Appendix F
Upper Middle Mainstem Columbia River Subbasin

CONSIDERATIONS FOR MONITORING IN SUBBASIN PLANS

FROM THE

PACIFIC NORTHWEST AQUATIC MONITORING PARTNERSHIP

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Introduction

At the request of the Northwest Power and Conservation Council (Council), the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) has developed this guidance to help subbasin planners design the monitoring elements of the subbasin plans being developed under the Council's Fish and Wildlife Program. It provides general and some specific considerations to the Council and subbasin planners on how their monitoring can fit within the broad range of monitoring activities in the Pacific Northwest. It also provides an explanation of general technical considerations for implementing the various types of monitoring and related topics.

PNAMP offers this initial guidance for monitoring efforts at the subbasin level as a step to encourage the coordination of local, tribal, state and federal programs. Subbasin planners can decide to whether or not, and to what degree, they may elect to use this guidance. PNAMP understands that this guidance is being offered very late in the planning process and therefore does not intend that it add new requirements, but rather that it provide near-term guidance to those still formulating or modifying the monitoring elements of their subbasin plans. This guidance will be less useful to those subbasin planers who are well along in the development of the monitoring elements of their plans, but should nonetheless provide information for those who may modify their plans at a later time.

Overview of the Pacific Northwest Aquatic Monitoring Partnership

Monitoring efforts have typically evolved in response to different organizational mandates and management questions. Despite inherent differences much overlap exists across broad geographical areas, and there are issues and questions shared in common. Collecting monitoring data in a fashion that can be "rolled-up" to larger scales is essential for information gathered at the scale of watersheds or subbasins to support evaluations at larger geographic scales, such as province or Evolutionarily Significant Unit (ESU). This necessitates a higher level of coordination and creates a new set of challenges at all levels of involvement. Toward that end, the PNAMP drafted a coordination plan for monitoring in the Pacific Northwest, *"Recommendations for Coordinating State, Federal, and Tribal Watershed and Salmon Monitoring Programs in the Pacific Northwest*" (PNAMP 2004).

The purpose of PNAMP "is to coordinate monitoring of important scientific information at the appropriate scales needed to inform public policy and resource management decisions" (PNAMP 2004). Members of PNAMP include state, federal, and tribal representatives with a common interest in regionally coordinating various aspects of watershed condition monitoring, fish population monitoring, action effectiveness monitoring, and data management (see Appendix A - Participants in PNAMP). The current focus of PNAMP is on watershed condition and anadromous fish. PNAMP has not made a decision at this time on whether to coordinate monitoring of resident fish and wildlife in the future. Consequently, the scope of this document is limited to monitoring of watershed condition and anadromous fish, and it does not address monitoring of resident fish and wildlife. Subbasin planners can consider the guidance developed by

Council for monitoring these species, as provided in the *Technical Guidelines for Subbasin Planners* and other documents.

Nexus with Subbasin Planning

In January and February of 2004, PNAMP provided briefings to the Council and other regional state, tribal and federal executive level groups on its draft coordination plan. At their briefing to the Council's Regional Coordination Group (RCG) for subbasin planning, PNAMP was asked to provide what guidance it could in the limited time available to assist subbasin planners in developing the monitoring elements of their subbasin plans. In response to that request, PNAMP is herein providing the Council and subbasin planners with guidance and considerations for monitoring. This guidance is advisory in nature, as PNAMP has no inherent authority. PNAMP is an ad hoc collaborative group currently operating without funding or charter that is motivated by the need for technical coordination between its members and across various programs. Despite these limitations, the group elected to provide guidance because several members of PNAMP are involved with subbasin planning, and because the Columbia River Basin constitutes a sizable portion of the geographic scope of PNAMP, from Canada to Northern California. In sum, it is not the intention of PNAMP to dictate a particular direction to subbasin planners, but rather to share the current thinking of the group on many topics relevant to the development of monitoring elements of subbasin plans.

In 2000 the Council initiated subbasin planning to help local entities work with resource experts and managers to develop their own restoration plans. Subbasin planning incorporates a bottom-up approach, with input from a wide range of stakeholders and professionals who are most familiar with the logistical needs in their areas. The Council has stipulated that subbasin plans include a monitoring element. (Monitoring is also required in salmonid recovery plans.) The Council requirements for the monitoring components of subbasin plans were first provided two years ago in the *Technical Guidance for Subbasin Planners* (NPPC 2001). Although subbasin planning remains a bottom-up initiative, several developments within the field of monitoring and data management over the last two years have shifted the Council's perspective on the efficacy of the bottom-up approach for monitoring.

Programmatic or Regional Approach: The need for more extensive, programmatic level habitat and fish population performance tracking and action effectiveness research have emerged as critical elements of survival and recovery plans for salmonids listed under the Endangered Species Act (ESA). Consequently, monitoring questions have been identified in the Federal Salmon Recovery Strategy and the Implementation Plan of the Action Agencies addressing the NOAA-Fisheries Biological Opinion (Biological Opinion) on the Federal Columbia River Power System (FCRPS). (Note: the Action Agencies are Bonneville Power Administration, the Army Corps of Engineers, and the Bureau of Reclamation.) The monitoring questions now being asked are best answered at large-scale landscape and ecosystem levels. The Federal Research, Monitoring and Evaluation Plan for the FCRPS Biological Opinion and the detailed Upper Columbia Monitoring Strategy document the need for this approach. Monitoring and evaluation is also required under the Pacific Coastal Salmon Recovery Fund. Furthermore, scientific reviews by the Independent Scientific Advisory Board and the Independent Scientific Review Panel have repeatedly called for a regionally coordinated approach to monitoring. Although the Council has reaffirmed the bottom-up approach in regard to other aspects of subbasin planning, the RCG has acknowledged the importance of developing a regional approach to monitoring that will support planning and the setting of restoration priorities across different geographic scales. This is a long-term need of the Council's Fish and Wildlife Program and an immediate need for ESA planners across the Pacific Northwest. One of the tasks of PNAMP is to identify the common metrics and designs necessary to address questions at and across these different scales.

Subbasin or Project Approach: PNAMP intends that this initial guidance constitute a first step in an on-going effort to support local programs in the Pacific Northwest as a means to grow a coordinated regional monitoring program over time. A majority of monitoring work is still occurring at the project scale, for example, in support of individual habitat projects. Yet, comprehensive monitoring strategies consistent with the federal initiatives are now being implemented at the state level in Oregon and Washington. Pilot projects are currently being implemented or planned in the Wenatchee, John Day, and Upper Salmon rivers to collect data and to test and develop more precise protocols and provide increasingly explicit guidance based on field-tested approaches at the subbasin level. (These pilot projects demonstrate how the top-down approach can work to create monitoring projects that have systemwide applications.)

For these reasons, it is clear that both bottom-up and top-down approaches are necessary to develop effective and efficient monitoring plans across the Pacific Northwest. PNAMP sits squarely in between a network of executives who administer resource management programs (top level) and PNAMP members and their constituent groups who implement restoration projects in support of these programs (bottom level). Thus, PNAMP is in the middle, coordinating the most effective system design and application of individual or local projects, such as the pilot studies and NMFS's trend monitoring project.

Collaborative Approach: The progress that PNAMP has made over the last several years is in large measure a result of its collaborative mode of operation. PNAMP is working to coordinate existing monitoring programs and to address issues that challenge practitioners of monitoring irrespective of their geographical location or jurisdictional mandate. PNAMP is not a planning forum or a program, but rather a technical work group whose primary incentive for coordination is the efficiencies to be gained through working collaboratively.

PNAMP, with its mission to improve coordination of monitoring across multiple regional monitoring and evaluation programs, recognizes the importance and challenges of coordinating across the many subbasin monitoring and evaluation plans. If these plans are not coordinated it will be very difficult to add up the results across multiple plans and make conclusions at broader scales, for example at the population level. PNAMP recognizes that while helping monitoring programs in the Pacific Northwest strive to achieve a greater degree of coordination there will be difficulty in making changes in ongoing monitoring programs. Yet subbasin planning presents PNAMP with an opportunity not unlike that of the Pacific Coastal Salmon Recovery Fund, in which a subset of members have a specific goal, the achievement of which is beneficial to the parent group.

It is important that PNAMP continue to develop technical tools and methodologies that are useful at different scales and for multiple efforts across constituent groups. PNAMP will endeavor to develop additional products for use in the Pacific Northwest that subbasin efforts can use for 2005 and later field seasons. PNAMP members have previously called for workshops on various topics of interest to its members across the Pacific Northwest Region. If these workshops are held (sometime after the subbasin planning submission deadline), they would benefit from the participation of subbasin planners.

PNAMP Coordination Plan: PNAMP intends to complete work on its coordination plan, by fashioning it into a forward-looking, Strategic Monitoring Framework. The exercise of completing the PNAMP plan will provide Tribal and State representatives to PNAMP a better vehicle for coordinating with subbasin planners into the future than this guidance can provide, since it is a response to a Council request for immediate assistance. PNAMP has long provided a forum for coordination amongst its current members, who number over thirty entities representing a broad array of entities and geographic areas. In light of the number of watersheds in the Columbia River Basin (62) and the even larger number between the Canadian border and Northern California, PNAMP members who represent state monitoring programs along with subbasin coordinators, will provide the initial points of contact for subbasin planners and PNAMP. During the implementation of subbasin plans in the Columbia River Basin, PNAMP can be viewed as a source of technical expertise on monitoring in the Pacific Northwest.

Limitations of This Guidance

The PNAMP guidance is divided into sections explaining general and specific considerations. The latter section outlines current PNAMP thinking and experience in regard to relevant technical issues. Please note that some of these considerations may change over time as this coordination effort develops further. Because the Council's *Technical Guidance for Subbasin Planning* (NPCC 2001) states, "the monitoring plan should not include project specific monitoring," this guidance does not address considerations for monitoring at the project scale.

PNAMP accepted the task of helping subbasin planers because of the significant opportunity it afforded to improve coordination of regional monitoring efforts. Despite the very tight deadlines with which subbasin planners are confronted, PNAMP has tried to provide the best guidance possible in the time available. However, PNAMP fully recognizes that the guidance has limitations. The guidance is not sufficiently detailed to represent a complete step-by-step "how-to-guide" or tutorial for monitoring, nor is it based (as would be desired) on a survey of all subbasin planning needs. However, PNAMP feels it represents a “checklist” of critical elements and other considerations for use in developing subbasin monitoring efforts, and it offers direction for access to example protocols.

This guidance is not intended to supplant the efforts of subbasin planers who are well along in the development of the monitoring elements of their plans. Rather, PNAMP hopes to provide guidance for these efforts and other similar efforts into the future, while providing near-term guidance to those still formulating the monitoring elements of their subbasin plan.

Assumptions Regarding Development of Monitoring Elements of Subbasin Plans

1. Monitoring and evaluation coordination and implementation will be an ongoing activity at the reach, subbasin, and regional levels. PNAMP assumes these iterative, concurrent processes at different scales will be coordinated to optimize when and where implementation occurs to increase learning from broader scale monitoring both within and across subbasins. It is important to note that PNAMP provides a coordination function; PNAMP itself will not implement monitoring.

2. Monitoring that is proposed will be more effective if it fits within a broader programmatic network of status monitoring programs and intensively monitored watersheds. PNAMP assumes subbasin efforts will be able to rely on the broader monitoring framework and programmatic activities to meet some of their needs.

3. PNAMP assumes local, bottom-up approaches developed within subbasins will have higher likelihood for successful funding and meaningful results if they reflect the approaches being developed within the comprehensive state, tribal initiatives, and federal pilot projects (Wenatchee, John Day, and Upper Salmon), and the top-down framework and considerations being developed by PNAMP.

4. PNAMP assumes monitoring elements of subbasin plans that diverge from PNAMP guidance will be explained and framed as pilot approaches to address uncertainties in monitoring strategies or protocols.

5. Additional coordination issues pertaining to larger spatial scales will be identified through PNAMP efforts.

General Considerations for Creating Monitoring and Evaluation Elements of Subbasin Plans

A Strategic Monitoring Framework for Subbasin Planning

The considerations in this section will help the Council and subbasin planners determine the appropriate scales of monitoring and evaluation needed to meet the vision, goals and objectives of subbasin plans. It provides an approach that can be voluntarily used as a foundation for a more detailed, regionally compatible monitoring and evaluation plan.

The implementation and adaptive management of subbasin plans will be difficult absent a well-developed and consistent monitoring framework for the region. The draft PNAMP monitoring coordination plan is intended to develop regional-level guidance for use by the various programs of the members. PNAMP recommends that the implementation of monitoring program elements identified through subbasin planning (bottom-up) be consistent, to the extent practical, with the draft PNAMP plan for coordinating monitoring across the Pacific Northwest (top-down) and recognizes the necessity of both. Conceptually, PNAMP's support for a hierarchical approach to monitoring is linked to guidance provided by the FCRPS Biological Opinion RME Plan and monitoring strategies developed by Oregon and Washington (Table 1). In general, PNAMP sees a role for monitoring within the subbasins with respect to documenting implementation of restoration actions. Subbasin and ESU scale status and trend monitoring are likely to be the responsibility of agency programs that will also need coordination. Evaluating the effectiveness of federal, tribal, and state programs will require participation and cooperation of all those involved with responsibility for evaluation of the plans(Table 2).

PNAMP is working to coordinate current regional monitoring programs that overlap one another at various spatial and temporal scales. Those programs include:

- Aquatic and Riparian Effectiveness Monitoring Program for the Northwest Forest Plan (AREMP);
- Pacfish/Infish Biological Opinion for the interior Columbia Basin (PIBO) Program;
- Interior Columbia Basin Ecosystem Management Program (ICBEMP);
- Columbia River Research, Monitoring, and Evaluation (RME) Program required by ESA Columbia River Biological Opinions and the Columbia River Federal Salmon Recovery Strategy MOU;
- EPA's Environmental Monitoring and Assessment Program;
- NOAA's Pacific Coastal Salmon Recovery Fund Program;
- Monitoring programs associated with salmon recovery and watershed restoration in Oregon, Washington, California, and Idaho;
- National Park Service Monitoring Program;
- Collective and individual tribal monitoring programs; and,
- Co-manager harvest and hatchery monitoring programs.

PNAMP expects to develop further information that should greatly aid monitoring coordination within the Columbia River Basin and across the entire Pacific Northwest.

Over the next year PNAMP will draft a Strategic Monitoring Framework that will identify:

1. A watershed condition and fish population status-monitoring network;
2. A network of Intensively Monitored Watersheds (IMWs) to monitor the effectiveness of different categories of actions on fish at watershed scales; and,
3. Linkages among an identified suite of local, reach specific, action effectiveness studies.

The Strategic Monitoring Framework will identify resources across the cooperating agencies that can help implementers of the subbasin plans to appropriately scale, design and fund their programs. In regards to watershed condition and fish population status monitoring, it is expected that this expanding network of monitoring programs will also lead to research relevant to a majority of the subbasins, including the identification of local, spatially, or temporally intensified monitoring needs. PNAMP suggests that subbasin plans identify their status monitoring needs as:

1. Relying upon work conducted under an existing monitoring program wherever possible;
2. A component of, or cooperator in, an existing monitoring program;
3. A needed addition under an existing or planned program; or
4. An independent, cooperating, contributor to the network of programs.

The federal Action Agencies are implementing three subbasin pilot studies as part of the requirements of the FCRPS Biological Opinion. The state of Washington is initiating IMW efforts that include work in the lower Columbia River. The Bonneville Environmental Foundation is also sponsoring a ten-year program for three IMWs. PNAMP suggests that subbasin plans indicate whether their subbasin is now designated as a subbasin pilot or an IMW, or whether planners think it may serve as a good candidate for this type of monitoring. Viable candidates for IMWs should have characteristics amenable to experimental design features as well as a reasonable potential for management manipulations involving monitoring at multiple treatment and control sites for different categories of individual or combination of actions across an entire watershed. IMWs depend on reliable and precise sampling of adult spawners and smolt outmigrants.

Principles for Coordinated Monitoring

As described in PNAMP (2004), monitoring involves the deliberate and systematic observation, detection, and recording of conditions, resources, and environmental effects of management and other activities. The clear articulation by policy makers of guiding principles helps partners recognize program elements and objectives they share in common. Although PNAMP's draft coordination plan for monitoring addresses an area of greater geographic scope than the Columbia River Basin, its principles may be useful to subbasin planners as they develop the monitoring element of their plans. PNAMP's

Table 1. Example of PNAMP Strategic Framework for Monitoring and Evaluation currently under development: Overview of spatial and temporal scale for monitoring activities with example monitoring types and indicators. Suggested protocols and funding sources under evaluation by PNAMP are included.

Spatial Scale	Frequency	Monitoring Type	Key Indicators	*Protocols to Consider*	Potential Funding Sources
Region – Wide States Major Basins	Infrequent Depending on Activity	Broad Scale: Remote Sensing, Qualitative Surveys, GIS Analysis	Land Use, Roads, Ownership, Vegetation Fish Presence, Intrinsic Habitat Potential	Established Protocols Enhanced Analysis	Existing Federal, State and local government programs.
Subbasin ESU Oregon Plan Report Area	Annual and/or Seasonal: Ongoing Duration	Status and Trend Spatially explicit, Rigorous, statistical sampling designs and protocols	Population Abundance, Distribution, Diversity Watershed Condition Riparian & Channel Habitat, Water Quality & Biotic Indicators	EMAP Based Sample Site Selection: Site specific activities (Upper Columbia Monitoring Strategy, AREMP, PIBO, Habitat, Water Qual., Fish Populations, etc)	State F&W or WQ Programs, BPA Fish Program, Action Agencies, NOAA, PCSRF, AREMP, other.
Watersheds 5^{th} -6^{th} Field (USGS HUC) WA WIRAS	Seasonal and Continuous: Long Term Duration (10-40+ yrs)	Intensively Monitored Watersheds Limiting Factors, BMP Evaluation& Compliance, Effectiveness	Landscape Assessment Watershed Condition and Processes, Salmonid Freshwater Survival & Productivity Management Actions	Upper Columbia Monitoring Strategy, CLAMS, AREMP, Current WA and OR IMW's. Paired-watersheds and/or sample-based watersheds	BPA, NOAA, PCSRF, States & Tribes, Landowner University Co-ops , USFS, BLM, others
Stream Reaches	Annual and Seasonal: Med. Duration (5-10 yrs)	Project Effectiveness Desired physical and biotic responses.	Channel and Riparian Habitat Response Fish Use / Productivity Water Quality	Upper Columbia Monitoring Strategy, OPSW Water Quality and Riparian Guides,	BPA, OWEB, SRFB, NOAA and other Funding Entities

				WA-SRFB Protocols, Ongoing PNAMP Process, etc.	
Sites	Seasonal: Short Term (1-5 yrs)	<u>Validation</u> Testing Restoration Methods	Expected vs. Response Conditions. What works, why, and where?	Various: See WA SRFB Draft Protocols, Upper Columbia Monitoring Strategy	BPA, PCSRF, OWEB, SRFB, other Funding Entities
Projects	Before/After Project Completion	<u>Implementation</u>	Location, Description of Activity, Target Species, Ecosystem Function or Habitat Condition	Documentation & Reporting via BiOp Implementation Plans, PRISM, OWEB, NOAA	Condition of Restoration Contract Acceptance (BPA, OWEB, SRFB, USFWS, others)

Table 2. Generalized Description of Sampling Approaches with Comparative Level of Federal, Tribal, State, and Local Participation.

Sampling Approach	Spatial Scale	Monitoring Type	Who Does the Work?
Comprehensive Low Intensity	Region – Wide State - Wide Major Basins	Broad Scale Remote Sensing and Surveys	NOAA, Contractors, University, State, Fed and Tribal GIS Programs
Sample Based Every Subbasin (~10-30% of fish distribution)	Subasin ESU Oregon Plan Report Area	Status and Trend	Action Agencies State Agencies Tribes
Sample Design or Opportunity Ideally 1 or 2 IMW's In Each Subbasin, ESU, or Report Area	Watersheds 4^{th}, 5^{th}, 6^{th} Field USGS HUC WA WIRA's	Intensively Monitored Watersheds	Multi-Agency University Research Lead Entities Land Owner or Manager
Sample Based Stratified by Activity & Location (~20% of Projects)	Stream Reaches	Project Effectiveness	Agencies Research Entities Lead Entities
Sample Based Stratified by Project Type (~10% of each type)	Sites	Technical Validation	Lead Entities Agencies
Every Project	Projects	Implementation	Subbasin Lead Entities Grantees

principles include several directives for its members that subbasin planners are encouraged to consider. These principles are:

1. Resource Policy and Management: The purpose of monitoring efforts is to provide the most important scientific information needed to inform public policy and resource management decisions.

- Acknowledge each party's mandates, objectives, and management milestones.
- Construct a monitoring program that meets each party's milestones and objectives through coordinating and sharing monitoring resources.
- Develop a monitoring program that is sufficiently robust to meet public policy needs; demonstrate the links between public policy needs and monitoring efforts.
- Develop a monitoring program that demonstrates compliance.
- Commit to resolving scientifically the most important policy and management questions using an adaptive management approach.

2. Efficiency and Effectiveness: Cooperative monitoring will enhance efficiencies and effectiveness of our respective and collective efforts.

- Participate fully in the PNAMP, including the identification of contact(s) for monitoring issues.
- Identify and coordinate goals, objectives, and budgets, and demonstrate resource savings over short and longer time frames.
- Cooperatively adapt programs and budgets to address monitoring gaps.
- State and federal agencies and the tribes commit to long term inter- and intra-agency monitoring programs.
- Encourage staff exchanges and shared training to learn what each other are doing (e.g., new innovations) and ensure consistency across programs.
- Develop common monitoring approaches, including quality control/quality assurance programs; shared evaluation tools; integrated status and trend monitoring efforts; land use, land cover, and riparian vegetation categorization; core data for representative subset of watersheds in all represented states.
- Perform all monitoring activities in a timely manner.

3. Scientifically Based: Environmental monitoring must be scientifically sound.

- Develop an integrated monitoring program (e.g., issues, disciplines, and values).
- Monitoring program is based on shared goals and objectives (e.g., census level, regional status and trends, cause and effect questions, effectiveness of regional efforts, identification of trouble spots).
- Address multiple spatial and temporal scales.
- Develop and use compatible data collection and analysis protocols.
- Recognize inherent diversity and variability and dynamic inter-relationships or resource conditions in monitoring design, analysis and interpretation.
- All environmental data should have a known level of precision.
- All baseline data on ecosystems are known and compiled between agencies.

4. Shared Information: Monitoring data should be accessible to all on a timely basis.

- Make strategic investments in information systems needed to make data useful.
- Monitoring databases would integrate a number of issues, disciplines and values.
- Data management systems and protocols provide a linkage for sharing data between agencies.
- Adopt and use common data sharing protocols.
- Adopt and use common database/s of core metadata, data, and electronically connected distribution systems.

Summary of General Considerations

1. It is important to first identify the management questions that any monitoring program is intended to address. (Appendix B provides examples of management questions that are the focus of several existing regional monitoring programs.) These broader level questions frame the objectives and scope of a monitoring strategy. Additional, more detailed questions then need to be developed and answered for developing a specific monitoring strategy or program design. (The section on Program Setup can help identify design level questions that need to be addressed in the development of a specific monitoring strategy.)

2. Subbasin plans and their implementation will be significantly strengthened if they incorporate and are consistent with the principles of the draft PNAMP coordination plan.

3. Subbasin plans will be more effective if they establish a method to link with the continuing development of a Strategic Monitoring Framework by PNAMP, and identify and incorporate guidance for local subbasin level monitoring and evaluation that can be incorporated within this framework.

4. Create a process within subbasin plans to incorporate additional guidance from efforts such as the federal Action Agencies' pilot studies, Collaborative Systemwide Monitoring and Evaluation Project (CSMEP), statewide monitoring initiatives, and further PNAMP guidance as it becomes available.

5. Subbasin plans will be more effective if they identify concrete actions and provide specific plans to promote and achieve needed monitoring and evaluation, and are not "plans to do planning."

6. Subbasin plans will be more effective if they identify existing, expanding, or future planned status and trend monitoring programs and action effectiveness research that can be used to partially or completely meet the monitoring and evaluation needs of subbasin plans. (Note: PNAMP has begun to identify the scope of existing monitoring programs.

7. Subbasin plans will be more effective if they explain how they incorporate existing monitoring guidance from federal, state or tribal programs.

8. PNAMP suggests that local habitat monitoring needs identified in subbasin plans be addressed using procedures and protocols that result in data that can be linked and interpreted at larger spatial scales (e.g., EMAP design, Upper Columbia Monitoring Strategy, and the Washington and Oregon monitoring strategies). This can be achieved by requiring standard monitoring designs and sampling protocols that have been agreed to or that are being compared within the PNAMP process. (Additional technical detail on appropriate fish, action effectiveness, data management and watershed condition sampling protocols will likely begin to be available from PNAMP and others this fall and beyond.)

9. Subbasin plans will be more effective if, to the extent possible, they utilize guidance on specific monitoring standards, protocols and methods as referenced in relevant ongoing efforts or existing documentation.

Specific Considerations Regarding the ISRP Review Checklist

PNAMP understands that the Council's Independent Scientific Advisory Board (ISAB), Independent Scientific Review Panel (ISRP), and Peer Review Groups will be reviewing the subbasin plans. To ensure consistency, the science group reviewers have been provided a checklist, available at: http://www.nwcouncil.org/library/isrp/SubbasinPlanReviewGuide.htm. In this section, PNAMP identifies considerations specific to the monitoring and evaluation elements of the checklist.

Monitoring Objectives (Checklist III.D.2)

PNAMP Consideration 2-1: Adopt a short list of measurable objectives designed to answer subbasin scale questions about the condition of the watersheds and associated imperiled fish. PNAMP recommends that subbasin planners carefully develop the monitoring questions to be answered within the subbasin. After the questions have been developed, they should be prioritized. It is unlikely there will be sufficient funds available to complete all the desired monitoring. Some possible questions include the following examples taken from Washington's Comprehensive Monitoring Strategy (WMOC 2002).

- How are the annual abundance and productivity of salmon by species, ESU, and life stage changing over time within the subbasin?
- What improvements are occurring in restoring the geographic distribution of salmon by ESU, species, and life stage within the subbasin?
- What is the quality of surface waters in the subbasin?
- How are surface water quality conditions changing over time?
- What are the overall impacts of human related activities on freshwater habitat and landscape processes within the subbasin?

Once the monitoring questions have been developed, specific measurable monitoring objectives can be defined to answer the monitoring questions. Following are examples of objectives that tie directly to the monitoring questions given as examples above.

- Measure status and track trends of the numbers of spawning salmon by stock in each subbasin.
- Measure the geographic distribution (identify drainages occupied by salmon) and evaluate trends of salmon in each subbasin. Determine whether their geographic distributions are improving.
- Measure status of identified water quality indicators.
- Measure the trend of identified water quality indicators at stations representing the cumulative effects of human caused impacts and natural conditions.
- Measure status and trends of identified freshwater habitat indicators in the subbasin. Evaluate whether they are improving relative to a desired target or objective

Monitoring Indicators (Checklist III.D.3)

PNAMP Consideration 3-1: Adopt a short list of measurable indicators designed to provide measures of subbasin scale objectives for the condition of the watersheds and associated fish and wildlife. The indicators should be found in commonly accepted protocols where estimates of their variance and coefficient of variation have been obtained, and there is confidence that the indicator can detect change within a reasonable amount of time. Although the PNAMP has not finalized the broader scale strategy and recommended indicators and associated protocols, the currently recommended indicators are described below under the various types of monitoring.

PNAMP Consideration 3-2: Collection of indicator data to meet the objectives of the monitoring program should be implemented using a structured sampling design. The recommended model for development of probabilistic sampling plans for status and trends is the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) strategy proposed by the federal Action Agencies and NOAA Fisheries in their "Draft Research, Monitoring and Evaluation Plan for the NOAA-Fisheries 2000 Federal Columbia River Power System Biological Opinion" (The Research, Monitoring and Evaluation Plan, http://www.efw.bpa.gov/cgi-bin/FW/welcome.cgi). PNAMP recommends that subbasin planners cooperate with Columbia Basin-wide attempts to develop common probabilistic (statistical) site selection procedures for population and habitat status monitoring. (Information about design approach of EMAP can be found at: http://www.epa.gov/nheerl/arm/).

PNAMP Consideration 3-3: PNAMP recommends that status and trends monitoring at the subbasin scale be part of a larger strategy for monitoring regional status and trends. PNAMP agrees with the ISRP that the EMAP probabilistic sampling plan is most appropriate for estimating status of habitat and fish and for tracking long-term trends in habitat, water quality and fish distribution. PNAMP recommends:

- Developing a regional aquatic monitoring network covering the states of Washington, Oregon, Idaho, and Northern California using the randomized, spatially balanced, probabilistic design developed by the EMAP (Peck et al. 2001). (PNAMP will help facilitate and coordinate this development.) The monitoring network would be flexible to allow reporting of status and trends at various spatial scales (eco-regions, ESUs, subbasins) and across institutional boundaries (i.e., states, tribes, AREMP, PIBO, Interior Columbia Basin). This will facilitate the integration and sharing of multi-agency data collection and interpretation at the broadest scale, statewide, with subbasins participating to add data points complementary to the broader effort and in cooperation with other federal and state efforts and capable of reporting status and trends at subbasin scales, e.g. OWEB, AREMP, and PIBO (Kershner et al., 2001).

- PNAMP will initiate a regional discussion about selecting monitoring sites across the states of the Pacific Northwest, an area within which the Columbia River Basin's 62 subbasins are included, in an effort to encourage individual subbasins toward a scenario where information will be integrated at coarser scales, such as ESUs.

- PNAMP recognizes that subbasin planners and implementers comprise a new and potentially large group of monitoring practitioners in the Pacific Northwest. PNAMP members involved in subbasin planning and implementation can share their experiences with PNAMP, and PNAMP can in turn develop products for its members in the Pacific Northwest that will be useful to subbasin planners. To initiate this interaction PNAMP recommends that a workshop be convened at the earliest opportunity, at which subbasin planners can learn more about the design, rationale, and mechanics of EMAP, and PNAMP members can learn more about the issues ranging across the Columbia Basin.

- The recently completed Pacific Coastal Salmon Recovery Fund (PCSRF) Data Dictionary provides a set of metrics for reporting data concerning the type and extent of salmon recovery work funded under PCSRF, the budget and the organizations involved. Information about projects funded by PCSRF will be accessible at the link: http://www.nwr.noaa.gov. (Look under Regional News Releases/Pacific Coast Salmon Recovery Fund for "PCSRF Performance Metrics/Data Definitions Excel spreadsheet 66k.") These metrics are recommended for use in the subbasin efforts to organize and report project level information regardless of funding source, but are not sufficient for reporting scientific data for monitoring and evaluation purposes.

PNAMP Consideration 3-4: PNAMP recommends subbasin planners inventory restoration projects within their subbasins and determine whether the funding entities have provided for reach scale effectiveness monitoring.

PNAMP Consideration 3-5: Monitoring in support of contract compliance is appropriate for individual actions and will need to conform to the requirements of the respective funding agencies.

Data and Information Archive (Checklist III.D.4)

Adequate access to information related to watershed health and salmon recovery is a critical unmet need. The reporting of recovery success depends on consistent data management standards, which in turn can support composite statistics showing cumulative actions of all federal state, tribal, and local entities. The PNAMP data management goal is to: develop or adopt fish and habitat data collection protocols, sampling protocols and analytical methods and, to ensure that data arising from these protocols can be managed, shared and used. There are many different existing interests/initiatives concerned with improving data collection or management in the Pacific Northwest that represents different constituencies, mandates and obligations. There is no common regional data management system of standards or protocols or network that links these interests and initiatives.

PNAMP recognizes a new effort called the Northwest Environmental Data (NED) network (formerly CBCIS) proposes to work within the region to adopt and maintain standards and protocols for data collection and sharing. The role of NED will be to identify, understand, and document where there are gaps and overlaps in collection protocols across the region, and to coordinate efforts to address those gaps and overlaps by identifying where expert work groups are needed. NED may have a key role in support of subbasin plan implementation and information management.

PNAMP Consideration 4-1: PNAMP recommends that subbasin planners not develop separate data management systems for each subbasin. This guidance should help to meet the standards of existing data management systems and to identify mechanisms so that subbasin planners can more easily access these systems. PNAMP recommends that subbasin planners follow a consistent data management methodology that breaks the tasks into distinct steps:

1. Assessing needs and gathering requirements. Understanding the necessary data products, the people who are involved, and when products are needed.
2. Developing a detailed Data Management Coordination Project Plan following forthcoming guidance from PNAMP. Set out the time frame for deliverables, who will do what and when and cost and cost share.
3. Analyzing the requirements. The requirements need to be described in data management terms.
4. To the degree possible, utilize existing database projects and systems.
5. Designing, developing and testing solutions.
6. Transition and training.
7. Deployment.
8. Maintenance.
9. Independent validation and verification.

It is likely that PNAMP will identify coordination and sharing tasks that will require the development and adoption of standard monitoring protocols for both the collection and management of data. The Upper Columbia Monitoring Strategy (UCMS) (Hillman 2004) provides an example of a protocol for collection of data in the field; that is sampling protocols, required variables, etc. Work under the federal pilot projects provides an example of protocols for the management of data, including data definitions, data organization and storage standards.

Coordination and Implementation (Checklist III.D.5)

PNAMP Consideration 5-1: An important goal of PNAMP is to facilitate coordination among monitoring practitioners across the many state and federal monitoring programs in the Pacific Northwest. PNAMP acknowledges that both the degree and the types of monitoring appropriate to implementing the strategies of a particular subbasin may be unique. Further, there are likely to be diverse and not necessarily compatible opportunities for data sharing among proximal monitoring programs. Therefore, PNAMP recommends that subbasin planners and implementers work with the Council and PNAMP to identify and facilitate opportunities for coordination.

RME Logic Path (Evaluation and Adaptive Management)(Checklist III.D.6)

PNAMP Consideration 6-1: Develop the biological vision, objectives, and strategies for the subbasin to be implemented through the management plan. Refer to the specific vision, objectives and/or strategies throughout the plan that tie the subbasin to the larger geographic area of the Columbia Basin and the specific ESUs of the listed species found within the basin. Tie together the monitoring approach to the programs adopted by the state where the subbasin resides, the federal RME plan for the FCRPS Biological Opinion, or recovery plans. The responsibility for decision-making evaluations and management responses is shared by those working on restoration within a subbasin and those working across subbasins.

PNAMP Consideration 6-2: Pilot efforts are an excellent way to coordinate and concentrate support, and explore avenues that may have widespread implications. PNAMP recommends that such work be informed by prior or on-going efforts outside of the subbasin in question. PNAMP is in the process of identifying a network of intensively monitored watersheds (IMWs) or equivalents across the Pacific Northwest. All subbasins do not necessarily need an intensively monitored watershed. PNAMP recommends the subbasins evaluate current monitoring efforts where validation monitoring is occurring or could occur with minimal extra effort or funding. PNAMP recommends IMWs treat specific target species and specific eco-regions. IMWs or equivalents currently under development or being implemented are included in Table 3.

Table 3. Intensively Monitored Watersheds

Watershed	Species	Funding Entity/Cooperators
Wenatchee River-Upper Columbia, WA	Chinook, steelhead	BPA, BOR, Upper Columbia Salmon Recovery Region, NOAA Fisheries

John Day River, OR	Chinook steelhead	BPA, ODFW, NOAA Fisheries, OWEB
Clearwater River , ID	Steelhead	Under discussion
Lower Columbia (Germany, Mill, Abernathy Creeks), WA	Chinook coho steelhead chum	SRFB, Lower Columbia Salmon Recovery region, WDFW, WECY
Hood Canal, WA	Coho steelhead chum	SRFB, Hood Canal Coordinating Council, WDFW, WECY

For status monitoring, PNAMP anticipates that much of the local need will be met by the expansion of the higher-level network of coordinated programs and recommends relying on and/or identifying how subbasins can contribute to that network of programs. For action effectiveness monitoring, PNAMP is working to coordinate the strategic placement of IMWs noted above that will address the effectiveness of different actions and a limited set of more local, reach specific studies. PNAMP encourages subbasin planners to identify subbasins and associated rationale for their consideration as possible candidate IMWs.

General Considerations for Creating Monitoring and Evaluation Elements of Subbasin Plans

A disciplined, and well coordinated, monitoring and evaluation program is needed to help confirm our scientific assumptions, resolve key scientific uncertainties, and provide the basis for performance tracking and adaptive management. A coordinated program will maximize efficiencies; avoid duplication, and improve experiments to minimize confounding factors or actions.

Relationship of Subbasin Plans to Existing Monitoring Efforts

The technical guidance provided to subbasin planners was helpful, but did not promote the consistent, coordinated monitoring that is needed for the combination and contrast of data at the Tribal Lands, States, Provinces, and Columbia Basin levels. PNAMP suggest that the monitoring sections of individual subbasin plans would benefit if they identify relationships to programmatic and regional or landscape-scale monitoring programs. Therefore, PNAMP suggests that subbasin planners provide the following information on their relationships to monitoring initiatives within the region.

1. A summary table of ongoing monitoring and evaluation activities at the reach, subbasin and watershed level that reports “who, what and where” attributes are urged at a minimum.
2. A short description of how the subbasin plan monitoring element:

    a. Assesses whether the goals of the subbasin plan are being met, or not;

b. Contributes to filling critical data gaps in the assessment;
c. Complements project effectiveness monitoring; and,
d. Describes how subbasin monitoring and evaluation contain complimentary components for measuring regional (e.g., ESU, province or landscape) scale status and trend for fish and wildlife populations.

3. Provides a brief statement about an implementation and coordination strategy.

PNAMP suggests that the following guidance from the Federal RM&E Plan may be useful for framing monitoring and evaluation goals.

1. Track the status of fish populations and their environment relative to required performance standards,
2. Identify the physical and biological responses to management actions,
3. Resolve critical uncertainties in the methods and data required for the evaluation of future population performance and needed survival improvements.

PNAMP suggest that the following guidance for salmon and steelhead may be useful for framing monitoring and evaluation goals.

1. Maintain and modify ongoing monitoring and evaluation efforts until a more structured and coordinated monitoring and evaluation framework and plans are developed and approved.
2. Expeditiously implement monitoring and evaluation actions that address high priority needs.
3. Collaborate with the NMFS recovery planning and research programs, the Federal Caucus' Basinwide Salmon Recovery Strategy, the NWPPC subbasin planning, and State and Tribal planning efforts to develop a basin wide monitoring and evaluation program and data management system.

PNAMP suggest that the following guidance for resident fish may be useful for framing monitoring and evaluation goals.

1. For species such as Kootenai River white sturgeon: define, monitor, and evaluate flows below impediments to meet natural reproduction objectives specified in the final recovery plan(s).
2. For bull trout, to work with the USFWS resident fish recovery planning efforts to obtain basic population and distribution data needed to develop performance standards and to identify critical monitoring and evaluation needs.

PNAMP suggest that the following guidance for developing an implementation and coordination strategy may be useful for framing monitoring and evaluation goal (example from the Oregon Plan).

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 an 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. Evaluation 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 partnerships.
9. Integrate information and product data products and reports.

The status and trend-monitoring program (NOAA Pilot Studies proposal) for anadromous salmonids and habitat in the Wenatchee and Grande Ronde River basins will serve three major data collection efforts:

- At the scale of a subbasin, assess on an annual basis the status of adult populations of anadromous salmonids.
- At the scale of a subbasin, assess on an annual basis the population status or productivity of juvenile anadromous salmonids.
- At the scale of a subbasin, assess on an annual basis the status of salmonid habitat.

Data from the status and trend-monitoring program will be used for a variety of resource management purposes. The primary utility of the information will be the annual assessment of status and resulting trend over time for these fishes and their habitat. However, monitoring and evaluation programs will also support restoration action planning and assessment by serving as the baseline information used for action siting, and the baseline against the biological impact of actions could be measured.

Other useful references and links include:

1. The Yakima Klickitat Fisheries Project: http://www.ykfp.org
2. The Northeast Oregon Hatchery: http://www.cbfwa.org/2001/projects/198805301.htm
3. The Columbia Basin Fish and Wildlife Authority (M&E): http://www.cbfwa.org/rme.htm
4. The State of Washington: Outline for Salmon Regional Recovery Plans. http://www.wdfw.wa.gov/recovery/recovery_model.htmCoordinated Management Strategy. http://www.iac.wa.gov/srfb/monitoring.htm

(Please see the reference sections of this document for a more comprehensive list of resources and full citations.)

This rest of this section is intended to outline considerations for subbasin programs and technical details, intended to facilitate consistency in format and in scientific rigor across subbasins. PNAMP has used the Upper Columbia Monitoring Strategy, or UCMS, (Hillman et al., 2004) as a template for this section because of its current relevancy.

The indicators and metrics contained in the UCMS are derived from NOAA Fisheries, the Federal Columbia River Research and Monitoring and Evaluation (RME) program and component BPA Pilot Projects; the state of Washington's Coordinated Monitoring Strategy, and the Oregon Plan Monitoring Program. Further, detailed guidance in the UCMS incorporates direction and considerations from programs such as: PIBO, AREMP, EMAP, and the WSRFB. Over 35 private, state, federal and tribal representatives have contributed to the development of the UCMS over the course of 2003 and 2004. Thus, the information contained therein, coupled with the following summarized sections, represents the most detailed guidance for program setup, implementation, design, methods, protocols, standards and indicators for monitoring that exist for a Columbia Basin subbasin at this time. Please note that the UCMS also contains many elements and a level of detail that is consistent with an IMW as described previously. However, the UCMS is more detailed than will be needed for all subbasin plans. The UCMS can be accessed online via the Columbia Basin Fish and Wildlife Authority at www.cbfwa.org under the RME section.

The intent of the material that follows is to offer for consideration by planners a concise overview or checklist of steps for development of monitoring plans that would generate statistically valid results. Although these steps are general, PNAMP recommends that planners address each one in order to develop complete understanding of status/trend and action effectiveness monitoring. Below is a suggested table of contents that organizes information according to the steps needed to setup and implement a monitoring program. Following that is an outline of the technical steps needed to effectively design status/trend and action effectiveness monitoring.

Suggested Table of Contents

1. Statement of Need and Program Outline
2. Summary of Indicators and Program Elements
3. Summary of Monitoring and Evaluation Priorities
4. Program Set Up Statistical Design
5. Sampling Design
    a. Sample Size
    b. Measurement Error
6. Fish Population Monitoring Overview
7. Habitat Monitoring Overview
8. Biological Variables
10. Physical/Environmental Variables
11. Spatial Scales
12. Performance Standards
13. Classification
14. Indicators to be used
15. Measuring Protocols to be used
16. Status Trend Monitoring
17. Effectiveness Monitoring
18. Data Management Needs Assessment and Data Management Plan

19. Peer Review and Annual Reporting
20. Adaptive Management
21. References
22. Appendices as needed

Program Setup

In order to setup a monitoring program, it will be important to follow a logical sequence of steps. By proceeding through each step, the planner will better understand the goals of monitoring and its strengths and limitations. These steps will aid the implementation of a valid monitoring program that reduces duplication of sampling efforts, and thus overall costs, but still meets the needs of the different entities. The plan assumes that all entities involved with implementing the plan will cooperate and freely share information. Setup steps are:

1. Identify the populations and/or subpopulations of interest (e.g., spring Chinook, steelhead, bull trout).
2. Identify the geographic boundaries (areas) of the populations or subpopulations of interest.
3. Describe the purpose for selecting these populations or subpopulations (i.e., what are the concerns?).
4. Identify the objectives for monitoring.
5. Select the appropriate monitoring approach (status/trend or effectiveness monitoring or both) for addressing the objectives.
6. Identify and review existing monitoring and research programs in the area of interest.
7. Determine if those programs satisfy the objectives of the proposed program.
8. If monitoring and evaluation data gaps exist, implement the appropriate monitoring approach by following the criteria outlined in 9-13.
9. Classify the landscape and streams in the area of interest.
10. Complete a data management needs assessment. Describe how data collection and management needs will be met and shared among the different entities.
11. Identify an existing database for storing biological and physical/environmental data.
12. Estimate costs of implementing the program.
13. Identify cost-sharing opportunities.

Detailed Technical Considerations Supporting the Table of Contents

Basic Statistical Considerations

This document defines "statistical design" as the logical structure of a monitoring study. It does not necessarily mean that all studies require rigorous statistical analysis. Rather, it implies that all studies, regardless of the objectives, be designed with a logical structure that reduces bias and the likelihood that rival hypotheses are correct. The purpose of this section is two-fold. First, it identifies the minimum requirements of valid statistical designs and second it identifies the appropriate designs for status/trend and effectiveness monitoring. The following discussions draw heavily on the work of Hairston (1989), Hicks et al. (1999), Krebs (1999), Manly (1992, 2001), and Hillman and Giorgi (2002). (See: Hillman et al. 2004) section 3, pages 9-13.)

Sampling Design Considerations

Once the investigator has selected a valid statistical design, the next step is to select "sampling" sites. *Sampling* is a process of selecting a number of units for a study in such a way that the units represent the larger group from which they were selected. The units selected comprise a *sample* and the larger group is referred to as a *population*.[1] All the possible sampling units available within the area (population) constitute the *sampling frame*.[2] The purpose of sampling is to gain information about a population. If the sample is well selected, results based on the sample can be generalized to the population. Statistical theory assists in the process of drawing conclusions about the population using information from a sample of units.

Defining the population and the sample units may not always be straightforward because the extent of the population may be unknown, and natural sample units may not exist. For example, a researcher may exclude livestock grazing from sensitive riparian areas in a watershed where grazing impacts are widespread. In this case the management action may affect aquatic habitat conditions well downstream from the area of grazing. Thus, the extent of the area (population) that might be affected by the management action may be unclear, and it may not be obvious which sections of streams to use as sampling units.

When the population and/or sample units cannot be clearly defined, the investigator should subjectively choose the potentially affected area and impose some type of sampling structure. For example, sampling units could be stream habitat types (e.g., pools, riffles, or glides), fixed lengths of stream (e.g., 150-m long stream reaches), or reach lengths that vary according to stream widths (e.g., see Simonson et al. 1994). Before selecting a sampling method, the investigator should define the population, size and number of sample units, and the sampling frame. (See: Hillman et al. 2004) section 4, pages 9-13).

Spatial Scale

Because monitoring will occur at a range of spatial scales, there may be some confusion between the roles of status/trend monitoring and effectiveness monitoring. Generally, one thinks of status/trend monitoring as monitoring that occurs at coarser scales and effectiveness monitoring at finer scales. In reality, both occur across different spatial scales, and the integration of both is needed to develop a valid monitoring program (ISAB 2003; AA/NOAA Fisheries 2003; WSRFB 2003).

[1] This definition makes it clear that a "*population*" is not limited to a group of organisms. In statistics, it is the total set of elements or units that are the target of our curiosity. For example, habitat parameters will be monitored at sites selected from the *population* of all possible stream sites in the watershed.
[2] The *sampling frame* is a "list" of all the available units or elements from which the sample can be selected. The sampling frame should have the property that every unit or element in the list has some chance of being selected in the sample. A sampling frame does not have to list all units or elements in the population.

The scale at which status/trend and effectiveness monitoring occurs depends on the objectives of the study, the size or distribution of the target population, and the indicators that will be measured. In status/trend monitoring, for example, the objective may be to measure egg-parr survival of spring Chinook salmon in the Wenatchee Basin. Because the Wenatchee Basin consists of one population of spring Chinook (ICBTRT 2003), the entire basin is the spatial scale at which egg-parr survival is monitored. In contrast, if the objective is to assess egg-parr survival of spring Chinook in the Chiwawa Basin (a sub-population of the Wenatchee population), the spatial scale at which monitoring occurs includes only the Chiwawa Basin, a much smaller area than the entire Wenatchee Basin. Thus, status/trend monitoring can occur at various scales depending on the distribution of the population of interest.

In the same way, effectiveness monitoring can occur at different spatial scales. That is, one can assess the effect of a tributary action on a specific Recovery Unit or ESU (which may encompass several populations), a specific population (may include several sub-populations), at the sub-population level (may encompass a watershed within a basin), or at the reach scale. Clearly, the objectives and hence the indicators measured dictate the spatial scale at which effectiveness monitoring is conducted. For example, if the objective is to assess the effects of nutrient enhancement on egg-smolt survival of spring Chinook in the Chiwawa Basin (a sub-population of the Wenatchee spring Chinook population), then the spatial scale covered by the study should include the entire area inhabited by the eggs, fry, parr, and smolts. If, on the other hand, the objective is to assess the effects of a sediment reduction project on egg-fry survival of a local group of spring Chinook (i.e., Chinook within a specific reach of stream), then the study area would only encompass the reach of stream used by spawners of that local group.

In theory there might be no limit to the scale at which effectiveness monitoring can be applied, but in practice there is a limit. This is because as the spatial scale increases, the tendency for multiple treatments (several habitat actions) affecting the same population increases. That is, at the spatial scale representing a Recovery Unit, ESU, or population, there may be many habitat actions within that area. Multiple treatment effects make it very difficult to assess the effects of specific actions on an ESU. Even though it may be impossible to assess specific treatment effects at larger spatial scales, it does not preclude one from conducting effectiveness monitoring at this scale. Indeed, one can assess the combined or cumulative effects of tributary actions on the Recovery Unit, ESU, or population. However, additional effectiveness monitoring may be needed at finer scales to assess the effects of individual actions on the ESU or population. (See: Hillman et al. 2004, section 5, pages 31-33.)

Classification

Both status/trend and effectiveness monitoring require landscape classification. The purpose of classification is to describe the "setting" in which monitoring occurs. This is necessary because biological and physical/environmental indicators may respond differently to tributary actions depending on landscape characteristics. A hierarchical classification system that captures a range of landscape characteristics should adequately describe the setting in which monitoring occurs. The idea advanced by hierarchical theory is that ecosystem processes and functions operating at different scales form a nested, interdependent system where one level influences other levels. Thus, an understanding of one level in a system is greatly informed by those levels above and below it.

A defensible classification system should include both ultimate and proximate control factors (Naiman et al. 1992). Ultimate controls include factors such as climate, geology, and vegetation that operate over large areas, are stable over long time periods, and act to shape the overall character and attainable conditions within a watershed or basin. Proximate controls are a function of ultimate factors and refer to local conditions of geology, landform, and biotic processes that operate over smaller areas and over shorter time periods. These factors include processes such as discharge, temperature, sediment input, and channel migration. Ultimate and proximate control characteristics help define flow (water and sediment) characteristics, which in turn help shape channel characteristics within broadly predictable ranges (Rosgen, 1996).

The UCMS plan proposes a classification system that incorporates the entire spectrum of processes influencing stream features and recognizes the tiered/nested nature of landscape and aquatic features. This system captures physical/environmental differences spanning from the largest scale (regional setting) down to the channel segment. The Action Agencies/NOAA Fisheries RME plan proposes a similar classification system. By recording these descriptive characteristics, the investigator will be able to assess differential responses of indicator variables to proposed actions within different classes of streams and watersheds. Importantly, the classification work described here fits well with Level 1 monitoring under the ISAB (2003) recommend strategies for restoring tributary habitat. Classification variables and recommend methods for measuring each variable are defined below. (See: Hillman et al. 2004) section 6, pages 33-45.)

Indicators

PNAMP has not yet convened a committee to negotiate a set of key indicators for the region. However, a workgroup which includes some PNAMP members has identified the following as a subset of key indicators: bank-full width, reach length, bank-full depth, sediment, wood, gradient, pools, residual pool depth, bank stability, temperature, invertebrates, shade, riparian characteristics. (Please note that this set of attributes has not been reviewed by PNAMP.)

Theses indicators represent a subset of variables that should be measured. Investigators can measure additional variables depending on their objectives and past activities. For example, reclamation of mining-impact areas may require the monitoring of pollutants, toxicants, or metals. Some management actions may require the measurement of thalweg[3] profile, placement of artificial instream structures, or livestock presence. Adding other needed indicators will supplement the core list.

Indicator variables identified in the UCMS template are consistent with those identified in the Action Agencies/NOAA Fisheries RME Plan and with most of the indicators identified in the WSRFB (2003) monitoring strategy. The Action Agencies/NOAA Fisheries selected indicators based on their review of the literature (e.g., Bjornn and Reiser 1991; Spence et al. 1996; and Gregory and Bisson 1997) and several regional monitoring programs (e.g., PIBO, AREMP, EMAP, WSRFB, and the Oregon Plan). They selected variables that met various purposes including assessment of fish production and survival, identifying limiting factors, assessing effects of various land uses, and evaluating habitat actions. Their criteria for selecting variables were based on the following characteristics:

- Indicators should be sensitive to land-use activities or stresses.
- They should be consistent with other regional monitoring programs.
- They should lend themselves to reliable measurement.
- Physical/environmental indicators would relate quantitatively with fish production.

Measuring Protocol

An important component of all regional monitoring strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) is that the same measurement method be used to measure a given indicator. The reason for this is to allow comparisons of biological and physical/environmental conditions within and among watersheds and basins.[4] This section identifies methods to be used to measure biological and physical/environmental indicators. The methods identified in this plan are consistent with those described in the Action Agencies/NOAA Fisheries RME Plan and, for the most part, consistent with EMAP and WSRFB protocols.

PNAMP is supporting an initiative to coordinate a side-by-side comparison of protocols and will communicate to subbasin planners which protocols will be included in the test. This comparison, which is proposed to take place in 2005, will be done to identify which protocols are best for determining watershed condition status and trend. It's possible a pilot study in the John Day basin will take place in 2004 if funding and logistical constraints are resolved.

The Action Agencies/NOAA Fisheries monitoring group reviewed several publications, including the work of Johnson et al. (2001) that describe methods for measuring indicators. Not surprisingly, there can be several different methods for measuring the same variable. For example, channel substrate can be described using surface visual

[3] "Thalweg" is defined as the path of a stream that follows the deepest part of the channel (Armantrout 1998).

[4] Bonar and Hubert (2002) and Hayes et al. (2003) review the benefits, challenges, and the need for standardized sampling.

analysis, pebble counts, or substrate core samples (either McNeil core samples or freeze-core samples). These techniques range from the easiest and fastest to the most involved and informative. As a result, one can define two levels of sampling methods. Level 1 (extensive methods) involves fast and easy methods that can be completed at multiple sites, while Level 2 (intensive methods) includes methods that increase accuracy and precision but require more sampling time. The Action Agencies/NOAA Fisheries monitoring group selected primarily Level 2 methods, which minimize sampling error, but maximizes cost.

Before identifying measuring protocols, it is important to define a few terms. These terms are consistent with the Action Agencies/NOAA Fisheries RME Plan.

Reach (effectiveness monitoring) – for effectiveness monitoring, a stream reach is defined as a relatively homogeneous stretch of a stream having similar regional, drainage basin, valley segment, and channel segment characteristics and a repetitious sequence of habitat types. Reaches are identified by using a list of classification (stratification) variables. Reaches may contain one or more sites. The starting point and ending point of reaches will be measured with Global Positioning System (GPS) and recorded as Universal Transverse Mercator (UTM).

Although the level of accuracy expected from GPS reporting of stream locations may not be sufficient for all subbasin monitoring and evaluation purposes, the researchers for the John day and Upper Columbia projects are planning to use it for the subbasin pilot efforts.

Reach (status/trend monitoring) – For status/trend monitoring, this section refers only to a "sampling reach" as defined by the EMAP design and referenced in the UC Strategy document. This is one method to consider using to initially locate a reach, with the "X" point being the place where bankfull width is determined. From this location the extent of the upstream and downstream boundaries (total reach length) are determined according to the protocol used. Data collected in the sampling reach should be linked to the best available hydrograpghy layers to facilitate mapping and use in a GIS. Typically the 1:100,000 scale has been used, but a routed 1:24,000 scale hydrography may soon become available.

Note: Standardized GIS and post processing of spatial data will require a standardized protocol that does not currently exist. In the interim PNAMP recommends the following: 1. all GIS data should be provided with Federal Geographic Data Committee compliant metadata, including information on projection used; 2. data should be linked to a standardized stream each identification system to facilitate mapping and use in GIS; and, 3. use existing 1:100,000 and 1:24,000 hydrography layers where they have been cleaned and routed, and if not, use the best available information.

Site (effectiveness monitoring) – a site is an area of the effectiveness monitoring stream reach that forms the smallest sampling unit with a defined boundary. Site length depends on the width of the stream channel. Sites will be 20 times the average bankfull width with a minimum length of 150 m and a maximum length of 500 m. Site lengths are measured along the thalweg. The upstream and downstream boundaries of the site will be measured with GPS and recorded as UTM. For purposes of re-measurements, these points will also be photographed, marked with permanent markers (e.g., orange plastic survey stakes), and carefully identified on maps and site diagrams. Site lengths and boundaries will be "fixed" the first time they are surveyed and they will not change over time even if future conditions change.

Transect – a transect is a straight line across a stream channel, perpendicular to the flow, along which habitat features such as width, depth, and substrate are measured at pre-determined intervals. Effectiveness monitoring sites and status/trend monitoring reaches will be divided into 11 evenly spaced transects by dividing the site into 10 equidistant intervals with "transect 1" at the downstream end of the site or reach and "transect 11" at the upstream end of the site or reach. The number of transects varies for different attributes.

Habitat Type – Habitat types, or channel geomorphic units, are discrete, relatively homogenous areas of a channel that differ in depth, velocity, and substrate characteristics from adjoining areas. This plan recommends that the investigator identify the habitat type under each transect within a site or reach following the Level II classification system in Hawkins et al. (1993). That is, habitat will be classified as turbulent fast water, non-turbulent fast water, scour pool, or dammed pool (see definitions in Hawkins et al. 1993). By definition, for a habitat unit to be classified, it should be longer than it is wide. Plunge pools, a type of scour pool, are the exception, because they can be shorter than they are wide. (See: Hillman et al. 2004) section 8, pages 59-76)

Status/Trend Monitoring

If the objective of the monitoring program is to assess the current status of populations and/or environmental conditions, or to assess long-term trends in these parameters, then the following steps will help the investigator design a valid status/trend monitoring program.

Problem Statement and Overarching Issues:

1. Identify and describe the problem to be addressed.
2. Identify boundaries of the study area.
3. Describe the goal or purpose of the study.
4. List hypotheses to be tested.

Statistical Design (see Section 3 of UCMS Strategy):

1. Describe the statistical design to be used (e.g., EMAP design).
2. List and describe potential threats to external validity and how these threats will be addressed.
3. If this is a pilot test, explain why it is needed.
4. Describe descriptive and inferential statistics to be used and how precision of statistical estimates will be calculated.

Sampling Design (see Sections 4 & 5 of UCMS Strategy):

1. Describe the statistical population(s) to be sampled.
2. Define and describe sampling units.
3. Identify the number of sampling units that make up the sampling frame.
4. Describe how sampling units will be selected (e.g., random, stratified-random, systematic, etc.).
5. Describe variability or estimated variability of the statistical population(s).
6. Define Type I and II errors to be used in statistical tests (the plan recommends no less than 0.80 power).

Measurements (see Sections 7 & 8 of UCMS Strategy):

1. Identify indicator variables to be measured.
2. Describe methods and instruments to be used to measure indicators.
3. Describe precision of measuring instruments.
4. Describe possible effects of measuring instruments on sampling units (e.g., core sampling for sediment may affect local sediment conditions). If such effects are expected, describe how the study will deal with them.
5. Describe steps to be taken to minimize systematic errors.
6. Describe QA/QC plan, if any.
7. Describe sampling frequency for field measurements.

Results:

1. Explain how the results of this study will yield information relevant to management decisions.

Subbasin planners should include a section regarding how the data from the study (with metadata) will be stored, managed and made available to others. A starting point for some subbasin data collection efforts, could be the data definitions document for the Upper Columbia and John Day pilot projects once it has been reviewed. Proponents for the Upper Columbia and John Day projects are reviewing the final data dictionary on which their data system will be developed. The mechanics of data management in the Upper Columbia and John Day systems are being developed by the respective project teams and need significant additional work.

Appendix A - Participants in PNAMP

Tribal
Columbia River Intertribal Fish Commission
Confederated Colville Tribes
Confederated Tribes of the Umatilla Indian Reservation
Northwest Indian Fisheries Commission

State Agencies
California Department of Fish and Game
Idaho Department of Fish and Game
Oregon Department of Environmental Quality
Oregon Department of Forestry
Oregon Department of Fish and Wildlife
Oregon Watershed Enhancement Board
Washington Interagency Committee for Outdoor Recreation
Washington Department of Ecology
Washington Department of Fish and Wildlife
Washington Governor's Salmon Recovery Office

Federal Agencies
Bonneville Power Administration
National Oceanic and Atmospheric Administration
National Park Service
U.S. Army Corps of Engineers
U.S. Bureau of Land Management
U.S. Bureau of Reclamation
U.S. Geological Survey
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Park Service

Regional
Columbia Basin Fish and Wildlife Authority
Northwest Power and Conservation Council
Pacific States Marine Fish Commission - StreamNet

Private Sector
BioAnalysts
Bonneville Environmental Foundation
Chelan County PUD
Keith Wolf Associates
Humboldt State University
Paulsen Environmental Research
TetraTech

Appendix B - Examples of Key Monitoring Questions

This section provides selected examples of management level questions that are being addressed under the Washington Comprehensive Monitoring Strategy; the Oregon Plan; the Draft Research, Monitoring and Evaluation Plan for the NOAA-Fisheries 2000 FCRPS Biological Opinion; and the Okanogan Baseline Program.

Washington Comprehensive Monitoring Strategy

1. How are the annual abundance and productivity of salmon by species, ESU, and life stage changing over time?

2. What improvements are occurring in restoring the geographic distribution of salmon by ESU, species, and life stage to their historic range?

3. Are the unique life history characteristics of salmon within a Salmon Recovery Region changing over time because of human activities?

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?

5. What are the trends in effects of hatchery production on the survival and productivity of wild salmon populations within each ESU?

6. How are surface water quality conditions changing over time?

7. How effective are clean water programs at meeting water quality criteria?

8. What are the trends in water quantity and flow characteristics?

9. 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?

10. Are habitat improvement projects effective?

Oregon Plan for Salmon and Watersheds Monitoring Framework

1. What is the condition of salmon populations at the ESU, Subbasin and watershed scale?

2. What is the status and what are the trends in aquatic habitats, water quality, and stream flow?

3. What are the critical factors that limit watershed function and salmon

productivity?

4. What constitutes detectable and meaningful change in habitat condition and populations?

5. What changes are occurring in watersheds that improve stream habitat quality?

6. What are the management practices and programs that enhance or restore watershed functions and salmon populations?

7. What habitat changes and biotic responses result from these projects, practices, and programs?

Draft Research, Monitoring and Evaluation Plan for the NOAA-Fisheries 2000 Federal Columbia River Power System Biological Opinion

1. What are the abundances, productivity, and distributions of Columbia River Basin (CRB) fish populations relative to performance standards or objectives?

2. What are the biological, chemical, and physical status of CRB fish habitat relative to performance standards or objectives?

3. What are the relationships between fish populations and freshwater and estuary/ocean habitat conditions that determine population-limiting factors?

4. What is the effect of a specific mitigation or management action on the habitat and/or population performance of CRB fish?

5. What is the combined effect of multiple watershed level mitigation or management actions on the habitat and/or population performance of CRB fish?

6. Are Federal and state mitigation actions achieving the necessary survival changes identified in the All H Federal Caucus Program and the FCRPS BO for each ESU?

Okanogan Baseline Program - The Colville Tribes (EMAP design):

1. What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of anadromous fish in the Upper Columbia Basin (status monitoring)?

2. How do these factors change over time (trend monitoring)?

3. What effects do tributary habitat actions have on fish populations and habitat conditions (effectiveness monitoring)?

4. What effects do fishery management actions have on fish populations (effectiveness monitoring)?

5. Is there is a statistically significant difference in the abundance, survival, and timing and life history characteristics of summer/fall, spring Chinook, sockeye, and steelhead (7-20+ year time frame)?

6. Is there is a statistically significant difference in selected physical habitat parameters and characteristics for summer/fall, spring Chinook, sockeye, and steelhead in the Okanogan basin resulting from the cumulative benefits of habitat actions (7-20+ year time frame)?

7. What is the in-basin and out-of-basin harvest and stock-specific harvest of hatchery and wild anadromous salmonids within the Okanogan subbasin (ongoing)?

8. How effective are selective fishing gears and sites for possible future use for selective Tribal subsistence fisheries?

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[Although this draft document states that it should not be cited or quoted, some of the material in the report is an important improvement to Lazorchak et al. (1998). By not citing the document, it may give the appearance that this document improves some of the methods outlined in the Lazorchak et al. report. To avoid this, PNAMP believes it is necessary to offer credit where credit is due.]

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