Integrating Aquatic Ecosystem and Fish Status and Trend Monitoring in the Lower Columbia River: Overview

Pacific Northwest Aquatic Monitoring Partnership
Integrated Status and Trend Monitoring Workgroup

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Overview

Executive Summary

The Pacific Northwest Aquatic Monitoring Partnership's (PNAMP) Integrated Status and Trend Monitoring (ISTM) project is intended to demonstrate the approaches and utility of integrating the collection of information to address multi-scale questions about the status and trends of fish (salmon, steelhead, and potentially bull trout), and physical, chemical, and biological attributes in stream networks. The overall intent is to assist PNAMP's participating members in developing strategic action plans for monitoring in the bi-state lower Columbia (LC) river demonstration area, as well as to demonstrate the general approach to developing such plans for other areas in the Pacific Northwest. The ISTM effort will provide entities tasked with monitoring fish populations and aquatic habitat in the Pacific Northwest with a roadmap for integration of scientifically sound monitoring programs intended to meet the needs of decision-makers and managers. Specifically, it will apply this approach and develop recommendations for integrated monitoring plans for salmon, steelhead, and potentially bull trout populations listed under the Endangered Species Act (ESA), and their habitats in the LC area. Among the many monitoring components, key features of this effort are improved understanding of the extent and qualities of existing information, key gaps, and how a region-wide "master sample" concept can be applied to select sampling locations where appropriate. Generic objectives in the ISTM project for both habitat and fish are:

1. Identify decisions, questions, and monitoring objectives
2. Review existing programs and designs
3. Identify monitoring designs, sampling frames, protocols, and analytical tools
4. Use trade-off analyses to develop recommendations for monitoring
5. Recommend implementation and reporting mechanisms

The ISTM effort is being accomplished using a collaborative approach involving PNAMP members and other local partners. Anticipated PNAMP products include development of design, analysis and implementation tools, coordination to integrate actions into planning and implementation of efforts addressing fish recovery and watershed health in the demonstration area, and products summarizing the approaches, tools, guidance, and results from the demonstration project for possible use in other parts of the Pacific Northwest. The master sample concept, along with other monitoring and monitoring design tools, has broad applicability to address status and trends questions in the estuarine and near shore marine areas (area-based master sample), in addition to the status and trends of attributes along linear stream networks.

As work proceeds, a series of ISTM documents are anticipated. To set the stage, this document provides a short ISTM overview; a separate document describes ongoing work regarding application of the master sample concept. Other reports will document ISTM integrated habitat and fish monitoring.

Overview

Acknowledgements

Participants in the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Integrated Status and Trend Monitoring (ISTM) workgroup include Jen Bayer, Aaron Borisenko, Jeff Breckel, Catherine Corbett, Tim Counihan, Bruce Crawford, Bob Cusimano, Ken Dzinbal, Jim Geiselman, Bernadette Graham Hudson, Gary Johnson, Krista Jones, Chris Jordan, Kirk Krueger, Steve Lanigan, Phil Larsen, Steve Leider, Ken MacDonald, Glenn Merritt, Dave Price, Sean Quigley, Dan Rawding, Jeff Rodgers, Jacque Schei, Russell Scranton, Jeannie Sifneos, Si Simenstad, and Don Stevens. Special thanks to Steve Leider (editor), Tim Counihan, Bernadette Graham Hudson, Phil Larsen, Jeff Rodgers, Russell Scranton, and Don Stevens for their contributions to this document.

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Table of Contents

Introduction

Each year millions of dollars are spent to monitor the status and trend of natural resources and determine the effectiveness of restoration programs in the Pacific Northwest. While there is increasing consensus among regional federal, private, state, tribal, and stakeholder organizations with respect to the need for access to integrated and standardized monitoring information, funding for these monitoring activities is generally limited and declining. As a result, there is an increasing need to improve the efficiency and cost effectiveness of existing and any new monitoring programs.

There are many ways decisions and questions about the status and trends of fish and aquatic ecosystems are expressed by the public, decision-makers, and scientists. Some monitoring-based decisions and questions are unique to particular agencies and organizations whereas others are more generic, such as:

Decisions:

- *Are changes needed to a course of action?*
- *Should funding for an activity be maintained/increased/decreased?*

Questions:

- *What are the status of fish and physical conditions at identified scales (population, watershed, listed species, region-wide)?*
- *How is that status changing over time?*
- *Are freshwater and estuarine habitats and fish populations healthy and productive?*

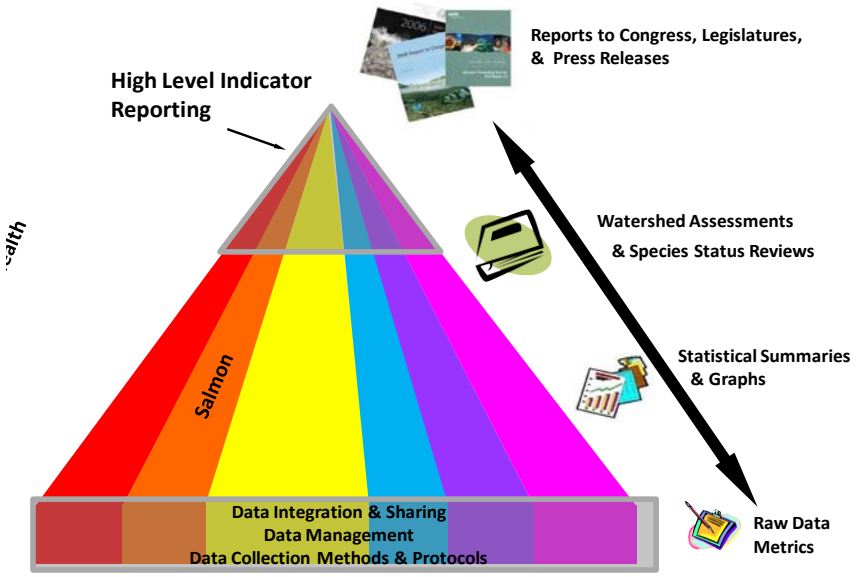
Common to entities involved in monitoring in the Pacific Northwest is the need for efficient collection of information on indicators and metrics on all or certain aspects of the status and trend of fish, habitat, and watershed health. By taking advantage of past monitoring work and applying well-coordinated monitoring approaches, technical and fiscal resources can be more effectively shared among interested parties, data can be shared, and resulting information can provide increased scientific credibility, cost-effectiveness in use of limited funds, and greater accountability to stakeholders (PNAMP 2005).

Logical improvements in the cost-effectiveness of monitoring efforts include reducing duplication of effort and implementing programs that will allow data collected by multiple entities and programs to inform a larger regional monitoring network. To do this, individual agencies and organizations will need to develop processes that promote data sharing with partner organizations, agree on an overarching set of monitoring questions that can be addressed with common or compatible indicators, coordinate activities, and develop common protocols and methods or ways to "crosswalk" data derived from disparate protocols.

The goal of the Integrated Status and Trend Monitoring (ISTM) project is to improve integration of existing and new efforts that are intended to address status and trend questions. As a demonstration effort, it will focus on processes and tools for the development and management of integrated regional strategic action plans or roadmaps for monitoring the status and trends of aquatic habitat, watershed health, salmon, steelhead and potentially bull trout populations.

The process and decisions necessary for implementing the roadmap will be demonstrated in the area encompassed by the Lower Columbia (LC) River. There are numerous fish populations in the area comprising multiple Evolutionarily Significant Units (ESUs) and Distinct Population Segments (DPSs) that are listed under the federal Endangered Species Act. In addition, the mainstem Columbia River is a common area through which these and all other upriver anadromous fish species pass and may rear as adults and juveniles while on their way to and from the Columbia River and the ocean. The demonstration will exemplify how the efforts of existing and planned fish and habitat monitoring can be integrated and coordinated within and between the states of Oregon and Washington (e.g., Cusimano et al. 2006; Suring et al. 2006; Crawford 2007), with federal land managers like the U.S. Forest Service (USFS) (Gallo et al. 2005), and with recovery plan implementers including the Lower Columbia Fish Recovery Board (LCFRB) (LCRFB 2004), Oregon Department of Fish and Wildlife (ODFW) (ODFW 2009), NOAA Fisheries, US Fish and Wildlife Service, and others.

This effort is intended to support monitoring goals at multiple scales, as illustrated in the pyramid to the right. This includes the ability to compile measurements to meet broader (e.g., high level indicator, rolled-up, extensive, region-wide, statewide) and finer-scale (e.g., population, watershed, intensive, densified) status and trend monitoring needs. At these multiple scales, information from status and trend monitoring provides context for interpretation of results from project effectiveness monitoring, and programs like intensively monitored watersheds (IMWs) aimed at validation monitoring to evaluate recovery strategies. The objective of improving the ability to share information will be enhanced and ensuing analyses can be more statistically rigorous and robust. When combined in a web-accessible system with documentation (metadata) of the indicators and protocols used to collect the data, local, state, federal, and regional entities will have a powerful resource for coordination and integration of monitoring information.



As this work proceeds, a series of documents will be produced. To set the stage, this document provides a short overview of the project; a separate document describes ongoing work regarding application of the master sample concept. As discussed below, subsequent reports will document ISTM integrating fish monitoring, and other aspects.

Anticipated products of ISTM efforts for habitat and fish include:

1. development of design, analysis, and implementation tools for incorporation into PNAMP recommendations to entities responsible for monitoring,
2. coordination of efforts to develop integrated, multiagency actions to implement monitoring plans addressing salmon recovery and watershed condition in the demonstration area, and
3. recommendations for transferring the approaches, tools, guidance, and results from the demonstration project to other parts of the Pacific Northwest.

Specific technical products associated with ISTM include:

- examples of how the LCFRB and ODFW integrated the use of the master sample with existing monitoring efforts to facilitate the design of their respective ESA salmon recovery monitoring programs,
- further development of metadata to describe how sub-samples are selected,
- clarification of how existing monitoring designs can be integrated into other designs, and
- how to document indicators, methods, and protocols that are used at sampling sites.

The ISTM project focused initially on linear stream networks with an emphasis on habitat condition and watershed health (PNAMP 2008), and more recently, probabilistic-based master sample approaches for salmon and steelhead populations, and non-wadable/estuarine areas (PNAMP 2009a). Integrated status and trend monitoring designs for both fish and habitat have been developed in this and other areas in the Pacific Northwest (e.g., Firman and Jacobs (undated); James et al. (2007); Nelle et al. (2007); Suring et al. (2006)). More work is needed to address potential application of approaches (including a master sample) to monitoring programs for non-wadeable streams and rivers, estuaries, and nearshore marine habitats.

Integration Objectives

To foster improved monitoring integration within and between habitat, fish, and potentially estuarine categories, the ISTM project will be guided by and address the following five generic objectives (Figure 1), each of which is outlined in more detail in the following text.

1. Identify decisions, questions, and monitoring objectives
2. Review existing programs and designs
3. Identify monitoring designs, sampling frames, protocols, and analytical tools
4. Use trade-off analyses to develop recommendations for monitoring
5. Recommend implementation and reporting mechanisms

1. Identify decisions and questions that habitat and fish monitoring in the demonstration area is intended to inform, and identify associated prioritized monitoring goals and objectives.

A frequent flaw in past monitoring programs is the failure to adequately identify and remember the reasons why monitoring is being conducted. All too often there are disconnects between the information that decision-makers and managers need to answer their priority questions, and what can or will be realistically provided by implemented monitoring programs. In addition, questions evolve over time. To avoid this situation, reaching

consensus with what is needed in the context of what is possible is key to the success of any monitoring program. For the ISTM effort, ESA recovery plan priorities for the LC area will serve as the foundation for identifying decisions and questions, and developing monitoring priorities. The current emphasis is on salmon and steelhead but has the potential to include bull trout and/or other species as warranted. This objective also considers linkages to other mandates (e.g., Clean Water Act).

2. **Identify and document the extent to which existing monitoring programs support and align with the priority monitoring objectives in #1 above.**

   There are a number of existing and some new habitat and fish monitoring programs being implemented in the LC area. Some of these monitoring programs may already be sufficient to meet the needs of decision-makers and managers and some may not. The technical veracity of these programs will be assessed to provide information on the relative performance of different monitoring survey design and field sampling protocol combinations needed for objectives #3 and 4. This will include a review of current habitat, and fish monitoring programs to ascertain the statistical bias, precision, and cost-effectiveness associated existing monitoring programs. Also included will be information on analytical tools and data management approached used.

3. **Identify and/or develop monitoring designs, sampling frames, field and data management protocols, and analytical tools to meet priority fish and habitat status and trend monitoring objectives identified in #1 above.**

   Monitoring design approaches, sampling frames, appropriate field and data management protocols and related analytical tools are fundamental aspects of the ISTM effort. Monitoring designs to meeting the objectives identified in #1 will be identified, along with a spatial framework for estimating the sampling frame for all listed salmon and steelhead in the LC area, including a process and timeline for updating the sample frame. Similarly, information on field sampling protocols, data management protocols, and analytical tools that are well-matched to the sampling design will be identified to ensure objectives in #1 can be met.

4. **Develop information on the pros and cons and costs associated with different monitoring design and field protocol combinations (both existing programs and potential new or modified programs). Based on this information develop recommendations for efficient habitat and fish monitoring programs to best achieve the priorities from objective #1.**

   To achieve the goal of developing integrated, scientifically sound habitat and fish monitoring programs that meet the needs of the recovery plans, monitoring priorities (as identified in objective #1) will be aligned with the efficacy and cost-effectiveness of existing programs (as identified in objective #2), and a realistic assessment of the constraints to and/or opportunities for modifying existing programs or implementing new programs

Establishing recommendations for monitoring will essentially involve trade-off analyses based on the regional priorities for monitoring and the costs of different sampling designs and field sampling protocols. Questions ISTM will address may include the following:

- How consistent are study designs with NOAA guidance (e.g., Crawford and Rumsey 2009)?
- When there is limited funding what is the balance between producing unbiased and precise estimates of abundance of only a few primary populations versus unbiased and less precise estimates of abundance for the entire ESU?
- How can different monitoring approaches be integrated to meet LC-wide habitat and fish information needs?

It is unlikely that a one-size-fits-all approach can be achieved due to major differences among the characteristics of species, logistical/access constraints, environmental/visibility limitations, and competing priorities. The purpose of this element is to explore relationships of NOAA guidance to a series of proven successful designs that could successfully be implemented to achieve multiple monitoring goals using a trade-off analysis.

5. Recommend mechanism(s) to implement and report the monitoring results from implemented monitoring programs.

The ISTM effort will result in recommendations to PNAMP and ISTM partners about implementation mechanisms and improved communications and reporting. It will also include recommendations for complementary data management and analytical approaches.

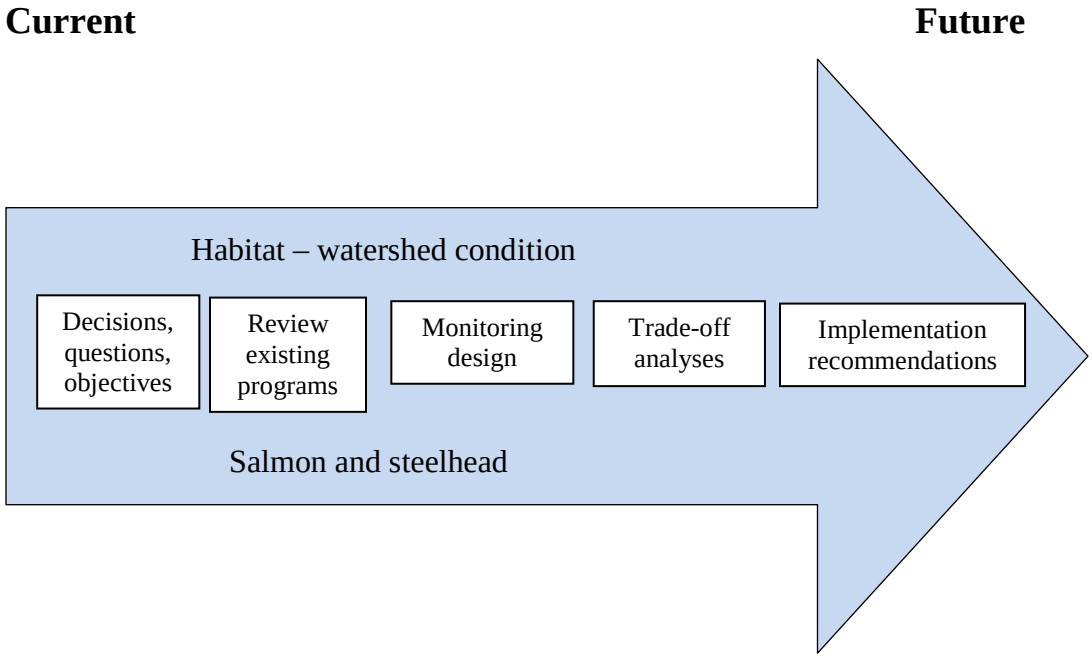


Figure 1. ISTM project integration pathway

Relationship to Columbia Basin Monitoring Planning Processes

Habitat and fish monitoring programs within the Columbia Basin inform a multitude of management needs. These needs include the requirements of the Biological Opinions on the operation of the Federal Columbia River Power System, tracking progress toward recovery of species listed under the Endangered Species Act, and addressing the needs of the Northwest Power and Conservation Council's Fish and Wildlife Program and state/tribal/federal management harvest and hatchery programs. A process is now underway aimed at development of a comprehensive strategic monitoring and evaluation plan within the Columbia River basin (henceforth referred to as the 'comprehensive anadromous monitoring strategy'). Current emphasis of that effort is on anadromous salmon and steelhead viability parameters, and habitat and hatchery effectiveness monitoring. Later emphasis may include habitat status and trends, other fish species, and other categories of effectiveness monitoring.

The ISTM project directly complements the development of the comprehensive anadromous monitoring strategy for the Columbia Basin. The ISTM project will provide a roadmap on the steps needed to develop coordinated status and trends monitoring of fish and habitat in wadeable and non-wadeable tributary streams. This roadmap should inform similar efforts outside of the LC area. The specific products developed by the ISTM project for the LC area will serve as valuable background and foundation information for the proposed comprehensive anadromous monitoring strategy development process for the LC area.

The ISTM project will provide a portion of the information needed to develop the comprehensive, prioritized, and strategic monitoring plan for the entire Columbia Basin. The complexity of a comprehensive anadromous monitoring strategy and where the ISTM project will provide information and guidance is illustrated in Figure 2. When considering the monitoring needs of ESA recovery plans within the Columbia basin, priorities (depicted in the figure with double-ended arrows) will need to be identified both within and across spatial scales, life-stage locations, within and between threat and VSP parameters, evaluation of actions, and research. The ISTM project is currently intended to provide guidance on ways to develop and integrate existing and new status and trend monitoring programs of fish and habitat in Columbia Basin tributaries in general and specifically for individual population areas in the LC area. It will not address other spatial scales or life-stage locations, nor will it address priorities for monitoring other threat categories.

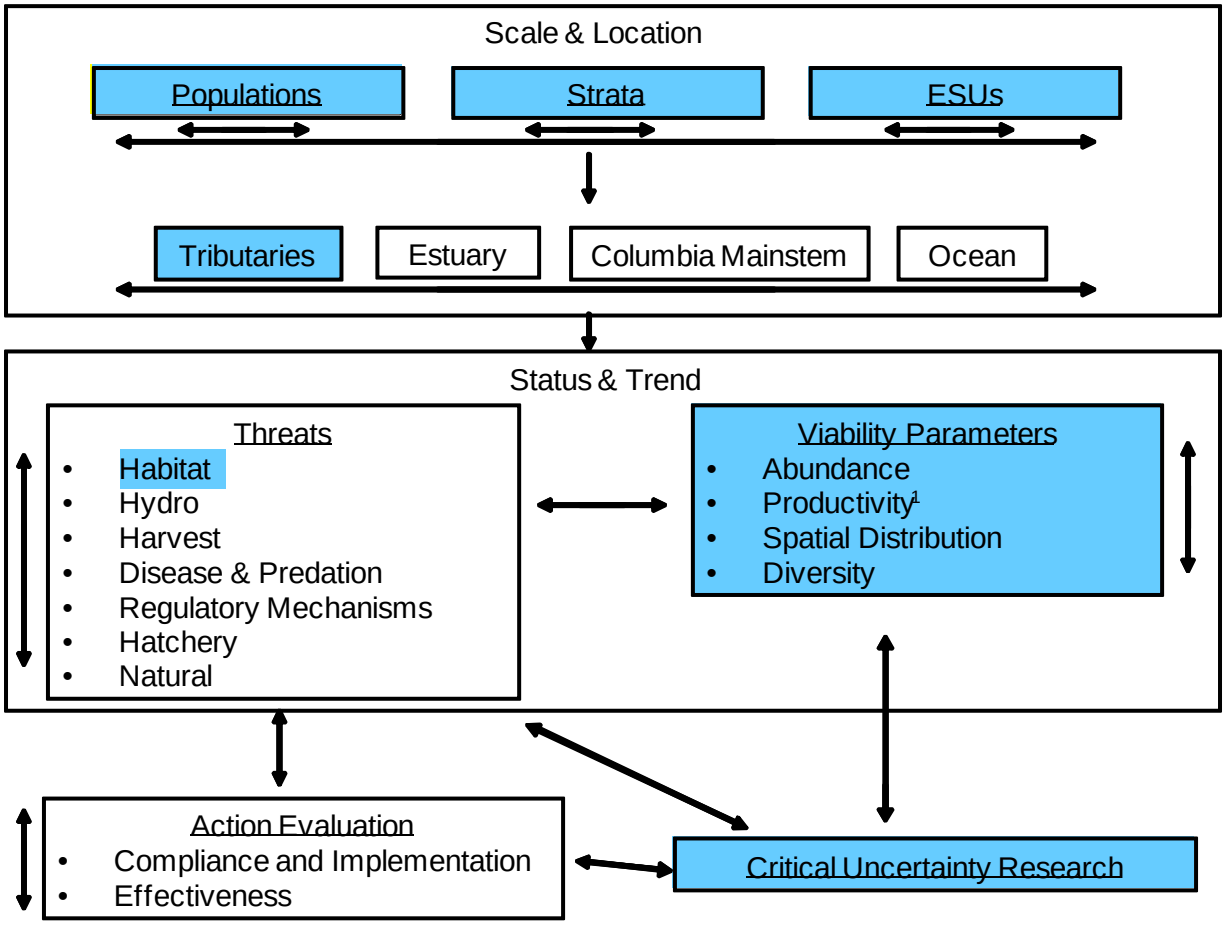


Figure 2. Components of a comprehensive anadromous monitoring strategy for the Columbia Basin. Highlighted are topical areas where the ISTM project will provide general guidance on the process for developing integrated monitoring programs for other areas in the Columbia basin and specific information for the LC area[1].

Strategic Approach

Lower Columbia Demonstration Area

To demonstrate the utility and tools associated with regionally and locally integrated status and trend monitoring, the PNAMP ISTM workgroup selected the geographic area encompassed by LC area (Figure 3). The reasons for selecting this area are that various entities have already or are in the process of reviewing and applying integration tools for habitat and fish in their monitoring plans. These entities include the ODFW, USFS, LCFRB, Washington departments of Ecology (ECY) and Fish and Wildlife (WDFW), NOAA Fisheries, and other monitoring agencies to facilitate a more coordinated approach to monitoring natural resources. This area is within the jurisdiction of two states (Oregon and Washington) and numerous federal, tribal, watershed council, county, and municipal entities. It is the focus of ongoing recovery efforts for

[1] The ISTM project will provide information and guidance on spawner abundance which is one component of productivity.

four ESA listed anadromous salmonid species (coho, chum, Chinook, and steelhead), and bull trout, and has diverse land use and increasing human population pressures.

Applying the Strategy

Due to the technical and non-technical complexities involved, implementation of the ISTM strategic action plan is being developed in the context of an adaptive management approach (Figure 4). The adaptive management cycle begins with identification of questions and objectives, followed by development of monitoring designs, data collection, data management, analysis, and reporting, followed by review of progress in light of objectives. Status and trends questions and objectives are available for mandates reflected in Table 1. The table shows the major biological, physical, and chemical monitoring components that would be informed by or use ISTM products.

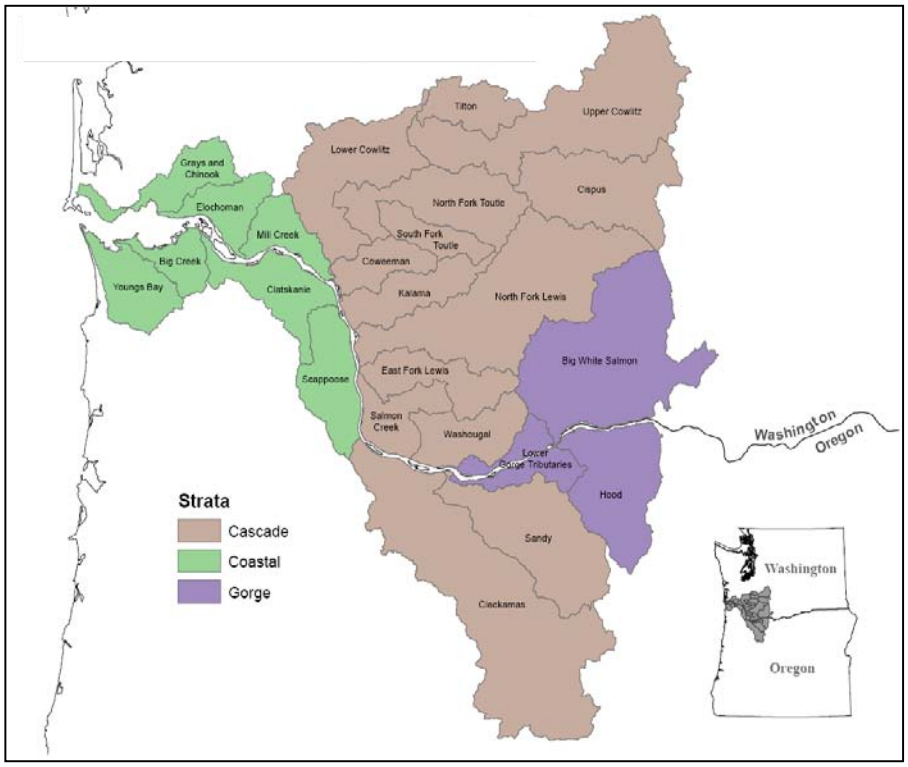


Figure 3. Lower Columbia River demonstration area showing the location of major population groups (strata) and population areas for salmon and steelhead listed under the ESA

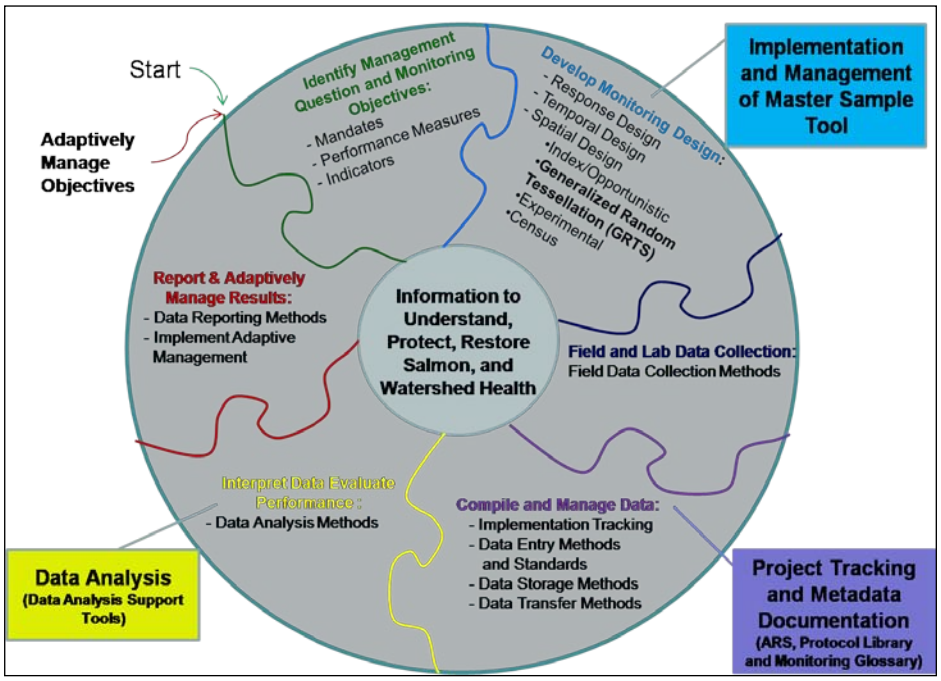


Figure 4. General adaptive management framework for ISTM products

Table 1. Alignment of key mandates, management questions, and performance measures for status and trend monitoring

	Biological Status		Watershed Health				
Mandates	Fish	Birds, Invertebrates, Mammals, Invasive sp., Amphibians, etc.	Water Quality	Hydrology	Riparian Condition	Wetland Condition	Aquatic Physical Habitat Condition
ESA Recovery Plans and Biological Opinions	x	x	x	x	x	x	x
Clean Water Act	x	x	x	x	x	x	
Oregon Plan for Salmon and Watersheds	x	x	x	x	x	x	x
Washington State of Salmon and Watershed Health Report	x	x	x	x	x	x	x
Northwest Forest Plan (AREMP)	x	x	x		x		x
CBFWA State of the Resource Report	x	x	x	x	x	x	x
Lower Columbia River Estuary Ecosystem Monitoring	x	x	x	x		x	x
Northwest Environmental Information Sharing (NWEIS) High Level Indicators	x		x	x	x	x	x

Initial Guidance

As the ISTM effort progresses, a broad range of products will be developed, including tools, guidance, data, and implementation recommendations. Initial statistical and design documentation guidance emphasizing probabilistic sampling is found in PNAMP (2009) which is briefly summarized here. Integration information and guidance for other types of sampling (e.g., fish, convenience-based, index sampling) will be developed as the ISTM project proceeds.

Integration of Existing Monitoring Programs

Several circumstances can be distinguished that require different approaches to integration of programs with an existing set of monitoring sites. Integration could occur at the design phase when potential sample sites are being selected, or it could occur at the analysis phase after data have been collected.

Integration at the Design Phase

In integrating at the design phase, there is a set of sites that has some history of being sampled. The sites may have come from a single prior sample or several independent samples and may have been selected using probability, convenience, or directed sampling. In the most straightforward case, the existing sites are the result of a probability sample from the same domain as the master sample. In the case of non-probability based existing samples, such as a set of index sites selected because of their high population productivity, convenience of access, or some other characteristic, the same process can be used; however, the basis for inference could be questionable. Before the existing sites are used, the rationale for selecting those sites should be determined and the implications for inferences clarified.

Integration at the Analysis Phase

Analysis of data from multiple sampling studies of the same population can be either model-based or design-based. A model-based analysis uses a model to establish the connection between the sample and the population. The validity of the resulting estimates or conclusions will rest on the validity of the model. A design-based analysis uses the process of sample selection (the "design") to establish that connection. A design-based analysis can only be applied to probability samples.

A distinguishing characteristic of a probability sample is that every sample site represents a known amount (i.e., a known number, length, or area) of the target population. That known amount is the weight attached to the site when the sample is expanded to infer a population characteristic. Non-probability samples do not have that property.

Integrating results from two probability samples is straightforward, at least in principle. The appropriate weight can be determined from knowledge of the selection processes used for each sample, and the target population for each sample. In practice, the process can be complex if target populations do not exactly coincide, or if different population frames were used. For

example, if one sample were selected using a 1:100k scale map and another using a 1:24k scale, it can be difficult to determine appropriate weights.

Integration of the data also deals with the overall evaluation of combined programs and monitoring strategies with use of multiple datasets for unintended uses. Documentation of metadata and weighting is essential for integration of analysis or use of data for alternative purposes.

Documentation

It is important that all elements of the adaptive management framework be adequately documented to ensure data and analyses can be reliably interpreted to inform management objectives. This includes documentation of monitoring questions and objectives, monitoring designs, field data collection protocols, data entry, storage and transfer protocols, data analysis tools used to translate measurements into metrics and/or higher level "indicators," and analytical tools to make statistical inferences.

Sampling Designs

To date the ISTM effort has emphasized documentation of designs for site selection using the master sample (PNAMP 2009a). In summary, sampling design documentation, whether selected separately or as a subset from a master sample, should contain information including: the key person responsible for the stewardship of the design, the domain to which the sample applies, the sample frame used, the specific requirements for the design, the site selection summary, description of the sample design output, frame and resultant sites selected, evaluation process, brief guidance on what is needed in order to generate data summaries, where to go for analytical tools, contacts for further information if different from the design steward, and a bibliography.

Tools and Resources

Activities are being implemented that will support ISTM efforts for habitat and fish. These include: (1) a web-based master sample management tool that will enable regional monitoring partners to share monitoring information for integrated assessments, and (2) dedicated analytical support for design and utilization of results of the monitoring design with emphasis on the master sample.

Master Sample Management Tool and Statistical Design and Analytical Support

PNAMP (2009a) describes ISTM efforts that will lead to a web-based master sample management tool and bolster capacity for statistical design and analytical support. A web-based master sample management tool will help coordinate data collection and sharing, to track where monitoring is being conducted, why it is being conducted, who is conducting it, and how it is being conducted. It will provide a catalog of a regional, comprehensive master sample. It will identify and incorporate into the site list database important attributes (indicators/metrics methods and protocols) associated with sample sites to aid entities in the stratification or sub-sampling of the site list for their needs.

One of the benefits of a master sample is that it provides access to rigorous statistical sampling designs for any organization using the master sample. To maintain that statistical rigor, the web-based tool must be developed with close cooperation between the tool developers and statisticians familiar with the Generalized Randomized-Tessellation Stratified (GRTS) technique (PNAMP 2009a; Stevens and Olsen 2004), one of the best methods to identify a representative set of sample locations. The principles underlying the application of the master sample are well-understood, and Larsen et al. (2008) present some examples of selecting focused samples from the master sample using ancillary information. However, implementation of a variety of design options, for example, stratification, rotating panels, and oversamples, will require statistical oversight. Also, statistical consultation support will be available to assist users with complex sampling issues.

Status and Key Needs

The ISTM effort is achieving its objectives by:

- Collaborating with groups in the LC area interested in integration of existing and new monitoring designs, plans, and activities for habitat and fish,
- Facilitating discussions among parties that may be interested in extending the utility of ISTM for area-based monitoring (e.g., LC estuaries and Columbia mainstem), and
- Reporting case studies that illustrate application of integration concepts in the LC area.

The series of objectives mentioned at the beginning of this document will guide ISTM and be useful to track progress and develop proposals for task work, leading to recommendations for improved integration both within and between habitat and fish status and trend monitoring categories.

As ISTM work increases in scope and complexity, the need for a lead technical **coordinator** to manage the overall project has become more important. The function of the coordinator would be to steward the various pieces that comprise the entirety of this integrated monitoring program, and to facilitate and support the work of the ISTM workgroup and contractors.

A critical aspect of the ISTM effort that needs additional attention pertains to **management of status and trends monitoring data**. Data from existing and new status and trend monitoring efforts will be stored in different systems and issues associated with development of coordinated systems to allow data sharing and/or consolidation from multiple participants for various analyses will need to be identified and resolved. Systems should be designed to be able to identify which individual sample measurements relate to the various panels and strata in the web-based sample management system. Projects and agencies that will manage their data independently will need sufficient guidance regarding how to structure their databases so that they can keep track of the complexities of samples from the master sample and other designs, and how data should be fed into analysis routines. Recommendations for financial support needed to build and operate these systems will also be needed.

Over the longer term, ISTM will address questions of the compatibility of field **sampling protocols** (options and recommendations), and develop approaches to expand ‘integration’ of

ISTM from status and trends work to other types of monitoring (effectiveness, validation) and evaluation (research). It will also address existing and new approaches for the **analysis and interpretation of data** from status and trends monitoring efforts.

The ISTM workgroup has identified the following elements that may become future supporting ISTM documents:

- Oregon example illustrating integration of fish, water quality, and habitat monitoring for status monitoring and validation monitoring
- LCFRB example illustrating the use of the master sample to design a new program for specific management objectives and strategies, showing integration with AREMP and IMW efforts (Ehinger et al. 2007)
- Washington example: integration of existing water quality monitoring (potential)

Linkages between the ISTM project and the following other ongoing PNAMP activities and products will be clarified:

- Protocol and methods library
- Monitoring glossary
- Aquatic Resources Schema
- RME project tracking databases

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Appendices

Appendix A - Table of existing habitat/watershed condition and salmon status and trend monitoring in the Lower Columbia

(To be revised later based on LCFRB RM&E plan, PNAMP Inventory, LCREP/PNNL Columbia River Estuary Monitoring table, etc)

Entity & Program Name	Area(s) of Inference	Type of design[2]	Purpose of Surveys
WA Ecology: Habitat status and trend monitoring	Salmon recovery regions statewide (Lower Columbia)	GRTS	Habitat status and trend information to support salmon recovery and watershed health, and high level indicators
ODFW	Lower Columbia	GRTS	Habitat and salmonid status and trends
USFS: AREMP	HUC 6	GRTS	Characterize watershed condition
WDFW: SASSI program	Salmon index reaches based on populations	Index census	Status and trend in: -Adult Coho, Chinook, Chum, salmon and steelhead spawner abundance, productivity, and spatial structure
WDFW: Smolt Program	Population based assessment based on a point estimate	Convenience-based	-Juvenile salmonid density and spatial structure Juvenile salmonid smolt traps productivity assessment
NPDES Water Quality Monitoring	Site specific pending permit requirement		Water Quality Assessment
Clark County Water Quality Monitoring	Clark County		Water Quality Assessment
LCREP/EPA/NOAA: Toxic sediment monitoring	Columbia River Estuary		Sediment toxic concentration
LCFRB Gap Analysis	Use LCFRB RM&E Program doc		
USGS/EPA: Proposed Water Quality Designs	From Columbia River Estuary Hydro geomorphic Assessment and Mainstem River	Area-based design	Identify the proposed program for the estuary and mainstem

[2] (1) Convenience-based; (2) surveys – census, simple random: stratified, cluster, nested, adaptive; systematic; GRTS; (3) model-based; and (4) comparative (space/time).