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February 2009

**Item #12:** **Monitoring Overview**

**Prepared By:** Ken Dzinbal, Monitoring Forum Coordinator

**Presented By:** Ken Dzinbal, Monitoring Forum Coordinator

**Approved by the Director:**

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**Proposed Action:** **Briefing**

## Summary

In 2008, the Salmon Recovery Funding Board (SRFB) provided $2.35 million to support several on-going monitoring programs, which is 10 percent of the federal 2008 PCSRF grant. As monitoring efforts mature and salmon recovery strategies are refined, it is important to periodically review and update the priorities and funding allocation among monitoring elements. In October 2008, the SRFB discussed its current approach and how to ensure that they invest in the most important and useful monitoring. This memo and a presentation to the SRFB will brief members on initial efforts to assist with that review.

## Background

Since its inception in 1999, the SRFB has provided over $360 million for habitat restoration and protection projects in Washington State. In conjunction with this investment, the SRFB also has supported a number of monitoring initiatives and programs, primarily to assess the effectiveness of restoration efforts.

The SRFB has relied on several sources in deciding how to invest and allocate monitoring resources, including the following documents.

- The *Washington Comprehensive Monitoring Strategy and Action Plan* – completed by the Monitoring Oversight Committee and submitted to the Legislature in December 2002
- The "Taylor Report" – Assessment of methods and benefits for SRFB projects and activities prepared by several consultants for the SRFB in June 2003
- The Monitoring and Evaluation Strategy for Habitat Restoration and Acquisition Projects (2003) – the SRFB's monitoring strategy document (draft) (Attachment B)
- The Washington State Framework for Monitoring Salmon Populations and Habitat (2007) (Attachment C)

The creation of the Washington Forum on Monitoring (Forum) in 2004[1] provided another venue to prioritize and coordinate monitoring statewide. Some members of the SRFB also serve on the Forum, and their dual membership has helped to ensure information sharing between the two bodies. However, there is no formal agreement between the two bodies with regard to roles and responsibilities for monitoring recommendations.

In 2008, the SRFB provided $2.35 million to support several on-going monitoring programs. One driver of this allocation was the federal Pacific Coast Salmon Recovery Fund (PCSRF) grant requirement that "a minimum of 10% of budget (be allocated) for monitoring." At the October 2008 SRFB meeting, two requests to fund ongoing monitoring programs led members to discuss how to ensure that they invest in the most important and useful monitoring. Some members of the SRFB expressed an interest in the Forum's input on the SRFB's monitoring priorities.

At its December 3, 2008 meeting, the Forum was briefed on the various monitoring programs funded by the SRFB and the request for input on the priorities. At that meeting, the Forum directed staff to form a workgroup that would review the SRFB's monitoring activities, and begin exploring common questions, policy drivers, indicators, and potential overlaps between the two entities.

The 2009 PCSRF grant again requires that 10 percent of the total grant amount be directed at effectiveness and status and trends monitoring. The state's application will include a request for $2.5 million (10 percent of our $25 million grant application) to be used for effectiveness and status and trends monitoring.

For purposes of the grant application, effectiveness monitoring includes reach-scale project effectiveness monitoring, which measures the outcome of individual restoration projects (e.g., did a specific riparian planting project increase shade at the project site?). It also includes intensively monitored watershed monitoring, which attempts to link overall restoration efforts within a watershed to observed changes in fish production. Status and trends monitoring is focused on the overall (average) condition (and any net changes in that condition over time) of the entire tributary, watershed, or salmon recovery region (e.g. what is the overall condition of riparian habitat along salmon-bearing streams in the recovery region?)

**Next Steps**

The Washington Forum on Monitoring has formed a workgroup of agency representatives to review monitoring priorities and potential overlaps between SRFB and Forum monitoring strategies. Initial recommendations or suggestions from the Forum's workgroup will be included in a presentation to the SRFB at the February meeting. The Forum is likely to provide formal recommendations to the SRFB later in the year.

The SRFB's current reach-scale project effectiveness monitoring contract expires in June 2009. The intensively monitored watershed monitoring contract expires in October 2009, and juvenile salmon abundance monitoring (one part of a status and trends monitoring program) will seek renewal by October 2009. Recommendations on an overall monitoring strategy and direction for new or amended contracts will be needed at or before the May 2009 SRFB meeting.

**Attachments**

A. Monitoring overview presentation
B. SRFB Framework
C. Forum Framework

[1] The Forum began as the Governor's Forum on Monitoring in 2004. It was established in statute as the Washington Forum on Monitoring in 2007.

# D R A F T 5/23/2003

# MONITORING AND EVALUATION STRATEGY

## For

# Habitat Restoration And Acquisition Projects

## Washington Salmon Recovery Funding Board

## 2003

This is a draft document and is available for public review and critique.

All contents are subject to change.

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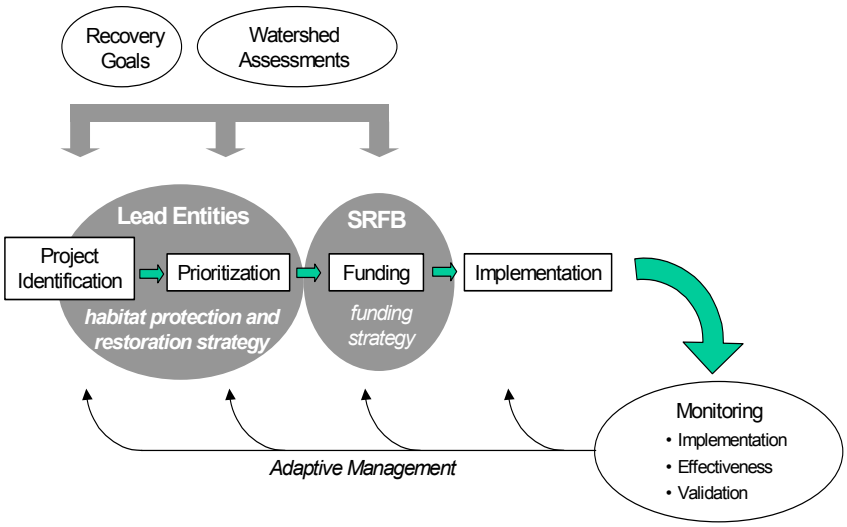
# OVERVIEW

The Salmon Recovery Funding Board (SRFB) was established in 1999 to fund salmon habitat restoration and protection projects and related activities. Starting in 2000, the SRFB established policies authorizing the types of projects eligible for funding and an evaluation process for selecting projects.

The SRFB, in their Policies and Guidelines, identified implementation, effectiveness, and validation monitoring as key components of their adaptive management model.

**Figure 1. SRFB Adaptive Management Model**




As part of past application processes, the SRFB has required applicants submit a monitoring plan that permitted up to 20 percent of the grant to be expended on monitoring.

**This document is intended to address elements of Washington's Comprehensive Monitoring Strategy (CMS), and it provides:**

- **Overall SRFB effectiveness and validation monitoring strategy;**
- **Prioritized monitoring by type and category;**
- **Estimated costs over the next ten years; and**
- **SRFB-NOAA Fisheries-OWEB-BPA agreed upon reporting metrics.**

Habitat restoration projects typically have a "nested hierarchy" of interrelated objectives and results. Projects individually operate at the site and reach scale, and when rolled up, operate at the watershed scale. This "nested hierarchy" also typically has associated monitoring at each level. For example, a riparian vegetation project might have the following series of objectives and associated levels of monitoring.

→Plant trees (Implementation monitoring Level 0)
→Did the trees live? (Level 1 design criteria)
→Increase shading of stream (Effectiveness monitoring Level 2)
→Reduce stream temperature (Effectiveness monitoring Level 2)
→Increase local salmon abundance (Effectiveness monitoring Level 3)
→Increase watershed salmon abundance (Validation [intensive] monitoring Level 4)

Implementation monitoring is related to project effectiveness monitoring, which in turn is related to validation monitoring. Doing one without the other would seriously limit the extent to which the SRFB could document whether the projects it funds have been effective in meeting SRFB goals.

**Project Implementation (Compliance) Monitoring - Level 0**

Implementation monitoring determines whether an action was implemented. It requires simply a yes/no answer and no environmental data. It is usually a low cost monitoring activity. Project monitoring is conducted by SRFB staff for all funded projects. The SRFB intends to monitor 100% of projects for implementation and compliance with pre-project design objectives and criteria.

**Monitoring Effectiveness of Projects in Meeting Engineering and Design Criteria – Level 1**

Many projects use design specifications that are intended to have benefits to fish. Over time, environmental or other circumstances can affect how well a project originally built to meet design criteria continues to meet those criteria. Projects for which engineering design criteria are utilized can be monitored to determine how well those criteria are achieved by the project over time. For example, fish passage projects involving culverts, weirs, dams, etc., are only effective as long as debris, floods, and other factors have not rendered an engineered solution ineffective. Therefore, the SRFB intends to monitor all categories of engineered projects to see how well they continue to meet their engineering and design criteria. Engineering and design criteria will be examined for the following monitoring categories:

- MP-1 Fish passage structures
- MP-2 Instream structures
- MP-3 Riparian plantings
- MP-4 Livestock exclusions
- MP-5 Constrained channels
- MP-6 Channel connectivity
- MP-7 Spawning gravel placement

- MP-8 Diversion screening
- MP-9 Estuarine habitat

**Monitoring Effectiveness of Projects on Habitat – Level 2**

Effectiveness monitoring measures environmental parameters to ascertain whether the actions implemented were effective in creating a desired outcome at the project site or reach scale. For example, did the planted trees produce shading for the stream is the first level of a cause and effect hypothesis? The entire hypothesis may be stated something like the following: If I plant trees near the stream, then they will grow and produce shade. The shade will help lower water temperature and stabilize the shoreline (Level 2 outcomes) and this will improve the fish habitat leading to more fish (Level 3 and 4 outcome). Project effectiveness monitoring is generally used to evaluate Level 2 outcomes, which are directly affected by the project. The relationships between the project and Level 2 and Level 3 and 4 outcomes are usually less direct. Watershed processes occurring upstream or upslope from the project increasingly influence higher-level outcomes. Outcomes not directly influenced by the project are usually best addressed at the watershed scale through validation (intensive) monitoring (Level 4). Most projects are implemented at a small scale, with defined sets of actions intended to protect or enhance specific habitat features or habitat-forming processes. An enhancement technique may be difficult to implement properly but very effective or, conversely, easy to implement but rarely effective. Implementation, effectiveness, and validation monitoring are necessary to evaluate specific projects or classes of projects. The SRFB intends to monitor effectiveness of projects on habitat by monitoring changes in habitat parameters for the following project categories;

- MP-2 Instream structures
- MP-3 Riparian plantings
- MP-4 Livestock exclusions
- MP-5 Constrained channels
- MP-6 Channel connectivity
- MP-7 Spawning gravel placement
- MP-9 Estuary restoration/creation
- MP-10 Habitat acquisitions

**Monitoring Effectiveness of Projects on Local Fish Abundance – Level 3**

Interest in evaluating the effectiveness of projects on fish abundance in the local project area is common to most restoration and funding entities. However, the current project effectiveness monitoring literature shows a wide variety of results in the ability to associate changes in fish abundance. Some studies have been unable to detect statistically significant changes in abundance in the project area after several years, while others have been able to show increases. As noted by the Independent Science Panel (ISP 2002) and others, detection of increased fish abundance at the project or reach level should not be interpreted to mean that overall abundance or productivity of the stream (e.g., smolt abundance) at the watershed scale has also increased. The

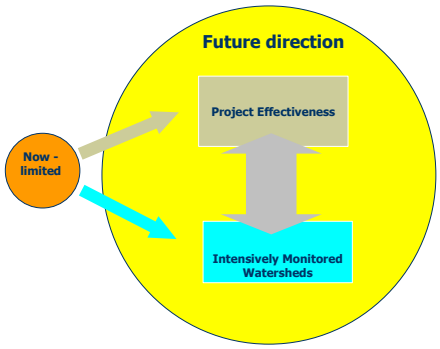
linkages to smolt production can only be done through validation monitoring in intensively monitored watersheds. The SRFB intends to monitor fish abundance at the project level for the following project categories:

- MP-1 Fish passage structures
- MP-2 Instream structures
- MP-6 Channel connectivity

The SRFB also intends that this level of project effectiveness monitoring (to determine local fish response) will be linked to level 4 (intensive) monitoring as outlined below to the extent possible.

**Intensive (Validation) Monitoring Level 4**

This type of monitoring is the only type of monitoring that can establish "cause and effect" relationships between fish, habitat, water quality, water quantity, and management actions. It operates at the watershed scale to evaluate projects and programs that conduct, promote, or regulate, activities meant to protect or enhance habitat, water quality, or fish production. As an example, one might study the impacts of categories of riparian habitat projects on a salmon in a specific stream. The common theme of these studies is to develop an understanding of the linkages between management actions and the responses in numbers of fish produced.




This type of monitoring is the most complex and technically rigorous, which often requires measuring many parameters to detect the variable affecting change. Counting juvenile and adult fish is essential. Once determined, the relationships between restoration actions and the numbers of fish produced in an intensively monitored watershed (IMW) may or may not be able to be directly extrapolated to other watersheds depending upon the strength of the information obtained. However, intensively monitored watersheds can be assumed to represent the overall responses of watersheds with similar characteristics and limiting factors to the same restoration impacts.

This part of the SRFB Monitoring Strategy pertains to monitoring that addresses how management and habitat restoration project activities, and their cumulative effects, specifically affect fish production. As is discussed in greater detail below, validation monitoring (or as termed here, intensive monitoring) is the only way this can be achieved (ISP 2002). Status and trends, effectiveness, and implementation monitoring are not able to determine causal relationships between management activities and fish production. Other types of monitoring are unable to answer questions like "to what extent did our recovery actions lead to more fish?"

The SRFB intends to support intensive monitoring in watersheds carefully chosen to allow efficient and meaningful results. Support will include initial development work in selected watersheds so that scientifically sound and integrated monitoring efforts can be most effectively linked to habitat project monitoring work in levels 2 and 3.

Compared to other types of monitoring, intensive or validation monitoring requires the greatest extent of scientific rigor and integration in monitoring design development and analysis of results, over a substantial time period. Interest in this type of monitoring has been expressed by various entities and opportunities for potential partnerships will be utilized.

# EFFECTIVENESS MONITORING STRATEGY

## *Key Elements of the Strategy*

**Level 1-3 monitoring at the project or reach scale**

- The Board staff will determine the overall sampling regime and sample size by project category.

- After the SRFB has selected projects to fund for a particular "Round", a subsample of the selected projects will be randomly selected by the staff for monitoring.

- The staff will use professional, qualified independent monitoring entities to field sample habitat restoration and acquisition projects at the reach or project level using Board adopted protocols, metadata, and procedures.

- The Board will use habitat assessment protocols developed by the nationally recognized Environmental Monitoring and Assessment Program administered by the U.S. EPA, as recommended in "*Washington's Comprehensive Monitoring Strategy*" and adopted by the Oregon Watershed Enhancement Board and the U.S. Forest Service (see "*SRFB Sampling Protocols*").

- The Board staff will be responsible for analyzing the results of monitoring from the monitoring entities, and to report to the Board and others the cumulative results of monitoring. In order to efficiently use monitoring dollars, a stratified random sample of projects by category will be taken. The sample will be sufficient to be 95% certain that the results of the projects sampled is within 5% of the true percentage of projects that are successful. Based upon past projects, approximately 68% of the projects by category should be sampled during Phase 1.

- Volunteers and project proponents may choose to monitor their projects as part of the sampling regime outlined in this Strategy. However, monitoring funded by the Board will meet requirements detailed under "*Required Elements For Locally Monitored Projects*" on page 23 of this Strategy.

- Not less than 5% of annually appropriated federal and state funds will be available to test effectiveness of projects designed to restore habitat and projects that protect habitat by acquisition at the site or reach scale.

- The Board staff will ensure that monitoring is "phased" so that future monitoring can be built upon knowledge gained from initial monitoring. Phase 1 monitoring will occur between 2003 and 2014. After 2014, results will be evaluated to determine what, if any, changes to the SRFB monitoring strategy are warranted.

**Level 4 intensive monitoring at the watershed scale**

- For long term intensive watershed scale monitoring, the Board will support development of IMWs in a few identified watersheds where the cumulative impacts of SRFB funded restoration projects can be assessed for their effects on total watershed salmon production and productivity.

- A portion of funded habitat restoration projects will be linked to and embedded in IMW designs. The number and kinds of projects placed in IMWs will be determined by the limiting factors identified in the IMWs and the monitoring design.

- Up to 5% of annually appropriated federal and state funds will be available for Board support of intensively monitored watersheds.

- Implementation of IMW efforts will use a phased approach. A team or consortium comprised of IMW partners and others will contribute to and help guide feasibility, design, implementation, analysis, and reporting activities. Key checkpoints will be identified based on experimental design timelines and frameworks for review of interim progress and results from IMW work.

## *Priorities for Project Effectiveness Monitoring*

Table 1 is an adaptation from data provided by Roni et al. (2002). It captures the overall qualitative value of each category of SRFB projects in terms of response and certainty. SRFB files provide average costs associated with implementing the various projects. Monitoring efforts are prioritized using multiple considerations detailed in Table 3.

These considerations include response time, probability that monitoring will be definitive enough to determine effectiveness of the project type, earliest reporting date, and cost of monitoring. It is expected that not only will monitoring determine the overall effectiveness of each project, but it will provide data on the overall longevity of SRFB project habitat restoration types and the amount of variability in success of projects types both in terms of overall statewide, but in terms of geographic areas of the state.

Response time will determine the number of years required to monitor. A culvert replacement may have fish utilizing the project area within one year. For most fish passage projects, a measurable response is expected within 5 years. For projects such as riparian vegetation restoration, response time may take 5 to 20 years. Therefore, the Board will extend monitoring over a longer time span to determine effectiveness.

The last column in Table 1 provides monitoring priorities for different types of projects. Some project categories rank high based upon their overall ability to detect change in a timely manner. These rankings are not intended to reflect the funding priority of the project type for restoration. Some projects are not very conducive to monitoring and, therefore, rank low. Instream projects, although marked low in terms of certainty and response, are considered a high priority for monitoring because they are the second

most often funded restoration project category. Nevertheless, monitoring may show that they are one of the least effective types of projects over time.

Monitoring for some project types and parameters may be too costly for the information obtained. Conifer conversions, nutrient enhancement projects (carcasses and fertilization) are very difficult to monitor and take extensive investments in time and money. Therefore, the Board will not monitor these project categories for effectiveness.

**Table 1. Project effectiveness monitoring time frames and priorities modified from Roni et al. (2002). Shading represents categories with relatively long overall response times and low probabilities of success. Crosshatching represents categories with medium overall response times and probabilities of success. Light shading represents categories with short overall response times and high probabilities of success. Monitoring priority in most cases reflects the composite of response times and success probabilities.**

| SRFB Category | Action | Response (years) | Longevity (years) | Success probability | Success variability | Cost of average project | Monitoring Priority |
|---|---|---|---|---|---|---|---|
| Fish Passage | Culverts, barriers | 1-5 Score 10 | 10-50+ Score 10 | H | L | $203,000 Opens 3.2miles $63,000/mile | H |
| | Off channel | 1-5 | 10-50+ | H | L | $508,000 Opens 1.4 miles 48 acres | H |
| | Instream diversion | 1-5 | 10-50+ | H | L | $170,000 Screens 8.4 diversion/project $17,000/screen | H |
| Estuarine | Habitat restoration | 5-20 | 10-50+ | M-H | M | $196,000 | H |
| | Road removal | 5-20 | Decades-centuries | H | L | $196,000 | H |
| | Road alteration | 5-20 | Decades-centuries | M-H | M | $196,000 | H |
| Riparian vegetation | Fencing | 5-20 | 10-50+ | M-H | L | $261,000 | H |
| | Riparian replanting | 5-20 | 10-50+ | M-H | L | $261,000 | H |
| | Grazing strategies | 5-20 | 10-50+ | M | M | $261,000 | L |
| | Conifer conver-sion | 10-100 | Centuries | L-M | H | $261,000 | L |
| Instream habitat | Artificial log structure | 1-5 | 5-20 | M | H | $221,000 | H |
| | Natural LWD | 1-5 | 5-20 | M | H | $221,000 | H |
| | Artificial log jams | 1-5 | 10-50+ | M-H | M | $221,000 | H |
| | Boulder placement | 1-5 | 5-20 | M | M | $221,000 | H |
| | Gabions | 1-5 | 10 | M | M | $221,000 | H |
| Nutrient enhanceme nt | Carcasses | 1-5 | Unknown | M-H | L | | L |
| | Fertiliza-tion | 1-5 | Unknown | M-H | M | | L |
| Create new habitat | Off channel | 1-5 | 10-50+ | M | H | | H |
| | Estuarine | 5-10 | 10-50+ | L | H | | H |
| Upland Habitat | | | | | | $156,000 | L |

H= High, M= Medium. L= Low

## *Experimental Design And Statistical Design*

The Board wishes to determine if there is a measurable change in the habitat and fish indicators in the area restored by the Board (Impact) compared to other areas (Control) where the Board has not taken action. We cannot measure the variance between the means of measurements in the Impact and the Control because we cannot assume the differences between the Impact and Control sections in each project will remain constant. The magnitude of the true difference between Impact and Control changes over time, thereby making it impossible to evaluate any times by location interactions.

Therefore, the Board will employ a "Before" and "After" Control Impact (BACI) design similar to one described by Stewart-Oaten et al. (1986). A BACI design samples the Control and Impact simultaneously at both locations at designated times before and after the impact has occurred. The object is to see whether the difference between Impact and Control abundances has changed as a result of the projects. The plan is to compare the before and after periods by a *t*-test for a difference between the mean of the before differences and the mean of the after differences for the projects sampled. The tests also assume that the observed differences calculated at different times are independent.

To implement the design, we will monitor the number of projects proposed for funding in each category based upon the calculated sample size needed to obtain statistically significant information in the shortest amount of time. If there are insufficient projects funded in any one year to obtain a proper sample size, then replicates of the design will be used in multiple years until the critical sample size is reached.

Each of the projects in each replicate will utilize one impact reach in the proposed project area and a paired control area near the project in an area with similar reach characteristics. In Year 0 (one year prior to project construction), (Before) sampling of the project Control and Impact reaches is completed. After the restoration project has been completed, the Control and Impact areas for each of the projects in each replicate will be sampled for three or more years (After) for changes in the selected habitat and/or fish abundance indicators. The variance associated with Impact and Control areas will not be known until sampling has occurred in Year 0 of both Impact and Control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of "Before" impact information for all projects in each replicate for both Control and Impact areas, and multiple years of "After" impact information for the same Control and Impact areas for each of the projects within each replicate. Testing for significant trends for some projects can begin as early as 2005.

Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Table 2 contains a summary description of the project category, the indicator that will be used to measure a significant change in habitat or fish conditions, the metric used to measure the indicator, and the statistical rule in terms of confidence in the results. It also contains the decision criteria at which the Board will consider a change meaningful. For example, under MP-1 Fish Passage in the table, a statistically significant change of 5% in the juvenile population in the area upstream of the project may be observed, but would not be considered a meaningful change unless is was greater than or equal to 20%. The test type is the kind of statistical test that will be employed upon completion of the monitoring.

**Table 2. SRFB Effectiveness monitoring statistical design table for habitat restoration/protection projects**

| SRFB Project Category | Monitoring Category | Level | Indicators | Metric | Test Type | Decision Criteria |
|---|---|---|---|---|---|---|
| **Instream Passage** | **MP-1 Fish Passage** | Level 1 | Eng. Design | Yes/No | None | ≥ 80% of projects are Yes by Year 5 |
| | | Level 3 | Juvenile salmon | #/m$^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 5 |
| | | Level 3 | Adult salmon | #/mile; redds/mi | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 5 |
| **Instream Habitat** | **MP-2 Instream habitat** | Level 1 | Artificial Instream structures | # | None | 80% or more remaining by Year 10 |
| | | Level 2 | Mean residual pool vertical profile area | m$^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Mean residual depth | cm | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 3 | Juvenile salmon | #/m$^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 3 | Adult salmon | #/mile; redds/mi | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| **Riparian Habitat** | **MP-3 Riparian plantings** | Level 1 | # of plantings | # | None | 50% or more remaining after 10 years |
| | | Level 2 | Mean percent canopy density at the bank Densiometer Reading | 1-17 score | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |

| SRFB Project Category | Monitoring Category | Level | Indicators | Metric | Test Type | Decision Criteria |
|---|---|---|---|---|---|---|
| | | Level 2 | 3-layer riparian vegetation presence (proportion of reach) | % | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| **Riparian Habitat** | **MP-4 Livestock exclusions** | Level 1 | Exclusion Area | Yes/No | None | Effective if 80% of projects are Yes |
| | | Level 2 | Mean percent canopy density at the bank Densiometer Reading | 1-17 score | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | 3-layer riparian vegetation presence (proportion of reach) | % | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Actively eroding banks | % | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| **Instream Habitat** | **MP-5 Constrained channel** | Level 2 | Mean residual pool vertical profile area | $m^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Mean residual depth | cm | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Mean bank full cross sectional area taken from mean bank full width and height | Ave. $m^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 5% change between impact and control by Year 10 |
| **Instream Habitat** | **MP-6 Channel Connectivity** | Level 1 | Reconnected channel | Yes/No | None | Effective if 80% of projects are Yes |
| | | Level 2 | Mean residual depth | cm | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Mean residual pool vertical profile area | $m^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 3 | Juvenile salmon | $\#/m^2$ | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |

| SRFB Project Category | Monitoring Category | Level | Indicators | Metric | Test Type | Decision Criteria |
|---|---|---|---|---|---|---|
| | | Level 2 | Mean percent canopy density at the bank Densiometer Reading | 1-17 score | BACI Paired T test | Alpha=0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | 3-layer riparian vegetation presence (proportion of reach) | % | BACI Paired T test | Alpha=0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 3 | Adult salmon | #/mile; redds/mi | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| **Instream Habitat** | **MP-7 Spawning gravel** | Level 1 | Gravel placed in stream | acreage | None | Effective if 80% of gravel placed at projects remains by Year 10 |
| | | Level 2 | Percent gravel embedded at mid-channel and margins | Percent | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Percent substrate embedded | Percent | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 2 | Percent substrate as fines | Percent | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| | | Level 3 | Adult salmon | #/mile; redds/mi | BACI Paired T test | Alpha =0.05 for one-sided test. Detect a minimum 20% change between impact and control by Year 10 |
| **Instream Diversion** | **MP-8 Diversion Screening** | Level | Screen design criteria | Yes/No | None | Effective if 80% of screened diversions at projects meet design by Year 5 |
| **Estuarine/ Marine Nearshore** | **MP-9 Estuarine Habitat restoration** | In progress | | | | |
| **Protection** | **MP-10 Acquisitions** | In progress | | | | |

## *Estimated Costs*

**Project effectiveness monitoring (levels 1 - 3):**

Annual costs will vary depending upon the number of projects by category and the level of monitoring sought. Level 1 monitoring of engineered structures and solutions is the cheapest effectiveness monitoring because it does not require extensive environmental measurements, but relies upon previous studies to document that the design is effective. Verification that the design remains functional is the sum of monitoring. Table 3 provides the estimated cost to monitor each category of project for Level 1, 2, and 3.

The third column in Table 3 displays the number of years that project monitoring will occur pre- and post-impact. The years sampled post impact may not be consecutive years, but may be staggered over a longer time span to allow for habitat response.

The column displaying sample size per replicate is based upon the number of randomly drawn samples needed to detect with certainty (a= 0.5) whether the projects in that category are effective. Since we do not know the overall proportion of projects expected to be effective ahead of time, for the purposes of estimating sample size, the proportion is assumed to be 0.5. Therefore, approximately 70% of the projects should be sampled initially until an estimate of the true proportion can be obtained.

Total cost for each of the levels was calculated by finding the product of the cost per project and the number of projects sampled.

Grand Total is the sum of each of the total costs for each monitoring Levels 1-3.

Average Cost Per Year shown in the last column is found by dividing the Grand Total by the number of years sampled.

Table 4 provides a tentative schedule over the next ten years. It reflects the need for multi-year monitoring (e.g. Fish Passage 1 and 2) to obtain sufficient numbers of projects to detect a statistically significant change in the indicator. Table 4 also reflects the estimated annual cost to monitor project effectiveness for the eight project categories completed to date.

**Watershed intensive monitoring (level 4)**:
The SRFB's intensive watershed monitoring strategy evolved from initial work on Index Watershed Monitoring from funding by the Legislature and the Board to the departments of Fish and Wildlife and Ecology (Summers 2001; Seiler et al. 2002). The cost of Index Monitoring work totaled $1,263k per biennium, which provided concurrent water quality and smolt monitoring in five locations in the state. The Board's current monitoring strategy refines and transitions that previous investment into an intensive watershed monitoring approach. Further detail on the IMW approach, tasks, timelines, partners/contributions are described separately in the IMW plan. That plan identifies initial work to be performed in two groups of IMW streams in: (1) Hood Canal – Big Beef, Stavis, Anderson, Seabeck creeks; and (2) Lower Columbia– Abernathy, Mill, Germany creeks. A complementary effort by IMW partners is funded separately and will be performed on a group of North Coast streams. In addition, potential IMWs in eastern Washington and potential related funding partners are being explored. The present package of intensive monitoring continues work in the three Lower Columbia streams that were included as part of Index Watershed Monitoring in 2002. The cost for smolt monitoring in six of the seven IMW streams is roughly $300,000 per year ($600,000 per biennium); costs for the seventh stream are covered by other funding. The Board acknowledges that funding of smolt monitoring in the other streams for which SRFB funds were previously provided (roughly $500,000 per biennium) is desirable and consistent with the CMS, but is outside the scope of the IMW framework.

Table 5 illustrates the projected annual costs for the intensive watershed monitoring work outlined here. Total costs will ultimately depend on the number of IMWs implemented in the state. The Board's contribution to IMWs will include enumeration of fish in IMW streams ($300,000), and the contributions from partners (e.g., funding, in-kind). Costs will change as IMW work progresses through various stages from scoping/design, through implementation/data collection, to final analysis/reporting.

Table 3. Level 1 –3 project effectiveness monitoring estimated time frames and costs per replicate.

| Action Effectiveness Monitoring | Number of years sampled. Total time to end of replicate | Sample Size per replicate | Cost per Project Level 1 | Total Cost Level 1 | Cost per Project Level 2 | Total cost Level 2 | Cost per Project Level 3 | Total Cost Level 3 | Grand Total per replicate | Ave. Cost per year |
|---|---|---|---|---|---|---|---|---|---|---|
| MP-1 Fish Passage Culverts, bridges, fishways, logjams, dam removal | 4 sample years 6 years total | 15 | $2,700 | $40,500 | 0 | 0 | $25,288 | $379,320 | $419,820 | $104,955 |
| MP-2 Instream habitat Channels, deflectors, weirs, large wood | 5 sample years 11 years total | 15 | $900 | $13,500 | $6,750 | $101,250 | $43,875 | $658,125 | $772,875 | $154,575 |
| MP-3 Riparian plantings | 5 sample years 11 years total | 10 | $2,700 | $27,000 | $4,500 | $45,000 | 0 | 0 | $72,000 | $14,400 |
| MP-4 Livestock exclusions | 5 sample years 11 years total | 3 | $3,100 | $9,300 | $4,500 | $13,500 | 0 | 0 | $22,8000 | $4,560 |
| MP-5 Constrained channel (dikes, rip-rap, fill, roads) | 5 sample years 11 years total | 2 | $2,450 | $4,900 | $6,750 | $13,500 | 0 | 0 | $18,400 | $3,680 |
| MP-6 Channel Connectivity (Off channel habitat, wetlands) | 4 sample years 6 years total | 5 | $1,800 | $9,000 | $5,400 | $27,000 | $43,875 | $658,125 | $694,125 | $173,531 |
| MP-7 Spawning gravel | 5 sample years 11 years total | 3 | $900 | $2,700 | $6,750 | $20,250 | $27,000 | $81,000 | $103,950 | $20,790 |
| MP-8 Diversion Screening | 4 sample years 6 years total | 2 | $2,700 | $5,400 | 0 | 0 | 0 | 0 | $5,400 | $1,350 |
| MP-9 Estuarine Habitat restoration | In progress | 4 | | | | | | | | |
| MP-10 Acquisitions | In progress | 14 | | | | | | | | |
| Total | | | | | | | | | | |

## *Annual Cost and Sampling Schedules*

The following tables (Table 4) illustrates the schedules for sampling each level of monitoring for the major categories of projects for Level 1-3. Note – Table 5 identifies the costs and schedule for IMWs.

**Table 4. Combined costs and schedule for Level 1- 3 monitoring.**

| Year | Sample | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MP-1 Passage 1 | 15 | $104,955 | $104,955 | $104,955 | | | $104,955 | Evaluate | | | | | |
| MP-1 Passage 2 | 15 | | $104,955 | $104,955 | $104,955 | | | $104,955 | | | | | |
| MP-2 Instream 1 | 15 | $154,575 | $154,575 | | $154,575 | | $154,575 | Evaluate | | | | $154,575 | |
| MP-2 Instream 2 | 15 | | $154,575 | $154,575 | | $154,575 | | $154,575 | | | | | $154,575 |
| MP-3 Riparian 1 | 10 | $14,400 | $14,400 | | $14,400 | | $14,400 | Evaluate | | | | $14,400 | |
| MP-3 Riparian 2 | 10 | | $14,400 | $14,400 | | $14,400 | | $14,400 | | | | | $14,400 |
| MP-4 Livestock 1 | 3 | $4,560 | $4,560 | | $4,560 | | $4,560 | | | | | $4,560 | |
| MP-4 Livestock 2 | 3 | | $4,560 | $4,560 | | $4,560 | | $4,560 | | | | | $4,560 |
| MP-5 Constrained Channel | 2 | $3,680 | $3,680 | | $3,680 | | $3,680 | | | | | $3,680 | |
| MP-5 Constrained Channel | 2 | | $3,680 | $3,680 | | $3,680 | | $3,680 | | | | | $3,680 |
| MP-6 Connect 1 | 3 | $173,531 | $173,531 | | $173,531 | | $173,531 | | | | | $173,531 | |
| MP-6 Connect 2 | 3 | | $173,531 | $173,531 | | $173,531 | | $173,531 | | | | | $173,531 |
| MP-7 Spawning gravel | 3 | $20,790 | $20,790 | | $20,790 | | $20,790 | | | | | $20,790 | |
| MP-7 Spawning gravel | 3 | | $20,790 | $20,790 | | $20,790 | | $20,790 | | | | | $20,790 |
| MP-8 Diversion 1 | 2 | $1,350 | $1,350 | $1,350 | | | $1,350 | | | | | | |
| MP-8 Diversion 2 | 2 | | $1,350 | $1,350 | $1,350 | | | $1,350 | | | | | |
| MP-9 Estuary 1 | 4 | | | | | | | | | | | | |
| MP-9 Estuary 2 | 4 | | | | | | | | | | | | |
| MP-10 Acquisition 1 | 14 | | | | | | | | | | | | |
| TOTAL | | $476,491 | $952,982 | $581.446 | $476,491, | $371,536 | $476,491 | $476,491 | $0 | $0 | $0 | $173,535 | $347,066 |

**Table 5. Costs and schedule for Level 4 intensive watershed monitoring. Total costs for two IMWs are included; they are not intended to reflect only the SRFB contribution.[1] Costs for fish sampling are noted separately for the first three years.**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Phase 1: pre-implementation | $300,000 (fish) $350,000 (other) | | | | | | | | | | |
| Phase 2: initial implementation | | $300,000 (fish) $250,000 (other) | | | | | | | | | |
| Phase 3: full implementation | | | **$400,000 (fish)** $500,000 (other) | | | | | | | | |
| Total (for 2 IMWs) | **$650,000** | **$550,000** | **$900,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** | **$1,000,000** |

[1] Current partners include: CMER, UW/ONRC, EPA; in-kind contributions from NWFSC, EPA, BIA, tribes, local groups.

### *Monitoring and Reporting Metrics*

The ability to communicate effectively the results of habitat restoration and acquisition projects and other salmon recovery activities is a continual challenge. Those individuals working closely with habitat and fish issues speak in technical terms and metrics not well understood by others. On the other hand, "decision-makers" at the highest levels of government, in the U.S. Congress and State Legislature want to know the answers

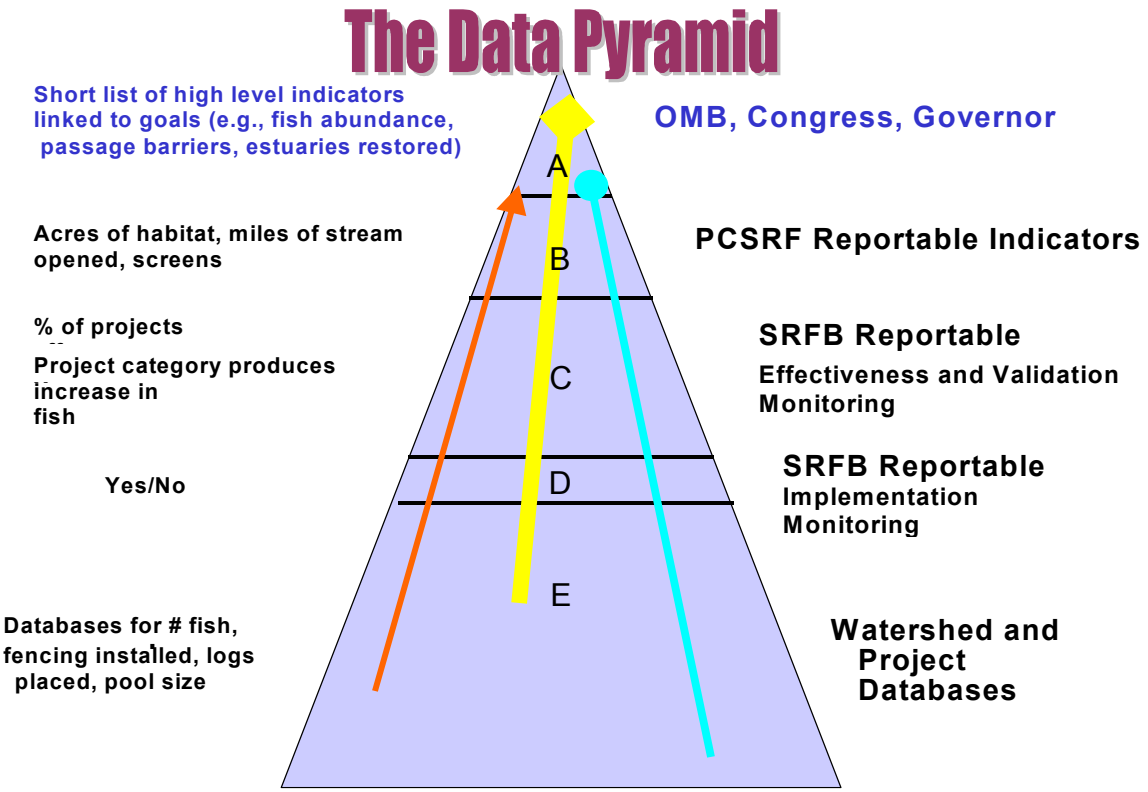



***Figure 2. The Effectiveness Monitoring Data Pyramid***

to basic accountability questions about the money they have appropriated to solve the salmon crisis. They seek answers to questions like: Have our efforts done any good? How many new fish have been produced? How much more money is needed? How much longer until we achieve success? These basic questions cannot be answered, unless a significant amount of existing and new information is obtained and rolled up in a manner that, to date, has typically not been done. To get answers to the most basic questions requires a variety of more detailed and complex underlying information. Figure 2 illustrates a data pyramid, reflecting the hierarchical nature of "information "chains that link detailed data up through intermediate layers to the highest level performance measures.

An effort is underway to reach agreement on common metrics designed to measure success in recovering habitat and salmon in the Pacific Northwest. Coordination is underway between the major funding entities including: Oregon Watershed Enhancement Board (OWEB), SRFB, Bonneville Power Administration, Northwest Power and Conservation Council, U.S Forest Service, and the Pacific Coastal Salmon Recovery Fund partners administered by NOAA Fisheries. Implementation monitoring metrics (Level D in the Pyramid) agreed upon to date are shown in Table 7 for habitat restoration projects. Additional work is underway to agree upon effectiveness monitoring metrics and the key few performance measures reportable to Congress, the Governor and the Legislature.

| Category | SRFB | Implementation Monitoring |
|---|---|---|
| Fish Screening Projects | In-Stream Diversions | Number of screens installed<br>Flow rate (cfs) of diversions treated<br>Duty (quantity of water allowed) in acre-feet |
| In-Stream Habitat | In-Stream Habitat Restoration | # of miles treated |
| Fish Passage Improvements | Culvert replacement<br>Dam removal<br>Debris removal | # of blockages removed<br># of miles accessed |
| Riparian Habitat | Fencing exclusions | # of miles treated<br># of acres treated<br># of acres of invasive species controlled |
| Upland Habitat | | # of actions<br># of acres treated |
| Roads | | # of miles of road decommissioned, upgraded, closed |
| Water Quantity | | Amount of water (cfs)<br># of gauges installed<br>% of lease/purchases with gauges |
| Water Quality | | Water Quality limitations addressed by project |
| Wetland Activity | | # of acres restored<br># of acres created<br># of acres invasive species controlled |
| Estuarine | Estuarine/Marine Nearshore | # of acres restored<br># of acres created<br># of acres invasive species controlled |
| Land Acquisitions | | # of acres protected<br># of miles of stream protected |

**Table 7. Implementation and effectiveness monitoring indicators of performance.**

# REQUIRED ELEMENTS FOR LOCALLY MONITORED PROJECTS

Lead Entities, Salmon Recovery Regions and others desiring to conduct monitoring for their proposed restoration projects as part of the Board's monitoring program shall meet the following requirements:

- Comply with and utilize SRFB "Sampling Procedures, Designs, and Projected Costs" manuals.
- Utilize applicable SRFB "Sampling Protocols".
- Submit a written monitoring plan detailing the timelines, costs, responsible organization, and plans for pre and post project monitoring.
- Report data in a timely manner to the PRISM database using required flat file format and metadata standards.
- Participate in QA/QC audits.
- Meet all reporting deadlines.

# QUALITY CONTROL/QUALITY ASSURANCE

### *Field Sampling Audit*

The SRFB will employ a consultant to annually report results from an audit of 25% of ongoing habitat effectiveness monitoring projects, randomly selected to determine how well they have implemented the monitoring design and field sampling Quality Assurance Protocols and Procedures.

### *Data Management Audit*

The SRFB will employ a consultant to annually audit on a random basis 25% of ongoing habitat effectiveness monitoring projects to determine if they are following the procedures for entering data into PRISM.

# REPORTS

### *Progress Reports*

Entities involved in project effectiveness and intensive monitoring must present to the SRFB in writing progress reports after the sampling season for each monitoring year. These reports will indicate how the monitoring relates to the SRFB's project effectiveness monitoring program, and linkages between project effectiveness monitoring and intensive watershed monitoring. Intensively Monitored Watershed reports will be jointly prepared by monitoring parties.

### *Final Reports*

Entities involved in project effectiveness and intensive monitoring must present to the SRFB a final report, in writing, after the sampling for all years is completed. Final

reports shall include monitoring objectives, assumptions, designs, field and statistical/analytical methods, results, and recommendations. Intensively Monitored Watershed reports will be jointly prepared by monitoring parties, and will describe linkages to project effectiveness monitoring. Final reports from all entities will include:

- Estimates of precision and variance for data collected
- Confidence limits for data collected
- Data and metadata required for PRISM database
- Determination of whether project met decision criteria for effectiveness
- Analysis of completeness of data, gaps, and sources of bias

The SRFB will periodically review results of monitoring during a regular meeting. PRISM database will be used as the repository of summarized monitoring information contained in Table 6, and will be reported and available over the Interagency Committee for Outdoor Recreation web site and the Washington Natural Resources Data Portal.

### *Monitoring Program Review*

To facilitate information sharing and coordination, and to improve the effectiveness of the Board's monitoring program, entities receiving SRFB funds for project effectiveness and intensive monitoring will be prepared to participate in an annual or biennial monitoring program review convened by SRFB staff. This may involve oral presentation and discussion of monitoring results.

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# Washington State Framework for Monitoring Salmon Populations Listed under the Federal Endangered Species Act and Associated Freshwater Habitats

Produced by

The Governor's Forum on Monitoring Salmon Recovery
and Watershed Health

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Edited by
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# Introduction

The Washington Legislature asked the Monitoring Oversight Committee (MOC) to develop a comprehensive monitoring strategy for the state that would address salmon recovery and watershed health (SSB5637). The strategy was delivered to the Governor and Legislature in 2002. The strategy evaluated existing monitoring and identified monitoring gaps that were important for tracking future conditions of Washington's natural resources and to determine, as part of the adaptive management process, whether management actions to restore habitat and fish populations have been effective from physical, biological, and economic perspectives. Seventy-six separate recommendations were made that would materially improve our ability to determine the health of Washington's natural resources.

Combined, this information would enable comprehensive and scientifically sound reporting to Congress, the Governor, Legislature, and to the public. Much of the federal funding available to the state is dependent upon the ability to provide accountable and transparent assessment of progress towards meeting our shared goals. Funding resources are under constant pressure to be reduced, or even eliminated, if progress cannot be demonstrated.

To begin to implement the recommendati*ons of the MOC,* The Governor's FORUM on Monitoring Salmon Recovery and Watershed Health (FORUM) was created by Executive Order 04-03 in August 2004, to coordinate monitoring consistent with the *Comprehensive Monitoring Strategy and Action Plan for Watershed Health and Salmon Recovery (CMS)*.

The FORUM is comprised of state and federal agencies, named by the Governor in the Executive Order, involved in watershed health and salmon recovery. It also includes representation from the Northwest Power and Conservation Council (NWPCC), non government organizations (NGOs), and the tribes, as well as local government. According to the Executive Order, the FORUM is chartered to:

> ***Provide a multi-agency venue for coordinating technical and policy issues and actions related to monitoring Washington's salmon recovery and watershed health.***

This framework document is the result of cooperative efforts of FORUM members and is offered as guidance to state natural resource agencies, regional salmon recovery groups, and federal and tribal co-managers.

# Why a Framework is Needed

There is a tendency for various agencies to attempt to meet Endangered Species Act (ESA) monitoring requirements without a connecting framework and "game plan" that allows the public, and government to determine the overall status of ESA listed salmon and their trends. This framework document only addresses fish abundance and productivity and habitat conditions. Future work may clarify how other listing factors should be addressed, as well as develop standards and increased consistency for other types of monitoring, such as implementation and effectiveness monitoring, which monitors habitat projects to increase accountability of funds. At this reporting, the framework is only partially funded.

At the October 2005 FORUM meeting, the Governor's Salmon Recovery Office (GSRO) and the National Marine Fisheries Service (NMFS) provided an overview of the criteria needed for de-listing salmon species listed under the ESA. The following chart (Figure 1) illustrates the two branches (biological and statutory) of the decision framework used in determining when a listed

species can be upgraded from “endangered” to “threatened” or is recovered and removed from the list. On the left-hand section of the chart are the fish population factors that must be considered for salmon Evolutionary Significant Unit (ESUs). The component populations to be deemed Viable Salmonid Populations (VSP) must address abundance, productivity, spatial distribution, and diversity. On the right side of the chart are statutory considerations; those threats and factors limiting survival that were the reasons for the listing. In making a determination to upgrade or de-list, NMFS must have a reasonable expectation that the listed ESU is viable and that the threats to the species have been corrected. Thus, the biological factors (left side) must be addressed in complete coordination with the physical and administrative factors (right side).

The bottom of the chart lists the evaluation of actions such as how effective various types of habitat restoration projects or habitat/water programs were, and allows for adaptive management. Actions in all three sections of the chart work together to form a complete cycle that informs the public and government of salmonid recovery progress.

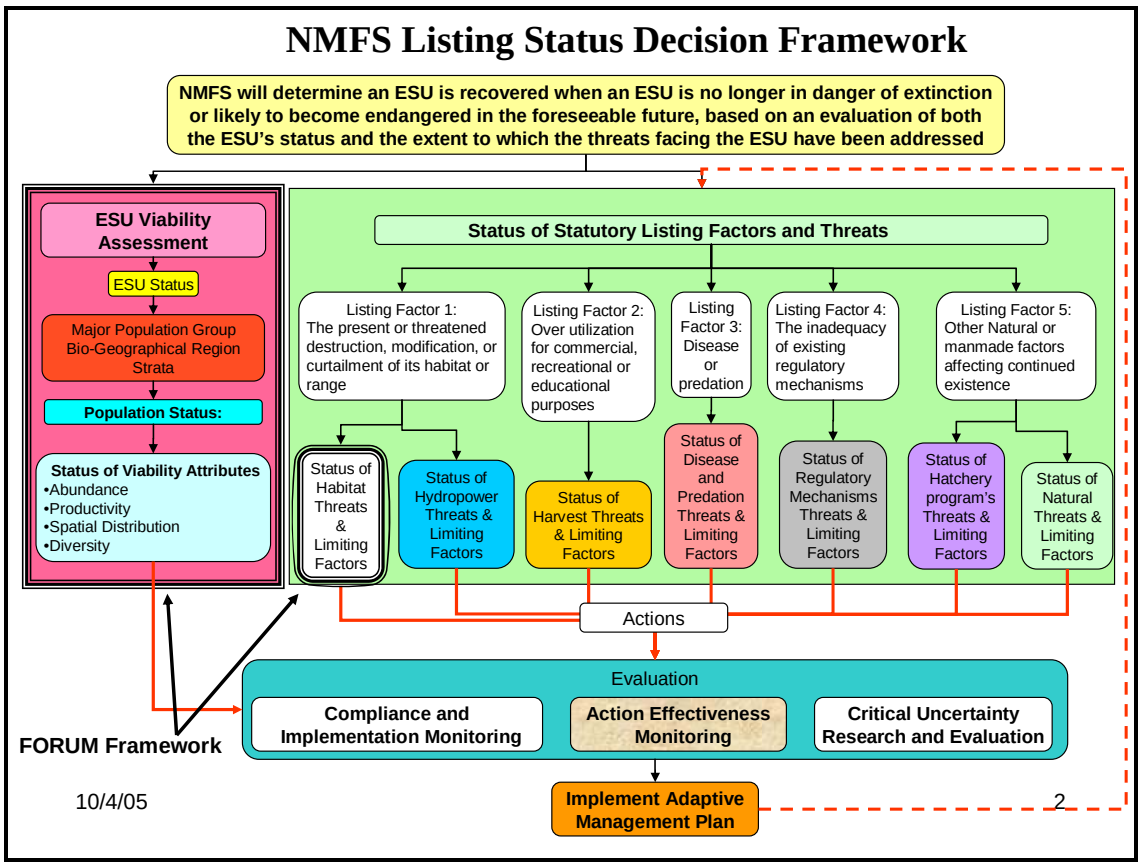


**Figure 1. NMFS listing status decision framework and relationship to the FORUM framework.**

In view of the above criteria and the complexity of salmon and their recovery, and given limitations of available funding for monitoring, the State of Washington will need to work with all salmon recovery partners to prioritize and sequence what is monitored and at what intensity in a statewide adaptive management approach. If funding were sufficient, it would be possible to measure all of the things shown in the diagram which would provide knowledge desired at all biological and geopolitical levels of interest (population, regional recovery region, ESU, etc.). Funding is limited however, and there is a need to find a balance between VSP fish monitoring and the status/trends of limiting factors and threats. This FORUM framework identifies a

reasonable approach to monitoring fish abundance, productivity and habitat. Especially important is the use of volunteers and technology.

Efforts are just beginning to develop consistency and data sharing to facilitate project monitoring (implementation and effectiveness monitoring) that is needed for fiscal accountability and adaptive management. However, work on these is too undeveloped to included in this framework.

### Viable Salmonid Populations (VSP) Criteria

The NMFS guidance has emphasized that the decision criteria for delisting at the ESU level will depend upon information available that the aggregate status and change in status of the major population groups (MPGs) in the ESU demonstrate a level of risk, natural sustainability, or probability of persistence sufficient to warrant a change in ESU listing status. NMFS will at their species status reviews, seek to answer the following questions with available information:

- "Are MPGs within the ESU at, or clearly trending toward, a low risk status?"
- "Are primary populations within the MPG at high viability/low risk consistent with recovery plans and Technical Review Team (TRT) recommendations?" A decision about population viability considers the population status indicators (abundance, productivity, diversity, spatial structure) based on TRT recommendations.

### Statutory Listing Factors (Habitat)

Statutory listing factors such as habitat will go through a similar process. Questions NMFS must ask include:

1. "Have statutory listing factors been addressed such that threats to the ESU have been ameliorated to the extent that they no longer pose a threat to the continued existence of the ESU?"
2. "Is the ESU achieving or clearly trending toward a low risk status in response to actions that have been implemented to diminish those factors limiting achievement of ESU viability objectives?" If there are habitat-related effects of limiting factors on observed abundance, productivity, diversity, or distribution of natural-origin fish, what is their significance for population viability?

This framework coordinates how the state can begin to address the VSP criteria on the left portion of the NMFS chart and Limiting Factor 1, the present or threatened destruction, modification, or curtailment of its habitat or range. This framework is a coordinated approach that monitors fish and habitat at complimentary scales and in a manner that will determine whether habitat destruction as a limiting factor is being reduced.

## Statewide Salmon Abundance Monitoring for ESA Salmon De-Listing

Although the Washington Department of Fish and Wildlife (WDFW) and the treaty tribes have monitored many adult salmon and steelhead populations important for harvest management for years, there are many others that have little or no information available. This is particularly true for determining watershed production by enumerating juvenile migrants.

The Salmon Monitoring Framework is a strategy outlined by the FORUM to track salmon abundance and productivity and to relate changes in freshwater productivity to habitat conditions. NMFS and their associated TRTs have identified 28 MPGs and a minimum of 86 primary populations that may require monitoring to effectively assess delisting criteria statewide. The concept driving the Salmon Monitoring Framework is based upon their guidance. The framework seeks to develop "fish in and fish out" specific information for selected primary populations and to

tie this fish abundance information directly to habitat and water quality conditions in those watersheds and the overall Salmon Recovery Region (SRR) and regional planning. It recognizes that it is not economically feasible for Washington to monitor all 86 salmon populations and their habitats at a level of intensity suggested by the criteria laid out under NMFS VSP criteria. Given the limited funding available from both state and federal sources, the state must determine what is the risk versus cost of obtaining less information, but sufficient information collected in a methodical and scientifically defensible approach that can lead to ESA de-listing in the future.

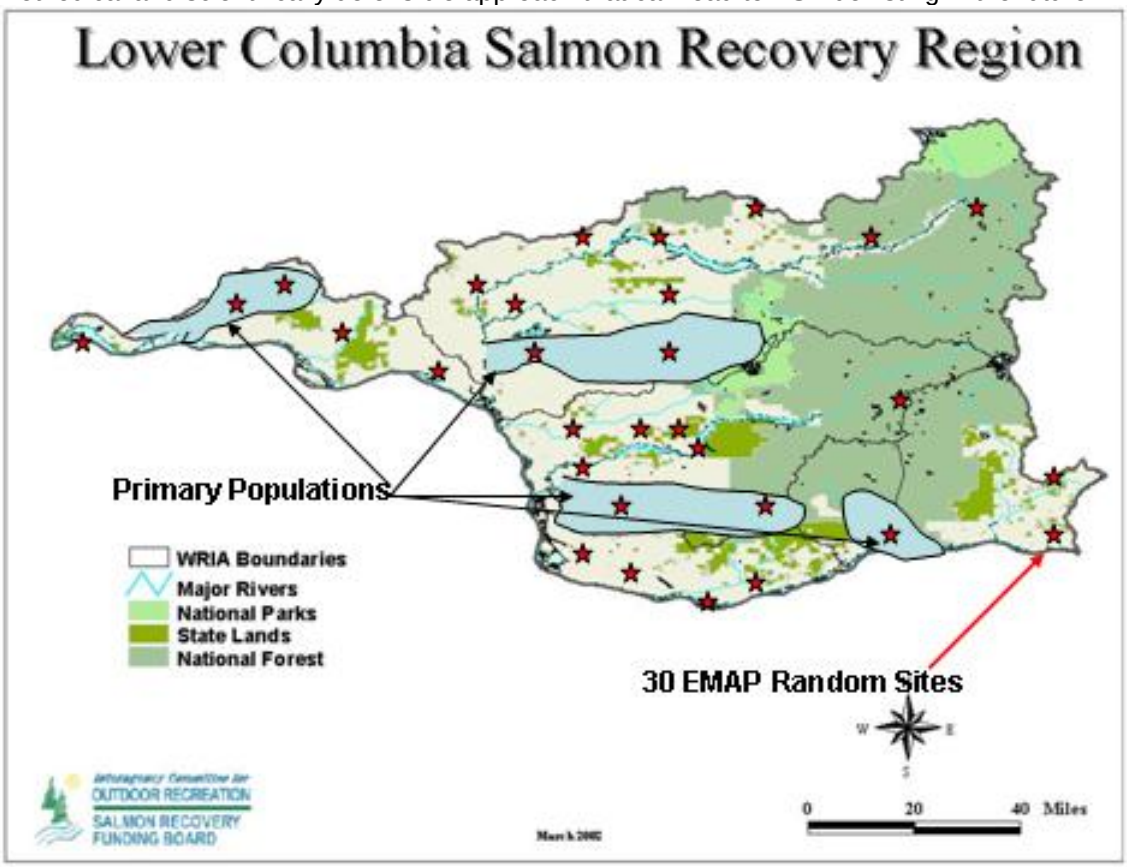


**Figure 2. Illustration of coordinated sampling of primary populations for "fish in" and "fish out" and randomized EMAP habitat sample points across the salmon recovery regions.**

## Simultaneous Monitoring of Juvenile Out Migrants and Adult Spawners

Data on both juveniles and adults should be simultaneously and continuously collected for at least one primary population for each major population group (MPG) within an ESU for all listed salmon statewide. Primary populations are those that must demonstrate low risk of extinction in order to recover the MPG and ESU. The FORUM has developed this statewide Framework that identifies a set of the most important populations, including at least one from each MPG, for monitoring. In total, the salmon framework identifies a cumulative total of 28 major population groups containing a total of 86 primary populations for chinook, coho, chum, and steelhead. The FORUM proposes to monitor juvenile migrants at the mouth of 34 rivers. By monitoring these 34 rivers, Washington will obtain information on 70 of the primary populations requiring monitoring. Currently, juvenile salmon production is monitored for 19 of these rivers. Additional funding is needed to fill gaps to provide juvenile monitoring for 15 rivers identified in the salmon framework. Funding should be provided through a consortium of interests including the state legislature, tribal governments, local governments, and the Bonneville Power Administration. Adult monitoring

gaps have been identified for Lower Columbia Coho. Adaptive management questions answered include:

- What is the status and trends in productivity of 70 primary populations statewide?
- What is the status and trends in adult spawner abundance for 70 primary populations statewide?
- What is the status and trends in juvenile migrant abundance for 70 primary populations statewide?
- What is the status and trends of fish abundance and productivity in 28 MPGs statewide?
- What is the status and trends of fish abundance and productivity in all ESA listed chinook, coho, and steelhead ESUs statewide?

Table 1 reflects the locations where it is feasible to collect fish in and out information and collected with the greatest number of primary populations encountered. To view the status of spawner abundance and juvenile migrant information for Washington please consult the Appendix.

**Table 1. Listing of targeted watersheds for fish-in and fish-out monitoring. It describes the current juvenile monitoring status and who is performing it. A watershed may have more than one listed species therefore having more than one primary population.**

| Salmon Recovery Region | Targeted Primary Watersheds For Juvenile Trapping | Number of primary populations within the watershed | Current Juvenile Trapping Status |
|---|---|---|---|
| Puget Sound | Nooksack | 2 | Yes - Tribal |
| | Skagit | 6 | Yes - WDFW |
| | Stillaguamish | 2 | Yes - Stillaguamish Tribe |
| | Skykomish | 1 | Yes - Tulalip Tribe |
| | Snoqualmie | 1 | Yes - Tulalip Tribe |
| | White | 1 | No |
| | Nisqually | 1 | No - State budget request |
| | Skokomish | 1 | No |
| | Dosewallips | 2 | No - State budget request |
| | Hamma Hamma | 1 | Yes - USFWS funded |
| | Elwha | 1 | Yes - Lower Elwha Tribe |
| | Dungeness | 1 | No - State budget request |
| Coast | Ozette | 1 | Yes - Makah Tribe |
| Lower Columbia | Grays | 3 | No - State budget request |
| | EF Lewis | 5 | No - State request |
| | Cedar Creek-NF Lewis | 2 | Yes - Ongoing SRFB Funding |
| | Kalama | 4 | Yes - WDFW Federal Funds |
| | Cowlitz | 3 | Yes - Tacoma City Light |
| | Coweeman | 3 | No - NPCC Proposal |
| | Toutle | 4 | No |
| | Mill | 1 | Yes - SRFB |
| | Wind | 2 | No - NWPCC Proposal |
| | Duncan Creek | 1 | No - NWPCC Proposal |
| Middle Columbia | Klickitat | 1 | Yes - Tribal/BPA |
| | Yakima | 3 | Yes - Tribal/BPA |
| | Touchet | 1 | No - State request |
| Upper Columbia | Wenatchee | 2 | Yes - PUD-Fed |
| | Entiat | 2 | Yes - USFWS |
| | Methow | 2 | Yes - PUD |
| | Okanogan | 1 | Yes - Tribal BPA |

| | | | |
|---|---|---|---|
| Snake | Tucannon | 2 | No - NWPCC Proposal |
| | Walla Walla | 1 | Yes - Umatilla Tribe |
| | Asotin | 2 | No - NWPCC Proposal |
| | Grand Ronde | 4 | No - State budget request |
| **Total** | **34** | **70** | **15 traps need funding** |

It is important to note here that, as we move into the follow sections, these efforts are not mutually exclusive to meeting goals and objectives. A holistic approach that includes adequate monitoring of both the biological (fish) and physical (listing and threats) elements is compulsory. Monitoring of fish populations and habitat health are equally important, and as efforts progress, improved project monitoring can be added to enable adaptive management and increased fiscal accountability. Finally, the FORUM is working to identify and eliminate monitoring activities that provide no benefit to the resource or the goals and objectives of the FORUM, Governor, Legislature and to the species populations themselves.

### Fish Sampling Protocols

Fish sampling protocols have been subject to wide variations and adaptations by field biologists. Recent activities sponsored by the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and EcoTrust have resulted in the Salmonid Field protocols handbook now in press.

## Habitat Monitoring Framework

In 2005, the Governor's FORUM on Monitoring Salmon Recovery and Watershed Health sponsored a workshop to determine whether high level indicators of salmon recovery and watershed health reported biennially in the Washington State of Salmon in Watersheds Report could be improved. It was concluded, and later affirmed by subcommittees of experts, that there is no current habitat evaluation program in practice today that can provide the status and trends necessary to inform the public and meet federal ESA recovery purposes, in contrast to existing efforts to monitor fish populations. Thus, the essential question remains whether habitat necessary for salmon is improving. It was also concluded that the state ambient monitoring program for water quality does not adequately typify water quality conditions over the landscape, but is useful for measuring trends at selected locations. In response to recommendations from the FORUM, the Washington State Salmon Recovery Funding Board (SRFB) provided funds to the Department of Ecology (Ecology) to produce a habitat monitoring framework to be used in addressing large data gaps for Washington currently existing in evaluating habitat and water quality. The concept is consistent with PNAMP which has recommended a regional monitoring framework using multiple jurisdictions and funding sources to complete the needed geographic coverage. The document, *"Status and Trend Monitoring for Watershed Health and Salmon recovery, Quality Assurance Monitoring Plan (2006)"* publication 06-03-203 can be accessed at the Ecology website at http://www.ecy.wa.gov/biblio/0603203.
The habitat framework relies upon remote sensing and instream and riparian sampling. The habitat framework has the following characteristics.

- It provides status and trends of land use and land cover using remote sensing.
- It provides a probability-based sampling framework that can be used at the state, SRR, and Water Resource Inventory Area (WRIA) scales by all levels of government and volunteers to assess the conditions of the state's aquatic resources.
- Initiates a sampling site selection process that provides a minimum of 80% confidence in the estimated status of wadeable and non-wadeable rivers and streams.
- Identifies the specific indicators that will be monitored as well as the protocols used to measure them.

- Incorporates existing information and monitoring data, where possible, into the assessment.
- Develops partnerships with other agencies, local governments, and volunteer groups to implement the monitoring plan or share data.

## Remote Sensing

The WDFW should acquire high altitude satellite imagery to compare changes in land conversion, impervious surfaces, and floodplain area for each SRR and ESA MPG in the state. Aerial photos would be used to generate a total census of the status and trends in riparian vegetation type and cover, roads, stream crossings, and where possible river channel morphology and large woody debris for at least one listed primary salmon population per major population group in each recovery region. Aerial photography monitoring would be done where there are complimentary salmon productivity (i.e., fish in-fish out) data and where local groups want to do monitoring. Remote sensing data provides "big picture" metrics of land use changes and avoids intrusion into private property. Remote sensing, however, cannot measure water quality, stream sedimentation and other parameters needed to quantify some aspects of watershed health. Therefore, a combination of remote sensing and on-the-ground probabilistic sampling is necessary. This will complement ongoing US Forest Service actions on federal forestlands in Washington where the Aquatic Resource Effectiveness Monitoring Program (AREMP) and Pacific Intermountain Biological Opinion (PIBO) sampling programs are using satellite imagery to typify forest seral changes and roads on the national forests. Satellite imagery provides low cost answers to large scale questions of habitat change in Washington. Monitoring questions answered include:

- What is the status of land cover and land use (agriculture, forestry, urban)?
- What are the trends in land cover and land use (agriculture, forestry, urban)?

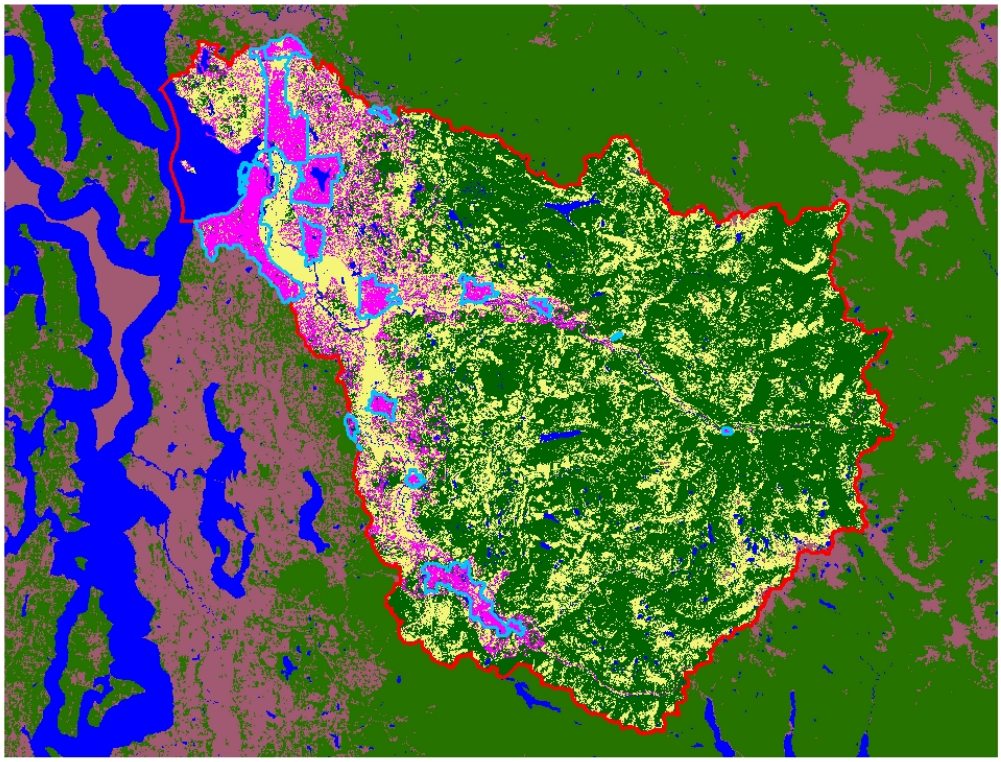

**Figure 3. Landsat view of forest cover Snohomish River basin**

## Habitat and Water Quality Status and Trends – On-The-Ground Sampling

The Salmon Recovery Regions can collaborate with WDFW, Ecology, and private industry to identify available local resources to conduct on-the-ground fieldwork. Partners may include local Regional Fisheries Enhancement Groups, conservation districts, municipalities, counties, private corporations, state agencies, and others having expertise and interest in participating in the monitoring activity. Salmon require clean gravel, cool water, hiding cover from down logs, food organisms, and a variety of stream structures for their various life history stages. On-the-ground sampling will collect physical, chemical, and biological data that will enable the SRRs and state to detect changes in water quality, changes in in-stream sedimentation, hiding cover, and stream structure essential to salmon, and changes in fish distribution and composition. In addition, changes to stream bank vegetation and structure can also be documented. The measures serve to track the status/trends not only in salmon habitat and water quality, but also monitors distribution of many invasive species and addresses biodiversity along our rivers and streams. Adaptive management questions answered include:

- What is the status/trend of stream water quality by WRIA, Salmon Recovery Region, and statewide?
- What is the status/trend of riparian stream vegetation by WRIA, Salmon Recovery Region, and statewide?
- What is the status/trend of stream physical characteristics (sedimentation, hiding cover, and stream structure) by WRIA, Salmon Recovery Region, and statewide?
- What is the status/trend of the distribution of native and exotic fish and invertebrates by WRIA, Salmon Recovery Region, and statewide?

It should be noted that this sampling does not provide information on pesticides, toxins, and other water quality issues of concern for watershed health and salmon recovery.

“On-the-ground” monitoring focuses on streams and rivers projected on a 1:24,000 scale hydrography coverage using Environmental Monitoring and Assessment Program (EMAP) sampling techniques. EMAP is a research program developed by the USEPA to develop the tools necessary to monitor and assess the status and trends of national ecological resources. It provides for sampling at a scale that provides statistically sound evaluation without measuring everything everywhere. EMAP has developed protocols for indicators to monitor the condition of ecological resources. EMAP also developed sampling designs that address the acquisition, aggregation, and analysis of multi-scale and multi-tier data.

EMAP design employed in the framework makes inferences about the habitat within WRIAs and Salmon Recovery Regions with +/-10% precision with 80% confidence. Data required to make these inferences would be collected over a five year period using a probabilistic rotating six panel sampling design. The panel design is shown in Figure 4 below.

## Site sampling rotation by Salmon Recovery Region

| Year | PS | Lower Columbia | Mid Columbia | Upper Columbia | Snake | Wa Coast | NE WA | Unlisted WA |
|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 5 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 9 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 13 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 17 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 21 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |
| 22 | 1 | 1 | 30 | 30 | 1 | 1 | 1 | 1 |
| 23 | 1 | 1 | 1 | 1 | 30 | 30 | 1 | 1 |
| 24 | 1 | 1 | 1 | 1 | 1 | 1 | 30 | 30 |
| 25 | 30 | 30 | 1 | 1 | 1 | 1 | 1 | 1 |

Same site sampled annually per SSR for trend

30 random sites sampled in each SRR every four years for status

**Figure 4. Sampling design for assessing habitat conditions of streams within each SRR. SRR status available every four years. Trend (3 data points) in instream and riparian habitat available after nine years.**

Sites have been selected from a master sample of site locations developed for this framework and available for anyone wishing to participate in the overall statewide approach. A sample drawing is merely a list of latitude and longitude positions along the stream segments within the SRR and WRIA. Each sample site has been selected randomly but stratified by stream size so that there is equal representation. Over 22,000 sites have been identified statewide. The master sample draw is available via the Internet at http://www.ecy.wa.gov/programs/eap/stsmf/ for any participating partner who wishes to begin sampling habitat in their area of interest.

**Table 2. A portion of the existing sample draw for Cowlitz WRIA 28.**

| WRIA Number | WRIA Name | Site ID | Latitude | Longitude |
|---|---|---|---|---|
| 28 | Cowlitz | WAM06600-000029 | 46.45061996 | -122.6503033 |
| 28 | Cowlitz | WAM06600-000041 | 46.33578164 | -122.8891076 |
| 28 | Cowlitz | WAM06600-000073 | 46.26910571 | -122.5425068 |
| 28 | Cowlitz | WAM06600.000117 | 46.22642802 | -122.2984985 |
| 28 | Cowlitz | WAM06600-000121 | 46.38159912 | -122.5077361 |
| 28 | Cowlitz | WAM06600-000125 | 46.55288221 | -122.3404624 |
| 28 | Cowlitz | WAM06600-000141 | 46.44425792 | -122.2414204 |
| 28 | Cowlitz | WAM06600-000146 | 46.62623092 | -122.3924478 |
| 28 | Cowlitz | WAM06600-000229 | 46.1978947 | -122.5582835 |

## Sampling Protocols for Habitat

A uniform framework with multiple agencies participating can only produce information usable and comparable across jurisdictions if common protocols are used. Accepted protocols have been in existence for many years for those scientists evaluating water quality. The protocols have been published through the "Standard Methods for the Examination of Water and Wastewater" sponsored by the American Waterworks Association and the Water Environment Federation. This has not been the case with habitat evaluations. There are numerous protocols in use and field biologists have been reluctant to subscribe to any one protocol. Johnson et al (2002) published a list of habitat protocols as a first step in helping to guide scientists toward standardization of protocols.

PNAMP sponsored a protocol comparison in 2005 of seven commonly used Pacific Northwest watershed condition protocols. The preliminary results of that comparison indicate that the following protocols produce reproducible information with adequate precision sufficient to be used for large scale comparisons across Washington jurisdictions in determining stream health:

- US EPA EMAP Protocols published by Peck et al. (2003 )
- US Forest Service AREMP protocols (AREMP 2006)
- US Forest Service PIBO protocols (Heitke et al. 2006)
- Upper Columbia River Protocols (Hillman 2006 )

The other protocols tested contain attributes that are measured well and are repeatable, but are less comprehensive. By stream health it is meant that if the total number of measured stream attributes are summed in some fashion, then the results of the above protocols will be comparable. Individual attributes such as stream sinuosity or bank full width may vary among the protocols in precision and variance, and if only sinuosity were to be studied then one protocol may be better.

The FORUM envisions that the Salmon Recovery Regions would collaborate with WDFW and Ecology to identify available local resources to conduct on-the-ground habitat fieldwork. The

CMS identified USEPA EMAP protocols as the preferred field sampling protocol. However, partners could be using any of the four protocols shown above and obtain comparable results. Partners may include local regional fisheries enhancement groups, conservation districts, municipalities, counties, private corporations, state agencies, and others having expertise and interest in participating in the monitoring activity. EMAP sampling identified here will provide approximately 60 randomly selected, representative sample points across two Salmon Recovery Regions per year. The sampling will be conducted using the randomly selected sampling locations developed by Ecology for the SRFB, and through the use of EMAP sampling protocols developed by the USEPA. Ecology will ensure that quality control measures and training needs are met among the various participants.

Together, the use of remote Landsat sensing, aerial photography and EMAP random sampling can provide information about all of the habitat limiting factors identified for the ESU's occurring in Washington. In addition, the information obtained from these sampling programs will compare directly with data being collected by the US Forest Service and Bureau of Land Management on federal lands in Washington.

# Framework Relationship to Existing Regional Monitoring Efforts

Regional recovery plans for listed species in Washington contain monitoring and evaluation to support adaptive management. Monitoring and evaluation components in each plan are multi-faceted and address implementation, effectiveness, validation, and status and trends monitoring questions. Monitoring and evaluation provisions in the plans are intended to be consistent with available state and federal guidance (e.g., the Comprehensive Monitoring Strategy (2002), FORUM guidance to the regional salmon recovery organizations (2005), and NMFS guidance). Monitoring and evaluation provisions in virtually all of the plans are currently in the process of being refined with new information and additional detail.

Information on the status and trends of fish and habitat condition is identified in each regional salmon recovery plan. The primary use of the fish information is to track abundance, productivity, diversity, and spatial structure of listed populations in major population groups. The primary use of habitat status and trends information is to track changes in key environmental characteristics associated with identified factors limiting recovery, which must be addressed for delisting to occur. In addition, understanding how habitat is changing over time provides crucial context to evaluate how well the implemented recovery actions in the plans are working. Finally, the framework provides a systematic and efficient approach to help integrate information and evaluate relationships of changes in habitat on fish.

The FORUM's Status and Trends Framework provides a multi-faceted statewide design approach, and identifies primary populations and a hierarchy of sites for on-the-ground sampling. The habitat approach applies to multiple scales of interest – from the very coarse scale (statewide), to a fine scale (e.g., watershed). In total, the framework provides a backbone of minimum design elements for fish and habitat, while providing for more intensive trend sampling at finer scales as funds become available. All information collected via the framework can be incorporated and rolled up to address higher level (regional and statewide) questions.

In summary, the framework design is consistent with, and will assist, regional recovery plan needs. Some regional salmon monitoring efforts, however, may want to implement the framework monitoring design at smaller scales and with a higher sampling intensity, contingent on the availability of additional funding.

## Data

Data sharing is an integral part of a workable framework, and much work remains in this area. One important example of inconsistent data is the hydro layer (river and stream GIS data). Currently, the State of Washington does not have one source for river and stream GIS data. A consolidated WDFW, DNR, and Ecology regulatory data set (stream typing, water quality, fish habitat) is needed. It should be managed and maintained with changes and updates made by all three agencies in one place. This action will affect municipal, county, and other entities relying upon accurate river and stream maps for regulatory and restoration planning and implementation.

There are currently multiple efforts underway to capture field data on both habitat projects and habitat health so that it can be used by multiple jurisdictions. The Conservation Commission is in the process of developing a new system to document conservation district projects, and has worked with IAC to assure compatibility with their database (PRISM) and with the GSRO for use in the State of the Salmon in Watersheds reports. Many databases have begun in the SRRs to track recovery efforts. Some of these are tied to state and federal databases. Continued work needs to take place to enable rollup of information at multiple scales using data portals, web-based GIS layers, and distributed database reporting systems.

## Effects and Risk of Not Implementing This Framework

Failure to implement this framework would force decisions to be based on non-existent, subjective, and/or outdated historical information for a resource that is in constant flux with the changing natural environment. WDFW, the tribes, and NMFS will have no credible basis for evaluating benefits from restoration or conservation plans for salmon and steelhead and for proposing delisting. Data gaps would remain for ten major population groups across the state. De-listing decisions would only be able to rely upon partial survey information, insufficient fishery data, or anecdotal information on population trends. Decisions such as these rarely go unchallenged or successfully and recent history leads us to believe that adjudicated outcomes are not in the best interest of the citizenry, government or the resource.

Without this framework Washington State would have no comprehensive monitoring program in place during the next two years when regional adaptive management and monitoring plans are completed.

It would mean that there would be no habitat status and trend data available to report salmon habitat recovery progress to the Legislature or Congress, putting this already unstable funding stream at further risk and shifting that risk to the states. The absence of reliable quantitative information may jeopardize federal and state funding that is targeted to processes that build community support for salmon recovery and improving watershed health. Reporting of salmon recovery would rely on anecdotal observations of habitat change to assess or describe progress.

Failure to implement this framework will likely delay or preclude subsequent federal NMFS de-listing decisions. Without habitat information that complements the information describing progress on Hatchery, Hydropower, and Harvest management, the federal government will resist delisting salmon even as salmon populations improve because evidence that the listing factors (threats) have been alleviated is a prerequisite for delisting (ESA Section 4(a)(1)).

Water quality status and trends analysis will continue to rely upon existing long-term ambient monitoring sites designed to support the National Pollution Discharge Elimination System (NPDES) and Total Maximum Daily Load (TMDL) programs. These stations are not intended to be representative of overall watershed conditions and are therefore inappropriate for deriving estimates of statewide or regional water quality under the USEPA Clean Water Act requirements.

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# Appendix

# Washington State Framework for Monitoring Salmon Populations Listed under the Federal Endangered Species Act and Associated Freshwater Habitats

Produced by

The Governor's Forum on Monitoring Salmon Recovery and Watershed Health

2007

**Table 3. Comparison of NOAA limiting habitat factors and indicators measured on federal and non-federal lands.**

| NOAA Major Habitat Limiting Factor | NOAA Recommended Indicators | USFS-BLM AREMP-PIBO Federal Lands in Washington | FORUM Landsat Statewide Non-federal lands | FORUM Aerial photography Primary Populations only | FORUM EMAP ESU and Statewide |
|---|---|---|---|---|---|
| Degraded Floodplain and channel structure | Trends in land use conversion | Landsat analysis of vegetation, GIS: roads, Landslides (developing model based on topographic features)<br><br>Verify vegetation data at ground sites | Landsat Land use, Land cover | Aerial photos of vegetation, roads, landslides | Verify and calibrate vegetation data at ground sites. |
| | Trends in stream depth-width ratio | • Bankfull width to depth ratio;<br>• Pool frequency, sinuosity, and gradient; Wood frequency;<br>• Percentage of fine sediments; water chemistry data | Not discernible by Landsat | Not discernible by aerial photography | • Bankfull width to depth ratio;<br>• Pool frequency, sinuosity, and gradient; Wood frequency;<br>• Percentage of fine sediments; water chemistry data |
| Degraded riparian forest and LWD recruitment | Trends in land use conversion | Landsat: vegetation, GIS: roads, Landslides (developing model based on topographic features)<br><br>Verify vegetation data at ground sites | Landsat Land use, Land cover | Aerial photos of vegetation, roads, landslides | Verify and calibrate vegetation data at ground sites |
| | Change in land use/land cover | Landsat: vegetation, GIS: roads, Landslides<br><br>Verify Vegetation data at ground sites | Land use, Land cover | Aerial photos of vegetation, roads, landslides | Verify and calibrate remote sensing vegetation data at ground sites. |

| NOAA Major Habitat Limiting Factor | NOAA Recommended Indicators | USFS-BLM AREMP-PIBO Federal Lands in Washington | FORUM Landsat Statewide Non-federal lands | FORUM Aerial photography Primary Populations only | FORUM EMAP ESU and Statewide |
|---|---|---|---|---|---|
| | Classification of large woody debris | large woody debris at ground sites, macroinvertebrates, periphyton | Not discernible by Landsat satellite | Believed to be possible for most streams | large woody debris, riparian vegetation, canopy cover, macroinvertebrates |
| | Trends in transportation impacts-miles of road crossings | GIS: roads, Landslides (developing model based on topgraphic features) | Roads and landslides | Roads and landslides | No<br>Scale too fine. |
| | Trends in riparian vegetation and canopy cover | Landsat vegetation, roads, Landslides<br><br>Riparian vegetation and canopy data at ground sites | Landsat vegetation, roads, Landslides | Trends in riparian vegetation cover type and canopy cover | Riparian vegetation and canopy data at ground sites |
| Estuarine habitat loss and degradation | Trends in riparian vegetation | Not covered | Landsat Land use, Land cover | Aerial photos should be able to determine changes to many habitat parameters | Not covered |
| Nearshore marine habitat loss and degradation | | Not covered | Landsat Land use, Land cover | Aerial photos should be able to determine changes to many habitat parameters | Not covered |
| Sediment routing dysfunction | Trends in water turbidity | Percent fines (at pool tail crests) | Not discernible by Landsat satellite | Not discernible by aerial photos | Yes<br>Percent fines |
| | Trends in soil erosion | Streambank stability; floodplain bare ground assessment | Not discernible by Landsat satellite | Not discernible by aerial photos | Streambank erosion |
| Degraded water quality[1] | Trends in impervious surface | GIS , roads | Landsat Land use, Land cover | Not discernible by aerial photos | No. Scale too fine. |

[1] Departments of Ecology and Agriculture note that pesticides, toxins, and other water quality issues are also important to monitori for salmon recovery.

| NOAA Major Habitat Limiting Factor | NOAA Recommended Indicators | USFS-BLM AREMP-PIBO Federal Lands in Washington | FORUM Landsat Statewide Non-federal lands | FORUM Aerial photography Primary Populations only | FORUM EMAP ESU and Statewide |
|---|---|---|---|---|---|
| | Trends in water temperature | Temperature probes in stream from July to September | Not discernible by Landsat satellite | Not discernible by aerial photos | Yes placement of thermographs |
| Degraded riparian forest and LWD recruitment | Trends in riparian vegetation and canopy cover | Landsat: vegetative cover<br><br>Tree counts, DBH, and cover by species at ground sites | Landsat Land use, Land cover | Aerial photos can determine changes to vegetation and canopy cover | **Yes** |
| Hydrologic alterations | Trends in stream flow | Not covered | Not discernible by Landsat | Not discernible by aerial photos | Not covered |
| | Trends in flow hydrology | Not covered | Not discernible by Landsat | Not discernible by aerial photos | Not covered |
| | Trends in transportation impacts - miles of roads and crossings | GIS: roads, Landslides (developing model based on topographic features) | Not discernible by Landsat | Roads and crossings can be detected | Not discernible with EMAP sites |
| | Trends in water temperature | Temperature probes in stream from July to September | Not discernible by Landsat | Not discernible by aerial photos | **Yes** |
| Impaired Fish Passage Conditions | Miles of newly inhabited spawning grounds | USFS barrier inventory | WDFW barrier inventory | May be possible to detect barriers | Yes. Ground verification of fish presence at EMAP sites |
| Man-made blocks to migration | Miles of newly inhabited spawning grounds | USFS barrier inventory | WDFW barrier inventory | May be possible to detect barriers | Yes. Ground verification of fish presence at EMAP sites |

**Table 4. Description of existing fish in and fish out monitoring in Washington.**

| Statewide Monitoring of listed species - Juveniles & Adults | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Proposed for FY07-09 GF-S Funding* | | | | | | | |
| | | | | | | *Proposed for FY07-09 GF-S and submitted for BPA funding* | | | | | | | |
| | | | | | | *Submitted for BPA funding* | | | | | | | |
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| | | | | | Juveniles | | | | | Adults | | | |
| **Recovery Region** | **Major Population Groups** | **WRIAs** | **Target Species** | **Primary Populations[16]** | **Smolt Sites** | **Production Index[2]** | **Smolt Trapping Agency** | **Funding** | | **Spawners (Stocks)** | **Data Quality[3]** | **Monitoring Agency** | **Funding** |
| Puget Sound | North Sound | 1 to 2 | Chinook | NF Nooksack | Nooksack | Index[4] | Lummi | Tribal | | NF/MF Nooksack | Very Good | | GFS |
| | | | | SF Nooksack | | | | | | SF Nooksack | Very Good | | GFS |
| | | | | | | | | | | Samish/MS Nooksack | Poor | | |
| | | | | | | | | | | | | | |
| | Whidbey Basin | 3 to 7 | Chinook | *Upper Skagit[17]* | Skagit | Yes | WDFW | Federal (Dingall/ Johnson) 50% Seattle PU 50% | | | Good | | |
| | | | | *Lower Skagit* | | | | | | Upper Skagit MS/Tribs | Very Good | | |
| | | | | *Upper Sauk (early)* | | | | | | Lower Sauk | Good | | |
| | | | | *Lower Sauk* | | | | | | Upper Sauk | Excel-lent | | |
| | | | | *Suiattle (early)* | | | | | | Suiattle | Excel-lent | | |
| | | | | *Cascade (early)* | | | | | | Upper Cascade | Excel-lent | | |
| | | | | NF Stillaguamish | Stillaguamish | Yes[4] | Stillaguamish | Tribal | | NF Stillaguamish | Good | | GFS |
| Puget | North | | | SF | | | | | | SF | Good | | GFS |

## Statewide Monitoring of listed species - Juveniles & Adults

*Proposed for FY07-09 GF-S Funding*

*Proposed for FY07-09 GF-S and submitted for BPA funding*

*Submitted for BPA funding*

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| Recovery Region | Major Population Groups | WRIAs | Target Species | Primary Populations[16] | Juveniles: Smolt Sites | Juveniles: Production Index[2] | Juveniles: Smolt Trapping Agency | Juveniles: Funding | Adults: Spawners (Stocks) | Adults: Data Quality[3] | Adults: Monitoring Agency | Adults: Funding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sound | Sound | | | Stillaguamish | | | | | Stillaguamish | | | |
| | | | | Skykomish | Skykomish/ | Yes[4] | Tulalip | Tribal | Skykomish | Good | | GFS |
| | | | | Snoqualmie | Snoqualmie | | | | Snoqualmie | Good | | GFS |
| | | | | | | | | | | | | |
| | Central South Sound Basin | 8 to 11 | Chinook | N/A | Cedar River | Yes | WDFW | Seattle PUD | Cedar | Good | | King Cons Dist GFS |
| | | | | N/A | Bear Creek | Yes | WDFW | King Co. | N Lk Washington Tribs | Good | | King Cons Dist GFS |
| | | | | N/A | Green River | Yes | WDFW | SRF Board | Green R (Duwamish) | Good | | 90% State GFS/ 10% Fed (PST) |
| | | | | N/A | Puyallup | Yes | Puyal-lup | Tribal | Puyallup | Poor (total esc est) | | State General Fund 50% / Tribal 50% |
| | | | | White River | | | | | White River Adult Trap | Good | | GFS 10%/ Tribal 90% |

## Statewide Monitoring of listed species - Juveniles & Adults

*Proposed for FY07-09 GF-S Funding*

*Proposed for FY07-09 GF-S and submitted for BPA funding*

*Submitted for BPA funding*

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| Recovery Region | Major Population Groups | WRIAs | Target Species | Primary Populations[16] | Juveniles: Smolt Sites | Juveniles: Production Index[2] | Juveniles: Smolt Trapping Agency | Juveniles: Funding | Adults: Spawners (Stocks) | Adults: Data Quality[3] | Adults: Monitoring Agency | Adults: Funding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | White River | | | | | White River Spawner Surveys | | | GFS 50%/ Tribal 50% |
| | | | | *Nisqually* | *Nisqually* | *Pro-posed* | *WDFW* | *GF-S* | Nisqually | | | GFS 50%/ Tribal 50% |
| | | | | | | | | | | | | |
| Puget Sound | Hood Canal | 16 | Chinook | N/A | Hamma Hamma River | Index[6] | LLK/HC SEG/ Port Gamble/ WDFW | USFWS (DOI) /Tribal/ State | | Good | | State General Fund (GFS) 90% / LLTK 10% |
| | | | | Skokomish | | | | | Skokomish | Good | | GFS 90%/ Tribal 10% |
| | | | | *Dosewallips* | *Dosewallips* | *Pro-posed* | *WDFW* | *GF-S* | Mid-Hood Canal / Dosewallips | Good | | State General Fund (GFS) 90% / |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | LLTK 10% |
| Puget Sound | | | Summer Chum | Quilcene | | | | | Quilcene | Good | | GFS 100% |
| | | | | *Dosewallips* | *Dosewallips* | *Pro-posed* | *WDFW* | *GF-S* | Dosewallips | Good | | GFS 100% |
| | | | | Duckabush | | | | | Duckabush | Good | | GFS 100% |
| | | | | Lilliwaup | | | | | Lilliwaup | Good | | GFS 100% |
| | | | | Union River | | | | | Union River | Good | | GFS 100% |
| | | | | Hamma Hamma | Hamma Hamma River | Produ ction[1 2] | LLK/HC SEG/ Port Gamble/ WDFW | USFWS (DOI) /Tribal/ State | | Good | | GFS 100% |
| | | | | | | | | | | | | |
| | Eastern JDF | 18 | Chinook | Dungeness | Dungeness River | Produ ction | WDFW | SRF Board | Dungeness | Excel-lent | | GFS 100% |
| | | | | Elwha | Elwha River | Produ ction | Lower Elwha | Tribal | Elwha | Excel-lent | | GFS 80%/ Tribal 20% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summer Chum | Jimmycome-lately | | | | | Jimmycome-lately | | | NOSC 60% /GFS 40% |
| | | | | Salmon/Snow | | | | | Salmon/Snow | | | NOSC 30% / GFS 70% |
| | | | | | | | | | | | | |
| Coastal | Ozette | 20 | Sock-eye | Lake Ozette | Ozette River | Index | Makah | Tribal | Ozette | Excel-lent | | Tribal |
| | | | | | | | | | | | | |
| Lower Columbia | Coast | 25 | Chinook | ***Grays/Chinook Falls*** | ***Grays River*** | ***Proposed*** | ***WDFW*** | ***NPCC BPA, GF-S*** | | | | |
| | | | | Elochoman/ Skamokawa Falls | | *Pro-posed* | *WDFW* | *NPCC/BPA* | | | | |
| | | | | N/A | Mill Creek | Production | WDFW | SRF Board | Mill/Abernathy/ Germany | Good | | SRF Board |
| | | | | | Abernathy Creek | Production | WDFW | | | | | |
| | | | | | Germany Creek | Production | WDFW | | | | | |
| | | | Chum | Mill/Abernathy / Germany | Mill Creek | Production | WDFW | SRF Board | Mill/Abernathy/ Germany | | | BPA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Abernathy Creek | Production | WDFW | | | | | |
| | | | | | Germany Creek | Production | WDFW | | | | | |
| | | | | ***Grays/Chinook Riv*** | ***Grays River*** | ***Proposed*** | ***WDFW*** | ***NPCC BPA, GF-S*** | | | | |
| | | | | *Elochoman/ Skamokawa* | *Elocho/Skamokawa* | *Pro-posed* | *WDFW* | *NPCC/BPA* | | | | |
| | | | Coho | ***Grays/Chinook*** | ***Grays River*** | ***Proposed*** | ***WDFW*** | ***NPCC BPA, GF-S*** | ***Grays River*** | *Pro-posed* | | *NPCC/BPA, GF-S* |
| | | | | *Elochoman/ Skamokawa* | *Elocho/Skamokawa* | *Pro-posed* | *WDFW* | *NPCC/BPA* | | | | |
| | | | | N/A | Mill Creek | Production | WDFW | SRF Board | Mill/Abernathy/ Germany | Very Good[7] | | SRF Board |
| | | | | | Abernathy Creek | Production | WDFW | | | | | |
| | | | | | Germany Creek | Production | WDFW | | | | | |
| | | | | | | | | | | | | |
| Lower Columbia | Cascade | 26 to 28 | Chinook | Upper Cowlitz Springs | Cowlitz Falls | Production | WDFW | Tacoma PUD | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower Columbia | | | | Cispus Springs | | | | | | | | |
| | | | | N/A | Mayfield Dam | Index | WDFW | Tacoma PUD | | | | |
| | | | | *Coweeman Falls* | *Coweeman* | *Pro-posed* | *WDFW* | *GF-S, Mitchell Act* | | | | |
| | | | | Kalama Falls | | | | | | | | |
| | | | | Kalama Springs | | | | | | | | |
| | | | | NF Lewis Falls | Cedar Creek | Index[11] | WDFW | State GFS/ SRF Board | | | | |
| | | | | NF Lewis Springs | | | | | | | | |
| | | | | *EF Lewis Falls* | *EF Lewis* | *Pro-posed* | *WDFW* | *GF-S* | | | | |
| | | | | Washougal Falls | | | | | | | | |
| | | | Chum | *EF Lewis* | *EF Lewis* | *Pro-posed* | *WDFW* | *GF-S* | | | | |
| | | | | Washougal | | | | | | | | |
| | | | Coho | N/A | Cowlitz Falls | Produ ction | WDFW | Tacoma PUD | Upper Cowlitz | NA[8] | | Tacoma PUD |
| | | | | | Mayfield Dam | Index | WDFW | Tacoma PUD | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower Columbia | Cascade | | | Lower Cowlitz | | | | | | | | |
| | | | | SF Toutle | | | | | | | | |
| | | | | NF Toutle | | | | | | | | |
| | | | | ***Coweeman*** | Coweeman | *Pro-posed* | *WDFW* | *GF-S, Mitchell Act* | | | | |
| | | | | N/A | Cedar Creek | Produ ction | WDFW | GF-S, SRFB | Lewis | N/A[5, 9] | | |
| | | | | *EF Lewis* | *EF Lewis* | *Pro-posed* | *WDFW* | *GF-S* | ***EF Lewis*** | ***propo sed*** | | ***NPCC BPA, GF-S*** |
| | | | Steel-head | N/A | Cowlitz Falls | Produ ction | WDFW | Tacoma PUD | Upper Cowlitz winter | NA[8] | | Tacoma PUD |
| | | | | | Mayfield Dam | Index | WDFW | Tacoma PUD | | | | |
| | | | | SF Toutle Winters | | | | | | | | |
| | | | | NF Toutle Winters | | | | | | | | |
| | | | | *Coweeman Winters* | *Coweeman* | *Pro-posed* | *WDFW* | *GF-S, Mitchell Act* | | | | |
| | | | | Kalama Winters | Kalama River | Produ ction | WDFW | Mitchell Act (NMFS-NOAA) | | Excel-lent | | Mitchell Act |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | (NMFS-NOAA) |
| | | | | Kalama Summers | | | | | Kalama winter | Good | | |
| | | | | N/A | Cedar Creek | Production | WDFW | GF-S, SRFB | NF Lewis summer | N/A[5, 9] | | State GFS/ SRF Brd |
| | | | | | | | | | NF Lewis winter | Just start-ing | | |
| | | | | *EF Lewis Winters* | *EF Lewis* | *Proposed* | *WDFW* | *GF-S* | | | | |
| | | | | *EF Lewis Summers* | *EF Lewis* | *Proposed* | *WDFW* | *GF-S* | | | | |
| | | | | Washougal Summers | | | | | | | | |
| | | | | | | | | | | | | |
| | Gorge | 29 | Chinook | N/A | NONE[10] | | | | Wind Tule Fall | Good | | |
| | | | | | | | | | Wind Springs[10] | Poor | | |
| | | | | | | | | | Wind Bright Fall | Poor | | |
| | | | | | | | | | White Salmon Tule Fall | | | |
| | | | | | | | | | White Salmon Bright Fall | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gorge | | Chum | Lower Gorge | Duncan Creek | Production | WDFW | NPCC/BPA | Duncan Creek | | | |
| | | | | | Hamilton Creek | | USFS | Federal: Forest Service | | | | |
| | | | | | Hardy Creek | | USFS | | Hardy Creek | | | |
| | | | Coho | Lower Gorge | | | | | | | | |
| | | | | Upper Gorge | Wind River[11] | Index | WDFW | NPCC/BPA | Bonneville Tributaries | Fair | | |
| | | | Steel-head | Lower Gorge Winters | | | | | | | | |
| | | | | Upper Gorge Summers | Wind River | Production | WDFW | NPCC/BPA | Wind summer | Good | | |
| | | | | | | | | | Wind winter | NONE | | |
| | | | | | | | | | | | | |
| Middle Columbia | Eastslope | 29 to 31 | Steel-head | Klickitat summer | Klickitat River[11] | Index | Yakama | Tribal (NPCC/BPA) | Klickitat summer | | | Tribal (NPCC/BPA) |
| | | | | | | | | | Klickitat winter | | | |
| | | | | | | | | | Rock Creek summer | | | |
| | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yakima | 37 to 39 | Steel-head | Satus Creek summer | Yakima River (Prosser Dam a.k.a. Chandler Juv. Eval. Facility) | Production | Yakama | Tribal (NPCC/BPA) | Satus Creek summer | NA | | Tribal (NPCC/BPA) |
| | | | | Toppenish Creek summer | | | | | Toppenish Creek summer | NA | | Tribal (NPCC/BPA) |
| | | | | Naches summer[20] | | | | | Naches summer | NA | | WDFW 50%; USFS 50% |
| | | | | Upper Yakima summer[20] | | | | | Upper Yakima summer | NA | | Tribal (NPCC/BPA); USBR |
| | | | | | | | | | | | | |
| | Walla Walla | 32 | Steelhead | Walla Walla | Walla Walla[13] | Production | Umatilla | Tribal | Walla Walla summer | poor in WA | CTUIR, WDFW | NPCC/BPA |
| | | | | ***Touchet*** | ***Touchet*** | ***Proposed[15]*** | ***WDFW*** | ***NPCC BPA, GF-S*** | Touchet summer | Fair-index | WDFW | LSRCP+ BPA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Snake | Lower Snake[14] | 33 to 35 | Chinook | Tucannon Spring | Tucannon River | Production | WDFW | NPCC/BPA | Tucannon spring | Good | WDFW | LSRCP/BPA |
| | | | | | | | | | Snake fall | Good | WDFW | LSRCP/BPA |
| | | | | Asotin Spring | Asotin Creek | Production | WDFW | BPA | Asotin Spring | Fair | WDFW | LSRCP/BPA |
| | | | Steelhead | Tucannon Summer | Tucannon River | Production | WDFW | BPA | Tucannon summer | Fair | WDFW | LSRCP/BPA |
| | | | | Asotin Summer | Asotin Creek | Production | WDFW | BPA | Asotin Creek summer | Fair | WDFW | LSRCP/BPA |
| | | | | | | | | Asotin Co. Conservation Dist | | | WDFW | Asotin Co. Conservation Dist//BPA |
| | | | | | | | | | | | | |
| | Grande Ronde | | Chinook | *Wenaha Spring* | *Grand Ronde* | *Index*[19] | *WDFW/ ODFW* | PSMFC | Wenaha Sprnig | Fair | ODFW/ CTUIR | NPCC/BPA |
| | | | Steelhead | *Joseph Summer* | | | | ***NPCC/BPA GF-S*** | Joseph Summer | Fair | ODFW | NA |
| | | | | *Lower Grande Ronde Summer* | | | | | Cottonwood Creek | Fair | WDFW | LSRCP/BPA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Columbia | East Cascades | 45 46 & 48 | Chinook | Wenatchee Spring | Wenatchee | Production | WDFW | Chelan Co PUD | Chiwawa spring | Excel-lent | | Chelan Co PUD |
| | | | | | | | | NMFS-NOAA | Nason Creek spring | Excel-lent | | Chelan Co PUD |
| | | | | | | | | NPCC BPA | Little Wenatchee spring | Excel-lent | | Chelan Co PUD |
| | | | | | | | | | White River spring | Excel-lent | | Chelan Co PUD |
| | | | | Entiat Spring | Entiat | Production | USFWS | Federal (DOI) | Entiat spring | Good | | |
| Upper Columbia | East Cascades | | Chinook | Methow spring | Methow | Production | WDFW | Douglas Co PUD | Methow spring | Excel-lent | | Douglas Co PUD |
| | | | | | | | | | Twisp spring | Excel-lent | | |
| | | | | | | | | | Chewuch spring | Excel-lent | | |
| | | | | | | | | | Lost River spring | Excel-lent | | |
| | | | Steelhead | Wenatchee summer | Wenatchee | Production | WDFW | Chelan Co PUD NMFS-NOAA NPCC/BPA | | Fair | | Chelan Co PUD |
| | | | | Entiat Summer | Entiat | Production | USFWS | Federal (DOI) | Entiat Summer | Fair | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Methow summer | Methow | Production | WDFW | Douglas Co PUD | | | | |
| | | | | Okanogan summer | Okanogan[18] | Production | Okan-ogan Tribe | BPA | Methow/Okan-ogan summer | Good | | Douglas Co PUD |