Evaluation and Prioritization of Stream Habitat Monitoring in the Lower Columbia Salmon and Steelhead Recovery Domain as related to the Habitat Monitoring Needs of ESA Recovery Plans

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Contents

Figures

Tables

Appendix Tables

Acknowledgements

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Table 1. Integrated Status and Trend Monitoring Habitat Workgroup members

Name	Organization	Monitoring Program
Karen Adams	Washington Department of Ecology	Status and Trends Monitoring for Watershed Health and Salmon Recovery
Heidi Andersen	U.S. Forest Service	Aquatic and Riparian Effectiveness Monitoring Program
Kara Anlauf-Dunn	Oregon Department of Fish and Wildlife	Aquatic Inventories Project
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Jeff Breckel	Lower Columbia Fish Recovery Board	Not Applicable
Bob Cusimano	Washington Department of Ecology	Status and Trends Monitoring for Watershed Health and Salmon Recovery
Pat Frazier	Lower Columbia Fish Recovery Board	Not Applicable
Bernadette Graham Hudson	Lower Columbia Fish Recovery Board	Not Applicable
Tricia Gross	Tetra Tech EC, Inc	Washington State Salmon Recovery Funding Board Action Effectiveness Monitoring Program
Shannon Hubler	Oregon Department of Environmental Quality	National Rivers and Streams Assessment
Chris Jordan	National Oceanic and Atmospheric Administration	Columbia Habitat Monitoring Program
Steve Lanigan	U.S. Forest Service	Aquatic and Riparian Effectiveness Monitoring Program
Glenn Merritt	Washington Department of Ecology	Status and Trends Monitoring for Watershed Health and Salmon Recovery
Stephanie Miller	U. S. Bureau of Land Management	Aquatic and Riparian Effectiveness Monitoring Program
Jennifer O'Neal	Tetra Tech EC, Inc	Washington State Salmon Recovery Funding Board Action Effectiveness Monitoring Program
Amy Puls	Pacific Northwest Aquatic Monitoring Partnership, U.S. Geological Survey	Not Applicable
Steve Rentmeester	Sitka Technology Group	Columbia Habitat Monitoring Program
Jeff Rodgers	Oregon Department of Fish and Wildlife	Aquatic Inventories Project
Jeff Schnabel	Clark County	Clark County Washington Clean Water Program
Charlie Stein	Oregon Department of Fish and Wildlife	Aquatic Inventories Project
Mike Ward	Terraqua, Inc.	Columbia Habitat Monitoring Program

Executive Summary

The lower Columbia River and its tributaries once supported abundant runs of salmon and steelhead; however, there are five species currently listed under the federal Endangered Species Act (ESA). The National Marine Fisheries Service has completed, and is proposing for adoption, a comprehensive ESA Recovery Plan for the Lower Columbia Evolutionarily Significant Units (ESUs) based on the recovery plans developed by Oregon and Washington. One of the primary factors attributed to the decline of these species is habitat degradation. There are numerous entities conducting status and/or trends monitoring of instream habitat in the lower Columbia River Basin, but because the programs were developed for agency specific reasons, 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 the ESA listed populations. The Pacific Northwest Aquatic Monitoring Partnership's Integrated Status and Trends Monitoring (ISTM) project was initiated to improve integration of existing and new monitoring efforts by developing recommendations for sampling frames, protocols, and data sharing. In an effort to meet the ISTM project goals, five objectives were identified: (1) identify and prioritize decisions, questions, and monitoring objectives, (2) evaluate how 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. This report summarizes the effort to address Objectives 1 and 2, detailing the commonalities among the habitat characteristics that all entities measure and monitor, and how the metrics align with the priorities listed in the comprehensive recovery plan for the Lower Columbia ESUs.

Background – Recovery Planning for ESA-Listed Salmonids

The lower Columbia River and its tributary rivers and streams were once among the most productive salmon and steelhead systems in the Pacific Northwest. These rivers supported tremendous biological diversity, including multiple salmonid species that filled practically every accessible niche and habitat. Now, pervasive, cumulative impacts from a variety of sources have driven these fish to the brink of elimination. Salmon (Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta,* and coho salmon *O. kisutch)*, steelhead trout (*O. mykiss*), and bull trout (*Salvelinus confluentus*) of the lower Columbia River Basin have been depleted to the point where five species have been listed under the federal Endangered Species Act (ESA). The Lower Columbia River Chinook salmon Evolutionary Significant Unit (ESU), Columbia River chum salmon ESU, Lower Columbia River coho salmon ESU, Lower Columbia River steelhead Distinct Populations Segments (DPS), and the Columbia River bull trout DPS were listed as Threatened under the ESA between 1998 and 2005. The area that encompasses these ESUs and DPSs will be collectively referred to as the Lower Columbia ESU for the purpose of this report.

In response to these listings, recovery plans have been developed to address recovery efforts in the Lower Columbia ESU and address the ESA threats criteria. The Lower Columbia Fish Recovery Board (LCFRB) completed the Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan for the Washington portion of the Lower Columbia ESU in 2004 (LCFRB 2004); this plan was adopted as an interim recovery plan by the National Marine Fisheries Service (NMFS) in 2006. In 2010, LCFRB updated this plan to include additional information for coho, which was listed after the initial plan completion (LCFRB 2010a, hereafter referred to as the Washington Recovery Plan). Also in 2010, the Oregon Department of Fish and Wildlife (ODFW) completed the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010, hereafter referred to as the Oregon Recovery Plan). In 2012, NMFS proposed the adoption of a comprehensive recovery plan for the entire Lower Columbia ESU (now final, NMFS

2013) that is comprised of the Oregon Recovery Plan, the Washington Recovery Plan, the Draft ESA Recovery Plan for the White Salmon River (now final, NMFS 2013), and the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (NMFS 2011a). The recovery process for bull trout is distinct from the process for salmon and steelhead; the U.S. Fish and Wildlife Service is responsible for developing the bull trout recovery plan (USFWS 2002). This report focuses just on the recovery plans for salmon and steelhead.

The Oregon Recovery Plan includes Research, Monitoring, and Evaluation (RME) recommendations to support efforts for the recovery of threatened salmonids. The plan identifies the need to assess the status of listed species and their habitat, track progress toward achieving recovery goals, and provide information needed to refine recovery strategies and actions through the process of adaptive management (ODFW 2010). ODFW's recommendations include RME aimed at assessing biological criteria (i.e., abundance, productivity, genetic diversity, and spatial structure) and listing criteria (i.e., habitat degradation, fish harvest, hatcheries, disease and predation, inadequate regulatory mechanisms, or other natural or manmade factors) affecting the continued existence of Oregon's salmon and steelhead populations in the lower Columbia River.

The LCFRB developed an RME Program for Lower Columbia salmon and steelhead (LCFRB 2010b) to provide a framework for monitoring associated with the Washington Recovery Plan. The LCFRB RME Program details the monitoring, research, and evaluation elements of a coordinated regional program supporting Lower Columbia salmon and steelhead recovery and watershed plan implementation efforts. Elements identified include: 1) biological status and trend monitoring, 2) habitat status and trend monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. Program elements were designed to address salmon status and threats consistent with ESA listing and recovery planning criteria and goals. The goal of LCFRB's RME program is to provide a template for action and overall guidance to participants involved in implementation of the Washington Recovery Plan and local watershed management plans. The program identifies existing monitoring in the region, evaluates their quality, identifies gaps, and provides a framework for addressing those gaps. The framework aims to meet the needs of monitoring for both the salmon recovery and watershed management plans, and relies on integration of existing monitoring programs in the region.

The Lower Columbia ESU has multiple ESA-listed salmonid species, several adopted recovery plans, and numerous entities involved in monitoring; however, it lacks a coordinated, comprehensive habitat monitoring program. Both Oregon and Washington Recovery Plans include recommendations for habitat status and trends monitoring. In order to track progress towards meeting recovery plan objectives of reducing impacts from habitat degradation, questions about habitat status and trends will need to be answered comprehensively at multiple recovery planning scales.

The ISTM effort

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Integrated Status and Trends Monitoring (ISTM) demonstration project supports the LCFRB's RME program and ODFW's monitoring efforts by providing recommendations for the development of a coordinated monitoring program for the Lower Columbia ESU, including recommendations for sampling frames, protocols, and data sharing. The primary purpose of the 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 and steelhead populations. The Lower Columbia ESU was chosen for this demonstration project because it is representative of the challenges faced when integrating monitoring across multiple ESUs and DPSs, within the boundaries of multiple states and local

municipalities, as well as being subject to federal and tribal management through U.S. v. Oregon (Civil No. 68-513-KI (D. Or.)) and the Pacific Salmon Treaty (Figure 1). Although numerous entities are involved in monitoring in the Lower Columbia ESU, 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 salmon and steelhead populations across the ESU/DPS.

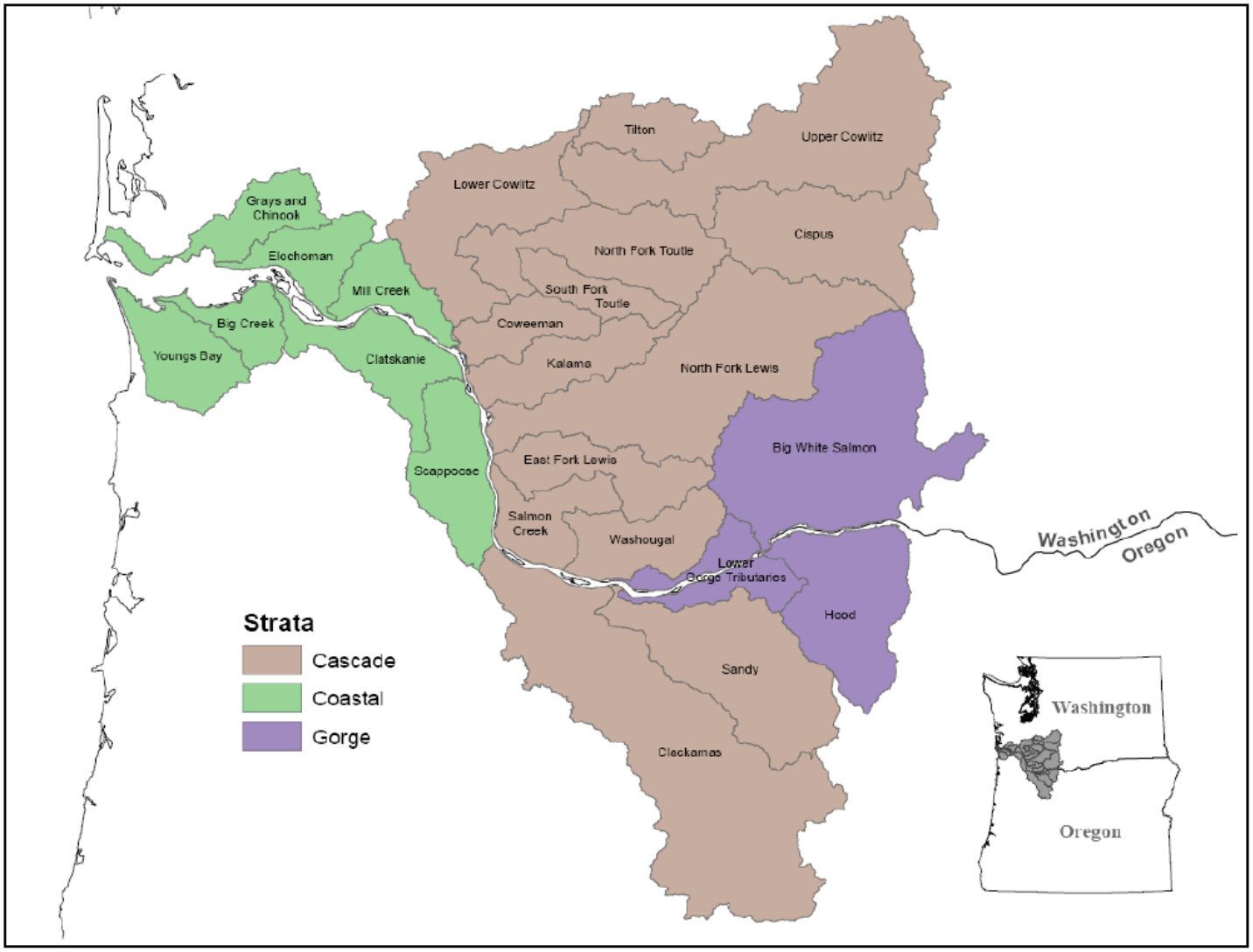

Figure 1. Lower Columbia River pilot project area showing ESA-listed salmon population boundaries and the regional groupings (i.e., strata) in which they occur.

The current ISTM effort is examining the qualities of existing information, key gaps, and how a region-wide "master sample" concept can be applied to select sampling locations where appropriate. The resulting framework will provide entities tasked with monitoring salmon and steelhead populations and aquatic habitat in the Pacific Northwest with a roadmap for integration of scientifically sound monitoring programs to meet the needs of decision-makers and managers.

The ISTM project includes efforts to develop a comprehensive, ESU-wide monitoring program for salmon and steelhead populations (fish component) and habitat conditions (habitat component). In both the fish and habitat components, the process includes five overall objectives:

1. Identify and prioritize management decisions, questions, and monitoring objectives.
2. Document and review existing programs and designs and evaluate the extent to which they align with the 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.
5. Recommend implementation and reporting mechanisms.

The overall goal of the ISTM Habitat component is to develop recommendations for a status and trends monitoring strategy for the lower Columbia region that can meet the priority objectives identified in the salmon recovery plans, be scientifically sound, and provide a roadmap for efficient monitoring across multiple entities. This report documents efforts to complete Objectives 1 and 2 for habitat status and trends monitoring. Additional information regarding the process for salmon and steelhead status and trends monitoring can be found on the PNAMP website at http://www.pnamp.org/project/3151.

State monitoring strategies and recovery plan objectives

To address ISTM Objective 1, the Habitat Workgroup identified priority monitoring objectives from the Oregon and Washington Recovery Plans, as well as the NMFS Lower Columbia Recovery Plan for the Lower Columbia ESU. Both Oregon and Washington Recovery Plans include monitoring priorities that correspond to the Willamette-Lower Columbia Technical Recovery Team's (TRT) salmon population boundaries. In addition, the spatial scale for reporting includes major population groups (MPGs, also known as strata), including the Coast, Cascade, and Gorge strata, and the ESU or DPS as a whole. Other scales for reporting include assessments within species distributions, by land use type, and by Water Resource Inventory Area (WRIA, in Washington only). Recommended sampling intervals vary depending on the spatial scale and monitoring designs.

The Oregon Recovery Plan (ODFW 2010) identifies the key habitat related threat question as: "Are there significant effects of habitat degradation on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?" To answer this question, ODFW identifies measurable criteria for the habitat related threats and the RME needed to assess those habitat related threats. The plan proposes assessments of seven habitat related criteria; a) Floodplain Connectivity and Function, b) Channel Structure and Complexity, c) Riparian Condition and Large Woody Debris (LWD) Recruitment, d) Stream Substrate, e) Stream Flow, f) Water Quality, and g) Fish Passage.

Five-year estimates of the status and spatial pattern of these habitat criteria will be used by ODFW to establish baseline conditions and trend in tributary streams within each lower Columbia River population area and in the estuary. These data will be acquired through spatially balanced, random surveys based on the generalized random tessellation stratified (GRTS) technique. Field sampling protocols will follow ODFW Aquatic Inventory protocols (Moore et al. 2007) and Oregon Department of Environmental Quality protocols for habitat and water quality data collection, respectively. Additional RME will include implementation and compliance monitoring, effectiveness monitoring in coordination with PNAMP, and critical uncertainty research.

Measurable criteria have been established by ODFW and are based on trends in habitat conditions for all species as they relate to habitat status and the quantity of restoration actions. An additional criterion for coho salmon includes the number of additional high quality miles of habitat equal or exceeding delisting and broad-sense goals (ODFW 2010). Based on the current status of habitat and the measurable criteria, a population is

categorized as having either passed or failed. The achievement of passing grades does not eliminate an ESU or population from the risk of extinction. Significant improvement in habitat condition is needed to realize recovery goals and conditions. The plan proposes five-year assessments of habitat conditions in order to evaluate whether the habitat status is improving, declining, or remaining the same. In order to gauge departure from pristine conditions, efforts to develop a least disturbed, "reference" dataset that can be compared to current habitat conditions would enable quantitative benchmarks to be established. While this is a common goal across monitoring programs, it is complicated by the variation in habitat metrics and limited power to detect trends. In general, there is a current lack of quantitative information linking habitat conditions to the biological criteria. Until a more sound linkage is established, measureable criteria based on trends in habitat condition are proposed.

In Washington, the LCFRB's RME program (LCFRB 2010b) identifies a comprehensive set of habitat monitoring activities designed to address the hierarchy of needs. The program identifies sampling components at three habitat scales: 1) stream corridor, 2) landscape, and 3) water quality and quantity. Monitoring components are identified for each of the three habitat scales.

At the stream corridor scale, LCFRB's RME program identifies priority attributes of channel conditions, riparian zone, floodplain and channel migration processes, and accessibility as key attributes to measure. Channel conditions include factors such as channel gradient and form, erosion and sedimentation, habitat types, and large woody debris. The riparian zone includes measures of vegetative cover, shade, invasive species, stream bank stability, and large wood recruitment potential. Floodplain and channel migration processes include channel migration zone encroachment and floodplain connectivity measures. Accessibility includes determination of anthropogenic and natural barriers.

At the landscape scale, key attributes identified in LCFRB's RME program include watershed conditions and hillslope processes, as well as channel migration processes and floodplain and wetland function. Watershed conditions measures include road density and stream crossing frequency, mass wasting, amount of impervious surfaces, and land use and cover measures. Measures of floodplain and wetland function include channel migration zone encroachment, wetland availability, and floodplain connectivity.

For water quantity, LCFRB's RME program identifies the key attribute of streamflow hydrograph measurements which includes measures of the normal hydrograph, low flow, and peak flow. For water quality, key measures identified in the RME program include temperature, dissolved oxygen, turbidity and suspended sediments, pH, conductivity, nutrients, and contaminants (metals and pollutants).

NMFS Lower Columbia Recovery Plan

The Lower Columbia Recovery Plan developed by NMFS identifies a regional strategy to address the limiting factors and threats related to tributary habitat (NMFS 2012), considering recommendations in both the Oregon and Washington recovery plans (Table 2). The tributary habitat strategy is focused on habitat protection and restoration to achieve adequate quantities of high-quality, well-functioning salmon and steelhead habitat. To accomplish this, the plan recommends: 1) site-specific projects that will protect habitat or provide benefits relatively quickly, 2) watershed-based actions that will repair habitat forming processes and provide benefits of the long term, and 3) landscape scale programmatic actions that affect the class of activities over multiple watersheds. The NMFS Lower Columbia recovery plan noted the immediate need to develop prioritization frameworks and while some prioritization work has already been developed (NMFS 2012), prioritization based on comprehensive monitoring needs has yet to occur.

Table 2. Alignment of the limiting factors and threats categories from the Oregon Recovery Plan (ODFW), Washington Recovery Plan (LCFRB), and the Lower Columbia Recovery Plan (NMFS).

Oregon	*Washington*	*NMFS Lower Columbia Plan*
Water quality	Water quality	Water quality
Stream flow	Water quantity	Water quantity
Channel structure and complexity	Channel condition	Channel structure and form
Stream substrate		Sediment conditions
Fish passage	Fish passage	Habitat quantity
Riparian condition and LWD recruitment	Riparian zone	Riparian conditions
Floodplain connectivity and function	Floodplain and channel migration processes	Peripheral and transitional habitats
	Floodplain and wetland functions	
	Watershed conditions and hillslope processes	

The NMFS Lower Columbia Recovery Plan will look to four listing factor criteria to determine whether an ESU or DPS has recovered:

1. Recovery plan actions addressing habitat limiting factors have been substantially implemented, including related research, monitoring, and evaluation actions.
2. The threat reduction targets for habitat have been met or habitat impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, and to track and periodically evaluate progress, specific metrics for assessing habitat conditions and action effectiveness will be needed.
3. Trends in overall habitat conditions, based on evaluation of the combined effect of factors, including, but not limited to, habitat access, hydrograph/water quantity, physical habitat quality and quantity, and water temperature and other water quality parameters, are stable or improving.
4. Functioning habitat areas, including those expected to be less vulnerable to impacts from climate change, have been protected. Other actions to support adaptation to climate change impacts have been implemented.

The plan highlights three different types of monitoring in order to support adaptive management, a process of adjusting management actions based on new or updated information about the ESU; 1) Implementation and compliance monitoring to evaluate whether recovery plans actions are being implemented, 2) Status and trends monitoring to assess changes in the status of an ESU, and 3) Effectiveness monitoring, which tests hypotheses about cause-and-effect relationships and determines whether an action should continue. Further, habitat related recommendations for monitoring recovery of salmon and steelhead in the Lower Columbia include the use of a GRTS sampling design, use of remote sensing of land use and land cover, and coordinated fish-in/fish-out monitoring (NMFS 2012).

The recovery plans discussed above provide a comprehensive resource for identifying priority aquatic ecosystem monitoring needs in the Lower Columbia ESU, but the limiting factors or threats have not been prioritized and the plans do not provide much guidance on the preferred approach for gathering the data necessary to evaluate the limiting factors or threats. The ISTM project will develop recommendations for more

coordinated, effective, and efficient habitat monitoring programs in the Lower Columbia ESU by using a combination of NMFS guidance and evaluation of commonalities among regional monitoring programs as the basis for identifying priorities. Under this premise, metrics that regional programs have in common, and that are believed to have the most direct effect on salmon and steelhead populations should become priorities for regional habitat monitoring. Using this approach means that the results of Objective 2 (evaluation of existing programs) will be an integral part of delineating common regional habitat monitoring priorities.

Framework for evaluation of existing monitoring programs

Objective 2 involved identifying the existing habitat monitoring programs in the lower Columbia, gathering information about their programs, such as their spatial inference domains, what attributes they currently measure, and their sampling methods, and documenting similarities and differences between the programs. The programs and partners involved in this process include Clark County Washington Clean Water Program, Columbia Habitat Monitoring Program, Oregon Department of Environmental Quality National Rivers and Streams Assessment, Oregon Department of Fish and Wildlife Aquatic Inventory, Washington State's Salmon Recovery Funding Board Action Effectiveness Monitoring, US Forest Service and Bureau of Land Management Aquatic and Riparian Effectiveness Monitoring Plan, and Washington Department of Ecology Monitoring for Watershed Health and Salmon Recovery. After compiling the information from all the programs, the ISTM Habitat Workgroup (comprised of representatives from each of the above programs) evaluated the potential to share habitat data among the programs, including documenting constraints to that sharing.

In order to more effectively identify similarities and differences in regional habitat monitoring programs, a conceptual framework, with clearly defined terminology, was developed for organizing the information gathered from the monitoring programs. The conceptual framework used to catalog habitat monitoring program information can essentially be broken down into two elements. The first element is a standardized language that describes the flow of habitat information from a field (or laboratory) data collection event to a regional (i.e., domain of inference) habitat characterization. Table 3 contains the three key terms used to describe the information that monitoring programs gather or produce. The characterization of a habitat attribute generally involves one or more field or lab measurements at a sampling point. The measurements are processed to produce a site metric for the attribute, which in turn can be processed with attribute metrics from other sites to produce a regional (or area of inference) indicator.

Table 3. Description of ISTM habitat terms.

Term	*Description*	*Scale*
Measurement	A value resulting from a field data collection event at a particular time and place.	Point
Metric	A value resulting from the reduction or processing of measurements taken across a site or over a unit of time.	Site
Indicator	A value resulting from the processing of metrics across multiple sites or across time.	Inference domain

The second element of the conceptual framework used to organize monitoring program information involves describing the four key components of a monitoring program design. Following the lead of a website that provides guidance on designing monitoring programs (http://www.monitoringadvisor.org/), the acronym STRIDE was used to outline the design structure and capture details for the monitoring programs. The design details, broken into four components, along with a standardized nomenclature for their sub-components, are described below:

- **S**patial design (how we select monitoring sites)
  - Census (full or partial)
  - Model-based (full or partial)
  - Survey or Probabilistic
    - Non-stratified or Stratified, Simple Random Sample
    - Non-stratified or Stratified Generalized Random-Tessellation Stratified (GRTS) Survey
    - Non-stratified or Stratified Systematic Survey
    - Random Cluster Sample Survey
    - Multistage Random Sample
    - Proportional to Size Survey
  - Opportunistic
    - Ease of access
    - Historic precedent
- **T**emporal design (how we select when we monitor sites)
  - Complete revisit
  - Never revisit
  - Complex revisit (repeating, rotating, and split designs)
  - Opportunistic revisit
- **R**esponse design (what and how we measure at sites)
  - What (i.e., attributes)
  - How (methods describing how to take measurements and calculate metrics)
- **I**nference **DE**sign (what data and how it is analyzed to generate indicators)

Detailed monitoring information for the 2011 field season was provided to PNAMP from each of the participating programs in a spreadsheet template based on the conceptual framework just described. For ease of analysis, the information was transferred from the spreadsheets into an Access database. After the information was compiled, the ISTM Habitat Workgroup evaluated the potential to share habitat data among the programs. The evaluation was done during seven web-conference work sessions. During the work sessions, information from each program for a given measurement or metric was displayed. Representatives from each program were then asked to review the information, ask questions if needed for clarification, and use best professional judgment to determine what data from the other programs they would be able to use alongside their own. This determination was primarily based on the method used to collect the measurements and how metrics are then calculated. Most of the attributes that are measured by three or more programs were reviewed using this process. The notes from the work sessions can be found online at http://www.pnamp.org/project/3152, and the database containing the detailed information can be found at http://www.pnamp.org/document/4321.

Program comparison and data comparability

An overview of the programs' monitoring design information can be found in Table 4. Across the seven programs' 2011 protocols there were 168 measurements used to calculate 443 metrics. Forty measurements (24%) and 98 metrics (22%) were measured/calculated by three or more of the programs. While all seven programs had 12 measurements (7%) and 15 metrics (3%) in common, there were 114 measurements (68%) and 230 metrics (52%) that are only measured/calculated by a single program (Table 5). The 12 measurements that all seven programs collect are: bankfull depth, bankfull height, bankfull width, gradient, large wood, pool maximum depth, pool tail crest depth, shade at mid-channel, site length, substrate particle size, thalweg depth, and wetted width. Further details about the specific measurements and metrics that the programs have in common can be found in Appendix Tables A1 and A2, respectively.

During the work sessions, program representatives decided that sharing site metrics (e.g. mean gradient) was preferable to sharing raw measurement data; therefore, the determination of comparability was done at the metric level. The one exception to this is macroinvertebrate data. Because of differences in the metrics programs were calculating, and potentially how species traits such as "pollution intolerance" are assigned, it was decided that sharing the raw macroinvertebrate taxa counts along with the area sampled was preferable. It was also agreed that the decision of data compatibility ultimately would need to take into consideration the precision, bias, and accuracy of the metrics; this information was not available at the time of the discussions. This caveat must be kept in mind when interpreting the results. Table 6 provides a summary of comparability for the metrics discussed during the work sessions; the details of the measurement methods, metric calculations, and the expert opinions on the comparability of data can be found in the Access database (see link above).

Table 4. Monitoring design information for the seven programs participating in the ISTM Habitat demonstration project.

Entity	US Forest Service and Bureau of Land Management	Bonneville Power Administration	Clark County, WA	Oregon Department of Environmental Quality	Oregon Department of Fish and Wildlife	Salmon Recovery Funding Board	Washington Department of Ecology
Program	Aquatic and Riparian Effectiveness Monitoring Program	Columbia Habitat Monitoring Program	Long-term Index Site Monitoring	National Rivers and Streams Assessment	ODFW Aquatic Inventory	Reach-Scale Effectiveness Monitoring	Watershed Health and Salmon Recovery
Report Abbreviation	AREMP	CHaMP	Clark Co	ODEQ	ODFW	SRFB	WADOE
Primary Objective	Status and Trend	Status and Trend, Effectiveness of Habitat Management Actions	Status and Trend	Status and Trend	Status and Trend	Reach-Scale Effectiveness	Status and Trend
Year Started	2002	2011	2002	2008/2009	2006	2004	2009
Base Temporal Scale	Annual	Annual	Annual	Every 5 years	Annual	Annual	Every 4 years per region, some annual statewide trends
Site Length	20x bankfull width categories (150m-500m)	20x bankfull width (150m-2km)	20x bankfull width	40x wetted width	1000 meters	20x bankfull width (150m-500m)	20x bankfull width (150m-2km)
Spatial Design	Non-stratified GRTS	Stratified GRTS	Opportunistic	Stratified GRTS	Non-stratified GRTS	Stratified random	Stratified GRTS
Quality Control	Field personnel training, standard protocol, 9 watersheds resurveyed	Field personnel training, standard protocol, 10% of sites resurveyed	Field personnel training, standard protocol, data QA/QC process	Field personnel training, standard protocol, 10% of sites resurveyed	Field personnel training, standard protocol, 10-20% of sites resurveyed	Field personnel training, standard protocol, data QA/QC process	Field personnel training, standard protocol, 10% of sites resurveyed

Table 4. Monitoring design information for the seven programs participating in the ISTM Habitat demonstration project.

Entity	US Forest Service and Bureau of Land Management	Bonneville Power Administration	Clark County, WA	Oregon Department of Environmental Quality	Oregon Department of Fish and Wildlife	Salmon Recovery Funding Board	Washington Department of Ecology
Program	Aquatic and Riparian Effectiveness Monitoring Program	Columbia Habitat Monitoring Program	Long-term Index Site Monitoring	National Rivers and Streams Assessment	ODFW Aquatic Inventory	Reach-Scale Effectiveness Monitoring	Watershed Health and Salmon Recovery
Report Abbreviation	AREMP	CHaMP	Clark Co	ODEQ	ODFW	SRFB	WADOE
Protocol	AREMP (http://www.reo.gov/monitoring/reports/watershed/2010.FieldProtocol.Final.pdf)	CHaMP (https://www.champmonitoring.org/Program/Details/1#protocol)	Modified EMAP	EMAP (http://www.epa.gov/wed/pages/projects/EMAPManual.pdf)	ODFW Aquatic Inventory (http://oregonstate.edu/dept/ODFW/freshwater/inventory/pdffiles/hmethd10_woFISHMANUAL.pdf)	Crawford 2011 protocols for effectivness monitoring (modified EMAP) (http://www.rco.wa.gov/monitoring/protocols.shtml)	WHSR (modified EMAP, ISEMP) (http://www.ecy.wa.gov/programs/eap/stsmf/participants.html)
Comments	Surveys conducted in wadeable streams within the Northwest Forest Plan area in watersheds with at least 25% of the 1:100K stream layer within federal ownership.	Surveys conducted in wadeable salmon accessible streams.		National surveys designed, managed, and funded by USEPA. Surveys are conducted on wadeable and non-wadeable streams and rivers in Oregon.	Surveys only conducted in wadeable streams within the current range of coho salmon spawning and rearing habitat.		Surveys are conducted on wadeable and non-wadeable streams and rivers in Washington.

Table 5. The number of measurements and metrics in common for the seven programs participating in the ISTM Habitat demonstration project based on their 2011 protocols. See Appendix Tables A1 and A2 for the lists of specific measurements and metrics.

Number of programs	*Number of measurements in common*	*Number of metrics in common*
7	12	15
6	1	1
5	4	4
4	9	19
3	14	59
2	14	115
1	114	230
Total	168	443

Metrics that were determined to be comparable between all 7 programs included: bankfull width, bankfull height, bankfull depth, bankfull width to depth ratio, bankfull width x depth, wetted width, thalweg/wetted depth, wetted width to depth ratio, wetted width x depth, and gradient, (Table 6). There were also 11 other metrics that were collected by 3, 4, or 5 programs that were comparable across all programs that collected them (Table 6).

In many cases it was determined that metrics were not comparable because of differences in measurement methodologies. Large wood, shade at mid-channel, and sinuosity, each of which is measured by all seven programs, had relatively poor comparability across programs (Table 6). The poor comparability of shade at mid-channel and sinuosity had to do with the equipment used to collect the data, whereas in the case of large wood, differences in the minimum size criterion to be considered a qualifying piece of large wood and the way data are binned into size classes in the field are the causes of poor comparability across programs (Figure 2).

In other cases it was not possible to determine metric comparability because of uncertainty about the effects of method differences. For example, the set of criteria used to define a pool differs between several of the programs. It is not currently known if or how the differences in pool criteria affect survey results, thus for programs with different pool criteria it was not possible to determine if the pool metrics are comparable. More broadly, the comparability of channel unit composition metrics (e.g. percent pools, percent riffles, percent fast water habitat) was unknown not only because of differences in criteria (mainly for pools and glides), but also because some programs use an area based calculation to determine percent composition whereas others use a transect approach. The area based methods divide the summed area for a given channel unit type by the area of the entire reach to determine percent composition, whereas the transect method categorizes evenly spaced points along the thalweg into channel unit types and the count of each type is divided by the total number of thaweg points. Comparability of substrate particle size and substrate composition metrics remains unknown between programs that evaluate substrate across the bankfull width compared to those that evaluate across the wetted width due to conflicting information as to whether this difference affects the results. Like channel unit composition, there is also uncertainty about the comparability of substrate composition metrics (e.g. percent fines, percent gravel, percent boulder) because of area vs. transect based calculations.

Table 6. Comparability of site level metrics (based on 2011 protocols) for the seven programs participating in the ISTM Habitat demonstration project as determined by expert opinion. An X indicates that data can be used "as is" from the provider, a blank cell indicates that data cannot be used as is, a question mark indicates that comparability could not be determined (see footnotes for further detail), and grey shading indicates that the metric is not calculated. See Table 4 for explanation of program abbreviations.

Data Provider ➤	AREMP						CHaMP						Clark Co.						ODEQ						ODFW						SRFB						WADOE					
Data User ➤	CHaMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	SRFB
Bankfull Width	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bankfull Height	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bankfull Depth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bankfull Width:Depth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bankfull WidthxDepth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wetted Width	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wetted Depth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wetted Width:Depth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wetted WidthxDepth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gradient	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Macroinvertebrates Counts*		X	X		X	X							X		X		X	X	X		X		X	X					X		X	X		X	X		X	X		X	
Residual Pool Vertical Profile Area															X		X	X			X		X	X					X		X	X		X	X		X	X		X	
Water Temperature 7 Day Max	X	X	X				X	X	X				X	X	X				X	X	X																						
Conductivity								X	X			X		X	X			X		X	X			X														X	X	X			
Chinook, Coho, Cutthroat Observed																						X	X	X				X	X	X				X	X	X				X	X	X
Shade at Banks																							X	X						X		X				X		X				X
% Pool Tail Fines	X				X		X				X																				X	X									
DO															X			X			X			X														X	X			
pH															X			X			X			X														X	X			
Phosphorous															X			X			X			X														X	X			
Turbidity															X			X			X			X														X	X			

* Not site averages, preference is to share raw count data along with area sampled (by site)

Table 6. Continued**.** Comparability of site level metrics (based on 2011 protocols) for the seven programs participating in the ISTM habitat demonstration project as determined by expert opinion. An X indicates that data can be used "as is" from the provider, a blank cell indicates that data cannot be used as is, a question mark indicates that comparability could not be determined (see footnotes for further detail), and grey shading indicates that the metric is not calculated. See Table 4 for explanation of program abbreviations.

Data Provider ➤	AREMP						CHaMP						Clark Co.						ODEQ						ODFW						SRFB						WADOE					
Data User ➤	CHaMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	SRFB
All Large Wood Metrics																		X																X						
Large Wood Vol and # of Pieces**		X	X		X	X							X		X		X	X	X		X		X	X						X		X	X		X	X		X	X		X
Large Wood Vol and # of Pieces***										X																X																	
Shade at Mid-channel															X		X	X			X		X	X									X	X		X			X	X		X
% Substrate Composition Metrics[1,2]	?	?	?	?	?	X	?	X	X	X	?	?	?	?	X	X	X	?	?	?	X	X	X	?	?	X	?	X	?	?	?	?	X	X	X	?	X	?	?	?	?	?
Substrate Particle Size (e.g. D50)[1]	?	?	?		?	X	?	X	X		?	?	?	?	X		X	?	?	?	X		X	?							?	?	X	X		?	X	?	?	?		?
Substrate Embeddedness								X							X		X				X		X										X			X			X			X
CU Composition - % Pool[2, 3]								?	?	?	?	?		?	X	?	X	X		?	X	?	X	X		?	?	?	?	?		?	X	X	?	X		?	X	X	?	X
CU Composition - % Fast Water[2]										X	X	X														X			X	X		?			?	X		?			?	X
CU Composition - % Cascade[2]								X	X	X	X			?	X	?	X			?	X	?	X			X	X	X	X			?	X	X	?							
CU Composition - % Rapid[2]								X	X	X	X			?	X	?	X			?	X	?	X			X	X	X	X			?	X	X	?							
CU Composition - % Riffle[2]								X	X	X	X			?	X	?	X			?	X	?	X			X	X	X	X			?	X	X	?							
CU Composition - % Glide[2, 4]								?	?	?	?			?	X	?	X			?	X	?	X			?	?	?	?			?	X	X	?							
CU Composition - % Dry Channel[2]																						?	X	X				X	X	X				X	?	X				X	?	X
CU Composition - % Side Channel[2]																						?		X				?		?				X	?							
Number Of Channel Units										X		X														?				X								?			X	

** For wood >5m length & >30cm diameter

*** For wood >3m length & >15cm diameter

1 Uncertainty regarding effect of measurements spanning wetted width vs. bankfull width

2 Uncertainty regarding effect of area vs. transect based calculations

3 Uncertainty due to differences in how a pool is defined

4 Uncertainty due to differences in how a glide is defined

Table 6. Continued**.** Comparability of site level metrics (based on 2011 protocols) for the seven programs participating in the ISTM habitat demonstration project as determined by expert opinion. An X indicates that data can be used "as is" from the provider, a blank cell indicates that data cannot be used as is, a question mark indicates that comparability could not be determined (see footnotes for further detail), and grey shading indicates that the metric is not calculated. See Table 4 for explanation of program abbreviations.

Data Provider ➤	AREMP						CHaMP						Clark Co.						ODEQ						ODFW						SRFB						WADOE					
Data User ➤	CHaMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	Clark Co.	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	ODEQ	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODFW	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	SRFB	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	WADOE	AREMP	CHaMP	Clark Co.	ODEQ	ODFW	SRFB
Sinuosity				X				X						X	X			X			X			X	X							X	X	X		X		X	X	X		
Pool Max Depth[3]	?	?	?	?	?	?	?	?	?	?	?	?	?	?	X	?	X	X	?	?	X	?	X	X	?	?	?	?	?	?	?	?	X	X	?	X	?	?	X	X	?	X
Pool Tail Crest Depth[3]	?	?	?	?	?	?	?	?	?	?	?	?	?	?	X	?	X	X	?	?	X	?	X	X	?	?	?	?	?	?	?	?	X	X	?	X	?	?	X	X	?	X
Residual Pool Depth[3]	?	?	?	?	?	?	?	?	?	?	?	?	?	?	X	?	X	X	?	?	X	?	X	X	?	?	?	?	?	?	?	?	X	X	?	X	?	?	X	X	?	X
Number Of Pools[3]	?		?	?		?	?		?	?		?							?	?		?		X	?	?		?		?							?	?		X	?	
Pool Frequency (Pools per 100 m)[3]	?		?	?		?	?		?	?		?							?	?		?		X	?	?		?		?							?	?		X	?	
Pool Area[3]									?	?		?								?		?		X		?		?		?								?		X	?	
Flow								X	X			X		X	X			X		X	X			X														X	X	X		
Riparian Vegetation Metrics									X		X	X								X			X	X								X		X		X		X		X		X
Fish Cover								X	X						X			X			X			X														X	X			
Amphibians Presence				X																				X	X														X			
Channel Form																		X																				X				
Erosion[5]																							X	?					X	?									?	?
Nitrogen															X						X																	X	X		

3 Uncertainty due to differences in how a pool is defined

5 Uncertainty due to differences in length of bank assessed

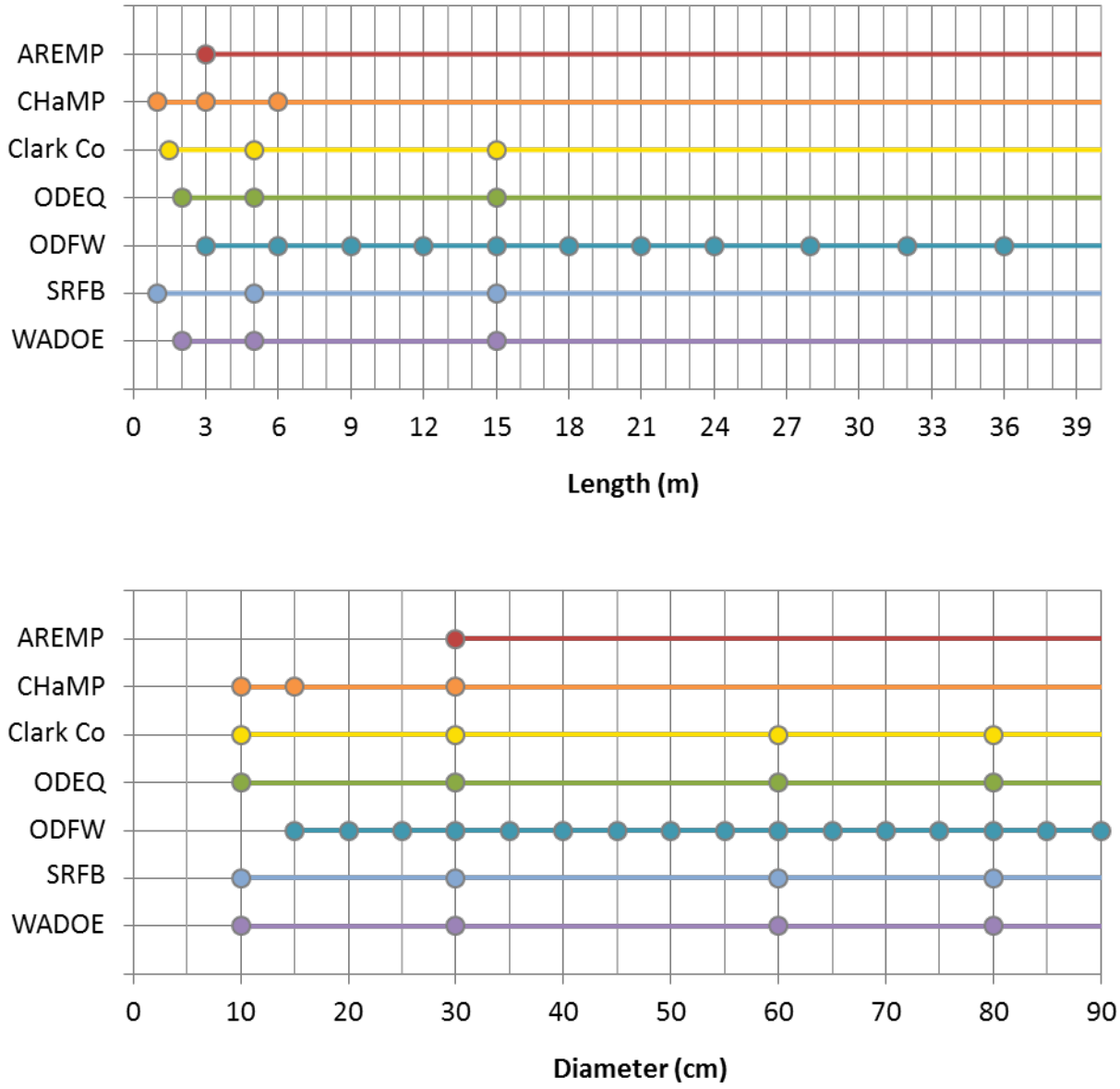

Figure 2. Large wood length and diameter size class break points for the seven programs participating in the ISTM Habitat demonstration project (based on 2011 protocols). With the exception of AREMP, who record a length and diameter for each piece of qualifying wood, all other programs tally qualifying pieces of wood by size classes based on length and diameter. For example, Washington Department of Ecology (WADOE), at sites west of the Cascade ridge, tallies pieces of large wood into 12 size classes; four diameter classes (10 to 30 cm, > 30 to 60 cm, > 60 to 80 cm, and > 80 cm) for each of three length classes (2 to 5 m, > 5 to 15 m, and > 15 m). Because of size class differences, comparability of data across all programs is limited. Some comparability can be achieved by combining size classes to a coarser resolution and excluding wood smaller than the lowest common size class. See Table 4 for explanation of program abbreviations.

Alignment to recovery plan objectives

The ISTM Habitat Workgroup has suggested that the prioritization of monitoring be based on commonalities found among the monitoring programs of multiple entities working in the Lower Columbia ESU in addition to satisfying the recovery plan RME needs. Metrics that regional programs have in common and that are believed to have the most direct effect on salmon and steelhead populations should become priorities for regional habitat monitoring. While the NMFS Lower Columbia Recovery Plan does not identify specifically which metrics to measure in order to assess habitat limiting factors and threats, it does identify categories of limiting factors and associated habitat concerns (NMFS 2012) (Table 7). In order to evaluate the extent to which existing monitoring programs align with the objectives of the comprehensive plan, we evaluated the metrics monitored by each program and assessed how those relate to the limiting factors highlighted in the comprehensive plan.

Table 7. Standardized list developed by NMFS to facilitate the use of common terms for discussing limiting factors in salmon and steelhead recovery plans.

NMFS Limiting Factors	*Habitat Concern Sub-category*
Channel structure and form	Bed and channel form
	Instream complexity
Habitat Quantity	Anthropogenic barriers
(i.e., Fish Passage and Accessibility)	Natural barriers
Peripheral and transitional habitats	Floodplain conditions
	Estuary conditions
	Nearshore conditions
Riparian condition	Riparian condition
	LWD recruitment
Sediment conditions	Decreased sediment quantity
	Increased sediment quantity
Water Quality	Temperature
	Oxygen
	Turbidity
	pH
	Salinity
Water Quantity	Increased water quantity
	Decreased water quantity
	Altered flow timing

Monitoring that meets the Lower Columbia Recovery Plan objectives

Each of the seven programs monitor a number of metrics associated with the limiting factors categories highlighted by the NMFS Lower Columbia Recovery Plan (Table 8).

Table 8. Number of metrics measured by each program categorized by NMFS limiting factor category. See Table 4 for explanation of program abbreviations. Appendix Table A2 has the detailed list of the metrics in each limiting factor category.

			Number of Metrics Calculated by Program						
Limiting Factor Category	*Number of Programs*	*Number of Metrics*	*AREMP*	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Channel Structure and Form	7	149	27	33	23	63	74	24	83
Fish Habitat Quantity	2	9	0	0	0	0	7	2	0
Peripheral and Transitional Habitats	4	40	0	0	0	27	15	4	25
Riparian Condition	7	66	3	5	1	18	21	14	34
Sediment Conditions	7	86	2	12	7	35	19	7	68
Water Quality	6	35	9	12	16	26	1	0	16
Water Quantity	6	6	0	1	1	1	3	2	1
Sub-total		391	41	63	48	170	140	53	227
Categories for Metrics not Classified as NMFS Limiting Factors for Salmon and Steelhead									
Amphibians	4	2	2	0	0	1	1	0	1
Fish	4	21	0	0	0	1	3	19	2
Macroinvertebrates	6	22	9	1	12	20	0	1	19
Mammals	2	2	1	0	0	0	1	0	0
Multi-Species	4	5	2	0	0	2	0	1	3
Sub-total		52	14	1	12	24	5	21	25
Total		443	55	64	60	194	145	74	252

All programs prioritize monitoring channel structure and form, riparian condition, and sediment condition, with the number of metrics monitored by each program under those limiting factor categories ranging from 1 to 83 (Table 8). The metrics falling within these categories can be seen in Appendix Table A2. Although there was considerable variability in the number of metrics monitored in each category, there were 14 metrics of channel structure and form that all entities monitor. For riparian condition, the only common metric across all entities is mid-channel shade (although 2012 was the last year this metric was collected by AREMP). For sediment conditions, there is no single metric that is common across all seven entities, although each entity does address this habitat factor thoroughly. All entities measure the composition of the substrate, but differ in the metrics they calculate (Table A2) as well as the extent that is evaluated (bankfull vs. wetted). A number of

entities monitor water quality meeting only one of the habitat concerns identified by the NMFS Lower Columbia Recovery Plan. Nearly all entities monitor water temperature, however differences in measurement frequency limit its applicability to address the habitat concern for some programs.

Fewer programs monitor metrics in peripheral and transitional habitats or fish habitat quantity categories. The majority of the metrics monitored that are associated with peripheral and transitional habitats are derived from a geographic information system (GIS) or pertain to land usage. Only three entities measure and monitor areas that fall outside the main channel (Table A2). Similarly, only two entities devote resources to monitoring fish habitat quantity by identifying the fish passage issues in the form of natural and artificial barriers and diversions.

Monitoring that meets programmatic objectives

Multiple entities monitor a number of categories not identified in the Oregon, Washington, or NMFS Lower Columbia recovery plans (Table 8). These are a reflection of the entities' program goals, aside from those stated in the recovery plans. All but one entity monitors macroinvertebrates. Some groups use this metric to describe habitat condition in lieu of instream habitat data collection, e.g. ODEQ infers fine sediment and temperature conditions based on the biological preference of the macroinvertebrates (Hubler 2008). The additional categories monitored include amphibians, fish, mammals, and invasive species. In some cases, these data are not time consuming to collect and have either been requested by outside groups or have tangential relations to fish, e.g. ODFW amphibian and beaver presence or absence.

Conclusions

Although there is some overlap in the status and trends monitoring designs of the programs monitoring in the Lower Columbia ESU, significant differences limit the comparability of the data being collected and the ability to combine data for basin-wide analysis. Among the metrics measured by all seven programs, several of the streambed dimension metrics are considered comparable across all programs (Table 6). However the precision, bias, and accuracy of the metrics should be considered before data are compared or combined. The remaining half of the metrics measured by all seven programs are either not comparable across all programs due to difference in methodologies, or their comparability cannot be determined without further investigation. Significant progress toward wider comparability of priority metrics could be achieved by making relatively minor adjustments to large wood, shade and sinuosity collection methodologies. And in the case of habitat unit and substrate composition metrics where it was not possible to determine comparability because of uncertainty about the effects of method differences, it behooves us to either determine if the differences affect the comparability of the data or eliminate the differences.

In general, all entities address most of the monitoring priorities highlighted in the NMFS Lower Columbia Recovery Plan, although some of the categories are not covered as well as others. And though commonalities can be found between the programs at the metric level to address the habitat concerns identified in the NMFS Lower Columbia Recovery Plan, the methodologies used to collect measurements and derive individual metrics often vary across entities. On the other hand, there are a number of metrics currently monitored by one or more programs that are not addressed in the NMFS Lower Columbia Recovery Plan. Some of those metrics, for example macroinvertebrate data, are valuable in order to obtain information about habitat condition when habitat data is lacking. However, it seems reasonable for programs to review their current monitoring design to see if resources could be shifted from non-priority metrics to address habitat concerns currently lacking comprehensive, consistent data (e.g. temperature monitoring, improving water quantity/fish passage data, and detailing peripheral and transitional habitats).

Next Steps

The PNAMP ISTM project was initiated to improve integration of existing and new status and trends monitoring efforts by developing recommendations for sampling frames, protocols, and data sharing. To meet the ISTM project goals, five objectives were identified: (1) identify and prioritize decisions, questions, and monitoring objectives; (2) evaluate how 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. This report summarizes work done in 2011 and 2012 to address Objectives 1 and 2 for habitat monitoring and identifies the commonalities among the habitat attributes that all entities measure and monitor and how the metrics align with the priorities listed in the NMFS Lower Columbia Recovery Plan. The intent was to use this information to inform the remaining three objectives.

In 2012 an opportunity arose to build on the ISTM Habitat Objectives 1 and 2 work and combine efforts with municipal stormwater managers in Southwest Washington to develop an integrated status and trends monitoring strategy for the Lower Columbia ESU. Using funding from the Washington Department of Ecology, the Lower Columbia Fish Recovery Board partnered with the City of Longview, Southwest Washington stormwater permittees, PNAMP and the ISTM partners, and others to develop a design that integrates stormwater permit monitoring with regional status and trends habitat monitoring and facilitates the exchange of water quality and habitat data for more robust and meaningful regional assessments. In 2014, the preliminary design from the first phase of the project is being refined with help from Stillwater Sciences and the input of stakeholders (http://www.pnamp.org/project/4585). The refinement of the design will also be informed by an evaluation of the potential ways existing data from these programs could be combined taking into consideration multiple spatial designs. A final report detailing recommendations will be completed by February of 2015.

In the meantime, the ISTM Habitat work group has expressed interest in convening to continue discussions of how to improve data comparability. There are a number of metrics identified in this report whose comparability cannot currently be assessed due to uncertainties in method differences. If method differences cannot be eliminated, field protocol comparisons are a robust approach to addressing the uncertainties; this involves analyzing data collected at the same locations in the same time frame using the differing methods. Two protocol comparison efforts have been recently undertaken. One effort looked at crosswalking ODFW and AREMP metrics using data collected in the John Day, Oregon, watershed in 2005. Another compared results from surveys at sites across the Pacific Northwest in 2012 using CHaMP and PIBO protocols. The outcomes of these efforts may help clarify current uncertainties. It has also been suggested that a larger scale protocol comparison involving more partners be undertaken; this idea will be scoped and vetted with regional monitoring programs in the coming year. Other ideas proposed for discussion include how programs interpret results to evaluate the condition of watersheds (good, poor) and whether it is possible to share data at a higher level (derived indicators rather than the metric level data). There is also interest more broadly from the region to develop a set of agreed upon high level indicators for habitat data. It has been over five years since the ISTM work first started, and although progress has been slow, many of the participating programs have made changes to improve the quality and comparability of monitoring data and are committed to continue to do so.

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URL:http://www.fws.gov/montanafieldoffice/Endangered_Species/Bull_Trout_consultation/Chapter1_Introductory.pdf

Appendix – Measurements and Metrics

Table A1. Field measurements collected by each program based on 2011 protocols (X = yes, blank = no) ordered by decreasing commonality. Measurement names have been standardized to facilitate comparison; each program's measurement names and descriptions can be found in the Measurements Table in the Access database (http://www.pnamp.org/document/4321). See Table 4 for explanation of program abbreviations.

Measurement	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Bankfull Depth	7	X	X	X	X	X	X	X
Bankfull Height	7	X	X	X	X	X	X	X
Bankfull Width	7	X	X	X	X	X	X	X
Gradient	7	X	X	X	X	X	X	X
Large Wood	7	X	X	X	X	X	X	X
Pool Maximum Depth	7	X	X	X	X	X	X	X
Pool Tail Crest Depth	7	X	X	X	X	X	X	X
Shade At Mid-Channel	7	X	X	X	X	X	X	X
Site Length	7	X	X	X	X	X	X	X
Substrate Particle Size	7	X	X	X	X	X	X	X
Thalweg Depth	7	X	X	X	X	X	X	X
Wetted Width	7	X	X	X	X	X	X	X
Channel Unit Type	6		X	X	X	X	X	X
Embeddedness	5		X	X	X		X	X
Fish Cover	5		X	X	X	X		X
Macroinvertebrate Abundance	5	X		X	X		X	X
Riparian Vegetation Structure Assessment	5		X		X	X	X	X
Amphibians Presence	4	X			X	X		X
Bearing	4			X	X		X	X
Channel Form	4		X	X		X		X
Conductivity	4		X	X	X			X
Fish Observed	4				X	X	X	X
Flow Volume	4		X	X	X			X
Large Wood-Log Jams	4		X		X	X		X
Percent Erosion	4			X		X	X	X
Water Temperature-Continuous	4	X	X	X	X			
Dissolved Oxygen	3			X	X			X
Flood-prone Width	3	X				X	X	
GIS Ecoregion Code	3				X	X		X
GIS Elevation	3				X	X		X
GIS Stream Order	3				X	X		X
Nitrogen-Total	3			X	X			X

Table A1- Field measurements, continued.

Measurement	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Number Of Habitat Units	3		X			X		X
pH	3			X	X			X
Phosphorus-Total	3			X	X			X
Pool Tail Fines <6mm	3	X	X				X	
Shade At Banks	3				X		X	X
Solids-Total	3			X	X			X
Turbidity	3			X	X			X
Water Temperature-Current	3				X	X		X
Alkalinity	2		X		X			
Aquatic Vertebrate Assemblage	2				X			X
Bank Angle	2		X		X			
Channel Unit Length	2		X			X		
Chloride	2				X			X
Copper (sediment)	2			X				X
GIS Geology Type	2				X	X		
GIS Watershed Area	2				X	X		
Human Influence	2				X			X
Land Use-Primary	2				X	X		
Land Use-Secondary	2				X	X		
Number of Pools	2	X				X		
Pool Form Cause	2				X			X
Residual Pool Volume	2		X	X				
Zinc (sediment)	2			X				X
1-Methylnaphthalene (sediment)	1							X
2-Chloronaphthalene (sediment)	1							X
2-Fluorobiphenyl (sediment)	1							X
2-Methylnaphthalene (sediment)	1							X
Acenaphthene (sediment)	1							X
Acenaphthylene (sediment)	1							X
Amphibians Count	1	X						
Anthracene (sediment)	1							X
Area of New Habitat	1						X	
Arsenic (sediment)	1							X
Artificial Barrier	1					X		
Bank Stability	1			X				
Beaver Presence	1					X		
Benz[a]anthracene (sediment)	1							X
Benzo(a)pyrene (sediment)	1							X
Benzo(b)fluoranthene (sediment)	1							X

Table A1- Field measurements, continued.

Measurement	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Benzo(ghi)perylene (sediment)	1							X
Benzo(k)fluoranthene (sediment)	1							X
Biological Oxygen Demand	1				X			
Boulder Count	1					X		
Bug Kill	1					X		
Carbazole (sediment)	1							X
Channel Constraint Removed	1						X	
Channel Stability	1			X				
Channel Unit Volumes	1		X					
Channelized Streambanks	1					X		
Chrysene (sediment)	1							X
Culvert Entry	1					X		
Dibenzo(a,h)anthracene (sediment)	1							X
Dibenzofuran (sediment)	1							X
Drift Biomass	1		X					
Dry Bar Width	1				X			
Duration of Inundation	1						X	
Exclusion Area	1						X	
Exclusion Design	1						X	
Fecal Coliform	1			X				
Feral Swine Presence	1	X						
Fish Cover-Undercut Banks- Depth	1				X			
Fish Passage Design	1						X	
Floodplain Connectivity	1			X				
Floodplain Width	1			X				
Floodprone Height	1					X		
Flow Category	1					X		
Fluoranthene (sediment)	1							X
Fluorene (sediment)	1							X
Gauging Station	1					X		
Gravel Area	1						X	
Height of constraining feature	1						X	
Human Influence - Bridge Crossing	1					X		
Human Influence - Fence Crossing	1					X		
Human Influence - Mining Presence	1					X		
Human Influence - Road Ford	1					X		
Incidental Invasives Presence	1	X						
Incised Height	1				X			
Indeno(1,2,3-cd)pyrene (sediment)	1							X

Table A1- Field measurements, continued.

Measurement	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Invasive Aquatic Animals	1						X	
Invasive Aquatic Animals Presence	1	X						
Invasive Aquatic Plant Presence	1	X						
Invasive Terrestrial Plant Presence	1	X						
Juvenile Fish Survey	1						X	
Landslides	1					X		
Large Wood-% Submerged	1	X						
Large Wood-Number of Log Jams	1					X		
Large Wood-Origin	1	X						
Large Wood-Pieces Touching	1	X						
Large Wood-Position	1	X						
Lead (sediment)	1							X
Main Channel With Side Channels	1							X
Naphthalene (sediment)	1							X
Natural Barrier	1					X		
Number of Artificial Habitat Structures	1					X		
Number of Beaver Dams	1					X		
Number of Cascades	1					X		
Number of Culverts	1					X		
Number of Glides	1					X		
Number of Riffles	1					X		
Number of Side Channels	1							X
Organic Carbon-Total (sediment)	1							X
Phenanthrene (sediment)	1							X
Pool Head Depth	1	X						
Pool Length	1	X						
p-Terphenyl-D14 (sediment)	1							X
Pyrene (sediment)	1							X
Pyrene-D10 (sediment)	1							X
Redd Survey	1						X	
Retene (sediment)	1							X
Riparian Area Planted	1						X	
Riparian Number of Plantings	1						X	
Screen Design	1						X	
Screened Diversion	1					X		
Sediment Chemistry Sample	1							X
Segment Length	1							X
Side Channel Length	1					X		
Spawner Survey	1						X	

Table A1- Field measurements, continued.

Measurement	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Spring or Seep	1					X		
Stream Stage	1			X				
Sulfate	1				X			
Survival of Plantings	1						X	
Terrace Height	1					X		
Terrace Width	1					X		
Topographic Point Collection	1		X					
TQ Mean	1			X				
Unscreened Diversion	1					X		
Upland Conifer Basal Area	1						X	
Upland Conifer Count	1						X	
Upland Hardwood Basal Area	1						X	
Upland Hardwood Count	1						X	
Upland Non-native Shrubs	1						X	
Upland Non-native Vascular Plants	1						X	
Upland Woody Species Mean Percent Cover	1						X	
Valley Floor Width	1					X		
Velocity	1		X					
Volume of New Habitat	1						X	

Table A2. Site-level metrics calculated by each program based on 2011 protocols (X=yes, blanks = no) grouped by Limiting Factors and ordered by decreasing commonality. Measurement names have been standardized to facilitate comparison; each program's measurement names and descriptions can be found in the Metrics Table in the Access database (http://www.pnamp.org/document/4321). This table, based on information provided by the program representatives, is intended to represent metrics that are actually calculated, not metrics that could be calculated. Therefore in some cases this table underrepresents the number of programs that *could* calculate a particular metric. See Table 4 for explanation of program abbreviations.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Limiting Factor: Channel Structure and Form								
Bankfull Depth	7	X	X	X	X	X	X	X
Bankfull Height	7	X	X	X	X	X	X	X
Bankfull Width	7	X	X	X	X	X	X	X
Bankfull Width To Depth Ratio	7	X	X	X	X	X	X	X
Bankfull Width X Depth	7	X	X	X	X	X	X	X
Gradient	7	X	X	X	X	X	X	X
Pool Maximum Depth	7	X	X	X	X	X	X	X
Pool Tail Crest Depth	7	X	X	X	X	X	X	X
Residual Pool Depth	7	X	X	X	X	X	X	X
Sinuosity	7	X	X	X	X	X	X	X
Thalweg Depth	7	X	X	X	X	X	X	X
Wetted Width	7	X	X	X	X	X	X	X
Wetted Width To Depth Ratio	7	X	X	X	X	X	X	X
Wetted WidthxDepth	7	X	X	X	X	X	X	X
Channel Unit Type Percent Composition-Pools	5		X	X	X	X		X
Pools per 100 m	5	X	X		X	X		X
Channel Form	4		X	X		X		X
Channel Unit Type Percent Composition-Fast Water Habitat	4			X	X	X		X
Large Wood-Pieces per 100 m	4	X		X	X			X
Large Wood-Volume per 100 m	4				X	X	X	X
Channel Unit Type Percent Composition-Dammed Pools	3				X	X		X
Channel Unit Type Percent Composition-Dry Channel	3				X	X		X
Channel Unit Type Percent Composition-Plunge Pools	3				X	X		X
Channel Unit Type Percent Composition-Scour Pools	3				X	X		X
Fish Cover-Artificial-Percent of Area	3		X		X			X
Fish Cover-Large Wood-Percent of Area	3		X		X			X
Fish Cover-Natural-Percent of Area	3			X	X			X
Fish Cover-Undercut Banks-Percent of Area	3		X		X			X
Large Wood-Key Pieces per Area	3	X			X			X
Large Wood-Log Jams	3				X	X		X
Large Wood-Pieces per Site	3	X			X			X
Large Wood-Pieces per Site per Size Category	3	X			X			X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Large Wood-Volume per Site	3		X		X			X
Mean Residual Pool Vertical Profile Area	3				X		X	X
Mean Residual Thalweg Depth	3				X		X	X
Number Of Habitat Units	3		X			X		X
Number of Pools	3	X				X		X
Pools 1 m or Deeper Per Kilometer	3	X				X		X
Bank Angle	2		X		X			
Channel Unit Area-Dry Channel	2				X	X		
Channel Unit Area-Glide	2				X	X		
Channel Unit Area-Lateral Scour Pool	2				X	X		
Channel Unit Area-Plunge Pool	2				X	X		
Channel Unit Area-Trench Pool	2				X	X		
Channel Unit Type Percent Composition-Cascades	2				X	X		
Channel Unit Type Percent Composition-Glide	2				X	X		
Channel Unit Type Percent Composition-Rapid	2				X	X		
Channel Unit Type Percent Composition-Riffle	2				X	X		
Channel Unit Type Percent Composition-Slow Water Habitat	2				X	X		
Entrenchment Ratio	2	X				X		
Fish Cover-Algae-Percent of Area	2				X			X
Fish Cover-All Types-Percent of Area	2				X			X
Fish Cover-Boulders-Percent of Area	2				X			X
Fish Cover-Brush-Percent of Area	2				X			X
Fish Cover-Large Items-Percent of Area	2				X			X
Fish Cover-Live Trees-Percent of Area	2				X			X
Fish Cover-Macrophytes-Percent of Area	2				X			X
Fish Cover-No Cover-Percent of Area	2		X					X
Fish Cover-Overhanging Vegetation and Live Trees-Percent of Area	2		X					X
Fish Cover-Overhanging Vegetation-Percent of Area	2				X			X
Flood-prone Width	2					X	X	
Habitat Units per 100 m	2					X		X
Large Wood-Key Pieces per 100 m	2				X	X		
Large Wood-Pieces Bridging per Site	2				X			X
Large Wood-Pieces per 100 m per Channel Unit	2					X		X
Large Wood-Pieces per 100 m per Size Category	2	X						X
Large Wood-Pieces per Area	2	X						X
Large Wood-Pieces per Area per Size Category	2	X						X
Large Wood-Volume per Area	2				X			X
Pool/Riffle Ratio	2				X		X	
Residual Pool Count > 100cm	2				X			X
Residual Pool Count Greater Than 75cm	2				X			X
Residual Pool Depth Per 100 m	2				X			X
Residual Pool Volume	2		X	X				

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Site Length	2	X				X		
Valley Floor Width	2	X				X		
Average Channel Capacity	1						X	
Bankfull Channel Capacity	1						X	
Bankfull Widths to Next Pool	1					X		
Channel Constraint Removed	1						X	
Channel Stability	1			X				
Channel Unit Area-Alcove	1					X		
Channel Unit Area-Backwater Pool	1					X		
Channel Unit Area-Beaver Dam Pool	1					X		
Channel Unit Area-Cascade Over Bedrock	1					X		
Channel Unit Area-Cascade Over Boulders	1					X		
Channel Unit Area-Isolated Pool	1					X		
Channel Unit Area-Non-Beaver Dam Pool	1					X		
Channel Unit Area-Rapid Over Bedrock	1					X		
Channel Unit Area-Rapid With Protruding Boulders	1					X		
Channel Unit Area-Riffle With Pockets	1					X		
Channel Unit Area-Riffle Without Pockets	1					X		
Channel Unit Area-Slackwater Pool	1					X		
Channel Unit Area-Straight Scour Pool	1					X		
Channel Unit Complexity	1		X					
Channel Unit Type Percent Composition-Edge Pools	1							X
Channel Unit Type Percent Composition-Falls	1				X			
Channel Unit Type Percent Composition-Fast, Non-turbulant Water Habitat	1							X
Channel Unit Type Percent Composition-Fast, Turbulant Water Habitat	1							X
Channel Unit Type Percent Composition-Wet Channel	1							X
Channel Unit Volumes	1		X					
Channelized Streambanks	1					X		
Fast Water Area	1					X		
Fish Cover-Algae-Percent Transect Presence	1							X
Fish Cover-Anything But Aquatic Vegetation-Percent of Area	1							X
Fish Cover-Anything But Aquatic Vegetation-Percent Transect Presence	1							X
Fish Cover-Artificial-Percent Transect Presence	1							X
Fish Cover-Boulders-Percent Transect Presence	1							X
Fish Cover-Brush-Percent Transect Presence	1							X
Fish Cover-Bryophytes-Percent of Area	1							X
Fish Cover-Bryophytes-Percent Transect Presence	1							X
Fish Cover-Large Items-Percent Transect Presence	1							X
Fish Cover-Large Wood-Percent Transect Presence	1							X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Fish Cover-Live Trees-Percent Transect Presence	1							X
Fish Cover-Macrophytes-Percent Transect Presence	1							X
Fish Cover-Natural-Percent Transect Presence	1							X
Fish Cover-Overhanging Vegetation-Percent Transect Presence	1							X
Fish Cover-Undercut Banks- Depth	1				X			
Fish Cover-Undercut Banks-Percent of Bank	1					X		
Fish Cover-Undercut Banks-Percent Transect Presence	1							X
Fish Cover-Undercut Banks-Weighted Percent of Bank	1					X		
Floodplain Connectivity	1			X				
Floodplain Width	1			X				
Floodprone Height	1					X		
Height of constraining feature	1						X	
Incised Height	1				X			
Large Wood-Key Pieces per Site	1					X		
Large Wood-Log Jam Pieces per 100 m	1		X					
Large Wood-Log Jam Pieces per 100 m by Channel Unit	1		X					
Large Wood-Log Jam Volume per Site	1		X					
Large Wood-Log Jam Volumne by Channel Unit	1		X					
Large Wood-Number of Log Jams	1					X		
Large Wood-Volume per 100m per Size Category	1							X
Large Wood-Volume per Area per Size Category	1							X
Large Wood-Volume per Channel Unit	1		X					
Large Wood-Volume per Site per Size Category	1							X
Main Channel Area	1					X		
Main Channel With Side Channels	1							X
Number of Beaver Dams	1					X		
Number of Cascades	1					X		
Number of Glides	1					X		
Number of Riffles	1					X		
Number of Side Channels	1							X
Pool Area	1					X		
Residual Pool Vertical Profile Area-Total	1							X
Sinuosity changes	1						X	
Terrace Height	1					X		
Terrace Width	1					X		
Valley Width Index	1					X		
Limiting Factor: Fish Passage and Accessibility								
Artificial Barrier	1					X		
Culvert Entry	1					X		
Fish Passage Design	1						X	
Natural Barrier	1					X		
Number of Artificial Habitat Structures	1					X		

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Number of Culverts	1					X		
Screen Design	1						X	
Screened Diversion	1					X		
Unscreened Diversion	1					X		
Limiting Factor: Peripheral and Transitional Habitats								
Channel Unit Type Percent Composition-Side Channel	3				X	X		X
GIS Ecoregion Code	3				X	X		X
GIS Elevation	3				X	X		X
GIS Stream Order	3				X	X		X
GIS Geology Type	2				X	X		
GIS Watershed Area	2				X	X		
Human Influence - Extent of Agriculture in Channel	2				X			X
Human Influence - Extent of Agriculture in Riparian	2				X			X
Human Influence - Extent of Human Influence in Channel	2				X			X
Human Influence - Extent of Human Influence in Riparian	2				X			X
Human Influence - Proximity Weighted Agriculture	2				X			X
Human Influence - Proximity Weighted All Human Disturbance	2				X			X
Human Influence - Proximity Weighted Buildings	2				X			X
Human Influence - Proximity Weighted Clearing	2				X			X
Human Influence - Proximity Weighted Landfill or Trash	2				X			X
Human Influence - Proximity Weighted Logging	2				X			X
Human Influence - Proximity Weighted Mining	2				X			X
Human Influence - Proximity Weighted Non-Agricultural Disturbance	2				X			X
Human Influence - Proximity Weighted Parks/Lawns	2				X			X
Human Influence - Proximity Weighted Pasture/Range/Hay Field	2				X			X
Human Influence - Proximity Weighted Paved Road or Railroad	2				X			X
Human Influence - Proximity Weighted Pavement	2				X			X
Human Influence - Proximity Weighted Pipes	2				X			X
Human Influence - Proximity Weighted Row Crops	2				X			X
Human Influence - Proximity Weighted Wall, Dike, or Revetment	2				X			X
Land Use-Primary	2				X	X		
Land Use-Secondary	2				X	X		
Area of New Habitat	1						X	
Exclusion Area	1						X	
Exclusion Design	1						X	
Human Influence - Bridge Crossing	1					X		
Human Influence - Fence Crossing	1					X		
Human Influence - Mining Presence	1					X		
Human Influence - Proximity Weighted Human Footpath	1							X
Human Influence - Proximity Weighted Unpaved Road	1							X
Human Influence - Road Ford	1					X		
Landslides	1					X		

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Side Channel Area	1					X		
Side Channel Length	1					X		
Volume of New Habitat	1						X	
Limiting Factor: Riparian Condition								
Shade At Mid-Channel	7	X	X	X	X	X	X	X
Riparian Canopy Percent Composition-Large Trees	3		X		X			X
Riparian Understory-Mean Percent Cover	3		X		X			X
Riparian Vegetation-Mean Percent Cover	3				X		X	X
Riparian Woody Vegetation-Mean Percent Cover	3				X		X	X
Shade At Banks	3				X		X	X
Proportion of Reach with Riparian Canopy that Consists of Conifers	2				X			X
Proportion of Reach with Riparian Vegetation in All Three Layers	2				X			X
Proportion of Reach with Riparian Vegetation in Canopy and Understory	2				X			X
Riparian Canopy and Understory-Mean Percent Cover	2				X			X
Riparian Canopy Percent Composition-Coniferous Trees	2		X					X
Riparian Canopy Percent Composition-Small Trees	2				X			X
Riparian Canopy, Understory, and Ground-Mean Percent Cover	2				X			X
Riparian Canopy-Mean Percent Cover	2				X			X
Riparian Ground Cover Percent Composition-Bare	2				X			X
Riparian Ground Cover Percent Composition-Non-woody	2				X			X
Riparian Ground Cover Percent Composition-Woody	2				X			X
Riparian Ground Cover-Mean Percent Cover	2		X					X
Riparian Understory Percent Composition-Non-woody	2				X			X
Riparian Understory Percent Composition-Woody	2				X			X
Bug Kill	1					X		
Dominant Riparian Vegetation Type	1					X		
Invasive Aquatic Plant Presence	1	X						
Invasive Terrestrial Plant Presence	1	X						
Proportion of Reach with Riparian Canopy of Mixed Type	1							X
Proportion of Reach with Riparian Canopy that Consists of Broadleaf Evergreen Trees	1							X
Proportion of Reach with Riparian Canopy that Consists of Deciduous Trees	1							X
Proportion of Reach with Riparian Canopy Vegetation	1							X
Proportion of Reach with Riparian Ground Cover Vegetation	1							X
Proportion of Reach with Riparian Understory of Mixed Type	1							X
Proportion of Reach with Riparian Understory that Consists of Broadleaf Evergreen Trees	1							X
Proportion of Reach with Riparian Understory that Consists of Conifers	1							X
Proportion of Reach with Riparian Understory that Consists of	1							X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Deciduous Trees								
Proportion of Reach with Riparian Understory Vegetation	1							X
Proportion of Reach with Riparian Vegetation	1							X
Proportion of Reach with Riparian Vegetation in Canopy or Understory	1							X
Riparian Area Planted	1						X	
Riparian Canopy and Understory Woody Vegetation-Mean Percent Cover	1							X
Riparian Canopy Percent Composition-Large and Small Trees	1							X
Riparian Conifers >=20 inches DBH per 1000 ft	1					X		
Riparian Conifers >=36 inches DBH per 1000 ft	1					X		
Riparian Conifers >15-30 cm DBH per 1000 ft	1					X		
Riparian Conifers >30-50 cm DBH per 1000 ft	1					X		
Riparian Conifers >3-15 cm DBH per 1000 ft	1					X		
Riparian Conifers >50-90 cm DBH per 1000 ft	1					X		
Riparian Conifers >90 cm DBH per 1000 ft	1					X		
Riparian Conifers 1-3 cm DBH per 1000 ft	1					X		
Riparian Conifers per 1000 ft	1					X		
Riparian Hardwoods >15-30 cm DBH per 1000 ft	1					X		
Riparian Hardwoods >30-50 cm DBH per 1000 ft	1					X		
Riparian Hardwoods >3-15 cm DBH per 1000 ft	1					X		
Riparian Hardwoods >50-90 cm DBH per 1000 ft	1					X		
Riparian Hardwoods >90 cm DBH per 1000 ft	1					X		
Riparian Hardwoods 1-3 cm DBH per 1000 ft	1					X		
Riparian Hardwoods per 1000 ft	1					X		
Riparian Number of Plantings	1						X	
Subdominant Riparian Vegetation Type	1					X		
Survival of Plantings	1						X	
Upland Conifer Basal Area	1						X	
Upland Conifer Count	1						X	
Upland Hardwood Basal Area	1						X	
Upland Hardwood Count	1						X	
Upland Non-native Shrubs	1						X	
Upland Non-native Vascular Plants	1						X	
Upland Woody Species Mean Percent Cover	1						X	
Weighted Percent Shade At Mid-Channel	1					X		
Limiting Factor: Sediment Conditions								
Substrate Particle Size (D50)	6	X	X	X	X		X	X
Embeddedness	5		X	X	X		X	X
Substrate Percent Composition-Sediment <2 mm	5		X	X	X	X		X
Percent Erosion	4			X		X	X	X
Substrate Percent Composition-Bedrock	4		X		X	X		X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Substrate Percent Composition-Cobble	4		X		X	X		X
Substrate Percent Composition-Fines	4		X		X		X	X
Bed Stability	3			X	X			X
Pool Tail Fines <2mm	3	X	X				X	
Substrate Percent Composition-Boulder	3		X		X			X
Substrate Percent Composition-Coarse Gravel	3		X		X			X
Substrate Percent Composition-Fine Gravel	3		X		X			X
Substrate Percent Composition-Gravel	3				X	X		X
Substrate Percent Composition-Large Boulders	3				X	X		X
Substrate Percent Composition-Sand	3		X		X			X
Bank Stability	2			X	X			
Pool Tail Fines <6mm	2		X				X	
Substrate Percent Composition-Coarse Gravel or Larger	2				X			X
Substrate Percent Composition-Cobble and Larger	2				X			X
Substrate Percent Composition-Fine Gravel or Smaller	2				X			X
Substrate Percent Composition-Gravel >16 mm	2			X	X			
Substrate Percent Composition-Hardpan	2				X			X
Substrate Percent Composition-Lithos as Coarse Gravel	2				X			X
Substrate Percent Composition-Lithos as Cobble	2				X			X
Substrate Percent Composition-Lithos as Fine Gravel	2				X			X
Substrate Percent Composition-Lithos as Fines	2				X			X
Substrate Percent Composition-Lithos as Large Boulders	2				X			X
Substrate Percent Composition-Lithos as Rough Bedrock	2				X			X
Substrate Percent Composition-Lithos as Sand	2				X			X
Substrate Percent Composition-Lithos as Small Boulders	2				X			X
Substrate Percent Composition-Lithos as Smooth Bedrock	2				X			X
Substrate Percent Composition-Other	2				X			X
Substrate Percent Composition-Pavement	2				X			X
Substrate Percent Composition-Rough Bedrock	2				X			X
Substrate Percent Composition-Sediment <2 mm in Riffles	2				X	X		
Substrate Percent Composition-Small Boulders	2				X			X
Substrate Percent Composition-Smooth Bedrock	2				X			X
Substrate Percent Composition-Wood	2				X			X
1-Methylnaphthalene (sediment)	1							X
2-Chloronaphthalene (sediment)	1							X
2-Fluorobiphenyl (sediment)	1							X
2-Methylnaphthalene (sediment)	1							X
Acenaphthene (sediment)	1							X
Acenaphthylene (sediment)	1							X
Anthracene (sediment)	1							X
Arsenic (sediment)	1							X
Benz[a]anthracene (sediment)	1							X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Benzo(a)pyrene (sediment)	1							X
Benzo(b)fluoranthene (sediment)	1							X
Benzo(ghi)perylene (sediment)	1							X
Benzo(k)fluoranthene (sediment)	1							X
Boulder Count	1					X		
Boulder Count per 100 m	1					X		
Carbazole (sediment)	1							X
Chrysene (sediment)	1							X
Copper (sediment)	1							X
Dibenzo(a,h)anthracene (sediment)	1							X
Dibenzofuran (sediment)	1							X
Embeddedness at Mid-Channel	1							X
Fluoranthene (sediment)	1							X
Fluorene (sediment)	1							X
Gravel Area	1						X	
Indeno(1,2,3-cd)pyrene (sediment)	1							X
Lead (sediment)	1							X
Naphthalene (sediment)	1							X
Organic Carbon-Total (sediment)	1							X
Phenanthrene (sediment)	1							X
p-Terphenyl-D14 (sediment)	1							X
Pyrene (sediment)	1							X
Pyrene-D10 (sediment)	1							X
Retene (sediment)	1							X
Substrate Percent Composition-Fines from Chemistry Sample	1							X
Substrate Percent Composition-Gravel from Chemistry Sample	1							X
Substrate Percent Composition-Gravel in Riffles	1					X		
Substrate Percent Composition-Gravel in Riffles and Rapids	1					X		
Substrate Percent Composition-Sand from Chemistry Sample	1							X
Substrate Weighted Percent Composition-Bedrock	1					X		
Substrate Weighted Percent Composition-Boulders	1					X		
Substrate Weighted Percent Composition-Cobble	1					X		
Substrate Weighted Percent Composition-Gravel	1					X		
Substrate Weighted Percent Composition-Gravel in Riffles	1					X		
Substrate Weighted Percent Composition-Gravel in Riffles and Rapids	1					X		
Substrate Weighted Percent Composition-Sediment <2 mm	1					X		
Substrate Weighted Percent Composition-Sediment <2 mm in Riffles	1					X		
Total Organic Carbon (sediment)	1							X
Zinc (sediment)	1							X
Limiting Factor: Water Quality								
Conductivity	4		X	X	X			X

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Water Temperature-7 Day Maximum	4	X	X	X	X			
Water Temperature-Daily Maximum	4	X	X	X	X			
Dissolved Oxygen	3			X	X			X
pH	3			X	X			X
Phosphorus-Total	3			X	X			X
Turbidity	3			X	X			X
Water Temperature-Average	3		X		X			X
Water Temperature-Current Temperature	3				X	X		X
Water Temperature-Maximum Daily Maximum Temperature	3	X	X		X			
Water Temperature-Maximum Weekly Maximum Temperature	3	X	X		X			
Water Temperature-Number of Days the Weekly Maximum Temperature (WMT) was Calculated	3	X	X		X			
Water Temperature-Weekly Maximum Temperature >12°C	3	X	X		X			
Water Temperature-Weekly Maximum Temperature > 18°C	3	X	X		X			
Water Temperature-Weekly Maximum Temperature > 22°C	3	X	X		X			
Alkalinity	2		X		X			
Chloride	2				X			X
Copper-Total	2			X				X
Nitrogen-Ammonia	2			X	X			
Nitrogen-Nitrate + Nitrite	2			X	X			
Nitrogen-Total	2				X			X
Solids-Suspended	2				X			X
Solids-Total	2			X	X			
Water Quality Index	2			X	X			
Water Temperature-Winter Low Temperatures	2	X	X					
Zinc-Dissolved	2			X				X
Zinc-Total	2			X				X
Arsenic-Dissolved	1							X
Arsenic-Total	1							X
Biological Oxygen Demand	1				X			
Copper-Dissolved	1			X				
Dissolved Organic Carbon	1							X
Fecal Coliform	1			X				
Sulfate	1				X			
Volatile Organic Compounds	1				X			
Limiting Factor: Water Quantity								
Flow Volume	4		X	X	X			X
Duration of Inundation	1						X	
Flow Category	1					X		
Frequency of Inundation	1						X	
Gauging Station	1					X		
Spring or Seep	1					X		

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Metrics not classified as Limiting Factors								
Amphibians Presence	4	X			X	X		X
Fish Observed	4				X	X	X	X
Macroinvertebrate-Clinger Richness	4	X		X	X			X
Macroinvertebrate-Ephemeroptera Richness	4	X		X	X			X
Macroinvertebrate-Plecoptera Richness	4	X		X	X			X
Macroinvertebrate-Pollution Intolerant Richness	4	X		X	X			X
Macroinvertebrate-Trichoptera Richness	4	X		X	X			X
Macroinvertebrate-Hilsenhoff Biotic Index	3			X	X			X
Macroinvertebrate-IBI	3			X	X			X
Macroinvertebrate-Multimetric IBI	3				X		X	X
Macroinvertebrate-Species Richness	3			X	X			X
Macroinvertebrate-Percent Clingers	3	X			X			X
Macroinvertebrate-Percent Dominant Taxa	3			X	X			X
Macroinvertebrate-Percent Ephemeroptera	3	X			X			X
Macroinvertebrate-Percent Filterers	3	X			X			X
Macroinvertebrate-Percent Pollution Tolerant	3	X			X			X
Macroinvertebrate-Percent Predator	3			X	X			X
Macroinvertebrate-Percent Tolerant Taxa	3			X	X			X
Macroinvertebrate-Semivoltine Richness	3			X	X			X
Aquatic Vertebrate Assemblage	2				X			X
Fish IBI	2						X	X
Invasive Aquatic Animals Presence	2	X						X
Macroinvertebrate-Observed/Expected Index	2				X			X
Vertebrate Index of Biotic Integrity	2				X			X
Amphibians Count	1	X						
Beaver Presence	1					X		
Bull Trout Redd Density	1						X	
Bull Trout Spawner Density	1						X	
Chinook Redd Density	1						X	
Chinook Spanwer Density	1						X	
Chum Redd Density	1						X	
Chum Spawner Density	1						X	
Coho Redd Density	1						X	
Coho Spawner Density	1						X	
Drift Biomass	1		X					
Feral Swine Presence	1	X						
Fine Sediment Stress	1				X			
Incidental Invasives Presence	1	X						
Invasive Aquatic Animals	1						X	
Juvenile Chinook Density	1						X	
Juvenile Coho Density	1						X	

Table A3. Site-level metrics, continued.

Metric	*Number of programs*	*Programs*						
		AREMP	*CHaMP*	*Clark Co*	*ODEQ*	*ODFW*	*SRFB*	*WADOE*
Kilometers of Species Presence	1							X
Pink Redd Density	1						X	
Pink Spawner Density	1						X	
Sockeye Redd Density	1						X	
Sockeye Spanwer Density	1						X	
Steelhead Parr Density	1						X	
Steelhead Redd Density	1						X	
Steelhead Spawner Density	1						X	
Summer Habitat Capacity - Juvenile Coho	1					X		
Temperature Stress	1				X			
Winter Habitat Capacity - Juvenile Coho	1					X		