Anglers): Recreational angler or creel surveys typically involve interviews of anglers to determine number and composition of the catch and provide estimates of catch per effort. The catch of interviewed anglers is typically sampled or subsampled for collection of biological measurements including any tagged or marked fish. Statistical surveys involve a random stratified sampling scheme either in a roving or access point survey. Non statistical surveys are also sometimes conducted to obtain descriptive fishery data or biological samples. Catch per effort data is typically combined with effort survey data to estimate total harvest. Effort surveys are an intensive and costly sampling method and typically utilized for large and significant fisheries.

Catch Record Cards (Recreational Anglers): Recreational anglers in Washington and Oregon are required to immediately record each salmon and steelhead harvested on catch record cards provided along with the fishing licenses. This is primarily an enforcement measure for ensuring that daily or annual bag limits are not exceeded. Catch record cards are also required to be returned to the respective state fish and wildlife departments each year. Numbers are periodically tabulated and provide an estimate of salmon harvest by species, date, and area. Estimates typically involve expansions for unreported tags (only a portion of catch record cards are returned as required) and corrections for a non-reporting bias (anglers that catch fish are typically more likely to return tags than anglers that don't catch fish). Catch record cards provide a general indication of the scale and timing of fisheries but this data tends to be much less certain than survey data.

Fish Receiving Tickets (Commercial): All commercial fish buyers in Oregon and Washington are required to complete and submit fish receiving tickets upon purchase of any fish. Catch is reported by species and weight. Only licensed fishers are allowed by law to sell fish and only licensed buyers are allowed to make large scale fish purchases. Some provisions are made for direct fisherman to consumer fish sales. These require a separate license and also have stringent reporting requirements. Columbia River Treaty Indian fisheries upstream from Bonneville Dam also sell fish direct to consumers ("over-the-bank sales") and these numbers

are estimated independently by tribal and intertribal fishery managers. Fish tickets are generally reported to the state fishery management agencies in real time and provide very accurate estimates of total harvest in commercial fisheries. These numbers are the basis for intensive in-season fishery management decisions.

Catch Sampling (Commercial): The commercial fishery is typically subsampled at representative commercial fish buying sites for collection of biological measurements including any tagged or marked fish. This information is used to identify stock composition and collect age, sex, and size information including average weight. Catch sampling can sometimes involve on-board observers where additional information is desired on things like number of fish released in selective fisheries or marine mammal encounters. In addition, test fisheries are sometimes implemented by fishery management agencies working with commercial fishers to collect information on fish relative abundance or stock composition.

Index Stock Marks and Tags: Stock identification in mixed-stock commercial and sport fisheries in the ocean and Columbia River mainstem is a critical component of current fishery monitoring efforts. Fisheries are generally regulated based on limits prescribed for index stocks selected for representation of different populations or groups of populations. A subsample of each index stocks is typically batch marked with coded wire tags placed in the snout of juveniles. CWT tagged fish in the sport or commercial harvest are identified by magnetic detectors. Snouts of these fish are removed to state laboratories and CWTs are recovered and read to identify the source stock and apportion the harvest. Adipose fin clips are also currently in use to distinguish hatchery and wild fish. All lower Columbia River hatchery coho, spring Chinook, fall Chinook and steelhead are currently being ad-marked. Some unmarked hatchery fish are still being released in streams upstream from Bonneville Dam.

Escapement Monitoring: Estimates of fishery exploitation, harvest, or impact rates require estimates of both harvest and escapement. Thus, accurate fishery action effectiveness monitoring also requires much of the same abundance data discussed in detail in the biological status monitoring section of this report.

Run Reconstructions: Run reconstructions are detailed analyses of fish numbers by stock or population based on estimates of harvest and escapement. They involve summary and synthesis of all of the information described above. This information is used for a wide variety of fishery management, hatchery management and stock assessment purposes.

6.3.4.3 Program Targets

This plan identifies the following representative sampling program targets as a starting point for further consideration and discussion by the fishery management programs.

- Annual estimates of net fishery impacts on indicator stocks representative of limiting population in each listed lower Columbia River ESU.
- Minimum of 20% mark sample rate of the harvest in significant fisheries to estimate stock composition (this is the current target rate).
- Documentation of estimation precision for effort and harvest by stock in significant fisheries.

- Estimation precision of net fishery impacts for each ESU of not less than the greater of: a) 10% of the target impact rate with 80% confidence or b) an absolute impact of ± 2% with 80% confidence.
- Identification and assessment of the magnitude of critical uncertainties in key assumptions of fishery estimates.

6.3.5 Current Monitoring Activities

Current fishery monitoring activities are summarized in the following table.

Table 42. Summary of current fishery monitoring activities and management process or authority.

Fishery	Effort surveys	Angler surveys	Catch Records	Fish Receiving Tickets	Catch Sampling	Reporting[1]
AK ocean	--	--	X	X	X	ADFG/PSC
BC ocean				X	X	BCDFO/PSC
WA ocean sport	X	X	X	--	X	WDFW/PFMC
WA ocean commercial	--	--	X	X	X	WDFW/PFMC
OR ocean sport	X	X	X	--	X	ODFW/PFMC
OR ocean commercial	--	--	X	X	X	ODFW/PFMC
Lower Col. R. Sport	X	X	X	--	X	WDFW/ODFW
Lower Col. R. Comm.	--	--	X	X	X	WDFW/ODFW
Tributary sport	limited	limited	X	--	limited	WDFW/ODFW
Col. R. Treaty Tribes	--	X	--	X	X	Tribes/CRITFC

[1] *ADFG = Alaska Department of Fish and Game, PSC = Pacific Salmon Commission, BCDFO = British Columbia Department of Fisheries and Oceans, WDFW = Washington Department of Fish and Wildlife, ODFW = Oregon Department of Fish and Wildlife, PFMC = Pacific Fishery Management Council, Tribes = Warm Springs, Yakama, Umatilla, Nez Perce. CRITFC = Columbia River Intertribal Fish Commission.*

6.3.6 Information Gaps

The following information gaps were identified in fishery monitoring based on a review of the available information including annual fishery reports, biological assessments, and research, monitoring and guidance documents. Many of these gaps involve critical assumptions or unknowns relative to the effects of fishing.

1. Improved accuracy in wild escapement estimates of coho, Chinook, and steelhead upon which fishery impacts estimates are based (as identified in the biological monitoring section of this plan).
2. Stock identification methods (tags or other markers) adequate to accurately estimate current freshwater fishery impact rates on early and late wild coho from the available harvest data.
3. Evaluations of the suitability of current index stocks for accurate evaluation of impacts of fisheries on wild Chinook.
4. Empirical estimates of indirect or incidental mortality in mark-selective fisheries and gear, time, and area selective fishing alternatives in the Columbia River.

5. Assessments of the accuracy and precision of all fishery impact estimates based on current information.
6. Assessments of the effects of current fishing rates, limits and strategies on risk/viability of listed ESUs (e.g. are prescribed levels consistent with recovery?).

6.3.7 Implementation Measures

M.M28. Maintain current monitoring programs of annual harvest and harvest rates of representative index stocks in ocean, Columbia River mainstem, and tributary fisheries.

Lead: WDFW, ODFW, NMFS, Tribes

Funding source: Various

Rationale: Current fishery monitoring programs provide accurate and timely estimates of fishery effort, harvest, and impacts on listed stocks. This information is used to regulate fisheries within prescribed limits that optimize opportunity and value while also seeking to ensure escapements adequate to protect long term sustainability of the fishery and viability of affected stocks. This information also provides a sound basis for continuing evaluations of the effectiveness of fishery actions for regulating harvest at appropriate levels.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M29. Implement additional intensive biological monitoring of wild adult escapements of all species in order to improve the accuracy of fishery impact assessments.

Lead: WDFW

Funding source: Various

Rationale: The accuracy of current fishery impact assessments is constrained by the quality of the available wild escapement data. This is particularly true for wild lower Columbia River coho.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M30. Evaluate and expand where appropriate current Chinook and coho wild index stock marking efforts to provide an adequate basis for stock identification and fishery impact estimation.

Lead: WDFW, ODFW

Funding source: To be determined.

Rationale: Current wild index stock identification methods are not adequate for accurate estimation of fishery impacts on wild salmon in Columbia River fisheries.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M31. Implement focused investigations of critical assumptions and uncertainties in current fishery monitoring and evaluation efforts (to include efficacy of selective fisheries).

Lead: WDFW, ODFW, NMFS, Tribes

Funding source: To be determined.

Rationale: Current fishery assessments rely on a series of critical assumptions which affect the accuracy of those estimates. With the widespread advent of mark-selective fisheries, assumptions regarding indirect mortality are among the more proximate concerns.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M32. Develop and implement a comprehensive annual assessment and report of fishery impact, effect, and opportunity information for each listed ESU (to include assessments of the accuracy of impact estimates and effects on ESU viability).

Lead: NMFS

Funding source: To be determined.

Rationale: Current fishery information is reported piecemeal for fisheries spread over a wide area of overlapping jurisdictions. Fishery effects on listed stocks are identified in semi-annual biological assessments of each fishery but comprehensive assessments are generally not available for net fishery effects on listed fish.

6-Year Implementation Work Schedule Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.

d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6.4 Hatchery

6.4.1 Objectives

Hatchery action effectiveness monitoring is intended to determine if hatchery management actions reduce or limit effects on wild fish to levels consistent with the conservation and recovery of listed fish species while also achieving desired fish production benefits (Box 8). Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat resulting from the Columbia River hydrosystem and widespread habitat development. Hatcheries provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates.

Box 8. Questions and hypotheses addressed by hatchery action effectiveness monitoring.

Question #1.	**Are hatchery impacts on sensitive stocks effectively limited to prescribed levels?**
Null hypothesis:	Hatchery actions do not limit impact rates to prescribed levels.
Alternative:	Hatchery actions limit impact rates to prescribed levels.
Question #2.	**Is hatchery performance consistent with objective benefits and risks identified for each program?**
Null hypothesis:	Performance is not consistent with objective benefits and risks prescribed for each program.
Alternative:	Performance is consistent with objective benefits and risks prescribed for each program.
Question #3.	**Are hatchery practices consistent with objectives identified for each program?**
Null hypothesis:	Practices are not consistent with program objectives.
Alternative:	Practices are consistent with program objectives.

6.4.2 Strategy

M.S53. Complete comprehensive assessments of hatchery action effectiveness at 6 year intervals as prescribed by the Recovery Plan.

A 6-year assessment interval is identified by the Recovery Plan for the effectiveness of hatchery actions relative to baseline conditions and benchmarks.

M.S54. Intensively monitor potential hatchery threats to wild population status for every salmon and steelhead hatchery program.

Hatchery influences are pervasive on many lower Columbia River salmon and steelhead populations. Hatchery effects have been identified as a significant threat to the status of these listed species.

M.S55. Monitor the potential impacts of hatcheries on the status of wild populations based on the annual incidence of natural spawning by hatchery fish and the contribution of natural origin fish to the hatchery brood stock.

Annual monitoring is necessary to regulate hatchery impacts within prescribed limits for each natural population. While the net effect of hatchery-origin fish spawning in the wild on wild fish is unknown, it is clearly related to the relative frequency of naturally-spawning hatchery fish and natural-origin fish in the hatchery broodstock.

M.S56. Monitor hatchery performance and practices in order to evaluate program benefits relative to associated risks and activities related to both risks and benefits.

Detailed hatchery production and return statistics provide a systematic quantitative basis for the evaluation of benefits associated with risks and corresponding hatchery actions. Production and return data are routinely collected by all hatcheries for use in program planning and evaluation relative to various production and mitigation goals. This same information will be useful in evaluations of conservation objectives or limitations associated with hatchery programs.

6.4.3 Indicators

6.4.3.1 Attributes & Metrics

Hatchery indicators are identified for impact, performance, and practice metrics (Table 43). Impact is defined in terms of hatchery contributions to naturally-spawning populations. Performance refers to hatchery production levels that are related to both hatchery benefits and risks. Practice refers to hatchery activities that affect impact and performance.

Table 43. Attributes, metrics, and example statistics for use as indicators of hatchery effects.

Attribute	Related Metrics	Example
Impact	--	Significance of hatchery interaction with natural populations
	Hatchery-origin spawners (pHOS)	Proportion hatchery-origin spawners in local natural population
	Out-of-basin strays	Proportion of total return that is observed in natural spawning areas outside the basin of origin
	Proportion natural influence (PNI)	Index of local hatchery effect (product of proportion of hatchery origin spawners and proportion of natural origin brood stock
Performance	--	Description of hatchery effectiveness
	Smolt-adult survival	Proportion of release surviving to return
	Fishery contribution	Number of hatchery-origin fish harvested in fisheries (by fishery)
	Hatchery return	Number of adults returning to hatchery collection facilities
	Age composition (adults)	Proportion by age of hatchery return
	Size at age (adults)	Average & range of length at age
	Migration & Spawn Timing	Temporal distribution of hatchery return relative to natural population
Practice	--	Description of hatchery activities related to hatchery effectiveness & effect on natural populations
	Brood stock no.	Number of broodstock spawned
	Brood stock origin (pNOB)	Proportion natural-origin fish incorporated into brood stock
	Egg take	Total number of eggs collected
	Release number	Total number of fish released
	Release size	Size at release (typically #/lb)
	Release practice	Acclimation type, release site, etc.
	Mark rate	Proportion of release marked by fin clip and coded wire tag

6.4.3.2 Criteria

Hatchery action effectiveness criteria are program specific and based on changes relative to historical base periods as well as specific objectives identified in Hatchery Genetic Management Plans (HGMPs) adopted for each program. Thus, generic criteria for evaluating hatchery performance are not included herein. HGMPs are developed and revised based on ESA consultations for the operation of specific programs. Reference values for evaluation of reductions in hatchery impacts to each wild population are also identified by the Recovery Plan consistent with the recovery priority of each population.

6.4.3.3 Example Hatchery Data Types

Example reporting templates for hatchery effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation of the impacts on listed stocks (Table 44) and performance and practice (Table 45 and Table 46). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 44. Example reporting template for net annual hatchery impacts on listed wild lower Columbia River salmon and steelhead.

		Hatchery fraction (average)			Proportion Natural Influence		
Species	**Population**	**Goal[1]**	**Base[2]**	**Recent[3]**	**Goal[1]**	**Base[2]**	**Recent[3]**
Chinook							
Spring	Kalama						
	Cowlitz						
	Lewis						
Fall	…						
…	…						

[1] Base period refers to historical average at the time of initial widespread listings prior to year 2000.
[2] Goals to be determined in hatchery implementation plans based on population recovery priorities.
[3] Recent refers to recent annual average for prescribed evaluation period.

Table 45. Example reporting template to summarize recent lower Columbia River hatchery release and return numbers in Washington subbasin hatchery programs.

		Releases			Returns (to hatchery)		
Species		**Base**	**Goal**	**Recent**	**Base**	**Goal**	**Recent**
Chinook							
Spring	Deep						
	L. Cowlitz						
	U. Cowlitz						
	Kalama						
	NF Lewis						
	Wind						
	L. White						
	Salmon						
	Totals						
…	…						

Table 46. Example reporting template to summarize __(each)___ Washington Lower Columbia River Program.

				Recent years					Recent
Species	**Metric**	**Goal**	**Base**	**2000**	**2001**	**2002**	**2003**	**2005**	**avg.**
…	Brood stock no.								
	Brood stock origin (pNOB)								
	Egg take								
	Release number								
	Release size								
	Release practice								
	Mark rate								
	Smolt-adult survival								
	Fishery contribution								
	Hatchery return								
	Age composition (adults)								
	Size at age (adults)								
	Migration & Spawn Timing								
…	…								

6.4.4 Sampling and Analytical Design

6.4.4.1 Framework

The hatchery effectiveness sampling design incorporates the following sampling and analytical design elements:

1. Systematic annual sampling of hatchery contributions to natural populations of every significant salmon and steelhead population targeted for protection or improvement to moderate or higher levels of viability (see biological status monitoring).
2. Systematic annual sampling of broodstock and production information in every hatchery program.
3. Fishery sampling programs adequate to estimate the contribution each hatchery program to the harvest (see fishery action effectiveness monitoring).
4. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.4.4.2 Methods

Hatchery monitoring activities include a number of common elements as described below.

Escapement Monitoring: Escapement monitoring is discussed in detail in the Biological Status Monitoring section. Estimates of the proportion of hatchery fish in natural spawning populations are a critical piece of hatchery action effectiveness monitoring. This information is obtained from stratified random samples of spawning escapements for marks or tags.

Broodstock Sampling: Current hatchery practices collect detailed count data on fish returning to hatchery collection facilities and also typically involve regular and systematic subsampling of the hatchery return for biological data. In many cases, current activities will provide most of the information identified as pertinent to monitoring for action effectiveness applications. In some cases, procedures might warrant more formal implementation to ensure that related needs are met.

Production Inventory: Current hatchery practices collect detailed count data on numbers, sizes and marks of fish released and as well as a variety of other production statistics (egg take). In many cases, current activities will provide most of the information identified as pertinent to monitoring for action effectiveness applications. In some cases, procedures might warrant more formal implementation to ensure that related needs are met.

Fishery Sampling: Fishery sampling provides information of hatchery contributions which is a critical component of evaluations of the hatchery benefits associated with risks to listed wild populations.

Index Stock Marks and Tags: Marks and tags of hatchery fish are used to distinguish naturally-spawning hatchery-origin fish and to identify stock composition in mixed-stock commercial and sport fisheries in the ocean and Columbia River mainstem. Lower Columbia River hatchery-origin spawners are (coho, steelhead and Spring Chinook) or will soon be (Fall Chinook) marked with ad-clips. A subsample of most significant hatchery production groups is tagged with coded wire tags which identify the hatchery of origin. Hatchery groups often serve as index stocks for estimating and regulating fishing rates.

Run Reconstructions: Run reconstructions are detailed analyses of fish numbers by stock or population based on estimates of harvest and escapement. They involve summary and synthesis of all of the information described above. This information is used for a wide variety of hatchery evaluation, fishery management, and biological status assessment purposes.

6.4.4.3 Program Targets

This plan identifies the following representative sampling program targets as a starting point for further consideration and discussion by the fishery management programs.

- Estimation precision of hatchery origin spawners for each primary and contributing population of not less than an absolute impact of ± 5% with 80% confidence.
- Estimation precision for hatchery production numbers of ± 10% with 80% confidence
- Minimum of 20% mark sample rate of the harvest in significant fisheries to estimate stock composition (this is the current target rate).

6.4.5 Current Monitoring Activities

Current hatchery programs and hatchery performance and practice monitoring responsibilities are summarized in Table 47.

Table 47. Washington lower Columbia River fish hatcheries currently in operation and species produced (LCFRB 2004).

			Chinook				Steelhead	
Hatchery	Location	Operator[1]	Spring	Fall	Chum	Coho	Winter	Summer
Sea Resources	Chinook	Sea Resources	--	X	--	X	--	--
Grays	Grays	WDFW			X	X	--	--
Elokomin	Elochoman	WDFW	--	X	--	X	X	--
Abernathy	Abernathy	WDFW	--	X	--	--	--	--
Cowlitz Trout	Cowlitz	WDFW	X	--	--	--	X	X
Cowlitz Salmon	Cowlitz	WDFW	X	X	--	X	--	--
Mossyrock	Cowlitz	WDFW	--	--	--	--	--	--
North Toutle	Toutle	WDFW	--	X	--	X	--	--
Fallert Creek	Kalama	WDFW	X	--	--	X	--	--
Kalama Falls	Kalama	WDFW	X	X	--	X	X	X
Lewis River	Lewis	WDFW	X	--	--	X	--	--
Merwin	Lewis	WDFW	--	--	--	--	X	X
Speelyai	Lewis	WDFW	X	--	--	--	--	--
Skamania	Washougal	WDFW	--	--	--	--	X	X
Washougal	Washougal	WDFW	--	X	X	X	--	--
Carson	Wind	USFWS	X	--	--	--	--	--
Willard	L. White Salmon	USFWS	--	--	--	--	--	--
Little White Salmon	L. White Salmon	USFWS	X	X	--	--	--	--
Spring Creek	Columbia	USFWS	--	X	--	--	--	--

[1] *WDFW = Washington Department of Fish and Wildlife, USFWS = Oregon Department of Fish and Wildlife.*

6.4.6 Information Gaps

The following information gaps were identified in hatchery monitoring based on a review of the available information including annual biological assessments, hatchery plans, and research, monitoring and guidance documents.

1. Improved accuracy in estimates of the hatchery origin spawners in wild coho, Chinook, and steelhead populations.
2. Empirical information on hatchery-wild interactions including the relative success of hatchery and wild spawners, effects of broodstock integration, the value of supplementation for recovery purposes, and other ecological effects of hatchery fish (see Research).

6.4.7 Implementation Measures

M.M33. Maintain current monitoring programs for performance and practice of every hatchery.

Lead: WDFW, ODFW, USFWS, NMFS, Tribes

Funding source: Various

Rationale: Current hatchery monitoring programs collect extensive information on production and returns. This information is used to guide and optimize hatchery operations. This information also provides a sound basis for continuing evaluations of the effectiveness of hatchery actions relative to objective benefits of each program.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

M.M34. Implement additional biological monitoring of adult escapements of all species in order to accurately assess levels of hatchery contribution to natural production.

Lead: WDFW, USFWS, ODFW

Funding source: Various

Rationale: Information on hatchery fractions in natural populations is widely collected but is incomplete, particularly for natural populations of coho. The accuracy of current hatchery impact assessments is constrained by the quality of the available escapement data. In part this is related to historic difficulties in distinguishing hatchery and wild fish. The advent of 100% adipose marking of hatchery fish is expected to greatly facilitate assessment of the proportion of hatchery origin spawners.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules.
c. Identify constraints and uncertainties.

d. Identify coordination considerations.

M.M35. Develop and implement a comprehensive regular assessment and report of hatchery impact, performance, and practice for all lower Columbia hatchery programs for use in periodic recovery action effectiveness assessments.

Lead: NMFS

Funding source: To be determined.

Rationale: Current hatchery information is collected by all programs and maintained by the respective operating agency (WDFW, ODFW, USFWS, Tribes). Various reporting protocols are followed by the various parties but regular comprehensive summaries that address the evaluation needs relative to ESA and Recovery Plan implementation are not available. NMFS currently completes periodic status assessment reviews that would include assessments of both biological status and threat factors including hatcheries.

6-Year Implementation Work Schedule Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M36. Implement collaborative research to resolve critical uncertainties regarding hatchery-wild interactions to guide assessments of hatchery effects. (See Research)

Lead: WDFW, ODFW, USFWS, Tribes, NMFS

Funding source: To be determined.

Rationale: Hatchery risks and benefits remain a source of continuing controversy with significant uncertainty in whether significant production hatchery influences are consistent with salmon recovery and if conservation hatchery programs may be an effective tool for recovery in some circumstances. Further research is needed to clarify the nature and magnitude of effects and to guide development of appropriate remedies.

6-Year Implementation Work Schedule Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6.5 Ecological Interactions

6.5.1 Objectives

Ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Limiting factors include interactions with non-native species, effects of salmon on system productivity (e.g. nutrient cycling), and native predators of salmon. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alteration. Ecological action effectiveness monitoring is intended to determine if current management activities are adequate to address current or developing threats involving new species invasions and potentially manageable predation. Several significant ecological elements are subject to detailed monitoring programs already in place and this chapter briefly summarizes those efforts and refers to the detailed plans for further information.

6.5.2 Strategy

M.S57. Complete comprehensive assessments of ecological interaction action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.

A 6-year assessment interval is identified by the Recovery Plan for the effectiveness of ecological interaction actions relative to baseline conditions and benchmarks. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

M.S58. Evaluate effectiveness of actions to address ecological interactions involving non-native species introductions and predation effects that currently limit or could grow to limit the viability of listed lower Columbia River populations.

The Recovery Plan identifies significant actions for the benefit of listed populations involving these categories.

M.S59. Implement a periodic systematic monitoring program for aquatic nonindigenous species of plants, invertebrates, and fishes in the Columbia River mainstem and estuary.

Recovery Plan measures include regulatory, control and education measures for the prevention of exotic species invasions. Effective treatment of this threat will involve early detection of invasion. Without a systematic sampling program involving both periodic surveys in at risk areas and adaptive sampling to response to newly-identified problems, emerging problems may not be recognized in time to be effectively addressed. This plan does not envision a large scale intensive statistical sampling program for all elements of the ecosystem owing to the expense and limited direct benefit of such an effort to salmon recovery. Rather, it envisions a surgical and focused systematic effort aimed at identifying emerging threats. Significant problems may then be candidates for more focused monitoring or research efforts specific to the nature of the particular problem.

M.S60. Monitor the status of existing introduced species including shad based on current information and appropriate refinements identified in critical uncertainty research regarding the potential significance of this threat.

Current fish sampling programs provide periodic information assumed to suffice for identifying significant changes that could alter the significance of existing threats. For instance, ladder counts of American shad at Columbia River mainstem dams provide extensive annual data on numbers and distribution throughout the system. Similarly, systematic angler surveys provide information on the occurrence of introduced sport fish species in the catch. The significance of a number of these potential threats is unclear and has been identified as a critical uncertainty that warrants future research. Additional monitoring needs in this area may be identified as a result of additional research.

M.S61. Conduct intensive annual monitoring and evaluation of the effectiveness of measures to manage predation in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals and piscivorous birds.

This includes the effectiveness of measures to discourage concentrated predation by pinnipeds in areas of salmon vulnerability downstream from Bonneville Dam, reduce predation by northern pikeminnow by exploitation in the sport reward fishery, and to redistribute Caspian Terns and other bird species from concentrated nesting areas of the estuary where predation on juvenile salmonids is significant. Note that assessments of the significance and trends of these factors are addressed by dedicated research projects identified in that section of this plan.

6.5.3 Indicators

6.5.3.1 Attributes & Metrics

Ecological indicators are identified for monitoring of non-native species and predation (Table 48). The examples below include metrics currently in use by existing monitoring and evaluation programs for aquatic nonindigenous species (Sytsma et al. 2004), avian predators (Collis et al. 2006), pikeminnow predators (Porter 2006), and pinnipeds (Stansell 2004; Wright et al. 2007).

Table 48. Categories of ecological interactions, including attributes monitored and example statistics.

Category	Focus	Attribute	Example
Non-native species	Invasive exotics	Occurrence	Presence/absence, density or distribution by species
	Shad	Numbers	Daily ladder counts in Columbia mainstem dams
Predators	Avian (Terns & cormorants)	Abundance	Numbers or index counts of nests & nesting adults
		Productivity	Nesting success/fledge rates, rate of population change
		Distribution	Nesting distribution
		Diet composition	% salmonids
		Predation rates	Minimum estimates based on PIT tag recoveries
	Fish (pikeminnow)	Angler participation	Numbers of sport reward participants
		Harvest	Number of pikeminnow harvested by sport reward anglers
		Exploitation rate	Proportion of population harvested annual by anglers
		Size & age structure	% of pikeminnow tagged and harvested by size over time
	Pinnipeds (seals & sea lions)	Abundance	Index numbers / observation frequency
		Distribution	Relative abundance near Bonneville & downstream
		Diet	Species composition by time and area
		Predation rate	Number of salmonids eaten near Bonneville Dam relative to dam count

6.5.3.2 Criteria

Monitoring criteria are program specific and based on changes relative to historical base periods as well as specific objectives identified in related action plans.

6.5.3.3 Example Data Types

Example reporting templates for ecological effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation (Table 49, Table 50, Table 51). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 49. Example monitoring data summary for avian predation in the Lower Columbia River.

Metric	Baseline or target	Long-term avg.	Recent years						Recent avg
			2002	2003	2004	2005	2006	2007	
Caspian terns									
Abundance									
E Sand Island %									
Juveniles/pair									
Diet % salmonids									
Salmonids eaten									
Cormorants									
Abundance									
E Sand Island %									
Juveniles/pair									
Diet % salmonids									
Salmonids eaten									

Table 50. Example monitoring data summary for the Northern Pikeminnow management program in the Lower Columbia River.

Metric	Baseline or target	Long-term avg.	Recent years						Recent avg
			2000	2001	2002	2003	2004	2005	
Anglers	--								
Catch/angler	--								
Harvest	--								
Average fish size	??								
Exploitation rate	10-20%								

Table 51. Example monitoring data summary for pinniped predation in the Bonneville Dam tailrace.

Metric	2002	2003	2004	2005	2006	2007	Avg
No of individuals							
Ca. sea lions							
Steller sea lions							
Harbor seals							
Max daily no.							
Days any present							
Predation loss (total)							
Deterrent engagements							
Number removed							

6.5.4 Sampling and Analytical Design

6.5.4.1 Framework

The ecological effectiveness sampling design incorporates the following sampling and analytical design elements:

1. A combination of systematic periodic and opportunistic sampling for invasive plants, invertebrates, and fishes at index sites in the estuary and mainstem.
2. Intensive systematic annual sampling of avian predators and predation in the estuary.
3. Intensive systematic annual sampling of the northern pikeminnow population and sport reward fishery for pikeminnow in the lower Columbia mainstem and estuary.
4. Systematic annual sampling of pinniped numbers and predation.
5. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.5.4.2 Methods

Methods employed for current action effectiveness monitoring programs related to ecological factors are summarized below.

Aquatic Nonindigenous Species: A comprehensive literature review and field survey of exotic species in the lower Columbia River was completed in 2001-2004 (Sytsma et al. 2004). This survey describes baseline conditions and establishes effective protocols for any future monitoring efforts. A variety of sampling projects have been conducted prior to 2004 but a systematic periodic sampling program has not been established.

Avian Predation: Avian predation is currently being monitored in the Columbia River estuary to: 1) evaluate the effectiveness of efforts to reduce impacts on juvenile salmonids by relocating nesting colonies of Caspian tern, 2) assess potential management options to reduce predation by double-crested cormorant, and 3) monitor colonies of other piscivorous waterbirds (Collis et al. 2007). Avian predation in the Columbia River estuary has been systematically monitored since 1997. Terns and cormorants have been identified as a significant mortality factor on juvenile salmonid migrants. Efforts are underway to reduce tern predation by relocating nesting colonies to estuary islands closer to the ocean where alternative food sources result in less salmonid mortality. The effectiveness of this action is being evaluated by monitoring the abundance, distribution, productivity and diet of nesting colonies. A Caspian Tern Management Plan for the Columbia River Estuary will guide further management of Caspian terns. Similar actions are being contemplated for cormorants based on results from the ongoing research and monitoring program.

Pikeminnow Predation: A northern pikeminnow management program has been underway in the Columbia River mainstem since 1990 (Porter 2006). This program provides monetary rewards to anglers for the harvest of pikeminnow and also includes contract anglers fishing in restricted areas of the dams where predators congregate. Previous research has concluded that nominal exploitation of this fish will significantly reduce predation on juvenile salmonids by reducing survival to large sizes of pikeminnow that account for the majority of the predation losses. The effectiveness of this program is based on trends in angler participation, catch rate,

harvest, annual exploitation rates, and size structure of the predator population. Angler effort, harvest and biological information is collected at participant registration stations. A sample of pikeminnow are caught, marked, and released prior to each fishing season in order to estimate exploitation rates from tag recoveries by anglers. Biological data includes size and age (estimated from bony structures).

Marine Mammal Predation: Marine mammal monitoring efforts in the lower Columbia mainstem and estuary have been implemented and expanded in recent years in response to growing numbers of California sea lions, Steller sea lions, and harbor seals throughout the lower river and increasing seasonal concentrations of sea lions and observations of predation in the tailrace of Bonneville Dam (NOAA 2007). Monitoring efforts include systematic observations of pinniped numbers and salmonids eaten by pinnipeds in the Bonneville Dam tailrace. Beginning in 2005, a hazing program was implemented to deter predation on vulnerable salmon and steelhead in the dam tailrace (Wright et al. 2007).

6.5.4.3 Program Targets

This plan currently relies on existing program targets for ecological interaction monitoring.

6.5.5 Current Monitoring Activities

Current ecological action effectiveness monitoring programs in the lower Columbia River are described in Table 52.

Table 52. Ongoing monitoring for ecological interactions in the Lower Columbia region.

Focus	Years	Implementors[1]
Invasive species	Periodic (none ongoing)	Various (see Sytsma et al. 2004)
Shad	1938 – present (dam counts)	USACE
Avian (Terns & cormorants)	1997-present	USGS, BPA
Fish (pikeminnow)	1990 – present	PSMFC, ODFW, WDFW, BPA
Pinnipeds	1999-present (Bonneville tailrace)	USACE, NMFS, WDFW, ODFW, CRITFC, PSMFC

[1] *CRITFC = Columbia River Inter-Tribal Fish Commission, BPA = Bonneville Power Administration, ODFW = Oregon Department of Fish and Wildlife, PSMFC = Pacific States Marine Fisheries Commission, USACE = U.S. Army Corps of Engineers, USGS = U. S. Geological Survey, NMFS = National Marine Fisheries Service, WDFW = Washington Department of Fish and Wildlife.*

6.5.6 Information Gaps

The following information gaps in ecological monitoring were identified based on a review of the available information including annual biological assessments, and research, monitoring and guidance documents.

1. Systematic monitoring for the occurrence and spread of new species invasive plants, invertebrates, and fishes in the Columbia River mainstem and estuary.
2. Marine mammal population levels and predation rates on adult salmonid in the lower Columbia River mainstem and estuary downstream from the immediate vicinity of the dam where current monitoring is concentrated.

6.5.7 Implementation Measures

M.M37. Monitor occurrences of new exotic aquatic fishes, invertebrates or plants based on a dedicated sampling program in indicator sites and incidental observations during other biological status monitoring, anecdotal reports, and follow-up sampling where appropriate.

Lead: TBD

Funding source: TBD

Rationale: The objective of this activity is to proactively identify emerging threats while there is still a possibility of containment. This will involve development of a program that does not currently exist.

6-Year Implementation Work Schedule Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M38. Continue to monitor abundance of American shad based on Bonneville Dam counts.

Lead: USACE

Funding source: BPA

Rationale: Dam counts continue to provide an inventory of status and trends in shad abundance and will identify any significant changes in numbers or population dynamics. They will provide a direct indicator of the response to any shad management actions that might be contemplated based on results of research on the significance of any interaction with salmonids.

6-Year Implementation Work Schedule Activities**:**

e. Identify appropriate opportunities and funding sources.
f. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
g. Identify constraints and uncertainties
h. Identify coordination considerations

M.M39. Monitor annual angler participation, harvest, and exploitation rate in northern pikeminnow management program in Columbia River mainstem.

Lead: PSMFC, ODFW, WDFW

Funding source: BPA

Rationale: Continued monitoring is needed to determine whether program is achieving desired 10-20% annual exploitation rates intended to reduce pikeminnow predation on

juvenile salmonids by 50%. In involves monitoring of anglers registered, numbers and sizes of fish caught, and the annual percentage of tagged fish caught.

6-Year Implementation Work Schedule Activities**:**

i. Identify appropriate opportunities and funding sources.
j. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
k. Identify constraints and uncertainties
l. Identify coordination considerations

M.M40. Conduct periodic censuses of the abundance, distribution, and diet of avian predator including Caspian terns and Cormorants.

Lead: USGS

Funding source: BPA

Rationale: This monitoring is needed to determine if management measures limit avian predator numbers and distribution achieve the desired effects.

6-Year Implementation Work Schedule Activities**:**

m. Identify appropriate opportunities and funding sources.
n. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
o. Identify constraints and uncertainties
p. Identify coordination considerations

M.M41. Conduct periodic censuses of the abundance, distribution, and diet of marine mammals throughout the lower Columbia River mainstem and near Bonneville Dam and evaluate response to hazing, exclusion, and other management measures as implemented.

Lead: NMFS

Funding source: BPA

Rationale: Monitoring of marine mammal status and behavior will determine the trend in this increasing mortality factor as well as the effectiveness of management measures.

6-Year Implementation Work Schedule Activities**:**

q. Identify appropriate opportunities and funding sources.
r. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
s. Identify constraints and uncertainties
t. Identify coordination considerations

6.6 Mainstem/Estuary

Mainstem/Estuary action effectiveness monitoring is intended to identify trends and effects of protection, restoration, and management actions affecting habitat conditions critical to salmon

migration and rearing. Estuary and lower Columbia mainstem habitats play an important but poorly understood role in the anadromous fish life cycle. Large scale changes in river flow, water circulation, sediment transport, and floodplain and wetland destruction or isolation have altered habitat conditions and processes important to migratory and resident fish and wildlife. Hydropower flow regulation, channel alternations, and floodplain development and diking have all contributed to these habitat changes. Estuary conditions and actions affect all salmon ESUs in the Columbia River basin and are treated in a comprehensive estuary recovery plan module (NOAA 2007b) and a dedicated research, monitoring, and evaluation program (Johnson et al. 2008). The Estuary RM&E program identified by Johnson et al. (2008) meets the status monitoring, action effectiveness monitoring, and uncertainties research needs of the Washington Lower Columbia Recovery Plan. Key elements are summarized below and the reader is referred to the regional plan for further detail.

6.6.1 Objectives

1. Measure the effects of individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives (termed effectiveness monitoring in the estuary plan).
2. Estimate the collective effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitat and performance (termed validation monitoring in the estuary plan).

6.6.2 Indicators

The framework organizing action effectiveness research is built on an estuary conceptual that relates stressors, controlling factors, ecosystem structures, ecosystem processes and ecosystem functions. Monitoring indicators corresponding to these factors are identified in Table 53.

Table 53. Indicators identified for application to estuary action effectiveness monitoring.

Category	Monitored indicators
Flow regulation	Water discharge
Passage/Flow Barriers	Passage Barriers
Invasive Species	Species composition, abundance, spatial distribution
Watershed conditions	Discharge, water velocity/temp., sediment budget, large woody debris
Geology sediments	Accretion rates, contaminants, Redox potential, soil composition
Hydrodynamics	Ground water level, Surface water elevation, water velocity
Bathymetry/Topography	Bathymetry, Floodplain topography
Water quality	Dissolved oxygen, nutrients, pH, Salinity
Temperature	Temperature
Landscape features	Ecosystem structures map, area restored, large woody debris
Tidal Channel Morphology	Edge/Density/Sinuosity
Vegetation cover	Percent cover by species
Food web	Foraging success, predation index, prey availability
Salmonid preference	Abundance, age/size structure, distribution, growth rate, migration pathways, residence time, species composition

6.6.3 Implementation Measures

The estuary research, monitoring, and evaluation program identifies two actions specific to action effectiveness research/monitoring in addition to a suite of actions for estuary status and trend monitoring, estuary uncertainties research, and estuary implementation compliance monitoring.

Action effectiveness measures are:

M.M42. New and ongoing projects should consider applying monitoring protocols in the plan.

M.M43. Develop an analytical model to quantify and evaluate the cumulative effects of multiple hydrologic reconnection restoration projects.

7. Uncertainty and Validation Research

Uncertainty and validation research targets specific issues that constrain effective Recovery and Watershed Plan implementation. Research includes evaluations of cause and effect relationships between fish and limiting factors, actions that address specific threats related to limiting factors, and testing of assumptions about population trends, land use trends, and flow and water quality conditions. Incomplete understanding of biological systems and of the human impact upon those systems results in uncertainty about the outcomes of the actions identified in the Recovery and Watershed Plans. These plans support the careful consideration of uncertainty by explicitly identifying assumptions and working hypotheses, incorporating safety factors into recovery scenarios, conducting validation research and studies to explore uncertainty, and adjusting implementation actions when appropriate. Research provides focused information on a variety of questions and often involves some type of intensive sampling program to determine if the initial plan assumptions are valid. Research can be costly, often evolves as a series of questions are answered, and ends when its purposes it met. Research can provide very specific and detailed information on key monitoring subjects, and results are often incorporated into long term monitoring programs in the form of sampling protocols, expansion factors or bias corrections, or estimates of precision and accuracy.

7.1 Objectives

The objective of uncertainty and validation research is to characterize unknown ecological relationships and critically examine cause and effect relationships between fish, limiting factors/threats, watershed processes, and actions that address specific factors/threats. These critical uncertainties constrain our ability to identify or evaluate the effects of specific actions.

7.2 Current Research Activities

Table 54 documents the long-term research studies including habitat or biological attributes, the entity, location, and variable or measurement being sampled. Also included are frequency of sampling, period, protocol and point of contact. By conducting long term monitoring efforts on a multitude of physical and biological factors, these programs will identify functional relationships relevant to recovery and watershed planning and thereby reduce uncertainty in planning efforts.

Although the research is varied in scope and scale, the following attributes are being investigated:

- Habitat complexity and cover
- Riparian vegetation, cover and structure
- Channel morphology
- Water quality
- Biological attributes
- Instream flows

Key entities involved in research at the subbasin level include:

- U.S. Forest Service

- U.S. Geological Survey
- Washington Department of Fish and Wildlife
- Washington Department of Ecology
- Lower Columbia Fish Recovery Board (LCFRB)
- Clark County Conservation District
- Columbia River Research Laboratory (CRRL)
- Underwood Conservation District
- Salmon Recovery Funding Board/Intensively Monitored Watersheds

Several subbasins have been designated as the focus of intensive research and monitoring programs designed to provide detailed information on the status and interactions of fish, stream habitat conditions, and watershed conditions as well as the effects of a variety of protection and restoration actions involving habitat and hatcheries. These Intensively Monitored Watersheds include East Fork Lewis, Mill/Germany/Abernathy complex and Wind River (Figure 22).

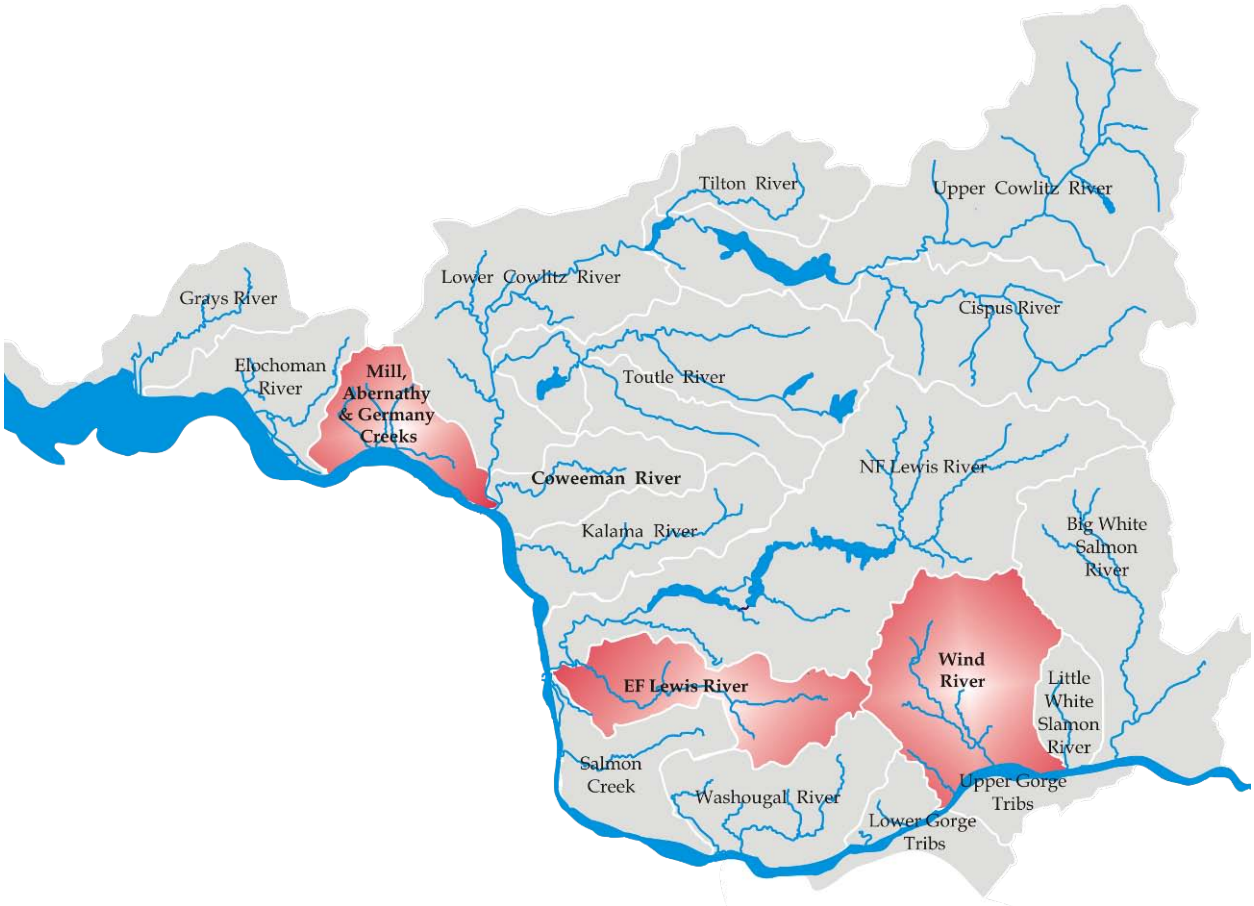

Figure 22. Map highlighting primary basins for study.

Table 54. Summary of significant critical uncertainty research activities at the subbasin scale.

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Habitat Complexity & Cover	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Riparian Vegetation Cover & Structure	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Channel Morphology	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Water Quality	USFS	EF Lewis Basin	Temperature	annual	WDEQ Protocol	1996-Present	NA	David Hu 360-891-5108 dhu@fs.fed.us
Water Quality	USGS	EF Lewis Basin	Temperature, nutrients, contaminants	Intermittent	WDEQ Protocol	1976-80, 1980	NA	http://wa.water.usgs.gov/data/
Habitat Complexity & Cover	WDFW	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	Salmon and Steelhead Habitat Inventory and Assessment Program - Level II	1991-Present (2004?)	NA	David Hu 360-891-5108 dhu@fs.fed.us
Water Quality	WDOE	EF Lewis Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present	NA	Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Habitat Complexity & Cover	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Bernadette Graham Hudson 360-425-1552 www.lcfrb.gen.wa.us
Riparian Vegetation Cover & Structure	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Bernadette Graham Hudson 360-425-1552 www.lcfrb.gen.wa.us
Channel Morphology	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Bernadette Graham Hudson 360-425-1552 www.lcfrb.gen.wa.us
Habitat Complexity & Cover	Clark County CD	EF Lewis River	Habitat Restoration Monitoring, Stream Surveys	Intermittent	?	?	64a	Denise Smee, 360-883-1987 http://www.clarkcd.org
Water Quality	Clark County CD	EF Lewis River	Water Quality	annual	WDEQ Protocol	1994-Present	NA	Denise Smee, 360-883-1987 http://www.clarkcd.org
Water Quality	SRFB / IMW	Mill/Germany	Aluminum concentrations & fish abundance	ongoing	WDEQ Protocol	2004 - present	NA	http://www.rco.wa.gov/boards/srfb.shtml

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Biological Attributes	SRFB / IMW	Mill/Germany/Abernathy	Juvenile Abundance Estimate (smolt trapping)	ongoing	mark recapture	2001-present	NA	http://www.rco.wa.gov/boards/srfb.shtml
Biological Attributes	SRFB / IMW	Mill/Germany/Abernathy	Spawning Surveys (coho, steelhead, Chinook, chum)	ongoing	TFW – spawning module	?	NA	http://www.rco.wa.gov/boards/srfb.shtml
Channel Morphology	SRFB / IMW	Mill/Germany/Abernathy	Sediment Surveys: sediment budgets	ongoing	Washington Watershed Assessment Module	2004 - present	NA	http://www.rco.wa.gov/boards/srfb.shtml
Channel Morphology	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2005	NA	http://www.rco.wa.gov/boards/srfb.shtml
Habitat Complexity & Cover	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2004 - present	NA	http://www.rco.wa.gov/boards/srfb.shtml
Instream Flows	SRFB / IMW	Mill/Germany/Abernathy	Flow Gages to assess altered flow regimes	ongoing	WDEQ Protocol	2004 - present	NA	http://www.rco.wa.gov/boards/srfb.shtml
Riparian Vegetation Cover & Structure	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2004	NA	http://www.rco.wa.gov/boards/srfb.shtml
Water Quality	SRFB / IMW	Mill/Germany/Abernathy	Temperature	ongoing	WDEQ Protocol	2004 - present	NA	http://www.rco.wa.gov/boards/srfb.shtml
Water Quality	Under-wood CD	Wind Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992	NA	Tova Cochrane 503-493-1936 ucd@gorge.net
Habitat Complexity & Cover	USFS	Wind Basin	Stream/Riparian Surveys	Intermittent	AREMP	1991-Present	NA	David Hu 360-891-5108 dhu@fs.fed.us
Biological Attributes	USFS-CGSA	Wind Basin	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead	1994-Present	NA	Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Water Quality	USGS	Wind Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1980	NA	http://wa.water.usgs.gov/data/
Biological Attributes	USGS – CRRL	Wind Basin	Chinook Spawning Surveys	NI	?	1998-present	NA	http://wfrc.usgs.gov/labs/columbia.htm

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Water Quality	USGS	Wind Basin	Salmon Carcass analog study	annual	Nutrients Water Quality and Chemistry monitoring. Macroinvertebrate response, juvenile salmonid response	2003-2006	NA	Matt Mesa 503-538-2299 ext 246 matt_mesa@usgs.gov
Habitat Complexity & Cover	USGS – CRRL	Wind Basin	Stream Habitat Surveys,	annual	Gradient, Riparian Condition, LWD, Pool Frequency		NA	http://wfrc.usgs.gov/labs/columbia.htm
Water Quality	USGS – CRRL	Wind Basin	Temperature Monitoring	annual	USGS	2001-present	NA	http://wfrc.usgs.gov/labs/columbia.htm
Instream Flows	USGS – CRRL	Wind Basin	Stream Gage	annual	WDEQ Protocol	1998-Present	NA	http://wfrc.usgs.gov/labs/columbia.htm
Biological Attributes	USGS – CRRL	Wind Basin	Snorkel Surveys, Electrofishing	annual	Population abundance	1998-Present	NA	http://wfrc.usgs.gov/labs/columbia.htm
Habitat Complexity & Cover	WDFW	Wind Basin	Stream/Riparian Surveys	Intermittent	Salmon and Steelhead Habitat Inventory and Assessment Program - Level II	1988-Present	NA	Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Water Quality	WDOE	Wind Basin	Temperature, nutrients, contaminants	annual	TMDL	1973 1976-83, 1995	NA	Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Instream Flows	WDOE	Wind Basin	Stream Gage	annual	WDEQ Protocol	1934-Present	NA	Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main .
Biological Attributes	WDFW	Wind Basin	Juvenile Steelhead Densities & Biomass	?	?	?	NA	Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Riparian Conditions & Function	Skamania County	Wind Basin	Riparian setback monitoring	ongoing	?	?	56o	Karen Witherspoon skamaniacounty.org
Biological Attributes	WDFW	Wind Basin	smolt trapping	?	mark recapture weir	?	NA	Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Wind Basin	spawning surveys	?	TFW - Spawning module	?	NA	Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov

Sources:

1. Salmon Recovery Funding Board (2004): http://www.ecy.wa.gov/programs/eap/imw/

2. Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan Volume II, Draft. Prepared By: Lower Columbia Fish Recovery Board for the Northwest Power & Conservation Council (http://www.nwppc.org/fw/subbasinplanning/lowerColumbia/plan/).

3. Personal Communication with entities listed above (May 2006)

7.3 Research Needs

Research needs were identified by a review of the literature and plans related to salmon status and recovery. Sources are referenced where a research need was specifically identified in a particular plan or report. Needs are listed by category.

7.3.1 Salmonid Status and Population Viability

1. Validate recovery goals and preliminary estimates of persistence probabilities based on life cycle analyses and long term data sets.
2. Empirically evaluate assumptions regarding the significance of Allee effects and depensation at small population sizes associated with quasi-extinction risk estimates.
3. Identify relationships and co-variation between marine and freshwater survival and productivity patterns for salmon.
4. Adapt and apply new genetic stock identification methods to population status assessments. Collect additional genetic data for lower Columbia stocks to improve baseline genetic library to allow better differentiation among lower Columbia populations.
5. Evaluate how different scenarios of climate change affect ecosystem dynamics, habitat characteristics, and ultimately population condition across all life stages.
6. Identify how effects of poor ocean conditions related to the Pacific Decadal Oscillation (PDO) or El Niño Southern Oscillation (ENSO) can be quantified and managed for in the future

7.3.2 Stream Habitat and Watershed Health

1. Apply monitoring feedback loops to inform EDT analysis (and other models used for evaluating limiting factors) and improve estimates of fish productivity and capacity based on habitat and fish productivity data.
2. Determine relative short term and long term tradeoffs in the benefits of site-specific and process based actions.
3. Identify the quantitative relationships between tributary in-stream flow and juvenile rearing and out-migrant survival.
4. Clarify the relationships between habitat type and quality to a quantitative fish productivity level.
5. Determine which habitats are most important in determining juvenile and adult migration patterns and potential for increases in viability.
6. Determine relationship between genotypic variations and habitat use.
7. Use ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.
8. Link action effectiveness to changes in population and ESU status and viability (multiple scales.
9. Evaluate the impacts of invasive species on salmon, and evaluate the potential to control those impacts.

10. Evaluate the relationships between micro- and macro-detrital inputs, transport, and end-points.
11. Improve understanding of the importance of the tidal portions of tributaries and adjacent confluence areas for tule fall Chinook and other species.
12. Investigate if monitoring efforts for other species can be tracked and related to salmonid habitat monitoring and/or population monitoring.
13. Evaluate the relationship between future ground water supply development and instream flows (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
14. Evaluate the relationships between forest harvest rates, maturation of forests, and instream flows and water quality (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
15. Evaluate the relationships between trends in agricultural lands, road densities, urban and rural development, and instream flows and water quality (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
16. Determine how observed trends in urban, rural, and industrial sectors relate to water demand predictions (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
17. Determine the extent to which development of groundwater supplies has impacted instream flows in priority streams (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
18. Based on instream flow monitoring, determine how instream flows responded to target flow, programmatic, and other actions designed to improve the flow regime (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).
19. Evaluate the relationship between observed instream flow responses and modeled responses (WRIA 25/26 and 27/28 Detailed Implementation Plans, Table 12).

7.3.3 Hydropower

1. Determine feasibility of re-establishing self-sustaining anadromous populations upstream of hydropower facilities in the Lewis, Cowlitz and Tilton systems.
2. Determine effects of flow on habitat in the estuary & lower mainstem.
3. Evaluate uncertainties related to estimates of delayed mortality and how they affect conclusions regarding population status and viability (all ESUs).
4. Evaluate pre-spawning mortality (all ESUs) as a result of hydropower operations.

7.3.4 Fisheries

1. Evaluate innovative techniques (e.g., terminal fisheries and tangle nets) to improve access to harvestable stocks and reduce undesirable direct and indirect impacts to wild populations.
2. Evaluate appropriateness of stocks used in weak stock management.
3. Determine how uncertainties in exploitation rate estimates affect evaluations of the effects of harvest on VSP and population status.
4. Evaluate uncertainty surrounding the use of indicator (hatchery) stocks to infer fishery mortality on natural-origin fish affect conclusions regarding population status and viability.

5. Determine if gaps exist in quantitative data available for analyses of fishery impacts at relevant units (e.g., by population, MPG, or ESU) and if so, how they affect the certainty of concluding the status of the population and ESU.
6. Evaluate how distributions (instead of point estimates) of parameter estimates have been used to improve our understanding of how harvest effects impact populations, and how our management is working to reduce negative impacts.
7. Determine if the accuracy of estimates of incidental mortality related to bycatch in non-target fisheries and from specific gear types in catch and release fisheries is known, and how that affects our management.

7.3.5 Hatcheries

1. Develop a strategy for assessing the interactions between hatchery and wild fish.
2. Determine relative performance of hatchery and wild fish in wild in relation to broodstock divergence and hatchery practices.
3. Experimentally determine net effects of positive and negative hatchery effects on wild populations.
4. Experimentally evaluate the efficacy of hatchery program integration, segregation, and supplementation.
5. Determine hatchery effects on disease and predation on wild fish.
6. Determine how uncertainties in estimates of reproductive success of hatchery and natural-origin fish spawning affect evaluations of the effect of hatchery practices on population status and viability.
7. Determine how surplus hatchery-origin fish on the spawning grounds affect the productivity and genetic integrity of the natural population.
8. Determine the short- and long-term effects of hatchery fish intervention on the status of viability attributes of natural-origin populations within the sub-basins as well as within the migratory corridors.
9. Determine if early spawn time of hatchery steelhead stocks is a successful management tool for segregating hatchery and natural fish.
10. Evaluate the effectiveness of fish culture techniques, such as acclimation, in segregating hatchery fish from natural populations.

7.3.6 Ecological Interactions

1. Experimentally evaluate nutrient enrichment benefits and risks using fish from hatcheries or suitable analogs.
2. Determine the interactions and effects of shad on salmonids.
3. Evaluate the significance and potential management of predation by marine mammals as a factor limiting the status of salmonid populations.
4. Determine the rate of infection of disease in the natural population.

5. Determine if the rate of transmission of disease is affected by anthropogenic impacts on physical and biological processes.

7.3.7 Mainstem/Estuary

A research, monitoring, and evaluation (RME) plan for the Columbia River estuary and plume was recently developed (Johnson et al. 2008) for the purpose of fulfilling certain requirements of Reasonable and Prudent Alternatives of the Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2008). Research needs were identified in that process at a 2003 workshop. Research needs at that workshop and additional needs are described below:

1. Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.
2. Implement selected restoration projects as experiments, so that we can learn as we go.
3. Implement pre- and post-restoration project monitoring programs, to increase the learning.
4. "Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.
5. Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.
6. Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.
7. Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.
8. Identify and implement off-site mitigation projects in Columbia River estuary tributaries.
9. Establish a data and information sharing network so that all researchers have ready and up-to-date access.
10. Increased genetic research to identify genotypic variations in habitat use. Additional genetic data collection should be conducted to improve the baseline genetic library to better differentiate among lower Columbia stocks.
11. Understanding salmonid estuarine ecology, including food web dynamics.
12. Understanding sediment transport and deposition processes in the estuary.
13. Understanding juvenile and adult migration patterns.
14. Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.
15. Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.

16. Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the Columbia River estuary and ocean.
17. Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.
18. Improve our understanding of the role between micro- and macro-detrital inputs, transport, and end-points.
19. Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.
20. Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.
21. Increase our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.
22. Determine the effects of flow on habitat in the estuary and lower mainstem.
23. Improve understanding of the importance of the tidal portions of tributaries and adjacent confluence areas for tule fall Chinook and other species.
24. Consider implementing an integrated status and trends monitoring (ISTM) process for the estuary to coordinate with the ISTM processes and monitoring design ongoing in the Washington and Oregon tributaries in the Lower Columbia region.
25. Determine if historical changes in estuary morphology and hydrology have affected habitat availability and ecosystem processes.

7.4 Implementation Measures

M.M44. Conduct research of salmonid status and population viability to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to salmonid status and population viability aim to validate recovery goals and evaluate other assumptions made regarding population viability and risk. In addition, the program should consider ways to improve understanding of ocean conditions and climatic impacts on salmon population viability.

M.M45. Conduct research on stream habitat and watershed health to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to stream habitat and watershed health should aim to validate assumptions made regarding impacts on salmon populations, including a feedback loop to inform EDT analysis and prioritization of habitat actions. Other research needs include better understanding of foodweb relationships, impacts of reduced instream flow and changes in water quality.

M.M46. Conduct research on hydropower operations and impacts to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to hydropower operations should aim to validate assumptions made regarding impacts of hydropower operations on salmonid status and viability. Efforts should investigate relationships between changes in flow regime and habitat conditions, as well as reintroduction measures above hydropower systems.

M.M47. Conduct research on fisheries impacts to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to fisheries should aim to validate assumptions made regarding impacts of fisheries on salmonid status and viability as well as evaluate potential alternative methods and fisheries management measures. Efforts might include evaluating innovative techniques (gear, time and area management), incidental mortality, and appropriateness of indicator stocks.

M.M48. Conduct research on hatchery impacts to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to hatcheries should aim to validate assumptions made regarding impacts of hatcheries on salmonid status and viability. Efforts might include improving understanding of interactions between hatchery and wild fish, including potential predation, competition, disease concerns, and negative effects on productivity. In addition, this measure should address evaluating appropriate source stocks for reintroduction and supplementation programs.

M.M49. Conduct research on ecological interactions to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to ecological interactions should aim to validate assumptions made regarding impacts of various interactions on salmonid status and viability. Efforts might include improving understanding of impacts of native and non-native species on salmon populations, as well as impacts of altered nutrient cycling.

M.M50. Conduct research on mainstem and estuary conditions to evaluate critical assumptions, reduce uncertainty, and guide Recovery Plan implementation.

Explanation: Research questions related to mainstem and estuary conditions should aim to validate assumptions made regarding mainstem and estuary habitat and its impact on salmonid status and viability. Efforts should include improving the understanding of the role of the estuary for various life history strategies, improving understanding of distribution and timing of salmonid use of the estuary, restoration

method validation, impacts of the altered hydrologic regime on habitat conditions, and impacts of altered water quality.

7. Programmatic Evaluation

The RM&E program directly supports the adaptive framework of the Lower Columbia Basin. Recovery and Watershed Plan implementation includes a series of checkpoints, assessments, benchmarks and decisions (Figure 23). As discussed in the programmatic overview, the program explicitly implements the checkpoints, assessments and benchmarks. Checkpoints are time-based decision points where substantive changes in direction will be considered. Assessments are formal evaluations of progress and results. Benchmarks are standards or criteria that will drive decisions depending on observed progress in implementation effort and effectiveness. Decisions identify refinements in efforts or new directions based on progress relative benchmarks observed at checkpoints.

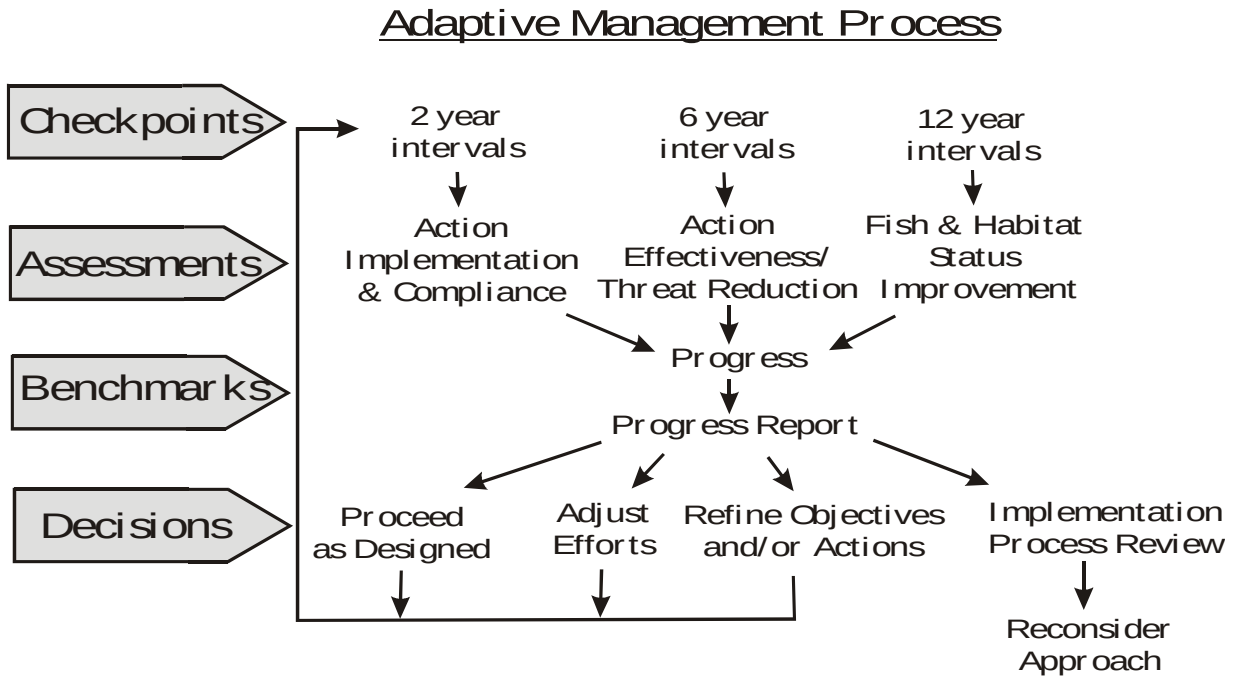

Figure 23. Elements and decision structure for adaptive management process for implementation of Washington Lower Columbia Salmon Recovery (LCFRB 2010) and Watershed Plans (LCFRB 2006).

Information is collected during periodic checkpoints and assessments and will be evaluated to determine whether goals and related criteria/benchmarks are being met or changes are needed to achieve the objectives. A general evaluation framework is presented below.

- Management Actions – all of the management actions designed to contribute to a plan objective are identified. These management actions are evaluated to determine success.
- Performance Metrics – for each management action, one or more units of measurement are used to evaluate the success of the action. The implementation metric is yes/no, while the effectiveness metric is typically a statistical or numeric measurement resulting from the study.

- Triggers – for each performance metric, a threshold is established that serves as the indicator (or trigger) when the adaptive management process starts. The trigger must be measurable in a timeframe meaningful for informing management changes.
- Management response – after the trigger is "tripped" for a given performance metric, the management response process begins.

As part of the evaluation process, the cost-benefit of a particular management action can be considered by incorporating cost information as a performance metric or a trigger. For example, one can consider how the actual cost to implement the action compares with the estimated cost or evaluate how the realized benefits of the action balance the cost to implement the action.

Management responses are developed after the monitoring data are evaluated. The responses are then incorporated into the implementation of the plan in a feedback loop. However, because of the limitations in information, the management response cannot always be known until the new information is collected and evaluated, and additional "negotiation" occurs. Therefore, three general responses can occur under adaptive management:

- Predefined mandatory management response – completely defined at the outset of the plan.
- Mandatory collaborative management response – mandatory if a specific triggering condition is observed, but the plan does not specifically describe in advance what the management response would be.
- Cooperative management response – result from opportunities to alter management activities that arise from observations during plan implementation.

Because many of the recommendations and policies in the plan are not enforceable on a "regulatory basis" many of the management responses are collaborative or cooperative in nature.

Appendix C provides an example of the relationship between performance metrics, triggers, and the management responses. This table includes an example for the stream flow management recommendations derived from the adopted Watershed Plans. A similar framework can be used for other implementation actions identified in the Salmon Recovery and Watershed Plans.

Decisions at each checkpoint depend on observed progress relative to benchmarks. Table 55 provides examples of the types of management actions that would result from the outcomes of action implementation, action effectiveness, and habitat and watershed status reviews.

Table 55. Example management actions in response to implementation assessment findings.

Review Findings	Action	Review Type
Action Implementation Review		
Progress meets or exceeds benchmarks	Proceed as planned	Policy
Progress falls below benchmarks	Revise implementation plan or approach	Policy
Action Effectiveness Review		
Effectiveness meets or exceeds benchmarks	Proceed as planned	Technical
Effectiveness falls below benchmarks	Evaluate action and revise strategy, measure and/or action(s). Revise implementation plan.	Technical/Policy
Biological and Habitat Status Review		
Biological response and habitat status (e.g., stream flows, water quality, etc.) meets or exceed benchmarks	Proceed as planned.	Technical
Biological response meets or exceeds and habitat status falls below benchmarks.	Evaluate and, as necessary, revise habitat measures and actions. Proceed as planned for other harvest and hatcheries. Revise implementation plans.	Technical/Policy
Biological response and habitat status fall below benchmarks	Evaluate and, as necessary, revise strategies, measures and actions for all H's. Revise implementation plans.	Technical/Policy
Biological response falls below and habitat status falls meet or exceed benchmarks	Evaluate and, as necessary, revise hatchery and harvest strategies, measures, and actions. Revise implementation plans.	Technical/Policy

8.1 Data and Reporting Implementation Measures

M.M51. Conduct a data management needs assessment and use it to develop a data management plan.

Explanation: Additional assessments are needed to coordinate with complementary data management activities throughout the region. For example, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is developing a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Although it is still under development with uncertain funding for the future, it will likely compliment the needs of the Lower Columbia RM&E program and thus warrant continued attention.

M.M52. Maintain consistent regionally-standardized datasets and archive in regional data storage and management facilities (e.g., Pacific State Marine Fisheries Commission StreamNet, Washington Department of Fish and Wildlife SSHIAP, NMFS' biological datasets).

Explanation: Existing infrastructures will be used to archive relevant data and metadata generated through monitoring and research activities. Data will be compiled and subject to rigorous quality assurance/quality control protocols by the collecting agency. Collecting agencies will be responsible for maintaining databases and providing access upon request. Information will be also distributed to multiple archives to maximize accessibility.

M.M53. Produce and distribute regular progress and completion reports for monitoring and research activities.

Explanation: Regular reporting is essential in making new information available to technical/scientific staff, decision-makers, stakeholders, and the public. It is likely that much of the routine reporting will be conducted electronically.

M.M54. Closely coordinate Washington lower Columbia River monitoring, research, and evaluation efforts with similar efforts throughout the basin, including prioritization of activities and standardization of data methods.

Explanation: Other RM&E efforts are underway at local and regional scales across the Pacific Northwest. Coordination of Washington lower Columbia River efforts will provide synergistic benefits. For instance, many critical uncertainties are common among different areas and need not be addressed in each area. Standardization of data methods will greatly enhance comparative and interpretative power of monitoring and research activities.

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Appendices

Appendix A. Other Monitoring, Research and Evaluation Programs

Governor's Forum on Monitoring Salmon Recovery and Watershed Health (GFM)

The mission of the GFM is to improve coordination of the state's monitoring efforts associated with salmon recovery and watershed health. GFM provides monitoring recommendations to the Salmon Recovery Funding Board, the Governor's Salmon Recovery Office and appropriate state agencies. Additionally, GFM works with local and regional watershed and salmon recovery groups, tribes, other states, the Northwest Power and Conservation Council, U.S. Environmental Protection Agency, NMFS, U.S. Fish and Wildlife Service, and U.S. Forest Service. http://www.rco.wa.gov/boards/forum.shtml

Salmon Recovery Funding Board (SRFB)

In 1999, the Washington State Legislature created the SRFB to help support salmon recovery by funding habitat protection and restoration projects. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SFRB program identified five purposes for monitoring including status and trend (Index) monitoring, implementation monitoring, project effectiveness monitoring, validation monitoring, and compliance monitoring. To date, SRFB has helped finance over 600 projects. http://www.rco.wa.gov/boards/srfb.shtml

Northwest Power & Conservation Council (NPCC)

The Council develops and maintains a regional power plan and a fish and wildlife program to balance the Northwest's environment and energy needs. They are tasked with developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin. In a collaborative effort with the National Marine Fisheries Service (NMFS) and the Columbia River Indian Tribes, NPCC contributes to the Independent Scientific Advisory Board (ISAB). In March 2006, the ISAB released a guidance document in which it describes an integrated 3-tier monitoring program for assessing recovery of tributary habitat based on trend or routine monitoring, statistical monitoring, and experimental research monitoring. The Northwest Power and Conservation Council and the National Marine Fisheries Service have also established an Independent Scientific Review Panel (ISRP) to provide independent scientific advice and recommendations on issues related to regional fish and wildlife recovery programs under the Northwest Power Act and the Endangered Species Act in the Columbia River Basin. *www.nwcouncil.org*

Pacific Coastal Salmon Recovery Fund (PCSRF)

PCSRF was established in 2000 to provide grants to the states and tribes, and to assist state, tribal and local salmon conservation and recovery efforts. The PCSRF was requested by the governors of the states of Washington, Oregon, California and Alaska in response to Endangered Species Act (ESA) listings of West Coast salmon and steelhead populations. The

PCSRF supplements existing state, tribal and federal programs to foster development of federal-state-tribal-local partnerships in salmon recovery and conservation; and promotes efficiencies and effectiveness in recovery efforts through enhanced sharing and pooling of capabilities, expertise and information. The goal of the PCSRF is to make significant contributions to the conservation, restoration, and sustainability of Pacific salmon and their habitat.

Upper Columbia Salmon Recovery Board (UCSRB)

Established in 1999, the UCSRB is a standing committee of the North Central Washington Resource Conservation and Development Council which coordinates all activities of sub-basin planning in the upper Columbia. In 2004, the technical team of the UCSRB released a monitoring strategy report (UCRTT 2004). Addressing statistical and sampling design, spatial scale, indicators, measurement protocols and implementation, UCRTT draws from existing strategies to develop a monitoring approach specific to the upper Columbia Basin.

Federal Columbia River Power System (FCRPS)

NMFS working with the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, developed a detailed and intensive research, monitoring, and evaluation plan for implementing the Federal Columbia River Power System Biological Opinion (FCRPS)(NMFS 2003). The FCRPS plan included six principle components; population and environmental status monitoring, action effectiveness research, critical uncertainty research, implementation/compliance monitoring, data management, and regional coordination. The 2008 FCRPS Biological Opinion (NMFS 2008) identified performance standards for FCRPS actions to limit or offset adverse effects on the listed species and adverse modification of their critical habitat during its ten year term. The Supplemental Biological Opinion (NMFS 2010), including the Adaptive Management Implementation Plan, enhances and strengthens implementation of activities, research, and contingencies within the adaptive management provisions. The recommendations include addressing uncertainties such as potential effects of climate change, ecological interactions, invasive species, and toxic contaminants.

Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program

The development of the estuary RME program (Johnson et al. 2008) was a cooperative effort among BPA, USACE, NMFS, PNNL, and LCREP. The purpose of the project is to coordinate and facilitate activities of the estuary/ocean subgroup for research, monitoring, and evaluation established in response to the 2000 and 2004 Federal Columbia River Power System Biological Opinions. The estuary program goal is to understand, conserve, and restore the estuary ecosystem to improve the performance of listed salmonid populations. The estuary RME program objectives include status and trends monitoring of habitat conditions, status and trends monitoring of juvenile salmonid performance, action effectiveness research, critical uncertainties research, implementation and compliance monitoring, and synthesis and evaluation.

Collaborative Systemwide Monitoring and Evaluation Project (CSMEP)

CSMEP is a coordinated effort to improve the quality, consistency, and focus of fish population and habitat data to answer key monitoring and evaluation questions relevant to major

decisions in the Columbia Basin. The CSMEP project was initiated in 2003 and is administered by the Columbia Basin Fish and Wildlife Authority, with participation from over 30 scientists from federal, state and tribal fish and wildlife agencies, and consulting firms.

Survey of Environmental Monitoring Programs and Associated Databases within Washington State (2003)

A survey was conducted by the SRFB of existing environmental monitoring programs and their associated databases in Washington State (as of October 2003). The survey identifies different monitoring or database programs which directly or indirectly support watershed health or salmon recovery. It describes the type of monitoring, geographic focus, whether data is available on-line, and data overlaps between entities.

Evaluating Watershed Response to Land Management and Restoration Actions: Intensively Monitored Watershed 2005 Progress Report

This document describes a series of intensively monitored watersheds (IMW) established expressly to measure the effect of habitat restoration on salmon and trout productivity. The Germany, Mill, and Abernathy watersheds were selected as IMW sites for the Lower Columbia Basin. Annual data is available regarding water/climate, habitat surveys, and fish populations for those watersheds http://www.ecy.wa.gov/programs/eap/imw/IMW_2005_PROG_RPT.pdf

Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) provides a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. PNAMP has developed a strategy document for subbasin planners based on a synthesis of existing strategies and plans. It includes a series of considerations regarding monitoring objectives, monitoring indicators, data reporting, coordination and management. The document identifies the types of monitoring being conducted, which entity is responsible for a particular action, protocols, and data analysis standards and advances a coordinated approach to regional monitoring. *www.pnamp.org*

Quality Assurance Monitoring Plan: Status and Trends Monitoring for Watershed Health and Salmon Recovery

This Quality Assurance monitoring plan guidance document describes a standardized monitoring protocol for assessing the water quality and habitat of our rivers and streams in the State of Washington. The monitoring plan was designed to answer major management questions about the current status and trends of our river and stream aquatic resources. http://www.ecy.wa.gov/biblio/0603203.html

Environmental Monitoring and Assessment Program (EMAP)

EMAP is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources. *http://www.epa.gov/emap/index.html*

State of the Salmon (SoS)

State of the Salmon is a nongovernmental consortium dedicated to improving understanding of salmon status and trends across the North Pacific. SoS has information on stock status and trends, international standards for monitoring data collection, and research and monitoring database. www.stateofthesalmon.org

Appendix B. Detailed Inventory of Ongoing Monitoring Activities

Appendix Table B-1. Ongoing habitat and biological status monitoring activities (sorted by implementing entity).

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	ongoing	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	annual, since 1992			www.efw.bpa.gov/
Instream Flows	BLM	Lower Columbia Basin	Maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam	ongoing		annual, since 1992			www.efw.bpa.gov/
Instream Flows	BPA	Lower Columbia Basin	Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods	ongoing		annual, since 1992			www.efw.bpa.gov/
Biological Attributes	BPA	Lower Columbia Basin	smolt trapping, spawning surveys, passage counts, P.I.T. data, migration timing	ongoing	unknown	annual, since 1992			www.efw.bpa.gov/
Channel morphology and complexity	BPA	Lower Columbia Basin	Stream/Riparian Surveys	ongoing		annual, since 1992			www.efw.bpa.gov/
Hydrologic Modeling	Clark County	Gee Creek, Mill Creek, Salmon Creek, Whipple Creek	HSPF hydrologic models						Clark County Clean Water Program cleanwater@clark.wa.gov Main phone: (360) 397-2121 ext. 4345

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality, Instream Flow, Channel Morphology and Complexity	Clark County	Clark County basins	Stream reconnaissance, channel geomorphology, water quality	Ongoing		2005 – present	Stormwater Needs Assessment Program		Clark County Clean Water Program cleanwater@clark.wa.gov Main phone: (360) 397-2121 ext. 4345
Water Quality	Clark County	Salmon Creek Basin	Temperature, macroinvertebrates, physical and chemical water quality, stormwater	annual	WDEQ Protocol	1998-Present		LISP and others	Clark County Clean Water Program cleanwater@clark.wa.gov Main phone: (360) 397-2121 ext. 4345
Channel morphology and complexity	Clark County	Salmon Creek Basin	Physical habitat	Ongoing		2001-present		LISP	Clark County Clean Water Program cleanwater@clark.wa.gov Main phone: (360) 397-2121 ext. 4345
Instream Flows	Clark County	Salmon Creek Basin, EF Lewis River Basin, Gee Creek	Stream flow, stormwater	Ongoing		2001-present		LISP and others	Clark County Clean Water Program cleanwater@clark.wa.gov Main phone: (360) 397-2121 ext. 4345
Channel morphology and complexity	Clark County CD	EF Lewis River, Salmon Creek, Gee Creek, Gibbons Creek	Habitat Restoration Monitoring	Intermittent					Denise Smee, 360-883-1987 http://www.clarkcd.org
Water Quality	Clark County CD	EF Lewis River, Salmon Creek, Gee Creek, Gibbons Creek	Water Quality	annual	WDEQ Protocol	1994-Present			Denise Smee, 360-883-1987 http://www.clarkcd.org
Channel morphology and complexity	Clark Public Utilities	Salmon Creek Watershed	Stream/Riparian Surveys	ongoing	Ad hoc surveys in relation to restoration projects				www.clarkpublicutilities.com

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Floodplain and wetland function; channel migration processes	Columbia River Estuary Task Force (CREST)	Lower Columbia Basin, Columbia River Estuary, Grays River Basin, Youngs Bay, Baker Bay	Tidal Wetlands Monitoring, Tide Gate Effectiveness Monitoring	ongoing					http://www.columbiaestuary.org/ 503-325-0435
Biological Attributes	Conservation Commission	Lower Columbia Basin	Statewide Salmon Habitat Limiting Factors Analysis	ongoing	ID habitat problems that are preventing natural spawning salmon populations from reaching their full potential.				360-407-6200 www.scc.wa.gov/districts/list/
Biological Attributes	Conservation Commission	Germany/ Mill/ Abernathy	Salmon and Steelhead Habitat Limiting Factors: Water Resource Inventory Area 25		WRIA 25 Inventory				360-407-6200 www.scc.wa.gov/districts/list/
Channel morphology and complexity	Cowlitz CD	Mill Basin	Stream/Riparian Surveys	Intermittent	unknown	1999-2003			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Cowlitz CD	Abernathy Basin	Stream/Riparian Surveys	Intermittent	unknown	1997-2003			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Cowlitz CD	Germany Basin	Stream/Riparian Surveys	Intermittent	unknown	1997-2003			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Cowlitz CD	Lower Cowlitz Basins	Stream/Riparian Surveys	Intermittent	unknown	1996-2001			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Cowlitz CD	Lower Cowlitz Basins	Stream/Riparian Surveys	Intermittent	unknown	1996-2001			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Cowlitz CD	Abernathy Basin	Temperature Monitoring	annual	WDEQ Protocol	2002			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Cowlitz CD	Coal Creek	Temperature Monitoring	annual	WDEQ Protocol	2002			Darin Houpt 360-425-1880 ccddmgr@teamelect.com

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	Cowlitz CD	Abernathy Basin	Temperature Monitoring	annual	WDEQ Protocol	2002			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Cowlitz CD	Arkansas Creek	Temperature Monitoring	annual	WDEQ Protocol	2002			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Watershed Conditions & Hillslope Processes	Cowlitz CD	Arkansas Creek	Arkansas Creek Watershed Plan						Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Watershed Conditions & Hillslope Processes	Cowlitz CD	Silver Lake	Watershed Plan						Darin Houpt 360-425-1880 ccddmgr@teamelect.com
	Cowlitz Indian Tribe	Toutle Basin, Cowlitz Basin							360-577-8140 www.cowlitz.org
Channel morphology and complexity	Cowlitz PUD	NF Lewis Basin	Spawning Gravel Study						360-423-2200 www.co.cowlitz.wa.us
Channel morphology and complexity	Cowlitz PUD	NF Lewis Basin	In-Stream Habitat Monitoring						360-423-2200 www.co.cowlitz.wa.us
Blocked Habitat	Cowlitz PUD	NF Lewis Basin	Fish Passage Study						360-423-2200 www.cowlitzpud.org
Water Quality	Cowlitz PUD	NF Lewis Basin	Temperature Monitoring		WDEQ Protocol				360-423-2200 www.cowlitzpud.org
Instream Flows	Cowlitz PUD	NF Lewis Basin	Velocity Barriers						360-423-2200 www.cowlitzpud.org
Biological Attributes	Cowlitz PUD	NF Lewis Basin	Predator Study						360-423-2200 www.cowlitzpud.org
Biological Attributes	FERC	NF Lewis Basin	NF Lewis (Pacific Corp & Cowlitz PUD), Cowlitz River Basin (Cowlitz and Lewis PUD, Tacoma City Light	NA	monitors for compliance with license permit (see specific license)	NA			Patrick Regan 503-522-2741 www.ferc.gov

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Biological Attributes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Channel morphology and complexity	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Channel morphology and complexity	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Blocked Habitat	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Floodplain and wetland function; channel migration processes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Water Quality	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Instream Flows	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Watershed Conditions & Hillslope Processes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA			www.rco.wa.gov/salmon_recovery/gsro.shtml
Watershed Conditions & Hillslope Processes	Lewis County	Salmon Creek Watershed	L Salmon Creek Watershed Study		watershed plan				360-747-1440 www.fortress.wa.gov/lewisco/home/
Blocked Habitat	Lewis County CD	Lower & Upper Cowlitz Basin, Newaukum, Skookumchuck	Culvert inventories & passage Assessment in Lewis County						lccd.scc.wa.gov
Water Quality	Lewis County Health Districts		Water Quality		sodium, magnesium, and iron				lewiscountywa.gov/publichealth
Blocked Habitat	Lewis County PUD	Cowlitz Basin	passage at dams						www.lcpud.org
Biological Attributes	Lewis County PUD	Cowlitz Basin	fish counts						www.lcpud.org
Biological Attributes	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	population monitoring		smolt trap (mark/recapture)				Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Channel morphology and complexity	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	Habitat Typing, Restoration Monitoring		TRF Ambient Monitoring Module				Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org
Water Quality	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	nutrients, temperature, dissolved oxygen		WDEQ Protocol				Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org
Blocked Habitat	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	regional culvert inventory		SSHEAR				Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org
Channel morphology and complexity	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Riparian Conditions & Function	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Channel morphology and complexity	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Blocked Habitat	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Water Quality	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Instream Flows	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Watershed Conditions & Hillslope Processes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Biological Attributes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present			www.lcfrb.gen.wa.us 360-425-1555
Water Quality	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Temperature, Dissolved Oxygen, Turbidity		WDEQ Protocol				www.lcrep.org 503-226-1565 lcrep@lcrep.org
Channel morphology and complexity	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery				www.lcrep.org 503-226-1565 lcrep@lcrep.org
Riparian Conditions & Function	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery				www.lcrep.org 503-226-1565 lcrep@lcrep.org

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Floodplain and wetland function; channel migration processes	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery				www.lcrep.org 503-226-1565 lcrep@lcrep.org
Biological Attributes	NMFS	Lower Columbia Basin	Estuary fish monitoring	NA	NA	NA			www.nwr.noaa.gov
Biological Attributes	NMFS	Lower Columbia Basin	Estuary - Limiting Factors Research	NA	NA	NA			www.nwr.noaa.gov
Biological Attributes	NMFS	Lower Columbia Basin	ESA Fishery Management Plans	NA	NA	NA			www.nwr.noaa.gov
Biological Attributes	NMFS	Lower Columbia Basin	Regulatory enforcement	NA	NA	NA			www.nwr.noaa.gov
Biological Attributes	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database, fish passage center, fish passage,	NA	The Council works to protect, mitigate and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA			www.nwcouncil.org
Channel morphology and complexity	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database	NA	The Council works to protect, mitigate and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA			www.nwcouncil.org
Water Quality	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database	NA	Project/Research Database	NA			www.nwcouncil.org
Watershed Conditions & Hillslope Processes	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database, restoration monitoring protocols (PNAMP)	NA	The Council guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA			www.nwcouncil.org
Blocked Habitat	National Power Planning Council (NPPC)	Lower Columbia Basin	Effective dam passage facilities	NA	Operate Fish Passage at Bonneville Dam	NA			www.nwcouncil.org

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	National Resource Conservation Service (NRCS)	Lower Columbia Basin	National Water & Climate Center Database		WDEQ Protocol				www.nrcs.usda.gov
Habitat Complexity & Cover	PacifiCorp	NF Lewis Basin	Stream/Riparian Surveys		Hankin/Reeves	1999-2003			Frank Shrier 503-813-6622
Habitat Complexity & Cover	PacifiCorp	Lewis Basin	Stream/Riparian Surveys		Hankin/Reeves	1989- 2004			Frank Shrier 503-813-6622
Water Quality	PacifiCorp	NF Lewis Basin	Temperature	annual	WDEQ Protocol	1999-2000	New licenses cont.		Frank Shrier 503-813-6622
Instream Flows	PacifiCorp	NF Lewis Basin	Stream Gage	annual	WDEQ Protocol	1926-Present	New licenses cont.		Frank Shrier 503-813-6622
Biological Attributes	PacifiCorp	NF Lewis Basin	Adult and juvenile passage, reintroduction of spring Chinook/coho/steel head	annual	Lewis River Monitoring Plan	2008-2057	Annual report		Frank Shrier 503-813-6622
Water Quality	PacifiCorp	NF Lewis Basin	Temperature	annual	WDEQ Protocol	2008-2058	Annual report		Frank Shrier 503-813-6622
Blocked Habitat	PacifiCorp	NF Lewis Basin	monitor flows in bypass reach	annual	WDEQ Protocol	2008-2059			Frank Shrier 503-813-6622
Habitat Complexity & Cover	PacifiCorp	NF Lewis Basin	habitat protection and improvement for salmon/steelhead/ bull trout	annual	Aquatic fund distribution and land purchase	2008-2060			Frank Shrier 503-813-6622
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	BPA monitoring and databases, GIS data, P.I.T. databases	NA	NA	NA			www.psmfc.org/
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	StreamNet database	NA	NA	NA			www.psmfc.org/
Water Quality	Port of Vancouver	Lower Columbia Basin	Pollution monitoring	ongoing	TMDL				360-992-1103 www.portvanusa.com

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
	SRFB	Lower Columbia Basin	Survey of environmental monitoring programs and associated databases within Washington state		Review of all RM&E efforts in Lower Columbia River by State, County, and Local agencies	NA			http://www.rco.wa.gov/
Riparian Conditions & Function	Skamania County	Washougal Basin		ongoing					Karen Witherspoon www.skamaniacounty.org
	State Noxious Weed Control Board	Lower Columbia Basin	Region 8 Class B Weed Designates	NA	WSNWB advises the Washington State Department of Agriculture about noxious weed control in Washington State. It also serves as the state's noxious weed coordination center.	NA			www.nwcb.wa.gov or noxiousweeds@agr.wa.gov
Channel morphology and complexity	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov
Riparian Conditions & Function	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov
Blocked Habitat	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov
Watershed Conditions & Hillslope Processes	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov
Water Quality	Tacoma Power	Cowlitz Basin	Temperature Monitoring	ongoing	WDEQ Protocol				Mark LaRiviere 253-502-8767
Biological Attributes	Tacoma Power	Cowlitz Basin	Fish Passage						Mark LaRiviere 253-502-8767
Water Quality	Underwood CD	Wind Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992			503-493-1936 ucd@gorge.net w3.gorge.net/ucd

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
	USACE	Lower Columbia Basin	Monitoring of aquatic and wetland mitigation efforts	ongoing	Monitoring of aquatic and wetland mitigation efforts as required by permit conditions.	NA			Chris L. McAuliffe chris.l.mcauliffe@usace.army.mil
	USACE	Lower Columbia Basin	Endangered Species Act Programmatic Consultation Compliance Monitoring	NA	Individual project monitoring of compliance with ESA programmatic consultation requirements by submitting reports on revegetation success, pollution, and erosion control measures, fish capture and release, and overall project success for restoration activities.	NA			Cindy Barger cindy.s.barger@usace.army.mil
Channel morphology and complexity	USFS	Toutle Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1985 - Present			Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest RegionR6 Regional Office, USDA Forest ServicePhone:(503) 808-2676; Fax:(503) 808-2469email: dkonnoff@fs.fed.us Data available on NRIS
Riparian Conditions & Function	USFS	Toutle Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/
Channel morphology and complexity	USFS	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present			Eric Archer - Project Leader PIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 435-755-3565 earcher@fs.fed.us
Riparian Conditions & Function	BLM	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present			Eric Archer - Project Leader PIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 435-755-3565 earcher@fs.fed.us

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Channel morphology and complexity	BLM	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present			Eric Archer - Project Leader PIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 435-755-3565 earcher@fs.fed.us
Channel morphology and complexity	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/
Channel morphology and complexity	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/
Riparian Conditions & Function	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/
Channel morphology and complexity	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	What are the existing aquatic and Riparian conditions? What are the factors limiting the productive capabilities of habitats? Are Stream habitat objectives being met? What are the cumulative watershed effects?	1985 - Present			Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest Region R6 Regional Office, USDA Forest Service Phone:(503) 808-2676; Fax:(503) 808-2469 email: dkonnoff@fs.fed.us Data available on NRIS
Riparian Conditions & Function	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	What are the existing aquatic and Riparian conditions?What are the factors limiting the productive capabilities of habitats?Are Stream habitat objectives being met?What are the cumulative watershed effects?	1985 - Present			Deborah KonnoffFish Habitat Relationships CoordinatorPacific Northwest RegionR6 Regional Office, USDA Forest ServicePhone: (503) 808-2676; Fax:(503) 808-2469email: dkonnoff@fs.fed.usData available on NRIS

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	Classify and determine the condition of in-stream habitat. Stream habitat information is collected for land use and project planning purposes, assessing environmental baseline conditions for ESA consultations, NEPA analysis, and assessing stream habitat conditions for grazing management.	1985 - Present			Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov
Channel morphology and complexity	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	Classify and determine the condition of in-stream habitat. Stream habitat information is collected for land use and project planning purposes, assessing environmental baseline conditions for ESA consultations, NEPA analysis, and assessing stream habitat conditions for grazing management.	1985 - Present			Al DoelkerAssistant Fisheries Program LeadOregon State Office333 SW 1st Ave.Portland, OR 97208Ph: 503-808-6067 Al_Doelker@or.blm.gov
Water Quality	USFS	Cowlitz Basin	Temperature	annual	WDEQ Protocol	1996-Present			
Water Quality	USFS	Cispus Basin	Temperature	annual	WDEQ Protocol	1996-Present			
Water Quality	USFS	Lewis Basin	Temperature	annual	WDEQ Protocol	1994-Present			
Water Quality	USFS	Washougal Basin	Temperature	annual	WDEQ Protocol	1994-present			Mark Kreiter 541-308-1744 mkreiter@fs.fed.us
Water Quality	USFS	Bonneville Tributaries	Temperature	annual	WDEQ Protocol	1994-present			Mark Kreiter 541-308-1744 mkreiter@fs.fed.us
Water Quality	USFS	Little White Salmon	Temperature	annual	WDEQ Protocol	1994-present			Mark Kreiter 541-308-1744 mkreiter@fs.fed.us
Riparian Conditions & Function	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1987-Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Channel morphology and complexity	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1987-Present			Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Water Quality	USFS	EF Lewis Basin	Temperature	annual	WDEQ Protocol	1996-Present			
Water Quality	USFS	Little White Salmon	Temperature	annual	WDEQ Protocol	1998-Present			
Biological Attributes	USFS- CGSA	Washougal, Bonneville Tributaries, Wind, Little White.	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present			Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Biological Attributes	USFS- CGSA	Bonneville Tributaries	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present			Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Biological Attributes	USFS- CGSA	Wind Basin	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present			Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Biological Attributes	USFS- CGSA	Little White Salmon	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present			Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Biological Attributes	USFS-Mt. St. Helens	Toutle Basin	Population Monitoring						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us
Channel morphology and complexity	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us
Channel morphology and complexity	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us
Riparian Conditions & Function	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us
Blocked Habitat	USFS-Mt. St. Helens	Toutle Basin	Passage Assessment						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us
Water Quality	USFS-Mt. St. Helens	Toutle Basin	Water Quality						Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	USFWS	Lower Gorge Basin, Wind River	Temperature		WDEQ Protocol				
Water Quality	USGS	Grays/Grays Bay Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1977			http://wa.water.usgs.gov/data/
Water Quality	USGS	Skamokawa Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1980			http://wa.water.usgs.gov/data/
Water Quality	USGS	Elochoman Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-77			http://wa.water.usgs.gov/data/
Water Quality	USGS	Lower Cowlitz Basins	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-86			http://wa.water.usgs.gov/data/
Water Quality	USGS	Coweeman Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-1975			http://wa.water.usgs.gov/data/
Water Quality	USGS	Toutle Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1960-2002			http://wa.water.usgs.gov/data/
Water Quality	USGS	Cowlitz Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1964-85, 2002			http://wa.water.usgs.gov/data/
Water Quality	USGS	Cispus Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1971-72, 1980-81			http://wa.water.usgs.gov/data/
Water Quality	USGS	Tilton Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1968			http://wa.water.usgs.gov/data/
Water Quality	USGS	Kalama Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-70, 1972-80			http://wa.water.usgs.gov/data/
Water Quality	USGS	NF Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1962-73, 1976-86, 1994			http://wa.water.usgs.gov/data/
Water Quality	USGS	Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1970-71, 1976, 1980-2002			http://wa.water.usgs.gov/data/
Water Quality	USGS	EF Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1976-80, 1980			http://wa.water.usgs.gov/data/
Water Quality	USGS	Salmon Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1968-73, 1978, 1980, 1997-98			http://wa.water.usgs.gov/data/

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	USGS	Washougal Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1964-70, 1974-77, 1981			http://wa.water.usgs.gov/data/
Water Quality	USGS	Lower Gorge Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1981			http://wa.water.usgs.gov/data/
Water Quality	USGS	Wind Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1980			http://wa.water.usgs.gov/data/
Biological Attributes	USGS-Columbia River Research Lab	Wind Basin	Chinook Spawning Surveys	NI		1998-present			wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Water Quality	USGS	Wind Basin	Nutrients	annual	Salmon Carcass analog study monitoring the effects of carcass nutrient enrichment in the upper Wind River. Water Quality and Chemistry monitoring. Macroinvertebrate response, juvenile salmonid response	2003-2006			Matt Mesa 503-538-2299 ext 246 matt_mesa@usgs.gov
Water Quality	USGS	Kalama Basin	Temperature	annual	WDEQ Protocol	1984-Present			
Instream Flows	USGS	Kalama Basin	Stream Gage	Annual	WDEQ Protocol				
Instream Flows	USGS	Little White Salmon	Stream Gage	Annual	WDEQ Protocol				
Channel morphology and complexity	USGS-Columbia River Research Lab	Wind Basin	Stream/Riparian Surveys	annual	Gradient, Riparian Condition, LWD, Pool Frequency				wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Blocked Habitat	USGS-Columbia River Research Lab	Cowlitz Basin	Fish Passage Study @ Cowlitz Falls Dam						wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Blocked Habitat	USGS-Columbia River Research Lab	Lower Columbia Basin	Movement & Behavior of Juvenile Salmonids at Bonneville Dam Columbia River						wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Water Quality	USGS-Columbia River Research Lab	Wind Basin	Temperature Monitoring	annual	USGS	2001-present			wfrc.usgs.gov/labs/columbia.htm 503-538-2299

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Instream Flows	USGS-Columbia River Research Lab	Wind Basin	Stream Gage	annual	WDEQ Protocol	1998-Present			wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Biological Attributes	USGS-Columbia River Research Lab	Wind Basin	Snorkel Surveys, Electrofishing for abundance	annual		1998-Present			wfrc.usgs.gov/labs/columbia.htm 503-538-2299
Channel morphology and complexity	Wahkiakum CD	Grays/Grays Bay Basin	Stream/Riparian Surveys		Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Wahkiakum CD	Skamokawa Basin	Stream/Riparian Surveys	Intermittent	Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996-2003			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Channel morphology and complexity	Wahkiakum CD	Elochoman Basin	Stream/Riparian Surveys	Intermittent	Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996-2003			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Grays/Grays Bay Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Skamokawa Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Elochoman Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Mill Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Abernathy Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Germany Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	Wahkiakum CD	Lower Cowlitz Basins	Temperature	annual	WDEQ Protocol	1999-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Water Quality	Wahkiakum CD	Coweeman Basin	Temperature	annual	WDEQ Protocol	2002-Present			Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Blocked Habitat	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Culvert & Tidegate inventories in Cowlitz and Wahkiakum Counties		WDFW Culvert Assessment Protocol				Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Watershed Conditions & Hillslope Processes	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Grays River Watershed Road Survey		Road surveys were conducted to provide road surface, cutslope, and hillslope conditions.				Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Watershed Conditions & Hillslope Processes	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Watershed Characteristic Portfolios for Cowlitz & Wahkiakum Counties		Stream types, soils, climate, geology, land use, ownership, and topography.				Darin Houpt 360-425-1880 ccddmgr@teamelect.com
Blocked Habitat	Wahkiakum County	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Fish Passage Barrier Identification and removal						Pete Ringen 360-795-3301
Floodplain and wetland function; channel migration processes	WDFW	Lower Columbia Basin	review of hydromodifications including anthropogenic structures that prohibit natural alluvial processes	NA	SSHIAP	NA			http://wdfw.wa.gov/hab/sshiap/

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Channel morphology and complexity	WDFW	Lower Columbia Basin	Stream/Riparian Surveys	NA	SSHIAP	NA			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Skamokawa Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1996-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Elochoman Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1996-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Mill Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1999-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Abernathy Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1997-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Germany Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1997-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Coweeman Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1995-2000			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Kalama Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1990, 2002-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	NF Lewis Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1999-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1991-2004			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Salmon Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	2002-2003			http://wdfw.wa.gov/hab/sshiap/
Channel morphology and complexity	WDFW	Washougal Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	2002-2003			http://wdfw.wa.gov/hab/sshiap/

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Channel morphology and complexity	WDFW	Wind Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1988-Present			http://wdfw.wa.gov/hab/sshiap/
Water Quality	WDFW	Kalama Basin	Temperature	annual	WDEQ Protocol	1984-Present			
Biological Attributes	WDFW	Lower Columbia Basin	Commercial Fish Tickets	annual	Capture information related to all commercial harvest of food fish and/or shellfish landed in the state.	? -Present			Lee Hoines 360-902-2310 Hoineljh@dfw.wa.gov
Biological Attributes	WDFW	Lower Columbia Basin	Coded Wire Tag Recoveries	annual	Provides counts of the observed and estimated numbers of returning CWT salmon and steelhead which are harvested or collected in Washington waters.	? -Present			Susan Markey 360-902-2777 www.rmis.org
Biological Attributes	WDFW	Washougal	Coded Wire Tag Recoveries	annual	Provides counts of the observed and estimated numbers of returning CWT salmon and steelhead which return to the Washougal and Skamania Hatcheries	? -Present			
Biological Attributes	WDFW	Lower Columbia Basin	Hatcheries Data	annual	Hatchery - disease, genetics; Hatchery - fish release, capture	? -Present			Kyle Adicks 360-902-2669 adickvka@dfw.wa.gov
Biological Attributes	WDFW	Lower Columbia Basin	Salmonid Spawning Ground Survey Database	annual	The Salmonid Spawning Ground Survey Database is built from a series of seasonal, systematic surveys of both index and "supplemental" stream sections for evidence of adult salmonid spawning activity. This database contains historical and current data from Puget Sound, the Straits of Juan de Fuca, and the Washington Coast. Counts of adult fish and redds (nests) are recorded, which provide some of the raw material for generating spawner escapement estimates by species and stock.	? -Present			Dick O'Connor 360-902-2778 oconnrjo@dfw.wa.gov

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Biological Attributes	WDFW	Lower Columbia Basin	Salmonid Stock Inventory Database (SaSi)	NA	The SaSI database provides information on individual salmonid stocks including spawning location, spawn timing, genetics information, stock status and data used to assess status (escapements, juvenile data, harvest) and agency contacts.	? -Present			wdfw.wa.gov/fish/sasi/
Biological Attributes	WDFW	Lower Columbia Basin	Smolt Monitoring	NA	Samonscape Database Quantifies the annual freshwater production of selected species and stocks of wild salmon.	? -Present			www.wdfw.wa.gov/mapping/salmonscape/
Biological Attributes	WDFW	Lower Columbia Basin	Sport Catch Estimates from catch record cards	annual	Annual post harvest estimates of salmon caught by recreational anglers. The estimates are produced using the harvest reported on sport catch record cards which are required to be returned to WDFW at the end of the fishing year.	? -Present			Terrie Manning mannitam@dfw.wa.gov
Biological Attributes	WDFW	Kalama Basin	Sport Catch Estimates from catch record cards	annual	Annual post harvest estimates of salmon caught by recreational anglers. The estimates are produced using the harvest reported on sport catch record cards which are required to be returned to WDFW at the end of the fishing year.	? -Present			Terrie Manning mannitam@dfw.wa.gov
Biological Attributes	WDFW	Lower Columbia Basin	StreamNet Fish Presence/Use Data	NA	StreamNet Database salmonid presence, spawning, and rearing reaches compiled onto the 1:100,000 resolution routed streams layer for Washington state.	? -Present			Martin Hudson www.streamnet.org/online-data/GISData.html

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Biological Attributes	WDFW	Lower Columbia Basin	Washington State Fish Passage Barrier and Surface Water Diversion Screening Database (SSHEAR)	NA	SSHEARbase includes data compiled from several WDFW and non-WDFW barrier and screening inventory efforts. The inventory efforts are intended to locate, identify, and prioritize correction of man-made fish Blocked Habitat and improperly screened surface water diversions. Identifying and correcting fish Blocked Habitat and improperly screened diversions are key components of salmon recovery.	? -Present			http://wdfw.wa.gov/hab/engineer/fishbarr.htm
Blocked Habitat	WDFW	Lower Columbia Basin	comprehensive fish barrier coverage	NA	SSHIAP	NA			
Biological Attributes	WDFW	Cowlitz River Basin, Grays River, Beaver Creek (Grays River Basin), Kalama River, Toutle, Washougal, Lewis River	Nutrient Enrichment, Carcass Inputs		(refer to basin)	? -Present			WDFW works with various NGO's
Water Quality	WDNR	Lower Columbia Basin	Dredged Material Management Program	NA	Dredged materials destined for open water disposal are evaluated for suitability, dredging and disposal activities are monitored for conformity to permit specifics, and disposal sites are environmentally monitored to evaluate environmental impacts.	NA			Robert Brenner robert.brenner@wadnr.gov
Watershed Conditions & Hillslope Processes	WDNR	Lower Columbia Basin	Hazard Zonation-Landslide Inventory	NA	Create a statewide GIS-based dataset of all available landslide inventories.	NA			Laura Vaugeois laura.vaugeois@wadnr.gov

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Biological Attributes	WDNR	Lower Columbia Basin	Natural Heritage Information System	NA	Maintain GIS and tabular information on the state's significant ecological features, including rare species and high quality terrestrial and aquatic communities.	NA			Sandy Moody Sandra.moody@wadnr.gov & NHIC webpage
Water Quality	WDNR	Lower Columbia Basin	TFW Cooperative Monitoring, Evaluation and Research	NA	CMER examines ways in which forestry activities such as timber harvest and road construction impact fish, wildlife and water quality; providing the technical and informational framework for making and evaluating resource management decisions; promoting understanding of ecosystem interactions.	NA			Geoffrey McNaughton geoffrey.mcnaughton@wadnr.gov
Watershed Conditions & Hillslope Processes	WDNR	Lower Columbia Basin	GIS Hydrography Data Layer	NA	Provide a statewide geographic information data layer of surface water features for data analysis and mapping in support of natural resource management.	NA			Sandra Bahr sandra.bahr@wadnr.gov
Water Quality	WDNR	Lower Columbia Basin	Transportation Database	NA	GIS, Transportation Route Structures, e.g. bridges, culverts and gates; Fish Passage Barrier Evaluations, that facilitate addressing Forest and Fish requirements; Road Engineering Projects.	NA			Sandra Bahr sandra.bahr@wadnr.gov
Water Quality	WDOE	Grays/Grays Bay Basin	Temperature, nutrients, contaminants	annual	TMDL	1973, 1976-7, 1998			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	Elochoman Basin	Temperature, nutrients, contaminants	annual	TMDL	1960, 1973, 1976-7, 1998			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	Lower Cowlitz Basins	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	WDOE	Kalama Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	EF Lewis Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	Salmon Basin	Temperature, nutrients, contaminants	annual	TMDL	1973, 2004 (Burnt Br. Creek)			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	Lower Gorge Basin	Temperature, nutrients, contaminants	annual	TMDL	1992, 2002 (Campen & Gibbons Creek)			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Water Quality	WDOE	Wind Basin	Temperature, nutrients, contaminants	annual	TMDL	1973 1976-83, 1995			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Instream Flows	WDOE	Grays/Grays Bay Basin	Stream Gage	annual	WDEQ Protocol	1949-1975			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Elochoman Basin	Stream Gage	annual	WDEQ Protocol	1940-1970			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Mill Basin	Stream Gage	annual	WDEQ Protocol	1949-1956			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Abernathy Basin	Stream Gage	annual	WDEQ Protocol	1949-1957			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Lower Cowlitz Basins	Stream Gage	annual	WDEQ Protocol	1926-Present			
Instream Flows	WDOE	Coweeman Basin	Stream Gage	annual	WDEQ Protocol	1950-1982			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Instream Flows	WDOE	Toutle Basin	Stream Gage	annual	WDEQ Protocol	1909-Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Cowlitz Basin	Stream Gage	annual	WDEQ Protocol	1911 - Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Cispus Basin	Stream Gage	annual	WDEQ Protocol	1910 - Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Tilton Basin	Stream Gage	annual	WDEQ Protocol	1941-Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Kalama Basin	Stream Gage	annual	WDEQ Protocol	1911-1982			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	NF Lewis Basin	Stream Gage	annual	WDEQ Protocol	1909-Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Lewis Basin	Stream Gage	annual	WDEQ Protocol	1927-1970			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Salmon Basin	Stream Gage	annual	WDEQ Protocol	1943-1990			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Wind Basin	Stream Gage	annual	WDEQ Protocol	1934-Present			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Instream Flows	WDOE	Little White Salmon	Stream Gage	annual	WDEQ Protocol	1944-1977			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main
Water Quality	WDOE	Lower Columbia Basin	Toxic Pollution Studies & Nonpoint Source Pollution Studies	annual	TMDL	1960-present			Will Kendra 360-407-6698 www.ecy.wa.gov/pubs.shtm

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Floodplain and wetland function; channel migration processes	WDOE	West Coast	Environmental Monitoring and Assessment Program (EMAP) – West Coast Pilot	annual	EMAP's monitoring and assessment tools to provide Water column measurements are combined with information about sediment characteristics and chemistry, benthic organisms, and data from fish trawls to describe the current estuarine condition.	1973-present			http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html
Water Quality	WDOE	West Coast	Well Log Imaging System	annual	Intranet/Web Access to Well Log Data and Images	?-present			http://aww.ads/welllog/
	WSDOT	Lower Columbia Basin	WSDOT Wetland Mitigation Monitoring Program	NA	Compliance monitoring of WSDOT affected wetlands	NA			http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm
Blocked Habitat	WSDOT	Lower Columbia Basin	Fish Passage Barrier Identification and removal	NA	WSDOT cooperates with WDFW to identify, prioritize, design and construct fish passage barrier removal projects (i.e., culvert replacements) that achieve the greatest possible benefits with limited funding.	NA			http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm
Biological Attributes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Mill/Abernathy/Germany Sub-basin Stock Summary and Habitat Priorities	ongoing	NA	2004			
Channel morphology and complexity	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005			Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Riparian Conditions & Function	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005			Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Channel morphology and complexity	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005			Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	EF Lewis Basin	Juvenile Steelhead Densities & Biomass						Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Wind Basin	Juvenile Steelhead Densities & Biomass						Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Riparian Conditions & Function	Skamania County	Wind Basin	Riparian setback monitoring	ongoing					Karen Witherspoon skamaniacounty.org
Biological Attributes	WDFW	Washougal Basin	Summer Steelhead mark-resight snorkel surveys		mark-resight snorkel surveys				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Wind Basin	smolt trapping		mark recapture weir				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Kalama Basin	Summer & Winter Steelhead mark-resight snorkel surveys		mark-resight snorkel surveys				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Kalama Basin	winter & summer weir counts		weir counts				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Toutle Basin	winter steelhead		weir counts				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Toutle Basin	Spawning Surveys	annual	cumulative (AUC) curves				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Coweeman Basin	escapement surveys for Fall Chinook	annual	carcass tagging				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	EF Lewis Basin	escapement surveys for Fall Chinook	annual	carcass tagging				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	NF Lewis Basin	escapement surveys for Fall Chinook	annual	carcass tagging				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Biological Attributes	WDFW	Grays/ Grays Bay Basin	escapement surveys for Chum Salmon	annual	carcass tagging expansion & AUC				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Water Quality	Underwood CD	White Salmon Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992			503-493-1936 ucd@gorge.net

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Biological Attributes	WDFW	Wind Basin	spawning surveys		TFW - Spawning module				Dan Rawding 360-906-6747 daniel.rawding@dfw.wa.gov
Watershed Conditions & Hillslope Processes		White Salmon Basin	EDT Analysis		The objectives of this Ecosystem Diagnosis and Treatment (EDT) assessment of the White Salmon Watershed will help develop and prioritize alternative riparian and in-stream habitat projects.				
Floodplain and wetland function; channel migration processes	NMFS	Lower Columbia Basin	Recovery Plan		Monitoring				
	SRFB	Lower Columbia Basin	Washington State Salmon Recovery Funding Board Reach-Scale Effectiveness Monitoring Program 2005 Annual Progress Report		Review of SRFB effectiveness monitoring	NA			http://www.rco.wa.gov/
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	Spawning Surveys & Coded Wire Tag Recoveries	NA	Staff conduct spawning ground surveys, marking redd sites, and collecting coded wire tags from returned spawners				www.psmfc.org/
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Kalama Basin	Spawning Surveys & Coded Wire Tag Recoveries	NA	Staff conduct spawning ground surveys, marking redd sites, and collecting coded wire tags from returned spawners				www.psmfc.org/
Biological Attributes	WDFW	Lower Columbia Basin	fish distribution by species, life stages	Intermittent	SSHIAP				http://wdfw.wa.gov/hab/sshiap/
Water Quality	USFS	Lower Columbia Basin	TMDL/303D Listing	annual	Clean Water Act and State water quality statues	1985-Present			Available from each forest or district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Water Quality	BLM	Lower Columbia Basin	TMDL/303D Listing	annual	Clean Water Act and State water quality statues	1985-Present			Available from each district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905
Water Quality	BLM	Lower Columbia Basin	Best Management Practices (BMPs): Implementation and Effectiveness	annual	Clean Water Act and Forest Service MOA with states	2005-Present			Available from each district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905
Water Quality	BLM	Lower Columbia Basin	Best Management Practices (BMPs): Effectiveness Monitoring	NA		2005-Present			Rosy Mazaika rmazaika@or.blm.gov 503-808-6076
Water Quality	USFS	Lower Columbia Basin	Best Management Practices (BMPs): Implementation and Effectiveness	annual	Clean Water Act and Forest Service MOA with states	2005-Present			Available from each Forest or District. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905
Blocked Habitat	USFS	Lower Columbia Basin	fish distribution by species, life stages	ongoing	What is the species composition of the fish assemblage? What is the distribution of ESA listed and special status fish species?	Present			Data is partially available on NRIS database Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest Region R6 Regional Office, USDA Forest Service Phone:(503) 808-2676; Fax:(503) 808-2469 email: dkonnoff@fs.fed.us

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Program Name	Project Name	Contact Information
Blocked Habitat	BLM	Lower Columbia Basin	fish distribution by species, life stages	ongoing	What is the species composition of the fish assemblage? What is the distribution of ESA listed and special status fish species?	Present			Data available upon request. Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov
Blocked Habitat	BLM	Lower Columbia Basin	fish passage assessment on all roads	ongoing	Fish passage through BLM culverts is assessed using a common state-wide protocol and is the same protocol that USFS R6 uses.	Present			Data available upon request. Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov
Blocked Habitat	USFS	Lower Columbia Basin	fish passage assessment on all roads	2001-2005	Fish passage through BLM culverts is assessed using a common state-wide protocol and is the same protocol that USFS R6 uses.	Present			Dave Heller R6 Fish Program Manager d.heller@fs.fed.us 503.808.2994 Data available upon request.
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Riparian planting	ongoing					clarkpublicutilities.com
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Temperature Monitoring	ongoing					clarkpublicutilities.com
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Water Quality	ongoing					clarkpublicutilities.com
Biological Attributes	FERC	Cowlitz Basin	NF Lewis (Pacific Corp & Cowlitz PUD), Cowlitz River Basin (Cowlitz and Lewis PUD, Tacoma City Light	NA	monitors for compliance with license permit (see specific license)	NA			Patrick Regan 503-522-2741 www.ferc.gov

Sources: *1. Salmon Recovery Funding Board: http://www.rco.wa.gov/documents/monitoring/Environmental_Monitoring_Survey.pdf*
2. Washington Department of Fish & Wildlife, SSHIAP: http://wdfw.wa.gov/hab/sshiap/
3. StreamNet: http://www.streamnet.org/
4. Ned Library: http://www.nwcouncil.org/ned/Default.asp
5. Personal Communication with entities listed above (May 2006)

Appendix C. Adaptive Management Framework for Stream Flow Management

Watershed Plan Policy/ Recommendation	Management Action	Type [1]	Performance Metrics	Trigger (if…)	Management Response (then…)
SFP-1	*Maintain existing stream flow gauges and install additional permanent gauges* ■ Maintain Heisson gauge and add at least one more stream gauge in the East Fork Lewis River subbasin ■ Replace former stream gauge at RM 9.2 and add at least one more gauge in the Washougal River subbasin ■ Add gauges in other streams where minimum instream flows or target flows are to be established.	I	*Implementation:* Evaluated through observation/inventory by coordination and oversight agency (COA)[2] or third party. Audit to occur after an initial 2-year period from adoption of Plan and subsequently on a biannual basis.	*Implementation: (yes/no)* Audit determines that stream gauges are not being maintained and no additional gauges are being installed. Furthermore, a minimum number of gauges may be specified for installation within a certain time frame, e.g. 4 new gauges within 2 years of Plan adoption.	*Collaborative Response:* *Implementation:* COA will work with other implementing agencies to develop and implement an action plan for achieving the recommendation. This may include conducting a funding review and options for staffing to enable installation and maintenance of gauges.
SFP-2	*Closures are preferred over use of minimum instream flows, except in selected areas* ■ Adopt closures and/or minimum instream flows in State Rule	I, E	*Implementation:* COA or third party audit of amendments to State Rule applicable to WRIAs 27 and 28. Audit to occur after an initial 2-year period from adoption of Plan and subsequently on a biannual basis. *Effectiveness:* Metrics will be developed to evaluate the impacts of the closures/minimum flows on protecting stream flows. May include: impacts to water rights applicants and changes in flow statistics (see target flows below). Metric to be evaluated at a minimum of every 5 years.	*Implementation: (yes/no)* Audit determines that no progress has been made toward developing closures/minimum instream flows; alternatively, audit determines agreements have been made on new closures or minimum instream flows but have not been adopted into rule. *Effectiveness:* Specific triggers will be developed if warranted after year 5 from Plan adoption as a mandatory collaborative agreement.	*Collaborative response:* *Implementation:* If no progress has been made, COA will work with Ecology to develop and implement an action plan for Ecology to develop the rule. If agreements have been made but have not been adopted, COA will work with Ecology to finalize or accelerate adoption schedule. *Effectiveness:* May require updates or revisions to closures or minimum instream flows based on effectiveness monitoring. This would require process to go through the rule-making process.
SFP-2	*Apply other land use and water use management in addition to stream closures to manage stream flows*	I	This policy refers to the use of the other specific recommendations and policies in the Plan to manage stream flow. Refer to other management actions for specific metrics, triggers, and responses.		
SFP-3	*State requirements for water conservation is sufficient for most communities* ■ Additional conservation efforts recommended for Battle Ground, Ridgefield, Yacolt, and Camas ■ Water conservation by farmers practicing irrigated agriculture, with assistance from Conservation Districts	I, E	*Implementation:* COA or third party audit of water conservation plans developed by the communities/irrigators as part of their water master plan/irrigation plan updates. Audit to occur at every water system/irrigation plan update after adoption of Watershed Plan. *Effectiveness:* Specific metrics on appropriate level of conservation for these	*Implementation: (yes/no)* Water conservation efforts only meet State's minimum requirements and no indications are evident that additional conservation efforts are planned. *Effectiveness:* Specific triggers will be developed if warranted after year 5 from Plan adoption as a mandatory collaborative	*Collaborative response:* *Implementation:* COA will work with communities/irrigators to develop and implement an action plan for achieving conservation goals. *Effectiveness:* Conservation goals may be revised if costs become too high or projected demands are not realized. Other

Watershed Plan Policy/ Recommendation	Management Action	Type [1]	Performance Metrics	Trigger (if…)	Management Response (then…)
			communities/irrigators to be developed, but may include percentage of projected demand or a total annual volume.	agreement. Triggers will consider measurable benefits with costs and inform future management actions for effectiveness and continuous improvement.	management options may need to be emphasized.
SFP-5	*Develop alternative water sources where stream flows are impacted that minimize these effects.* ■ Cities of Battle Ground and Ridgefield should consider whole sale purchase of water from CPU ■ Camas should consider purchase from Vancouver	I, E	*Implementation:* COA or third party audit of water master plan updates or other engineering/planning studies to determine whether alternative water sources are being evaluated. Audit to occur at every water system plan update or after two years after adoption of Watershed Plan. *Effectiveness:* Specific metrics to be	*Implementation: (yes/no)* Audit indicates that communities are not considering other source of water. A finding is made that indicates a departure or an opportunity for improvement. *Effectiveness:* Specific triggers will be	*Collaborative response:* *Implementation:* Coordination and oversight agency (COA) will develop and implement an action plan for refining source substitution goals. *Effectiveness:* Alternative supply sources may be eliminated if feasibility study indicates limitations for
			developed, but may include: the feasibility of the alternative sources based on new studies or information, other opportunities for improvements in the source of supply as they are identified.	developed if warranted after year 5 from Plan adoption as a mandatory collaborative agreement. Triggers will consider measurable benefits with costs and inform future management actions for effectiveness and continuous improvement.	proceeding. May need to consider other alternatives as they are identified. May identify other communities that need to consider alternative sources.
SFP-6	*Ecology should use State Trust Program to identify water rights for sale or donation* ■ Battle Ground, Ridgefield, and Yacolt, and Camas should consider transferring water rights to Trust, if source substitution is pursued	I, E	*Implementation:* COA or third party audit of number of water rights in State Trust for sale or lease. Participation of specific communities listed is dependent on whether alternative sources are pursued from SFP-5. *Effectiveness:* Specific metrics to be developed, but may include: the size of the water rights and whether water rights are being sold or leased once alternative sources are identified.	*Implementation: (yes/no)* No water rights are being submitted to State Trust. (An actual minimum number may be specified). A finding is made that indicates a departure or an opportunity for improvement. *Effectiveness:* Specific triggers will be developed if warranted after year 5 from Plan adoption as a mandatory collaborative agreement.	*Collaborative response:* *Implementation:* In conjunction with Ecology, COA will work directly with communities that have opportunities to transfer their rights to the State Trust and will refine goals for transferring to State Trust.
SFP-7	*Ecology to conduct initial surveys for unauthorized water use and take enforcement action when necessary*	I, E	*Implementation*: COA or third party audit of whether Ecology has conducted the survey after two years from adoption of the Watershed Plan. *Effectiveness*: Metrics will be developed after Ecology does initial survey, but may include number of unauthorized users or annual volume of use.	*Implementation: (yes/no)* Ecology has not conducted surveys after 2 years from Plan adoption. *Effectiveness:* Specific triggers will be developed if warranted after year 5 from Plan adoption as a mandatory collaborative agreement.	*Collaborative response:* *Implementation:* COA to work with Ecology to develop and implement an action plan for accelerating the survey schedule. *Effectiveness:* COA to work with Ecology to develop a response depending on the extent of unauthorized use and the cost-benefits of enforcement.
SFP-9	*Consider effects of forest management*	I, E	*Implementation:*	*Implementation: (yes/no)*	*Collaborative response:*

Watershed Plan Policy/ Recommendation	Management Action	Type [1]	Performance Metrics	Trigger (if…)	Management Response (then…)
	practices on stream flow in making forest management decisions, and monitor the effects and provide public documentation		COA or third party audit of USFS, DNR, and private land owner compliance with F&F and Northwest Forest Plan requirements, specifically implementation of monitoring requirements. *Effectiveness:* Specific metrics to be developed, but may include: length of roads upgraded (in compliance), percent sediment reduction, compliance with other BMPs.	Audit indicates non-compliance with forest management requirements. *Effectiveness:* A finding is made that indicates a departure or an opportunity for improvement. Monitoring studies will compare measurable benefits with costs and inform future management actions for effectiveness and continuous improvement.	*Implementation:* COA to work with USFS, DNR, and private land owners to improve compliance. *Effectiveness:* Based on findings from monitoring activities, revise or create enhanced BMPs for forest practice requirements/recommendations.
SFP-10	*Clark, Cowlitz Counties and Vancouver, Camas, Washougal, Battle Ground should carry out legal responsibilities for stormwater management; other communities and Skamania Co. should review ordinances for protectiveness*	I, E	*Implementation:* Percent BMP compliance as determined by a combination of State, internal, and COA or third party audits. *Effectiveness:* Specific metrics to be developed, but may include: flow impacts to adjacent streams, water quality impacts, compliance with other BMPs.	*Implementation: (yes/no)* Compliance rate is less than some specified percentage or is some specific requirement(s) are not being complied with. *Effectiveness:* A finding is made that indicates a departure or an opportunity for improvement. Monitoring studies will compare measurable benefits with costs and inform future management actions for effectiveness and continuous improvement.	*Collaborative response:* *Implementation:* COA to work communities to improve compliance. *Effectiveness:* Based on findings from monitoring activities, revise or create enhanced BMPs for stormwater management requirements/recommendations.
SFP-11	*When modifying or adopting comprehensive plans, zoning designations, or other land use regulations, jurisdictions should consider the water balance implications of allowing extension of sewer service to communities formerly served by septic systems*.	I	*Implementation:* COA or third party to audit whether counties have considered water balance implications of sewer extension.	*Implementation: (yes/no)* Counties have not considered water balance implications of sewer extension after 2 years from Plan adoption.	*Collaborative response:* *Implementation:* COA to work with counties to develop and implement an action plan considering water balance implications of sewer extensions.
SFP-12	*Within authorities, local jurisdictions with land-management responsibilities should protect existing floodplains and identify floodplains for restoration*	I, E	*Implementation:* COA or third party to audit number and locations of floodplain restoration projects and the number of designated floodplains for protection every 5 years *Effectiveness:* COA or third party to audit number and locations of floodplain restoration projects every 5 years; in addition, the flow impacts from the floodplain restoration efforts.	*Implementation: (yes/no)* Audit indicates that only a certain percentage of the floodplain survey for restoration has been completed or only a certain percentage of total floodplains has been designated for protection. *Effectiveness:* A finding is made that indicates a departure or an opportunity for improvement. Monitoring studies will compare measurable benefits with costs and inform future management actions for effectiveness and continuous improvement	*Collaborative response:* *Implementation:* COA to work with counties to develop and implement an action plan for accelerating the floodplain survey schedule and assessment for protection. *Effectiveness:* Based on findings from monitoring activities, revise or create floodplain restoration recommendations. Restoration activities may be reduced if flow impacts are minimal (unless habitat benefits provide justification).
SFP-13	*In conjunction with the Planning Unit,*	I	*Implementation:*	*Implementation: (yes/no)*	*Collaborative response:*

Watershed Plan Policy/ Recommendation	Management Action	Type [1]	Performance Metrics	Trigger (if…)	Management Response (then…)
	Counties should explore funding opportunities for conducting a county-wide wetland assessment that includes evaluation of hydrological functions. Counties should also require evaluation of hydrological function as part of any site-specific wetland assessments conducted under their critical areas, wetland or other land use ordinances. Their wetlands ordinances should be modified as needed to include hydrologic functions in the wetland protection hierarchy. Counties to consider strengthening mitigation ratios for selected wetlands		COA or third party to audit whether wetlands surveys for hydrologic function have been completed within 5 years from Plan adoption.	Counties have not conducted wetlands surveys or have completed only a certain percentage of the survey (e.g. 25%).	*Implementation:* COA and Planning Unit to work with counties to develop and implement an action plan for accelerating the survey schedule.
SFP-4	*Major water users should develop policies and procedures for state-declared drought emergencies* ▪ City of Camas should consider developing a curtailment plan	I	*Implementation:* COA or third party audit of major water users' water master plan updates to occur after an initial 2-year period from adoption of Plan or at first water master plan update.	*Implementation: (yes/no)* Audit determines that major water users have not completed policies and procedures for drought emergencies.	*Collaborative Response:* COA will develop and implement an action plan for accelerating the schedule to develop policies and procedures.
Target Flows	Establish target flow monitoring and management program.	I, E	*Implementation:* COA or third party to audit whether target flows have been established at other locations in the basin. Implementation of this action is directly tied to the installation of stream flow gauges (SFP-1). *Effectiveness:* This recommendation is the general (or "programmatic") metric for the combined effects of the stream flow management actions. The percentage change (5%) is the performance metric to be evaluated and requires significant period of record (e.g. greater than 10-15 years of flow data).	*Implementation: (yes/no)* Audit determines that target flows are not being developed and no additional gauges are being installed. Furthermore, a minimum number of target flows may be specified for development within a certain time frame, e.g. 4 new target flow locations within 2 years of Plan adoption. *Effectiveness:* Flow statistics have not changed (or have changed less then 1% for example); alternatively, flow statistics change beyond the 5% within the planning period. Monitoring study will compare measurable benefits with costs and inform future management actions for effectiveness and continuous improvement	*Collaborative Response:* *Implementation*: COA will work with other implementing agencies to develop and implement an action plan for achieving the number of target flows to be defined. This work would be completed in conjunction with SFP-1. *Effectiveness:* Revise or update flow management actions based upon how flow statistics change. It should be noted that depending on the type of monitoring, it may be difficult to attribute cause-effect relationships in this case, unless specific management actions from above are being monitored individually to measure their effects on flow.

Notes:

[1] Monitoring Types:

I – Implementation monitoring

E – Effectiveness monitoring

V – Validation monitoring

[2] Coordination and oversight agency (COA) – as discussed in Section 8.3, it is recommended that the WRIAs27 and 28 Planning Unit transition from planning functions to coordination and oversight functions to follow-up on selected areas of implementation. This same group or agency is used as the "surrogate" with responsibilities for tracking the triggers in this table.

Appendix D. Gap Analysis of Biological Monitoring Programs

Current Monitoring Activities (2004 baseline)

Biological status of salmon populations is currently being monitored for a subsample of populations and attributes. Some level of monitoring is currently being conducted in a majority of watersheds for most species (Appendix Table D- 1).

Information Gaps

Current sampling efforts were evaluated based on major population group- and population-level sampling criteria to highlight species, life history types, and strata where information may be incomplete. The gap analysis indicates that existing programs fall far short of adequate coverage necessary to provide the biological data needed to evaluate progress toward recovery objectives with moderate or high levels of certainty.

Major population group-level gaps where identified based on depth, breadth, and coverage in the number of populations currently sampled. Some information is available for all major population groups, but moderate and high certainty major population group criteria are met only for Cascade spring Chinook and Cascade winter steelhead (Appendix Table D- 2). However, most of this monitoring in the Cascade strata is focused on reintroduction efforts in the Cowlitz basin which is not be representative of other populations in the strata. Moderate certainty major population group criteria are met for all spring Chinook, summer steelhead, and coho major population groups, but at least one major population group falls short for fall Chinook, winter steelhead, and chum. Significant monitoring gaps are identified at the moderate certainty level for fall Chinook in the Cascade and Gorge strata (lack of intensive adult monitoring and juvenile monitoring), Gorge winter steelhead (adults and juveniles), Cascade and Gorge chum (adults and juveniles), and Washington populations of coho (adults and juveniles). A summary of current data quality relative to population-level sampling criteria is detailed in Appendix Table D- 3.

Assessments of gaps in current monitoring programs and additional sampling needs to meet sampling criteria are described in further detail for each species in the following sections. These sections also identify additional sampling needed by population based on major population group and population-level needs, population-specific sampling feasibility, opportunities to meet multiple needs by focused sampling in specific subbasins, and other opportunities based on planned action effectiveness monitoring. These priorities highlight several subbasins where more intensive sampling programs may produce economies of scale by providing information on multiple species. Oregon priorities are placeholders for consideration by the Oregon recovery planning process.

Appendix Table D- 1. Current biological status monitoring types by subbasin and species. Dashes denote subbasins where stock is not present. Asterisks (*) are populations where significant monitoring is not conducted. Multiple subbasins comprising a single population are denoted with boxes.

		Fall Chinook		Spring	Chum	Steelhead		Coho	Data source
		Tule	Bright	Chinook		Winter	Summer		
COA S T[2]	Grays/Chinook (WA)	A1[1]/J1[5]	--	--	A1/J2[5]	A1[2]/J1	--	A3[10]/J1	WDFW
	Elochoman/Skamokawa (WA)	A1[1]	--	--	A3	A1[2]	--	A3[10]	WDFW
	Mill/Abernathy/Germany (WA)	AI/JI	--	--	A1/J1	A1/J1[7,2]	--	A1/J1	WDFW
	Youngs Bay (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Big Creek (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Clatskanie (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Scappoose (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
CA S CADE	Lower Cowlitz (WA)	A2[11]/JT	--	A1	A3	A2	--	A3[10]	WDFW
	Upper Cowlitz (WA)	*	--	A1/J1[3]	*	A1/J1	--	A1/J1	WDFW
	Cispus (WA)	*	--	A1/J1[3]	*	A1/J1	--	A1/J1	WDFW
	Tilton (WA)	A1/J1	--	--	*	A1/J1	--	A1/J1	WDFW
	SF Toutle (WA)	A2[11]	--	*	*	A1	--	*	WDFW
	NF Toutle (WA)	A2[11]	--	*	*	A2[8]	--	A2	WDFW
	Coweeman (WA)	A2[11]/J3	--	--	A3	A1/J3	--	A2/J3	WDFW
	Kalama (WA)	A2[11]	--	A1/J2	A3	A1/J1	A1/J1	*	WDFW
	Lewis NF (WA)	A2[11]/J2	A1/J1/JT	A1/J1[4]	A3	A2/J2[9]	*	A2/J2	WDFW, PacifiCorp
	Lewis EF (WA)	A2[11]	--	--	A3	A1	A1	*	WDFW
	Salmon (WA)	*	--	--	*	*	--	*	WDFW
	Washougal (WA)	A2[11]	--	--	A3	A1	A1	A3[10]	WDFW
	Sandy (OR)	A1	A1	A1	*	A2/J2	--	A2/J2	ODFW, PGE, USFS
	Clackamas (OR)	A3	--	A1/J2	*	A2/J2	--	A1/J2	ODFW, PGE, USFS
GORGE	Lower Gorge (WA/OR)	A2[11]	A2[2]	--	A2/J2[6]	*	--	A3[10]	WDFW, USFWS
	Upper Gorge (WA/OR)	A2[11]	A2[2]	A2	A1	*	A2/J2	A3/J2[10]	WDFW, USGS
	White Salmon (WA)	A2[11]	A2[2]	*	--	--	--	*	WDFW, USFS
	Hood (OR)	A3	--	A1/J1	--	A1/J1	A1/J1	AI/J1	ODFW, CTWSRO, USFS

A1 = Adult intensive monitoring (annual abundance based dam/weir counts or expanded survey counts), A2 = Adult inventory monitoring (Annual relative measure of numbers typically reported as redds/mile for the sample area), A3 =Adult indicator monitoring (periodic). J1 = Annual intensive juvenile abundance, J2 = Juvenile inventory monitoring, J3 = Juvenile indicator monitoring, JT = Juvenile coded-wire tagging.

WDFW = Washington Department of Fish and Wildlife, ODFW = Oregon Department of Fish and Wildlife, PGE = Portland General Electric, CTWSRO = Warm Springs Tribe, USFWS = U.S, Fish and Wildlife Service, USGS = U. S. Geological Survey, US Forest Service.

[1] *Adult abundance estimates based on weir counts and spawning surveys.*

[2] *Not part of lower Columbia ESU.*

[3] *Juvenile accounting at Cowlitz Falls Dam. Does not separate Upper Cowlitz and Cispus production.*

[4] *Monitoring will be conducted per the 2008 License and reintroduction strategy*

[5] *Juvenile productivity monitoring from smolt trap installed starting 2008*

[6] *Juvenile abundance monitoring for Hamilton, Hardy, and Duncan Creeks. Juvenile inventory monitoring for mainstem Columbia near Ives Island.*

[7] *Intensive adult and juvenile monitoring as part of the Mill-Abernathy-Germany IMW Complex.*

[8] *Adult monitoring for NF Toutle. Adult index for Green River.*

[9] *Includes Cedar Creek only. Adult and juvenile monitoring will likely begin in new hydro license period.*

[10] *Coho adult monitoring is incidental to Chinook and chum monitoring.*

[11] *Adult abundance estimates may not include entire spawning are or time and area replicates*

Appendix Table D- 2. Summary of current sample sizes (adults/juveniles) at intensive, inventory, and indicator sampling intensities and assessment of whether moderate or high certainty sample size criteria are met by current sampling efforts (combined Washington and Oregon sampling efforts).

Type	Strata	# pop	Intensive	Inventory	Indicator	Moderate	High
Chinook							
Spring	Cascade	7	7/3	0/2	0/0	Yes	Yes
	Gorge	2	1/1	1/0	0/0	Yes	**No**
Fall	Coast	7	7/2	0/0	0/0	Yes	Yes
	Cascade	10	2/1	6/2	1/1	Yes	**No**
	Gorge	4	0/0	3/0	1/0	**No**	**No**
Late Fall	Cascade	2	2/1	0/0	0/0	Yes	**No**
Steelhead							
Winter	Coast	7	3/2	4/0	0/0	Yes	Yes
	Cascade	14	8/4	5/3	0/1	Yes	Yes
	Gorge	3	1/1	0/0	0/0	**No**	**No**
Summer	Cascade	4	3/1	0/0	0/0	Yes	**No**
	Gorge	2	1/1	1/1	0/0	Yes	**No**
Chum							
	Coast	7	2/1	0/1	5/0	Yes	**No**
	Cascade	7	0/0	0/0	4/0	**No**	**No**
	Gorge	2	1/0	1/1	0/0	**No**	**No**
Coho							
	Coast	7	5/2	0/0	2/0	Yes	Yes
	Cascade	14	4/3	4/3	2/1	Yes	Yes
	Gorge	4	1/1	0/1	2/0	Yes	**No**

Appendix Table D- 3. Summary of current data quality (A = very high, B = high, C = medium, D = low) relative to population-level sampling criteria by population recovery targets (Primary, Contributing, Stabilizing).[1] Populations where additional sampling is needed to meet population-level criteria are denoted by black shading. (Oregon information is a placeholder).

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
COAST	Grays/Chinook	Contributing (A)	--	--	Primary (A)	Primary (A)	--	Primary (B)
	Elochoman/Skamokawa	Primary (B)	--	--	**Primary (D)**	Contributing (B)	--	**Primary (D)**
	Mill/Abernathy/Germany	Primary (A)	--	--	Primary (A)	Primary (A)	--	Contributing (A)
	Youngs Bay (OR)	Stabilizing (B)	--	--	Stabilizing (D)	**Primary (C)**	--	Stabilizing (B)
	Big Creek (OR)	Contributing (B)	--	--	Stabilizing (D)	**Primary (C)**	--	Stabilizing (B)
	Clatskanie (OR)	Primary (B)	--	--	**Primary (D)**	**Primary (C)**	--	Primary(B)
	Scappoose (OR)	Primary (B)	--	--	**Primary (D)**	**Primary (C)**	--	Primary(B)
CASCADE	Lower Cowlitz	Contributing (B)	--	--	**Contributing (D)**	Contributing (C)	--	**Primary (D)**
	Upper Cowlitz	Stabilizing (--)	--	Primary (A)	--	Primary (A)	--	Primary (A)
	Cispus	--	--	Primary (A)	--	Primary (A)	--	Primary (A)
	Tilton	--	--	Stabilizing (--)	--	Contributing (A)	--	Stabilizing (A)
	Toutle SF	--	--	**Contributing (--)**	--	Primary (B)	--	**Primary (--)**
	Toutle (NF)	**Primary (C)**	--	--	--	**Primary (C)**	--	**Primary (C)**
	Coweeman	**Primary (C)**	--	--	--	Primary (B)	--	**Primary (C)**
	Kalama	Contributing (C)	--	Contributing (A)	**Contributing (D)**	Primary (A)	Primary (A)	**Contributing (--)**
	Lewis NF	--	Primary (A)	Primary (A)	--	Contributing (B)	Stabilizing (--)	Contributing (B)
	Lewis EF	**Primary (C)**	--	--	**Primary (D)**	Primary (B)	Primary (B)	**Primary (--)**
	Salmon	Stabilizing (--)	--	--	Stabilizing (D)	Stabilizing (--)	--	Stabilizing (--)
	Washougal	**Primary (C)**	--	--	**Primary (D)**	Contributing (B)	Primary (B)	**Contributing (D)**
	Sandy (OR)	Contributing (B)	Primary (B)	Primary (B)	**Primary (--)**	Primary (B)	--	Primary (B)
	Clackamas (OR)	**Contributing (D)**	--	Primary (A)	**Contributing (--)**	Primary (B)	--	Primary (A)
GORGE	Lower Gorge	Contributing (C)	--	--	Primary (B)	**Primary (--)**	--	**Primary (D)**
	Upper Gorge	Contributing (C)	--	--	Contributing (B)	Stabilizing (--)	Primary (B)	**Primary (C)**
	White Salmon	Contributing (C)	--	Contributing (C)	--	--	--	**Primary (--)**
	Hood (OR)	**Primary (D)**	--	Primary (A)	--	Primary (A)	Primary (A)	Contributing (A)

[1] *Criteria are A or B data quality for primary populations and C or higher for Contributing populations.*

Spring Chinook

Spring Chinook are well represented by current programs due to their occurrence in upper portions of large subbasins upstream of hydropower facilities where regulatory commitments and obligations require monitoring (Appendix Table D- 4). Intensive or inventory monitoring programs are underway in the Cowlitz, Lewis, and Sandy systems, which account for the majority of lower Columbia spring Chinook production. Long-term viability of spring Chinook depends largely on the success of reintroduction efforts into the upper Cowlitz, Lewis, and Hood systems, which makes monitoring of those populations a high priority. The Sandy population is also key and a high priority for monitoring. More intensive monitoring of juvenile and adult Lewis River spring Chinook will also be appropriate as part of experimental reintroduction evaluations. Adult and juvenile monitoring in the Big White Salmon subbasin would increase if passage is restored over Condit Dam, or the dam is breached. Because spring Chinook monitoring needs are generally being met by existing programs and priorities, management emphasis should be placed on maintenance of existing efforts. However, action effectiveness monitoring will require additional information also pertinent to biological status evaluations.

Appendix Table D- 4. Assessment of current monitoring data for lower Columbia River spring Chinook populations and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Cascade									
Cowlitz	WA	1	1	A	Primary	--	--	--	--
Cispus	WA	1	1	A	Primary	--	--	--	--
Tilton	WA	--	--	--	Stabilizing	--	--	--	--
Toutle	WA	--	--	--	Contributing	2	--	2	--
Kalama	WA	1	2	A	Contributing	--	--	--	--
Lewis NF	WA	1[5]	1[5]	A	Primary	--	--	--	--
Sandy	OR	1	--	B	Primary	--	--	--	--
Gorge									
Upper	WA	2	--	C	Contributing	--	--	1[5]	1[5]
Hood	OR	1	1	A	Primary	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA Recovery Plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of reintroduction efforts.*

Fall Chinook

Most lower Columbia tule fall Chinook populations are intensively monitored for adults for use in ocean and in-river fishery management. Fall Chinook status and trends are effectively monitored using adult spawner surveys because spawning distribution is limited, redds and fish are conspicuous, and carcasses are easily sampled. Juvenile data on fall Chinook is limited to the Mill/Abernathy/Germany Intensively Monitored Watershed (IMW) program, which has only recently been implemented. Juvenile fall Chinook are difficult to monitor due to their small size, protracted timing of outmigration, and occurrence in the lower portions of large systems. Fall Chinook monitoring meets high coverage guidelines for adults but additional monitoring of

juveniles would be needed for the Cascade and Gorge strata in order to clarify differences in in-basin and out-of-basin productivities (Appendix Table D- 5). Maintenance of existing sampling levels for adults is also of high priority. More intensive sampling of selected parameters for several representative populations would also clarify the accuracy and precision of current survey methods to meet population-level sampling criteria. These include time and area expansion assumptions and relative contributions of hatchery spawners to recruitment. In order to more effectively evaluate effects of hatchery interactions at a high level of certainty, more intensive periodic sampling of primary populations of adults should include watersheds that have both natural and hatchery fall Chinook populations (e.g. Kalama, and Washougal), areas where fall Chinook hatchery production occurred for many years but was recently eliminated (Grays), and watersheds with only natural fall Chinook populations (East Fork Lewis and Coweeman).

Appendix Table D- 5. Assessment of current monitoring data for lower Columbia River fall (tule) Chinook and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Coast									
Grays/Chinook	WA	1	1	A	Contributing	--	--	--	--
Eloch/Skam	WA	1	--	B	Primary	--	--	--	--
Mill/Aber/Germ	WA	1	1	A	Primary	--	--	--	--
Youngs Bay	OR	1	--	B	Stabilizing	--	--	--	--
Big Creek	OR	1	--	B	Contributing	--	--	--	--
Clatskanie	OR	1	--	B	Primary	--	--	--	--
Scappoose	OR	1	--	B	Primary	--	--	--	--
Cascade									
Lower Cowlitz	WA	2	2	B	Contributing	--	--	--	--
Upper Cowlitz	WA	--	--	--	Stabilizing	--	--	--	--
Toutle	WA	2	--	C	Primary	1	--	1	1
Coweeman	WA	2	3	C	Primary	1	1	1	1
Kalama	WA	2	--	C	Contributing	--	--	--	--
Lewis (EF)	WA	2	2	C	Primary	1	--	1	--
Salmon	WA	--	--	--	Stabilizing	--	--	--	--
Washougal	WA	2	--	C	Primary	1	--	1	--
Clackamas	OR	3	--	D	Contributing	2	--	2	--
Sandy	OR	1	--	B	Contributing	--	--	--	--
Gorge									
L. Gorge	WA/OR	2	--	C	Contributing	--	--	--	--[5]
U. Gorge	WA	2	--	C	Contributing	--	--	--	--[5]
White Salmon	WA	2	--	C	Contributing	1[6]	1[6]	1[6]	1[6]
Hood	OR	3	--	D	Primary	1	--	1	1

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Indicator.*

[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity)*

[3] *Priority designation in WA Recovery Plan.*

[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*

[5] *Intensive monitoring of gorge tule fall Chinook is problematic. The lower gorge population spawns primarily in the mainstem Columbia River. Wind River tule Chinook fish largely spawn downstream from any suitable sampling site. Production also includes non-listed bright fall Chinook, hence will require DNA analysis to distinguish.*

[6] *The USFWS is planning to initiate monitoring on the White Salmon River. Estimation of White Salmon tule fall Chinook production will require DNA analysis to distinguish the contribution of non-listed bright fall Chinook stocks.*

Late Fall Chinook

Bright fall Chinook are intensively monitored in the NF Lewis with an existing WDFW/PacifiCorp program (Appendix Table D- 6). Monitoring of NF Lewis fish also includes a long term CWT program that provides detailed productivity and fishery information. The Sandy population is intensively monitored for adults. This represents 100% coverage of populations for adults and 50% for juveniles. LR bright fall Chinook populations are currently at high or very high levels of viability. The priority for bright fall Chinook monitoring is to maintain current levels of effort. Intensive sampling of Sandy juveniles would be required to reach high certainty monitoring criteria for this major population group.

Appendix Table D- 6. Assessment of current monitoring data for lower Columbia River late fall (bright) Chinook and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Cascade									
Lewis NF	WA	1	1	A	Primary	--	--	--	--
Sandy	OR	1	--	B	Primary	--	--	--	**1**

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA Recovery Plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*

Summer steelhead

Summer steelhead are currently being monitored with moderate levels of coverage in both strata where they occur. Intensive monitoring of adults and juveniles occurs in the Kalama and Hood rivers. Additional intensive monitoring of juveniles in both strata would be required to meet high status certainty criteria (Appendix Table D- 7). The Wind River indexing program is a critical monitoring component for the Gorge strata and more intensive sampling of selected parameters for this population would increase accuracy and precision of current survey methods (time and area expansions and relative contributions of hatchery spawners to recruitment).

Appendix Table D- 7. Assessment of current monitoring data for lower Columbia River summer steelhead and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Cascade									
Kalama	WA	1	1	A	Primary	--	--	--	--
N.F. Lewis	WA	--	--	--	Stabilizing	--	--	--	--
E.F. Lewis	WA	1	--	B	Primary	--	--	--	**1**
Washougal	WA	1	--	B	Primary	--	--	--	--
Gorge									
Wind	WA	2	2	B	Primary	--	--	**1**	**1**
Hood	OR	1	1	A	Contributing	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory,3 = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA Recovery Plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*

Winter steelhead

Almost all winter steelhead populations are monitored at some level with intensive sampling efforts represented in Coast and Cascade strata (Appendix Table D- 8). Sampling efforts in the Cascade strata meet high coverage criteria. Note that Coast strata winter steelhead are not listed under the ESA, but are addressed in the WA Recovery Plan. Monitoring efforts for Oregon lower Columbia steelhead populations have been bolstered by Oregon's implementation of a statistical sampling program. Intensive juvenile and adult programs are associated with reintroduction efforts in the upper Cowlitz and from a long-term research effort on the Kalama, although these populations may not be entirely representative of other areas. Excellent adult data is also available from dam counts in the Clackamas and Sandy systems. Dam count data in the Clackamas are also supported with intensive surveys in lower basin streams. One of three Gorge populations is monitored (Hood), but this monitoring involves an intensive sampling program. Other Gorge winter steelhead populations are small and difficult to sample. The priority for winter steelhead is to maintain existing sampling efforts. More intensive sampling of several Cascade populations is needed to ensure representative sampling of this large major population group and to support potential reintroduction efforts. Additional monitoring of Gorge winter steelhead populations would also be required to meet moderate or high levels of coverage.

Appendix Table D- 8. Assessment of current monitoring data for lower Columbia River winter steelhead and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Coast									
Grays/Chinook	WA	1	1	A	Primary	--	--	--	--
Eloch/Skam	WA	1	--	B	Contributing	--	--	--	--
Mill/Ab/Germ	WA	1	1	A	Primary	--	--	--	--
Youngs Bay	OR	2	--	C	Primary	1	--	1	--
Big Creek	OR	2	--	C	Primary	1	--	1	--
Clatskanie	OR	2	--	C	Primary	1	--	1	--
Scappoose	OR	2	--	C	Primary	1	--	1	--
Cascade									
Lower Cowlitz	WA	2	--	C	Contributing	--	--	--	--
Coweeman	WA	1	3	B	Primary	--	--	--	--
NF Toutle	WA	2	--	C	Primary	1	--	1	--
SF Toutle	WA	1	--	B	Primary	--	--	--	--
Upper Cowlitz	WA	1	1	A	Primary	--	--	--	--
Cispus	WA	1	1	A	Primary	--	--	--	--
Tilton	WA	1	1	A	Contributing	--	--	--	--
Kalama	WA	1	1	A	Primary	--	--	--	--
N.F. Lewis	WA	2	2	B	Contributing	--	--	1[5]	1[5]
E.F. Lewis	WA	1	--	B	Primary	--	--	--	--
Salmon	WA	--	--	--	Stabilizing	--	--	--	--
Washougal	WA	1	--	B	Contributing	--	--	--	--
Clackamas	OR	2	2	A	Contributing	--	--	--	--
Sandy	OR	2	2	B	Primary	--	--	--	--
Gorge									
L. Gorge	WA/ OR	--	--	--	Primary	1	--	1	1
U. Gorge	WA/OR	--	--	--	Stabilizing	--	--	--	--
Hood	OR	1	1	A	Primary	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA Recovery Plan.*
[4] *Additional monitoring needed to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of potential reintroduction efforts will be needed. Current sampling is not adequate for evaluation.*

Chum

Annual chum salmon adult monitoring programs are largely restricted to the two significant remaining populations in the Grays River and the lower Gorge. Adult and juvenile chum are sampled by the intensive monitoring program of Mill, Abernathy, and Germany salmon populations. Washington recently completed a project indexing numbers of chum in remnant populations throughout the lower Columbia region. Oregon collects indicator-level information on chum occurrence in systematic fall salmon surveys. Significant juvenile monitoring of chum is limited to the intensive monitoring program at Mill, Abernathy, and Germany, and index monitoring of migrants in the lower gorge population (Duncan, Hardy, Hamilton, and mainstem Ives Island areas) by WDFW and USFWS. The small size of age 0 juvenile chum migrants makes them very difficult to sample effectively.

Additional sampling efforts will be required to adequately monitor chum salmon populations for ESA recovery purposes (Appendix Table D- 9). Chum are perhaps the least monitored ESU in the lower Columbia Region. Chum sampling priorities include continuation of current sampling, implementation of systematic annual intensive and inventory sampling efforts for adults and juveniles in multiple populations. This proposed program generally focuses on adult sampling because of sampling difficulties for juvenile chum. Much of this sampling will likely be associated with effectiveness monitoring of intensive chum restoration efforts.

Appendix Table D- 9. Assessment of current monitoring data for lower Columbia River chum and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Coast									
Grays/Chinook	WA	1	2	A	Primary	--	--	--	**1**
Eloch/Skam	WA	3	--	D	Primary	**1**	--	**1**	--
Mill/Ab/Germ	WA	1	1	A	Primary	--	--	--	--
Youngs	OR	3	--	D	Stabilizing	**--**	--	**--**	**--**
Big Creek	OR	3	--	D	Stabilizing	**--**	--	**--**	--
Clatskanie	OR	3	--	D	Primary	**1**	--	**1**	--
Scappoose	OR	3	--	D	Primary	**1**	--	**1**	--
Cascade									
Cowlitz	WA	3	--	D	Contributing	**2**	--	**2**	--
Kalama	WA	3	--	D	Contributing	**2**	--	**2**	--
Lewis (EF)	WA	3	--	D	Primary	**1**	**1**	**1**	**1**
Salmon	WA	3	--	D	Stabilizing	--	--	--	--
Washougal	WA	3	--	D	Primary	**1**	--	**1**	**1**
Clackamas	OR	--	--	--	Contributing	**2**	--	**2**	--
Sandy	OR	--	--	--	Primary	**1**	--	**1**	--
Gorge									
Lower Gorge	WA/OR	2	2	B	Primary	**1**	--[5]	**1**	--[5]
Upper Gorge	WA/OR	1	--	B	Contributing	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA Recovery Plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of chum in the mainstem Columbia would be costly relative to the value.*

Coho

Status assessments of wild coho are hampered by a lack of monitoring data, particularly long-term time series of data. Washington samples are limited to reintroduction efforts in the upper Cowlitz and juvenile migrant sampling of a few populations. Long term dam count data is available for the Clackamas and Sandy rivers. The Clackamas data includes juvenile indices from downstream passage monitoring at North Fork Dam as well as systematic sampling of tributaries downstream from the dam. Oregon has recently implemented a systematic statistical sampling program in Coast strata tributaries. Adult coho are difficult to survey because of their run timing during fall freshets and wide dispersion throughout a subbasin. Current effort levels for coho are not adequate to meet major population group- or population-level monitoring criteria (Appendix Table D- 10). Additional intensive and inventory surveys of coho will be required in many areas, particularly in Washington tributaries.

Appendix Table D- 10. Assessment of current monitoring data for lower Columbia River coho and additional needs to achieve moderate and high levels of certainty in major population group status assessment as well as population priority criteria. Populations where additional sampling is needed are denoted by black shading.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Coast									
Grays/Chinook	WA	3	1	B	Primary	--	--	1	--
Eloch/Skam	WA	3	--	D	Primary	1	--	1	--
Mill/Ab/Germ	WA	1	1	A	Contributing	--	--	--	--
Youngs	OR	1	--	B	Stabilizing	--	--	--	--
Big Creek	OR	1	--	B	Stabilizing	--	--	--	--
Clatskanie	OR	1	--	B	Primary	--	--	--	--
Scappoose	OR	1	--	B	Primary	--	--	--	--
Cascade									
Lower Cowlitz	WA	3	--	D	Primary	2[7]	2[7]	2[7]	2[7]
Coweeman	WA	2	--	C	Primary	2[7]	2[7]	2[7]	2[7]
NF Toutle	WA	2	--	C	Primary	2[7]	2[7]	2[7]	2[7]
SF Toutle	WA	--	--	D	Primary	2[7]	2[7]	2[7]	2[7]
Upper Cowlitz	WA	1	1	A	Primary	--	--	--	--
Cispus	WA	1	1	A	Primary	--	--	--	--
Tilton	WA	1	1	A	Stabilizing	--	--	--	--
Kalama	WA	--	--	--	Contributing	--	2	--	2
NF Lewis	WA	2	2	B	Contributing	1[5] 2[7]	1[5] 2[7]	1[5] 2[7]	1[5] 2[7]
EF Lewis	WA	--	--	--	Primary				
Salmon	WA	--	--	--	Stabilizing	--	--	--	--
Washougal	WA	3	--	D	Contributing	--	2	--	2
Clackamas	OR	1	2	A	Primary	--	--	--	--
Sandy	OR	2	2	B	Primary	--	--	--	--
Gorge									
L Gorge	WA /OR	3	--	D	Primary	2[7]	2[7]	2[7]	2[7]
U Gorge	WA /OR	3	2	D	Primary	2[7]	2[7]	2[7]	2[7]
White Salmon	WA	--	--	--	Primary	1[6]	1[6]	1[6]	1[6]
Hood	OR	1	1	A	Contributing	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Indicator.*

[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*

[3] *Priority designation in WA Recovery Plan.*

[4] *Additional monitoring need to reach prescribed level of certainty based on criteria: 1 = Intensive, 2 = Inventory.*

[5] *Intensive monitoring of potential reintroduction efforts will be needed. Current sampling is not adequate for evaluation.*

[6] *The USFWS is initiating monitoring on the White Salmon River in association with Condit Dam removal.*

[7] *Monitoring guidelines can be met for Primary populations either with Inventory monitoring of both adults and juveniles or intensive monitoring of adults or juveniles.*