

PACIFIC NORTHWEST AQUATIC MONITORING PARTNERSHIP

Annual Report for FY2005

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Executive Summary

Federal, state, tribal, local, and private aquatic monitoring programs in the Pacific Northwest have evolved independently in response to different organizational mandates, jurisdictional needs, issues and questions. Planning and coordination of federal, state and tribal monitoring activities have evolved slowly but steadily over the past ten years. In 2004, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) emerged from an ad hoc effort to become a formal institution charged with providing a forum for coordination of aquatic monitoring efforts in the region. To date, 19 state, tribal, federal, and regional entities are signatory to the PNAMP Charter.

The basis of PNAMP is that monitoring will be improved if we:

Collaborate

- Incorporate monitoring as critical element of program planning and support monitoring policy and management objectives
- Support collaborative teams across agency boundaries
- Seek efficiencies and cost-effectiveness across monitoring programs through compatible and cooperative monitoring efforts

Use consistent approaches and protocols

- Agree on a scientific foundation
- Agree on common attributes and how to measure them
- Agree on sets of widely used indicators

Collect and present information in a manner that can be shared

- Agree on data standards
- Support regional activity to link information systems

In FY2005, PNAMP focused on providing opportunity for inter-organizational committees to work together to identify and address elements of the goals above. Some accomplishments from 2005 include: completion of the “PNAMP Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest”; initiation of protocol comparison and development of some aspects of watershed monitoring and fish population monitoring, completion of a regional plan to establish a network of intensively monitored watersheds, initiation of coordination of high level indicators on a regional scale; preparation of technical forums (open to the public): “Large-scale Monitoring” symposium at the American Fisheries Society NPIC meeting; “Remote Sensing Workshop”; and the “Fish Practitioners Workshop.

In addition to these specific tasks, PNAMP continuously functions as a forum where monitoring practitioners and policy staff can interact and exchange information. This opportunity to collectively focus on issues, results, and future needs related to monitoring increases coordination and collaboration in the near term, and in the long term, effectiveness and efficiency of aquatic resource monitoring on a regional scale.

I. Background

Federal, state, tribal, local, and private aquatic monitoring programs in the Pacific Northwest have evolved independently in response to different organizational mandates, jurisdictional needs, issues and questions. Planning and coordination of federal, state and tribal monitoring activities have evolved slowly but steadily over the past ten years. In 2004, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) emerged from an ad hoc effort to become a formal institution charged with providing a forum for coordination of aquatic monitoring efforts in the region. The geographic area of this coordination includes the Pacific Northwest region from Northern California to Canada where the participating entities are implementing monitoring efforts. To date, 19 state, tribal, federal, and regional entities signed the PNAMP Charter (Appendix A).

The basis of PNAMP is that monitoring will be improved if: all programs use consistent monitoring approaches and protocols; follow a scientific foundation; support monitoring policy and management objectives; and collect and present information in a manner that can be shared. These goals will require considerable effort and commitment to collaboration by many entities and individuals. PNAMP strives to provide the forum where this collaboration can occur and to facilitate the exchange among technical experts and between technical and policy staff that is necessary to accomplish these goals.

Although we are eager for more participation, we believe PNAMP has the right combination of types of participants to address these goals. PNAMP's organizational structure includes a Steering Committee, Coordinator, and technical workgroups defined by aquatic monitoring topics: watershed condition monitoring, fish population monitoring, estuary monitoring, effectiveness monitoring, and data management. The Steering Committee is composed of representatives from all entities that are signatory to the Charter and leaders of the technical workgroups, a combination which allows the interface of technical and policy interests.

The agency representatives are responsible for communication to PNAMP regarding their respective agencies' work and needs, as well as delivering PNAMP progress and challenges to their agencies.

As PNAMP matures, we better understand how the goals and tasks of each technical workgroup, PNAMP subcommittee, and individual partners are inherently interdependent. PNAMP has identified a number of concepts important to establishing a regional partnership for aquatic resource monitoring that bridge technical focus areas and individual agencies. These are critical elements of a large scale, efficient, coordinated effort to monitor resources. We refer to these as "cross cut tasks":

- Protocols: what to measure and how to measure it
- Survey design: how to decide where monitor
- Data management: what are our data needs; what must we do before, during, and after data collection to facilitate data sharing
- Monitoring inventory: better facilitate coordination by describing 'who is doing what monitoring where'
- High level indicators: seek agreement on a set of indicators (and metrics necessary to determine indicators) to describe landscape level changes in the region
- Facilitate regional network of monitoring efforts: explore ways to continuously improve our efficiency and effectiveness of monitoring on a regional scale

Each of these tasks is complex and resolution will involve collaboration with other regional and national organizations as well as many individual participants. However, successful coordination and collaboration on these fundamentals could be a first step in the creation of a regional monitoring effort.

The PNAMP Steering Committee, Workgroup Leaders and Coordinator share the responsibility to work across PNAMP to accomplish our goals efficiently and consistently. We encourage those in the region who seek assistance with aquatic resource monitoring issues to contribute to PNAMP. Coordination on complex topics with many partners takes time and hard work. Since PNAMP is a voluntary organization, our progress is directly correlated to

participation. Support is also essential for PNAMP to respond to needs of the region; we need to hear from both technical and policy staff what is needed for better coordinated aquatic resource monitoring.

Section II. Fiscal Year 2005 Activities in Detail

Section II a. PNAMP Steering Committee Activities in FY2005

The PNAMP Steering Committee (SC) provides the science-policy interface between the Executive partners and technical workgroups, guides work of technical workgroups, obtains resources needed to accomplish tasks, and directs the activities of the Coordinator. The SC provides assistance to PNAMP initiatives by participating in the formulation, development, and review of recommendations for activities of PNAMP workgroups and integrating these activities with agency activities. The SC facilitates the transfer of information between PNAMP and their respective agencies. By promoting communication among organizations, the SC strives to assure that monitoring plans and information are coordinated across the Pacific Northwest.

In FY 2005, the Steering Committee drafted the “PNAMP Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest” (March 2005), which is a long-range guidance document, intended to articulate a vision for the future and channel PNAMP activities. In addition, the SC has focused on identification of issues that “cross cut” PNAMP technical workgroups. These issues are of importance to a variety of monitoring types and technical emphasis, and if coordinated, we believe would contribute to regional monitoring. In particular, the SC led tasks to:

- coordinate high level indicators on a regional scale,
- identify management questions relevant to PNAMP partners, and
- develop a plan to conduct an inventory of aquatic monitoring activities in the Pacific Northwest.

Meetings and Workshops

- Monthly Steering Committee (SC) meetings have occurred on schedule throughout the year, with occasional additional teleconferences as necessary. The primary activity at these meetings is tracking the implementation of FY05 workplan, preparation for FY06 workplan, and long range planning. These meetings also facilitate of information exchange between SC and Workgroups. The PNAMP Coordinator facilitates meetings and prepares notes following the meeting.
- Workshops were held on specific topics as necessary, including:
 - Annual Steering Committee Retreat: goal was to provide opportunity for leadership body of PNAMP (Steering Committee) to examine organization function, review current annual workplan, and initiate next annual workplan.

Section II b. PNAMP Coordination Team Activities in FY05

The PNAMP Coordination Team includes the Coordinator (Jennifer Bayer) and Administrative Assistant (Debra Niemann). The Coordination Team's goals are to facilitate the transfer of information within PNAMP and across all relevant organizations, work to support relationships between science and monitoring, and promote communication among organizations to help assure that monitoring plans and information are coordinated across the Pacific Northwest. The Coordination Team works to initiate and facilitate the development, presentation, and distribution of products aimed as heightening understanding of PNAMP issues, successes, and problems and to serve as a clearinghouse for PNAMP activities and products.

The Coordination Team is responsible for administrative requirements of PNAMP activities (e.g. meeting logistical support, record keeping, responsibility for maintenance of membership information). Organizational support was provided to PNAMP by developing and negotiating fiscal support with government and non-government entities, and managing budgets

and associated contracts with government and non-government entities. Required progress reporting regarding Coordinator's activities (within PNAMP) and PNAMP activities to interested external parties was completed.

Meetings and Workshops

- Monthly Steering Committee (SC) meetings have occurred on schedule throughout the year, with occasional additional teleconferences as necessary. The primary activity at these meetings is tracking the implementation of FY2005 workplan and preparation for FY2006 workplan. These meetings also facilitate of information exchange between SC and Workgroups. The PNAMP Coordinator facilitates meetings and prepares notes following the meeting.
- PNAMP Technical Workgroup (WG) Meetings have occurred throughout the year. Workgroup leaders initiate these meetings; the Coordination Team assists with preparation, facilitation, and meeting follow-up, as well as assisting with WG products.
 - Fish Population Monitoring WG: met December 15, 2004, January 12, 2005 and June 8, 2005.
 - Effectiveness Monitoring WG (and IMW subgroup): met September 2005
 - Watershed Monitoring WG: met May 5, 2005
 - Data Management WG (meets jointly with the Northwest Environmental Data Network): met January, February 9, March 9, April 6, May 3, June 8, August 3, and September 7.
 - Estuary WG: met May 28, June 16, July 19, August 16, and September 20.
- Workshops were held on specific topics as necessary, including:

- Annual Steering Committee Retreat: goal was to provide opportunity for leadership body of PNAMP (Steering Committee) to examine organization function, review current annual workplan, and initiate next annual workplan.
- Remote Sensing Information Workshop: goal was to explore remote sensing techniques of interest to aquatic monitoring projects in the Pacific Northwest via a 1-day workshop to include presentation by regional experts and discussion among participants.

Section II c. PNAMP Technical Workgroups Activities in FY2005

In addition to the existing four technical workgroups within PNAMP (Watershed Monitoring, Project Effectiveness Monitoring, Fish Population Monitoring, and Data Management), a new workgroup was formed (Estuary Monitoring). Each workgroup is comprised of varying numbers of technical experts from many state, federal, and tribal agencies in the northwest.

Watershed Monitoring Workgroup

Background and Goal: It is expected that each agency may have different monitoring questions.

Our goal is to standardize attribute protocols so that each agency can answer their own questions, as well as share data to help other agencies answer their respective questions. The principal goals of the PNAMP watershed aquatic monitoring coordination efforts are to:

- standardize sampling designs,
- standardize sampling protocols, and
- ensure that existing and new data can be shared among all interested parties.

FY05 Accomplishments

1. Initiated the design of a common probabilistic survey design (“Universal Survey Design”). In coordination with other PNAMP workgroups and others (e.g., CBFWA and CSMEP, bull trout

RMEG), meetings were convened to discuss the general integrated sample design concept developed by Phil Larsen (EPA). This task will continue in FY06.

2. Implemented study to compare watershed condition field attributes and sampling protocols (“Side-by-side Protocol Test”). Elements of the protocol comparison test include:

- Identify and recommend a core set of indicators and their associated attributes and protocols that state, federal, and tribal monitoring programs use for assessing status and trends in watershed condition.
- Develop a process for determining what protocols to use (e.g., based on cost, precision and variance, trend detection capability, repeatability, has “statistical blessing”)
- In parallel with developing a unified set of protocols, we will also develop calibrations for older protocols (*aka* a “crosswalk”) in order to preserve the value of legacy data where possible.
- Recommend which physical, chemical, and biological in-channel attributes and robust protocols should be used

Twelve agencies participated to compare eight protocol sets in the study:

- Aquatic-Riparian Effectiveness Monitoring Program (AREMP) – Steve Lanigan
- PacFish/Infish Biological Opinion Monitoring Program (PIBO) – Rick Henderson
- EPA Environmental Monitoring and Assessment Program (EMAP) – Phil Kaufman
- Oregon Department of Fish and Wildlife – Jim Ruzycki
- Oregon Department of Environmental Quality – Shannon Hubler
- Washington Department of Ecology – Steve Butkus
- US Forest Service Region 6 Stream Survey Program – Deb Konhoff.
- Upper Columbia Basin Monitoring Group – Mike Ward
- California Department of Fish and Game – Scott Downie
- Northwest Indian Fisheries Commission (Timber, Fish & Wildlife protocol) – Allen Pleus
- John Buffington – USFS Rocky Mt Research Station (establish “truth”)

Funding was provided by participating agencies as well as NOAA Fisheries, US Bureau of Reclamation, Bonneville Power Administration, Bureau of Land Management, and the Oregon Watershed Enhancement Board. Fieldwork was completed August 2005 and results will be analyzed during the fall of 2005. Results and recommendations, including a draft manuscript for peer review publication, are anticipated by spring 2006.

Effectiveness Monitoring Workgroup

Background and Goal: The Effectiveness Monitoring Workgroup was formed to coordinate initiatives begun by various state, federal, and tribal governments to monitor whether restoration and management actions ongoing in the Pacific Northwest are being effective in restoring salmon and steelhead populations and watershed health. The attention has been focused upon the major expenditures of the NPCC through the BPA, Oregon watershed Enhancement Board (OWEB), Washington Salmon Recovery Funding Board (SRFB) and the activities of the US Bureau of Reclamation and the NOAA Fisheries Service in regard to implementing pilot watershed monitoring in the Wenatchee and John Day Rivers. An important component has been the initial development of reporting metrics for participating agencies in the Pacific Coastal Salmon Recovery Fund. The focus has been on avoiding duplication of effort among the action agencies, coordinating data collection and disposition in order to facilitate future rollup of information in reporting to the Congress and state Legislatures on progress made. In keeping with higher level reporting of success, the group is also working on agreeing upon a limited number of high level metrics suitable for reporting from all state and federal action agencies.

FY05 Accomplishments

1. Initiated development of a regional data dictionary for effectiveness monitoring reach scale and watershed scale physical, chemical, and biological attributes.

2. Initiated development of a list of high level indicators for reporting on effectiveness of projects.
3. Completed draft regional plan to establish a network of intensively monitored watersheds.
4. Initiated development of common sampling protocols for testing effectiveness of projects at both the reach and watershed scale.

Fish Population Monitoring Workgroup

Background and Goal: Inventory and monitoring methods, sampling designs, and data management efforts for fish populations are not yet consistent across the Pacific Northwest. Effective monitoring requires a rigorously reviewed, vetted and standardized set of protocols. Flexibility and adaptability must be an inherent part of any set of protocols as environmental conditions will dictate logistics and implementation effectiveness. To facilitate a successful effort at addressing the issues noted above, a close examination of methods and protocols will be conducted by the Fish Population Monitoring Workgroup (FPM). The goal of this effort is to provide regional consistency such that individual data collection programs can be aggregated into larger analytical, management and decision-making levels.

Due to the interconnected nature of monitoring and design development efforts across tribal, state and federal participants, the FPM group works closely with the Coordinated Systemwide Monitoring and Evaluation Program (CSMEP) which is administered by the Columbia Basin Fish and Wildlife Authority (CBFWA) and funded by the Bonneville Power Administration (BPA). The CSMEP effort this year focused on assessing strengths and weaknesses of existing datasets in up to 10 pilot sub-basins, and developing sampling design templates and with the Upper Columbia, John Day and Salmon basins as coordinated monitoring

programs are implemented and reviewed. The FPM group has worked cooperatively with CSMEP to see that this information is disseminated and reviewed.

FY05 Accomplishments

1. Hosted a workshop with a group of scientists and fish managers to identify overall fish population RME needs in the Pacific Northwest. Workshop was held in conjunction with CSMEP participants to facilitate discussion of PNAMP/CSMEP interaction. The FPM solicited proposals for future PNAMP/FPM projects and/or initiatives, which will be incorporated into future workplans (December 2004).
2. Hosted a “Practitioner’s Workshop”. The FPM brought M&E field practitioners together from the Okanogan, Wenatchee, the IMW’s, John Day and the SRFB (IAC) to hold a one-day "what worked, what didn't" meeting between those developing protocols and processes and those attempting to implement M&E projects/protocols. The goal of the meeting was to share retrospective information from the 2004 field season with an eye towards increased standardization of efforts and approaches (January 2005).
3. Supported presentations at the Large-Scale Monitoring Symposium—American Fisheries Society NPIC Meeting November 1-3, 2004.
4. Reviewed Fish Monitoring Protocols from the draft paper of: David H. Johnson, Brianna M. Shrier, Jennifer O'Neal, John Knutzen, Todd N. Pearsons, Thomas A. O'Neil, Brett Roper, Xan Augerot. This review occurred October 2004- September 2005. The review group has assisted the authors with a protocol publications plan. The FPM workgroup will facilitate implementation of protocols by and through PNAMP partners. This task is still ongoing; other possible products may include production of a protocol(s) training video(s), and the

publication of a protocol field manual. Logically, this effort must also include other protocols under development in California, Oregon, and Washington and beyond, as those protocols are proposed in the future.

Data Management Workgroup

Background and Goal: There is a critical need for improvements to Northwest regional aquatic monitoring information systems in order to provide adequate access to information related to salmon recovery and watershed health. The PNAMP data management goal is to assist scientists on the identification and development of data standards as related to fish and aquatic habitat data. This includes identifying the subject area data needs and assessing a uniform approach to representing that information so that the data can be shared across organizations. The merger of subject matter experts and information technology management is the first step toward representing project study information in a commonly agreed upon format for implementation across the region.

The PNAMP data management coordination effort is currently at the first step of its overall methodology, involving the definition of its data management needs and requirements. The ‘clients’ for the effort are the four PNAMP workgroups: Watershed Condition Monitoring, Fish Population Monitoring, and Effectiveness Monitoring and Estuarine. In addition, the PNAMP group as a whole is expected to have data coordination needs that go beyond individual work group needs or cut across work group boundaries.

FY05 Accomplishments

1. Initiated process to understand PNAMP WG data management needs.
2. Facilitated regular interaction with the Northwest Environmental Network efforts by creating joint NED/PNAMP Data Management WG meetings.
3. Participated in NED workgroups and workshops

- a. PNAMP participated in NED Regional Spatial definitions workgroup
 - b. PNAMP participated in NED Data Sharing and Exchange workshop.
4. Identified a basic data management methodology that was approved by the PNAMP SC.
 5. Worked with the SC to understand PNAMP high-level data management needs. The Steering Committee reviewed the 2003 SAIC Needs Assessment and decided that the SAIC recommendations represent a useful starting point for working towards PNAMP data sharing and exchange. The SC also reviewed the NWFSC Spatial Data needs assessment and will use this assessment as a starting point for PNAMP identification of its spatial data needs.
 6. Participated in the Bureau of Reclamation review of the Protocol Builder/Manager.
 7. Drafted a Data Management section for the PNAMP Strategic Plan.
 8. Participated in the PNAMP Retreat and identified data management as a key PNAMP cross-cutting issue.
 9. Hosted a one day workshop with PNAMP Workgroup leads and Co-leads to identify overall PNAMP Project Inventory needs.
 10. Drafted Statements of work for PNAMP needs assessment (on hold) and PNAMP Project Inventory task.

Estuary Monitoring Workgroup

Background and goal: The PNAMP Estuary Monitoring Workgroup was formed in 2005.

Recognizing that estuarine monitoring is a large and integral part of Pacific States aquatic monitoring activities, and acknowledging the need for coordinating estuarine monitoring, research activities and management questions, the collective of PNAMP partners formed the Estuary Monitoring Workgroup. The Estuary Monitoring Workgroup's activities are focused on coordinating monitoring strategies, methods, protocols and management questions related to estuarine systems and integrating these activities with the larger collective of PNAMP partners.

FY05 Accomplishments

1. Completed new section for the PNAMP Strategy document for coordination of estuary monitoring. Section will be inserted into the PNAMP Strategy when next revised. Section will be titled “Objective 6. Coordinate Pacific Northwest Estuary Monitoring Efforts”.
2. Completed WG FY2006 workplan. Work has commenced on three activities listed as highest priority on the workplan
 - a. compile and create an inventory of Pacific states estuaries monitoring activities;
 - b. create a list/white paper of management questions;
 - c. coordinate w/ the PNAMP Data Management WG.

III. CHALLENGES

PNAMP has made significant strides as a fledgling organization, successfully negotiating the way from ad hoc to formal entity and laying out a plan for future steps due to the hard work of a dedicated group of active participants. However, there are always challenges for any activity. Here are some of PNAMP's challenges as we head into our second year:

- Need to increase technical participation in workgroups: PNAMP is a voluntary organization, and with the exception of the Coordinator, has no salaried professional staff. Therefore, the biggest challenge facing PNAMP is securing sufficient in-kind contribution of time from partner agencies to populate workgroups and subcommittees. PNAMP can provide the communication framework and facilitation necessary to support inter-organizational work teams. However, the progress of PNAMP remains directly correlated with volunteer participation; we do not intend for PNAMP to develop a large staff. In order to address regional monitoring needs, we need people to help address these needs.
- Need better communication of regional priorities for aquatic monitoring: PNAMP is drafting a formal communication plan to more effectively disseminate the organization's progress, products and needs. PNAMP also seeks better communication with other regional efforts in the aquatic resource monitoring arena.
- Need to improve consideration of data management: generally, data management coordination has been assigned a low priority by many technical monitoring professionals and decision makers. In order to establish coordinated monitoring efforts, we must improve our willingness to coordinate on data management issues.
- Need to understand current monitoring efforts: PNAMP seeks to conduct an inventory of current aquatic monitoring efforts in the region in order to facilitate coordination. In the absence of a "clearinghouse" of monitoring activities, many are unaware of monitoring occurring, data available, etc.

IV. RECOMMENDATIONS

The basis of PNAMP is that aquatic resource monitoring will be improved if we collaborate, use consistent approaches and protocols, and collect and present information in a manner that can be shared. PNAMP tasks can be viewed as a series of steps towards these goals and ultimately, coordinated monitoring efforts on a region wide scale. While it may take years to complete these steps, we seek PNAMP partners' consideration of the following recommendations resulting from our 2005 accomplishments:

- Agreement on standard set of fish collection and enumeration protocols will benefit the region. The Salmon Field Protocols Handbook, initiated by Washington Department of Wildlife and the State of the Salmon project and in collaboration with PNAMP, will be published in 2006 and will contain complete protocols for many common techniques used for monitoring fish populations;
- The region will benefit from a regional plan to establish a network of intensively monitored watersheds (IMWs) to evaluate the effectiveness of restoration projects, programs and policies at the landscape scale. The IMWs should be coordinated to reflect differing ecoregions, species, and treatments. Selection of IMWs should be a cooperative process between federal and State agencies, and local watersheds.

- Appendix A. Entities signatory to the PNAMP Charter, November 2005.

Bonneville Power Administration
California Department of Fish and Game
Columbia Basin Fish and Wildlife Authority
Columbia River Intertribal Fish Commission
Confederated Tribes of the Colville Reservation
Environmental Protection Agency
NOAA Fisheries
Northwest Indian Fisheries Commission
Northwest Power and Conservation Council
Oregon Watershed Enhancement Board (also representing ODFW, ODEQ, ODF)
Pacific States Marine Fisheries Commission
US Army Corps of Engineers
US Bureau of Land Management
US Bureau of Reclamation
US Forest Service
US Geological Survey
Washington Department of Ecology
Washington Governor's Salmon Recovery Office
Washington Salmon Recovery Funding Board

Appendix B. Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest

Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest

April 5, 2005

Pacific Northwest Aquatic Monitoring Partnership

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Introduction

The U.S. Congress, the Northwest Power and Conservation Council, and state Legislatures allocate hundreds of millions of dollars each year to aid recovery of salmonid species listed under the Endangered Species Act, and enhancement of other non-listed anadromous and resident fish. There is a tremendous need to document the contribution that these efforts are making to improvements in watershed condition and listed species.

Basic questions about how fish respond to well-intended actions cannot be answered unless a significant amount of existing and new information is obtained and rolled up in a manner that, to date has typically not been done (IAC 2002, ISP 2002, Bayley 2002). There is a growing realization and risk of losing significant funding for salmon and habitat recovery if the region does not demonstrate the coordinated monitoring necessary to answer basic questions posed by appropriators (GAO 2002).

Along with other complementary monitoring activities, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), a consortium of entities with a common interest in coordination of monitoring, has recommended establishing a regional network of “Intensively Monitored Watersheds” (IMWs) to evaluate the effectiveness of restoration projects, programs and policies at the landscape scale (PNAMP 2004). Effectiveness monitoring at the IMW scale addresses the following general questions:

Does the collective effect of restoration and/or management actions result in improved watershed condition and fish response? Why or why not? What are the causes of those responses?

The PNAMP Strategy (PNAMP 2005 v2/23/05) contains specific objectives and actions associated with effectiveness monitoring objectives aimed at IMW outcomes that are excerpted below.

“Objective 4. Coordinate Pacific Northwest effectiveness monitoring efforts”

“Outcome G. Develop a network of Intensively Monitored Watersheds (IMW) and reach specific studies for effectiveness monitoring.

Intensively monitored watersheds are designed to address key questions in a disciplined scientific manner. All possible factors need to be considered: accurate measures of fish populations including spawners entering the watershed and juvenile migrants leaving the watershed, and accurate estimates of mortality factors such as marine conditions, harvest, hydro, predation, and other factors directly affecting salmon abundance and survival. Without a holistic approach, it will not be possible to determine the response of salmon to habitat restoration and other management efforts.

Action item 1. *Recommend a strategy for placing IMWs throughout the Pacific Northwest to monitor and evaluate “cause and effect” relationships between habitat restoration and management actions, and changes in fish population responses and other viable salmonids population criteria.*

Action item #2. *Develop a regional map with agencies identified geographically that will be responsible for funding and implementing intensively monitored watershed monitoring.*

The IMWs should be coordinated to reflect differing ecoregions, species, and treatments. Selection of IMWs should be a cooperative process between federal and State agencies, and local watersheds.

Action Item 3. *To reduce the risk of not being able to detect a change resulting from habitat improvements, PNAMP will encourage federal and state governments that select and fund habitat restoration projects to cluster them in the identified intensively monitored watersheds so that the amount of habitat improved can be at a scale measurable in terms of migrant salmonids produced.”*

Distinguishing features of the IMW approach, in contrast to other PNAMP effectiveness monitoring recommendations, are that IMWs will provide:

- integrative watershed-scale evaluations,
- assessment of fish population responses to habitat actions evaluated at the watershed scale in terms of causal or correlative relationships, and
- results from rigorous designs used to adequately address confounding factors and experimental controls or reference conditions.

There may be ongoing or future research or investigations in intensively “studied” watersheds that do not meet all of the distinguishing features of IMWs listed above. Although that research would not be part of the PNAMP IMW network, it is likely that mutual benefits would accrue from improved coordination and information exchange.

Although the emphasis of the PNAMP IMW network is on monitoring the responses of fish to habitat projects or habitat management actions, there may be IMWs in the network whose experimental design emphasis addresses fish related management questions (e.g., supplementation) in a watershed scale context with broad implications for habitat management activities.

Broad interpretation of results from IMWs will be most effective if information from concurrent status and trend monitoring of specific ecosystem components, including watershed habitat conditions, water quality, stream morphology, riparian condition, and the viability of salmonid populations is available. Status and trend information provides a context within which results of IMWs can be interpreted and extrapolated beyond the local IMWs. IMWs need to be designed to assess the relative contribution of restoration and management actions in the context of other factors or ecological stressors.

This document outlines the PNAMP strategy and action plan for the implementation of a network of IMWs across the Pacific Northwest. Implementation activities will involve interactions within and between a number of ongoing watershed monitoring efforts in the PNAMP area (e.g., Federal Columbia River Power System pilot watersheds (Jordan et al. 2003), Washington IMWs (WSRFB 2003; Bilby et al. 2004). Where appropriate, existing efforts will be incorporated as part of the IMW network either in the early or later phases of this work.

Conceptual Framework

The basic premise of Intensively Monitored Watersheds is that the complex relationships controlling salmon response to habitat conditions can best be understood by concentrating and integrating rigorous monitoring and research efforts at a few locations. Intensively Monitored Watersheds reduce the complications of monitoring project effectiveness, increase the comprehensiveness of monitoring, and increase efficiencies through shared responsibilities.

Addressing the complications

The types of data required to evaluate the response of fish populations to management actions that affect habitat quality or quantity are difficult and expensive to collect and analyze. Evaluating biological responses is complicated, requiring an understanding of how various management actions interact to affect habitat conditions and how system biology responds to these habitat changes. The response of fish is dependent on the relative availability of the habitat types it requires, which changes through the period of freshwater rearing, and the manner in which these habitat types are influenced by application of a management action. Further complicating the issue is the fact that the relative importance of each habitat type in determining fish survival changes from year-to-year due to variations in weather and flow, the abundance of fish spawning within the watershed and other factors. For example, smolt production can be dictated by spawning habitat availability and quality during years when flood flows occur during incubation and greatly decrease egg survival. However, during years of more benign flow conditions during egg incubation, population performance may be more influenced by the availability of food during spring and summer or adequate winter habitat. Furthermore, changes in habitat are often linked with large disturbance events and/or may occur slowly over long periods of time, necessitating a significant time commitment to the IMW strategy to see results. Untangling the various factors that determine performance of the salmon and how these factors respond to land use actions or restoration efforts can only be accomplished with an intensive monitoring approach (Hillman 2003).

The ultimate objective of most habitat restoration efforts and land management programs aimed at salmon is to increase the abundance of naturally spawning fish. As a result, the most meaningful measure of program effectiveness for anadromous species is the survival of the fish from adult spawning through smolting of their offspring. Because salmon use multiple habitat types during their freshwater residency, the spatial and temporal scales at which evaluations are conducted should be large enough to encompass all the habitats required for the salmon to complete this phase of their life history and of sufficient duration to allow changes to occur. The size of the area required to capture the full range of habitats needed to complete freshwater rearing will vary by species.

Individually, and most importantly, collectively IMWs may be the most efficient method of achieving the level of sampling intensity necessary to monitor the response of salmon to management actions (ISP 2002).

Addressing the comprehensiveness of monitoring – constraints

Implementing an intercommunicating, coordinated network of IMWs is a critical step in the region's ability to respond to fundamental policy and public questions about results and accountability. However, there will be limits to what IMWs will be able to deliver. For example, technical feasibility, funding constraints, and political realities will inevitably preclude some hypotheses from being tested. Development and implementation of the approach outlined here will help clarify those limitations.

Finally, availability of funding will likely constrain the extent to which the IMW network can be fully implemented. The PNAMP IMW strategy represents a phased approach, where initial implementation will be followed by additional analysis, review, and refinements as needed.

Addressing the efficiencies – an IMW network

Development of individual IMWs will require considerable effort for scoping, assessment, analysis, design, implementation, analysis, and eventually multifaceted integrated syntheses and reporting of results. Because of differences in ecological and geological circumstances, and management contexts among IMWs, each IMW will be able to address only a part of the general question stated above. **However, the systematic development and implementation of a distributed “network” of IMWs is intended to address a range of species, ecological contexts, and management scenarios that are most relevant to policy interests, and that are technically feasible.** It will provide a framework to facilitate coordination and sharing of common interests, technical resources, fiscal impacts, and communication needs (Figure 1).

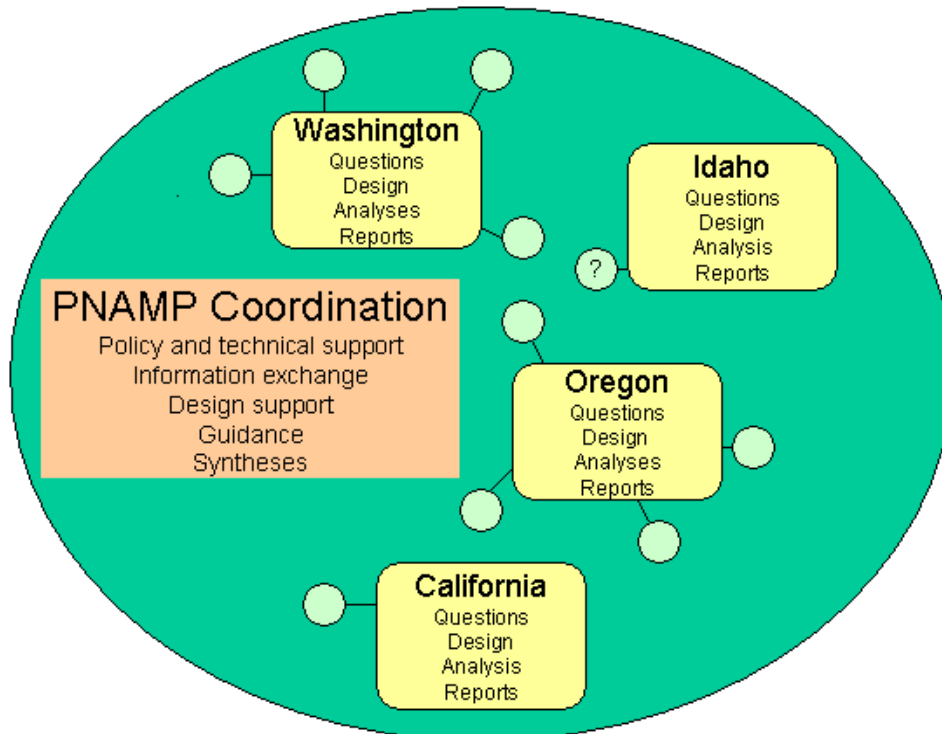


Figure 1. Network of PNAMP IMWs (small circles) and functions across geographic areas of the Pacific Northwest.

The network of IMWs will be based policy needs, technical considerations and practical opportunities (e.g., funding). Emphasis will be placed on achieving efficiencies through use of a hierarchy and diversity of IMWs deployed in a network across the PNAMP area.

Importantly, because monitoring in an IMW context is just getting underway, the relationships among them – the degree to which they will constitute a unified network – is a work in progress. However, in the same way that PNAMP encourages its members to do compatible, comparable status and trend monitoring, we also encourage interested parties to design their IMW activities so that direct comparisons can be made for different watersheds throughout the Northwest. Ideally, all IMWs would sample and measure the same fish and habitat indicators using similar protocols. If this can be done, or if reasonable “adapters” can be developed that allow different approaches to be understood and reconciled, it should be possible to make credible comparisons between the effects of similar habitat actions in different areas (e.g., interior Columbia and the Oregon coast).

A range of practical problems will make implementation and direct comparisons difficult. For example, although many IMWs measure juvenile output using traps or weirs, high spring flows will make this type of measurement impossible in many watersheds where it would be desirable. Juvenile life-stage survival rates can be estimated easily in some streams but not others. Similar constraints will probably apply to direct counts of adult spawners entering a watershed. It may be possible to perform near-census level habitat inventories in smaller watersheds, while larger areas will require EMAP-style random sampling. In some cases, IMWs may be located in the same areas with other long-term monitoring and research, increasing the type and extent of coordination issues.

It remains to be seen to what extent these and other problems will make direct comparisons between IMWs difficult or impossible. Without a clearly elucidated design template, however, useful comparisons across watersheds are almost guaranteed to be impossible. This is the motivation behind the PNAMP IMW design: to increase the odds that one can use results from a network of many IMWs in such a way that the sum of the combined results is more informative than the sum of the individual IMW analyses.

Addressing applicability – extrapolation of results

The PNAMP area is being classified based on physical and biological characteristics to enable identification of strata to aid prioritization of candidate IMW locations for implementation. However, it is possible that IMWs will be unable to be implemented in all identified strata. Extension of results from a limited number of IMWs to other watersheds cannot be accomplished by the traditional method of increasing the sample size (number of watersheds monitored) until a sufficient level of statistical certainty is achieved. The applicability of results will be determined using classification information based on similarity of physical and biological characteristics in relation to the watersheds included in the IMW network. Watersheds, which have biophysical characteristics and patterns of human activities comparable to IMWs, will be locations where IMW results can be extended with the greatest degree of certainty. A brief description of the classification analysis to be used in identifying candidate IMWs and extrapolating IMW results is found in Bilby et al. (2004).

The initial goal of the IMW extrapolation exercise is to classify and group watersheds with similar physical, biological and anthropogenic impact characteristics in relation to IMWs. Ultimately, the classification process will:

- support the extrapolation of expected results from restoration projects between monitored and non-monitored watersheds,
- inform the design and distribution of future restoration and monitoring projects, and
- support the interpolation of data across areas not monitored as intensively as the IMWs.

Briefly, to generate landscape classification schemes for this purpose requires choosing biophysical variables that capture most of the information pertinent to salmonid productivity. The choice of these variables is therefore critical to the success of this exercise. Variables will be chosen based on the current understanding of fish-habitat relationships available in the literature. The two main assumptions underlying this exercise are that the variables used are: (1) some of the most important determinants of the overall characteristic of a watershed, and (2) important determinants of salmonid population processes.

The basic list of variables currently thought to correlate to fish productivity includes climate, geology, watershed topology, vegetation, channel confinement and gradient, land-use/cover, ownership, and wetlands. In addition, recent work shows that channel size (e.g., drainage area

or some regionally calibrated estimate of discharge) and elevation are also important. A variety of studies have shown empirical correlations between fish numbers and these variables. It is feasible to simply seek correlations between the distribution (histograms, cumulative distributions) of these attributes and fish species and population sizes, which would allow extrapolation to other basins that lack monitoring data. However, it will also be useful to look at how these attributes affect fish directly, which may provide a more powerful means of extrapolation.

Ultimately each attribute included in the extrapolation process somehow affects aquatic habitat and these effects occur point by point through the channel network. Thus, it is the combined suite of variables at each point that is important. For example, the relationship of channel gradient and valley width for a reach is lost when the distribution for each variable is viewed independently. A measure of basin productivity requires a method of assessing the effects and interaction of all variables point by point and then aggregating that information over the basin. A number of recent examples of constructing similar geomorphically based watershed intrinsic potential metrics have been very useful for the management and recovery planning of listed anadromous salmonids.

Existing approaches to classifying landscapes for the purpose of managing and recovering anadromous salmonid populations have not included parallel assessments of immutable characteristics of watersheds and human land-use impacts on the watersheds. Therefore, to extend the current understanding of and approaches towards landscape classification specific to aquatic resources, similar methods must be applied to both the geomorphic and anthropogenic determinants of watershed intrinsic potential. Human activity over the past 100 years in the Pacific Northwest has dramatically altered the region's land- and waterscapes. As such, human activity has impacted the productive potential of most of the region's aquatic systems. In fact, some of the immutable factors used above to describe the inherent potential of aquatic systems have been changed by human activities (e.g., channel confinement, local climate). However, the primary mode by which human activities impact aquatic ecosystems is indirectly through land use practices (e.g., agriculture, urbanization). Therefore, any exercise to characterize broad scale patterns of aquatic productivity would be naïve to ignore the impacts of these activities. Thus, the effect of human activity on the landscape will be assessed through a parallel effort to develop a regional classification of watershed condition as a function solely of human activity. The potential list of human land use practices and activities that have the potential to alter relevant physical and biological processes will include: agricultural activities, forest practices, livestock activities, transportation, channel alteration, mining, urbanization.

Further IMW design development will identify the strata into which initial IMWs occur, explore the desired number of IMWs per targeted strata, and explore the implications of the extrapolation on implementation approaches.

Criteria for inclusion in the network

A number of policy and technical criteria will be used to delineate IMWs during implementation of the PNAMP network. In at least the near term, it will be important to identify and capitalize on opportunities in watersheds where there is an existing body of suitable scientific knowledge from which to address other criteria and design issues. Categories of policy criteria for which priorities may be identified include: cooperator support, species, type of ecological community, class of management action, geographic or political area(s) of concern, desired level of certainty or confidence in results, and costs. In its earliest phases, delineation of IMWs will tend to be opportunistic, whereas in subsequent phases candidates will be identified to fill gaps, through deliberate policy and technical analyses.

By definition, smolt and adult monitoring are essential for inclusion in the IMW network.

Moreover, drawing upon existing smolt and adult monitoring resources and programs will lower costs and shorten startup time. To the extent that the precision of the fish abundance estimates is known, much effort will be saved that would otherwise need to be expended in finding suitable locations, installing new traps and sampling schemes, and verifying the accuracy of the estimates. Issues related to differing scales of fish sampling will be resolved as part of experimental design development for each IMW.

Primary technical criteria include:

1. *Activities in the IMW can be controlled to the extent necessary to maintain the integrity of the experimental design throughout the life of the project.*
2. *Suitable control or reference streams exist to provide comparisons to the treatment stream(s) that will remain adequately unaffected by the restoration actions of management actions being evaluated.*
3. *The degree of certainty with which management/monitoring questions are to be answered is known or will be developed, affecting design, sampling frequency, and feasibility.*

Secondary technical criteria include:

1. *Size is sufficient to be able to detect significant changes in the context of the management scenario(s) (or treatments) being evaluated.*
2. *The desired time frame for study results is known.*
3. *Multiple, similar watersheds with contrasting land management are preferred. While true experimental 'control' watersheds may not be available, insight into the relative effects of different land management or habitat restoration strategies can be evaluated by comparing basins which are similar in all respects but the management scenario.*

In summary, the above criteria are recast below as initial policy and technical criteria to form the basis for inclusion in the IMW network over time.

The IMW network:

- a. shall capitalize to the extent possible on the pre-existing availability of suitable scientific knowledge
- b. shall have long term commitments to juvenile, outmigrant, and adult fish monitoring
- c. shall support important management questions of PNAMP members
- d. shall be distributed across areas/ecoregions, species, and categories of project and/or management activities consistent with (a)

- e. shall have sufficient type and duration of management actions for reliable implementation of long term experimental designs
- f. shall apply experimental designs with appropriate and viable controls
- g. shall have broad base of support in the locally affected area

Initial opportunities

A number of IMWs have been or are currently being planned for implementation and form the **first phase** of implementation of the PNAMP IMW strategy. These IMW efforts are intended to take advantage of existing opportunities, and include local support. The extent to which they meet all PNAMP criteria for inclusion as IMWs is being analyzed as part of Phase 1. This analysis will also include development and/or refinement of management hypotheses, monitoring questions, experimental design and implementation plans. Phase 1 IMW opportunities are identified in Table 1 with locations shown in Figure 2.

Appendix 1 provides more detail on individual IMWs.

Table 1. Phase 1 IMW network opportunities

Washington	Puget Sound: - Skagit River estuary - Straight of Juan de Fuca: Deep Creek, East and West Twin rivers - Hood Canal: Big Beef, Little Anderson, Seabeck, Stavis creeks
	Lower Columbia: Germany, Abernathy, Mill creeks
	Upper Columbia: - Wenatchee River: Nason, Peshastin, Chiwawa creeks - Entiat River (lower) - Methow River: Libby, Gold, Beaver creeks
	Snake: Tucannon River (potential)
Oregon	Coast: - Nehalem-Coos River area (6 basins) - East Fork and Upper Lobster creeks - Cummins and Tenmile creeks - Trask River
	Cascades: Hinkle Creek
	Lower Columbia: North Fork Scappoose
	Middle Columbia: - John Day River: upper Middle Fork and Lower South Fork
Idaho	Lemhi River in Salmon River drainage
California	Hollow Tree Creek in South Fork Eel River drainage

Based the information in Appendix 1, over 80% of the Phase 1 IMWs in Table 1 address species listed under the ESA. The remainder of the IMWs address many of these same ESA species but in areas that are not currently listed. Phase 1 IMWs are located in areas having a variety of land use types (Figure 3) and efforts will address management and monitoring questions associated with a range of management activities (Figure 4).

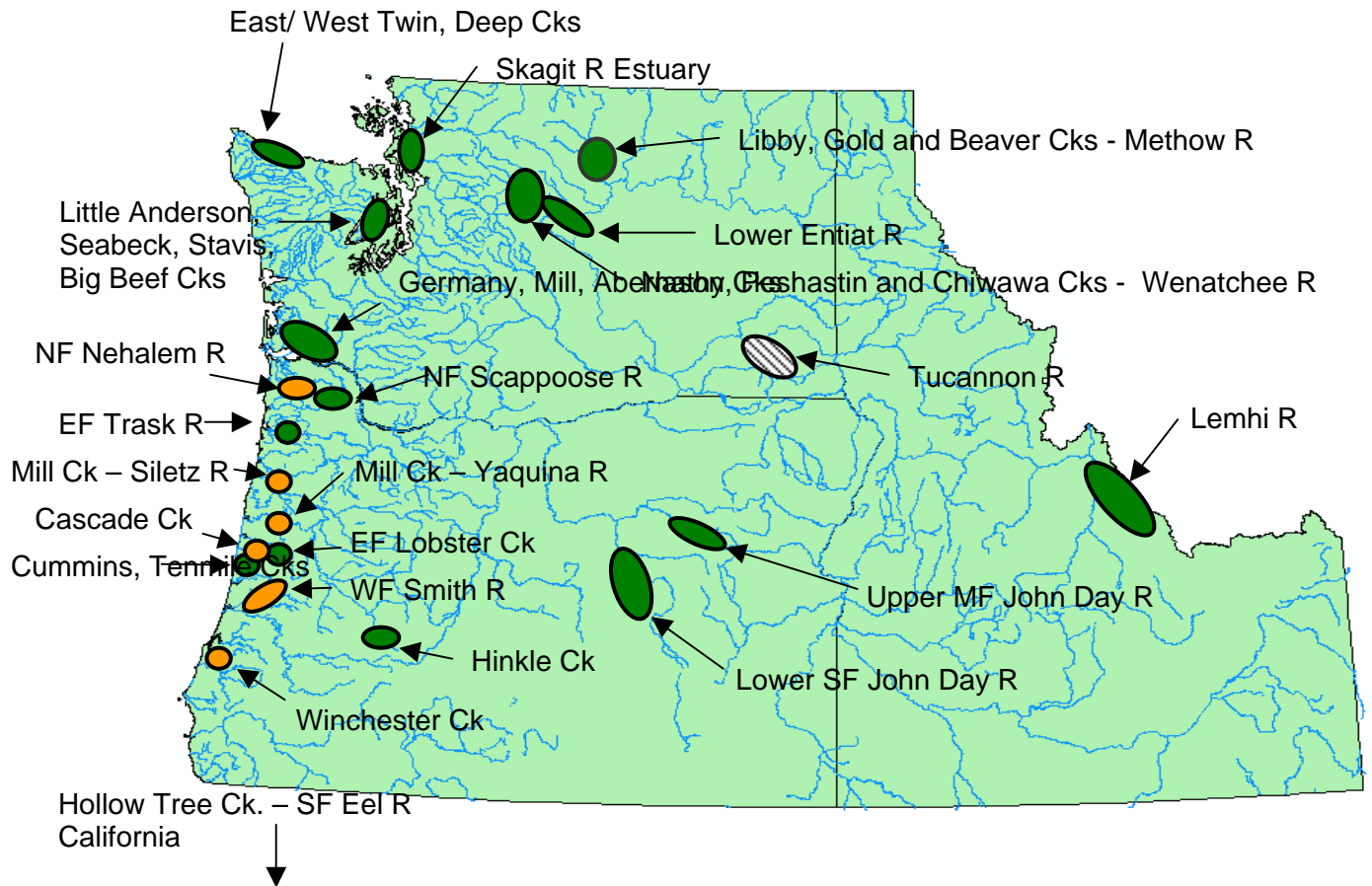


Figure 2. Map of watersheds in Phase 1 of the PNAMP IMW network described in Appendix 1. Locations shown with diagonal pattern are under consideration for inclusion in Phase 1.

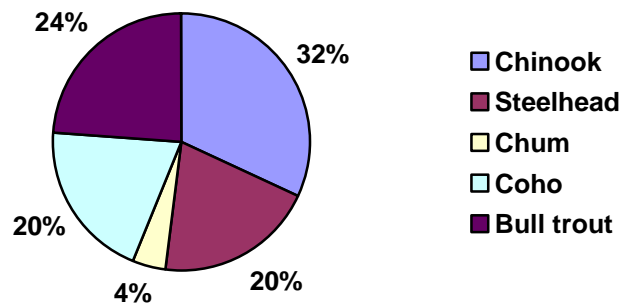


Figure 3. Distribution of ESA-listed species in Phase 1 IMWs.

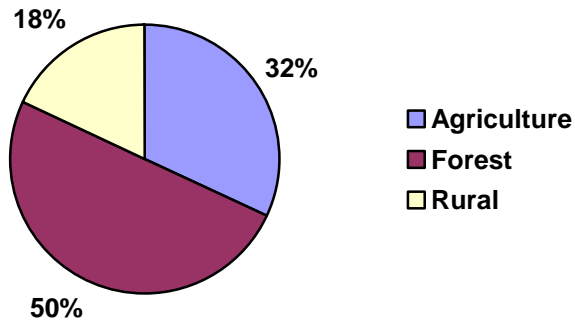


Figure 4. Land use types in Phase 1 IMWs.

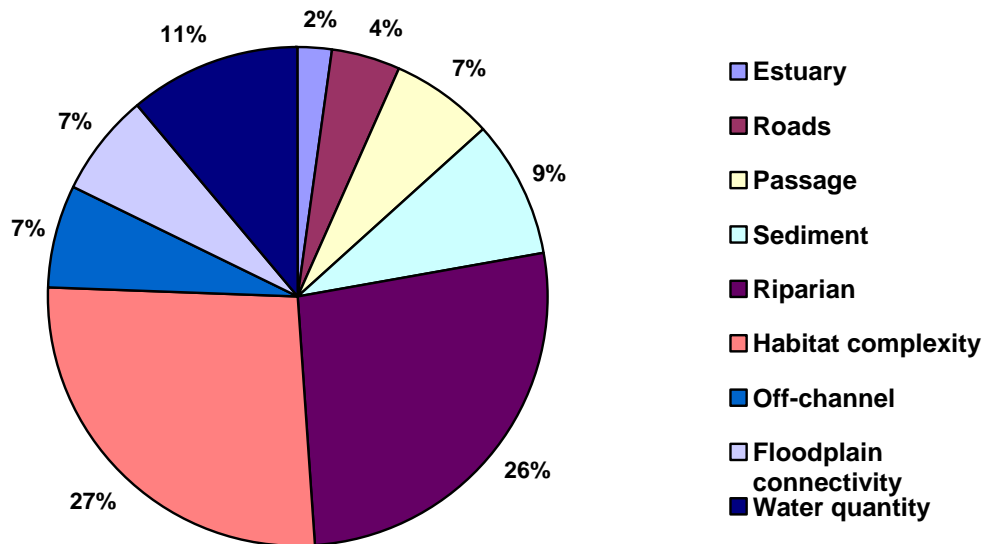


Figure 5. Habitat protection and restoration efforts addressed in Phase 1 IMWs.

Implementation Plan

The action plan outlined here identifies key tasks using a phased strategic approach. Implementing in phases will allow IMWs identified in initial work to be further reviewed and analyzed, and changes will be made to refinements or modify subsequent phases.

Phase 1: identify and evaluate initial IMWs guided by and in the context of stated policy and technical criteria and classification information

- describe initial IMW opportunities based on criteria
- stratify/classify PNAMP area
- review placement of initial IMWs in context of criteria and classification
- identify preliminary limits to extrapolation of results based on initial opportunities
- assess and review policy implications of Phase 1 IMW network with Executives

Phase 2: review/refine initial IMW selection criteria as needed, including changes in policy context, possible refinement of policy-relevant statistical and other criteria (e.g., number of IMWs per target strata; meta-design and analyses; timeframes)

- identify gaps in coverage consistent with refined criteria
- identify and prioritize candidates to address gaps
- perform scoping or feasibility analyses, etc as needed
- identify final IMW priority candidates
- identify work needs for subsequent phases
- assess and review policy implications of Phase 2 IMW work with Executives

Phase 1 and beyond: (ongoing implementation and integration of IMW products)

- support development and refinement of experimental designs for individual IMW efforts
- support development of cross-network design guidance and implementation
- identify/expand collaborators and partners
- identify technical and policy gaps in implementation of current and/or new IMWs
- identify funding needs and assist development of funding strategies
- bring policy issues to the attention of the PNAMP Steering Committee and Executive Network

PNAMP IMW products:

- Host annual IMW reviews (separately, or as part of larger PNAMP information exchange efforts) to (1) summarize progress, (2) identify key results, and (3) identify and address coordination issues within the PNAMP IMW network, and regarding other PNAMP activities (project effectiveness monitoring, status and trend monitoring, etc). This may include coordination those performing focused studies in watersheds outside the PNAMP IMW network.
- PNAMP IMW Implementation Reports

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Appendix 1. Overview of the Phase 1 Intensively Monitored Watershed network

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Washington	Puget Sound: Northern (WRIA 3: Lower Skagit)	Skagit River estuary	Chinook*	Chinook smolt counts upstream of estuary. Adult Chinook	Project scale (10-100s ha) experiments planned. Evaluate the relative frequency, spatial distribution, growth, and survival of identified life history strategies as a function of estuary restoration.	Estuary restoration, including dike removal, and restoring distributional channels within the estuary	Agriculture and hydrological modifications to the estuary	Phase 1 funding (2003-04) from SRFB to WA Depts of Ecology, and Fish and Wildlife. Other partners include Weyco, NWFSC, EPA, UW, with local support from Skagit System Cooperative, Skagit Watershed Council Lead PNAMP contact: Bill Ehinger (WA Dept of Ecology)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Washington	Puget Sound: Eastern Hood Canal (WRIA 15 – Kitsap)	Big Beef, Little Anderson, Seabeck, and Stavis creeks; all drain directly into saltwater	coho steelhead cutthroat fall chum summer chum*	WDFW: coho, steelhead, and cutthroat production measured annually since 1978 in Big Beef, 1992 in Anderson, and 1993 in Seabeck and Stavis creeks Adult coho, chum, and Chinook trapped since 1976 in Big Beef Creek Coho and chum spawner surveys conducted in some but not all years	Small: 3,000 to 9,000 acres Paired control and treatment streams	Big Beef Creek: Reservoir rehabilitation, control sediment delivery/routing, temperature, low summer discharge, habitat complexity L Anderson Creek: Habitat complexity, sediment routing, water delivery/routing, off-channel habitat, LWD Seabeck Creek: Low summer discharge, sediment routing, habitat complexity Stavis Creek: Control All to monitor the effectiveness of land-use regulations and forestry rules	Mix of forest and residential development FPB Watershed Analysis (1998) Kitsap Refugia Study (2003) Mass wasting, erosion High/low flows exacerbated by development and forest practices	Phase 1 funding (2003-04) from SRFB to WA Depts of Ecology, and Fish and Wildlife. Other partners include Weyco, NWFSC, EPA, UW, with local support from Hood Canal Coordinating Council Technical Committee, Kitsap County, and the Hood Canal Salmon Enhancement Group Lead PNAMP contact: Bill Ehinger (WA Dept of Ecology)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Washington	Coast: (Strait of Juan de Fuca) (WRIA 19–Lyre/Hoko)	Deep Creek, and East Twin and West Twin rivers; all drain directly into saltwater	coho steelhead cutthroat chum	Lower Elwha Klallam Tribe and WDFW	Small Paired control and treatment streams	Passage, road improvements, large wood, riparian plantings, off-channel habitat creation	Mix of private, state and federal forest. Watershed analyses are available. Watersheds are recovering from past forest practices.	Funding through EPA (RARE grant). Also includes Phase 1 funding (2003-04) from SRFB to WA Depts of Ecology, and Fish and Wildlife. Other partners include Weyco, NWFSC, EPA, Lower Elwha Klallam Tribe. Lead PNAMP contact: Bill Ehinger (WA Dept of Ecology)
Washington	Lower Columbia (WRIA 25 - Grays – Elochoman)	Germany, Abernathy, and Mill creeks; all drain into the lower Columbia River estuary	steelhead coho cutthroat	WDFW: Juvenile steelhead, coho and cutthroat production annually measured since 2001 Adult enumeration options are being explored for Abernathy Creek	Small to medium: 14,000 to 19,000 acres Paired control and treatment streams	The following were derived from a LCFRB initiated EDT analysis: Delivery and routing of water and sediment, riparian management, LWD, temperature, channel stability/complexity, floodplain connectivity Intend to validate hypotheses and site potential projects through habitat surveys in 2004	Forest Private and state timber lands with some agriculture in lower reaches State limiting factors analysis (2002) Riparian condition, large wood, pools, floodplain connectivity	Phase 1 funding (2003-04) from SRFB to WA Depts of Ecology, and Fish and Wildlife. Other partners include Weyco, NWFSC, EPA, with local support from Lower Columbia Fish Recovery Board Technical Advisory Committee and the Wahkiakum Conservation District Lead PNAMP contact: Bill Ehinger (WA Dept of Ecology)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Washington	Upper Columbia Region (WRIA 45 - Wenatchee)	Nason, Peshastin and Chiwawa Creeks - Wenatchee River system; drains into Columbia River mainstem	Chinook* steelhead* bull trout* westslope cutthroat Pacific lamprey sockeye	Adult and juvenile counts WDFW USFWS Chelan PUD YN USFS	Large Multiple “independent” watersheds w/differing levels of impact	Road decommissioning, water quantity, water quality, off-channel habitat, floodplain and riparian restoration, passage obstructions Protection of ecosystems in the upper basin (e.g., White, Little Wenatchee, Chiwawa)	Forestry in upper watershed, agriculture in lower Roads, culverts, diversions Habitat overall in reasonably good shape in the upper portions of the basin	BPA funding as part of the FCRPS BiOp pilot RME projects. Other partners include Upper Columbia Fish Recovery Board Regional Technical Team (state, federal, tribal members and contractors), and PUDS through HCPs Lead PNAMP contact: Chris Jordan (NWFSC)
Washington	Upper Columbia Region (WRIA - 46 Entiat)	Lower Entiat River; drains into Columbia mainstem	steelhead* Chinook* bull trout*	Adult and juvenile WDFW USFWS	Medium Single unreplicated treatment with control reaches	Habitat complexity restoration (off channel and in-channel)	Agriculture Rural development Channel confinement and simplification	BPA funding as part of FCRPS BiOp pilot RME projects. WA SRFB Other partners include Upper Columbia Fish Recovery Board Regional Technical Team (state, federal, tribal members and contractors). Lead PNAMP contact: Chris Jordan (NWFSC)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Washington	Upper Columbia Region (WRIA - 48 Methow)	Libby, Gold and Beaver Creeks – Methow River system; drains into Columbia mainstem	steelhead* Chinook* bull trout*	Adult and juvenile WDFW USFWS USFS Douglas PUD YN	Small Multiple projects	Habitat access modification (push up dam replacement)	Agriculture Rural development Water withdrawal structures	US Bureau of Reclamation Lead PNAMP contact: Chris Jordan (NWFSC)
Washington	Snake	Tucannon River	Spring and fall Chinook* Bull trout* steelhead*	WDFW via LSRCP	Under examination	Floodplain and channel function Riparian Instream habitat Upland sediment	Forestry in upper watershed; Dryland farming in uplands; Irrigated agriculture in bottomlands	Lower Snake River Compensation Program funding as part of a Lower Snake mitigation program. WDFW leads monitoring efforts. Local Lead: Mark Schuck Lead PNAMP contact: Chris Jordan (NWFSC)
Oregon	Lower Columbia	NF Scappoose	coho cutthroat steelhead	Adult and smolt trapping since 1998	Medium Potential? yes IMW basins at appropriate scales being identified	Riparian, instream	Forest, rural residential Habitat complexity	Funded by ODFW, OWEB Other support from USFWS Lead PNAMP contact: Jeff Rodgers (ODFW)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Oregon	Coast	<p>“Life Cycle Monitoring” from Nehalem River to Coos River:</p> <p>NF Nehalem R</p> <p>Mill Creek (Siletz R)</p> <p>Mill Creek (Yaquina R)</p> <p>Cascade Ck (Alsea R)</p> <p>WF Smith R (Smith/Umpqua)</p> <p>Winchester Ck (South Slough-Coos Bay)</p>	coho* cutthroat steelhead	Adult and smolt trapping since 1998	<p>Small to medium</p> <p>Potential? yes</p> <p>IMW basins at appropriate scales being identified</p>	Riparian, instream	<p>Forest</p> <p>Habitat complexity</p>	<p>ODFW and OWEB funding</p> <p>Other cooperators: private timber, State forest, USFS, USFWS</p> <p>Lead PNAMP contact: Jeff Rodgers (ODFW)</p>
Oregon	Coast	EF and Upper Lobster Creek	coho* cutthroat steelhead	Smolt trapping and adult spawning surveys since 1988	<p>Small</p> <p>Potential? Yes</p> <p>IMW basins at appropriate scales being identified</p>	Riparian, instream	<p>Forest</p> <p>Habitat complexity</p>	<p>BLM funding</p> <p>Other partners: ODFW, USFWS</p> <p>Lead PNAMP contact: Jeff Rodgers (ODFW)</p>

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Oregon	Coast	Cummins and Tenmile Creeks	coho* cutthroat steelhead	Smolt trapping since 1991	Small, medium Potential? Yes IMW basins at appropriate scales being identified	Riparian, instream	Forest Habitat complexity	ODFW funding Other cooperators: USFS, USFWS Lead PNAMP contact: Jeff Rodgers (ODFW)
Oregon	Coast	Trask River: EF or the SF	coho*	Smolt trapping since fall 2004	Medium Currently evaluating potential for paired watersheds in the headwaters	Riparian protection State and private forest management strategies	Forest Habitat complexity	ODF and ODFW funding Lead PNAMP contact: Liz Dent (ODF)
Oregon	Cascades	Hinkle Creek	cutthroat steelhead	Adult and juvenile sampling since 2001	Small/medium Paired control and treatment watersheds	Riparian protection and management around small headwater streams; effects on aquatic habitat and biota	Forest	Private, state and federal funding on a biennial basis Partners include private forest landowners, multiple state agencies, counties, BLM Lead PNAMP contact: Liz Dent (ODF)

State	Region	Watershed or stream complex	Species – ESA listed species indicated by *	Adult and smolt counting (past/present)	Scale(s) and potential for controlled experiments	Types of habitat protection/restoration problems (hypotheses) to be addressed	General land use, predominant limiting factors to salmon	Funding status, sponsors, cooperators, and lead PNAMP contact
Oregon	Middle Columbia	Upper MF and Lower SF of the John Day River system; drains into Columbia River mainstem	Chinook* steelhead bull trout*	ODFW, CTWSR Long-term spawning indices for spring Chinook (almost census) and steelhead (sparse) Systematic EMAP juvenile and adult monitoring beginning	Large Multiple “independent” watersheds w/differing levels of impact IMW basins at appropriate scales being identified	Forestry practices (past), riparian vegetation restoration Intensive irrigation, flow augmentation Grazing Barrier removals or modifications Stream complexity	Ranching, with associated agriculture and water withdrawals. Summer rearing temperatures Winter survival due to poor summer conditions Sedimentation	BPA funding as part of the FCRPS BiOp draft RME plan. Bureau of Reclamation funding Cooperators: ODFW, NWFSC, OWEB Lead PNAMP contact: Chris Jordan (NWFSC)
Idaho	Central	Lemhi River in Salmon River drainage	steelhead* Chinook*	Adult and juveniles IDFG	Small, medium Single uncontrolled treatment, or multiple small watersheds	Water quantity and habitat connectivity issues addressed with managed hydrograph	Agriculture Water withdrawals	BPA funding as part of the FCRPS BiOp RME pilot projects. Lead PNAMP contact: Chris Jordan (NWFSC)
California	Northern	Hollow Tree Ck (SF Eel River)	Chinook* coho* steelhead*	Adult, juvenile and some smolt counts since 1980s	Small to medium; Potential: perhaps (private land)	Responses to upslope, riparian, and instream treatments	Forest Sediment, Habitat complexity	CDFG and private restoration funding: (no monitoring funds at this time) Lead PNAMP contact: Scott Downie (CDFG)

Appendix 2. Approach to design and implementation of IMWs

General guidance

Multiple experimental designs will be utilized in IMWs, depending upon the questions being addressed and the scale at which the assessment must be conducted. Analyses have been used to investigate the relationships between stream flow and smolt production and these analyses should also be used in IMW investigations to the extent possible. Many of the objectives of IMWs can be addressed by before-after/control-impact (BACI) experimental designs. This type of design enhances the ability to differentiate treatment responses from responses due to variations in weather or other factors not directly affected by the treatments.

The principal value of BACI in experimental design is in isolating the treatment from relevant spatial and temporal controls. However, BACI does not constitute a statistical test; it is but one element of experimental design. Other considerations for experimental design will include the details of the statistical test performed -- the "analysis design". For example, it is anticipated that habitat data collected in parallel with fish abundance data will be used to create sensitive tests of the effectiveness of restoration projects. This will likely result in the use of multivariate analyses of covariance to discriminate the more subtle and diverse impacts of projects. On the other hand, there may be situations where a straightforward t-test will be sufficient to discriminate the effect of habitat projects. These alternatives place different demands on the type and quantity of data collected, and consequently the design of the monitoring plan. In another example, if the inferences reached in the effectiveness evaluation of projects in a single IMW are to be extended to other watersheds rather than made only with respect to the IMW itself, then sample sites for treatments and controls may be chosen with a different criteria--resulting in different sites being selected. Clearly then, the choice of test will be dependant on the specific features of the question being asked and the characteristics of the system being evaluated. In this way the analysis design used once the data are collected places demands on data acquisition. From the previous example, if the analysis will depend on habitat data that is spatially and temporally correlated with the fish response data, then clearly sampling designs and protocols for habitat data must be identified that preserve temporal and spatial associations with the fish data. Thus, the diverse and strong relationship between the analysis design and the monitoring design must be appreciated at all steps in the development of a monitoring plan for IMWs. The vehicle for maintaining this association will be clear and complete articulation of the technical questions that the data collection is designed to address. The articulation of the question must include spatial and temporal scales, species of interest and all other features of the monitoring plan design, as will be outlined later in this appendix.

All approaches will benefit from:

- the evaluation of two or more basins in each IMW study complex.
- at least one basin that will serve as a reference site where no experimental treatments are implemented during the period of IMW work
- a calibration period prior to applying treatments is required to determine how the reference and treatment basins compare and establish stable and predictable relationships for the key response variables prior to any habitat manipulation. The length of time required to develop this baseline will vary among IMWs. The calibration period for sites with existing information on spawner abundance and

smolt output would be much shorter than for IMWs where these data have not been collected.

Treated and untreated sites can be paired at a multiple spatial scales within the IWM design, the scale dependent on the question being addressed. In fact, reference sites for some reach-level projects could be within the basin designated for treatment. These reference sites would consist of portions of the basin comparable in initial condition to the location where a restoration action is applied but where no habitat manipulation would occur during the period of evaluation. Questions that can be addressed at this finer scale include life-history specific biological responses or physical habitat responses to management actions. For evaluations of effects at the scale of the entire basin, a comparison with a nearby basin that is not undergoing treatment is required. Notably, **the IMW approach requires sufficient management discipline to ensure that reference sites remain untreated through the duration of study. This does not imply that any and all management activities in the reference watershed will compromise the integrity of the study. The validity of the study design will be maintained provided that the management activities not directly related to the restoration actions being evaluated are comparable at the reference and treated locations.** For example, the effectiveness of restoration actions can be evaluated in watersheds being actively managed for wood production provided that the type and intensity of forest management activities in the treated and reference watersheds are comparable.

Experimental treatments applied in the treated basins will vary depending upon their initial condition, the perceived factors limiting fish production, and the feasibility of applying treatments. The identification of the most effective treatments should be based on assessments of current conditions. Many IMWs will have had some type of watershed assessment already conducted (e.g., limiting factors analysis, Washington State watershed analysis, EDT). Working in conjunction with local watershed or sub-basin groups, these analyses will be used to identify the suite of habitat restoration efforts most likely to positively influence the salmon and trout production.

An example

Fundamental to the IWM approach is the establishment of a set of overarching objectives, which provide the context for the application of ecological restoration and to which individual projects and activities can easily be related. As the goal of most habitat restoration efforts for salmon and trout is to improve the survival of the fish through their entire period of freshwater residency, goals that relate to this outcome should be a component of the objectives. Individual restoration projects should collectively contribute to the attainment of the watershed level objectives. To determine whether this is occurring, projects applied at the reach scale should be nested within and related to the watershed-level objectives for habitat condition and fish populations. Such nesting creates an interconnectedness among projects that is critical to assessing the ultimate efficacy of the restoration effort.

Implementation of an IMW effort should begin with assessments of the current condition of the watersheds to be monitored. There are a number of tools that are appropriate for this task. The information generated by these assessments will indicate the factors that are likely limiting fish production in the watershed. For example, if the assessments identify a lack of large wood in the streams in the watershed, the hypothesis could be posed that lack of pool habitat is limiting available rearing space. An experiment to evaluate this hypothesis might involve deliberate addition of wood to channel segments

and measurement of the change in pool habitat and summer and winter rearing populations at these sites relative to populations at untreated reaches (reach-level evaluation). However, even if this analysis indicates an increase in the number of fish rearing at treated sites, it does not provide information about the effect that these projects have had on the overall productivity of the fish population. In order to determine whether the wood addition has actually changed system productivity, rather than simply attracted fish to the treated reach that would have reared elsewhere, measures of watershed-level productivity are required.

The specifics of the biological, physical and habitat attributes measured in an IWM effort will vary depending on the questions being addressed. It will take a number of fish generations to get definitive results about the effectiveness of habitat restoration. However, by implementing these evaluations with clear objectives, careful consideration of experimental and statistical design, disciplined adherence to the experimental constraints at the treatment and reference sites, and patience, results can be produced that will greatly improve our ability to promote salmon recovery.

To evaluate watershed-scale responses, the treatments (e.g., wood additions) need to be applied at enough locations so that a population response can be detected. If the initial hypothesis proves correct and rearing habitat does have a controlling influence on fish production in the watershed, the number of smolts produced or survival rate from egg-to-smolt should increase. The number of treatment sites required to detect a watershed-level response can be evaluated as wood-addition projects are successively implemented. Due to the expense and labor involved in wood additions to channels, application of treatments will occur over a period of years. Small increases in density of rearing fish at the reach level would indicate that watershed-scale responses would only be discernible when a large number of sites had been so treated. A very dramatic density response at the site level might suggest that changes in population should be measurable with treatment of fewer sites.

At a minimum, information on number of spawning adult fish and smolt output are required to evaluate watershed-level responses. Counting fences or weirs at the downstream end of a watershed provide the most accurate measure of adult salmon returning to spawn. This method is very accurate but labor intensive and provides no information about spawner distribution within the watershed. Counts of fish on the spawning grounds or mark-recapture estimates of spawning fish or carcasses conducted periodically during the time of spawning is not as accurate as counts at weirs in determining total number of fish but does provide data on distribution. The application of statistically valid techniques of reach selection and frequent, consistent surveys of each reach can improve the accuracy of estimates of spawner abundance.

Such a method has been developed and implemented on the Oregon coast for coho salmon. Smolts leaving the sampling area must be sampled using some type of trap. Typical trap types include fences or weirs that capture all smolts exiting the watershed (although fences may become inoperable at high flows), or scoop or screw traps that capture a portion of the fish. Partial sampling traps are easier to maintain and can be utilized in channels too large for fences. However, these types of sampling devices require frequent calibration to determine the proportion of smolts being captured. ***With adult and smolt data it is possible to calculate the survival of the fish from spawning through smolting. The objective of nearly all salmon habitat restoration efforts (although often unstated) is to increase this value. Therefore, regardless of the methods selected to measure adult salmon and smolt abundance, these***

measures are critical to any comprehensive effort to evaluate fish response to restoration and must be included at all IMW sites. Augmenting the smolt and spawner data with information on egg survival and the distribution, abundance and survival of juvenile salmon from emergence from the gravel through smolting can enable salmon response to individual restoration projects to be linked with response at the scale of the whole watershed. Capturing fish seasonally (spring, late summer, winter) by electrofishing, seining or trapping at multiple locations across the watershed would enable an estimate of fish distribution, abundance, growth rate, species, and age class composition. An alternative to capturing fish is a visual survey using an extensive sampling approach like Hankin-Reeves (Hankin and Reeves 1988) although this method does not provide information on fish species and size that is as accurate as methods that involve capturing fish, it is rapid and would enable sampling of the entire stream network in a sampled watershed. A combination of the two approaches, a complete survey coupled with subsamples at selected sites where the fish are captured and measured, would provide the most complete information. The method selected will depend on how critical the measurement is, the characteristics of the site, and the resources available to be dedicated to obtaining the measurement.

Differential tagging of salmon captured during the sampling of different stream reaches and subsequent capture at smolt traps could provide additional information on survival rates of fish rearing in different areas of the watershed and the effectiveness of individual restoration projects. Differences in survival among reaches or habitat types may provide an indication of key mortality factors operating in the river and aid in the identification of restoration efforts likely to have the greatest effect on salmon populations. There are numerous tagging technologies available. Passively induced transponder (PIT) tags, which are appropriate for larger fish (>70mm) have been used extensively on the Columbia River and enable individual identification of fish. Visible implant (VI) tags also can be used to identify individual fish although reading the tags is more difficult than with PIT tags. The injection of colored dyes or polymers into various transparent tissues of the fish enables determination of the location where a fish was tagged but cannot be used to identify individual fish. However, this type of tag may be very appropriate for addressing many of the questions related to restoration effectiveness.

The collection of data on fish populations must be coupled with information on the habitat attribute, habitat-forming watershed processes, and climatic conditions. As fish are very sensitive to variations in flow, temperature and other factors that might not be directly influenced by restoration treatments, interpretation of the fish data can be enhanced by the collection of this information. At a minimum, a recording flow gauge is required at the mouth of the reference and treatment watersheds. In addition, if some of the restoration efforts are attempting to alter flow patterns, secondary flow gauges should be installed at the locations where these efforts are undertaken. A weather station collecting data on precipitation and air temperature should be located near the downstream end of the watershed. Water temperature also should be recorded year round at each gauging station and at all sites where one of the purposes of a restoration action is to alter water temperature. Instruments to record flow, weather and water temperature information data have improved dramatically in the last decade and costs have decreased. Thus, costs are reasonable for installing this equipment. However, maintaining the instruments and the database are labor intensive.

Data on habitat can be collected concurrently with fish sampling. These data are especially important at sites where restoration projects will be implemented. Habitat

data can include physical characteristics of the channel (e.g., pools, riffles etc.), riparian area condition, levels of sediment deposited in pools and in spawning gravel, water quality (e.g., temperature, suspended sediment), nutrient levels and trophic productivity. The variables measured will depend on the objectives of the restoration actions. For example, projects designed to increase pool habitat will focus on the physical attributes of the channel while measures of nutrient levels and trophic production would be the most appropriate measures of a salmon carcass addition project.

Pre-treatment data should be collected for a period of one or two years. No treatments would be applied at any of the sites during this time. Pre-treatment data would be collected on sediment production and delivery, habitat conditions in the stream and fish populations. Treatments would commence in year 2 and could extend over a period of several years if the plan is to sequentially treat multiple tributary watersheds. Treatments might include reconfiguration of drainage systems to divert ditch flow onto the forest floor, paving bridge approaches and utilization of harder surfacing materials.

Assessments implemented at the reach level would focus on the effect of sediment-reduction efforts implemented at a single location on sediment production and input to the channel. These site-specific assessments would not be conducted at every project site. Several representative examples of each project type would be assessed. Sediment input can be assessed with periodic grab samples or pump samplers deployed above and below the treatment location. The corresponding habitat attribute of interest at this scale would be the level of fine sediment in gravel or the amount of sediment deposited in pools. Measurements of these attributes would be taken annually at the project site and at a reference site in an untreated tributary watershed.

There are numerous methods for determining fine sediment levels in streambed gravel. Residual pool depth or closely spaced cross sections at pools could be used to determine changes in pool volume. The only relevant biological attribute at this scale would be the survival of eggs in the gravel before and after implementation of the sediment reduction measures and how this value compares with a nearby, physically comparable but untreated reach. There are a number of methods for measuring egg survival.

Types of monitoring questions and responses at appropriate spatial scales.

<i>Scale</i>	<i>Response Type</i>		
	Physical	Habitat	Biological
Reach	Do individual treatments reduce sediment delivery to the channel?	Does reduction in sediment input correspond to a reduction in sediment in streambed gravel and/or a reduction in deposited sediment in pools immediately downstream from the project area?	Does a reduction in sediment in streambed gravel correspond to an increase in egg survival at the project site?
Tributary Watershed	Does the application of multiple treatments result in lower suspended sediment export at the mouth of the treated tributary?	Is there an increase in the volume of pools in the treated watershed?	Are there increases in the density of rearing juvenile salmon in the treated watershed?
Watershed	none	none	Is there an overall increase in the number of smolts produced or egg-to-smolt survival rate following application of treatments?

The next relevant spatial scale for this analysis is the tributary watershed. At this scale, a reduction in suspended sediment export at the mouth of the treated tributary would be the physical attribute most sensitive to the application of multiple sediment reduction treatments. Suspended sediment can be measured with grab samples or pump samplers at the downstream end of the tributary watershed. Changes in pool volume through time in the treated tributary watershed would be compared with changes in pool volume in a reference tributary watershed. Various survey techniques have been developed that are appropriate for extensive assessment of pool volume. Increased pool habitat and increased survival of eggs in the gravel should correspond to an increase in the abundance of rearing salmon in the treated tributary watershed. This response can be addressed by conducting an extensive survey of fish abundance (e.g., snorkel survey) in all areas supporting fish in the treated and reference tributary watersheds.

If sediment input to fish-bearing streams is truly a factor of consequence in determining the survival of salmon from spawning through smolting, an increase in smolt output should be detectable, provided that a sufficiently large area of the watershed is treated. Changes in smolt output would be judged relative to smolt production from a reference watershed. There are a number of ways to evaluate smolt response. Change in the total number of smolts produced per unit area or unit stream length from the watershed where the treatments were applied relative to a corresponding measure from the reference watershed is the most straightforward approach. With accurate counts of spawning adults, the smolt data can be used to generate estimates of egg-to-smolt survival. This measure may be more sensitive than simple smolt production as it does provide some ability to account for differences in the abundance of spawning adult salmon, which could be impacted by factors other than sediment levels. If sediment input was correctly identified as a factor limiting the production of salmon in the treated watershed, an increase in survival should become apparent as progressively larger areas of the watershed undergo treatment.

Comparable approaches could be used to assess other types of restoration projects. Regardless of the type of restoration approach being applied, treatments and assessments must be applied in integrated manner that allows biological and physical responses at each spatial scale to be connected.

Additional statistical and experimental design guidance

The following is adapted from the Washington Comprehensive Monitoring Strategy (IAC 2002).

The ability to draw inferences from IMWs depends on framing hypotheses as clearly as possible, with clearly defined controls and/or references, and collecting the data in a manner having the least possible uncertainty.

In general, an example principal hypothesis is: recovery action X will make fish response of life stage Y higher in area Z. In this case, “fish response” reflects fish characteristics, such as abundance, productivity, and diversity. A specific application is: use of agricultural diversion screens has increased the numbers of salmon yearlings in river Z. How much action is needed to test these hypotheses and to have confidence in the answer obtained? Alternatively, how much uncertainty can we tolerate?

To illustrate, how critical is it to detect a 5% change in a population within a 4-year period, 19 times out of 20? If that power of resolution is critically needed, then a corresponding level of effort can be calculated and applied, and its associated cost can be determined. These issues pertain to statistical power analysis, which involves knowing four critical things:

1. **Sample size** (if measurements can only be taken for four years, how many sites/projects need to be monitored?)
2. **Confidence** (can we afford to be wrong one time in 20? Can we tolerate being wrong half the time? Most of the time?)
3. **Variability** in the data (what is the reliability of the measurements we are making?)
4. **Effect size** (what difference do we need to see? $\pm 5\%$? $\pm 50\%$? $\pm 150\%$?)

All four of these parameters are interdependent: specifying any three of them affects the fourth. In reality, some parameters will be set by available resources, variability of the population, and other factors which will be out of the control of the parties conducting the monitoring.

If features of the analytical process are viewed as statistical planning tools, then both policy and science need to influence this process at different points to affect the implemented monitoring plan. For example, if it is going to take 125 years to see a small effect size (e.g., 5%) that may have been specified, the cost is likely to be prohibitive. On the other hand, if being “wrong” in population abundance monitoring is equivalent to extinction of the salmon we are trying to monitor, are we willing to be “wrong” half the time (i.e., confidence of 0.5)?

Articulation of testable hypotheses will involve identifying biological effects of the management action and appropriate controls. The hypothesis should also identify the geographic area of influence of the action. Further details of specific experimental design choices are presented in MacDonald et al. (1991) and Conquest and Ralph (1998).

Generic design planning questions

A significant challenge in implementing IMWs is balancing the different levels of technical expertise of those conducting the monitoring with the diversity of demands of monitoring to be performed across the range of management actions implemented and the environments that salmon occupy. Crafting a “cookbook” of specific IMW monitoring plans that contains recipes for every management action in each habitat type across the PNAMP area would be prohibitive. Outlined below is an approach that if followed, will result in custom-made adequate IMW monitoring plans. Importantly, this will generate data that is useful both within the context of individual recovery actions, and also in the context of broader (i.e., regional, cross-regional) comparisons within classes of recovery actions.

Those developing IMW plans should address the generic technical questions below. If these questions were collectively answered adequately, a high degree of confidence would exist that the IMW monitoring plan would produce useful results. It is particularly important to evaluate the sources of uncertainty in IMW plans to maximize the probability that data from various IMWs can be usefully compared, and classes of recovery management actions identified.

Generic scientific questions that address issues common to all actions:

1. What are the scientific questions that are framed by the management action(s)?
2. What are the management questions?
3. What is the hypothesis(es) to be tested? (If the hypothesis is explicit it is easier to evaluate the choice of controls and indicators.)
4. What are the controls?
5. What is being measured?
6. Are measures primary or correlated indicators, and how does the measurement being made relate to the specific question?
7. What are the connection between what is being measured and the biological result that is desired? This is another way of defining the assumptions implicit in the choice of monitoring strategies—for example, are you measuring actual fish numbers, or a surrogate figure such as carcasses or redds?
8. Explicitly, what are the assumptions of the monitoring plan?
9. What is the spatial area of effect of the management action? Is the extent of the area incorporated into the monitoring plan? How? If not, why?
10. Are inferences from this IMW intended to be extended to other watersheds, or are inferences intended for the IMW only?
11. How long into the future is the need for updated answers?
12. Are the consequences of being wrong or failing to fully examine a hypothesis understood?

Variability:

1. What is the measurement error of the technique used to make the measurement?
2. What is the net accuracy of the measurement technique, sampling design, and experimental design?
3. What is the net precision/variability of the measurement technique, sampling design, and experimental design?
4. To what degree is the data collected spatially explicit?
5. What is the largest and smallest spatial scale over which the data are expected to vary?
6. What is the largest and smallest temporal scale of which the data are expected to vary?
7. What level of statistical power is desired? In other words, what level of biological response (fish numbers, growth rate, diversity, etc.) is desired, and, given the obtainable accuracy and precision of our measurements, how long must one monitor to obtain this level of result?

Effect size:

1. How have estimates of historic fish densities or possible carrying capacity been addressed?
2. Does the program monitor year-round, seasonally, or just for a few weeks in a particular season(s)?
3. If it is presumed that the action is expected to result in $\mu > 0.0$, what value of μ is required? Is this answer based on biology, or based on politics? Was this value arbitrarily determined?
4. Do you know beforehand how precise you need to be about estimating μ ?
5. What technique was used to calculate μ ? Why was that technique chosen?

Sample size:

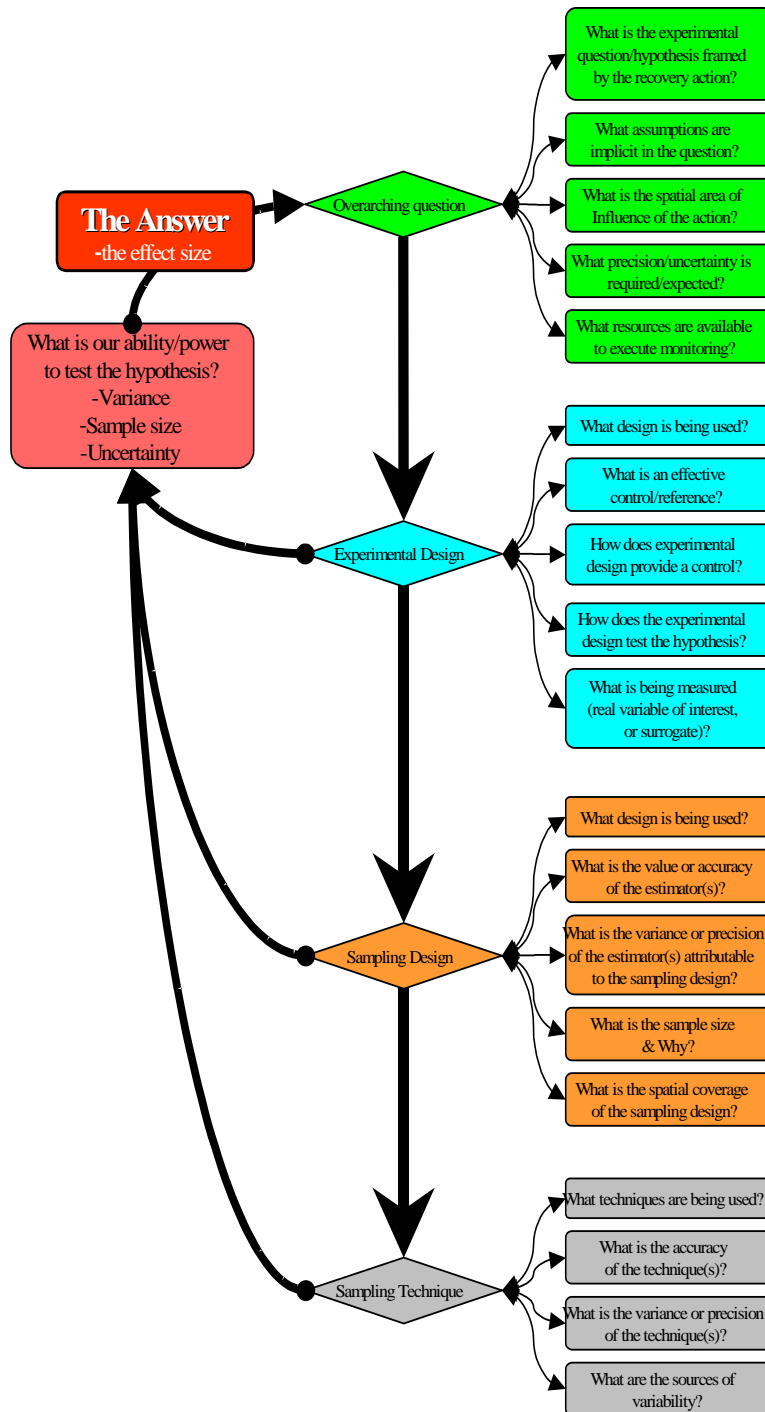
1. How does the duration of the monitoring correlate with the generation period of the salmonids affected by the management action?
2. What technique was used to determine sample size?
3. What set of protocols were used that will lead to cost savings?
4. Is there an historic/legacy data set being used, continuity with which needs to be preserved?

Confidence:

1. What level of confidence is being used?
2. How was this value derived?
3. What are the implications or consequences of being wrong?

Fish ecology questions:

1. What is the fish response to the management action?
2. What species and life stages use the affected area?
3. What is the change in salmonid egg-fry survival with the action?
4. What is the change in salmonid fry-smolt survival with the action?
5. Are there changes in juvenile salmonid density with the action?
6. Which life-history change shows the largest response to the action?
7. Are there changes in non-salmonid densities with the action?



The Pacific Northwest Aquatic Monitoring Partnership (PNAMP)
Fish Population Monitoring Workgroup



Summary Report from the January 12, 2005

Monitoring and Evaluation Practitioners Workshop

*Jointly sponsored by the PNAMP Fish Population Monitoring Work Group
and the Upper Columbia Regional Technical Team*

Executive Summary

On January 12, 2005, a group of fifty resource managers, scientists, and monitoring field practitioners met in Wenatchee Washington to discuss monitoring efforts taking place in the Pacific Northwest. The workshop-style meeting was designed to initiate a regional discussion on “what’s working, and what’s not” with respect to field *implementation* of standardized approaches to monitoring and evaluation for aquatic populations.

Summarized elements from this workshop are provided in this report and are intended for those tasked with improving monitoring design, protocols, and methods, and importantly, for guiding efforts directed at improving communication and coordination between and among M&E practitioners and planners.

The consensus of the workshop group was that this meeting was useful and yielded valuable insights into how technical and policy monitoring issues are currently being managed. The group also indicated that annual (or semi-annual) meetings/symposia of this type would be beneficial. To this end, a feedback form has been distributed to the group soliciting input on what scope, venue and approach is best suited to continue the dialogue and work initiated at this workshop.

Workshop Structure

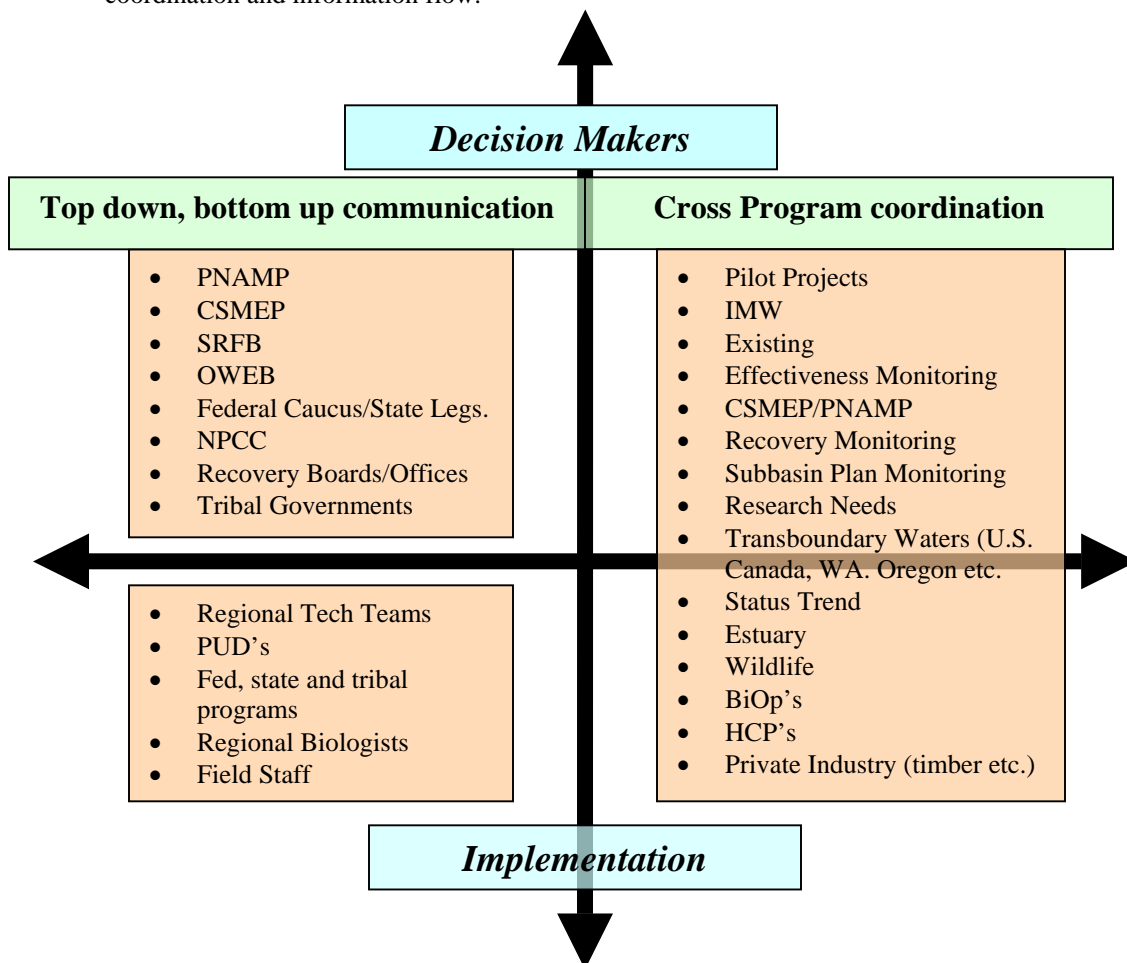
While it was the *Fish Population Workgroup* of PNAMP that sponsored this meeting (in conjunction with the Upper Columbia Regional Technical Team), technical issues (questions and challenges) spanning both biological and physical indicators, variables, analysis and design elements were discussed with a high level of information and idea sharing.

Generally, the group gravitated towards four themes/findings:

1. There is a need for improved communications pathways between and among M&E practitioners (cross-program and top-down, bottom up—see figure 1.),
2. Many technical issues remain unresolved. Sustained and detailed discussions aimed at solving persistent questions are necessary.
3. Broad input, participation and deliberation are required to reach a high level of understanding and consensus as new designs are proposed.
4. There are underexploited opportunities for promoting cost-effective implementation, data sharing and management and reporting to decision makers.

The workshop group included field staff at the implementation level, M&E developers at the design level, and decision-makers at the mid-policy level.

Figure 1. Cross Program and Top Down, Bottom Up Coordination and Communication. (bullets are example organizations and programs only). Goal of integrated decision-making is made more difficult and error bound without implementation of a model that *integrates* the coordination and information flow.



The specific goals of the workshop were:

1. Share retrospective information from the 2004 field season with an eye towards increased science rigor, efficiency and standardization of efforts and approaches.
2. Review on-the-ground implementation results and elicit input on how to improve coordination across regional monitoring efforts.
3. For the future: Inaugurate a recurrent process for cross-program coordination and multi-level M&E discussions (local levels and broader coordination processes).
4. Identify near and long-term coordination needs and devise an action strategy to address those needs.

This report intends to provide products for use by the participants, the PNAMP steering committee and others involved in development of M&E programs in the Pacific Northwest. This report contains:

- Final Agenda (attachment 1)
- Summary of Presentations
- Contact information for all attendees (attachment 2)
- Summary of technical issues and contemporaneous input
- Post workshop email comments/questions
- A feedback form for participants with results due in March 2005 (attachment 3)

Presentation Summary

Dr. Tracy Hillman, BioAnalysts, Inc., Upper Columbia Monitoring Strategy

Tracy Hillman presented about the Upper Columbia Monitoring Strategy. Many of the plan authors were present and provided input into the development of this regional strategy that encompasses the Upper Columbia ESU. Updates to this plan are envisioned as results from the Okanogan, Methow, Entiat and Wenatchee programs progress and specifically as the Upper Columbia Salmon and Steelhead Recovery Plan strives to identify “recovery” criteria.

The Upper Columbia Strategy addresses status and trends monitoring as well as effectiveness monitoring of selected projects in the region. The strategy incorporates a rotating panel design, with one panel of projects sampled every year and other panels sampled on rotating schedules. The site selection uses the EMAP based Generalized Random Tessellation Sampling (GRTS) with 100 percent over sample to allow for 50 percent of the sites not to be viable and still retain an adequate sample size.

Sites are selected to address two sampling universes – 1)Habitat and fish – includes the entire watershed stratified based on gradient; 2) Steelhead spawning universe does not sample in high gradient areas, but does sample above barriers.

The effort involves both classification of the areas in the basin by geomorphic and stream class as well as measurement of physical and biological elements across the basin. The classification element of the project is complete. Several physical and biological indicators are measured including several life stages (adults, redds, juveniles) of salmonids, macroinvertebrates, instream habitat parameters, and land use variables. Protocols for monitoring these indicators were selected from published documents that provided precise and accurate measurements were feasible, and affordable. One of the goals is to test for relationships among and between indicators in four ways 1) relationship among physical indicators, 2) relationships among biological indicators, 3) relationships between physical and biological indicators, and 4) relationships between classifications and physical and biological indicators.

Mike Ward of Terraqua Inc. is working on the report for the Wenatchee effort. Each agency involved may also produce a separate report.

Paul Wagner from KWA Ecological Sciences, Inc. asked specific questions about water quality testing in the strategy. In the Wenatchee, temperature is measured at the EMAP sites, but other continuous water quality measurements are taken at the mouths of the major waterways in the basin.

Bruce Crawford asked about targets in the basin to compare the data to. Tracy noted that some of the EMAP sites were in pristine areas of the basin and could serve as reference sites. Also, that the indicators he is using can be compared to the NOAA Properly Functioning Conditions ratings.

The data collected in the Strategy can be used as baseline for effectiveness monitoring work and data is available for pre-treatment information for other groups.

Keith Wolf from KWA Ecological Sciences, Inc. identified as a goal to create a template Memorandum of Understanding for data sharing and publication rights to help facilitate a higher level of data and analysis sharing.

Andrew Murdoch of WDFW asked about teasing out the impacts of hatchery programs, especially with respect to recovery planning. Tracy suggested using marking and/or genetic testing to determine impacts. He noted that native stock in hatcheries are part of the recovery process and these effects would need to be separated from natural spawning to really determine the impacts.

This program allows specific research questions to be separated out and addressed by either the status and trends efforts or the effectiveness efforts. Chelan PUD, WDFW, USFWS, DOE, and the Yakima Nation are all monitoring in the Wenatchee Basin. These efforts require and would benefit from interagency coordination.

This strategy was originally set up as a five-year program, but funding may be extended until the data indicate the direction that should be taken for restoration efforts in the Wenatchee Basin.

There are currently three NOAA pilot projects: Wenatchee, Salmon River, and an estuary program. There is likely to be expansion to other areas and coordination of information would occur through PNAMP.

Keith also mentioned the data inventory process conducted by Dick O’Conner, Paul Wagner and Pete Hahn to catalogue metadata and make it available as a web-based tool through the CSMEP process and the PNAMP effort to catalogue monitoring efforts across the PNW.

Glenn Merritt – WA Department of Ecology, Wenatchee Basin Pilot Project

This effort is the field test of the Upper Columbia Monitoring Strategy. It uses an EMAP site layout based on a reach length of 20 times bankfull width. Issues that came up during the monitoring are listed below:

- LWD Tally – size classes may not match across monitoring programs (e.g. USFS) (John A. mentioned that in the Okanogan the LWD size classes were based on break points along what other protocols are doing (e.g. 30 cm as a break point in both programs, and in EDT – allows data to be compared.)
- Pool Tally – Required pools to be at least as long as wide, with a max depth 1.5 times the crest depth. Shallow pools met these requirements, but it was questions as to whether they are biologically meaningful as pools.
- Off-channel Habitat – what is the cut-off size for counting?
- Habitat codes – different than those used in EMAP, four classes of fast/slow water.
- Invertebrates – need to establish a standard level of taxonomic ID. Check with the Xerces Society- Jeff Adams for standards. The targeted riffle approach with a kick net sample of 8 square feet was used. Gretchen Hayslip (EPA) also helps to coordinate invertebrate sampling across the region for the level of identification and metrics. There was discussion of the diagnostic uses of invertebrates and how they could be used to detect water quality or sediment problems. May be able to replace some of the other measurements at some point.
- Gradient – used a hand level for these measurements. Should bring two of these and a clinometer as a backup into the field.
- Dominant substrate – in bankfull width, part of the transect is bordering on terrestrial habitat which may not reflect channel conditions.
- Embeddedness – sand intermingled with moss was often misidentified. (sand vs. hardpan). Deep particles that were large presented problems for estimating embeddedness.
- Wetted width – make sure you are perpendicular to the stream.
- Flood prone width – needed for Rosgen classification. Not possible to measure on large rivers. Used map derived numbers on larger system.

- Canopy cover – Densiometer is what most are using. Some prefer Solar Pathfinder. Tough to standardize this measurement. Lots of discussion and definitions to try to calibrate these estimates.
- Bank stability – more instability noted above bankfull level
- Human disturbance – trails were classed as roads. May need to add a trails category.

Resampling was done at 10 % of the sites for QA/QC. Paul Wagner mentioned that QA/QC was a concern for many programs. What level of difference is cause for concern? What would be the corrective action? Sharing crew members between teams was mentioned as a helpful strategy.

John Arterburn (Colville Tribes Fish and Wildlife Department) and Paul Wagner (KWA)– Okanogan Basin Monitoring

John discussed site selection and the rule the Okanogan team has applied to make the EPA site selection more focused. Rules are listed below:

1. No sites outside historic anadromous zone.
2. No sites above barriers that are likely to be in place for the next 10 years.
3. No sites with low (natural?) discharge (no 1st order streams)
4. No irrigation channels
5. No lakes in U.S. (Canadian sites in Okanogan will sample lakes).

Still need to evaluate sites in the field. May use EDT reaches for stratification in the future.

Okanogan has a field manual with data definitions, protocols and methods for crew training. Existing sources were used for these definitions and then refined in the field. John asked for feedback on the definitions from the group as far as whether they are clear or should be improved.

Indicator issues are identified below:

- Riparian Vegetaion – subjective and very difficult to train staff. Also used riparian widths as a quantifiable measure of vegetation that was not as subjective. However, need to define riparian to accurately measure the width.
- Used EDT classifications for habitat codes as they were more detailed and could likely be rolled up. Had to develop definitions for these.

Bruce Crawford – Monitoring in Washington State

Data pyramid shows the large number of field practitioners vs. the small number of executives making funding decisions on monitoring. Need accountability for spending if funding is going to continue.

Data collected on federal lands does not get into the State of the Salmon Report and would contribute to the overall picture. PNAMP is working on comparing the data dictionaries from the various programs and decide on names and definitions for a core set of variables. Two focus areas for these efforts 1) large scale status-trend information

(How are things in the region?) 2) Local management – where are the local problems and what needs to be fixed first? There are large costs for fine scale monitoring efforts.

Don't need the state to fund status and trend monitoring in areas where it is already being done (Wenatchee, etc.)

VSP parameters may not all be addressed (genetics) but the other three are likely to be addressed by EMAP monitoring.

Greg Volkhardt – Intensively Monitored Watersheds

One of the main questions for this effort is to address is fish production/productivity improving? Looking for population level changes from land management practices.

Three complexes identified for the effort (Strait of Juan de Fuca, Hood Canal, and Lower Columbia). Also Skagit and Wenatchee by different groups.

BACI on a watershed scale for small watersheds. Before/After for large watersheds. Project scale monitoring will also be done using a BACI design and will focus on lifestages believed to be affected by the project.

!0 total watersheds to be sampled. Flow, turbidity, and temp monitored at 10 locations. One climate station per complex. Monthly water quality monitoring. Reference points established at 100 m intervals over the anadromous zones; stratified by EDT or SSHIAP. These points allow for orientation on the stream and would include waypoints, photos, bankfull and wetted widths, substrate class, Montgomery-Buffington and Rosgen classifications, and channel confinement. Also notes would be made on any problems or restoration opportunities. Gradient was measured, but may switch to LIDAR for this (like in the Okanogan).

Riparian Assessment was done using methods from T. O'Neil as described in Johnson et al. 2003. (Habitat Relationships). Hankin and Reeves assessments were conducted basin wide to identify limiting factors. Planned for first year. Would only be repeated after major events.

Annual sampling using EMAP.

Fish abundance looking at eggs, parr, juveniles, smolts, and adults at the watershed scale. Adults are measured through weir counts, mark recapture, and redd count expansions from weekly spawner counts at high probability sites. Smolt to adult ratios are calculated and marine survival is expected to be the same for a given complex. Egg deposition is calculated from escapement x fecundity. Parr are collected during the summer using electrofishing at EMAP reaches. Fish are ad-clipped or tagged. Resampled as juveniles to get survival. Electrofishing was single pass with some three-pass for calibration. Would coordinate with USFWS in the Lower Columbia on electrofishing. Smolts monitored using variety of traps and wiers. Screw and scoop traps were shown to have different selectivities so both are used.

Number of sites per watershed reduced from 30 to 10 based on feasibility. Habitat unit element dropped from Hankin and Reeves as it will be picked up in EMAP. Continue with reference points and log jam monitoring.

R.D. Nelle – Bull Trout Monitoring

Bull trout redd surveys discussed. Do Index sites represent the watershed? Do we need more frequent surveys for better redd ID in areas where more than one species are spawning? Redd surveys are more difficult for resident populations. Confidence ratings are given for bull trout redds. For “Probable” redds, these could be addressed by surveying the spawning areas before the fish come in to not hydraulic disturbance. Coordination would also help.

Bull trout telemetry was also done. May need to change antenna design as it was thought to be getting caught. Rotary screw trap on Entiat and Peshastin Creek – may not be able to detect peak in spawning run due to low numbers. Sub-adults not trapped well. Snorkel surveys are being used, but precision is uncertain in larger systems. May need to adjust protocol.

Discussion

Work on the Payette NF has shown Wolman Counts to be very successful.

Main drivers for fish response are wood, pools, riparian vegetation and substrate. These are the hardest to get at with monitoring. These elements should be important parts of the protocol testing effort by Steve Lanigan.

Sample size – do we know if 50 sites is enough? Should be easy to tell if 50 is too many, but harder to tell if we need more. Power analyses should be able to tell us more. This could be done using existing data.

Detailed Group Discussion Notes (use for review at future meetings and PNAMP general discussion on “topics.”

1. Specific Indicators that require clarification or standardization

- LWD Tally and size classes
- Off channel habitat
- Criteria for pools
- Habitat codes
- Taxonomic levels for inverts
- Riparian veg (EMAP vs O’Neil)
- Dominant substrate and embeddedness rating
- Macroinvertebrates as indicators for substrate embeddedness
- Sensitivity issues for macroinvertebrates as indicators
- Percent fines as indicator of sedimentation and embeddedness

2. Definitions in EMAP not necessarily same as those in EDT. Most Columbia Basin using EDT as one analysis tool. Need to coordinate M&E to provide analysis tools/models with specific input or retool models to include current indicators.
3. Side by side comparison of embeddedness indicators, but need to identify which indicator is most appropriate for questions asked. Look for associations between embeddedness and fish compared with association between substrate composition and fish. Data are available in some streams to make these comparisons.
4. Need to simplify some indicators, particularly for embeddedness.
5. Easy to identify a few indicators for effectiveness monitoring—a little more challenging to address status/trend.
6. Identify priority indicators—OWEB and SRFB specific needs. Key is to identify the causal factor for decline and establish indicators that address those factors within a measurable reach or assessment unit. Tough when you got multiple factors.
7. Sensitivity analysis is required, but few indicators have sufficient data to detect changes.
8. Disturbances screw up status/trend monitoring—particularly eastside fires. Annual sampling addresses most of the indicators. Identification of correct scale in sampling.
9. The key indicators for status/trend (water quality, woody debris, substrate composition, riparian cover, and pools) are the most difficult to correctly measure.
10. Five years may be appropriate period to conduct power analysis and to isolate which indicators do the best job. Remote sensing may be used in near future to address spatial scale indicators, with side-by-side comparison to physical habitat measurements.
11. Need to identify the linkage of biotic factors to physical habitat indicators—poorly seeded habitats or reaches upstream of barriers. Perhaps other biotic factors indicators may be used for ecosystem health.
12. Suggest looking at some of the indicators to see if there are correlations among the data sets or if some appear independent. Should have sufficient data to being these autocorrelations.
13. AREMP using roads and vegetation as indicators in NW Forest Plan.
14. Sensitivity analyses for watershed condition indicators.

15. Some debate on whether to reduce the EMAP 50 site in rotating panel or to reduce the number of indicators in EMAP sampling sites.
16. Physical and Biological Variables for status, trend, effectiveness and/or recovery
17. Concern about capability of GRTS design to detect changes at the subbasin scale.
18. Identify leads for periodic practitioners review session.
19. Protocol builder? Use for all programs to establish common data definitions, forms etc. BOR—John Day developing.

Notes from flip charts/wall

- PARR PROB. (Variable)
 - Use smelt imp for mark/rer-p
 - Methods from IMW
 - (Permitting Issues)
 - Shock for pit
 - Timing
- Bull Trout
 - Index sites – compromise
 - (See RP bpt for list)

PROTOCOLS/METHODS

- Sample areas above passage barriers is key
- Embeddeness
- Many subjective at implementation
- Remote site sampling
- IS 50 sites/year
 - Correct? - Power analysis

PROTOCOL/METHODS

- BFW V. WW (X20, XYO)
- NW hydrography layer
 - (0\$) – National hl
- Crosswalk LWD
- Standardize
- XERCES.ORG
 - Sensitivity, etc.
 - (What's needed to assess)?
 - Index of health?

- & pres, disc. of results
 - Decisions (who and why?)
 - Gov, Congress
- Mid-level policy and tech levels need to interface
 - PNAMP to Compare/contrast
 - Defs. (UC?IAC?OK....)
 - Coord. Efforts
 - Entiat ex (IAC & OK)
 - M & E for Recovery
 - (VSP) under described and underdeveloped as guidance

COORDINATION

- Data availability?
- Hatchery effects?
- Effectiveness
- Standardize GIS proj./scale
- Match w EDT etc.
- Acceptable level of error

COORDINATION

- Landowner issues
(outreach program?)
- Meshing Objectives
- Intra-agency
- Annual practitioners/field crew meeting
(scale?) – Resource
Sharing

COORDINATION

- What RME Question
- What analytical process
(these condition design)
- Uniform approved to “score” (BC) for roll up
- CREW SHARING ACROSS SUBBASINS

CROSS & TOP/UP COORD. CONT.

- Email forum
- Link comms to levels (BC. Ex.)
- Feedback form
- RMEG for B/T formed up on “recovery”, delisting
(Status, trend??)

CROSS-PROGRAM COMMUNICATION

- 2-day mtg. (split 2nd policy/tech)
- PA system
- Phone Bridge
- Regional v. local (need both)
- Peer-review process?
- Future meeting will/should incl. analysis of data

PROTOCOLS/METHODS

- B/T: when is a redd a redd (Shepard/Graham)?
- Livestock!! Humans!
- Tagging problems
 - Broken antennae
 - Entangled
- Snorkel for B/T uses
Peterson in larger systems applicable?

- BT DAY/NIGHT SNORKELING

PROTOCOLS/METHODS

- GRTS (+) challenges (define universe
Can use EDT reaches
- Broad enough to detect limiting factors
- Field Guide
Dist. review...
- TRAINING & QA/QC
Tools – video?

INDICATORS/VARIABLES

- QA/QC w/replicates eval. Variability
- Clear set of defs. Eg; - Barrier
- Riparian width as surrogate for structure?
Other attributes as correlates
- Finer scales as needed
- WQ networks problematic

INDICATORS/VARIABLES

- Smolts for prod./FW
- M & E for recovery
- Dist. – Spawner abundance

INDICATORS, VARIABLES.....

- Periphyton?
- Analysis – Relationships
- Glenn Mendel's List

Recommendations for Future Workshops (compiled)

Note: feedback forms being distributed to all participants ask for specific recommendations on this topic. Results from this survey will be available in March 2005.

Some general themes from contemporaneous feedback follow:

1. Host specific issue workshops
2. Two-day meeting/workshop is required. First day general coordination and information sharing, second day = workgroup sessions on specifics (physical, biological protocols, data management, analytical approaches, goals.
3. DO THIS AGAIN! Continue to communicate with implementers and decision makers.
4. Host a single regional website for M&E resources and information sharing
5. Who is PNAMP? Who is CSMEP? What are they exactly, what are they supposed to do and how do implementers participate?
6. QA/QC process at the field, data and analysis levels need methods and rules
7. Resource Sharing and Multi-Agency Coordination needs to increase
8. Need Listing of resources and attendance list to establish top-down/bottom-up forum.
9. April symposium on broad-scale monitoring efforts for differing species and issues.
10. Establish/expand the PNAMP mailing list for work groups and protocol development and standardization.
11. Need for detailed field manual for sampling, protocols, and training.
12. Work is being done in 2005 by Rocky Mtn Station to identify what set of attributes the protocols are established for, precision and accuracy calibration. This could be available by 2006.
13. Structure annual meeting with sufficient time to have data and metadata available
14. More on the ground reviews (with data in hand) of problems and opportunities with field sampling techniques. Possible linkage with WDAFS for symposium on protocols and indicators.
15. Balancing the separate needs for smaller meeting of on the ground practitioners, with the top/down linkage.
16. First day is large scale coordination issues, followed by second day of local practitioners.
17. Include symposia/workshop to review analysis of status, trend and effectiveness data.

Post Workshop e-mail Questions/Comments

Thoughts on Upper Columbia monitoring meeting, Jan. 12, 2005, Wenatchee, WA
Dana Weigel, Bureau of Reclamation

During the meeting, biologists expressed frustration in being able to define habitat parameters and protocols, and the time and expense that describing habitat trends will cost (i.e. weighing numbers of samples vs the limited budgets). Tracy Hillman relayed a vision that the habitat monitoring would choose a few (4-5) variables that can be easily measured, monitored, and comparable across basins that would track a trend.

Thirty five years ago, the abundances of juvenile and adult salmonid populations were found to be well-described using 4 variables: gradient, elevation (or stream width), temperature, and % pool. Since then, these relationships were shown to hold true throughout the nation (east, west and Midwest). These four variables, in combination, frequently describe 75-90% of the variation in fish abundances by species and size class. In addition, it is well known that the high annual variation in anadromous fish abundances makes them difficult populations to monitor and identify cause and effect relationships (for ex. see NAJFM paper about 1999?). Given this information, it is possible that the habitat trend monitoring and the fish population trend monitoring may have too much annual, site, and measurement variability to have long term confidence (particularly statistically significant).

In addition, many agencies in the NW have spent the last 2 decades describing fish habitat and abundances through various methods (such as Hankin and Reeves, R1/R4, and other variations). Although these methods are useful in cataloging conditions on the landscape, they provide little information on the reasons for inter-basin differences in fish production. For example, some basins may have high impacts from land management activities, yet they remain good fish producers (or vice versa).

In recent Biological Opinions, NOAA Fisheries identified a lack of studies on the effectiveness of classes of habitat actions, and the relationship of these to fish survival.

Considering these facts, I have a few concerns:

- 1) Are we spending too much effort, detail, and money on basin wide monitoring at the expense of smaller innovative studies that will give us better information and links to fish survival and production?
- 2) Considering that gradient, elevation, temperature and % pool habitat are likely capable of describing the majority of the variation in fish abundance, and these variables can be measured with remote sensing methods, can a reasonably inexpensive program be accomplished in numerous basins based on these predictors over time?
- 3) Are we putting the majority of effort and funding into monitoring programs that may yield little or no additional information about fish/habitat relationships than we have acquired over the last 35 years of fisheries science?
- 4) In this effort, are we ignoring site level and effectiveness monitoring studies that are based on hypothesis testing that may give meaning to the trend monitoring studies?

- 5) What is the fall-back strategy if this EMAP based basin habitat monitoring does not provide explanative relationships with fish production? Should we even expect it to?
- 6) The USFS has been implementing a similar program (PiBO) for several years. This program should have tested protocols, intensive field personnel training, and a QA/QC system. It seems that this effort should work cooperatively with them, with PiBO on federal lands and the BPA funded efforts concentrating on private lands using similar methodologies and site selection techniques (at least in the pilot basins). This would double the money and effort being spent. We did not hear much from the FS about their monitoring activities (past or present) in the upper Columbia, or evaluate their existing efforts and lessons learned.

-----Original Message-----

From: Karl M Polivka [mailto:kpolivka@fs.fed.us]
Sent: Sunday, January 16, 2005 5:21 PM
To: Bob Bugert
Cc: Richard Woodsmith
Subject: M&E workshop

Dear Bob:

I have a few comments to make that might be worth adding to the white paper outline you were preparing at the M&E workshop the other day. The discussion of sediment has been addressed recently in the literature. I was going to pipe up and say the following, but the discussion at the meeting took a different track and I never got my \$0.02 in. So here goes:

I think the question of how to measure sediment depends on what question is being asked -- i.e., are you measuring sediment to determine how spawning habitat has been affected or to determine how it might affect the food base that provides energy for growth and survival of juveniles. Mary Power's lab has a recent paper in Ecological Applications in which they constructed in-stream channels and artificially added sediment to achieve a wide range of embeddedness levels. They found that the invertebrate assemblage shifted from taxa that were vulnerable to fish (grazers, predators, etc.) to burrowing taxa such as oligochaetes, Dipteran larvae, etc. Burrowing made these species unavailable to foraging steelhead and fish growth rates were reduced 4-5 fold as embeddedness ranged from 0 to 100%. So the effects of sediment are complex and often require experimental work to determine what different levels of sedimentation might mean for fish performance. Other relevant questions might include how the flow regime in a particular system might interact with sediment -- i.e., how long to study reaches remain embedded? Do changes in flow flush sediment out of affected reaches on a temporal scale that might make the effects of sedimentation less detrimental to fish? In other words, I'd advocate a more integrated approach to the measurement of the effects of sedimentation in affected reaches that would include determining whether shifts in the abundance of invertebrates

linked to salmonids via trophic relationships have occurred. It just seems to be very difficult to come to conclusions about the performance of salmon based on individual measurements of particle size or embeddedness.

For reference, the article I referenced is:

Suttle, K. B., M. E. Power, J. M. Levine, and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. *Ecological Applications* 14:969-974.

I hope this is helpful to the group -- please share as you feel is appropriate. Thanks for an interesting and informative meeting! I'll look forward to hearing everyone's progress in the future.

kp

Karl M. Polivka, Ph. D.
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From John Arterburn:

On another note one more thing that came up on the habitat protocols is how the canopy cover data is collected and used. Most protocols collect it from four points along a transect and get % for the reach but this data is collected at 6 locations and gives information on the center of the stream and the bank but not a value for the entire reach. Lots of possible combinations might be worth discussing at more length.

**Monitoring and Evaluation Resource Links (not exhaustive)*

1. **The Pacific Northwest Aquatic Monitoring Partnership (PNAMP).** Jen Bayer (Coordinator), Bruce Crawford (Habitat), Keith Wolf and Jennifer O'Neal (Fish), Steve Lieder (Steering Committee), Steward Toshach (Data Management), Steve Lanigan (Watershed Conditions [habitat]). No public website available at this time.
2. **The Coordinated System Wide Monitoring and Evaluation Project (CSMEP).** Frank Young (CBFWA) and Dave Marmorek (ESSA).
<http://www.cbfgwa.org/committees/csmep/default.cfm> &
<https://nrmp.dfw.state.or.us/csmep/default.aspx>
3. **The Northwest Power and Conservation Council-**Dr. Steve Waste.
<http://www.nwppc.org/>

4. **The Wild Salmon Center/State of the Salmon Project.** [Xan Augerot, Ph.D.,](http://www.stateofthesalmon.org/)
<http://www.stateofthesalmon.org/>
5. **The Bonneville Power Administration (RME/Fed. Caucus).** Jim Geiselman.
<http://www.salmonrecovery.gov/federalcaucus.shtml>
6. **The Northwest Fisheries Science Center.** Dr. Chris Jordan and Steve Katz.
<http://www.nwfsc.noaa.gov/>
7. **The Washington State Salmon Recovery Funding Board.** Bruce Crawford.
<http://www.iac.wa.gov/>
8. The Pacific Coastal Salmon Recovery Fund, <http://www.nwr.noaa.gov/pcsr/>
9. **The Upper Columbia Regional Technical Team.** Bob Bugert
10. **The Lower Columbia Fish Recovery Board.** Melody Tereski and Jeff Breckel
<http://www.lcfrb.gen.wa.us/>
11. **The Colville Tribes Fish and Wildlife Department.** John Arterburn.
<http://www.colvilletribes.com>
12. **KWA Ecological Sciences, Inc.** Paul Wagner and Keith Wolf.
<http://www.kwaecoscience.com>
13. **The U.S. Bureau of Reclamation.** Michael Newsom and Michael Beaty.
<http://www.usbr.gov/>
14. **BioAnalysts.** Tracy Hillman
15. <http://www.xerces.org/aquatic/standard.htm>

**See workshop attendee attachment for email and telephone numbers.*

Appendix D. Pacific Northwest Aquatic Monitoring Partnership (PNAMP)
2005 Accomplishments Summary

PNAMP GOALS:

- Improve communication among monitoring programs across state, tribal, and federal organizations.
- Improve scientific information needed to inform resource policy and management questions and decisions.
- Seek efficiencies and cost-effectiveness across monitoring programs through compatible and cooperative monitoring efforts.
- Promote science-based credibility of monitoring and assessment efforts.
- Share resources and information among monitoring programs across state, tribal, and federal organizations.

FY2005 ACCOMPLISHMENTS and PRODUCTS

PNAMP provides leadership and coordination for interagency and multi-organizational responses to major resource monitoring efforts. PNAMP has provided a forum for inter-organizational committees to work to integrate resource monitoring programs of state, federal, tribal, local, and private organizations in the Pacific Northwest.

In 2005 PNAMP:

- Became a formal organization by drafting a Charter and Business Practices, subsequently signed by 19 state, federal, tribal and regional entities.
- Drafted a long-range strategic planning document (“PNAMP Strategy For Coordinating Monitoring of Aquatic Environments In The Pacific Northwest” March 2005).
- Used the PNAMP Steering Committee to increase understanding across PNAMP partners of large scale needs, such as: key management questions that drive monitoring in the region and high level indicators (draft summary documents in progress).
- Used the PNAMP technical workgroups to facilitate coordination and collaboration among monitoring practitioners on monitoring design, protocols, data standards. These workgroups are organized by aquatic monitoring topics: Watershed Monitoring, Effectiveness Monitoring, Fish Population Monitoring, Estuary Monitoring, and Data Management.
- Participated in the Northwest Environmental Data Network to support existing data coordination efforts and leverage PNAMP needs with larger goals.
- Facilitated coordination between PNAMP Fish Population Monitoring Workgroup and the Collaborative System-wide Monitoring and Evaluation Project to ensure efficiency and avoid redundancy.

- Created a public website (www.reo.gov/PNAMP), technical poster (for technical meetings), and a variety of presentations to disseminate information about PNAMP to regional and national meetings
- Supported technical forums (open to the public): “Large-scale Monitoring” symposium at the American Fisheries Society NPIC meeting; “Remote Sensing Workshop”; “Fish Practitioners Workshop”.
- Conducted briefings for executive bodies RIEC, Federal Caucus, ATNI, OWEB, SRFB, and individual executive, policy staff, and technical forum (AFS Symposium) public meetings (watershed councils).
- Provided for professional staff to Coordinate PNAMP: fulltime Coordinator and ½ time Administrative Assistant (through USGS) dedicated to PNAMP needs.

PNAMP facilitates forums among technical experts and between scientists, managers, and liaison groups for the collective evaluation and interpretation of current and new knowledge regarding issues in monitoring.

In 2005, PNAMP

- Implemented a study to conduct a side-by-side protocol test in which field attributes and sampling protocols are compared across numerous agencies
- Facilitated review of Fish Monitoring Protocols from the draft paper of: David H. Johnson (et al). Review, assist with protocol publications plan , and facilitate implementation of protocols by and through PNAMP partners
- Drafted regional plan to establish a network of intensively monitored watersheds (IMWs)
- Supported technical forums (open to the public): “Large-scale Monitoring” symposium at the American Fisheries Society NPIC meeting; “Remote Sensing Workshop”; “Fish Practitioners Workshop”.