Identification and Prioritization of Management Decisions, Questions, and Objectives for Lower Columbia River Integrated Status and Trend Salmon and Steelhead Monitoring

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Executive Summary

The primary purpose of the Integrated Status and Trend Monitoring (ISTM) project is to improve integration of existing and new efforts that are intended to address status and trend monitoring needs. As a demonstration effort, it focuses on processes and tools for the development and management of integrated regional strategic action plans or roadmaps for monitoring the status and trends of aquatic habitat, watershed health, and salmon populations (including steelhead). The Lower Columbia River (LCR) area has been chosen for this demonstration project because it is representative of the challenges faced when integrating monitoring across multiple Evolutionary Significant Units (ESU) and Distinct Populations Segments (DPS), between the states of Oregon and Washington, including the operation of the Federal Columbia River Power System (FCRPS) and Bonneville Dam, and federal and tribal management through U.S. v. Oregon and the Pacific Salmon Treaty. Five objectives were identified to meet ISTM project goals including: 1) Identify and prioritize management decisions, questions, and objectives, 2) Evaluate the extent to which existing programs align with these management decisions, questions, and objectives, 3) Identify the most appropriate monitoring design to inform priority management decisions, questions, and objectives, 4) Use trade-off analysis to develop specific recommendations for monitoring based on outcomes of objectives 1-3, and 5) Recommend implementation and reporting mechanisms. The identified monitoring needs from recovery plans and monitoring guidance provided a framework to make informed decisions on where to allocate limited monitoring resources. To this end, we developed a prioritization tool that includes factors such as population recovery priority, current natural origin abundance, the potential for fish in/out monitoring, and special cases identified in the recovery plans along with the prioritization of VSP population monitoring indicators. The tool incorporated spatially explicit information on *both* the priority of the monitoring data and the feasibility/relative expense of obtaining it. This report describes the results of completing Objective 1. It identifies and prioritizes management decisions, questions, and objectives for integrated status and trend monitoring of salmon and steelhead populations in the Lower Columbia River planning domain and the results from the application of the prioritization tool across monitoring filters, VSP indicators, and adult and juvenile life stages at various spatial scales.

Background

Most salmon populations in the Pacific Northwest are currently listed under the Endangered Species Act (ESA). In support of recovery efforts, millions of dollars are spent annually to determine the status and trend of these salmon populations, as well as to evaluate the effectiveness of actions taken to improve their status. With increasing needs for information and decreasing financial resources, there is a need to develop cost-effective, efficient, and coordinated monitoring programs. By taking advantage of past monitoring experiences and developing well-coordinated monitoring approaches, technical and fiscal resources can be more effectively shared among interested parties, data can be shared, and resulting information can provide increased scientific credibility, cost-effectiveness in use of limited funds, and greater accountability to stakeholders (PNAMP 2005).

Many types of monitoring are generally associated with salmon monitoring (MOC 2002, LCFRB 2010a).

- *Compliance monitoring* tracks compliance with rules and laws
- *Implementation monitoring* determines whether actions were carried out as planned
- *Effectiveness monitoring* evaluates whether the actions achieved their desired effect or goal
- *Validation monitoring* is used to establish a "cause and effect" relationship between salmon response and the individual projects or management actions
- *Critical uncertainties monitoring*/*research* verifies the basic assumptions behind effectiveness monitoring and models, prioritization of limiting factors and threats, or any other topic for which assumptions have been made, which if untrue, would significantly alter the actions identified for implementation
- *Status monitoring* is used to characterize existing conditions, establish a baseline for future comparisons, and capture temporal and spatial variability in the parameters of interest
- *Trend monitoring* involves measurements taken at regular time or space intervals to assess the long-term trend in a particular parameter.

The primary purpose of the Integrated Status and Trend Monitoring (ISTM) project is to improve integration of existing and new efforts that are intended to address status and trend monitoring needs (PNAMP 2009). As a demonstration effort, it focuses on processes and tools for the development and management of integrated regional strategic action plans or roadmaps for monitoring the status and trends of aquatic habitat, watershed health, and salmon populations (including steelhead). The Lower Columbia River (LCR) area has been chosen for this demonstration project because it is representative of the challenges faced when integrating monitoring across multiple Evolutionary Significant Units (ESU) and Distinct Populations Segments (DPS), between the states of Oregon and Washington, including the operation of the Federal Columbia River Power System (FCRPS) and Bonneville Dam, and federal and tribal management through U.S. v. Oregon and the Pacific Salmon Treaty (Figure 1). Although numerous entities are involved in monitoring in the LCR, the existing monitoring efforts are not well coordinated, and often lack the spatial coverage, certainty, or species coverage

necessary to answer questions related to status and trends of fish populations across the ESU/DPS.

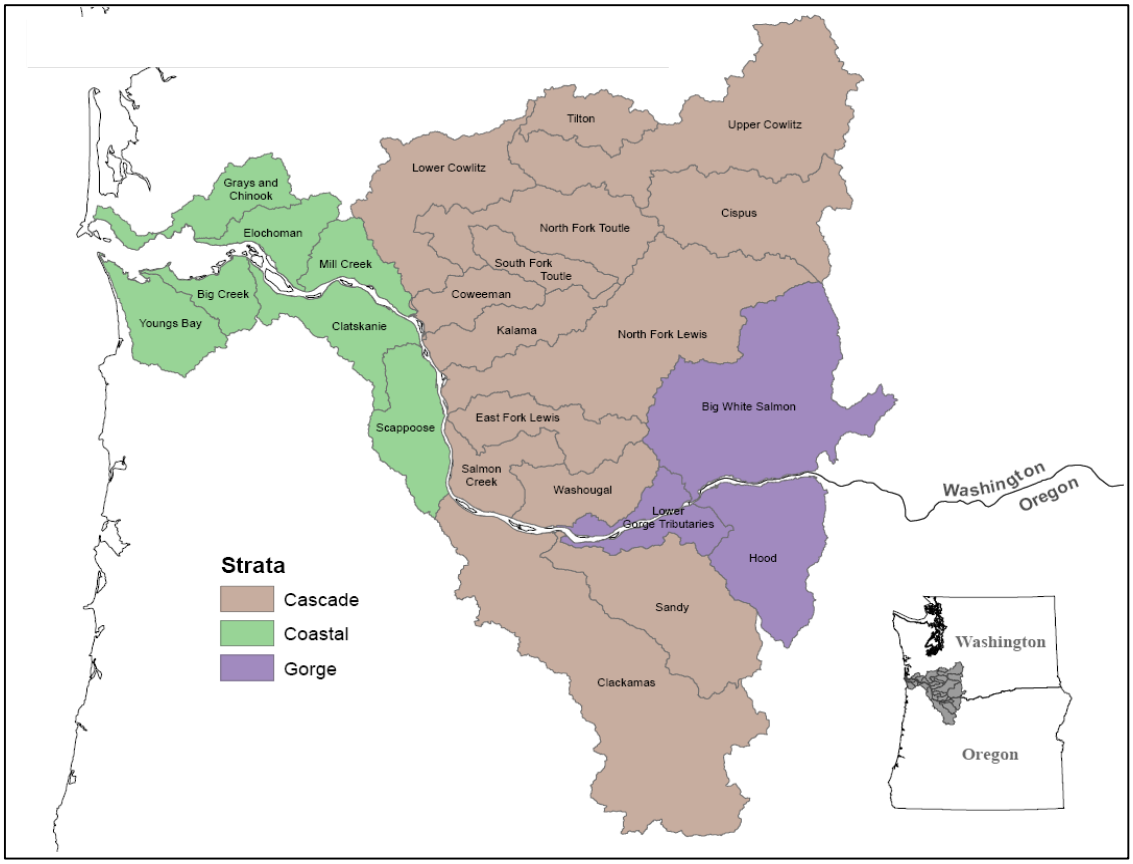


Figure 1. Lower Columbia River pilot project area showing ESA-listed salmon population boundaries and the regional groupings (i.e. strata) in which they occur.

The specific goal of the fish sub-workgroup of the ISTM project is to develop a coordinated Viable Salmonid Population (VSP) monitoring program that addresses key regional (priority) monitoring questions and develops study designs of sufficient quality and quantity to determine status and trend of LCR salmon and steelhead. This will provide entities tasked with monitoring salmon and steelhead populations in the Pacific Northwest with a roadmap of the steps needed to develop an integrated, scientifically sound monitoring program that meets the needs of regional decision-makers and managers. We will apply this approach to develop a specific monitoring plan for ESA listed salmon and steelhead populations in the LCR, concentrating on the monitoring of VSP parameters. VSP monitoring utilizes four primary metrics to assess salmon status: abundance, spatial structure, diversity, and productivity (McElhany et al. 2000). The first three metrics are independent metrics to categorize the abundance of salmon, their distribution, and genetic and life history diversity. The final metric, productivity, is a time series or density dependent cohort analysis based on the abundance and diversity metrics.

We anticipate this project will ultimately lead to a transparent, scientifically credible, and cost-effective fish monitoring program in the LCR, which can be used as a model for the remainder of the Columbia Basin. The following five objectives will be accomplished to meet these goals:

1. Identify and prioritize management decisions, questions, and objectives.
2. Evaluate the extent to which existing programs align with these management decisions, questions, and objectives.
3. Identify the most appropriate monitoring design(s) to inform priority management decisions, questions, and objectives.
4. Use trade-off analysis to develop specific recommendations for monitoring based on outcomes of objectives 1-3.
5. Recommend implementation and reporting mechanisms.

This report describes the results of completing Objective 1 and identifies and prioritizes management decisions, questions, and objectives for integrated status and trend monitoring of salmon and steelhead populations in the Lower Columbia River planning domain.

Connecting Information Needs with Monitoring Feasibility

A frequent flaw in many monitoring programs is failure to adequately identify the reasons why monitoring is being conducted. All too often there is disconnect between the information that decision-makers and managers need to answer their priority questions and what can or will be provided by implemented monitoring programs, and their respective timelines. Reaching consensus on what is needed in the context of what is possible is the key to avoiding this situation. Because it is inevitable that the wish list of information needs will exceed available funding, there is a need to develop a prioritized list of monitoring needs.

To develop priority management decisions, questions, and objectives for monitoring salmon and steelhead populations in the LCR, we reviewed and summarized the different objectives, questions, and decisions from current planning documents that applied to the LCR. These included state of Oregon and Washington Salmon and Steelhead Recovery plans (LCFRB 2010a, LCFRB 2010b, and ODFW 2010) and statewide monitoring documents that identified and prioritized management decisions (MOC 2002; Dent et al. 2005; OWEB 2003; and ODFW 2003). We also reviewed two federal documents which provided monitoring guidance for ESA listed populations and listed priority management questions for the Columbia Basin from the Northwest Power and Conservation Council (Crawford and Rumsey 2009; NPCC 2010).

In addition, we held two workshops on January 28 and March 12, 2010, in Portland, Oregon, with state and federal agency representatives (Table 1). The purpose of the meetings with these biologists, scientists, and policy representatives was to summarize the priority management decisions from these plans and share the process we developed

to prioritize between and among plans, populations, and life stages given our stated highest management priority of integrated status and trend monitoring.

Table 1. List of participants in monitoring priorities meetings.

January 28 Meeting		March 12 Meeting	
Name	**Organization**	**Name**	**Organization**
Jen Bayer (observer)	USGS	Jen Bayer (observer)	USGS
Kasey Bliesner (observer)	ODFW	Jeff Breckel	LCFRB
Jeff Breckel	LCFRB	Brian Allee	NOAA
Brian Allee	NOAA	Pat Frazier	WDFW
Craig Busack	NOAA	Jim Geiselman	BPA
Mark Chilcote	NOAA	Bernadette Graham Hudson	LCFRB
Cedric Cooney (observer)	ODFW	Steve Leider	WA GSRO
Brodie Cox (observer)	WDFW	Paul McElhany	NOAA
Pat Frazier	WDFW	Dan Rawding (moderator)	WDFW
Jim Geiselman	BPA	Jeff Rodgers (moderator)	ODFW
Bernadette Graham Hudson	LCFRB	Scott Rumsey	NOAA
Steve Leider	WA GSRO	Jacque Schei (observer)	USGS
Bruce McIntosh	ODFW	Russell Scranton	BPA
Erik Neatherlin	WDFW		
Sean Quigley (observer)	USGS		
Dan Rawding (moderator)	WDFW		
Jeff Rodgers (moderator)	ODFW		
Scott Rumsey	NOAA		
Jacque Schei (observer)	USGS		
Russell Scranton	BPA		

Summary of Priorities Identified in Current Planning Documents

Oregon Plan for Salmon and Watersheds Monitoring Strategy

The Oregon Plan for Salmon and Watersheds Monitoring Strategy (OWEB 2003) lists three questions that are intended to provide guidance on information needs of the Oregon Plan for Salmon and Watersheds:

- What is the condition and capacity of aquatic habitat and watershed systems?
- What is the benefit of Oregon Plan restoration projects, management practices, and conservation programs relative to adverse impacts and to natural ecosystem variability?
- Does the Monitoring Program provide information and analysis for adaptive review of restoration actions, management practices, and Oregon Plan policies?

To answer these questions the document outlines nine monitoring implementation strategies.

1. Assess status and trends of watershed conditions and salmon populations regionally.
2. Monitor habitat, water quality, biotic health, and salmon, in select watersheds.
3. Analyze habitat, water quality and population trends at the landscape scale.
4. Document conservation and restoration projects, activities, and programs.
5. Evaluate effectiveness of restoration and management efforts locally.
6. Evaluate the combined effectiveness of restoration and conservation efforts in select watersheds.
7. Standardize monitoring collection, management, and analysis efforts.
8. Coordinate and support public-private monitoring and partnerships.
9. Integrate information and produce data products and reports.

Environmental Indicators for the Oregon Plan for Salmon and Watersheds

The report on Environmental Indicators for the Oregon Plan for Salmon and Watersheds (Dent et al. 2005) identifies the need for information on 15 specific environmental indicators of basin condition. The following five indicators from that group are identified as of immediate priority:

- Anadromous fish abundance, distribution, and life histories
- Coldwater Index of Biotic Integrity (IBI) for fish and for macroinvertebrates
- Water Quality Index
- Area, distribution, and types of riparian and wetland vegetation
- Change in land use and land cover

Oregon Department of Fish and Wildlife Native Fish Conservation Policy

The Oregon Department of Fish and Wildlife Native Fish Conservation Policy (ODFW 2003) identifies priorities for monitoring spatially. Highest priority is on species management units having one or more of the following characteristics:

- Listed fish or native fish populations with continued decline or extirpation from significant portion of range.
- New hatchery programs or existing hatchery programs that need substantial change.
- High public interest, economic or other impact on the local community.
- Where efforts will likely lead to significant increase in naturally produced native fish.

It also identifies seven primary evaluation criteria (distribution, adult abundance, diversity, connectivity, survival, population growth, and persistence) and seven potential secondary evaluation criteria (migration & spawn timing, age structure, sex ratios, stray rates, habitat complexity, artificial barriers, and harvest rates.

The policy also states that “Plans shall be developed in collaboration with management partners and the public, … the Oregon Plan for Salmon and Watersheds, as well as other local and regional forums, shall provide the context for development, implementation and coordination of these plans.”

Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead

The Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010) uses the concept of measurable criteria to describe monitoring needed to assess the progress being made toward achieving the conservation and recovery goals of the plan. Measurable criteria are established in the plan for all four VSP parameters. The plan essentially mirrors the recommendations for monitoring described in Crawford and Rumsey (2009) although it does not provide prioritization of the indicators. The plan does provide a listing of critical uncertainty research needs (i.e., information needed to verify the basic assumptions behind effectiveness monitoring and models, prioritization of limiting factors and threats, or any other topic for which assumptions have been made, which if untrue, would significantly alter the actions identified for implementation by the Plan).

Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery

The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery (MOC 2002) listed 24 monitoring questions, 23 management questions, and 62 objectives for salmon recovery and watershed health. The first management question was regarding status and trend monitoring of salmon populations, the next series of questions focused on effectiveness of regulations on addressing ESA threats, and one question addressed the effectiveness of restoration. The highest priority management questions in order from MOC (2002) are:

1. Are salmon populations healthy?
2. Is the State meeting requirements of the Endangered Species Act and Clean Water Act?
3. Are human related activities consistent with salmon recovery?
4. Are harvest activities consistent with salmon recovery?
5. Is the state's approach to cleaning polluted waters adequate to ensure clean water for watershed health and salmon recovery?
6. Are hatchery operations consistent with salmon recovery?
7. Are state and federally-funded habitat protection and restoration projects resulting in improvements in watershed health and salmon recovery?
8. Are current stream and wetland buffer widths protecting habitat to ensure watershed health and salmon recovery?

Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan

The Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (LCFRB 2010b) and its associated Research, Monitoring and Evaluation Program for Lower Columbia Salmon and Steelhead (LCFRB 2010a) identify six key monitoring elements, including: 1) biological status and trends monitoring, 2) habitat status and trends monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. The biological status and trends monitoring element addresses monitoring to evaluate long-term persistence of fish populations. The recovery plan and Research, Monitoring, and Evaluation (RME) program describe strategies and an approach for monitoring VSP attributes across species in the LCR. The recovery plan and RME program also provide a

framework for action effectiveness monitoring within threat categories (habitat, hydropower, fisheries, hatchery, and ecological interactions), as well as highlighting research and critical uncertainty needs within each monitoring element.

Northwest Power and Conservation Council (NPCC) Monitoring, Evaluation, Research, and Reporting Plan

In the draft Monitoring, Evaluation, Research, and Reporting (MERR) plan, the NPCC (2010) identified the following management questions:

1. Are Columbia River Basin fish and wildlife abundant, diverse, productive, spatially distributed, and sustainable?
2. Are Columbia River Basin ecosystems healthy?
3. Are ocean conditions affecting Columbia River Basin anadromous fish?
4. Is climate change affecting fish and wildlife in the Columbia River Basin?
5. Are fish, wildlife and their habitat responding to the implemented actions as anticipated?
6. Are NPCC Program actions coordinated within the Program and with other programs?
7. Are mainstem hydrosystem operations and system configuration improvements meeting the Council Fish and Wildlife Program's survival and passage objectives?
8. Is harvest consistent with the Council Fish and Wildlife Program's vision?
9. Does artificial production complement resident and anadromous fish recovery and harvest goals within the Columbia River Basin?

NOAA Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead

Crawford and Rumsey (2009) provide a guidance document to assist those involved with salmon recovery in understanding the recovery monitoring needs and the associated level of certainty at the regional, local, and project level. It is NOAA's intention that these recommendations will be considered as the desired level of monitoring to be conducted and will provide a consistency across ESU domains. Recommendations include monitoring that addresses all of theVSPcriteria and the listing factors and threats, and for monitoring, data collection, and reporting. A total of at least 74 questions and evaluations from this document can be applied to the LCR recovery domain.

Synthesis of Priority Monitoring Needs in Reviewed Planning Documents

Answering questions related to the status and trend in the health of salmon populations were the highest or among the highest management needs identified in all of the reviewed documents. For example:

- Are salmon populations healthy (MOC 2002)?
- What is the current adult and juvenile population size, productivity, distribution, and life history patterns and trend relative to the recovery objective (LCFRB 2010a)?
- Are Columbia River Basin fish and wildlife abundant, diverse, productive, spatially distributed, and sustainable (NPCC 2010)?

Most of these documents focus on higher level monitoring and do not provide specific and detailed recommendations on the prioritization of VSP parameters between and within populations, reporting time frames, and precision standards that are needed to develop detailed fish monitoring programs. The current NOAA guidance does provide a series of specific prioritized recommendations for estimates of adult and juvenile abundance (including precision goals), estimates of origin (hatchery and wild), age structure, sex ratios, run and spawning time, fecundity, and occupancy rate for adult salmonids, and a power analysis to detect changes in occupancy, and adult and juvenile abundance, but does not provide guidance on prioritization spatially, temporally, or with regards to the level of certainty required for all indicators.

A second priority monitoring need identified in the documents was assessment of the implementation and effectiveness of recovery actions. In other words, are actions being implemented to improve the status of salmon and are those actions actually being effective.

The third priority monitoring need identified in the recovery plans (ODFW 2010, LCFRB 2010a, LCFRB 2010b) is critical uncertainties research to validate key assumptions for monitoring and viability analysis. An example is the use of an expansion factor of 1.6 adults per redd for winter steelhead in the LCR, which is obtained from a WDFW research stream study in Puget Sound. This key assumption is used because adults per redd are not measured for every population in the LCR and in fact there is no information on adults per redd in the LCR. If the actual estimates are closer to 1 or 3 in the LCR this critical assumption could have substantial changes in viability. The need for action effectiveness monitoring and uncertainty research is included in this ISTM effort as special case filters described below.

A final priority need, expressed well in the NOAA (Crawford and Rumsey 2009) and NPCC (2010) documents, is that of data management and reporting. Without it the information does not reach policy makers for those management decisions. Efforts to improve data management are being conducted in conjunction with this ISTM project.

Development of a Monitoring Needs Prioritization and Feasibility Scoring Tool for Lower Columbia River Salmon and Steelhead Populations

Need

The monitoring needs identified above provide a framework within which specific constraints can be evaluated to develop a prioritization tool. In order to make informed decisions on where to allocate limited monitoring resources, a tool is needed that incorporates spatially explicit information on *both* the priority of the monitoring data and the feasibility/relative expense of obtaining it. Both components are needed to avoid one or more of the following:

- Allocating valuable monitoring resources to gather low priority information.
- Implementing monitoring in areas where there is a low chance of success.

- Implementing monitoring in one area that could more cost effectively be obtained in another area.

For example, suppose that you have three candidate populations for implementing life cycle monitoring (i.e. adults in and smolt out). Based on their recovery priority, two of these populations are targeted to be recovered to a high viability level (primary populations), whereas the third is targeted to remain at its current viability level (stabilizing population). Of the two populations targeted for high viability, one has an existing infrastructure (a fish ladder) where, with relatively minimal expense, adult fish could be counted as they pass upstream. In this example, the population targeted for a high viability that has an existing infrastructure for adult trapping might receive the highest priority for limited monitoring funds, followed by the high viability population with no trapping infrastructure, with lowest priority given to the population not targeted for improvement (left at current viability level) that has no existing trapping infrastructure.

Approach

Prior to the first workshop, we developed a preliminary scoring matrix that gave a numerical score by LCR salmon and steelhead population (Myers et al. 2006) for the priority of fish status and trend indicators (Crawford and Rumsey 2009), population recovery priority (LCFRB 2010b, ODFW 2010), and population current status (McElhany et al. 2003). We used this scoring system to demonstrate to the workshop participants various ways of combining the individual scores into a scoring system that provides a view of the relative importance and feasibility of monitoring different fish status and trend indicators across salmon and steelhead populations in the LCR. Based on feedback from the first workshop participants, we revised the scoring system prior to convening the second workshop where participants provided additional recommendations for refining the scoring matrix.

The following describes the individual components of the monitoring prioritization and feasibility scoring matrix that we developed through the workshop process.

Filters

We use the term filters for components of the scoring matrix that can be individually or collectively used in the scoring matrix to provide different perspectives on the prioritization of VSP indicators. These filters, and the scoring system associated with them (where applicable) are described below.

Population: The basic spatial organization level for which priority and feasibility scores are established; based on population delineations of McElhany et al. 2003.

Recovery Priority: Based on recovery target specified in the Oregon or Washington recovery plans (LCFRB 2010b, ODFW 2010).

3 - Primary populations (targeted for high or better viability) are high priority
2 - Contributing populations (targeted for medium viability) are moderate priority
1 - Stabilizing populations (maintain current viability level) are low priority

Rationale: Everything else being equal, more resources would be devoted to populations anticipated to play a major role in recovery than those anticipated to play a minor role. In Washington, primary populations are those that are targeted for a very high or high probability of persistence, contributing populations are targeted for a moderate probability of persistence, and populations with a lower persistence rating are considered stabilizing populations. These have rankings of 3,2, and 1 respectively.

Current Natural Origin Abundance: Based, where possible, on observed spawner abundances. For populations lacking data, professional judgment of local biologists was used.

3 - average of >500 natural origin spawners over last six years
2 - average of 100-500 natural origin spawners over last six years
1 - average of <100 natural origin spawners over last six years

Rationale: It will be difficult to obtain relatively precise estimates of the VSP indicators for populations that are currently functionally extinct or at extremely low abundance levels. When salmon populations exceed 500, there is a reasonable opportunity to achieve adult abundance precision goals using mark-recapture methods. When populations are below 100 spawners, it may be difficult to locate low number of fish in a watershed without a census, which may lead to very imprecise estimates.

In/Out Potential: Based on whether or not there is existing infrastructure (i.e. dams, fish ladders, weirs, etc.) within a population area that is amenable to development of adult or juvenile migrant trapping.

3 - High priority where existing infrastructure and methods allow for unbiased and precise adult and smolt abundance estimates (CV < 15%) for a substantial portion of the population area (>30%)
2 - Moderate priority where existing infrastructure and methods allow for an unbiased and precise adult and smolt abundance estimates (CV < 15%) for a smaller portion of the population area (<30%)
1 - Low priority where existing infrastructure and methods do not allow for unbiased and precise adult and smolt abundance estimates (CV > 15%)

Rationale: One of WLC-TRT recommendations was to monitor juvenile outmigration abundance (smolts) in one primary population per strata. Fish in/out allows survival estimates to be partitioned into freshwater and marine components. The freshwater component allows critical uncertainties and action effectiveness, especially in salmonid response to habitat restoration or productivity responses to major hatchery program modifications, to be addressed. The scoring scale was developed based on the likely precision of the outmigrant estimate for this filter.

Special Case: The need for monitoring based on other management needs (not related to recovery plan priorities) or critical uncertainty research needs (including action effectiveness).

3 –High priority
2 - Moderate priority

1 - Low Priority

Rationale: Monitoring for the status and trend of VSP parameters related to recovery plan priorities will be most cost effective and efficient if, where possible, it is integrated with monitoring that may be conducted for other reasons. These special cases generally involve special efforts identified in the recovery plan. For example, special cases are the re-introduction of chum salmon into Scappoose and Clatskanie populations, reintroduction of anadromous salmonids into the upper Lewis River above the dams, or the establishment of an intensively monitored watershed in Mill, Abernathy, and Germany Creeks to measure fish response to habitat restoration actions.

VSP Indicators

The following describes the VSP indicators and their associated scoring systems. Note that we do not include a specific indicator for productivity because it is a VSP indicator that is derived from other indicators (e.g. recruits and spawners).

Abundance - Fry/Parr:

2 - moderate priority at strata scale for coho and steelhead

1 - low priority for chum and Chinook

Rationale: Monitoring an index of fry/parr abundance is a useful and relatively cost effective tool for evaluating abundance trends for coho and steelhead. It can help to identify potential bottlenecks impacting a population. However, because the ultimate currency on which population viability is measured is adult abundance, monitoring for fry/parr abundance does not rank a high priority compared to monitoring adult abundance.

Abundance - Juvenile Migrants:

3 - High priority if population priority is high

2 – Moderate priority if population priority is moderate

1 – Low priority if population priority is low

Rationale: Monitoring the abundance of juvenile outmigrants (JOM) is an important component of accessing the productivity of a population and the condition of the habitat that supports it. The rankings are linked to the recovery priorities because while important, information on JOM are not explicitly required for all populations and are most useful for populations where significant habitat actions are planned and to estimate marine survival of natural origin fish.

Abundance - Adult Recruits

3 - High priority at population scale for all populations

Rationale: Information on adult recruits (i.e. harvest) is a key component of evaluating population productivity which is a key component of evaluating population viability.

Abundance - Spawners

3 - High priority at population scale for all populations

Rationale: Information on spawner abundance is a key component of evaluating population viability.

Diversity - Age Structure

3 - High priority at population scale for all populations

Rationale: Although the TRT gives information on diversity a lesser weight in viability calculations compared to information on abundance and productivity, information on age structure is required for productivity calculations, which is a key component of evaluating population viability.

Diversity - Migration/Spawning Timing

2 - Moderate priority for all populations

Rationale: Migration timing is an important component of diversity. However, because the TRT gives information on diversity a lesser weight in viability calculations compared to information on abundance and productivity, migration timing is given a moderate score.

Diversity - Sex Ratio

3 - High priority at population scale for all populations

Rationale: Although the TRT gives information on diversity a lesser weight in viability calculations compared to information on abundance and productivity, information on sex ratio is an important component of productivity calculations, which is a key component of evaluating population viability.

Diversity - Origin

3 - High priority at population scale for all populations

Rationale: Although the TRT gives information on diversity a lesser weight in viability calculations compared to information on abundance and productivity, information on age structure, sex, and origin are important components of productivity, which is a key component of evaluating population viability.

Spatial Structure - Fry/Parr Distribution

2 - Moderate priority for strata scale

Rationale: The distribution of juvenile salmon and steelhead can provide an important snapshot of the spatial structure of a population as well as provide insights to habitat conditions. Surveys for juvenile fish are generally less costly than surveys for adult fish and therefore may be a cost effective alternative to distribution surveys for adults. However, as with abundance estimates, because the ultimate currency on which population viability is measured is adult abundance, monitoring for fry/parr abundance does not rank a high priority compared to monitoring spawner distribution.

Spatial Structure - Spawner Distribution

3 - High priority at population scale for all populations

Rationale: The spatial structure of spawners is an important component of status assessments. Although as with diversity, the TRT gives information on spatial

structure a lesser weight in viability calculations compared to information on abundance and productivity, we give spatial structure for spawners a high priority because it is also an important aspect of assessing the overall impact of habitat actions in a population.

Calculations

In addition to generating the prioritization scores for the individual filters and indicators, we developed a series of calculations that allow us to "roll up" the scores to provide rankings at the population level for individual species as well as for all species within a subbasin or drainage area. We gave Recovery Priority twice the weight as the other three filters because of the importance of recovery priority to the success of conservation and recovery plans and we normalized scores by dividing by 5, which is the sum of the weighted recovery priority score, current natural origin abundance score, in/out potential score, and special cases score.

The following outlines these calculations.

Total Species Population Score =
(∑All indicator Scores for a Species & Population) x ((2 x Recovery Priority Score) + Current Natural Origin Abundance Score + In/Out Potential Score + Special Cases Score)/5)

Total Adult Species Population Score =
(∑Adult indicator Scores for a Species & Population) x ((2 x Recovery Priority Score) + Current Natural Origin Abundance Score + In/Out Potential Score + Special Cases Score)/5)

Total Juvenile Species Population Score =
(∑Juvenile indicator Scores for a Species & Population) x ((2 x Recovery Priority Score) + Current Natural Origin Abundance Score + In/Out Potential Score + Special Cases Score)/5)

Total Population Subbasin Score = ∑Total Species Population Scores

Total Adult Population Subbasin Score = ∑Total Adult Species Population Scores

Total Juvenile Species Subbasin Score = ∑Total Juvenile Species Population Scores

Results

Chum Salmon

The chum salmon filters for integrated status and trends monitoring are displayed in Figure 2. As expected priority populations are highly ranked in the recovery priority filter. Only the Grays and Lower Gorge populations have in excess of 500 spawners so

these populations are rated high in the current abundance category. For the fish in/out potential the Grays is ranked highest because existing adult and juvenile monitoring programs are meeting precision goals. Juvenile monitoring of mainstem Columbia River spawners is very difficult, so this score drops to moderate since only Lower Gorge tributaries such as Hamilton, Hardy, and Duncan Creeks can be monitored. Chum salmon reintroduction in Scapoose, Clatskanie, and Duncan, donor stocks from the Grays River and Lower Gorge for reintroduction, and the intensively monitored watershed program in Mill, Abernathy, and Germany creeks (MAG) make up the special cases for chum salmon.

As described above in the VSP monitoring section, we rated adult spawner abundance, recruitment, age, origin, sex, and distribution as the highest priority since all this information is needed to estimate viability curves and persistence probability (Figure 3). The juvenile migrant priority for chum salmon reflected their recovery priority. Since other diversity metrics (age, origin, and sex) were rated highest priority, spawning and migration timing, which is the remaining diversity metric, was rated a moderate priority. The last indicator priority is fry/parr abundance. Since chum salmon emigrate shortly after emergence, this metric would be difficult to collect and provide little additional information and is rated low.

The juvenile, adult, and summary chum salmon scores are listed in Figures 4 to 6. For the reasons mentioned above, the Grays and Lower Gorge provide the highest monitoring opportunity, followed by MAG, Clatskanie, Scapoose, and Elochoman. All other populations remain at a lower priority for routine ISTM monitoring until re-introduction efforts are initiated.

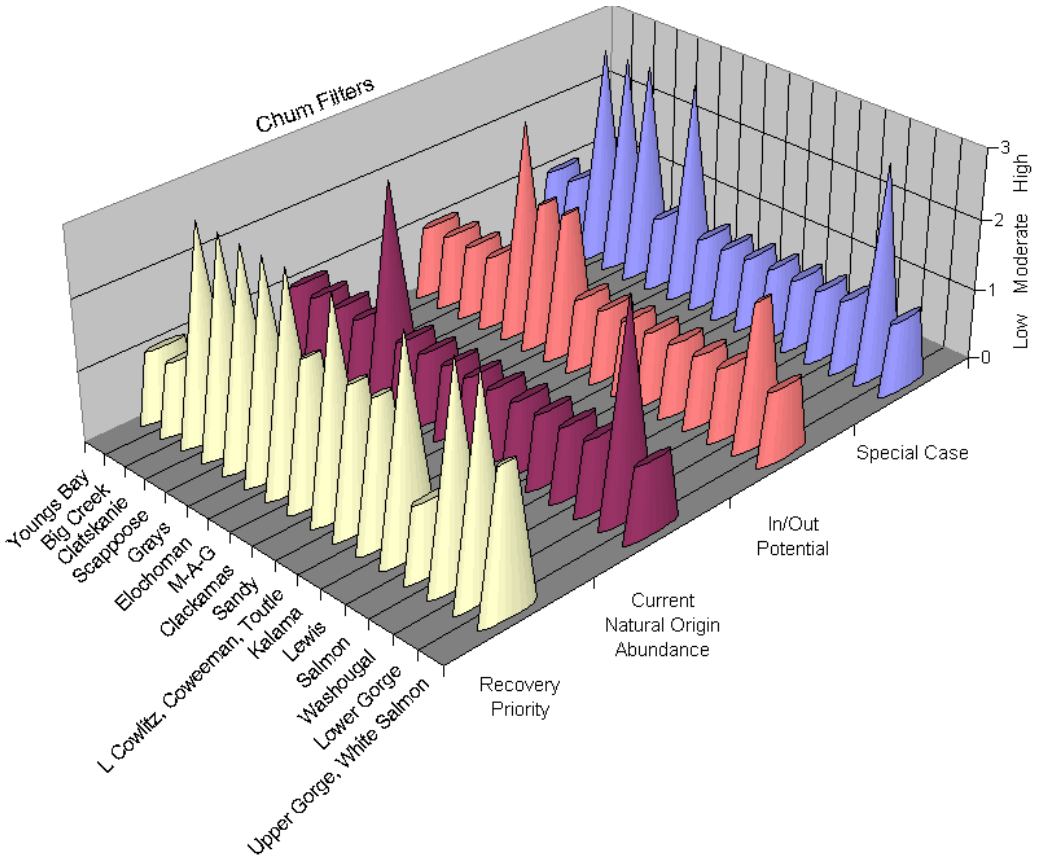


Figure 2. Chum salmon monitoring filter scores.

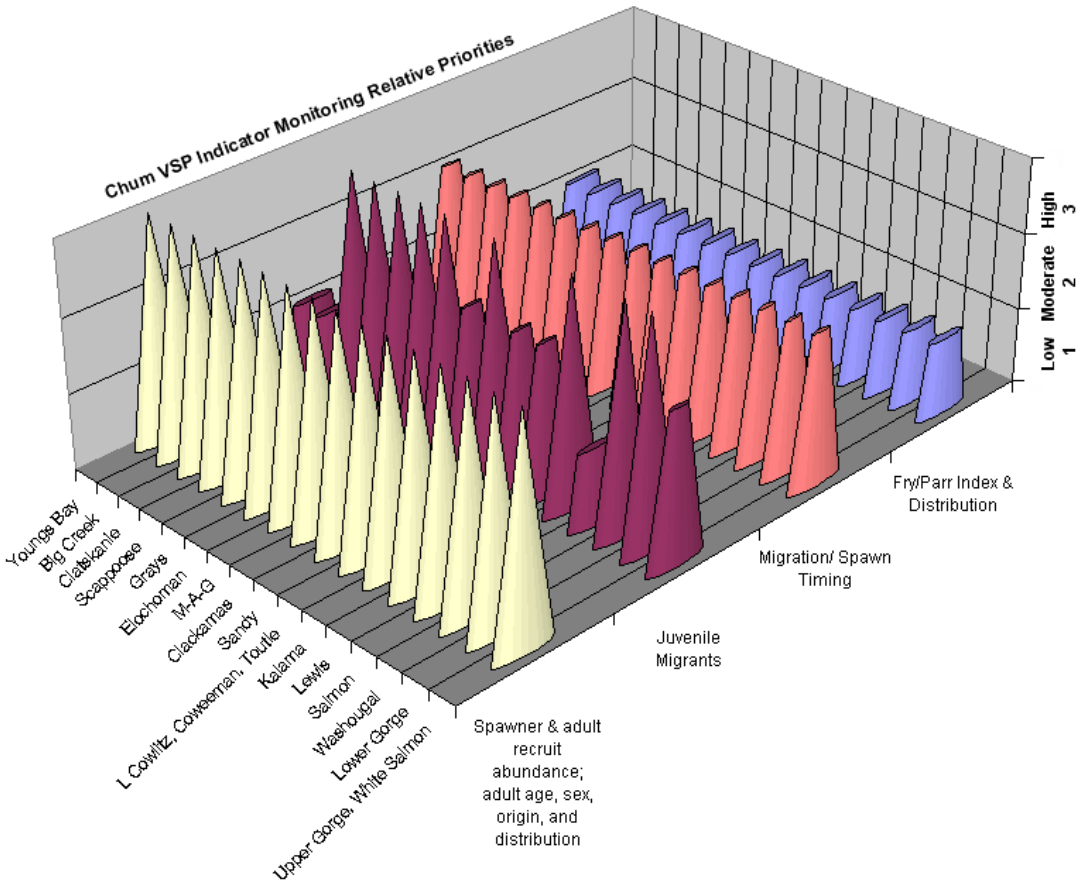


Figure 3. Chum salmon VSP indicator monitoring relative priority scores.

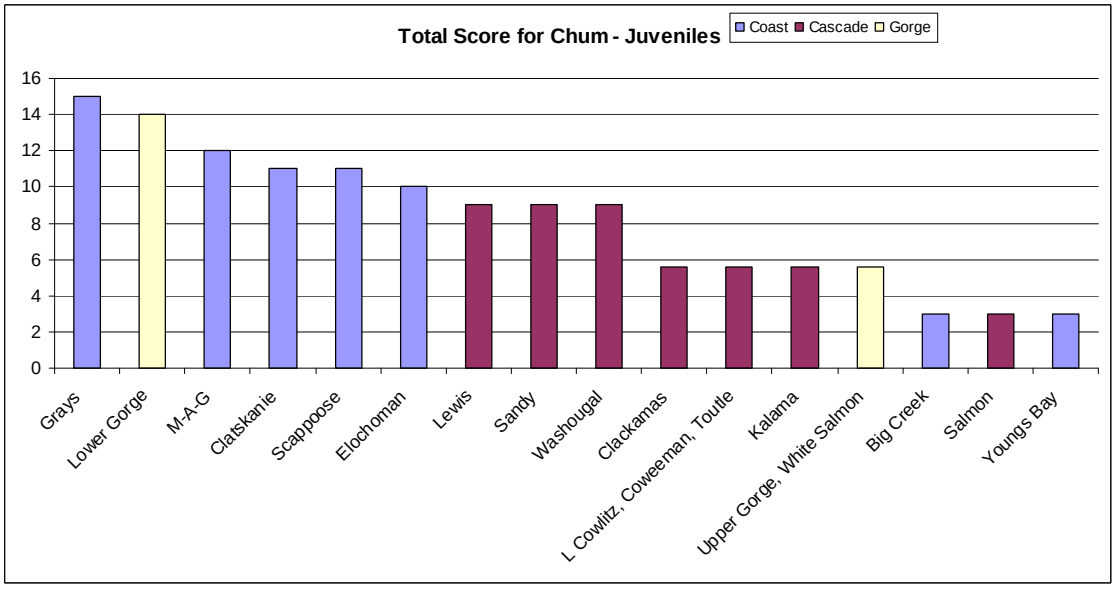


Figure 4. Juvenile chum salmon total scores.

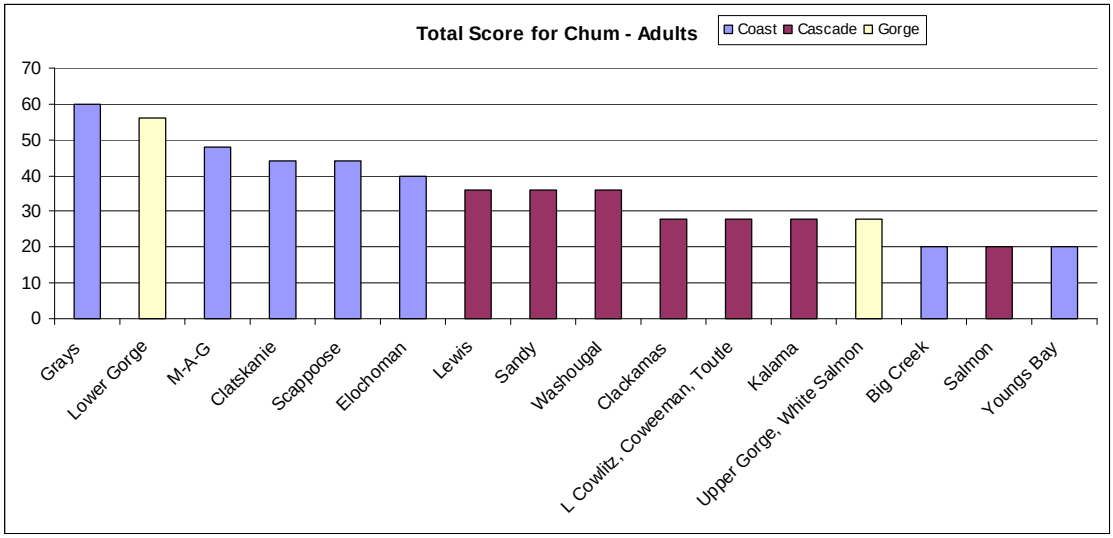


Figure 5. Adult chum salmon total scores.

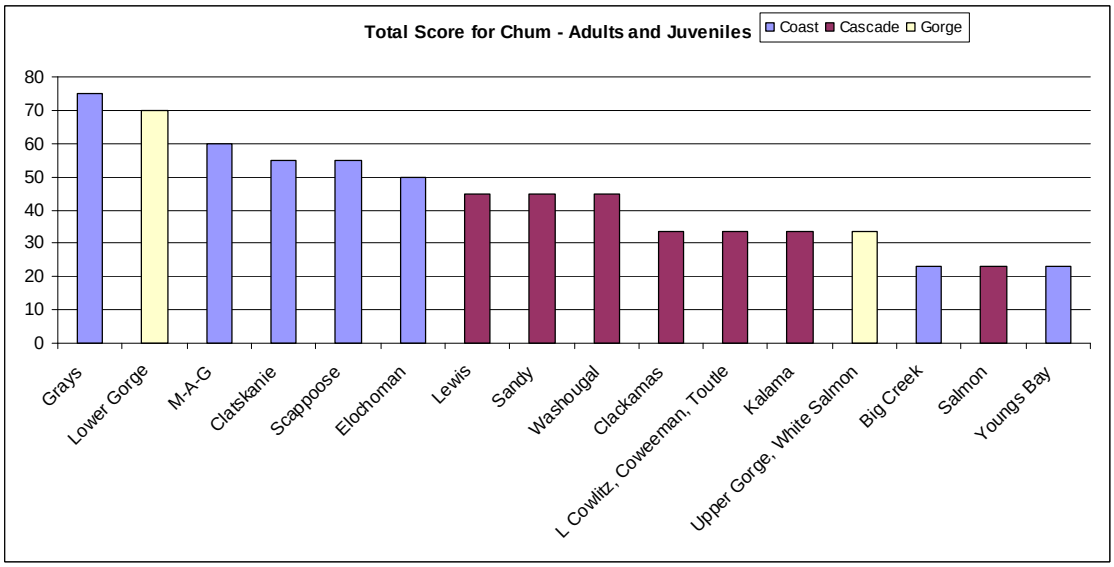


Figure 6. Summary adult and juvenile chum salmon total scores.

Coho Salmon

This species provides a different view of monitoring priorities than chum salmon due to their higher abundance and greater existing monitoring infrastructure. There are more primary coho salmon populations, and many more have current abundance in excess of 500 adults. There are also many more populations with fish in/out monitoring opportunities. Only one special case has been identified for coho salmon, which is the

IMW project in MAG (Figure 7). Figure 8 reflects the basic VSP monitoring strategy by life stage as described for chum salmon except the parr monitoring priority is elevated to moderate due to the yearling life history of this species.

The adult, juvenile, and combined adult and juvenile monitoring priorities are similar (Figures 9-11). The highest priority populations for coho monitoring include the Cispus and Upper Cowlitz, followed by the Clackamas, Clatskanie, Coweeman, and NF Toutle . There are also many populations with a moderate ranking. The lowest priorities for coho monitoring include Salmon, Youngs Bay, Kalama, and Big Creek populations.

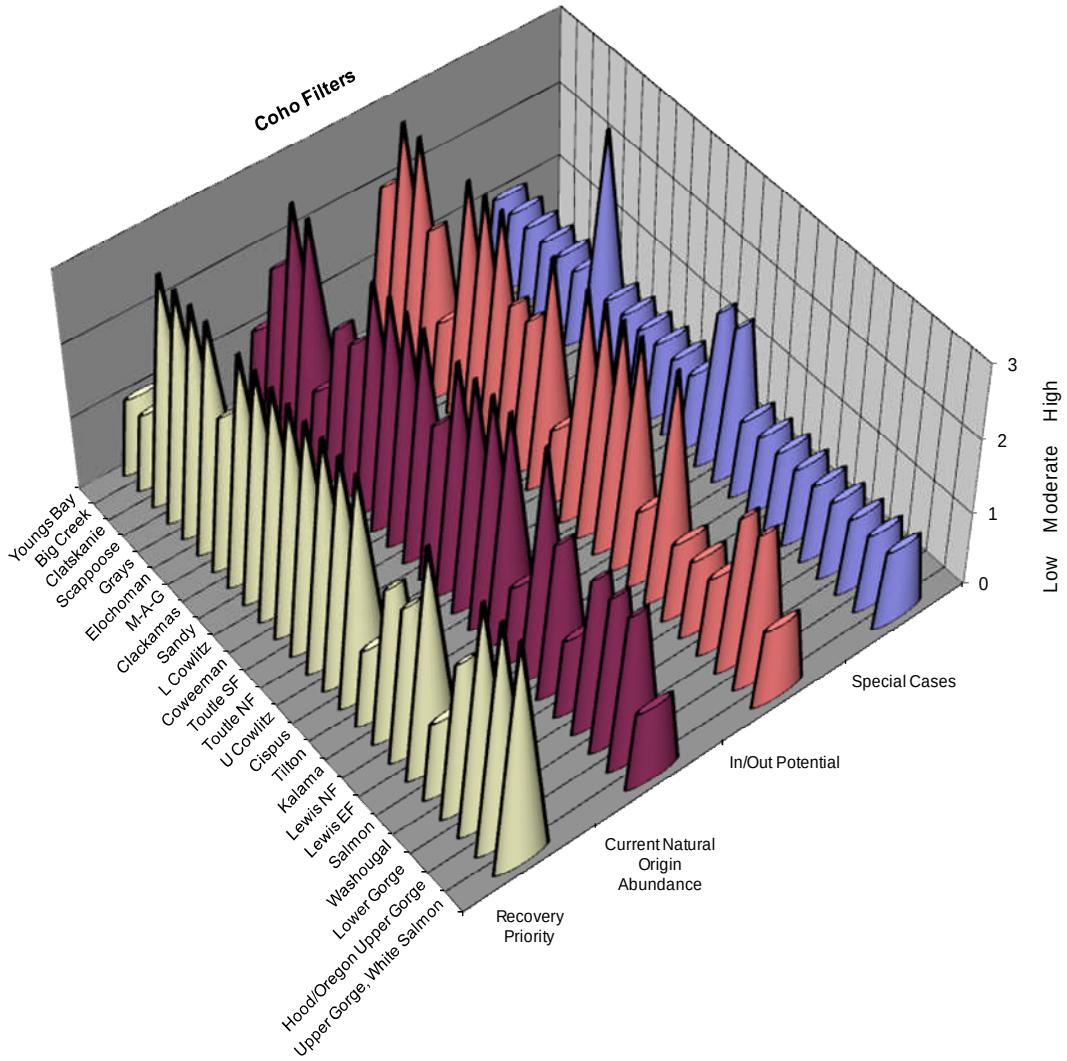


Figure 7. Coho salmon monitoring filter scores.

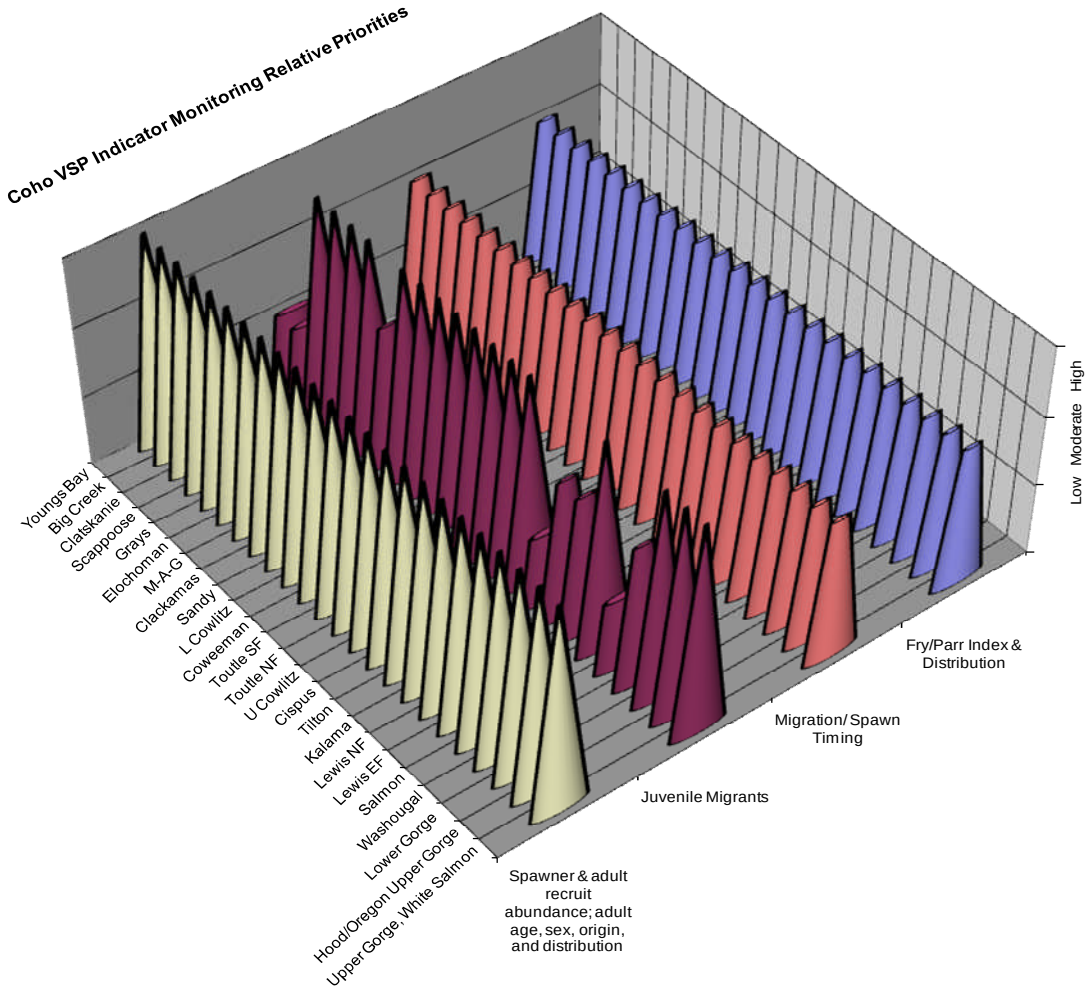


Figure 8. Coho salmon VSP indicator monitoring relative priority scores.

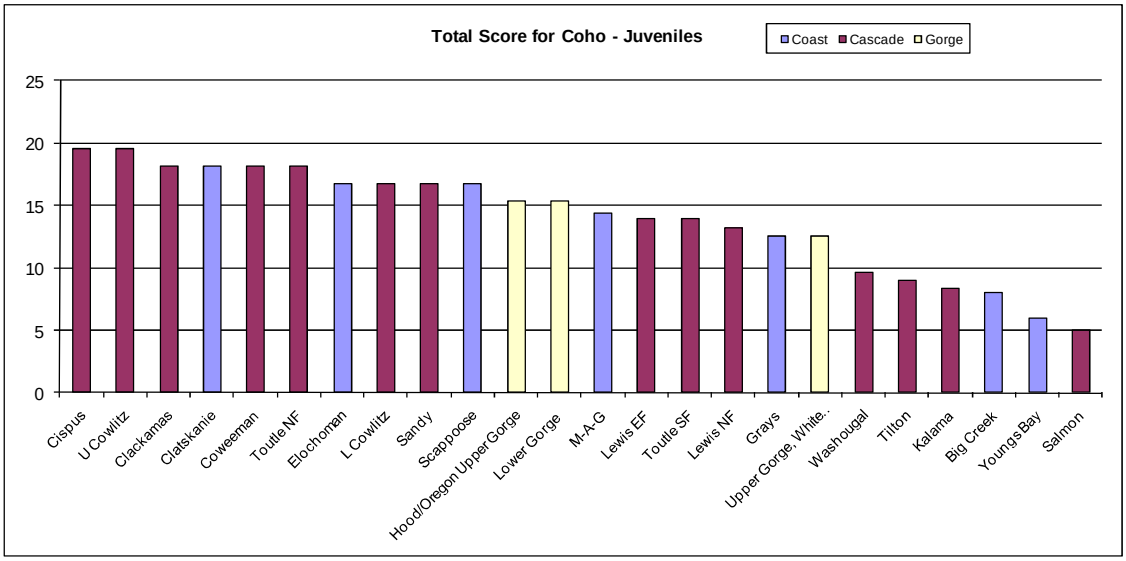


Figure 9. Juvenile coho salmon total scores.

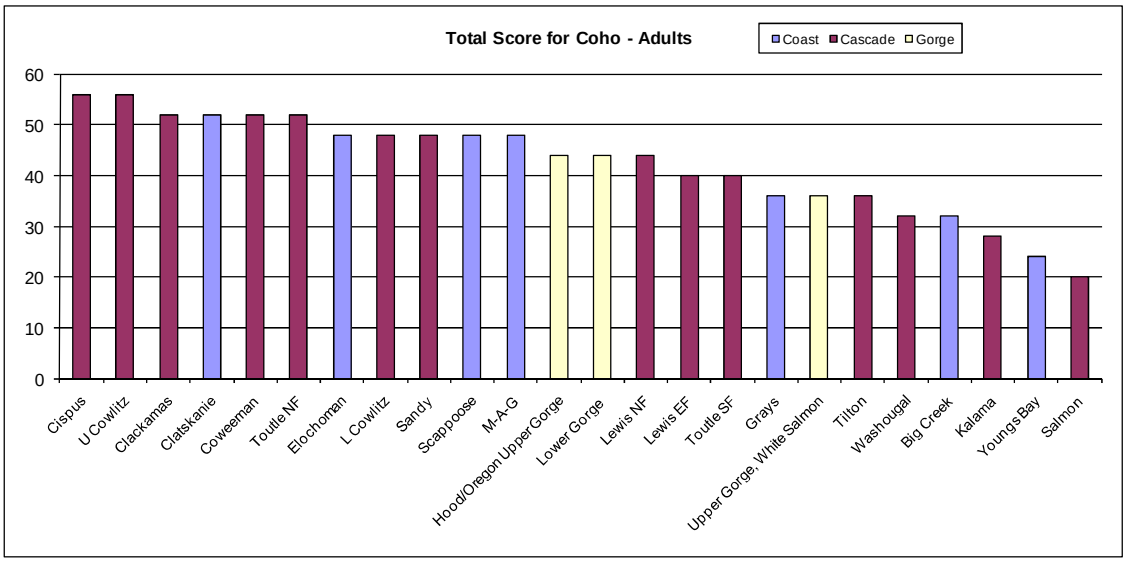


Figure 10. Adult coho salmon total scores.

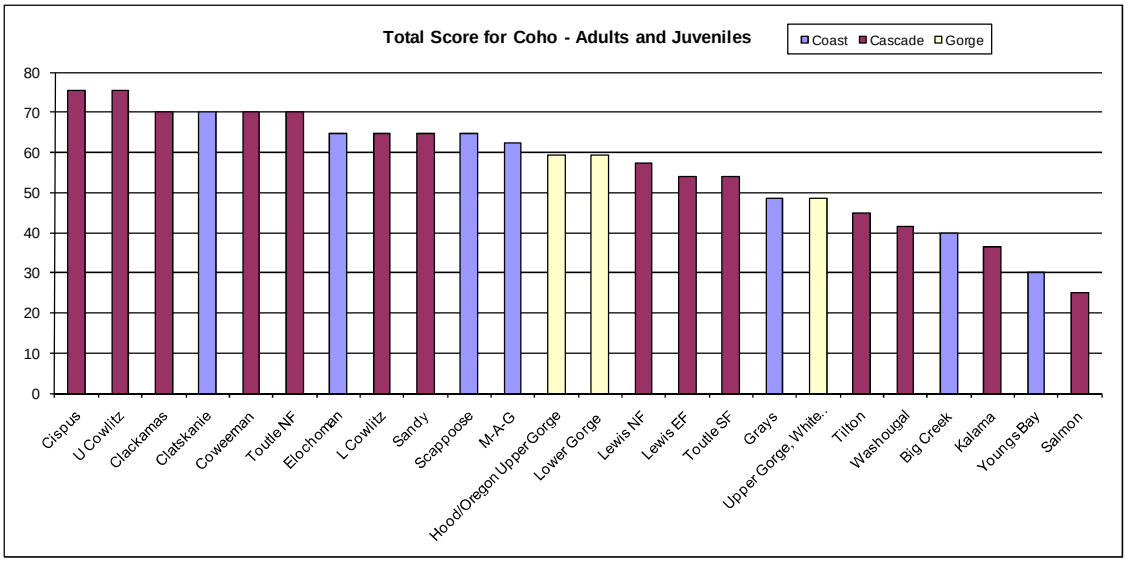


Figure 11. Summary adult and juvenile coho salmon total scores.

Tule Fall Chinook Salmon

Similar to the situation for coho, there are broad opportunities for monitoring tule fall Chinook because of abundance levels above 500, the effectiveness of carcass tagging population estimates using the Jolly-Seber model, and demonstrated success in smolt trapping in all but the largest basins. Special cases include the IMW program in MAG and a relative reproductive success study in the Coweeman (Figure 12). VSP monitoring indicators are very similar to chum salmon except the juvenile migrant priority reflects a different recovery population priority (Figure 13).

The highest priority populations for tule fall Chinook monitoring are the Coweeman, MAG, Lewis, Toutle, Washougal, and Elochoman (Figure 14-16). The higher priority for Washington populations is a reflection of larger drainage areas supporting higher levels of abundance. Figures 13-17 show a summary of the scoring for LCR Tule fall Chinook populations. The lowest priorities for fall Chinook monitoring include Salmon, Youngs Bay, Big Creek, and the Cowlitz above Mayfield populations due to low recovery priority, low abundance, and lack of a current re-introduction in the Cowlitz.

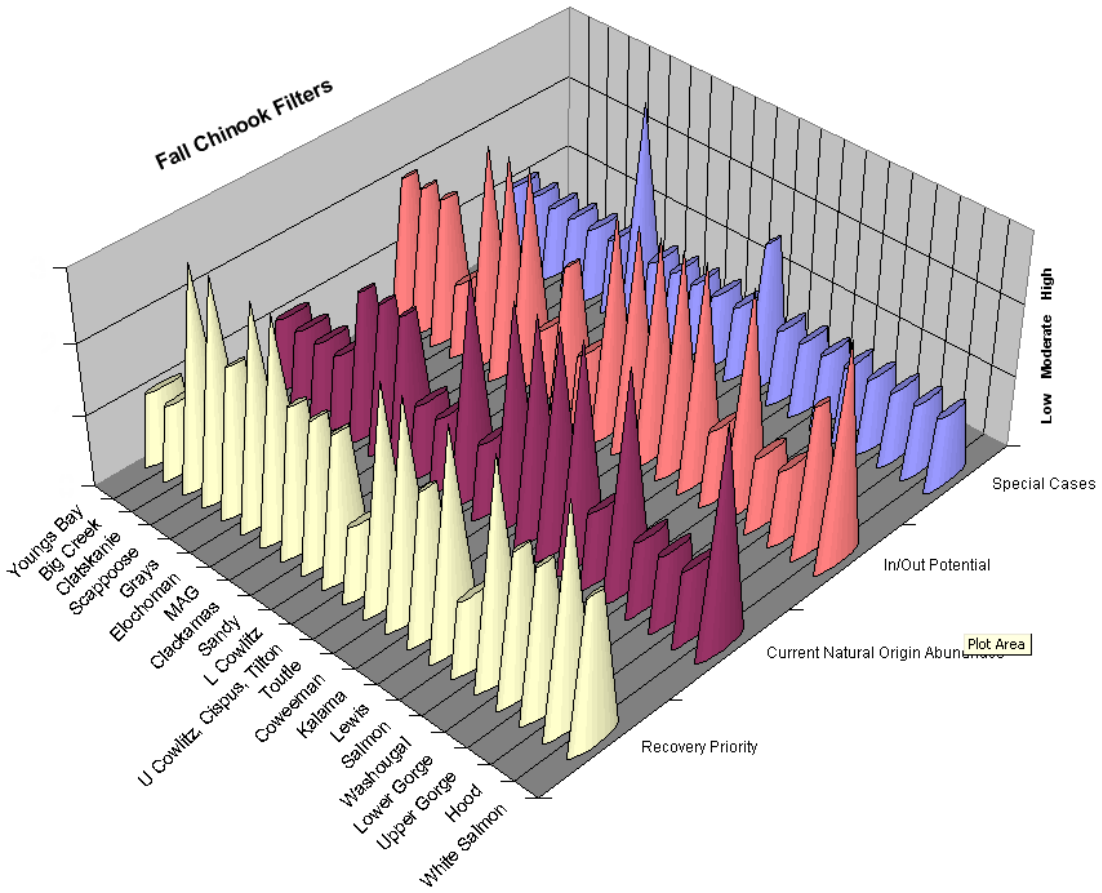


Figure 12. Fall Chinook salmon monitoring filter scores.

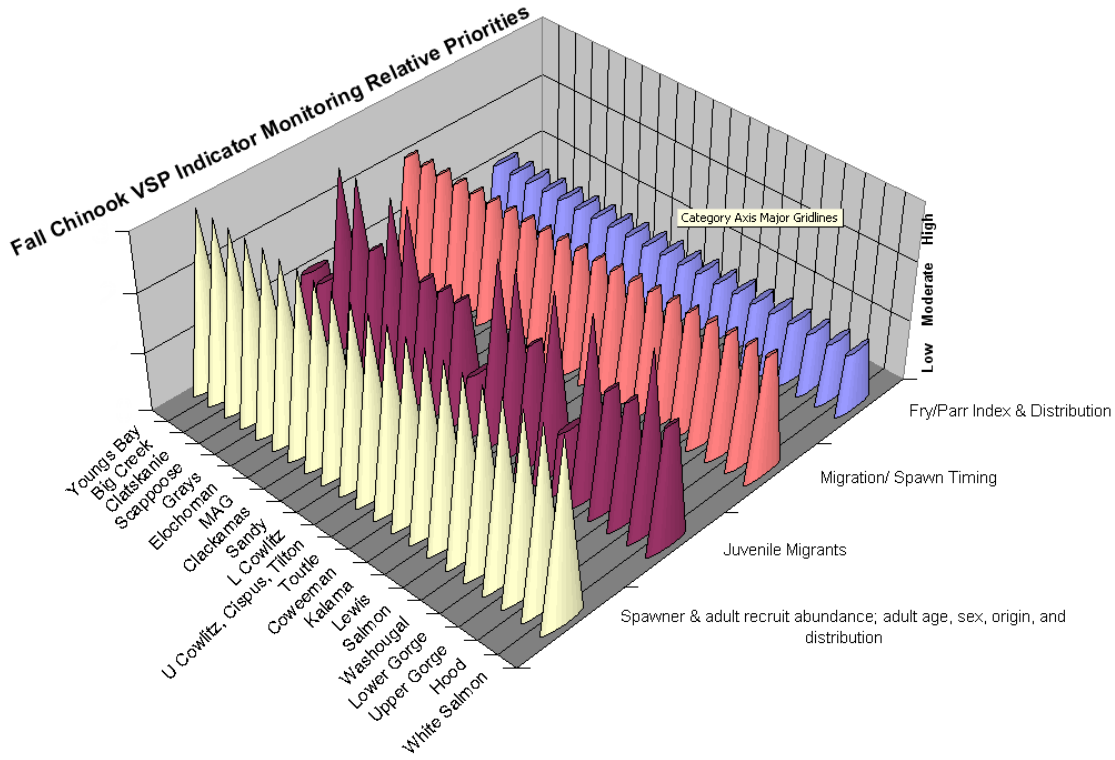


Figure 13. Fall Chinook salmon VSP indicator monitoring relative priority scores.

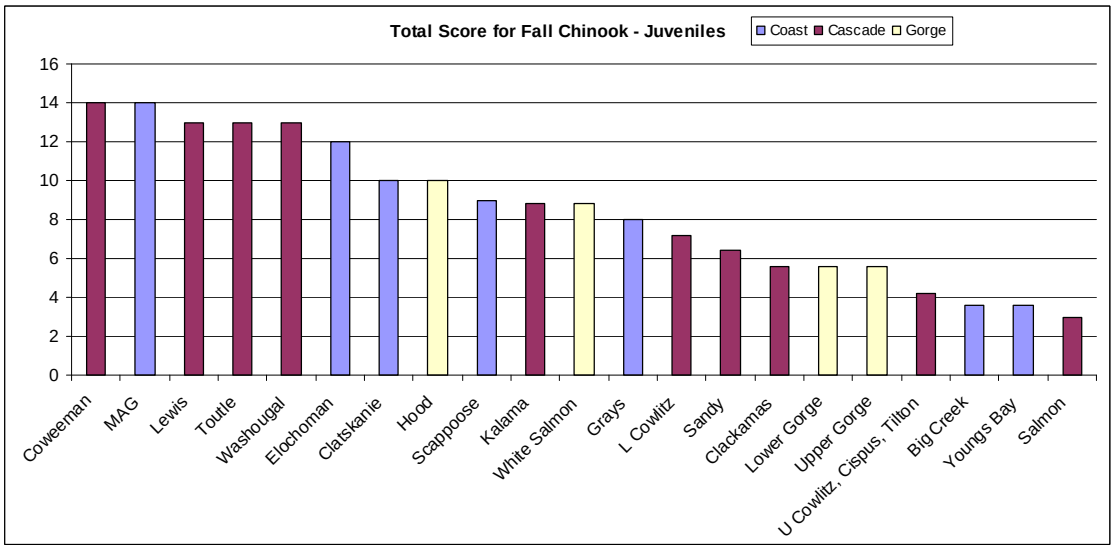


Figure 14. Juvenile fall Chinook salmon total scores.

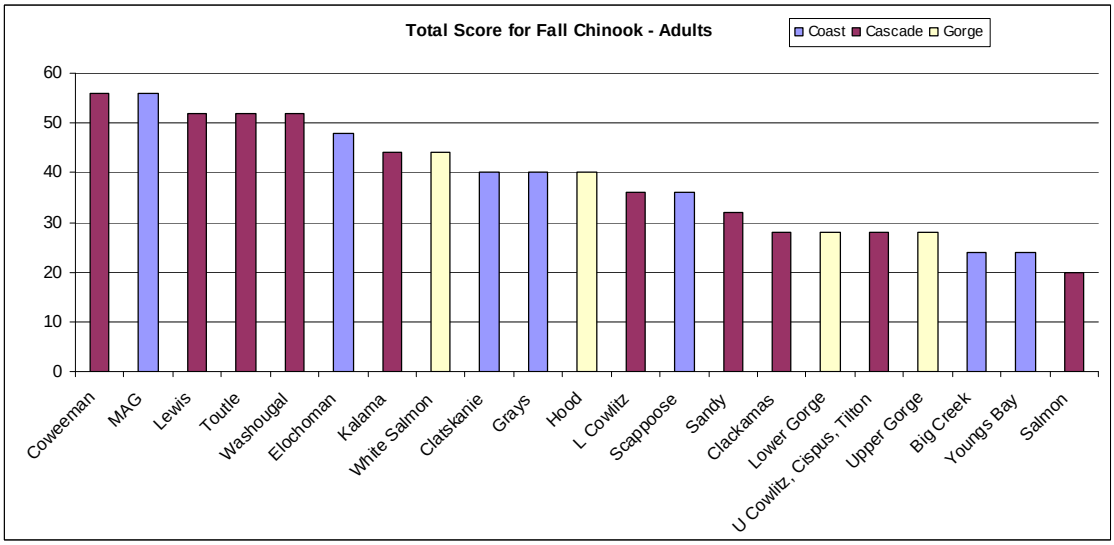


Figure 15. Adult fall Chinook salmon total scores.

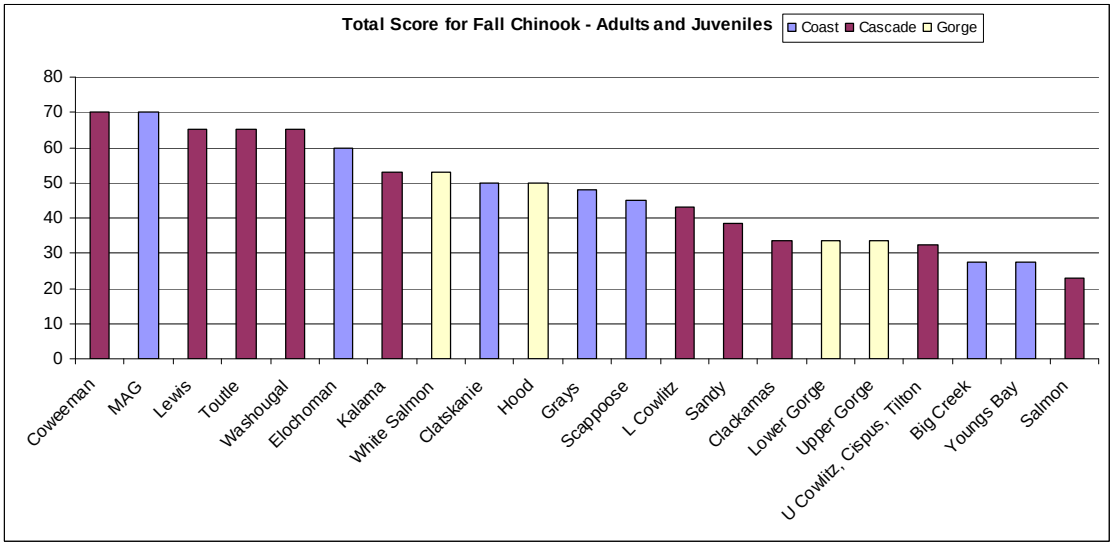


Figure 16. Summary adult and juvenile fall Chinook salmon total scores.

Late Fall Chinook Salmon

Late Fall Chinook salmon or "Bright" populations exist in the Lewis and Sandy basins. Since only two populations exist, they are both priorities for monitoring. The Lewis currently has slightly greater monitoring potential due to an existing juvenile coded wire tag program, which is also used to estimate juvenile outmigrant abundance. Graphs for this species are not shown.

Spring Chinook Salmon

Since there were only ten historical populations, currently many are designated as high priority for recovery. The Sandy and Clackamas populations rank high for current

abundance because abundance is low for all Washington populations. Many spring Chinook rivers have hydroelectric facilities and this infrastructure improves the potential for fish in/out monitoring. Special cases for this species include re-introduction programs in the upper Cowlitz, Cispus, and upper Lewis Rivers (Figure 17). For VSP indicator monitoring, scores are the same except juvenile migrant scores are highest in systems with dams - Clackamas, Cowlitz, and Lewis, along with the Sandy and Hood Rivers (Figure 18). Juvenile, adult, and combined summary rankings reflect similar priorities with the highest priorities and similar scores in the Cispus, Clackamas, NF Lewis, Upper Cowlitz and Sandy (Figures 19-21). Populations with lower priorities include the Tilton, White Salmon, and Toutle, which represent functionally extinct populations.

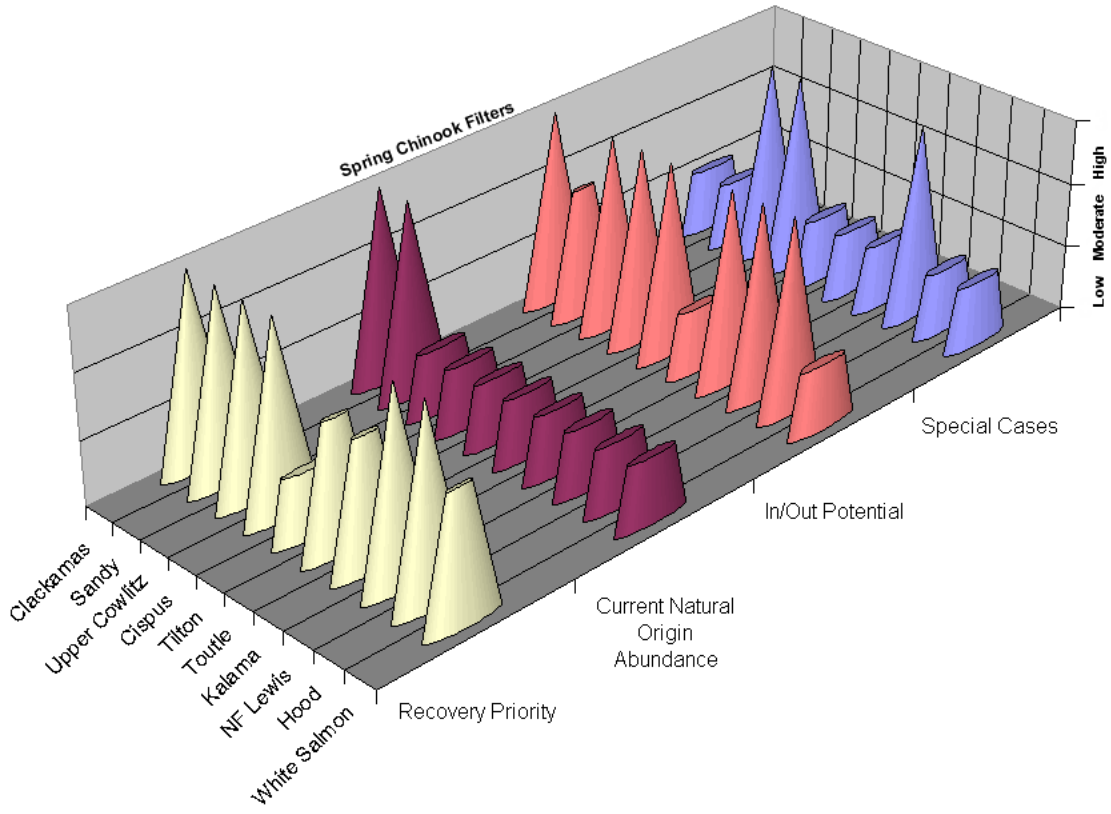


Figure 17. Spring Chinook salmon monitoring filter scores.

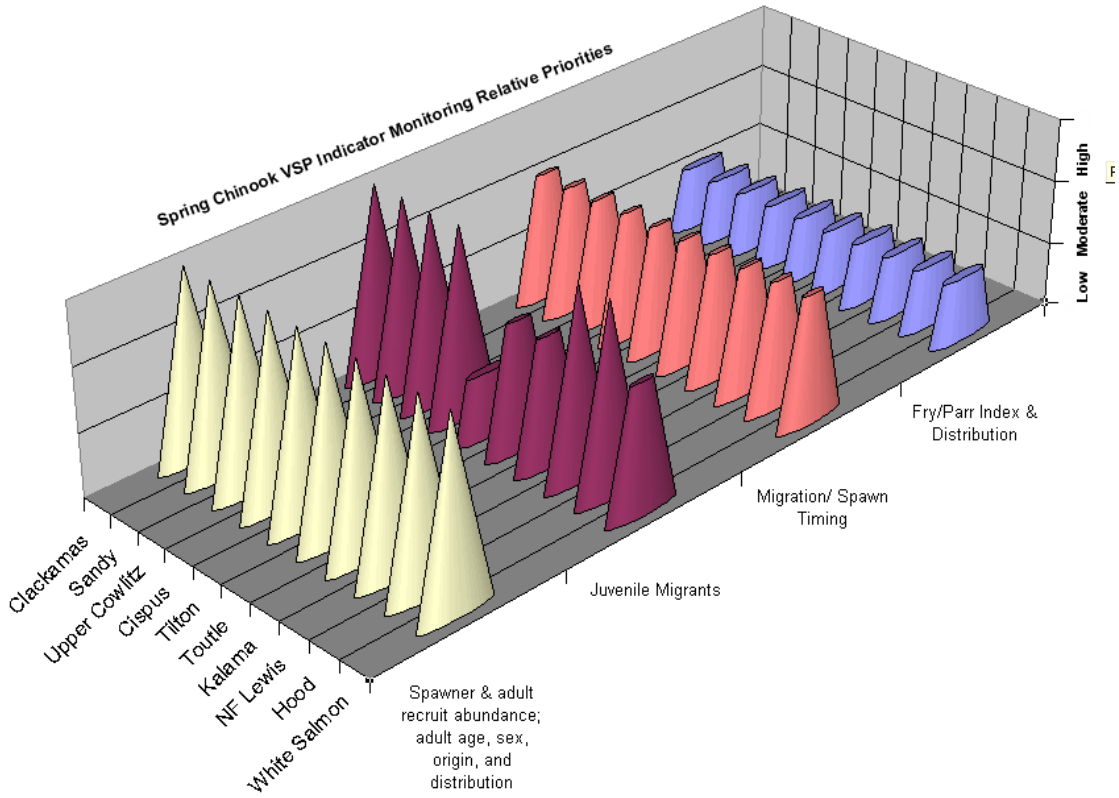
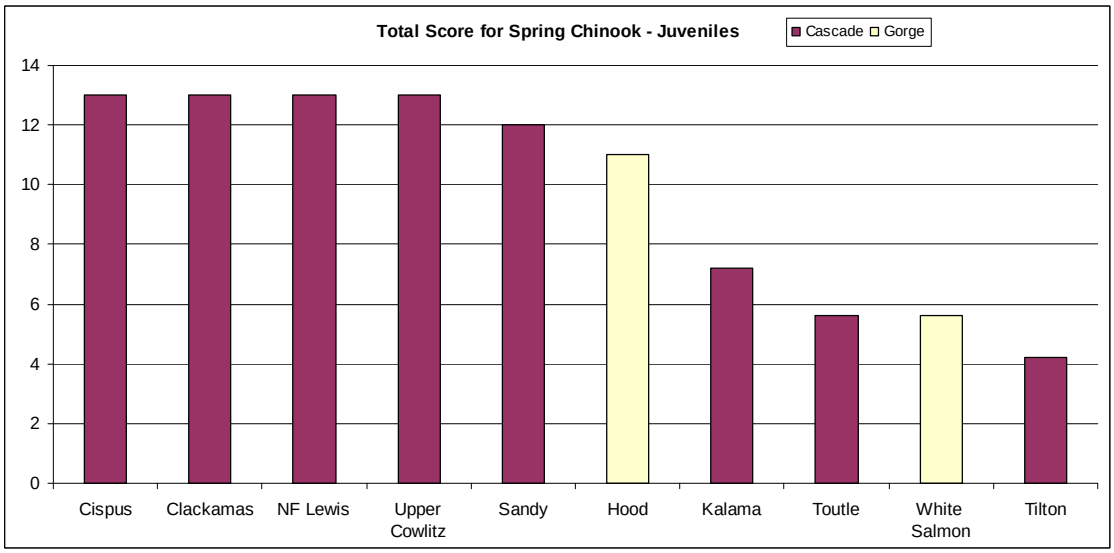


Figure 18. Spring Chinook salmon VSP indicator monitoring relative priority scores.



. Figure 19. Juvenile spring Chinook salmon total scores.

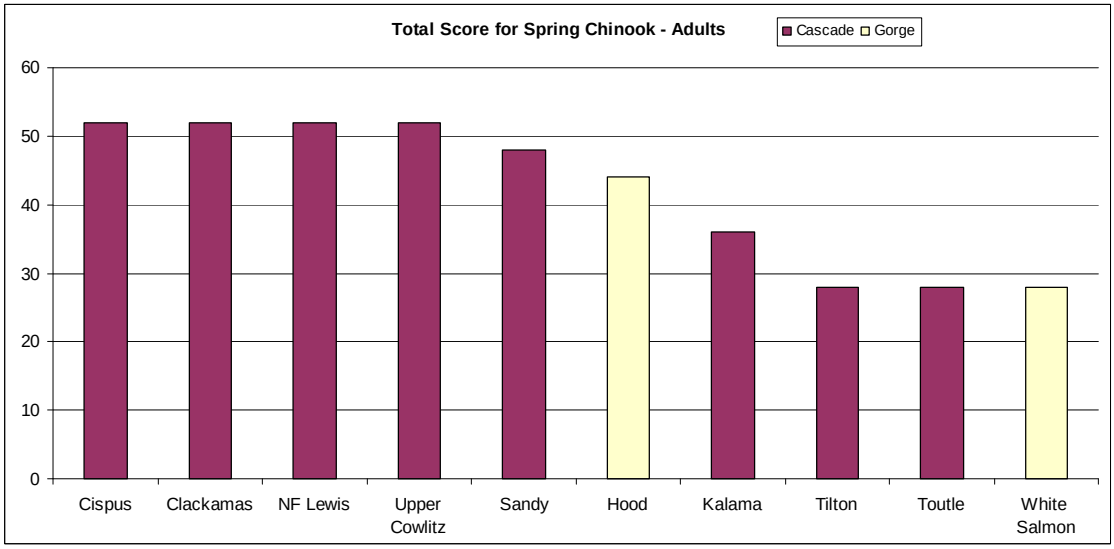


Figure 20. Adult spring Chinook salmon total scores.

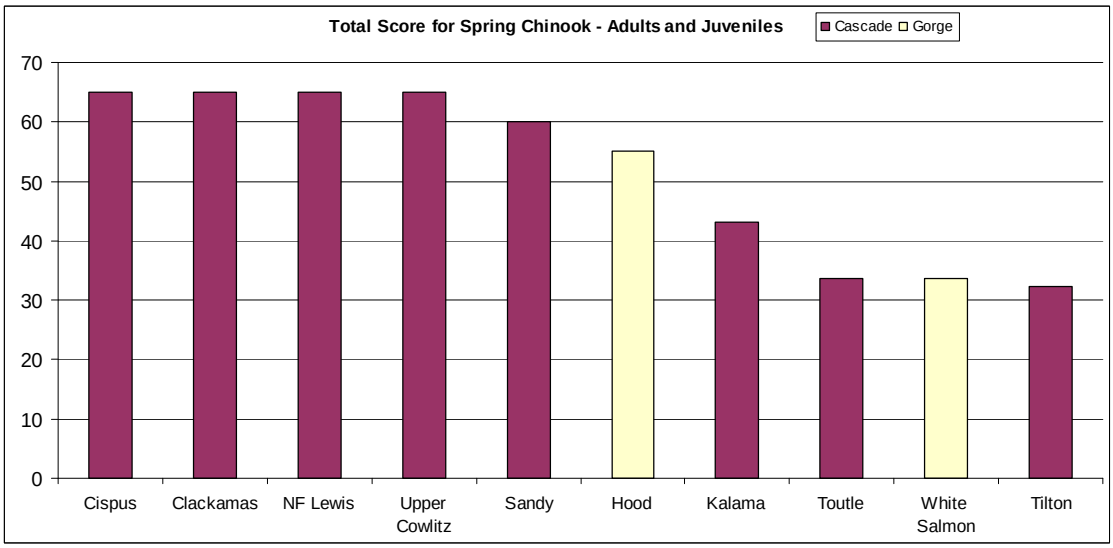


Figure 21. Summary adult and juvenile fall Chinook salmon total scores.

Winter Steelhead

A total of 17 of 24 winter steelhead populations are rated as primary for recovery. Sixteen are also rated high for current abundance (Figure 22). Fish in/out potential is high for populations above dams along with Big Creek, Clatskanie, Elochoman, and MAG. Further assumptions for fish in/out potential will need to be made in watersheds that support sympatric races of summer and winter steelhead such as the Kalama, EF Lewis, Washougal, Wind and Hood River or other basins where hatchery summer steelhead are successful spawners. MAG remains a special case for steelhead as it is an ongoing IMW, although other populations maybe elevated to IMW status in the future.

Winter steelhead VSP indicator monitoring priorities are similar to coho salmon except for the difference in recovery priority (Figure 23). Adult and juvenile monitoring priorities were similar (Figures 24 and 25). For summary monitoring priorities, populations with dams (Cispus, Upper Cowlitz, NF Toutle, Clackamas, and Kalama) along with Big Creek, MAG, and Coweeman were rated highest (Figure 26). The lowest priorities include the Salmon, Upper George, Lower Cowlitz and Tilton populations due to low abundance and recovery priority.

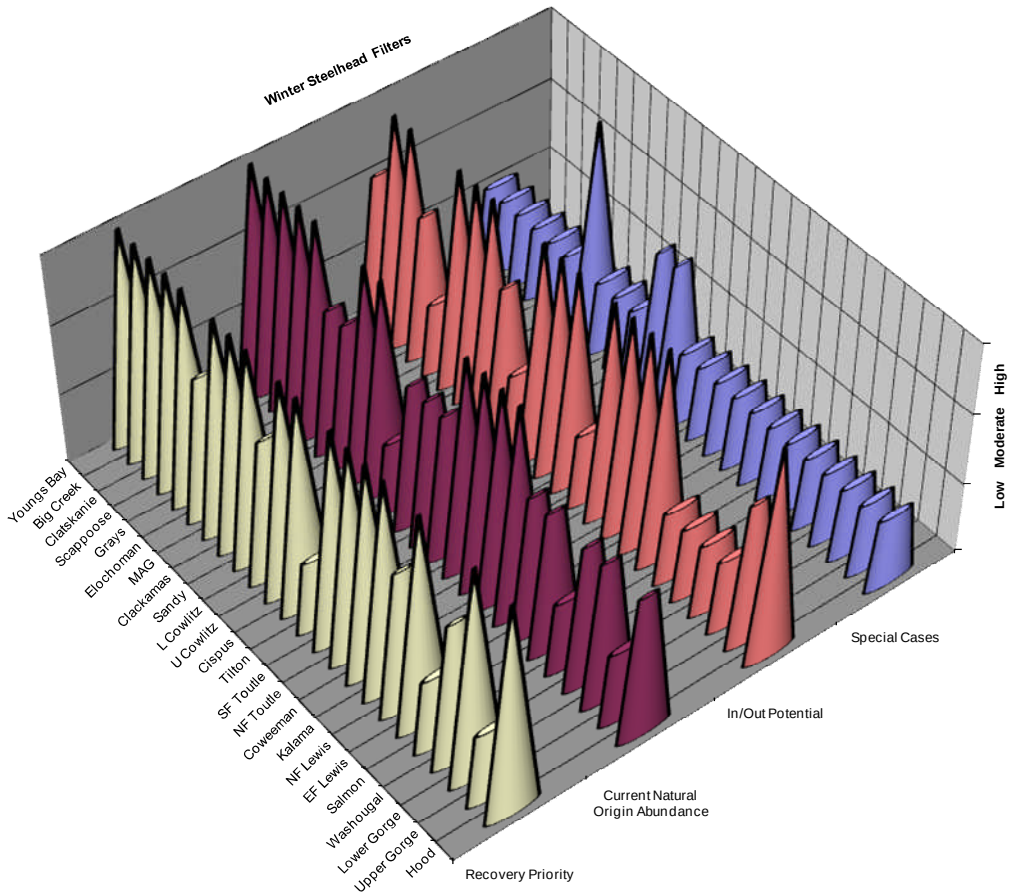


Figure 22. Winter steelhead salmon monitoring filter scores.

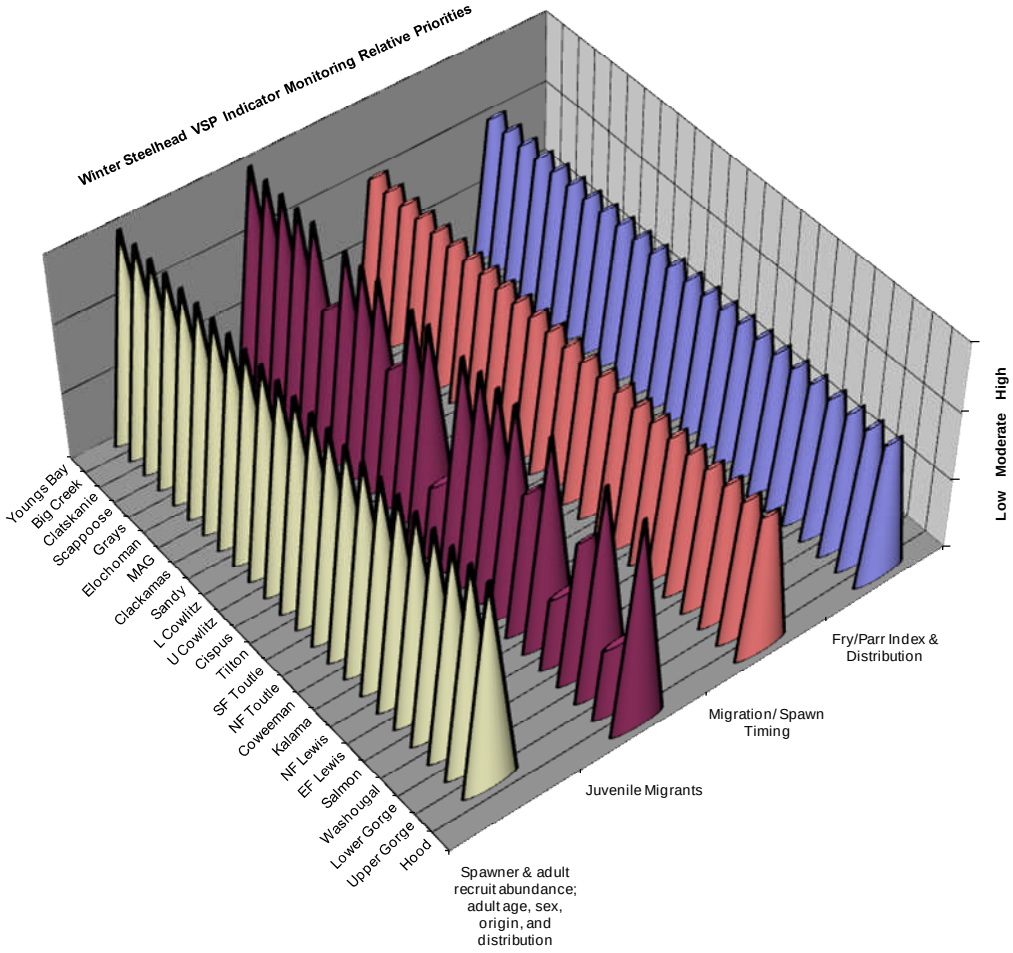


Figure 23. Winter steelhead VSP indicator monitoring relative priority scores.

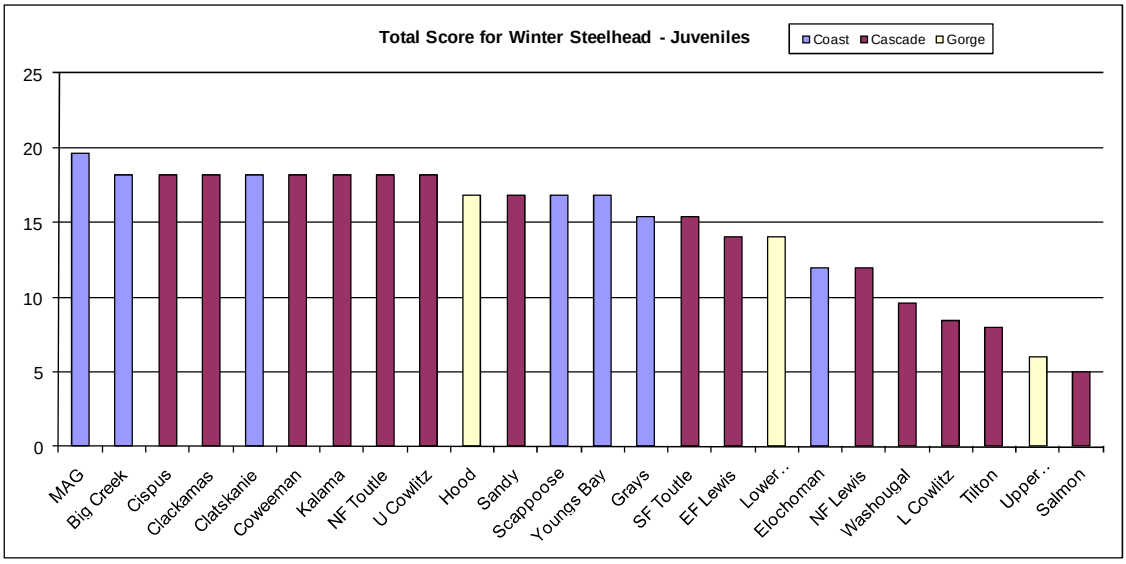


Figure 24. Winter steelhead salmon total scores for juveniles.

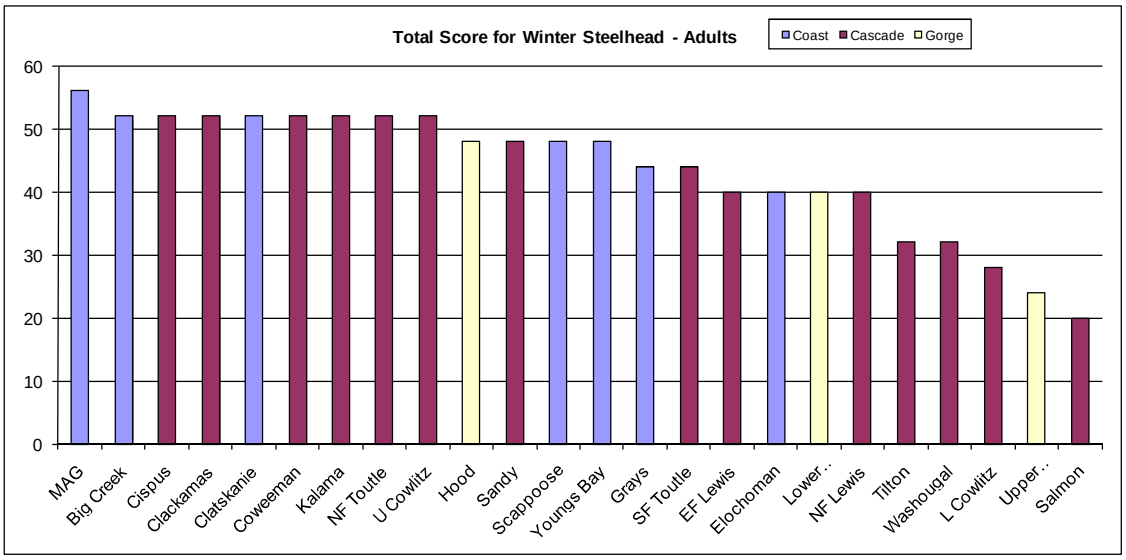


Figure 25. Winter steelhead salmon total scores for adults.

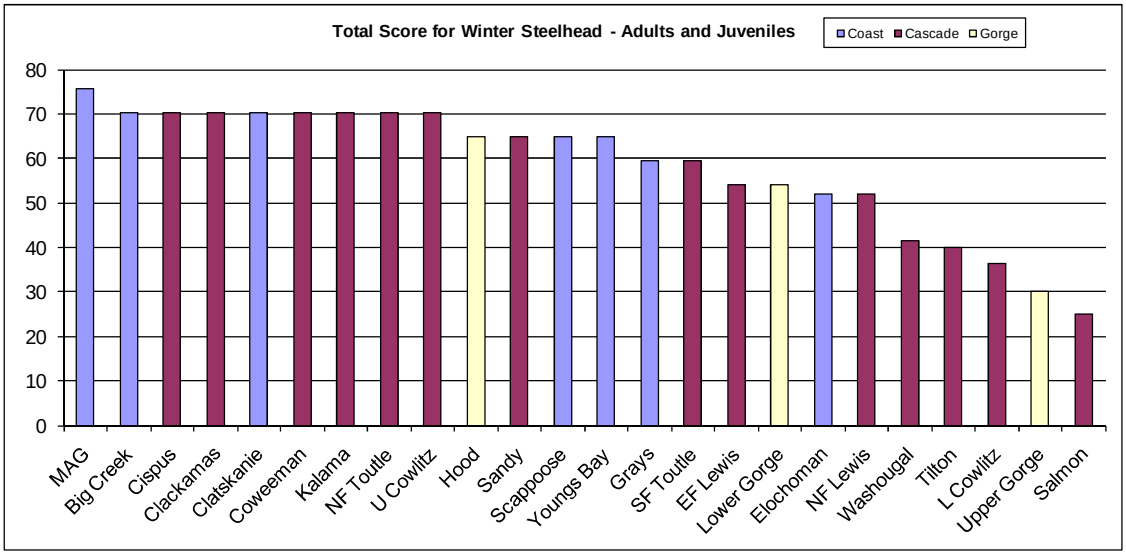


Figure 26. Summary adult and juvenile winter steelhead total scores.

Summer Steelhead There are a total of six summer steelhead populations in the LCR and five of these are classified as primary (targeted for high or better viability at recovery). The current abundance of spawners in the Kalama, Washougal, and Wind exceeds 500 fish, which leads to a high monitoring opportunity. Fish in/out potential is high for all populations except the Hood due to uncertainty in monitoring following the removal of the ODFW fish counting facility. The two special cases for summer steelhead include the recent IMW status of Wind River and ongoing relative reproductive success work in the Kalama River (Figure 27).

As described above in the VSP monitoring section we rated adult spawner abundance, recruitment, age, origin, sex, and distribution as the highest priority since all this

information is needed to estimate viability curves and persistence probability (Figure 27). The juvenile migrant priority for steelhead reflected their recovery priority (Figure 28 and 29). Since other diversity metrics (age, origin, and sex) were rated highest priority, spawning and migration timing, which is the remaining diversity metric, was rated a moderate priority. The last indicator priority is fry/parr abundance. Since steelhead rear in freshwater for one to four years, this metric was rated as moderate.

When all summer steelhead priorities were viewed at the juvenile, adult and combined adult population scales, the highest priority populations are the Wind and Kalama, followed by the Washougal and EF Lewis (Figure 30 and 31). Historically, the NF Lewis population was likely a small population and was extirpated after the constructing of Merwin Dam blocked access to its habitat. Its current low priority for reintroduction and lack of abundance rate it the lowest population priority.

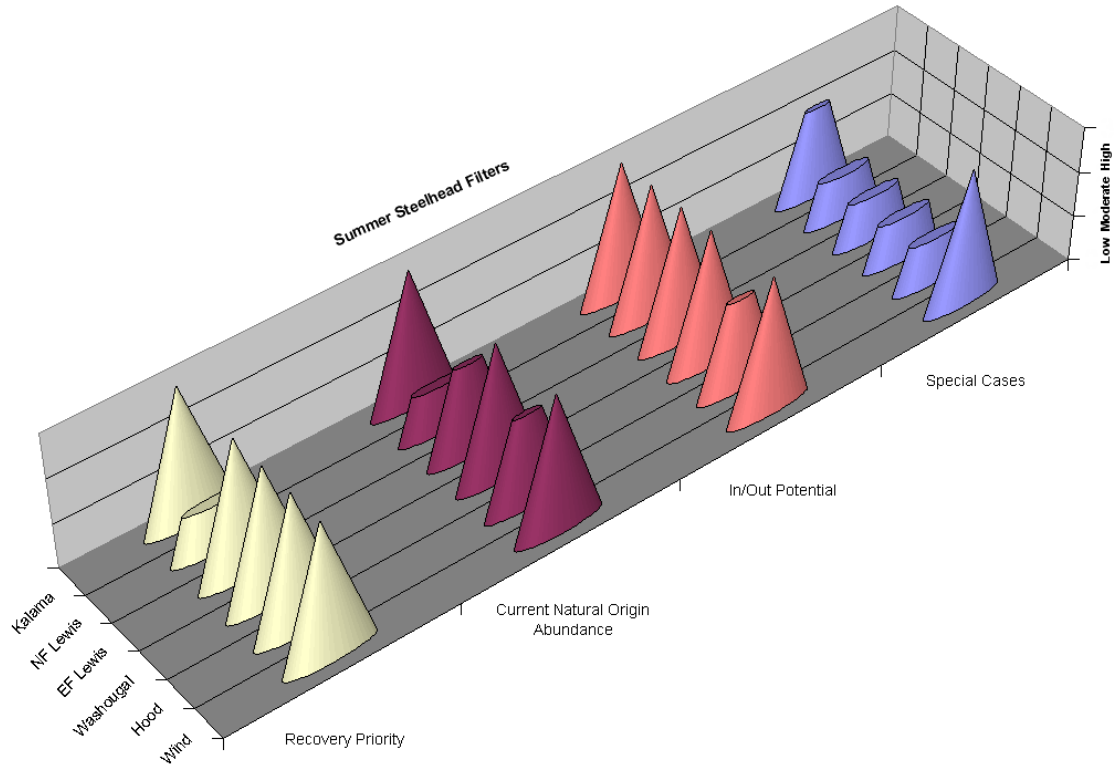


Figure 27. Summer steelhead salmon monitoring filter scores.

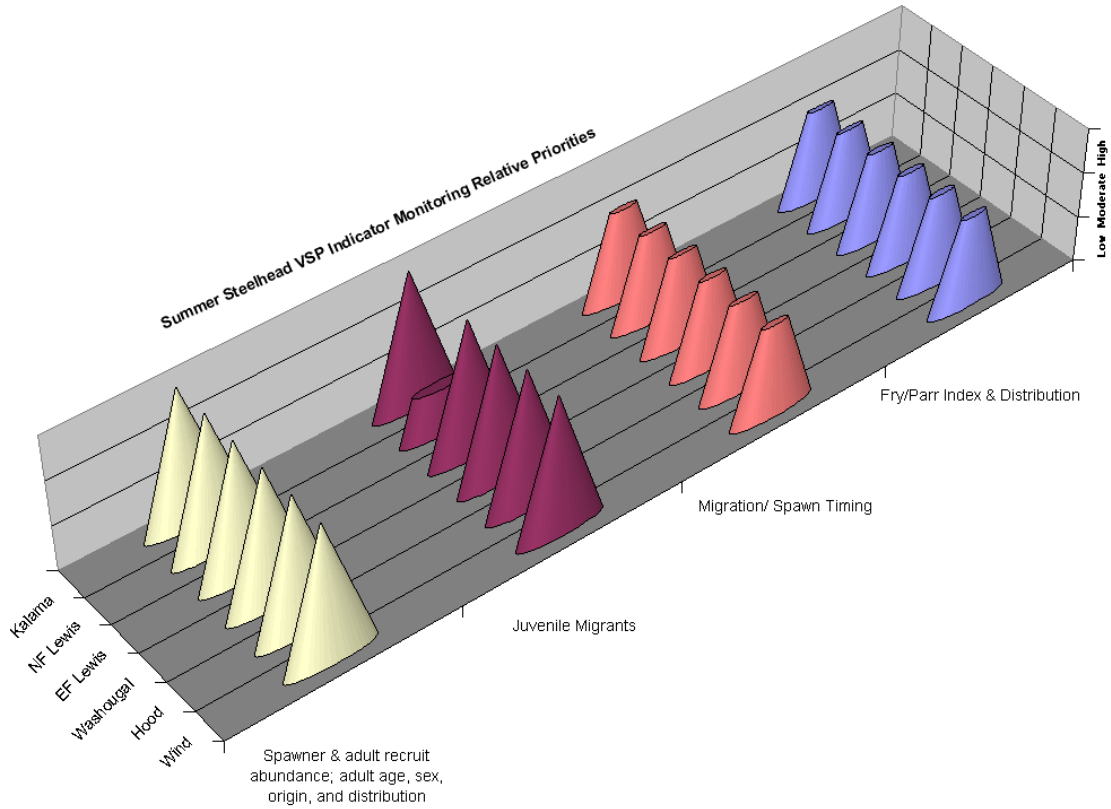


Figure 28. Summer steelhead VSP indicator monitoring relative priority scores.

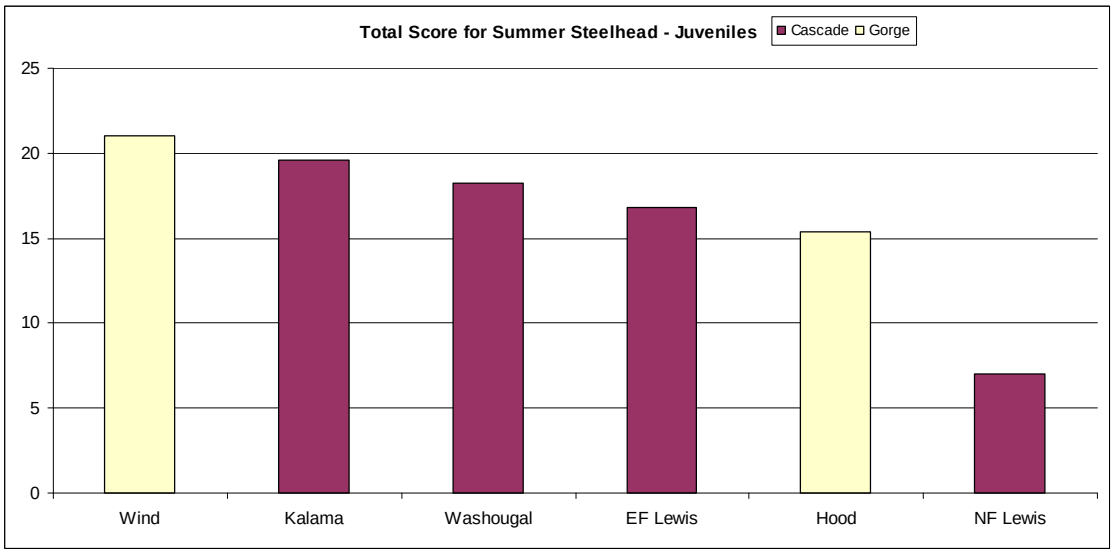


Figure 29. Summer steelhead salmon total scores for juveniles.

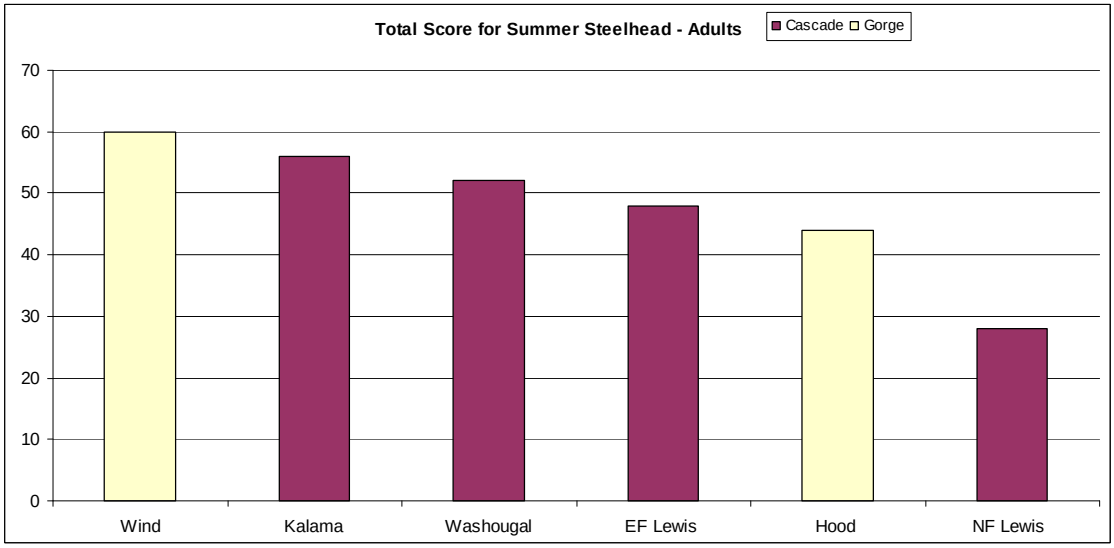


Figure 30. Summer steelhead salmon total scores for adults.

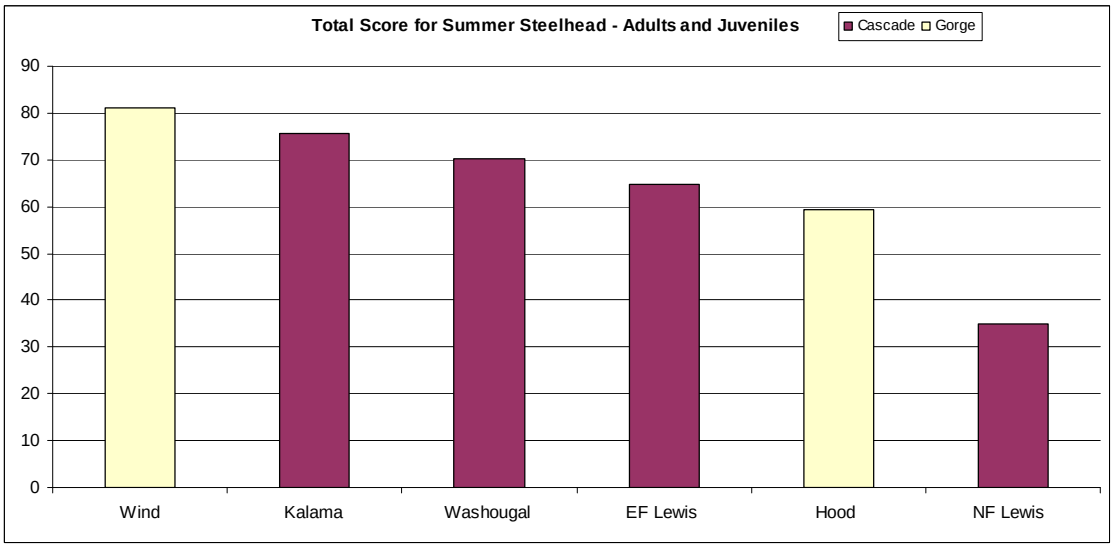


Figure 31. Summary adult and juvenile summer steelhead total scores.

Subbasin Comparisons

Comparisons of the sum of juvenile, adult and both juvenile and adult scores for all species and populations within a subbasin are shown in Figures 32-34. In this summary, subbasins with more populations, more higher priority recovery populations, higher natural origin abundance levels, higher fish in/out potential, and special cases were rated higher than other populations. For juvenile monitoring, the subbasins that were rated highest include the NF Lewis, Upper Gorge, Sandy, Hood and Kalama. For adults the greatest monitoring opportunities included the NF Lewis, Sandy, Kalama, Hood and Clackamas. The greatest adult monitoring opportunities across all species are present in the NF Lewis, Sandy, and Kalama subbasins. For combined adults and juveniles the highest rated monitoring opportunities include NF Lewis, Sandy, Hood, Kalama, EF

Lewis, and Clackamas. The fewest opportunities include Salmon, Youngs Bay, Tilton, and Big Creek due to their combination of fewer primary populations, lower abundance, challenges in fish in/out monitoring, lack of special cases, and diversity of species.

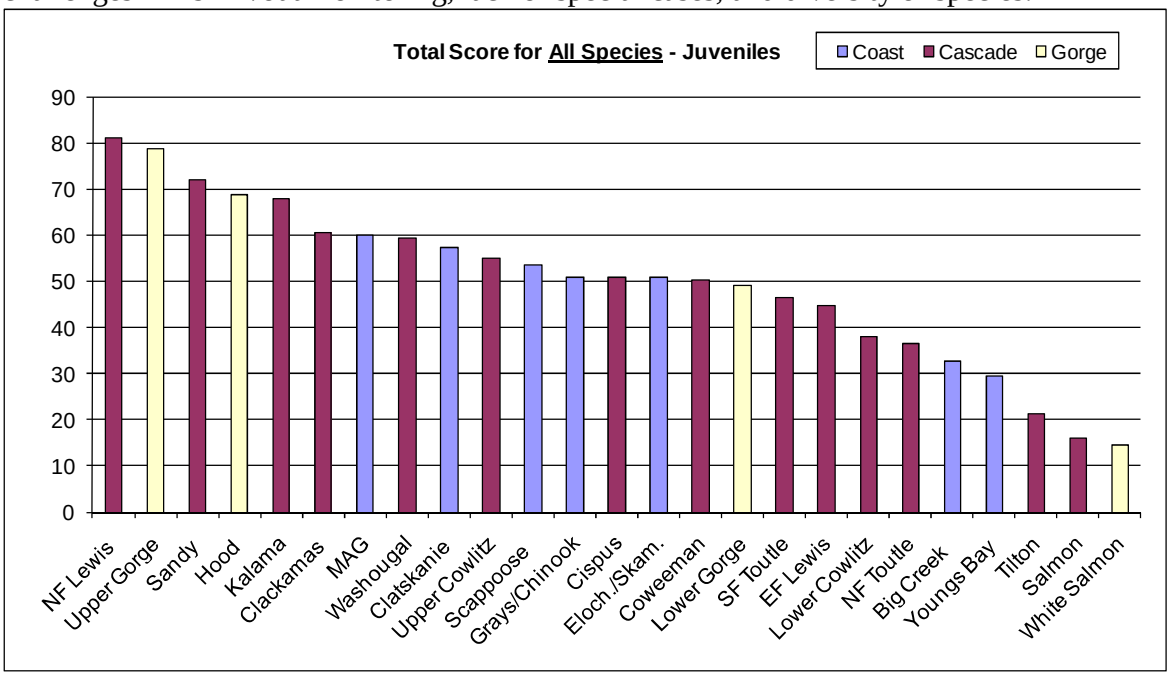


Figure 32. Combined scores for juvenile monitoring of all salmon and steelhead species by subbasin.

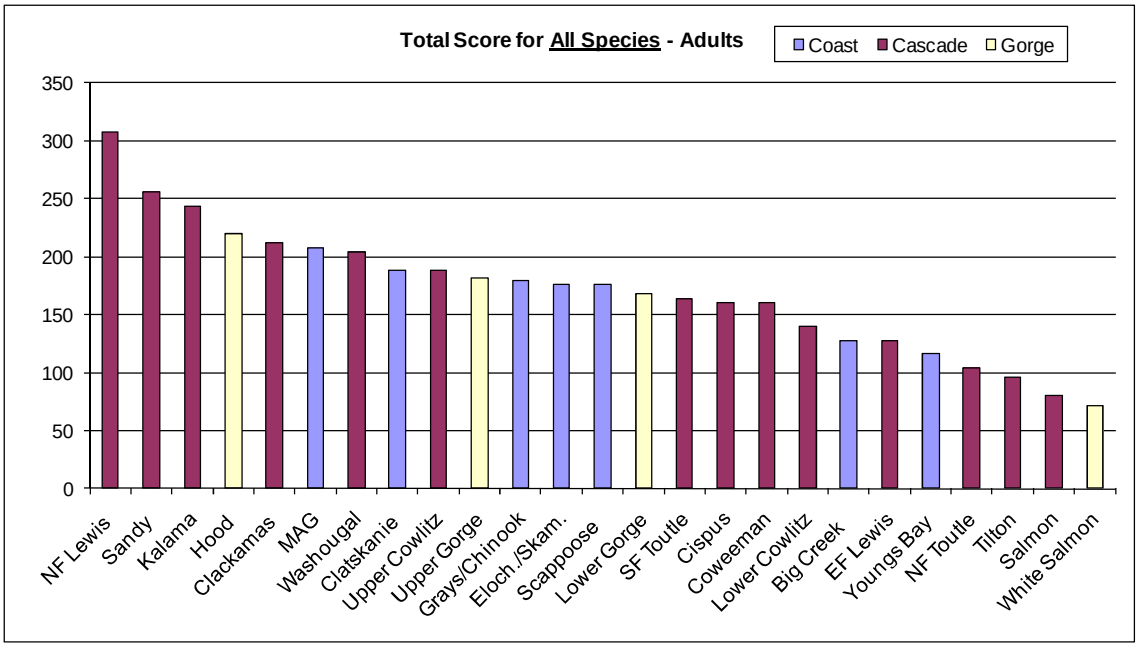


Figure 33. Combined scores for adult monitoring of all salmon and steelhead species by subbasin.

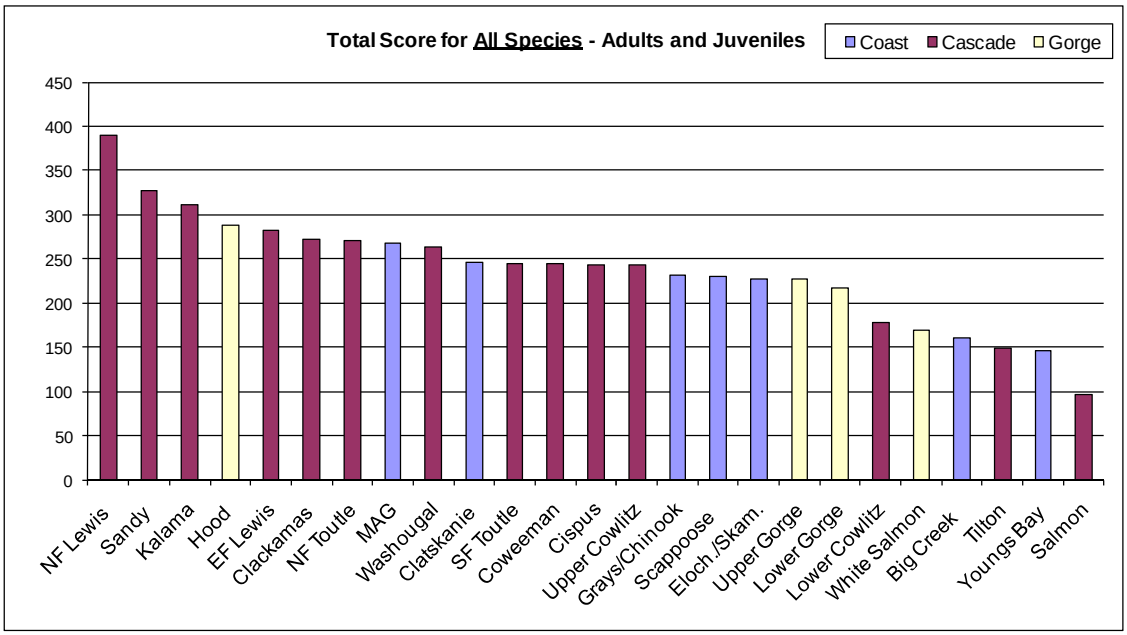


Figure 34. Combined scores for adults and juvenile monitoring of all salmon and steelhead species by subbasin.

Discussion

The scoring system we developed provides decision makers with a visual tool for evaluating and understanding the relative priorities for VSP monitoring for each salmon and steelhead population in the LCR. It also provides them with a visual tool for understanding where they should expect the highest quality and quantity of information once monitoring is implemented. The combination of these two tools provides us with a better understanding of where our priorities should be with regards to VSP indicator monitoring in the LCR.

The results presented in this report represent the completion of the first of the five objectives of the PNAMP ISTM Fish Monitoring Project. There are four remaining objectives for this project (see background section for a discussion of the five project objectives). The next objective for this project is to take the priority information needs developed in this report and evaluate whether or not existing monitoring programs are meeting these needs. Once priority information gaps are identified, we will develop appropriate monitoring plans to fill the gaps and alternate implementation scenarios based on different potential funding levels.

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Appendix 1. Excerpt from Crawford, B.A. and S. Rumsey. 2009. Guidance for monitoring recovery of salmon and steelhead listed under the federal Endangered Species Act (Idaho, Oregon, and Washington). Draft June 12, 2009.

VSP VIABILITY ASSESSMENT QUESTIONS & NOAA STATUS ASSESSMENT

QUESTIONS

- What is the overall status/trend of VSP criteria for each population within each MPG?

EVALUATIONS

- What is the abundance/productivity status of the populations based on viability curves or natural origin fish return ratio?
- What is the status of spatial structure of the population?
- What is the current state, and change in state, of measures of population diversity across each ESU?

Key population abundance status/trend monitoring questions

QUESTIONS

- What is the status/trend of natural origin adult spawners for the primary populations within each MPG?
- What is the proportion of hatchery origin fish on the spawning grounds for each population within the MPG?
- What is the age structure and cohort structure for each population?
- What are the harvest mortalities of fisheries conducted throughout its range?
- If this population is supplemented, what is the viability of the population with and without supplementation?

EVALUATIONS

- Determine whether the populations monitored have exceeded the minimum criteria established in the recovery plan for meeting long term ESU viability.
- Determine the change in status for each population with information at the time of listing

Monitoring questions that address population productivity

QUESTIONS

- What is the Adult to adult productivity ratio of primary population's natural abundance?
- What is the smolt to adult ratio of selected primary population's natural abundance?
- What is the long term trend in productivity for the primary populations?
- What is the variance about the adult and smolt estimates?

EVALUATIONS

- Determine the change in adult to adult productivity for each population.
- Determine the change in smolt to adult productivity for those populations where juvenile abundance is monitored.
- Determine whether the populations monitored have met the TRT productivity goals

Key monitoring questions for determining spatial structure of populations
QUESTIONS

- Has there been a change in the spawner distribution within populations?
- What is the variance about the estimate?

EVALUATIONS

- Determine the percent of occupied habitat in adult and juvenile distribution for each population with information at the time of listing.
- Determine whether the change in distribution improves the TRT productivity goals for meeting long term viability.

Monitoring questions associated with evaluating species diversity
QUESTIONS

- Has there been a change in the species diversity of populations within the MPG?

EVALUATION

- Determine the change in species diversity for each population.

QUESTIONS FOR ESA THREATS

- **NO FCRPS or PREDATION AS A RESULTS OF FCRPS QUESTIONS ADDRESSED IN THIS THEATS SECTION**

HABITAT THREATS
HabitatStatus/Trend Monitoring for habitat loss
QUESTIONS

- What is the overall status/trends of habitat for each population within an ESU?

DETERMINATIONS

- Determine the trend for habitat within each ESU given the sum total of both habitat restoration actions and habitat losses due to natural and manmade causes

List of effectiveness monitoring questions for restoring lost habitat or the monitoring Effectiveness of Habitat Restoration Programs, Habitat Conservation Plans, and Biological Opinions
QUESTIONS

- Have the recovery participants monitored whether habitat restoration actions at the site level were effective in improving habitat and range?
- Have the recovery participants monitored whether the cumulative restoration actions at the watershed level been effective in improving fish production?
- Have the HCPs, BiOps, or FERC requirements been effective in restoring and protecting habitat?

EVALUATIONS

- Review the evidence available from effectiveness studies to ascertain that restoration actions are shown to be effective
- Review the BMP effectiveness studies associated with HCPs to determine their effectiveness. IMWs could be used to perform this evaluation.

- Review data for habitat on HCP lands to determine whether BMPs have been effective

HYDROPOWER THREATS

Key monitoring questions for addressing hydropower threats non-FCRPS sites

- Determine status/trends of smolt survival passing dams
- Determine migration timing at dams sites
- Determine the condition of smolts at all dam sites
- Determine status/trends of smolt survival passing dams
- Determine status/trends of adult survival passing dams sites
- Implement predator control at specific dam sites

HARVEST THREATS

Key ESA harvest monitoring questions and NOAA evaluations

Status/trend Monitoring

- What is the individual and cumulative impact of authorized coastal and terminal fisheries on each identified population within an ESU/DPS?
- What is the individual total catch and escapement of natural origin fish (NOF) and hatchery origin fish (HOF)?

Monitoring Management Actions Intended To Control Overutilization (Harvest) Implementation (Compliance) with Harvest Restrictions

- Did state and tribal fisheries comply with "take" quotas and other terms and conditions stipulated in section 7, 4(d) limits or section 10 authorizations?
- Did the states and tribes enforce rules and quotas in their allowable fisheries?
- How many state fisheries and tribal fisheries that take listed fish have ESA authorizations
- By fishery, what percentage of fishers reported total catch by turning in annual commercial, tribal, and sport results?

Effectiveness of Harvest restrictions

- Are harvest restrictions implemented in the PST, PFMC and local state and tribal fisheries adequate to enable populations to increase as productivity improves?
- Which gear types are more effective in reducing mortality and by catch?
- Is harvest an effective means to reduce the ratio of natural origin spawners and hatchery spawners on the spawning grounds?

Validation of Harvest restriction outcomes

- Have listed populations been able to meet their recovery plan escapement goals within the harvest restrictions per ESU?
- What is the effect of harvest seasons on the observed abundance, productivity, spatial distribution and diversity of the natural origin fish in the population, MPG, and ESU?

PREDATION THREATS

Status/trend Monitoring

- What is the status/trend of mortality due to freshwater competition with invasive trout species?
- What is the status/trend of seal and sea lion populations in coastal Oregon and Washington?
- What is the status/trend in salmon and steelhead mortality due to seal and sea lion populations at selected problem sites
- What is the status/trend of salmon and steelhead mortality due to bird predation?

INADEQUACY OF REGULATORY REGULATIONS THREATS

Key monitoring questions that address threats due to inadequacy of regulations or implementation (Compliance) with Existing Regulatory Mechanisms

- Did federal, state, tribal, and local entities enact regulations designed to adequately protect salmon or adequately maintain or improve salmon habitat as identified in section 7 consultations, recovery plans and HCPs?
- Did federal, state, tribal, and local entities adequately monitor and enforce regulations designed to protect or maintain or improve salmon habitat as identified in section 7 consultations, recovery plans and HCPs?

Key monitoring questions that address management actions due to inadequacy of regulations

Implementation (Compliance) with Existing Regulatory Mechanisms

- Did federal, state, tribal, and local entities enact and/or enforce regulations designed to adequately protect salmon and/or to adequately maintain or improve salmon habitat as identified in section 7 consultations, recovery plans, and HCPs?

Effectiveness of Existing Regulatory Mechanisms

- Are the existing regulatory actions effective in protecting salmon and maintaining or restoring critical habitat?
- Are the existing regulatory actions effective enough to allow fish populations to reach recovery viability within protected timelines?

HATCHERY THREATS

Key monitoring questions that address hatchery threats to recovery.

Status/Trend Monitoring

- What is the hatchery and natural stock DNA genotype and phenotype?
- What is the annual status/trend of HOS/NOS percentages for each primary and contributing population by ESU/DPS?

Implementation (Compliance) with Hatchery Genetic and Management Plans

- Do all hatcheries in the ESU have an approved HGMP per 4(d) rule or Section 10?
- Did federal, state and tribal entities implement their HGMPs?
- Are hatchery actions implemented that address threats?

Effectiveness of Hatchery Genetic and Management Plans

- Have the HGMP strategies demonstrated that they have been effective in addressing genetic and other hatchery threat effects on abundance and productivity?
- Are the hatchery programs effective in reducing the ratio of HOS through the use of harvest, weirs, or a mixture of techniques?

Validation of Hatchery Genetic and Management Plans outcomes

- Have the fitness of natural populations within the watersheds improved or remained static due to the HGMPs?

Questions to be answered for monitoring disease at hatchery facilities
Implementation (Compliance) with Disease Restrictions

- Are the state and tribal hatcheries maintaining a disease monitoring program at all hatchery facilities in compliance with regional co-manager disease policies and the recommendations of the Pacific Northwest Fish Health Protection Committee's "Model Comprehensive Fish Health Protection Program"?
- Are the state and tribal hatcheries following disease related requirements within their HGMPs?

Effectiveness of Disease detection and control measures

- Have disease detection and prophylaxis been effective in controlling the occurrence and spread of fish pathogens in the hatchery and natural populations of the Columbia River, Puget Sound and the coast?

NATURAL THREATS

Key monitoring questions that address threats due to climate and other natural causes.
Status/Trend Monitoring

- What is the status/trend of PNW stream flow?
- What is the status/trend of Pacific Ocean Gyre sea surface temperatures?
- What is the status/trend of PNW snowpack water content?
- What is the status/trend of stream temperatures?

Appendix 2. Excerpt from Monitoring Oversight Committee (MOC). 2002. The Washington Comprehensive Monitoring Strategy and Action Plan for Watershed Health and Salmon Recovery. Volume 1. 26pp.
http://www.rco.wa.gov/documents/monitoring/Executive_Report_final.pdf

Question 1: How are the annual abundance and productivity of salmon by species, ESU, and life stage changing over time?
Objective 1A: Measure status and track trends of the numbers of spawning salmon by stock in each Salmon Recovery Region. Evaluate whether numbers are improving.
Objective 1B: Measure status and track trends of the numbers of juvenile migrant salmon for selected index watersheds. Evaluate whether the numbers are improving.
Objective 1C: Measure status and track trends of the number of resident juvenile cutthroat and bull trout for each stock. Evaluate whether numbers are improving.
Objective 1D: Measure status and track trends of salmon productivity for selected index watersheds.

Question 2: What improvements are occurring in restoring the geographic distribution of salmon by ESU, species, and life stage to their historic range?
Objective 2A: Measure the geographic distribution and evaluate trends of salmon in each Salmon Recovery Region. Determine whether their geographic distributions are improving.

Question 3: Are the unique life history characteristics of salmon within a Salmon Recovery Region changing over time because of human activities?
Objective 3A: Determine the status and trends of genetic and other diversity characteristics of salmon in each Salmon Recovery Region. Evaluate whether they are improving.

Question 4: What are the trends in the climate of the Pacific Northwest that will allow the State to anticipate and account for such conditions in initiating and monitoring management actions for watershed health and salmon recovery What trends in climate may mask or expose the status of freshwater habitat and its role in salmon recovery?
Objective 4A: Determine the status and trends of climate and ocean conditions affecting Washington salmon production.

Question 5: In the context of other sources of natural and human-caused mortality, is predation by avian, marine mammals, or other aquatic species inhibiting the recovery of salmon within each ESU?
Objective 5A: Measure status and trends in the rate of consumption of Threatened and Endangered salmonids by seals and sea lions
Objective 5B: Measure status and trends in seal and sea lion populations in Washington State.
Objective 5C: Determine status and trends of Caspian tern populations at the mouth of the Columbia River and elsewhere in Washington. Determine whether predation rates previously identified are valid.
Objective 5D: Measure status and trends in squawfish populations in Columbia River reservoirs.
Objective 5E: Determine whether squawfish control measures have been effective in reducing predation on juvenile salmon to target levels.

Question 6: What are the trends in effects of hatchery production on the survival and productivity of wild salmon populations within each ESU?
Objective 6A: Determine whether hatchery Best Management Practices (BMP) have been implemented as required under the Wild Salmonid Policy and ESA 4(d) rules.

Objective 6B: Determine whether hatchery BMP have been effective in reducing or eliminating the adverse effects of hatchery fish upon wild salmon productivity and production within each ESU.

Question 7: What is the impact of harvest upon the recovery of wild salmon populations?
Objective 7A: Measure salmon harvest rates and total numbers of harvested salmon for stocks in each Salmon Recovery Region; and determine trends.
Objective 7B: Determine whether harvest restrictions have been implemented as required under the ESA 4(d) rules.
Objective 7C: Determine whether harvest restrictions have been effective in allowing adequate spawner escapement.
Objective 7D: Determine if age-, size-, or sex-selective harvest has been detrimental to natural populations.
Objective 7E: Measure status and trends of illegally harvested salmon.

Question 8: What hydroelectric facilities in each ESU are being operated and/or modified in a manner that is compatible with salmon survival and recovery?
Objective 8A: Measure current status of major hydropower projects upon salmon survival and recovery. Evaluate whether projects are improving.
Objective 8B: Determine how many major hydropower projects have fully implemented fish recovery measures into their operations as required in their license. Determine their status and trends.
Objective 8C: Measure whether mitigation actions at hydro projects have been effective in restoring fish passage and meeting salmon recovery goals.

Question 9: What is the quality of surface waters?
Objective 9A: Measure status of identified water quality indicators.
Objective 9B: Measure status of identified water quality indicators in agricultural, forest, and urban lands.

Question 10: How are surface water quality conditions changing over time?
Objective 10A: Measure the trend of identified water quality indicators at stations representing the cumulative effects of human caused impacts and natural conditions.
Objective 10B: Assess the change in the area wide conditions of identified water quality indicators estimated under question 9.

Question 11: Where do the water quality conditions not support aquatic life and recreational uses?
Objective 11A: Identify waters where aquatic life and recreational uses are impaired due to surface water quality conditions.

Question 12: How effective are clean water programs at meeting water quality criteria?
Objective 12A: Measure effectiveness of clean water programs in meeting water quality goals.

Question 13: Where have standards for water quantity been established?
Objective 13A: Measure quantity of instream flow necessary to sustain salmonids.

Question 14: Where do water quantity and flow characteristics limit salmon productivity?
Objective 14A: Derive indicators of flow characteristics related to salmon productivity.

Question 15: What are the trends in water quantity and flow characteristics?

Objective 15A: Measure change in identified water quantity and flow characteristics.

Question 16: How effective are the State's water resource management programs for protecting and restoring instream flows?
Objective 16A: Measure identified indicators related to the performance of managing water resources.

Question 17: What are the overall impacts of human related activities on freshwater habitat and landscape processes as they relate to watershed health and salmon recovery?
Objective 17A: Measure status and trends of identified freshwater habitat indicators in agricultural, forest, and urban lands. Evaluate whether they are improving.
Objective 17B: Measure implementation of agricultural conservation practices identified in the Strategy that affect habitat. Evaluate their status, and trends.
Objective 17C: Determine how effective agricultural conservation practices are in improving status of habitat as shown by their indicators.
Objective 17D: Confirm that the Washington Department of Natural Resources (DNR) continues to implement the habitat conservation strategies identified in the agency's 1997 Habitat Conservation Plan (HCP) relative to compliance with the ESA.
Objective 17E: Measure how effectively DNR's HCP management actions contribute to restoring and enhancing salmon habitat as measured by indicators. Evaluate the status and trends.
Objective 17F: Measure success of implementation of habitat conservation practices on forest lands identified in modifications to the Forest Practices Act (FPA) established under ESHB 2091 (also known as the Forest and Fish Agreement).
Objective 17G: Measure how effective modifications to the FPA, (also known as the Forest and Fish Agreement) are in improving status of identified forest habitat.
Objective 17H: Determine status and trends of the identified freshwater habitat and landscape forming indicators identified in the Aquatic/Riparian Effectiveness Monitoring Plan (AREMP) and PACFISH/INFISH (PIBO) in federal lands in Washington. Evaluate whether the indicators are improving.
Objective 17I: Determine how successful the U.S. Forest Service is in implementing identified forest conservation practices identified in the Northwest Forest Plan (NFP) and PACFISH/INFISH. Evaluate status and trends.
Objective 17J: Determine effectiveness of treatments prescribed in the NFP and PACFISH/INFISH in improving the status of identified habitat and landscape forming indicators.
Objective 17K: Determine the success of state and local governments in implementing riparian buffers, water quality treatment Best Management Practices, and storm water control measures identified in the CMS. Evaluate status and trends.
Objective 17L: Determine how effective urban resource conservation measures have been in improving status of identified freshwater habitat and landscape forming indicators.

Question 18: What are the status and trends in habitat-forming landscape processes in riverine tidal, estuarine, and nearshore ecosystems as they relate to watershed health and salmon recovery?
Objective 18A: Measure the current status and trends of the identified habitat indicators in near shore marine areas. Evaluate whether indicators are improving.
Objective 18B: Determine how effective conservation practices are in improving status of identified near shore marine habitat as determined by key indicators.

Question 19: What is the progress of the State in restoring fish passage at barriers?
Objective 19A: Determine the number of human-caused fish passage barriers statewide. Determine and evaluate trends in fish passage barriers.

Objective 19B: Measure the status of fish passage at human-caused passage barriers statewide. Evaluate their status and the trends.
Objective 19C: Determine how effective restoring fish passage at human-caused barriers has been in increasing the geographic distribution of salmon as measured by the identified indicators.
Objective 19D: Measure the state's rate of compliance with fish screening requirements at human-caused barriers.

Question 20: What is the progress of the State in restoring connectivity of freshwater habitat?
Objective 20A: Determine the current amount of fish habitat that has been disconnected by human caused activities. Determine and evaluate trends in freshwater habitat connectivity.
Objective 20B: Measure how successful the state has been in implementing freshwater habitat connectivity restoration projects statewide.
Objective 20C: Determine how effective restoring freshwater fish habitat connectivity has been in increasing the production of salmon as measured by identified indicators.
Objective 20D: Determine whether measures taken at specific sites to restore freshwater habitat connectivity have been effective over time.

Question 21: Are habitat improvement projects effective?
Objective 21A: Provide guidance to the Salmon Recovery Funding Board (SRFB) and other funding entities for best monitoring protocols for habitat projects.
Objective 21B: Determine whether habitat improvement projects are effective in increasing the number of salmon produced.
Objective 21C: Determine what kinds of salmon recovery projects are the most cost effective.
Objective 21D: Determine whether habitat improvement projects were properly implemented.

Question 22: How can monitoring information be effectively shared and coordinated with the public and all levels of government?
Objective 22A: Establish a web portal that will provide monitoring information to all levels of government and to the public.
Objective 22B: Develop a consensus approach among monitoring participants for statewide data sharing protocols.
Objective 22C: Identify crucial data repositories.

Question 23: Are watershed lead agencies developing monitoring strategies complimentary with the Comprehensive Monitoring Strategy?
Objective 23A: Provide guidance to the watershed lead agencies for monitoring types and protocols that would be complimentary to the Comprehensive Monitoring Strategy.

Table 2. Management Decision Matrix.

	Priority	Management Question	Monitoring Question
A	High	Are salmon populations healthy?	1-23
B	High	Is the State meeting requirements of the Endangered Species Act and Clean Water Act?	3, 6, 7, 9, 10, 11, 12, 21
C	High	Are human related activities consistent with salmon recovery?	1, 4, 8, 9, 14, 15, 16
D	High	Are harvest activities consistent with salmon recovery?	2, 3, 11, 21
E	High	Is the state's approach to cleaning polluted waters adequate to ensure clean water for watershed health and salmon recovery?	6, 7, 9, 12

F	High	Are hatchery operations consistent with salmon recovery?	3, 10, 14, 21
G	High	Are state and federally-funded habitat protection and restoration projects resulting in improvements in watershed health and salmon recovery?	1, 3, 7, 9, 11, 14, 15, 16, 18
H	High	Are current stream and wetland buffer widths protecting habitat to ensure watershed health and salmon recovery?	1, 3, 6, 7, 9, 15, 16
I	Mod.	Are efforts to improve instream flows adequate for protecting watershed health and recovering salmon?	3, 5, 17, 18, 19, 20, 23
J	Mod.	Is watershed health and salmon information understandable accessible, and useable by the general public and other entities?	2, 3, 13, 17
K	Mod.	Are current management infrastructures adequate in supporting watershed health and salmon recovery?	2, 5, 6, 7, 9, 10, 12, 13, 17, 19, 20, 23
L	Mod.	If estuarine and nearshore marine area habitat conditions are not improving, what further restrictions on bulkheads and other shoreline development constraints are necessary?	3, 4, 15
M	Mod.	Are dams operating in a manner that protects watershed health and is consistent with salmon recovery?	3, 5, 8, 11, 14, 19
N	Mod.	Are we adequately enforcing our timber harvest, land use, and water supply regulations?	2, 4, 5, 7, 9, 12, 20, 23
O	Low	Does the public support salmon recovery and watershed health improvements?	3, 5, 13
P	Low	Is climate and ocean condition information sufficient in anticipating and/or modifying our habitat and harvest activities?	3, 18
Q	Low	Are habitat protection measures on state lands improving watershed health and achieving salmon recovery?	1, 3, 7, 9, 15, 16
R	Low	Should the state ask the federal government to take additional management actions to reduce natural predation of salmon?	3, 22
S	Low	Are efforts to improve fish passage effective and timely enough to recover salmon?	3, 5, 11, 14, 15
T	Low	Are salmon protection measures in the Forests and Fish Agreement improving salmon recovery and watershed health on private forestlands?	1, 3, 7, 9, 15
U	Low	Are habitat protection measures on federal lands improving watershed health and salmon recovery?	1, 3, 7, 9, 15
V	Low	Should the state petition federal agencies to list or de-list salmon, steelhead, or trout?	1, 3, 11, 21

Appendix 3. Excerpts from the Lower Columbia Fish Recovery Board's Research, Monitoring, and Evaluation Program for Lower Columbia Salmon and Steelhead (LCFRB 2010a) describing aspects of the monitoring program associated with the Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (LCFRB 2010b).

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

1. Monitor adult spawning abundance of representative populations of Chinook, chum, coho, and steelhead.
Questions: What is the current population size and trend relative to the recovery objective?
Data: Estimates of absolute or relative abundance from counts of live fish, carcasses, or redds
Sampling: Representative long term index sites (dams, weirs, snorkel, ground or aerial surveys)
Analysis: Geometric mean number of spawners and annualized population growth rate.

2. Monitor juvenile abundance of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.
Questions: What is current juvenile abundance and trend relative to the recovery objective?
Data: Juvenile migrant population estimates or indices of abundance, size, age, migration dates.
Sampling: Collection of migrating juveniles at representative index sites (traps, mark-recapture, catch per unit effort).
Analysis: Annualized population growth rate, juveniles per spawner.

3. Monitor productivity of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.
Questions: What is current productivity and trend in productivity relative to the recovery objective?
Data: Numbers, ages, hatchery/wild origin.
Sampling: Annual size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data.
Analysis: Natural juvenile and/or adult recruits per spawner based on cohort run reconstructions.

4. Monitor distribution/spatial structure of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.
Questions: How many reaches are used for spawning and how has distribution of spawners among reaches varied in relation to abundance, accessibility and historical use?
Data: Indices of relative abundance of adults from counts of live fish, carcasses or redds and/or juveniles based on snorkel, electrofishing, or seining surveys.

Sampling: Replicate random samples stratified by time period and area in one or more years, repeated at periodic intervals.
Analysis: Relative abundance, range, patchiness, used vs. available area, representation of index sites identified in routine sampling.

5. Monitor trends and variation in diversity of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.
Questions: Do all life history patterns continue to be represented and are traits changing relative to objective descriptions?
Data: Sex, size, fecundity, migration timing, hatchery influence, genetic characteristics.
Sampling: Representative individual samples from adult or juvenile fish or carcasses in conjunction with adult or juvenile abundance and distribution sampling.
Analysis: Averages and frequency distributions of data over time.

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

Question #1. Are habitat conditions stable or changing as a result of fish protection and restoration actions, and other factors?
Null hypothesis: Stream habitat conditions are unchanged since listing.
Alternative: Stream habitat conditions have changed since listing.

Question #2. How are fish limiting factors affected by stream habitat status and trends?
Null hypothesis: Stream habitat limitations for fish are unchanged.
Alternative: Changes in stream habitat have affected critical fish limiting factors such that improvements in fish status are likely.

Question #3. Which streams and stream reaches are most important to fish protection and/or restoration?
Null hypothesis: All streams and stream reaches are of equal importance to fish.
Alternative: Some streams and stream reaches are more important than others.

Question #4. What is the fish production and abundance capacity of the stream habitat and how has it changed?
Null hypothesis: There are no significant differences in habitat productivity and capacity for fish among areas or trends over time.
Alternative: There are significant differences in habitat productivity and capacity for fish among areas and/or trends over time.

Question #5. Have specific stream habitat improvement actions achieved the desired physical and biological effects? (see action effectiveness monitoring section)
Null hypothesis: Actions resulted in no change in physical or biological conditions.
Alternative: Physical or biological conditions changes as a result of the action.

Question #6. How is fish status related to stream conditions and how are stream conditions affected by landscape/watershed factors and stream flow patterns? (see uncertainty and validation research section)
Null hypothesis: Stream conditions do not affect fish status and are unaffected landscape/watershed factors or stream flow patterns.
Alternative: Stream conditions affect fish status and are affected landscape/watershed factors or stream flow patterns.

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

Question #1. Are landscape conditions stable or changing as a result of fish protection and restoration actions, and other factors?
Null hypothesis: Watershed, upland/hill slope and wetland conditions are unchanged since listing. Alternative: Watershed, upland/hill slope and wetland conditions have changed since listing.

Question #2. Which landscape-level areas and factors are most important to stream habitat conditions in key fish production areas?
Null hypothesis: All watershed, upland/hill slope and wetland areas and factors are of equal importance to fish.
Alternative: Some watersheds, upland/hill slope and wetland areas and factors are more important than others.

Question #3. Have specific landscape-level actions achieved the desired physical effects? (see action effectiveness monitoring section)
Null hypothesis: Actions resulted in no change in watershed, upland/hill slope and wetland conditions. Alternative: Changes in watershed, upland/hill slope and wetland conditions are a result of the action.

Question #4. How are stream conditions affected by landscape/watershed factors? (see uncertainty and validation research section
Null hypothesis: Stream conditions are unaffected landscape factors or stream flow patterns.
Alternative: Stream conditions are affected by landscape factors or stream flow patterns.

Box 5. Questions addressed by habitat action effectiveness monitoring.

- Have passage improvement actions increased access to significant amounts of suitable habitat for salmonids?
- Have channel structure and bank stability improvement actions increased habitat quantity and quality for salmonids?
- Have off-channel and side-channel improvement actions increased habitat quantity and quality for salmonids?
- Have floodplain restoration actions increased habitat quantity and quality for salmonids?

- Have water quality improvement actions increased habitat quantity and quality for salmonids?
- Have water flow-related actions increased habitat quantity and quality for salmonids?
- Have watershed actions increased watershed functions deemed beneficial to stream salmonid habitats?

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

Question #1. Are the target levels for juvenile and adult passage and survival through hydropower facilities consistent with recovery?
Null hypothesis: Juvenile and adult passage and survival through hydropower facilities are not effectively limited to target levels for each program consistent with recovery.
Alternative: Juvenile and adult passage and survival through hydropower facilities are effectively limited to target levels for each program consistent with recovery.

Question #2. Are upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities consistent with recovery?
Null hypothesis: Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are not effectively limited to target levels for each program consistent with recovery.
Alternative: Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are effectively limited to target levels for each program consistent with recovery.

Question #3. Are fish reintroduction efforts into previously-blocked tributaries meeting population viability objectives identified in the Recovery Plan?
Null hypothesis: Fish reintroduction efforts in tributaries are not meeting population viability objectives identified in the Recovery Plan.
Alternative: Fish reintroduction efforts in tributaries are meeting population viability objectives identified in the Recovery Plan.

Question #4. Are hydropower mitigation benefits for fish adequately meeting prescribed program objectives?
Null hypothesis: Mitigation benefits are not meeting program objectives.
Alternative: Mitigation benefits are meeting program objectives.

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

Question #1. Are fishery impacts on sensitive stocks effectively limited to prescribed levels?
Null hypothesis: Fishery management systems and actions do not limit impact rates to prescribed levels.

Alternative: Fishery management systems and actions limit impact rates to prescribed levels.

Question #2. Are prescribed fishing levels consistent with long term viability of listed stocks?
Null hypothesis: Prescribed fishery impact rates do not pose significant jeopardy to the long term viability of listed species.
Alternative: Prescribed fishery impact rates pose significant jeopardy to the long term viability of listed species.

Question #3. Are significant fishery opportunity and harvest being sustained by existing populations and management?
Null hypothesis: Fishery opportunity and harvest is not being sustained at levels adequate to meet broad sense goals.
Alternative: Fishery opportunity and harvest is being sustained at levels adequate to meet broad sense goals.

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

Question #1. Are hatchery impacts on sensitive stocks effectively limited to prescribed levels?
Null hypothesis: Hatchery actions do not limit impact rates to prescribed levels.
Alternative: Hatchery actions limit impact rates to prescribed levels.

Question #2. Is hatchery performance consistent with objective benefits and risks identified for each program?
Null hypothesis: Performance is not consistent with objective benefits and risks prescribed for each program.
Alternative: Performance is consistent with objective benefits and risks prescribed for each program.

Question #3. Are hatchery practices consistent with objectives identified for each program?
Null hypothesis: Practices are not consistent with program objectives. Alternative: Practices are consistent with program objectives.

Appendix 4. Excerpt from Northwest Power and Conservation Council. 2010. Draft-Columbia River Basin Monitoring, Evaluation, Research, and Reporting (MERR) Plan. Northwest Power and Conservation Council, Portland, Oregon.

The nine management questions that the Northwest Power and Conservation Council (NPCC) seeks to answer are:

1. Are Columbia River Basin fish and wildlife abundant, diverse, productive, spatially distributed, and sustainable?
2. Are Columbia River Basin ecosystems healthy?
3. Are ocean conditions affecting Columbia River Basin anadromous fish?
4. Is climate change affecting fish and wildlife in the Columbia River Basin?
5. Are fish, wildlife and their habitat responding to the implemented actions as anticipated?
6. Are Council Program actions coordinated within the Program and with other programs?
7. Are mainstem hydrosystem operations and system configuration improvements meeting the Council Fish and Wildlife Program's survival and passage objectives?
8. Is harvest consistent with the Council Fish and Wildlife Program's vision?
9. Does artificial production complement resident and anadromous fish recovery and harvest goals within the Columbia River Basin?