Puget Sound Chinook Salmon Recovery Plan

MONITORING AND ADAPTIVE MANAGEMENT PLAN

VOLUME II

DRAFT

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MONITORING PLAN FOR PUGET SOUND CHINOOK SALMON

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Introduction

A robust monitoring and adaptive management approach (MAMA) must address a wide variety of key management questions and decisions. Those management questions and decisions are set forth in Volume I of this MAMA Plan. This Volume II provides the overall monitoring plan framework under which data and information will be collected, analyzed and then reported to the Recovery Council and Watershed planning groups and NOAA, who are collectively responsible for the strategies and actions set forth in the Recovery Plan. For more information on the roles and responsibilities for implementation and adaptive management of the Recovery Plan, see Volume I.

This Monitoring Plan must be able to produce information that enables these decision-makers to track the progress of salmon recovery in Puget Sound at multiple scales (e.g., watershed, regional) and over relevant time frames. To get there, this plan includes basic descriptive monitoring:

- tracking **implementation** of strategies and actions,
- tracking **status and trends** in salmon populations, watershed condition (habitat and water quality) other limiting factors (harvest, hatcheries, hydropower), natural factors affecting salmon populations (predation, disease, ocean and climate conditions);
- **determining the effectiveness** of strategies and actions; and
- **validating hypotheses** (which tell us whether the implemented actions caused the resulting habitat and/or biological changes in salmon).

In an ideal world it would be possible to monitor everything everywhere to address all questions. However, such an approach is cost prohibitive. Efficiencies can be gained by using an integrated framework and drawing upon existing efforts to the extent possible. The approach will ultimately serve to address the extent to which recovery plan actions are effective in:

1. Moving key populations within the ESU to low risk
2. Protecting habitat and/or habitat forming processes
3. Restoring habitat forming processes, and
4. Removing threats (limiting factors, plus the other NOAA criteria, such as disease, predation, natural factors such as natural global variations in ocean conditions; man-made change such as climate change, etc.)

General structure of the Regional Monitoring Plan

As noted above, the monitoring framework for the Puget Sound Chinook Salmon Recovery Plan is designed according to the type of information needed to answer the management questions associated with benchmarks in Volume I, which are established for each major strategy in the Recovery Plan. Those management questions drive the design of the Monitoring Plan. Three different categories of monitoring will be utilized: implementation monitoring, status and trends monitoring, and effectiveness monitoring to answer specific biological effects questions where uncertainties exist. Each of them is briefly described below. Following those descriptions are the detailed monitoring plan proposals for each the three different categories of monitoring. The information gained from these different categories of monitoring will be used to answer the management questions described in Volume I, which will guide the adaptive management of the Recovery Plan over time.

The next section of the Monitoring Plan defines the data management system requirements that are necessary to provide transparency and accountability to the adaptive management system, along with a proposal for how data will be managed in the short-term until such a system is available.
Finally, this Plan provides a first assessment of the monitoring gap that exists in the region that will need to be filled if we are to begin implementation of the Monitoring and Adaptive Management Plan in 2008. A proposed schedule for implementation of the MAMA Plan is set forth in Volume I.

Implementation monitoring

This type of monitoring answers the question, “Are the strategies and actions outlined in the Puget Sound Salmon Recovery Plan being accomplished?” Results from implementation monitoring show progress in the near term. In general, implementation monitoring metrics inform the public and those who fund our efforts how efficiently salmon recovery actions are being implemented. These metrics help decision-makers determine where and why we see implementation successes and failures.

Management Questions related to Implementation of the Recovery Plan

Implementation monitoring metrics should provide the Recovery Council, Partnership and Watersheds with information as to the following questions:

- Did we complete the number of priority actions that were planned for the year? If not, why not?
- Are the strategies detailed in the Recovery Plan being implemented at a pace that will achieve the desired milestones?
- How well are we implementing our proposed strategies and actions?
- Do we have the necessary funding, staffing capacity, and public and political support necessary to sustain implementation over time?
- Are we implementing our strategies in an integrated way that maximizes efficiencies and the benefits of actions across the H’s?
- Have our efforts to implement recovery strategies been constrained in some way? If so, how?
- How many key uncertainties are being assessed through specific research plans?
- When assessing the overall effort to implement the Recovery Plan, do key assumptions or hypotheses need to be revised? Does the Recovery Plan need to be adjusted in some significant way?

These questions are in addition to the specific management questions that are set forth in Volume I for each factor and sub-factor attached to a benchmark.

Status and trends monitoring

For the purposes of this document, “status and trends monitoring” refers to the status and trends of regional conditions relating to certain benchmarks factors described in Volume I (See Chapter Two). This type of monitoring asks whether recovery actions are cumulatively resulting in an improvement in salmon viability and the factors affecting viability. Status and trends monitoring answers:

- What is the status and trend in salmon VSP characteristics? (benchmark 1)
- What is the status and trend of primary limiting factors (habitat, harvest, hydropower, hatcheries, predation and disease, ocean conditions and climate change)? (benchmark 2)

For all of the benchmark factors, it is recognized that baseline monitoring data will be essential. Baseline data helps establish current conditions and historical trends within a watershed or at another spatial scale. Some baseline data for the indicators described in this section may already exist, is currently being collected or collection is planned. Before this adaptive management and monitoring plan is implemented, an effort will be made to collect and summarize existing monitoring data in order to gain a clear picture of the gaps and needs for additional monitoring.

Effectiveness monitoring

This type of monitoring relates to the *expected physical and biological responses* resulting a recovery action. It answers the question, "Did recovery actions cause a desired *physical change* and/or *expected biological response.* This type of monitoring essentially helps us understand the cause and effect of actions and results. Results from effectiveness monitoring will show progress in long-term time frames, approximately 10 to 20 year timeframes, so it is important to begin this type of monitoring soon.

Effectiveness monitoring metrics should answer the following specific management questions:

- What is the hypothesis supporting each major strategy in the Recovery Plan?
- What are the expected physical, biological changes and timeframes for those changes?
- What is the overall effectiveness of recovery actions? (e.g., are negative trends in habitat quality being reversed? Is quality habitat being restored faster than it is being lost?)
- Are there certain categories of salmon recovery actions that are consistently failing or succeeding?
- How does the integrated suite of actions in all of the H-sectors affect each of the VSP parameters?

CHAPTER ONE

IMPLEMENTATION MONITORING

As noted above in the introduction, this section tracks how well the Recovery Plan is being implemented. It assumes that all Recovery Plan strategies will be completed by 2017. Under this Plan it is recommended that implementation **monitoring occur annually, with progress reports occurring twice a year** in the Spring and Fall.

A. The Master Implementation Monitoring Schedule

In order to facilitate this process, a **Master Implementation Monitoring Schedule (MIMS)** covering the major strategies in the Recovery Plan has been prepared and is included in Volume III as Appendix A. It was created by analyzing the actions and strategies in each major component of the Recovery Plan and documenting the important steps ("benchmarks") that must be taken within each to move the effort forward. Critical dates for achieving benchmarks are established for each major strategy in the MIMS, so that the Recovery Council, Watersheds and NOAA can measure the pace of plan implementation.

Given that some strategies require further work and planning to establish specific actions to achieve the intended result, this chapter also identifies the steps that need to be taken to accomplish that work within the timeframe of the Plan.

The MIMS also contains a set of specific events ("triggers") which have the potential to impact successful implementation of each strategy. When a triggering event occurs, it is expected that reporting will occur immediately (at the next available meeting of the Recovery Council or Watershed planning group) so that the responsible decision-makers are fully informed in a timely manner and able to adjust their recovery actions or take other efforts as needed to ensure the successful implementation of the Plan.

The MIMS should ultimately reside in a database that is available to decision-makers, implementers and the public. **It is proposed that the Puget Sound Partnership initially take responsibility for maintaining the Master Implementation Monitoring Schedule during the 2008 transition** of the salmon recovery work to the Partnership, to ensure that this critical monitoring component is staffed and implemented.

The MIMS currently includes schedules for all regional strategies in the Recovery Plan relating to all listing factors, except as noted below by an asterisk (*). Where an implementation schedule has not yet been completed, it is anticipated that those will be completed by the end of the second quarter of 2008. When completed, those schedules will be added to the Master Implementation Schedule attached to this Plan at Appendix A. Strategies that are incomplete and need further development or strategies that have not yet been developed are noted below with a (+) symbol. It is anticipated that a work program will be established for each of the incomplete or non-existent strategies in the Recovery Plan, and that their development will occur throughout 2008-2009. Once established, these work programs should be placed on the MIMS and monitored to ensure completion.

Appendix A: Master Implementation Monitoring Schedule

ESU (Regional) Scale:

- Habitat Recovery Plan Strategies+
- Hatchery Management Plan Strategies
- Harvest Management Plan Strategies
- Natural Factors (predation, disease, ocean and climate)*+
- H-Integration
- Funding Strategy
- Outreach and Education Strategies+
- Capacity Building in Watersheds and the Region

Population (Watershed) Scale:

- Habitat Recovery Plan Strategies*
- Hatchery Management Plan Strategies*
- Harvest Management Plan Strategies*
- Outreach and Education Strategies+
- H-Integration

Relationship to Watershed-Specific Implementation Monitoring.

It is anticipated that work will begin with individual watersheds in early 2008 to create implementation monitoring frameworks where they do not already exist for each population-specific set of recovery strategies. It is the goal of the MAMA Plan to provide guidance and a helpful framework for watersheds to use in creating an implementation tracking system, but not to mandate a single approach that must be used within each watershed. The important outcome will be for each watershed to reliably track their progress in implementing local strategies and actions, and report that progress to the region in a manner that allows for a regional view of the efforts across the ESU to implement the Recovery Plan.

Some watershed planning groups are presently monitoring the implementation of their strategies and actions. The asterisk associated with all watershed scale strategies simply refers to the fact that a MIMS has not yet been completed for those watersheds and added to the Master schedule attached at Appendix A. Once information is received from all sources (regional and watershed) about implementation, a report card approach will be used to gauge progress on strategies and actions. The report card will inform the Recovery Council, Watershed planning groups and other parties where focused attention and support is needed to accomplish the work.

Additional Work Needed to Complete the Overall Implementation Monitoring System

It should be noted that there are strategies within the Recovery Plan that require further work and the identification of actions to implement them. (Examples include actions to carry out the nearshore regional strategies, the identification of a specific set of actions to carry out monitoring and adaptive management, etc.) When this work is completed, the actions should be added to the MIMS and tracked so that the parties responsible for the Recovery Plan have a full picture of what needs to be accomplished and the time frames associated with that work.

B. Proposal for Implementation Monitoring

Setting Priorities for Implementation Monitoring

The MIMS sets forth a schedule for implementing all regional actions set forth in the Recovery Plan. However, it is recognized that resources may not be available to accomplish every action in the first five years of implementation. Accordingly, it is important that the Recovery Council, Partnership and Watersheds identify the highest priority needs and focus implementation tracking on those items. At this stage, this MAMA does not provide a specific proposal for high priority needs. This should be accomplished by the end of the first quarter of 2008.

CHAPTER TWO

STATUS AND TRENDS MONITORING OF LISTING FACTORS

INTRODUCTION

This section addresses describes the proposed approach to performing status and trends monitoring for salmon viability (benchmark 1), as well as each major listing factor affecting salmon viability (benchmark 2). They include:

- Salmon Viability Characteristics (VSP)
- Habitat and Hydropower Conditions
- Hatcheries and Harvest
- Disease and Predation
- Ocean and Climate Conditions

A. Status and Trends Monitoring of Salmon Viability (VSP)

Understanding the status and changes over time in fish and environmental conditions provides essential information from which to interpret how well the recovery plan is achieving its goals. It is fundamentally supportive to effectiveness monitoring. This type of monitoring should be performed for each of the 22 salmon populations that make up the five biogeographical regions within the ESU, however the level of intensity of the monitoring which occurs may vary by population.

The components included in this status and trends monitoring approach address the following key question:

What is the status and trend in salmon VSP characteristics?

Answering this key question will involve monitoring adults and juveniles, and viewing that information at population, biogeographical (or MPG) and ESU scales. Importantly, monitoring of spawner abundance is ongoing for all populations in the Puget Sound Chinook ESU (See Appendix C). This monitoring provides basic information necessary to assess general trends in population productivity as measured from the adult-to-adult stage. However, to address trends in freshwater productivity, juvenile monitoring is also needed.

To that end the Governor's Forum on Monitoring advocates implementation of a "fish-in/fish-out" approach for identified primary populations[1]. In those locations, juvenile salmon migrating downstream (smolts) and the number of fish surviving to return as adults would be monitoring together in each MPG in the Puget Sound Chinook ESU. The Forum's Framework proposes to achieve a minimum of one monitored "fish-in/fish-out" population for each MPG to represent the ESU as a whole. This monitoring is intended to determine if populations in each of the five Chinook MPGs comprising the ESU are achieving the abundance and productivity goals established in the recovery plan.

For the purpose of answering specific management questions at the regional scale (MPG and ESU), this Plan proposes to use an intensified version of the Forum's status and trends monitoring approach. The level of activity and pace of monitoring under that approach is a policy question for the Recovery Council to consider. A set of policy options for performing this monitoring is set forth below in

[1] Primary populations are those that have a high significance and must achieve a low risk of not meeting viability criteria (of extinction) as identified in recovery plans (GSRO 2006). For the Whidbey Basin MPG, populations needed at low risk status will include at least two to four populations, at least one of which is an early-run population.

Chapter Two, Section (F). Once the policy option is chosen, additional design work will need to occur in order to finalize the details of where and when specific status and trends monitoring will be performed.

Although spawner abundance monitoring occurs for each population of Puget Sound Chinook, juvenile outmigrant monitoring does not. Appendix C identifies current adult and juvenile population monitoring by MPG, monitoring organization and funding source. More work is needed to identify primary populations for the Whidbey Basin and Central/South Sound Basin MPGs, to explore options to fill juvenile outmigrant monitoring gaps to meet or exceed Forum criteria (i.e., monitor a minimum of one primary population per MPG), and determine how those gaps might be feasibly addressed.

Table 1 identifies for each VSP parameter the monitoring questions, objectives, indicators, sampling tools and analysis needed. Currently ongoing or planned adult and juvenile out-migrant monitoring across Puget Sound is summarized in Appendix C. Key fish monitoring needs or gaps are summarized in Appendix D.

TABLE 1 – Monitoring status and trends in biological effects -What is the status and trend in VSP parameters?

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Abundance	What are the size and trend in population spawner abundance relative to recovery objectives? What are the current juvenile abundance and trend relative to the recovery objective?	Monitor abundance of representative populations of adult spawning Chinook in each MPG/bioregion Monitor juvenile abundance of representative populations of Chinook in each MPG/bioregion	Estimates of absolute or relative abundance from counts of live fish, carcasses, or redds hatchery/wild origin Juvenile migrant population estimates or indices of abundance, size, age, migration dates	Representative long term sites (dams, weirs, snorkel, ground or aerial surveys) Collection of migrating juveniles at representative index sites (traps, mark-recapture, catch per unit effort)	Geometric mean number of spawners and annualized population growth rate Annualized population growth rate, juveniles per spawner
Productivity	What are the current productivity and trend in productivity relative to the recovery objectives?	Monitor productivity of representative populations of Chinook in each MPG/bioregion	Numbers, ages, hatchery/wild origin	Annual size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data	Natural juvenile and/or adult recruits per spawner based on cohort run reconstructions
Spatial structure	How many reaches are used for spawning and how has distribution of spawners among reaches varied in relation to abundance, accessibility and historical use?	Monitor distribution/spatial structure of representative populations of Chinook in each MPG/bioregion	Indices of relative abundance of adults from counts of live fish, carcasses or redds and/or juveniles based on snorkel, electrofishing, or seining surveys	Representative long term sites (dams, weirs, snorkel, ground or aerial surveys); and replicate random samples stratified by time period and area in one or more years, repeated at periodic intervals	Relative abundance, range, patchiness, used vs. available area, representation of index sites identified in routine sampling
Diversity	Do all life history patterns continue to be represented and are traits changing relative to objective descriptions?	Monitor trends and variation in diversity of representative populations of Chinook in each MPG/bioregion	Sex, size, fecundity, migration timing, hatchery influence, genetic characteristics	Representative individual samples from adult or juvenile fish or carcasses in conjunction with adult or juvenile abundance and distribution sampling	Averages and frequency distributions over time

Key Terms: A complete glossary for the MAMA is set forth in Volume I, however, for purposes of understanding certain terms used in Table 1, a set of key terms are defined below:

Indicators: [add definition here]
Absolute or Relative Abundance: is derived from an analysis of counts of live salmon, carcasses, or redds. (this should distinguish Hatchery Origin Salmon (HOS) from Natural Origin Salmon (NOS) where possible.
Age Class/Jacks:
Migration Timing: The time in which a population/run enters an estuary, and the time the run reaches it's spawning grounds is used to determine is variations in the timing of runs may impact the viability of salmon.
Spawn Timing: the time which a population/run spawns/makes redds.
Fecundity: The number of eggs or progeny per adult or female. How is this collected. Is it based on size. (note it would be good for spawning surveys to identify the sex and size of a fish and the origin to evaluate changes in fecundity or to make better estimates of egg production, to improve survival estimates
Sex: is the adult male or female. This is used to evaluate changes in ratios of males and females
Productivity: Adult cohort spawner to progeny spawner abundance ratio
Juvenile Abundance/productivity: Juvenile migrant population estimates or indices of abundance, size, age, migration dates used to identify freshwater productivity, estuary nearshore and possibly ocean productivity.

B. Status and Trends Monitoring of Habitat Conditions

Outlined below is an approach to monitor the status and trends of habitat condition of Puget Sound watershed, estuarine and nearshore habitat and water quality and quantity on non-federal lands. This program should partner with federal agencies to complete a comprehensive analysis of water quality, water quantity and habitat condition. This program provides the ability to track changes in major habitat limiting factors identified in the recovery plan and provides information to answer key uncertainties in how significantly other limiting factors impact a population. This status and trends approach aligns monitoring needed to address the key question:

What are the status and trends of primary habitat limiting factors?

This plan builds on the statewide monitoring "Framework" recommended by the Governor's Forum on Monitoring but recommends more intensive monitoring by adding additional sites within the ESU[2]. Answering this key question will involve various habitat status and trend monitoring approaches, and will require analysis of the information at multiple scales.

This MAMA Plan proposes to monitor habitat status and trends as follows:

1. Perform coarse scale region-wide tracking of changes in habitat and water quality indicators (limiting factors) at the population level using remote sensing of land cover, impervious surfaces, and floodplain area via satellite coverage,

2. Perform Fine Grained monitoring on-the-ground (EMAP) field sampling of other habitat parameters (stream bank and channel condition, substrate/sediment, wood, water quality, invertebrates) using the Forum's probabilistic master sample draw and sampling protocols.

3. Perform mid-grained tracking of habitat indicators in an identified set of watersheds distributed across Puget Sound using (1) aerial photography and combining it with the coarse-scale habitat information gained from satellite imagery and on the ground field sampling; and (2) perform this monitoring in at least one primary population in each of the five MPGs[3] in order to track changes in freshwater productivity (e.g., combine aerial photography with other information on riparian vegetation, channel morphology, LWD).

4. Provide a design for refined site-specific monitoring of habitat indicators. The Governor's Forum Habitat monitoring plan provides a sampling design that can be used to incorporate additional monitoring to evaluate reach or site-specific problems as well. This will allow the inclusion of site-specific monitoring proposed by individual watershed planning groups in areas of known concern where the probabilistic sample draw would not focus on such sites. This proposal will require additional information from watersheds as to what is desired or needed for a particular population within specific stream reaches or systems.

Additional details for the four components of the Habitat Status and Trends Monitoring Proposals are set forth below.

[2] Washington State framework for monitoring salmon populations listed under the federal Endangered Species Act and associated freshwater habitats. 2007. Governor's Forum on Monitoring Salmon Recovery and Watershed Health. Edited by B. A. Crawford. www.iac.wa.gov/Documents/Monitoring/Framework_Document.pdf

[3] This proposal is a policy decision subject to scaling as shown in Section XX below,

1. Coarse scale and mid-grained region-wide monitoring of habitat and water quality

Remote sensing data from satellites (coarse scale) and aerial photos and additional GIS (Geographic Information System) (mid-grained scale) data will be obtained to evaluate changes in land conversion, impervious surfaces, and floodplain area across the Puget Sound region. Aerial photos will be used to generate a total census of the status and trends in habitat classification of riparian,vegetation type and cover, floodplain, estuarine & nearshore habitat types and where possible river channel morphology and large woody debris. Aerial photography can be used to update the status of mass wasting events, roads, stream crossings GIS data. Aerial photography monitoring will be done where there are complimentary salmon productivity (i.e., fish in-fish out) data and where local interests exist. Remote sensing data provides "big picture" indicators of land use changes. In this plan remote sensing, however, is not be intended to measure fine scale habitat indicators or water quality, stream sedimentation, and other parameters needed to quantify some aspects of watershed health. Therefore, a combination of remote sensing and on-the-ground probabilistic sampling is necessary.

This work will complement ongoing efforts on federal lands in Puget Sound where the Aquatic and Riparian Effectiveness Monitoring Program (AREMP) is using satellite imagery to track changes on federal lands. (Future work with higher resolution remote sensing technology like Lidar and FLIR data, validated by the on the ground EMAP program may prove to be valuable tools for more extensive mapping of habitat limiting factors and threats like water temperature, floodplain condition and impervious surfaces of larger systems.)

2. On-the-ground (EMAP) field sampling of other habitat parameters

Probabalistic sample design. On-the-ground field sampling advocated by the Forum Framework is based on a sampling design and protocols adapted from the Environmental Monitoring and Assessment Program (EMAP) developed by the Environmental Protection Agency. It has been tested and applied widely. It is a statistical sampling approach not a census approach, and provides information for statistically valid evaluations without measuring everything everywhere.

The Forum Framework identifies collection physical, chemical, and biological data that will allow detection of changes to factors limiting salmon. It will allow detection of changes in fresh water quality, changes in sedimentation, fish cover, and instream structure, along with changes in fish and macroinvertebrate distribution and species composition. Changes to stream bank vegetation and structure can also be documented to compare with and validate information obtained from remote sensing. It can detect and monitor the occurrence and distribution of many invasive species. It should be noted that the Forum Framework did not include monitoring of pesticides and toxics, water quantity, estuarine and nearshore habitat condition. Additional work will be required to identify the status and trend monitoring that should be performed to fill these gaps.

The locations for sampling will be drawn from a master sample of sites on non-federal lands across all Puget Sound WRIAs (www.ecy.wa.gov/programs/eap/stsmf/). The master sample was developed by the Department of Ecology for the Salmon Recovery Funding Board. Applied to Puget Sound, the Forum Framework targets sampling of approximately 30-50 randomly selected (stratified by stream size), representative sample points from the master sample, every five years. More frequent or locally intensive sampling using the master sample could occur depending on the need and availability of funding.

Site-specific sampling. As noted above, the Governor's Forum Habitat monitoring plan provides a sampling design that can be used to incorporate additional monitoring to evaluate reach or site-specific problems as well. This will allow the inclusion of site-specific monitoring proposed by individual watershed planning groups in areas of known concern where the probabilistic sample draw would not focus on such sites. This proposal will require additional information from watersheds as to what is desired or needed for a particular population within specific stream reaches or systems. Data from previous and ongoing efforts can be incorporated, depending upon the consistency of those data with the master sample draw. Options for conducting this work are set forth in Chapter Two, Section F, below.

Getting Started

Logistics and resources for on-the-ground habitat field work will be determined in 2008 within the ESU, as implementation begins. Potential partners for conducting this monitoring work include Watershed planning groups, Regional Fisheries Enhancement Groups, conservation districts, municipalities, counties, private corporations, state agencies, and others having experience expertise and interest in participating in the monitoring activity. Contingent upon funding, the Department of Ecology will ensure that quality control measures and training needs are met to implement the EMAP sampling design among the various participants. Work will also need to be done to align current, ongoing water quality monitoring such as local government NPDES-driven monitoring programs and the Department of Ecology's TMDL program, as well as stream flow monitoring work that is ongoing by the US Geological survey, the Department of Ecology and any existing local government flow monitoring programs.

Watershed Monitoring Information Needs

Table 2 identifies, by general limiting factor the monitoring questions, objectives, indicators, sampling tools, and analysis needed to evaluate the status of habitat listing factors. Habitat status and trends monitoring (or component pieces of it) may be occurring now or may be planned within the ESU or an individual watershed, however, a complete assessment of the habitat monitoring effort needs to be completed as one of the first stages in implementing this part of the MAMA Plan. Once known, the key habitat and water quality monitoring needs and gaps should be summarized in an Appendix and attached to this Plan. It is essential that baseline information on habitat status is collected for each population so a frame of reference can be established to determine is habitat conditions are improving or degrading in the Puget Sound.

TABLE 2 - Habitat Limiting Factors Status and Trends Monitoring

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Degraded nearshore/marine and estuarine conditions and habitat loss	Is nearshore/marine and estuarine habitat improving?	Monitor Change in status of Estuarine and Nearshore habitat condition and quality	Tidal Marsh habitat Submerge Habitat Condition and Quality Shore protection structures and shore habitat status Structures Eel grass and Kelp Forests Biodiversity Species richness Estuarine and Nearshore productivity Contaminate concentration (sediment and in food web) Micro and Macro Detritus Status (See Scranton's email on indicators)	GIS and remote sensing analysis Field surveys	Decision support and GIS analysis of change in area of habitat
Degraded	Are floodplain and	Monitor floodplain	Land use/land cover	Remote sensing, GIS,	Maps of habitat

Floodplain, Channel structure	in-river channel structure habitats improving?	and in-river channel structure in representative areas in each MPG/bioregion	Thalweg Pool area Pool:riffle ratio LWD per mile Channel and bank length Off-channel area Width:depth Sediment load Bed scour Area of modified habitat removed from flood plain (miles of dikes or rip rap)	and field surveys using Forum framework	characteristics Time trend analyses Cumulative frequency distributions
Riparian area degradation and loss of in-river LWD	Are riparian and in-river large woody debris (LWD) habitats improving?	Monitor riparian habitat and in-river LWD in representative areas in each MPG/bioregion	Land use/land cover Vegetated area LWD per mile Area mature forest Canopy cover (Stream Temperature)	Remote sensing, GIS, and field surveys using Forum framework on non-federal lands; Aquatic and Riparian Effectiveness Monitoring Program (AREMP) on federal lands	
Altered channel morphology	Is channel morphology improving?	Monitor channel morphology in representative areas in each MPG/bioregion	Thalweg Pool area pools/mile Pool:riffle LWD/mile Channel and bank length Off-channel area Width:depth Substrate (See below)	Field surveys using Forum framework on non-federal lands Aquatic and Riparian Effectiveness Monitoring Program (AREMP) on federal lands	
Excessive sediment or impaired sediment recruitment	Is sedimentation improving?	Monitor sedimentation in representative areas in each MPG/bioregion	Road density and crossings Fine sediment Embeddedness Turbidity (See water Quality) Quality of Spawning Gravel	Field surveys using Forum framework on non-federal lands Aquatic and Riparian Effectiveness Monitoring Program (AREMP) on federal lands	

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Degraded water quality and temperature	Are water quality and temperature improving?	Monitor water quality (including temperature) in representative areas in each MPG/bioregion	Water temperature Toxics & pharmaceutical concentration Ph Dissolved oxygen Nutrients(N & P)	Field surveys using Forum framework on non-federal lands Aquatic and Riparian Effectiveness Monitoring Program (AREMP) on federal lands	
Impaired instream flows	Are instream flow regimes improving?	Monitor instream flow regimes in representative areas in each MPG/bioregion	Hydrograph Withdrawal/ consumption rate Impervious surfaces	Remote sensing, GIS Stream flow gauges Ground water withdrawal Water rights	

				allocation and use	
Barriers to fish passage	Is fish passage improving?	Monitor improvements to fish passage	Area of spawning and rearing blocked & area opened	Barrier inventories	
Watershed Condition	Are trends in watershed condition improving?		Road Density, Impervious surfaces Mass Wasting Land use/ land cover Wetland availability	GIS/remote sensing	US Forest Service AREMP Program Coordination
Food web	Is the food web changing in the watershed s		Macroinvertebrate	Field surveys	AREMP or PNAMP methods

See Chapter Two, Section F, below, for an integrated proposal for Priority 1 monitoring of fish and habitat as part of the first phase of implementing status and trends monitoring.

3. Nearshore Habitat Monitoring Information Needs

With respect to monitoring for the nearshore, little is known about its role in salmon viability and if or when nearshore habitat. Key questions that need to be understood are:

- What is the quantity, quality, distribution and diversity of nearshore habitat necessary to achieve the habitat functions and processes that support Chinook salmon populations?
- What is the "carrying capacity" of nearshore habitat (relative to hatchery vs. wild fish)?
- How do upland actions impact the functions and processes of nearshore habitats?
- Are we protecting and restoring nearshore habitat in the places where it is needed most to support Chinook salmon populations?

In order to reduce the risks associated with this scientific uncertainty, basic research should be performed to address a number of important questions such as those set forth in Table 3. Additionally, the Recovery Plan provides regional strategies to protect and restore nearshore processes, but further work is needed to develop a list of prioritized actions to achieve those strategies. Once known, status and trends monitoring should be performed on critical nearshore habitats, and effectiveness monitoring should be performed to assess the performance of actions. It is anticipated that a work program will be established by the Recovery Council in 2008 to begin scoping the actions and studies needed to further our understanding, protection and restoration of the nearshore.

Table 3. Research Questions to Address Critical Uncertainties related to the Nearshore

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Food Web	What are the species primarily consumed by juvenile salmon in the nearshore ?		**Status of primary producers**: Eel grass, sea algae, salt marsh plants, riparian plant micro detritus others (Some of these can be assessed by measuring quantity of habitat, while others are measure in the water column or in the herbivores **Status of Juvenile Salmon Prey** (Primary and secondary consumers): Plankton, copepods, amphipods and others.		
Food Web	What are the species primarily consumed by Adult salmon in the nearshore? (See ocean condition index)				
Food Web	What is the status of nearshore habitat?		**Nearshore pollutant/contaminant concentration:** Status of contaminats in sediments: More relevant is the status of pollutants or contaminant concentration in prey species or juveniles salmon as an indicator for water quality.		
	What is the status of juvenile salmon abundance in the nearshore: how many juveniles are caught in seines or tows?				

(Examples from the NOAA Fisheries Columbia River Estuary Module Recovery Plan) [finish the table]

- Water quality—Concentrations of toxics and contaminants.
  - Toxic Contaminant Concentration
- Change in Temperature
- Flows—daily average, maximum and minimum (m^3/s).
  -Changes in Peak Flows: Time, magnitude and duration
- Velocities—daily average, maximum and minimum (m/s).
- Elevation—daily average, maximum and minimum (m).
- Snowpack—Average levels in meters.
- Change in tidal Wetlands acreage, Intertidal habitat Acreage and Submerged aquatic acreage by Habitat type (Acres of habitat gained and lost, Topographic Elevation, Bathymetry, Water Elevation, Vegetion Change, habitat type & Landscape features (Remote Sensing IR photo, Lidar, Hyperspectral), Invasive species)
- Water Discharge/withdrawl
- Passage Barriers/ Connectivity

- Invasive Species Index
- Biological Diversity
- American Shad Index
- Predation/competition
- Disease
- Status or Change in Status of Riparian Condition
- Change of in-channel structures
- Sedimentation
- Status of dredge spoils
- Wake Stranding
- Change in Micro detritus and Macro detritus

4. Hydropower and Flood Control Structure Monitoring Information Needs

Hydro system monitoring is directly related to habitat monitoring attributes previously identified. Licensed facilities should provide information on the status of habitat impacts. If facilities do not provide adequate information, additional information may be requested during relicensing or federal consultations.

Table 4 – Status and Trends Monitoring related to Hydropower and Flood Control

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Degraded water quality and temperature	Are water quality and temperature improving?	Monitor water quality for gas content Monitor reservoir temperature.	Water Temperature Dissolved gas concentration		
Barriers to fish passage	Is fish passage improving?	Monitor improvements to fish passage	Adults mortality in passage Juvenile mortality in Passage	Barrier inventories	Are methods
Predation	Is predation a significant factor at these barrier (Ballard Locks)	Determine how populations are impacted by predators that use structures to their advantage.	Predator abundance Predation rate		
Impaired instream flows	Are instream flow requirements met?	Monitor instream flow regimes in representative areas in each MPG/bioregion	Hydrograph Withdrawal/ (CFS)	Stream flow gauges	
Impaired sediment recruitment	Is sedimentation below dams improving?	Monitor sedimentation below structures	Embedded ness Quality of Spawning Gravel	Field surveys using Pebble Count and AREMP methods	

C. Status and Trends Monitoring of Hatcheries and Harvest

The Puget Sound Chinook Salmon Recovery Plan has incorporated resource management plans for harvest and hatcheries for purposes of establishing the recovery strategies and actions needed to remove threats from those activities to salmon viability. As such, this MAMA Plan includes those resource management plans for purposes of guiding monitoring and adaptive management related to harvest and hatcheries.

Hatchery Management and Reform

The Co-managers have proposed a Draft Resource Management Plan for Chinook Salmon Hatcheries, ("RMP" or "Hatchery Resource Management Plan"), a component of the Comprehensive Chinook Salmon Management Plan developed by Washington Department of Fish and Wildlife and Puget Sound Treaty Tribes. It states:

Research, monitoring, and evaluation are important tools in guiding the future changes of these hatchery programs and in integrating the overall benefits of hatchery, fishery management, and habitat recovery actions for chinook salmon and other species. Recognizing this, scientists from the tribes and WDFW are actively working to:

- Develop adaptive management tools for hatchery management and production protocols based on the results of new research conducted in the region that focuses on the effects of artificial propagation on listed natural salmonid populations;

- Coordinate with NMFS and the HSRG to plan, seek funding for, and conduct research in the Puget Sound region that will help indicate the genetic, ecological, and demographic effects of chinook salmon artificial propagation programs on the survival and productivity of listed and non- listed salmonid populations, and

- Integrate analysis of hatchery, fishery management, and habitat recovery activities to be able to make effective management decisions in individual watersheds and across the ESU.

The Washington State Department of Fish and Wildlife, as co-managers working with Treaty Tribes, has stated that their goal is to

> …protect, restore, and enhance the productivity, abundance, and diversity of salmon and their ecosystems to sustain ceremonial, subsistence, commercial, and recreational fisheries, non-consumptive fish benefits and other cultural and ecological values. Restoring populations of Puget Sound chinook salmon will depend on integrated management of all factors affecting the salmon throughout their life cycle, including freshwater, estuarine and marine habitats, ecological interactions, harvest, and hatchery programs.

The purpose of the Hatchery Resource Management Plan is to describe the operating procedures for chinook salmon hatcheries in Puget Sound, their role in achieving the co-managers' resource management goals, and their consistency with the protection given to Puget Sound chinook salmon by the Endangered Species Act (ESA). The Plan describes both Tribal and WDFW hatcheries, because these hatcheries are tightly linked – they often operate in the same watersheds, exchange eggs, and share rearing space to maximize the effectiveness of the programs. The benefits of the programs are also shared, including the perpetuation of critically depressed populations and the harvest of returning adults.

The court-ordered Puget Sound Salmon Management Plan provides the framework for coordinating these programs, treaty fishing rights, artificial production objectives, and artificial production levels. Based on this framework, the parties to *United States v. Washington*, with the National Marine Fisheries Service (NMFS), developed a Plan jointly as part of the Comprehensive Chinook Salmon Management Plan, which identifies interim goals for harvest and hatcheries.

The draft RMP describes the scientific foundation and general principles for evaluating artificial production programs and for continued hatchery reform. It builds on a biological assessment of tribal hatchery programs submitted to NMFS by the Bureau of Indian Affairs (BIA) in October, 1999, as required by section 7 of the ESA, and incorporates management alternatives subsequently developed by NMFS and the tribes. It also draws from the recommendations of the Hatchery Scientific Review Group (HSRG), a panel of independent scientists charged by the U.S. Congress with promoting hatchery reform.

The following general principles guide the Plan:

- Hatchery programs need clearly stated goals, performance objectives, and performance indicators.
- Hatchery programs need to coordinate with fishery management programs to maximize benefits and minimize biological risks so that they do not compromise overall plans to conserve populations.
- Priorities for brood stock collection of listed fish depend on the status of the donor population, relative to critical or viable population thresholds. Highest priority for brood stock collection of listed populations below the viable threshold is conservation. Brood stock collection for other priorities depends on meeting the conservation goals and not appreciably slowing recovery to viable levels.
- Hatchery programs need protocols to manage risks associated with fish health, brood stock collection, spawning, rearing, and release of juveniles; disposition of adults; and catastrophes within the hatchery.
- Hatchery programs need to assess and manage the ecological and genetic risks to natural populations.
- Hatchery programs must have adequate facilities and maintenance to rear fish, maintain fish health and diversity, and minimize domestication in fish of naturally spawned brood stock.
- Hatchery programs should be based on adaptive management, which includes having adequate monitoring and evaluation to determine whether the program is meeting its objectives and a process for making revisions to the program based on evaluating the monitoring data.
- Hatchery programs must be consistent with the plans and conditions identified by Federal courts with jurisdiction over tribal harvest allocations.
- Hatchery programs will monitor the “take” of listed salmon occurring in the program and will provide that information as needed.

In addition to the benefits provided by artificial production, the scientific literature indicates that artificial production may pose risks to wild chinook salmon populations. These potential risks include: 1) genetic impacts, which affect the loss of diversity within and among populations and reproductive success in the wild; 2) ecological impacts, such as competition, predation, and disease; and 3) demographic impacts, which directly affect the physical condition, abundance, distribution, and survival of wild fish.

The risks and benefits resulting from each artificial production program for chinook salmon in Puget Sound were evaluated in multiple ways, including the Benefit Risk Assessment Procedure, recommendations of the Hatchery Science Review Group (HSRG), and extensive discussions with NOAA Fisheries staff. This multifaceted review, in conjunction with numerous actions previously initiated by the comanagers, has resulted in significant improvements in chinook salmon programs in Puget Sound, and extensive commitments to monitoring and evaluation. Key elements of the plan are summarized below:

Genetic Impacts. The development and implementation in 1991 of a new stock transfer policy (WDFW 1991) designed to foster local brood stocks resulted in a significant reduction in the transfer of eggs and juveniles between watersheds. In recent years brood stocks established from Green River fish have been also been eliminated or replaced in rivers with extant indigenous stocks.

Ecological Interactions. The Puget Sound Tribes, WDFW, and the HSRG are now conducting numerous studies to evaluate the risks posed by ecological interactions of chinook salmon of hatchery and natural origin. Data collected through the studies will be used to adjust, if necessary, release numbers, release timing, or characteristics of the programs. In the interim period, hatchery programs will apply measures based on the best available science to reduce the risks posed by ecological interactions. These actions include:

1. Terminating the net pen programs discussed above;
2. Terminating the McAllister Creek Yearling program;
3. Reducing the Wallace Yearling summer chinook production from 520,000 to 250,000;
4. Releasing fish at a time, size, and physiologically condition that provides a low likelihood of residualization and promotes rapid migration through the estuary to marine waters. Programs typically release subyearling chinook salmon that are in the 40 to 90 fish per pound (77 to 100mm fork length) during the months of May and June. Fish released at this time and size are fully smolted, are unlikely to residualize, and are expected to move rapidly through estuarine areas;
5. Releasing subyearling fish that are a larger size than natural-origin chinook salmon of the same brood year to reduce the potential for diet overlap with any co-occuring natural origin fish in marine waters.
6. Limiting the total releases of chinook salmon in Puget Sound and reducing or minimizing releases affecting key stocks. The chinook salmon programs proposed in this plan constitute a 37% reduction in production relative to 1990, including a 35% reduction in yearling production;
7. Implementing fish health policies and procedures (PNFHPC 1989; Comanagers 1991; WDFW 1996); and
8. Maintaining state-of-the-art fish health monitoring, facility disinfecting, and disease management procedures presently applied in the operation of Puget Sound hatcheries.

Direct Demographic Impacts. The operation of hatchery facilities was analyzed, potential concerns identified, and actions undertaken and/or capital funding requested for facility modification. These actions and funding requests include:

1. Screening all water intakes at Dungeness Hatchery to prevent adverse impacts to listed fish;
2. Exploring removal of the Canyon Creek intake to allow passage of juvenile and adult chinook salmon to available spawning and rearing habitat;
3. Building an expanded incubation and early rearing facility at the Elwha Hatchery; and
4. Exploring capital improvements to the pollution abatement system and the adult trapping/holding ponds at the Wallace River Hatchery to facilitate sorting of natural and hatchery-origin fish.

Research, Monitoring and Evaluation. Significant uncertainty exists in the threats posed by artificial production programs. To address these uncertainties, this plan includes substantial commitments to research, monitoring, and evaluation:

1. Marking all chinook salmon artificial production from Puget Sound, including program specific marks where multiple program(s) may affect a stock;

2. Monitoring chinook salmon escapements to estimate the number of tagged, untagged, and marked fish;
3. Collecting and analyzing genetic data, including natural spawners in the North Fork Stillaguamish River, South Fork Stillaguamish River, Puyallup River, Nisqually River,
4. Conducting a study to determine the relative reproductive success of naturally and hatchery produced chinook salmon in the Green River; and
5. Conducting studies on the incidence and effects of competition and predation in fresh and marine waters.

The co-managers are committed to the ongoing transformation of hatcheries from one of the all-H (habitat, hydro, harvest, and hatcheries) risk factors to an integrated, productive, recovery tool. The draft RMP takes a significant step forward, while recognizing the role that hatcheries must play in mitigating for the land and water- use decisions that have resulted in the permanent loss or degradation of salmon producing habitat.[4]

Given that the RMP provides the necessary policy and scientific framework for managing hatchery impacts to salmon and will includes monitoring and adaptive management strategies for hatcheries run by both the WDFW and Tribes, this MAMA Plan shall include the Hatchery Resource Management Plan as part of its overall framework. As such, no additional status and trends monitoring for hatcheries is proposed in this Monitoring Plan.

Table 5. Hatchery monitoring needs (Note: most hatchery monitoring information needs are identified in the VSP monitoring section)

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Hatcheries	What is the effect of broodstock collection on the population's abundance and productivity?	Number Natural Origin adults taken at facilities	Natural Origin adults and impact to productivity without broodstock as NOS Number of Hatchery fish allowed on Spawning Grounds Number of Hatcher fish removed by harvest or hatchery facility management Number Of facilities operating under ESA Authorized HGMPs		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs
Hatcheries	What is the effect of genetic introgression/ residualism on the population's diversity?	Track changes in gene flow Note: Residualism primarily occurs in steelhead	Genetic marking, the loss of genetic features to hatchery fish genes		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs
Hatcheries	What is the effect of domestication on the	Evaluate ability of	Fecundity and Freshwater productivity		

[4]Source: *See*, WDFW website at http://wdfw.wa.gov/hat/reports/chinook_manage.htm

	population's diversity?	NOS to survive in wild			
Hatcheries	What is the effect of hatchery-related disease on the abundance, productivity, distribution or diversity of the population?	Diseases treated at a hatchery, Locations and concentrations of disease in Tributary and nearshore habitat	Disease presence and ratio of presence in Hatchery or Natural origin fish, location and timing		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs
Hatcheries	What is the effect of hatchery-related competition/density dependent effects on the abundance, productivity and distribution of the population?		Hatchery Origin fish fitness Total carrying capacity of habitat (Habitat productivity)		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs
Hatcheries	What is the effect of hatchery-related changes to predation rates on the abundance, productivity, diversity and distribution of the population?	Does the abundance of H origin Salmon increase the predator population and it's habitat capacity	Number of Predators Consumption rates Ratio of H & N origin salmon consumed by predators Rate By predator Adult and juvenile run timing		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs, and NOAA NWFSC Puget Sound disease Research Program
Hatcheries	What is the effect of hatchery-related changes to ecosystem nutrient dynamics on the abundance, productivity and distribution of the population?	Determine if abundance of hatchery fish impacts Natural oring salmon through competition or other effects	Timing of release of hatchery fish Change in food web in watershed and nearshore habitat		
Hatcheries	What is the effect of hatchery spawning times on the diversity of the population?		Ratio of NOS to HOS Timing of spawning Masking (number of Hatchery origin fish marked) Fecundity		

Table 6 Harvest Monitoring Needs (Note: some Harvest monitoring information needs are identified in the VSP monitoring section (Escapement is typically the same as abundance)

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Harvest	What is the impact of this threat, expressed in terms of current total fishery exploitation rate, Catch and Spawner escapeemtn on the population?		**Exploitation Rate** **Spawner Escapement** **Total Catch**	Total fishing mortality rate in a fishery expressed as a sum of all fishery-related mortalities divided by that sum plus escapement. For Chinook salmon, exploitation rate is often presented as "adult equivalent" exploitation. Adult equivalency is the potential for a fish of a given age to contribute to the mature run (spawning escapement) in the absence of fishing. Because of natural mortality and unaccounted losses, not all unharvested fish contribute to spawning escapement, this is especially true for species like Chinook that do not all mature at the same age. For example, a two-year old Chinook has lower probability of surviving to spawn, in the absence of fishing, than does a five-year old; these two age classes have different adult equivalents.	ESA Authorized Fishery Managemtn and evaluation plans and Tribal resource Managemetn plans should evaluate these factors annual
Harvest	Does Harvest Impact Diversity	Does harvest shorten run timing by selective fishing on spefici run timing?	Harvest Timing		

Harvest	Does Harvest Impact Spatial Distribution	Does the location of a fishery limit spatial distribution VSP requirements	**Location of fishery (for Spatial distribution impacts)**		
Harvest	Does Harvest Impact ratio of NOS and HOS	Is the Impact of HOS reduced by Harvest?	Total Catch of NOS and HOS		
Harvest	Implementation needs	Does current Harvest meet or exceed allocated take	Total Catch and goals		
Harvest	Implementation needs	Are Fisheries operating with out ESA Authorization?	Number of Non ESA Authorized fisheries or TRMP's and FMEPs		

D. Status and Trends Monitoring of Other Natural Factors

Predation and Disease

The Recovery Plan does not yet include specific strategies to address other natural threat factors such as predation and disease. NOAA is currently performing some monitoring for each of these threat factors, and the Co-Managers are also working through the HSRG project to perform scientific research to address uncertainties about the impacts of hatcheries on wild salmon populations, including disease impacts.

More work needs to be done to create specific recovery strategies associated with these other threat factors, and to identify ongoing monitoring and additional monitoring that needs to be performed in conjunction with those recovery strategies.

Additionally, where predation risks to salmon are associated with other ESA-listed species for which recovery plans are being drafted or already exist (e.g., Southern Resident Killer Whales, Bull Trout, Steelhead, etc.), strategies and actions for those species will need to be closely coordinated in order to ensure positive outcomes are achieved for all ESA-listed species.

[Note: This section needs completion. It requires the identification of monitoring in the form of SARs that is underway in Puget Sound for certain marine mammals and pinnipeds subject to the ESA and MMPA, that prey on chinook salmon as a major food source. It is anticipated that NOAA can provide information to articulate the work that is underway].

Table 7: Predation, Disease and Competition Monitoring Needs

Parameter	Monitoring questions	Monitoring objective	Indicators/data	Sampling Tools	Analysis
Predation	What is the impact of this threat, expressed on populations ?	Determine predation rates and level of impact by predators	**Status of Predator populations - Marine Mammals: Killer Whales, Seals and Sea Lions. - Predatory Birds: Terns - Fish: Non native Bass or Walleye populations, Cod and Rock fish**	Census surveys or estimates, Research on predation rates	
Disease	What is the effect of disease on the abundance, productivity, distribution or diversity of the population?	Identification of impacts of Locations and concentrations of disease in Tributary and nearshore habitat	Disease presence and ratio of presence in Hatchery or Natural origin fish, location and timing		Coordinate with WDFW, Tribal and USFWS hatchery HGMP M&E programs

Competition	What is the effect of disease on the abundance, productivity, distribution or diversity of the population?		Invasive Species Species Richness or Biodiversity Index Changes in habitat productivity or capacity		

D. Status and Trends Monitoring of Other Natural Factors

Ocean and Climate Conditions

The Recovery Plan does not yet include specific strategies to address other natural threat factors such as ocean and climate conditions. NOAA and the West Coast University Oceanographic programs are currently performing some monitoring for each of these threat factors. However, more work needs to be done to create specific recovery strategies associated with these other threat factors, and to identify ongoing monitoring and additional monitoring that needs to be performed in conjunction with those recovery strategies.

The following is a list of parameters from NOAA that should be monitored to detect changes in ocean conditions:

Status and Trends of Ocean Conditions

Derived Variables:

- Large Scale North Pacific: Pacific Decadal Oscillation (PDO) Index
- Large Scale North Pacific: MEI: El Nino Southern Oscillation (ENSO) Index
- Local and regional physical conditions (Upwelling index based on Ekman mass transport calculation)
- Sea Surface Temperatures /NOAA Buoy or Satellite (Sea Surface Temperatures, Sea surface elevation, ENSO, PDO, Productivity index)
- Deep Water Temp & Salinity
- Puget Sound Hydro Model
- Zooplankton Index
  Copepod Species Richness, Northern Copepod Biomass Anomolies
- Predator Fish Abundance
- Hake Index (catch per volume from trawl samples)
- Transition and coho survival
- Forage Fish Abundance
- Catches of Coho in September trawl Survey
- Catches of Spring Chinook in June trawl Survey
- Spring Transition
- Local Ecosystem conditions

Status and Trends of Climate Change in Puget Sound

The metrics needed to assess drought conditions are currently measured by state and federal agencies throughout the Puget Sound. Even though a module has not been developed for climate change, monitoring within the sub-basin should be consistent with other regional programs. Research and monitoring for climate change is currently being conducted by NOAA, UW, Tribes, USGS and others. A regional module for monitoring climate change impacts on salmon and watershed health should be developed based on what is identified in regional salmon recovery monitoring plans to help further coordinate this program. Outlined below is relevant information from these programs.

Monitoring Questions:

- What is the trend in drought conditions within Puget Sound?
- What is the trend in peak flows? (See Flows)

- What is the trend in Scour? (See width to depth ratio, and sediment)
- What is the trend in water quality conditions within Puget Sound? (See: Habitat water quality monitoring program)

Sampling Design:

Spatial/Temporal Scale:

Measured Variables:

- Peak and duration of High and low stream flows (cms or cfs)
- Air temperature (°C)
- Precipitation (mm)
- Snowpack (ft)
- Change in Glacial Icepack (Volume?)
- Water temperature (°C)

Measurement Protocols:

Derived Variables:

- Annual peak and base stream flows.
- Trend in bed scour.
- Seasonal averages (June-August, September-November, December-February, and March-May) of air temperature and precipitation.
- Palmer Drought Severity Index (PDSI).
- Change in average instream temperature

[Note: Additional work is needed to complete this section of the MAMA plan. NOAA Fisheries should be able to provide a model to evaluate the impacts of climate change on populations based on the attributes listed above and VSP or relevant salmon life stage information].

F. PROPOSAL FOR PRIORITIZING AND FUNDING STATUS & TRENDS MONITORING

An Integrated Approach to Achieving Our Highest Priority Monitoring Needs

As noted in the introduction, Status and Trends Monitoring is a critical component of successful adaptive management of the Recovery Plan because it provides the foundation from which we can evaluate if a trend is negatively or positively impacted listed populations. Baseline status information is still needed for many of the listing factors affecting salmon and fish viability attributes. Although there is a great deal of adult salmon VSP monitoring occurring today (mostly as a result of the work of the harvest and hatchery co-managers), more sampling is needed of juvenile salmon in order to assess habitat productivity parameters. Additionally, there is no coordinated or consistent habitat status baseline data covering the entire ESU.

There is also a need to perform status monitoring of hatchery fish to evaluate effects on wild salmon populations. Other status and trends monitoring for the additional factors affecting salmon (predation, disease, ocean and climate conditions) are already underway at some level by NOAA or other research institutions and organizations, but additional coordinated monitoring and program development is needed to provide the type of information required to answer the management questions for those additional factors as described in Volume I.

The Puget Sound Chinook Salmon Recovery Council recognizes that there are limited funds available to perform all of the desired monitoring for the Recovery Plan. As a result, monitoring must be prioritized according to the highest priority information needs.

To summarize the types of status and trends monitoring described above, this Plan calls for:

- <u>Fish VSP and Habitat Status and Trends Monitoring</u>. This includes salmon VSP monitoring program for all populations and juvenile monitoring program for selected populations and the monitoring of the baseline Watershed habitat conditions as identified in this chapter.
- <u>Harvest and Hatchery Status and Trends Monitoring.</u> This includes ongoing monitoring that is performed by the co-managers pursuant to approved ESA management plans.
- <u>Other Limiting Factors Status and Trends Monitoring</u>. This includes additional monitoring of primary limiting factors not covered by the programs identified above. This may include additional essential baseline habitat monitoring in monitoring of estuary & nearshore habitat, water quantity, for predation competition and disease impacts, as well as ocean and climate conditions affects on salmon. This work calls for the development of a coordinated nearshore and estuary monitoring program to be developed by PSAMP, PSNERP, the Puget Sound Partnership, the Puget Sound Federal Caucus and other Partners
- <u>Coordinated Status and trend monitoring that aids in effectiveness monitoring in intensively monitored and manipulated watersheds.</u> Finally, this type of monitoring that is done to aid effectiveness monitoring efforts for any of the benchmark factors identified in Volume I.

This Plan recommends that the Recovery Council and Partnership seek funding to begin Fish VSP and Habitat Status and Trends Monitoring for the period of 2009-2011 in order to coincide with state and federal funding cycles. This recommendation is based on the assumption that NOAA, the co-managers (WDFW and tribes) and other research organizations are already funding or pursuing additional funding for Harvest and Hatchery Status and Trends Monitoring. It also acknowledges that further work and coordination needs to be done on the other types of status and trends monitoring listed above, to prepare for a coordinated funding request.

Table 8 below, outlines four policy options for accomplishing Fish VSP and Habitat Status and Trends Monitoring, and includes a rough estimate of the funding necessary to accomplish each of them. This integrated approach builds off of the Governor's Monitoring Forum statewide recommendations for accomplishing a network of status and trends monitoring of salmon VSP and watershed habitat conditions. Each option includes a different degree of information collected, complexity and cost. **It is recommended that the Recovery Council and Partnership support at least Option 2 as providing the minimum amount of information required at the pace necessary to meet our first 10-year recovery goals.**

TABLE 8. Alternatives for Fish VSP and Habitat Status & Trends Monitoring – How Much is Enough?

Option	Fish	Habitat	Comments
Option 1	Adults: all populations Juvenile outmigrants: one low risk (primary) population (fish-in/fish-out watershed) per each of the five MPGs (minimum = 5 fish-in/fish-out watersheds)	Satellite imagery: region-wide every 2 years Aerial photography: each of the 5 fish-in/fish-out watersheds every 2 years Field sampling: 30-50 sites region-wide, on a five year sampling interval	Lowest cost option Implements the Forum's Basic Framework in Puget Sound. Some say this doesn't include enough sites.
Option 2	Adults: same as above Juvenile outmigrants: same as above	Satellite imagery: same as above Aerial photography: same as above Field sampling: As above but would target sampling in each of the 5 fish-in/fish-out watersheds (30-50 sites each, 180+ sites region-wide)	Bolsters region-wide EMAP habitat/water data by also collecting field data for each of the 5 "fish-in/fish-out" watersheds. Represents a higher level of effort in fish-in/fish-out watersheds and associated costs compared to the Forum Framework. Would provide more information for low risk populations on indicators associated with limiting factors and freshwater productivity, and increase information for trend analyses and action effectiveness.
Option 3	Adults: same as above Juvenile outmigrants: at least two low risk (primary) populations (fish-in/fish-out watersheds) per each of the five MPGs (minimum = 10 fish-in/fish-out watersheds)	Satellite imagery: same as above Aerial photography: same as above but increase to each of the 10 fish-in/fish-out watersheds every 2 years Field sampling: in each of the 10 fish-in/fish-out watersheds (360+ sites region-wide)	This increases the number of "fish-in/fish-out" watersheds from a minimum of 1 per MPG, to 2 low risk pops per MPG. This would increase the targeted level of effort to 10 "fish-in/fish-out" watersheds across Puget Sound. Represents a higher level of effort and cost compared to Options 1 and 2, but it would provide key information for most if not all low risk populations on indicators associated with limiting factors and freshwater productivity, and increase information for trend analyses and action effectiveness for low risk populations. May present logistical challenge in early years due to geographic scope of monitoring.
Option 4	Adults: same as above Juvenile outmigrants : all populations that are feasible to monitor	Satellite imagery: same as above Aerial photography: all fish-in/fish-out watersheds every 2 years Field sampling: all fish-in/fish-out watersheds	Highest cost option Feasibility is unclear to due geographic scope and intensity of monitoring program.

CHAPTER THREE

MONITORING THE EFFECTIVENESS OF RECOVERY PLAN STRATEGIES AND CONDUCTING UNCERTAINTY RESEARCH

Introduction

This type of monitoring relates to the *expected physical response* of a recovery action and answers the question, "Did recovery actions produce the desired physical changes?" Results from effectiveness monitoring show progress in mid-term time frames, approximately five- to ten-year periods.

Effectiveness monitoring metrics should answer the following specific management questions:

- What is the hypothesis supporting each major strategy in the Recovery Plan?
  - What are the expected physical, biological changes and timeframes for those changes?
- What is the overall effectiveness of recovery actions? (e.g., are negative trends in habitat quality being reversed? Is quality habitat being restored faster than it is being lost?)
- Are there certain categories of salmon recovery actions that are consistently failing or succeeding?

Effectiveness monitoring addresses questions that are related to performance and accountability concerns. This is in contrast to status and trend monitoring, which provides fundamental baseline descriptive information that is directly related to recovery outcomes in the context of how VSP and limiting factors are changing over time. Status and trends monitoring alone does not directly address the causes of the observed changes. However, effectiveness monitoring does address cause-and-effect questions that are driven by need to track performance provide accountability.

Effectiveness monitoring as used here is broadly defined to encompass what is often called validation monitoring, and will address effectiveness of strategies, actions, projects, and BMPs. It will address key questions including:

- To the extent strategies and actions have been implemented, are they effective in meeting their objectives?
- Are recovery actions at the site, watershed, or programmatic scale producing the desired physical and biological changes?
- Are there categories of salmon recovery actions that are consistently more successful than others in meeting their objectives?

Overview of Ecosystem/Action Effectiveness Monitoring[5]

In general, the implementation of region-wide watershed recovery actions are intended to increase pre-spawning survival of adults, increase the survival of juveniles (e.g., egg-smolt), and/or expand the geographic distribution of target populations. In all cases, the ultimate performance measure is survival (or productivity) and/or distribution of the "population." That is, successful restoration or improvements

[5] This section is adapted from material submitted by BPA to the Pacific Northwest Aquatic Monitoring Partnership's Action Effectiveness Workgroup.

should translate into survival and distribution benefits at the scale of populations, not just at the scale of the implemented actions. Monitoring should therefore be sensitive to responses not only at small spatial scales (e.g., reach or small watershed), but also at the scale of populations.

This burden is not easily resolved under traditional monitoring programs, because most programs have lacked critical elements of experimental design (replication, randomization, independence, and controls/references), have collected data at the wrong spatial or temporal scales, or lacked sufficient institutional controls to maintain the integrity of the monitoring design over a time period sufficient to generate reliable results. Nevertheless, existing monitoring programs can be adjusted or new programs can be developed, that should provide information necessary to detect changes at the appropriate spatial and temporal scales.

Effectiveness Monitoring Principles

In general, lessons from past monitoring activities of habitat actions in watersheds include:

(1) Status and trend monitoring of population and habitat conditions is needed to establish baseline conditions and to develop a reference for large-scale, long-term patterns that may confound population-scale analyses of habitat restoration effects.

(2) Population-level responses to habitat actions can only be detected at the appropriate spatial and temporal scales. Measurements of the effects of restoration actions may occur at multiple spatial and temporal scales, but monitoring programs must be designed to evaluate responses at population scales, or at least the scale of major life-history components, and over multiple years or generations.

(3) Individual habitat actions generally do not directly impact population processes. Their direct effect is to modify physical or biological habitat condition. Therefore, responses of individual habitat actions are most easily detected at the scale of the action (i.e., reach or habitat unit scale).

(4) The mechanism(s) by which a given action generates a response at the population scale is usually unknown and may differ across populations.

With these principles in mind, we next examine the methods available to develop valid approaches to monitoring the effects of actions.

Ideal Effectiveness Monitoring Approaches

In general, the basic Before-After, Control-Impact (BACI) experimental design provides a foundation for monitoring the effects of actions on population productivity and distribution. The validity of the basic BACI design can be extended by including sampling at multiple Control and Impact locations on multiple occasions during the Before and After periods (MBACI). Better yet, the certainty of inferences may be further improved by establishing several pairs of Control and Impact locations that are sampled on multiple occasions during the Before and After periods (MBACI(P)). The intent of these designs is to reduce the likelihood of alternative explanations for differences seen in treatment and control locations. These designs, if implemented correctly, include the four essential ingredients of an ideal design: randomization, replication, controls, and independence.

Problems with Ideal Approaches

In practice, the “ideal” design is rarely, if ever, feasible at population scales because of losses of control and/or treatment areas, spatial arrangements of populations, lack of randomization, lack of independence, the nature of variables measured, and institutional and economic arrangements. BACI-type designs require institutional controls over the time and place of implementation of treatments and the selection and preservation of control areas. This is rarely feasible at the scale of populations. In reality, controlling social, economic, and political arrangements at the scale of populations is very difficult and the lack of experimental control often results in treatments being implemented at different times and intensities, and control areas being treated (loss of independence). Maintaining control populations for comparison with treated populations for long periods of time is very difficult institutionally.

In addition, some performance measures, such as fish abundance, biomass, and productivity are quite variable in space and time. Variability in fish metrics may result from different seeding levels (recruitment) and density-dependent factors that can be independent of habitat conditions. Large variability in fish metrics makes it difficult to assess effects of habitat actions on population productivity.

Given the problems associated with implementing BACI-type designs at the scale of populations, complementary alternative approaches are needed. Although these alternatives do not provide the level of certainty of inference that attends MBACI or MBACI(P) designs, the alternatives may demonstrate causation at the population scale if implemented correctly.

Other Effectiveness Monitoring Approaches

There are two general types of approaches that can be implemented to assess action 'treatment effects' on population productivity and distribution: (1) intensively monitored watershed approaches and (2) levels-of-evidence approaches.

A. Intensively Monitored Watershed (IMW) Approaches

Intensively monitored watersheds (IMWs) represent a rigorous form of monitoring intended to evaluate physical and biological responses (i.e., especially fish) to restoration projects, programs, and policies to at the landscape scale. Other types of monitoring can detect changes in environmental conditions or fish, or can document localized (e.g., site or reach) responses to management actions. However, without adequately rigorous experiments at IMW scales, it is not possible to attribute observed changes to particular causes, or to understand how such changes may translate into outcome-oriented production of more fish at the watershed or population scales.

Among the early actions implemented under the state's 2002 comprehensive monitoring strategy, the Salmon Recovery Funding Board (SRFB) in 2003 began funding the initial development and implementation of the IMW strategy in western Washington, involving three efforts in Puget Sound[6](Hood Canal, the Strait of Juan de Fuca, and Skagit estuary).

The IMWs represent long-term (at least 10 years) efforts intended to address how management and habitat restoration activities lead to increased production of fish in watersheds and answer questions like "*does habitat restoration produce more fish*" and "*how can we improve the efficacy of our restoration efforts*?" Such questions require knowledge about the causal mechanisms between habitat restoration and fish production.

There are at least two IMW approaches that differ depending on the number of types of habitat actions implemented:

[6] SRFB-funded efforts in another western Washington IMW are underway in the Lower Columbia (IMW complex includes Germany, Abernathy, Mill creeks).

(1) ***Intensively Monitored Watershed (Single Habitat Action Type)***—This IMW involves the implementation of a <u>single</u> action type in a population-scale area. The treated area is matched with a control population-scale area. Effects of a specific action type are assessed through monitoring population productivity in a treatment-control or intervention-analysis context.

(2) ***Intensively Monitored Watersheds (Multiple Habitat Action Types)***—This IMW involves the implementation of <u>multiple</u> action types in a population-scale area. The treated area is matched with a control population-scale area. Cumulative effects of the actions are assessed through monitoring population productivity in a treatment-control or intervention-analysis context. This approach cannot by itself separate the effects of individual action types on population productivity.

Both IMW approaches provide inferences at the population scale; however, only the IMW (single habitat action type) can assess the effects of specific action types on population productivity. The lack of spatial replication and randomization limits the certainty of inferences of IMWs. In addition, they require long-term institutional controls, which means that relatively few of these can be implemented successfully.

Two examples of IMW efforts currently underway within the ESU include the Hood Canal and Strait of Juan de Fuca IMWs. They involve:

- Long-term, paired-watershed (before-after/control-treatment) experimental designs
- Small watersheds that focus on steelhead, coho and cutthroat, because:
  - Compared to ocean-type Chinook and some other anadromous species, these species spend more time in freshwater, and thus results from these IMWs should be generally informative due to their responsiveness to changes in the quality and quantity of freshwater habitat;
  - These species utilize smaller watersheds for rearing, where fish responses to management actions can be assessed using a before-after/control-impact design, in an effective and affordable manner compared to what would be required in larger systems; and
  - Small watersheds allow the requisite treatments to be most practicably applied to large proportions of the salmon habitat, thus having the best chance of seeing detectable responses in fish.
- Types of restoration treatments emphasizing road abandonment, riparian plantings/management, in-channel wood placement, and connection/creation of off-channel habitats.

In contrast, the IMW effort in the **Skagit River estuary** focuses on the effects of tidal delta restoration and reconnection on juvenile Chinook salmon changes in abundance, spatial distribution, survival, and life history variation (body size, life history types). In contrast to the design approach used in the Hood Canal and Strait of Juan de Fuca IMW complexes, the Skagit design addresses the most important ocean-type Chinook life-stage, rather than encompassing the entire fresh-water rearing period. The larger area would make it very difficult and expensive to use a treatment-reference approach at the scale of the entire watershed.

Chinook salmon are well known for utilizing natal river tidal deltas, non-natal "pocket estuaries" (nearshore lagoons and marshes), and other estuarine habitats for rearing during outmigration. Several studies have linked population responses to availability of estuary habitat, either by examining return rates of groups of fish given access to different habitat or by comparing survival rates of fish from populations with varying levels of estuary habitat degradation. However, these necessarily coarse-scale studies have ignored how large-scale estuarine habitat restoration within a watershed contributes to population characteristics. These issues may be critical to understand how to best restore Chinook salmon populations, as many estuaries within Puget Sound and elsewhere have been converted to agriculture and urban land uses. For example, the Duwamish River has lost more than 99% of its tidal delta habitat (Simenstad et al 1982), while the Skagit River, which contains the largest tidal delta in Puget Sound, has lost 80-90% of its aquatic habitat area (Collins et al. 2003).

Study plans and annual reports of results for these and other SRFB-funded IMW efforts in Washington are available online at www.rco.wa.gov/srfb/docs.htm#monitoring

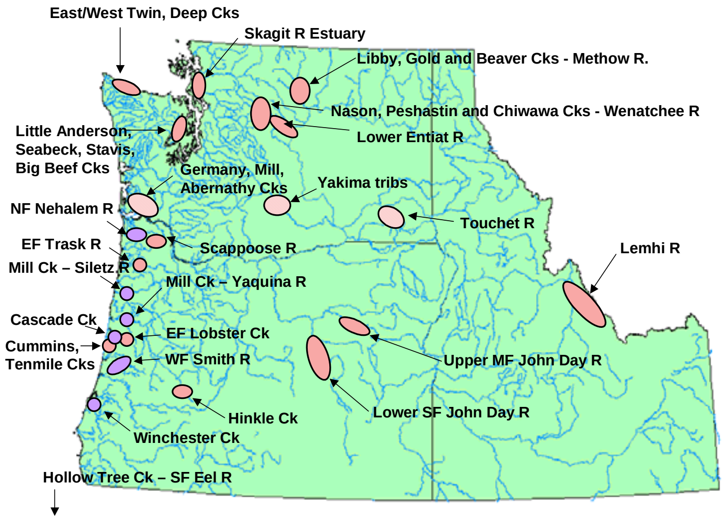
Table 9. Characteristics of the SRFB-funded IMW efforts in Puget Sound

	Strait of Juan de Fuca	**Hood Canal**	**Skagit Estuary**
Watersheds	West Twin East Twin Deep	Stavis Little Anderson Big Beef Seabeck	Tidal delta
Focal species	coho steelhead	coho steelhead	ocean-type Chinook
Land Use	forest – private, state, federal	urban, rural residential, forest – private and state	rural, agriculture
Complex Area (watershed)	113 km^2 (22, 25, 45 km^2)	78 km^2 (15, 13, 36, 14 km^2)	
Geology	mixed sedimentary and metamorphic	glacial till	
Precipitation	190 cm/yr	105 cm/yr	

Important IMW efforts involving Chinook salmon and other species are underway in other parts of Washington (e.g., Lower Columbia, Wenatchee River) and elsewhere across the Pacific Northwest. For example, since 2005 the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) has been working to establish a network of intensively monitored watersheds across the Northwest to evaluate the effectiveness of restoration projects, programs, and policies at the landscape scale[7]. At present PNAMP has identified 19 such IMW efforts (Figure 1), and is working to coordinate among them to increase the utility of each to the IMW network and to reduce unnecessary redundancy. The IMW efforts in Puget Sound are included in the broader network. Puget Sound restoration and recovery effectiveness monitoring efforts will contribute to and draw from results and inferences from the broader IMW network. An overarching landscape classification effort is also underway to explore the extent to which results from IMWs can be extrapolated across broader areas. Further clarification on IMW efforts and guidance for those considering development of IMWs are available in PNAMP (2005).

[7] PNAMP. 2005. *Establishing a Network of Intensively Monitored Watersheds in the Pacific Northwest*, Pacific Northwest Aquatic Monitoring Partnership, www.pnamp.org

Figure 1. Current IMW network (PNAMP)



With few exceptions, current IMW efforts in Washington and elsewhere focus on evaluations of effect in response to habitat restoration actions. Exceptions include a few IMW efforts where evaluations of best management practices (BMPs) associated with forest practices are the focus. To date, IMW efforts have not focused on cause-effect questions associated with ***habitat protection*** (e.g., protection of critical areas, shorelines, water quantity), in urban or non-urban settings.

Although complex, exploring the experimental design and socio-political challenges for development of IMW efforts aimed at effectiveness questions associated with protection strategies/actions has merit. Lessons learned and guidance from past and ongoing restoration-oriented IMWs would be informative in that regard.

B. Levels-of-Evidence Approaches

The levels-of-evidence approaches consist of at least three interdependent approaches to monitoring actions to determine biological benefit:

(1) ***Status/Trend Monitoring***—Status/trend monitoring of population productivity and habitat condition is a long-term effort (decades) that can assess effects of actions through correlation of productivity change to habitat condition and action reporting. Status/trend monitoring provides higher certainty of inference if before-after data are collected at the population scale and physical and biological effects are measured at the reach or habitat unit scale.

(2) ***Project-based Monitoring***—Project-based monitoring includes measuring physical and biological effects of individual actions at a reach or habitat unit scale. Because this type of monitoring does not directly measure the effects of actions on the population, complementary status/trend monitoring is needed to assess possible changes at the scale of the population. Effects of individual actions or classes of actions can be assessed through extrapolation of action influence and modeled connection of habitat condition to population processes.

(3) ***Watershed-scale Monitoring***—This approach is similar to IMWs, but is implemented at a sub-population scale (a watershed scale smaller than the geographic area of the population). As with

IMWs, this approach may include control-treatments in multiple habitat action types or single action types. Because watershed-scale monitoring does not directly measure the effects of actions at the population scale, status/trend monitoring should be used to assess possible changes at the scale of the population.

These approaches are not mutually exclusive, and as shown in Table 10, lie along a gradient of inferential certainty from relatively strong to relatively weak. IMWs provide more inferential certainty at the population scale than do levels-of-evidence approaches, to the extent that IMWs are design-based at the population scale. That is, inferences from IMWs are based on the design rather than model assumptions. However, the lack of randomization and replication of IMWs may not allow their results to be easily generalized to other populations.

TABLE 10. Comparison of approaches to determine population-scale biological effect of restoration and protection actions.

Monitoring Approach	Scale		Type of Inference		Certainty of Cause-and-Effect at Population Scale	Identify Mechanism (Action specific)	Sensitivity to Institutional Control	Notes
	Spatial	Temporal	Design Based (Test/Control)	Model Based (Correlational)				
IMW (one or more action type)	Watershed-Population	Short	Yes at all scales	No	High	Yes at all scales	High	Difficult to implement, rare opportunities
Level of evidence: Watershed scale	Watershed-sub-population (scaled to population indirectly using status/trend)	Short-Moderate	Yes at all scales	No	High	Yes at small scale. No at population scale.	High	Confounded with multiple treatments, rare opportunities
Level of evidence: Action-based (Reach or site scale)	Small (but scaled to population indirectly using status/trend)	Long (decades)	Yes at small scale. No at population scale.	No at small scale. Yes at population scale.	Low-Moderate	Yes at small scale. No at population scale.	Medium at small scale. Low at population scale.	Relatively inexpensive, and does not provide population level answers
Level of evidence: Status/Trend	Large (population, MPG, ESU)	Long (decades)	No	Yes	Low-Moderate	No	Low	Confounded by lack of controls, replicates, and multiple treatments

The three levels-of-evidence approaches rely on correlative data to try and make a case for causal inference. Correlation is used to rule out alternative hypotheses (note-as much if not more is known by disproving plausible alternatives than by showing that data are consistent with an hypothesis). Although the levels-of-evidence approaches may allow robust inferences at small spatial scales (scales smaller than the population), inferences at the population scale are usually inferred from correlation. The following criteria are often used to demonstrate causation from levels-of-evidence approaches:

- *Strength of Association*—Measures the size of the change in performance measures associated with the incidence of treatments. In some respects, this is similar to gradient analysis. One can compare the percentage difference in average value of performance measures at locations that received treatments to those that did not.

- *Consistency of Association*—An association between performance measures and the treatment that is observed many times provides higher confidence than if no such consistency is observed.

- *Specificity of Association*—The association is only seen in the presence of the treatment (i.e., an observed change in the performance measures occurs after the onset of the treatment).

- *Temporality*—If the treatment causes some change, then the change must follow the onset of the treatment. Temporality is a particularly useful criterion, because it has the potential to discard explanations – either the treatment explanation or alternative ones.

- *Biological or Ecological Gradient*—If one can observe a distinct increase in the magnitude of effect with increasing intensity of the treatment, then there is further evidence of causality.

C. Proposal for Effectiveness Monitoring

Based on the information presented above, this Plan recommends that the following effectiveness monitoring programs be prioritized in the first phase of MAMA Plan implementation:

1. Develop at least one IMW to address the effectiveness of habitat protection and restoration. Given the importance of habitat protection as a fundamental recovery strategy for Puget Sound Chinook salmon, it is critical to know the effectiveness of this strategy. Accordingly, this Plan recommends the development of at least one IMW within the ESU to assess the effectiveness of habitat protection strategies and actions on salmon viability.

Given the uncertainty of maintaining the integrity of robust monitoring designs (e.g., BACI designs, IMWs, etc.), implementing an effectiveness monitoring effort using a combination of approaches seems most appropriate. To account for inherent variability, implementation of IMWs should be limited to where the institutional control on the integrity of the design can be maintained for at least 12 years, or about three generations. Project-based and/or watershed-based monitoring in concert with status/trend monitoring should be implemented where institutional control is less feasible.

2. Develop at least one level-of-evidence effectiveness monitoring approach for each priority strategy in the Puget Sound Chinook Salmon Recovery Plan. This recommendation requires the Recovery Council, Watersheds and others to examine the strategies set forth in the Recovery Plan and prioritize those strategies that are most critical to the success of the Plan. Once accomplished, an effectiveness monitoring program should be designed for each of them in order to ensure that the most important hypotheses are being tested for effectiveness.

Some effectiveness monitoring data described in this section may already exist, is currently being collected or collection is planned. Before this adaptive management and monitoring plan is implemented, an effort will be made to collect and summarize existing effectiveness monitoring data in order to gain a clear picture of the gaps and needs for additional monitoring.

3. Address critical uncertainties through enhanced communication and coordination among research scientists. In many ways critical uncertainties are being tested and evaluated through effectiveness monitoring. However it is also important to take the time to prioritize regional research that produces results that may significantly change strategies for recovery. (For example, current research on toxics and pesticide evaluate impacts of only one pesticide at a time. Scientists are uncertain as to the cumulative impact of those chemicals when they combine in the natural environment). **In order to maximize research funding and provide answers to these questions in the most efficient way possible, research scientists should create a publicized list of questions they are attempting to answer through research and, where possible, collaborate with others to perform experiments and studies.** This will avoid duplicative work and spotlight the need for additional work where gaps exist.

4. To maximize effectiveness monitoring research that has benefits for all salmonid species, work with the NOAA, state agencies, universities and other implementing partners to identify and prioritize effectiveness-monitoring programs and uncertainty research programs from concerns identified in the Puget Sound Shared Strategies Chinook Salmon Recovery Plan, the Hood Canal Summer Chum Recovery Plan and NOAA Fisheries Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance.

CHAPTER FOUR

DATA COLLECTION AND MANAGEMENT

This MAMA Plan proposes to use several different types of monitoring to collect the information required to answer the management questions that will guide salmon recovery efforts. The adoption of common protocols with specified methodologies or Standard Operating Procedures (SOPs) is essential for collecting data in the field, storing and transferring data in data management systems and in the process of analyzing data to derive indicators used in performance measures to evaluate progress relative to agreed upon benchmarks. Collecting the information needed for each of these types of monitoring will require different tools and methodologies, which provide quality assurance and quality control (QA/QC).

[Insert slide of Ecosystem information management framework]

Data Collection Protocols

1. For <u>implementation monitoring</u>, the parties responsible for leading implementation actions will provide information on their progress against benchmarks twice a year using a report format to be developed in 2008 by the Puget Sound Partnership in conjunction with the Recovery Council and Watershed planning groups. The Recovery Council will analyze the reported information and prepare a report card for each action item. Additional standard methodologies for collecting information on habitat restoration and acquisition projects and other recovery actions are being developed through collaborations between the NOAA NWFSC's Pacific Northwest Habitat Restoration Project Database, the Pacific Coast Salmon Recovery Fund Database, the WA Prism Database, the WDFW Habitat Work Schedule, the WA Conservation Commission's WPDD database, PNAMP and the WA Governor's Forum on Monitoring Salmon and Watershed Health's Implementation and effectiveness Sub Committee.

2. For <u>status and trends monitoring of salmon habitat,</u> the parties responsible for performing data collections will use the probabilistic sampling design described in the Governor's Forum on Monitoring *Status and Trends Statewide Monitoring Framework,* and shall follow the sampling protocols and field sampling procedures, measurement procedures and quality control procedures described in the Governor's Forum on Monitoring 2007 monitoring guidance. Specifically the guidance endorses the use protocols and methods of the USFS AREMP or PIBO programs , the EPA EMAP program or the Upper Columbia Monitoring Strategy by Tracey Hillman *Status and Trends Monitoring for Watershed Health and Salmon Recovery - Quality Assurance Monitoring Plan,* Ecology Publication No. 06-03-203. With regard to Water Quality Monitoring, standard operating procedures (SOPs) are already used and regional endorsed by EPA and Department of Ecology. For estuary and nearshore habitat monitoring, several known protocols exist, including the Columbia River Estuary's Estuarine Habitat Assessment Protocol developed by the Pacific Northwest Laboratory.

3. For <u>status and trends monitoring of fish viability</u>, the parties responsible for performing data collection will use [Note: This section needs to be completed by adding the monitoring protocols used for fish VSP monitoring].

4. For <u>status and trends monitoring of major limiting predation and disease</u>, methods need to be identified and validated for monitoring attributes identified in the tables in Chapter 2. This includes identification of monitoring standard operating procedures (SOPs) for birds, marine mammals, and other predators, and Water Qunatity/stream flow,

5. For <u>status and trends monitoring of ocean and climate conditions</u>, NOAA and various universities along the West Coast are coordinating research and monitoring through specified methodologies. Climate Change

monitoring methods are in common use in various forums, however, this Plan recommends that these methods should be standardized in the development of a Northwest climate change module.

6. For effectiveness monitoring, the parties responsible for leading the research projects shall collect the desired information using accepted scientific principles and methodologies. (See Chapter Three for several methods).

Data Management

Although the information collected through the field monitoring approaches above will come from many sources and exist in many forms, one thing is universal: it must be available for examination by many parties, including the public, so that the work of salmon recovery is transparent and credible. Therefore data must be stored, or transferred electronically in data management systems which operate under information management and storage SOPs.

Today, no single data management system, or data warehouse exists that will serve all of the needs of this Monitoring and Adaptive Management Plan. However, a series of distributed networks of individual agency or entity data warehouses are being developed to share data between partners. Currently there is a great deal of focus and discussion on this issue occurring throughout the State, primarily driven by State & Federal agencies in the Governor's Forum on Monitoring and through the Northwest Monitoring and Data Management Executive Summit held on October 2nd of 2007. **This Plan recommends that further work be performed throughout 2008 to identify and/or create the data management system(s) that will house monitoring data collected under this Plan. A gap analysis should be done to identify where data management systems exist that may serve the purposes identified in this chapter.** It will be critical to the success of this Plan to identify the systems that will hold data (even if temporarily while other system(s) are being created) in the short-term because this Plan recommends that implementation monitoring begin in 2008, and that status and trends monitoring begin in 2009 or earlier, if funding allows.

Through the Shared Strategy, early scoping work was done that developed a set of principles for the creation of a Verification and Accountability System (V&A System). The V&A System work ultimately guided the creation of this MAMA Plan, and established certain principles for the development of any data management systems which will serve Plan, which still hold today. These principles should be met with whatever data management system(s) is chosen by the Recovery Council, Partnership or Watersheds to serve as the accountability tool for adaptive management and monitoring work under this MAMA Plan.

Principles for V&A System Development and Implementation

1. Build on what is working: Each watershed in the ESU has mobilized to develop and implement salmon recovery, and many have given consideration to how they will track and communicate implementation progress and results. Multiple databases or data management tools, for example Managing for Success, the Habitat Work Schedule, or the Pacific Coastal Salmon Recovery Fund (PCSRF) database. Each of these systems could help meet system purposes are being used or are in development.

Several watersheds actively maintain web pages that are dedicated to providing information about how they are advancing plan implementation. Several watersheds have also taken significant steps toward implementing Adaptive Management and Monitoring programs that include collection of data that will be integral to this system. By building on existing tools and processes that can help meet its purposes this system will make the most efficient use of resources directed toward assessing and ensuring progress toward recovery goals.

2. Leverage NMFS/USFWS' status review task and data management systems: NMFS and USFWS are required to track and report every 5 years on the status of ESA listed species for which the Recovery Plans

have been developed and how many of the actions in the Plans have been implemented. The information these agencies will need for this task will also be useful to watersheds and the region in assessing progress.

3. Connect the Hs: Progress has been made in improving the coordination of the work by habitat, harvest, and hatchery managers in support of achieving recovery goals, but more remains to be done. Completion of H-integration for all populations will encourage and enable continuing coordination among H-managers. A data management system that provides timely reporting of results, that can be reviewed jointly those H-managers is crucial to the success of salmon recovery efforts.

4. Engage implementers at multiple levels: Users of any data management systems created to serve this MAAM framework will connect to it for a variety of reasons, ranging from a desire to see a graph showing the trend of natural origin escapement in neighboring watersheds, to a need to assess how effectively federal and state funding is being used the region. The system should be responsive to the need for information at watershed and regional scales, across the Hs, and across technical and policy issue areas.

5. Communicate "on time": The frequency at which different types of information are gathered, disseminated and analyzed should be responsive to critical biological, management, and fiscal cycles. For example, population abundance data can be gathered in the field annually, with an analysis that follows during the last date of field data collection, but can only be reported as reflecting a trend after multiple generations. Also, project implementation data can be monitored and updated almost continuously but it will be of greater importance to report on implementation status in relation to major funding cycles like the state biennium budget cycle.

The overall V&A System should be responsive to the needs of the following parties as they implement actions, prioritize expenditures, and maintain a constituency for achieving recovery goals:

- The general public
- Watershed planning groups
- Puget Sound Salmon Recovery Council
- Individual implementing entities: tribes, state and local governments, federal agencies, non-governmental organizations, and others
- Puget Sound Partnership
- Environmental organizations
- Business organizations
- Agricultural organizations
- Tribal governments and the NWIFC
- Federal elected and appointed officials
- State elected and appointed officials
- Local elected and appointed officials
- NOAA Fisheries
- USFWS
- Pacific Salmon Commission

The System should also capitalize on the unique authorities and expertise of these parties in building and connecting the elements of the System and funding and fostering its use.

Including Multiple Species Recovery Efforts

Most if not all of the Puget Sound basin is affected by Endangered Species Act listings – for summer chum, bull trout, orcas, and others – or is engaged in conservation planning and action for species other than Chinook. While the V&A System is primarily geared toward supporting implementation of the Chinook

Recovery Plan, the concepts and tools it employs may be similarly advantageous for other recovery or conservation efforts. To the extent that these other efforts have a comparable need for the concepts and tools, the V&A System may be modified to incorporate other species.

The Role of Independent Review

An independent review of the proposed V&A Database System should be implemented prior to its finalization and implementation and periodically over time to ensure it meets its stated purposes.

Decision-makers also have the option to employ independent review to validate the conclusions drawn from the indicators and metrics employed within the System. Given the timeframe for collecting data of sufficient breadth and depth to draw defensible conclusions regarding population response (i.e., VSP measurements), such a review would likely only be possible and appropriate after at least one full salmon generation from the start of data collection for the full set of metrics and indicators. The actual timeframe would be influenced by the conclusions under scrutiny in the review.

CHAPTER FIVE

DATA ANALYSIS AND REPORTING

The process of turning data and information into conclusions about progress that will guide strategic improvements and future investments will entail the close coordination of implementers at the watershed and regional levels. This system incorporates information synthesis processes at both the watershed and regional levels, and a significant degree of coordination between watersheds and the region to avoid duplication of efforts and to encourage an open, learning environment. Drawing conclusions will likely be an iterative process within watersheds and at the regional level, and then between watersheds and the region. This iteration will help ensure that conclusions are well vetted before they are final and that as a whole the conclusions are internally consistent.

As noted throughout this MAMA Plan, analyzing monitoring data and other information and synthesizing it to address key questions and to support key decision is a fundamental component of the adaptive management process. Monitoring data and other information will be synthesized to address whether the recovery plan actions are effective in:

a. **Moving key populations within the ESU to low risk**
   - This will be addressed via effectiveness monitoring in context of VSP status and trends monitoring and correlative inferences

b. **Protecting habitat and/or habitat forming processes**
   - This will be addressed via effectiveness monitoring in context of habitat/water status and trends monitoring, other information, and correlative inferences

c. **Restoring habitat forming processes**
   - This will be addressed via effectiveness monitoring in context of habitat/water status and trends monitoring, other information, and correlative inferences

d. **Removing or limiting other threats (limiting factors, plus the other NOAA listing factors and threats, such as disease, predation, natural factors such as natural variations in ocean conditions and climate change, etc.)**
   - This will be addressed via habitat/water status and trends monitoring, and a diversity of other available information

Importance of Models for Analysis of Monitoring Information

It should be clear that not all actions can be monitored, nor can the effects of actions be measured for all populations. Therefore, analytical tools are needed to assess the potential effects of actions on population productivity across the many populations that will be treated with recovery actions. Analytical tools range from the simple (professional-judgment-guided models) to the more complex qualitative and quantitative models (e.g., Ecosystem Diagnosis and Treatment or NWFSC SHIRAZ models). The goal should be to apply transparent models across different landscapes and populations, and provide reasonably accurate results. It is important that monitoring contribute toward the development of analytical tools. This means that monitoring should be conducted at spatial and temporal scales sufficient to develop and populate models and to provide data to validate the models.

Overall the analysis of quantitative and qualitative data through assessment from complete census monitoring or the use of these models to extrapolate the results of Random Sample design monitoring programs needs to clearly state where assumptions and uncertainties in the analysis exist. The lack of data or qualified assumptions may be what is needed for Shared Strategies and the Puget Sound Partnership to determine the plan is on the right track, or the need to implement adaptive management or for NOAA to delist the species.

Reporting Progress

Watershed and regional levels will share responsibility for reporting on the status of recovery plan implementation and the results that have been generated. A formalized reporting task will provide value by establishing a predictable schedule and format for distilling a diverse array of data and information about recovery efforts into a short set of powerful conclusions about successes and where additional work is needed.

Agreement on Information for Reporting.

The precursors to producing actual reports include fundamental activities like identifying the metrics and indicators that will be tracked, building databases to hold and provide access to raw data, and collecting data. With these activities advancing effectively, implementers will be building toward a comprehensive and compelling view of their recovery efforts. One additional essential action in regards to metrics and indicators that will ensure reports are credible and informative is reaching agreement up front on what data and information will be used in the reporting process. This agreement will provide assurance that the data and information are of sufficient quality to be used in drawing conclusions and will provide implementers and the audience for the reports an early sense of what topics and issues will be addressed in the report.

An example of a reporting process that employs this agreement step is harvest management. Early in the process of evaluating the effectiveness of the current harvest management regime technical staff from the co-managers and the Services review the available data and information describing the outcomes from the management regime and determine which data and information is technically adequate to inform management decisions. Employing this step in what can be complex and controversial decision-making processes can help ensure decisions are based on good information and minimize surprises that can derail important improvements to recovery strategies.

This agreement step will primarily involve technical staff from the co-managers, watershed technical committees, the NMFS Science Center, and the NMFS Regional Office.

Watershed and Regional Reporting.

Once conclusions have been distilled, the reporting process can move to conclusion. The reporting task will likely generate products including written reports and other materials that can be shared with those who fund our efforts, the public, and other recovery plan implementers. Initial expectations are that watersheds will provide reports on an annual basis and regional reports, rolling up watershed level work and describing work on regional issues, will be completed bi-annually. Implementation metrics that describe how well actions are completed will show changes annually, while longer-term metrics (e.g. habitat action effectiveness monitoring) will only show change over longer periods (every 5-10 years). The first round of reporting is expected to be completed by the fall of 2008, in time for communicating key conclusions to state and federal budget-makers. The content and structure of these reports will be determined in discussions during early 2008 as part of implementing this MAMA Plan.

Developing Common Messages of Progress.

The final step in the reporting process is to pull the key messages from the completed watershed and regional reports into a single product that can communicate to a wide audience at a high level. This will be an important tool to use with those who fund our efforts and the interested public. Developing this short list of key messages will be facilitated by preceding steps that make the reporting process fully transparent. To the extent that these steps are effective and participants are engaged from the start, key messages should be readily apparent.