Bonneville Power Administration
FY 2003 Provincial Project Review

PART 2. Narrative

Project ID: 35019

Title: Develop and Implement An Integrated Subbasin-scale Status and Watershed-scale Effectiveness Monitoring Program for Salmonid Populations and Habitat as called for in the NMFS 2000 FCRPS Biological Opinion (Revised Proposal – resubmitted March 10, 2003 – Initial proposal title: Develop and Implement a Pilot Status and Trend Monitoring Program for Salmonids and their Habitat in the Wenatchee and Grande Ronde River Basins).

Section 9 of 10. Project description

This project proposal is directly tied to four other proposals submitted for re-review (35016, 35020, 35024, and 35048). Together these five proposals form a pilot program approach to a comprehensive status and effectiveness monitoring program for Columbia River basin anadromous salmonids and their habitat. This suite of proposals aims to implement the critical missing components (status monitoring, effectiveness monitoring and data management) of a regional Research, Monitoring and Evaluation (RME) program as called for in the 2000 NMFS FCRPS Biological Opinion (BiOp: RPA Action Items 180, 181, 183 and 198). While all attempts to make each proposal a stand-alone project have been made, the five projects have been developed in concert to meet independent, yet closely related, RME needs of the BiOp implementation plan.

a. Abstract

This proposal seeks to develop two novel monitoring and evaluation programs: (i) subbasin-scale pilot status and trend monitoring efforts for anadromous salmonids and their habitat in the Wenatchee, John Day and upper Salmon River basins, and (ii) effectiveness monitoring for suites of habitat restoration projects in selected watersheds within the three target subbasins. This work builds on current status and trend monitoring programs within each of these basins; however, the proposed work differs structurally from much of the ongoing status and trend monitoring work as it focuses on the explicit development and testing of the sampling protocols and methodologies required for generating habitat and population monitoring data of known spatio-temporal resolution, accuracy and precision. In addition, the proposed work expands on the utility of status monitoring data to explicitly address watershed-scale questions of habitat restoration action effectiveness.

(i) The status and trend monitoring program for anadromous salmonids and habitat in the Wenatchee, John Day and upper Salmon River basins will serve three major data collection efforts:

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

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

(ii) The effectiveness monitoring program for assessing the watershed-scale impact of restoration actions in selected portion of the Wenatchee, John Day and upper Salmon River basins will explicitly address questions of action efficacy:

--At the scale of a watershed, what is the biological benefit to anadromous salmonid populations of the implementation of ongoing habitat restoration actions?
--Within and between target watershed in a single subbasin, what is the distribution of physical/environmental habitat condition as a function of ongoing habitat restoration actions?

To support the implementation of the above two monitoring and evaluation programs, this proposal also develops several broadscale monitoring efforts. These additional monitoring efforts are to be distributed across the entire anadromous portion of the Columbia River basin to address two key status monitoring uncertainties:

--Intensify population status monitoring programs to assess the abundance and spatial extent of Steelhead spawning adults and rearing juveniles.
--Intensify the assessment of the extent to which anadromous salmonids of hatchery origin spawn naturally in the wild as indicated by the spatial extent of wild spawning hatchery fish, the fraction of natural spawners hatchery fish represent, and their range of spawning behavior or activity.

b. Technical and/or scientific background

Proposal development background

The genesis of the current form of this proposal has two major components. First is the development of habitat and population status monitoring guidelines for the Mainstem / Systemwide Province (Jordan et al. 2002) and parallel efforts to define the status and effectiveness monitoring requirements of the 2000 NMFS FCRPS Biological Opinion (RPA 180, 181, and 183: Tier 1, Tier 2, and Tier 3) and the Basinwide Salmon Recovery Strategy. While both of these suites of monitoring protocols were developed by regional fisheries managers, the program as a whole has never been adequately tested in the Columbia River basin. To meet the status monitoring component of these needs, this proposal was initially drafted and submitted in response to the programmatic solicitations of the Mainstem/Systemwide Provincial Review. The proposal generated significant interest ("Urgent" rating by CBFWA, "Fund" recommendation by the ISRP); however, the proposal also stimulated discussions as to the practicality and advisability of implementing only a portion of an integrated, comprehensive multi-scale status and effectiveness monitoring program. Therefore, in the second phase of its development, the proposal was extensively modified to incorporate additional monitoring and evaluation components, thereby increasing its integrative and comprehensive nature. The resulting proposed status and effectiveness monitoring program seeks to implement landscape and reach scale habitat and population status monitoring in parallel with watershed-scale habitat restoration action effectiveness monitoring for anadromous salmonid populations of the Columbia River basin. As such, the proposed work herein is designed to move our current knowledge of monitoring programs forward through field testing and on-the ground evaluation. The status monitoring needs for anadromous salmonid populations and habitat are clear, as are the gaps in our existing status monitoring programs and data. Even more necessary is a large-scale assessment of the efficacy of habitat restoration actions. What the region lacks is an implemented comprehensive habitat and population status and effectiveness monitoring program – this proposal addresses these needs directly.

A complete salmonid habitat and population monitoring program should simultaneously assess long-term landscape scale status components, short-term reach to population scale status components, and project specific reach scale effectiveness monitoring. In fact, the guidelines for monitoring developed for the NMFS 2000 FCRPS Biological Opinion (BiOp) call for just such a 3-tiered approach to monitoring populations and habitat. While this proposal alone does not capture all components of the BiOp required tributary monitoring program, the proposal was submitted in concert with four other proposals, and together the five proposals aim to implement the complete tributary status and effectiveness monitoring program. The initial phase of implementation captured by these proposals involves limiting the geographic scope of the program (pilot studies, rather than the entire Columbia River basin), with planned expansion as the individual components are developed and tested. Of the complete monitoring program, this proposal addresses issues of landscape scale status and trend monitoring, subbasin scale annual status and trend monitoring, and watershed or population scale habitat action effectiveness monitoring. The work proposed here directly linked to proposals 35020 and 35024 as they propose to implement the project scale habitat action effectiveness monitoring. In addition, the work proposed here is also linked to proposal 35016, a complete development of the landscape scale status and trend monitoring analysis tools that will underlie the large scale, long period assessments fundamental to placing all of the other monitoring and evaluation work in an ecological context. These four proposals were developed in parallel, from the same set of guidelines, and are meant to be implemented separately; however, when integrated via the regional data management system proposed in 35048 the four proposals together constitute pilot scale implementation of the comprehensive monitoring program called for by the region.

In addition to the four proposals mentioned above, this work is potentially coupled to other Mainstem/Systemwide Provincial Review proposals currently under funding consideration. Of particular note is proposal 35033. This proposal contains the necessary collaborative components to facilitate the implementation of a comprehensive monitoring program basinwide.

In the initial review of this proposal, the ISRP suggested that proposals 35033 and 35019 (and by extension, 35016, 35020, 35024 and 35048) be somehow combined to provide a systemwide monitoring and evaluation project. The absolutely essential elements of 35033 that the other projects lack is the basinwide perspective, both in the collaborative representation of nearly all fisheries management agencies, as well as the inclusion of fishes other than anadromous salmonids. Ultimately, the most efficient manner for the Columbia River basin to approach a comprehensive monitoring program would be in the form of integrated aquatic ecosystem health assessment. Components of the above six projects, plus many ongoing monitoring programs, if coordinated within a single purpose, design, and data management and evaluation framework, could produce the ideal monitoring program for the basin's aquatic natural resources.

A coordinated monitoring and evaluation program for anadromous salmonids in the Columbia River basin is long over due. This proposal seeks to fill this gap by implementing existing status and effectiveness monitoring guidelines on a pilot study basis. Parallel to the implementation of habitat and population status monitoring programs and watershed-scale effectiveness monitoring programs is the necessary assessment of the measurement, sampling and evaluation protocols called for in these guidelines. Only through implementation within an evaluative framework will efficient and effective monitoring programs emerge.

Overview of proposed work

The following outline describes the basic process by which this proposal seeks to develop subbasin scale status, trend, and effectiveness monitoring programs for anadromous salmonids and their habitat. This monitoring program's development is meant to pilot the development of a comprehensive monitoring program for the entire Columbia River basin. As such, the primary focus of this work is on the development and testing of the approach. Therefore, during program assessment and evaluation, addressing questions of how the pilot programs will scale up to cover a larger spatial extent will be critical.

The monitoring program is proposed for development in the Wenatchee, John Day and upper Salmon River basins (wadeable portions of the subbasins: above Tumwater canyon on the Wenatchee River, above Kimberly on the John Day River, and the East Fork and above on the Salmon River), targeting natural spawning and rearing of steelhead (*O. mykiss*) and spring chinook (*O. tshawytscha*). The spatial extent of the proposed monitoring program is limited by two major considerations, firstly the protocols and approaches being tested are specifically designed for wadeable streams, and secondly, as pilot programs the focus is on testing and development, rather than complete basin-wide coverage. In addition, by restricting the program's extent to portions of these three major each subbasin will be considered to consist of 4 major watersheds (Wenatchee: Nason, White/Little Wenatchee, Peshastin, Chiwawa; John Day: North Fork, Middle Fork, upper mainstem and South Fork; and upper Salmon: East Fork, Yankee Fork, Valley Ck., and Sawtooth valley). The division of the subbasins into major watersheds is based roughly on population structure information being developed by the Interior Columbia River Technical Recovery Team, and will be used for organizational purposes, for post-hoc stratification of data to address issues of monitoring program scale, and effectiveness monitoring and evaluation of demographic units as a function of land management and restoration practices.

The Wenatchee, John Day, and upper Salmon River basins were chosen as potential monitoring pilot program locations for a variety of programmatic, logistical and biological reasons. Each basin has breeding and rearing listed and non-listed anadromous salmonid species. Listed species imply the attention and interest of resource management agencies while non-listed species might allow opportunities to develop approaches prior to implementation on listed species. Each river basin is of interest for monitoring program development by USFWS, NMFS, FCRPS Biological Opinion Action Agencies, multiple Tribal entities, States of Washington, Oregon, and Idaho, and others. Each river basin can be thought of as four major watersheds of similar size covering a wide range of human impacts, uses and management levels including wilderness areas as reference points, all with reasonable access. In each basin there are high quality existing status monitoring efforts against which a sampling framework could be tested. For example, in the Wenatchee there is an annual census of adult chinook and steelhead spawning grounds, and the US Forest Service has conducted modified Hankin-Reeves survey of upper watersheds. While in the John Day ODFW and others have significant historical and on-going life-history and life-stage survival research on spring Chinook, and in the upper Salmon River basin, IDFG has a long-term redd survey program. Thus, in each basin there is the potential for expanding the ability to verify difficult sampling procedures, e.g., smolt traps on major watersheds to test snorkel-based sampling. And finally, each river basin has a range of hatchery impacts, with clearly identified areas that represent completely natural production watersheds.

While the genesis of this proposed work was initially strictly status and trend monitoring of populations and habitat condition a natural extension of these data collection programs is a watershed scale assessment of habitat action efficacy. Habitat restoration actions are generally implemented on a reach or habitat unit scale and can be assessed for effectiveness at that scale (see companion proposals 35020, 35024). However, when needing to determine the population level response to restoration actions, the actions' cumulative impact must be assessed on the scale of the demographic unit as a whole. At this scale, determining the effect of multiple simultaneous actions is more an issue of differences in population growth rates (alternatively stage specific survivals, or productivity expressed as juveniles per adult) than an elucidation of the mechanism by which a particular action or class of actions alters the population processes of these fishes. Therefore, assessments of watershed scale population trajectories so closely resembles status monitoring that their combination is a natural pairing.

Effectiveness monitoring of tributary habitat restoration actions is a multi-dimensional undertaking. The designers of such programs have struggled to best capture the range of spatial scales involved with understanding simultaneously the mechanisms by which a particular action alters physical environmental conditions that in turn impact local population processes that ultimately manifest themselves as altered population dynamics (MDT 2002, RME Framework 2003). As a result, a multi-scale approach to effectiveness monitoring is often recommended, one that addresses the following three questions either within a single program, or as multiple coordinated programs.

Q1 – Is this project effective?
Q2 – Did projects within a subpopulation or subwatershed on aggregate effect the demographic unit?
Q3 – Are classes of projects effective?

For these questions, "effective" refers to having the anticipated impact on the habitat and the correlated fish demographic response.

While all of these questions are raised in the BiOp in the context of Action Effectiveness Research, answering them places quite different expectations on the monitoring program. Among these, Q1 is largely of interest to individual project sponsors. Q2 operates on a spatial scale that is defined by the characteristics of the demographic unit of study – usually a larger scale than individual projects and within the framework established by status monitoring programs. Q3, on the other hand, is not defined by a single spatial scale; rather, it addresses characteristics of project categories – wherever they may be implemented. This proposal is explicitly designed to address Q2. A high-resolution project based effectiveness monitoring program to address Q1 and Q3 is contained in proposals 35020 and 35024.

Even though this proposed work will address habitat and population status monitoring and watershed scale effectiveness monitoring within the same program, the status and trend monitoring remains distinctly different from the watershed scale effectiveness monitoring. The distinction arises from the manner by which sampling locations are chosen in space. The proposed status monitoring program is based on a spatially balanced random sampling design (EPA's EMAP) to capture unbiased representative samples of physical/environmental indicators across the landscape. The watershed scale effectiveness monitoring program will sample the same suite of reach scale physical / environmental indicators at each project location, but because the project locations are not randomly distributed in space these samples represent the population of projects, not the background habitat condition. However, the two programs do overlap in the evaluation phase – the habitat status samples can serve as within and between watershed control sites if the appropriate covariate matching is performed (Rosenbaum, 1995).

Outline of proposed work

Objective 1.

Define cooperative agreements under which the salmonid and habitat status, trend and effectiveness monitoring program design, development and implementation will occur. Detailed cooperative agreements to partition the implementation of particular tasks during monitoring program development are needed. The development of the cooperative agreement will occur in parallel to the initial phases of monitoring program development (*Tasks* associated with *Objective 2*), but must be finalized prior to initiating *Tasks* associated with *Objective 3* and *Objective 4.*

Task 1.1.

Currently individuals and Agency members of the Upper Columbia Regional Technical Team, Interior Columbia Technical Recovery Team, Washington State Comprehensive Monitoring Strategy, Environmental Protection Agency, and the NMFS-FCRPS-BiOp-Action-Agency RME Team are participating in the coordination of monitoring program development and implementation in the Wenatchee River basin. Refine cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5.*

Task 1.2.

Currently individuals and Agency members from Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Watershed Enhancement Board, Confederated Tribes of the Warm Springs Reservation, US Forest Service, Environmental Protection Agency, and the NMFS-FCRPS-BiOp Action Agency RME Team are participating in the coordination of monitoring program development and implementation in the John Day River basin. Refine cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5*.

Task 1.3.

Currently individuals and Agency members from Idaho Department of Fish and Game, Nez Perce Tribe, US Forest Service, Environmental Protection Agency, and the NMFS-FCRPS-BiOp Action Agency RME Team are participating in discussions regarding monitoring program development and implementation in the Salmon River basin. Develop cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5*.

Objective 2.

Develop a salmonid population and habitat status and trend monitoring approach with known accuracy and precision through field-testing of protocols and sampling design.

Task 2.1. Develop and test a status monitoring program specific to the Wenatchee River basin ecosystem.

2.1.1. – Test habitat assessment methods.
2.1.2. – Test adult population assessment methods.
2.1.3. – Test juvenile population/productivity assessment methods.
2.1.4. – Test probabilistic sampling based approaches.

Task 2.2. Develop and test a status monitoring program specific to the John Day River basin ecosystem.

2.2.1. – Test habitat assessment methods.
2.2.2. – Test adult population assessment methods.
2.2.3. – Test juvenile population/productivity assessment methods.
2.2.4. – Test probabilistic sampling based approaches.

Task 2.3. Develop and test a status monitoring program specific to the Salmon River basin ecosystem.

2.3.1. – Test habitat assessment methods.
2.3.2. – Test adult population assessment methods.
2.3.3. – Test juvenile population/productivity assessment methods.
2.3.4. – Test probabilistic sampling based approaches.

Objective 3.

Implement the salmonid and habitat status and trend monitoring program developed in *Objective 2* through the cooperative agreement developed in *Objective 1*.

Task 3.1.

Implement a pilot status and trend monitoring program for salmonids and their habitat in the Wenatchee River basin.

Task 3.2.

Implement a pilot status and trend monitoring program for salmonids and their habitat in the John Day River basin.

Task 3.3.

Implement a pilot status and trend monitoring program for salmonids and their habitat in the Salmon River basin.

Objective 4.

Implement a watershed scale habitat restoration action effectiveness monitoring approach with known accuracy and precision through field-testing of protocols and sampling design.

Task 4.1.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the Wenatchee River basin.

4.1.1. – Develop landscape scale stratification/covariate data layer.

4.1.2. – Monitor physical/environmental indicators at each project location within target watershed.

4.1.3. – Monitoring integration response variables at base of each target watershed.

4.1.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

Task 4.2.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the John Day River basin.

4.2.1. – Develop landscape scale stratification/covariate data layer.

4.2.2. – Monitor physical/environmental indicators at each project location within target watershed.

4.2.3. – Monitoring integration response variables at base of each target watershed.

4.2.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

Task 4.3.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the Salmon River basin.

4.3.1. – Develop landscape scale stratification/covariate data layer.

4.3.2. – Monitor physical/environmental indicators at each project location within target watershed.

4.3.3. – Monitoring integration response variables at base of each target watershed.

4.3.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

Objective 5.

Develop an evaluation framework for the status, trend and watershed scale effectiveness monitoring program.

Task 5.1.

Compile and evaluate the annual assessments of population and habitat status.

Task 5.2.

Compile and evaluate the annual assessments of watershed scale habitat action effectiveness.

Objective 6.

Develop and implement a long-range status, trend, and watershed scale effectiveness monitoring program.

Task 6.1.

Expand the proposed program to additional subbasins and watersheds as needed to meet regional and programmatic monitoring requirements, in particular, the complete implementation of the RME program of the NMFS 2000 FCRPS Biological Opinion.

Objective7.

Address status monitoring critical uncertainties. These additional monitoring efforts are to be distributed across the entire anadromous portion of the Columbia River basin to address key status monitoring uncertainties.

Task 7.1.

Intensify population status monitoring programs to assess the abundance and spatial extent of Steelhead spawning adults and rearing juveniles.

Task 7.2.

Intensify the assessment of the extent to which anadromous salmonids of hatchery origin spawn naturally in the wild as indicated by the spatial extent of wild spawning hatchery fish, the fraction of natural spawners hatchery fish represent, and their range of spawning behavior or activity.

Scientific and programmatic background

There have been numerous recent administrative and scientific calls for a comprehensive monitoring and evaluation program to provide consistent, region-wide information about the status of salmon populations and their response to management actions (Botkin *et al.* 2000, ISAB 2001, RSRP 2001). In addition, the 2000 Biological Opinion on the Federal Columbia River Power System requires the development and implementation of a coordinated monitoring and evaluation program (NMFS 2000a). The call for developing a consistent, region-wide monitoring program has been strong and widespread because once implemented, such a program will address a number of outstanding scientific agendas. First, it will provide a scientifically robust method to evaluate the status of populations and ESUs, and thereby gauge progress toward recovery goals, such as the de-listing criteria defined by the regional TRT's (NMFS 2000b). Second, it provides the means to develop and refine appropriate performance measures and standards for conservation actions. Finally, it will provide managers with the tools to assess quantitatively the impact of single or composite actions on fish populations, thereby increasing our ability to conduct effective recovery planning.

The pilot status, trend and effectiveness monitoring program proposed here will address not only these scientifically-based policy agendas, but will also provide the framework in which to address a substantive administrative issue – implementing the requirements for developing the monitoring and evaluation program outlined in the NMFS 2000 Biological Opinion on the Federal Columbia River Power System (Actions 180-184, 188, 190, 191, 193, and 195-7), specifically, population and habitat status monitoring for anadromouns salmonids as required under Action Item 180, and elements of the habitat action effectiveness monitoring as required under Action Item 183.

A well-designed monitoring and evaluation program is a critical component of any conservation or restoration activity. Monitoring is vital in determining whether specific management actions have been effective, and large-scale monitoring and evaluation is important in assessing the success of integrated actions having achieved desired population size, distribution and trends. Moreover, well-coordinated management actions, when coupled with relevant monitoring and evaluation programs, can reduce uncertainty about the effect of those actions on population productivity.

The primary goal of this monitoring and evaluation effort is to design and implement a system of statistically rigorous data collection schemes to answer questions fundamental to the management and recovery of anadromous salmonids. In spite of tremendous past efforts many of the most important questions remain unanswered due to basic uncertainties in these fishes' population processes, both with respect to trends in abundance as well as the factors that regulate salmonid population dynamics.

At present there are a number of high-quality population and habitat monitoring and assessment programs within the Columbia River Basin (e.g. Oregon Plan 1997; Alverts *et al.* 1997, CBFWA 2001). However, none of these programs has both comprehensive geographic coverage and a sampling theoretic basis. In particular, there are no comprehensive guidelines to be drawn from these plans that can be used as a template for monitoring the status and recovery of impacted populations as well as their breeding, rearing and migratory corridor habitat in the entire Columbia River Basin. At issue is both the type of data traditionally collected to assess population and habitat status, as well as the manner by which the data collection scheme is implemented in time and space.

The primary objective of this proposed monitoring plan for Columbia River Basin is a statistically sound sampling design that when implemented will generate useful data with known analytical and predictive power. Several technical challenges are immediately apparent, and this work is distinct from previous efforts in how we will approach these challenges. The primary complication arises from the enormous spatial scale and resulting heterogeneity of the sampling areas and indicators. As such, the manner of population and habitat sampling, and the manner in which the samples are distributed in time and space, will strongly influence the assessment of status and effectiveness. To satisfy this constraint requires considerable knowledge of both the spatial extent of true demographic units and the mechanisms of population regulation, potentially more than we currently posses. However, lacking these key pieces of information does not mean that we are unable to accurately assess population and habitat status, but it does mean that we must do so under a modern and statistically rigorous sampling program informed by our knowledge of demographic and habitat processes. This work is intended to develop and test status, trend, and effectiveness monitoring approaches capable of the statistical rigor specifically required by the region's natural resource management agencies and personnel.

c. Rationale and significance to Regional Programs

This proposed work directly addresses calls for the development of salmonid population and habitat monitoring programs in the NWPPC's Fish and Wildlife Program (NWPPC 2000), CBFWA's Program Summaries for the Mainstem/Systemwide Province (Jordan et al. 2002), Federal Caucus Basinwide Salmon Recovery Strategy (Federal Caucus 2000,) and the NMFS Biological Opinion on the Operation and Maintenance of the Federal Columbia River Power System (NMFS 2000a).

Of particular relevance are the requests for proposals to help meet BPA's obligations under the NMFS FCRPS Biological Opinion for a population and habitat monitoring program for listed anadromous salmonids in the Columbia River basin (statusmonitorrpa180.pdf, FutureNeeds.pdf, GapAnalysis.pdf). The NMFS 2000 FCRPS Biological Opinion outlines basinwide monitoring programmatic needs, and performance standards for the monitoring program. At an absolute minimum the anadromous salmonid monitoring program for the Columbia River Basin must collect data that can be used to answer the following four questions. These questions arise as specific requirements for assessing the status of ESA listed salmonid species in the Columbia River Basin relative to the implementation of the BiOp Action Items (NMFS 2000 FCRPS BO, 9.2.2.1).

1. Is the annual population growth rate greater in 2005 and 2008 than during the base period (1980 – 2000)?
2. Is the annual population growth rate in 2005 and 2008 greater than or equal to the projected growth rate based on improvements made and expected from actions taken in the 1995 biological opinion, reductions in harvest that occurred after the base period, and the survival standards in the Mid-Columbia Habitat Conservation Plan.
3. Is the annual population growth rate in 2005 and 2008 equal to or greater than the projected growth rates based on expected hydrosystem improvements and realized effects of offsite mitigation actions, and do these projected rates meet or exceed those necessary to achieve the 48-year recovery criteria.
4. Is the annual adult return of wild fish as represented by the 5-year geometric mean for each ESU and population greater than the ESU and population size (5-year geometric mean) in 2000?

In addition, RPAs 9, 180, 181, 198, of the FCRPS Biological Opinion directly address the responsibilities of the Action Agencies and other regional entities for the development of system-wide fish and habitat status monitoring. In addition to information needed to address these population level questions for ESA listed populations, the Action Agencies and the region will require information to assess progress toward performance standards for the hydro corridor and for tributary, mainstem, and estuary habitat conditions. Thus, the development of the status and effectiveness monitoring program must be within the context of a Columbia River basin-wide research, monitoring and evaluation plan. Furthermore, the research, monitoring and evaluation program will be supported by a regional data management system to facilitate the collection, analysis and dissemination of the monitoring data.

d. Relationships to other projects

This is a new program request; however, it is strongly based on the status and trend monitoring work currently underway in the target subbasins (e.g., John Day: BPA #1998-016-00, #25010). This project proposal is also linked to others submitted for consideration under the Mainstem/Systemwide Provincial Review Process. These proposals (35016, 35020, 35024, 35033, 35048), together with this proposal, form a pilot program approach to a comprehensive status and effectiveness monitoring program for Columbia River basin salmonids and their habitat. This suite of proposals aims to implement the critical missing components (status monitoring, effectiveness monitoring and data management) of a regional Research, Monitoring and Evaluation program as called for in the 2000 NMFS FCRPS Biological Opinion (RPA Action Items 180, 181, 183 and 198).

The status and effectiveness monitoring program development as proposed herein will require extensive collaborative work with ongoing research and monitoring programs. The design and testing phase for this project will require collaboration with US Environmental Protection Agency research staff. For field work and implementation of the program in the Wenatchee River basin the Principal Investigator will work directly with the following ongoing efforts: US Forest Service's Aquatic Habitat survey program, Chelan County PUD's juvenile salmonid sampling program, Washington Department of F&W's juvenile and adult salmonid sampling program, Washington Department of Ecology's Regional Environmental Monitoring and Assessment Program. For field work and implementation of the program in the John Day River basin the Principal Investigator will work directly with the following ongoing efforts: Oregon Department of F&W's juvenile and adult salmonid sampling program, Consolidated Tribes of the Warm Spring Reservation's ongoing juvenile and adult salmonid sampling program, US Forest Service's environmental monitoring programs. For field work and implementation of the program in the upper Salmon River basin, the Principal Investigator will work directly with the following ongoing efforts: Idaho Department of Fish and Game's adult and juvenile sampling program, US Forest Service and Bureau of Land Management's environmental monitoring programs. In each river basin additional Local, Tribal, State and Federal partnerships will be possible, and highly beneficial to the outcome of this work.

e. Project history

This is a new project.

f. Proposal objectives, tasks and methods

Subbasin Scale Status and Trend Monitoring
A comprehensive status monitoring program should address the three major attributes of fish populations and their habitats that together provide indicators of ecosystem productivity and

resilience in the face of environmental uncertainty: (1) The absolute *abundance and survival* of fish populations and their trends through time (e.g., indicators of productivity); (2) The *geographic patterns* (e.g., spatio-temporal distribution, genetic, and life-history diversity) of populations relative to their habitats (e.g., indicators of biological adaptation in a heterogeneous environment); and (3) The *variance* of populations through time (e.g., an indicator of resilience). In addition to these population indicators, the program also requires an understanding of (4) *ecological processes* such as climatic, hydrologic, or biotic interactions that naturally cause changes in fish populations. Indicators of these processes are critical to determine whether population responses are due to restoration activities, unrelated fluctuations in the natural environment, or some interaction of these effects. Failure to account for the background processes of variation may lead to erroneous conclusions about the success or failure of recovery measures. The status monitoring program proposed for development will explicitly address these four critical attributes of salmonid populations and habitat. Generating data to assess these four attributes requires a monitoring program that is designed with the specifics of these fishes natural history in mind, as well as a detailed knowledge of their geographic distribution and its spatio-temporal dependence on landscape scale features and ecological processes. Lacking these critical components that underlie the design process requires and explicit design phase to elucidate these important determinants of the performance of the proposed monitoring program. Developing this monitoring program will involve a 3-step process, the components of which are organizational, logistical, statistical and biological. The three primary steps are detailed below, expressed as *Objectives* with associated *Tasks* and *Methods*. The *Objectives* are sequentially arranged, but could be implemented in a somewhat parallel or phased manner.

Objective 1.

Define cooperative agreements under which the salmonid and habitat status and trend monitoring program design, development and implementation will occur. Detailed cooperative agreements to partition the implementation of particular tasks during monitoring program development are needed. The development of the cooperative agreement will occur in parallel to the initial phases of monitoring program development (*Tasks* associated with *Objective 2*), but must be finalized prior to initiating *Tasks* associated with *Objective 3*.

Task 1.1.

Currently individuals and Agency members of the Upper Columbia Regional Technical Team, Interior Columbia Technical Recovery Team, Washington State Comprehensive Monitoring Strategy, and the NMFS-FCRPS-BiOp-Action-Agency RME Team are participating in the coordination of monitoring program development and implementation in the Wenatchee River basin. Refine cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5*.

Methods 1.1.

The Principal Investigator will continue to work collaboratively with the identified agency personnel to develop a cooperative agreement for the implementation of the on-the-ground portions of this work. Current informal agreements will be formalized in the form of statements of work and subcontracts. The bulk of the work required in the *Tasks* associated with *Objectives 2-4* will be developed as separate contracts during the contract negotiation phase with BPA.

Task 1.2.

Currently individuals and Agency members from Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Watershed Enhancement Board, Confederated Tribes of the Warm Springs Reservation, US Environmental Protection Agency, and the NMFS-FCRPS-BiOp Action Agency RME Team are participating in the coordination of monitoring program development and implementation in the John Day River basin. Refine cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5*.

Methods 1.2.

The Principal Investigator will continue to work collaboratively with the identified agency personnel to develop a cooperative agreement for the implementation of the on-the-ground portions of this work. Current informal agreements will be formalized in the form of statements of work and subcontracts. The bulk of the work required in the *Tasks* associated with *Objectives 2-4* will be developed as separate contracts during the contract negotiation phase with BPA.

Task 1.3.

Currently individuals and Agency members from Idaho Department of Fish and Game, Nez Perce Tribe, US Environmental Protection Agency, and the NMFS-FCRPS-BiOp Action Agency RME Team have begun to discuss the coordination of monitoring program development and implementation in the Salmon River basin. Refine cooperative agreement between these parties (identifying other participants if necessary) to implement *Tasks* associated with *Objectives 2-5*.

Methods 1.2.

The Principal Investigator will continue to work collaboratively with the identified agency personnel to develop a cooperative agreement for the implementation of the on-the-ground portions of this work. Current informal agreements will be formalized in the form of statements of work and subcontracts. The bulk of the work required in the *Tasks* associated with *Objectives 2-4* will be developed as separate contracts during the contract negotiation phase with BPA.

Objective 2.

Develop a salmonid population and habitat status and trend monitoring approach with known accuracy and precision through field-testing of protocols and sampling design.

Task 2.1. – Develop and test a status monitoring program specific to the Wenatchee River basin ecosystem.

The testing and development of habitat assessment methods involves three components: assessing the measurement error associated with the recommended protocols, quantifying the spatio-temporal variance components for each indicator based on recommended sampling program coverage, and assessing the information content of the indicators given uncertainty in indicator value due to sampling/measurement/process error and correlation of indicator to salmonid population abundance/productivity metrics. The three components of this task are accomplished within a single field-testing framework by implementing a suite of habitat indicator protocols under a variety of sampling regimens.

A key feature of the testing framework is the use of census or validation reaches. These are locations where the indicator in question is known with high accuracy and precision through extensive sampling or a census independent of the protocol testing process. For example, for habitat survey method testing in the absence of any background information or other monitoring programs, a reach is chosen that represents the diversity of natural conditions to be encountered in a random sampling of the watershed. The validation reach is then extensively mapped by expert personnel other than those on project field crews. This reach can then be used as a test case, since the 'true' value of its habitat indicators are known. Alternatively, in locations with smolt traps, or exhaustive adult spawning surveys, these areas will represent 'true' values against which indicator and sampling protocols can be assessed.

With validation reaches it is reasonably straightforward to design test for protocols, crews and sampling schemes. Measurement error is assessed absolutely for a crew or protocol by sampling within the area of known habitat indicator values. For relative measurement error between crews or protocols, resampling of randomly chosen reaches will be used, provided the resampling is done within 7 days of the initial pass. Important components of the variance structure of indicators can be determined by resampling on a variety of spatio-temporal scales (Larsen et al. 2001). On some spatio-temporal scales all habitat and population indicators will be highly autocorrelated (e.g., two points in a watershed separated by several meters are more likely to be similar than two point separated by 100s of meters). However, while such spatio-temporal similarities should generally decay with increasing time/distance, there are numerous situations where this is not the general case (e.g., periodic patterns due to ocean/climate cycles or strong brood year cycles). Therefore, to properly assess the spatio-temporal component of habitat and population indicator variance, a component of the sampling program should always be within and between years and watersheds. Finally, to determine the natural resource management value, or information content, of each monitoring variable or indicator, habitat and population indicator sampling will be conducted within an analytical evaluation framework. Simultaneously constructing and testing hierarchical correlative models of habitat indicators and population processes will support the development of both the data collection process and the evaluation of monitoring data in a management context. Validation or census reaches will be particularly valuable in this context as the predictive power of random variables is strongly determined by their error term (Holmes 2001, Holmes and Fagan 2002)– data collection associated with validation/census areas allows for the further partitioning of the variance terms discussed above into their process and non-process components.

Subtask 2.1.1. – Test habitat assessment methods.

Methods 2.1.1. – Habitat and Riparian Survey

Ideally, channel habitat and riparian surveys will be conducted as described by Moore et al. (1997). However, modification will be required to adapt these methods to the Wenatchee River basin. Some known modifications will include: survey lengths of 500-1000m and measurement of all habitat unit lengths and widths (as opposed to estimation; based on experience with these methods, Thom et al. 1999, 2000, 2001). Additional modifications will arise due to field-testing of methods and measurement error estimation approach described below.

All habitat survey locations will be determined using a spatially balanced random sampling site selection process with the sampling universe determined by the spatial extent of the fish species of interest. The project proponents propose to use the USEPA's EMAP site selection algorithms. The advantage to using these well developed site selection algorithms is the additional supporting work that has been done on refining the estimators of the sample data (most importantly, the variance terms). Alternative sampling schemes would be possible, but the long history of development, refinement and implementation of, and statistical support (provided by the USEPA's western research lab, Corvallis, OR) for, EMAP makes this approach the most sensible.

Survey teams will collect field data based on stream, reach, and channel unit characteristics. Each field crew is comprised of two people with each member responsible for specific tasks. The "Estimator" will focus on the identification of channel unit characteristics. The "Numerator" will focus on the counts and relative distribution of several unit attributes and will verify the length and width estimates for a subset of units. The "Estimator" and "Numerator" share the responsibility for describing reach characteristics, riparian conditions, identifying habitat unit types, and for quantifying the amount of large woody debris. Crewmembers may switch responsibility for estimator or numerator when they start a new stream. They will not, however, switch estimator and numerator jobs on the same stream. The methods and indicator variables collected with this protocol can be viewed at http://osu.orst.edu/Dept/ODFW/freshwater/inventory/pdffiles/habmethod.pdf.

To quantify within-season habitat variation and differences in estimates between survey crews, sites will be resampled with a separate two-person crew. Repeat surveys will be a randomly selected sub-sample from each survey crew. Variation in survey location was assumed minimal because survey starting and ending points were marked in the field. The precision of individual metrics will be calculated using the mean variance of the resurveyed streams "Noise" and the overall variance encountered in the habitat surveys "Signal". Three measures of precision are calculated, the standard deviation of the repeat surveys SDrep, the coefficient of variation of the repeat surveys (CVrep), and the signal to noise ratio (S:N). S:N ratios of < 2 can lead to distorted estimates of distributions and limit regression and correlation analysis. S:N ratios > 10 have insignificant error caused by field measurements and short term habitat fluctuations (Kauffman et al. 1999).

Habitat conditions will be described using a series of cumulative distributions of frequency (CDF). The variables described are indicators of habitat structure, sediment supply and quality, riparian forest connectivity and health, and in-stream habitat complexity. The specific attributes are:

Density of woody debris pieces (> 3 m length, >0.15 m diameter)
Density of woody debris volume (> 3 m length, >0.15 m diameter)
Density of key woody debris pieces (>10 m length, >0.6 m diameter)
Density of wood jams (groupings of more than 4 wood pieces)
Density of deep pools (pools >1 m in depth)
Percent pool area
Density of riparian conifers (>0.5 m DBH) within 30 m of the stream channel
Percent of channel shading (percent of 180 degrees)
Percent of substrate area with fine sediments (<2 mm) in riffle units
Percent of substrate area with gravel (2-64 mm) in riffle units

While these attributes do not describe all of the conditions necessary for high quality salmonid habitat, they do describe important attributes of habitat structure within and adjacent to the stream channel. The attributes are also indicative of streamside and upland processes. Water quality and quantity, as well as food production, are not addressed in the discussion ofphysical habitat, but are critical elements for the Oregon Department of Environmental Qualities EMAP program. The median and first and third quartiles will be used to describe the range and central tendencies of the frequency distributions of the key habitat attributes used in the analysis of current habitat conditions (Zar 1984). Frequency distributions will be tested to determine if significant differences ($p<0.05$) exist between subbasins for each habitat attribute (Thom et al. 2000). The information content, or predictive power of the habitat indicators will be assessed within a hierarchical modeling framework to test the extent of correlation between habitat indicators and fish indicators within and between baseline reaches and sampling reaches.

Subtask 2.1.2. – Test adult population assessment methods.

Methods 2.1.2. – Adult Steelhead and Spring Chinook Redd Surveys
The Wenatchee River basin has considerable adult survey work currently underway to exhaustively enumerate adult spring Chinook. The development of a probabilistic sampling scheme for redd counts is meant to complement this work, if the methods prove sufficiently accurate and precise for regional needs. The key to testing the following sampling based approaches will be the ongoing census based surveys that will act as the 'truth' against with the sampling data can be compared. For steelhead surveys, the testing will focus on the protocol/method development due to the logistical difficulty of surveying these fishes during the spring. In this case, assessments of population status could be strongly influence by uncontrolled measurement error. Methods for assessing the accuracy and precision of steelhead redd surveys will be developed in conjunction with adult counting facilities (e.g. explore potential for instrumenting Tumwater Dam).

Certainly there is sampling and measurement error associated with ongoing "census" work for adult population assessments in the Wenatchee River basins. However, due to the extensive nature of the spawning ground surveys (weekly counts with all redds identified and flagged) and the potential for total adult counts in a number of watersheds (dam counts and hatchery weirs), good estimates of accuracy and precision of these counts can be developed. The idea being to have a population estimate of known characteristic against which to test sampling methods. Ideally, the sampling methods could return data of known accuracy and precision that is sufficient for management decisions, but is less labor intensive (i.e., costly) to generate. In particular, if range expansion is anticipated to accompany extensive habitat restoration, then an alternative status monitoring program that can capture an increasing scale of interest without the concomitant increase in cost would be a very valuable and attractive tool for resource managers.

Fifty sites will be selected for each subbasin and are visited on a bi-weekly basis throughout the season to quantify the cumulative redd count at each site. At each sample site, the sample reach is split in two with each surveyor responsible for one half of the survey. Each surveyor samples upstream from the downstream end of each survey reach. Each surveyor counts live fish and determines the fin-mark status of all live fish through observations. All redds are counted, flagged and rocked with a painted rock. Data are recorded on the spawning survey form, redd longevity form, and spawning location description form. Survey crews review survey forms daily and deliver hard copies bi-weekly to the crew chief. Crew chiefs conduct weekly site visits with each crew. Data entry is conducted as time allows throughout the survey season and is completed within one month of the end of fieldwork. The population status will be indexed through cumulative redd counts. Expected precision at the provincial scale will be ±25% and ±40% at the subbasin scale. Hatchery: wild ratios will be estimated by observing the occurrence of adipose fin-clipped and unmarked live fish on spawning grounds.

To quantify observer error we will implement the following procedures. Each site is visited bi-weekly with the surveyors swapping sample reaches every survey. The surveyor records the number of flagged/rocked redds, new redds, and redds missed during the previous survey. Missed redds are distinguished from new redds by the amount of periphytic growth in the redd pocket. New redds will be devoid of periphyton whereas older redds become obscured by periphytic growth. The independent estimate of marked versus unmarked redds from survey to survey will provide an estimate of the error associated with identifying steelhead redds. To validate whether cumulative redd counts are a reliable indicator of populations status, we will compare subbasin redd estimates to steelhead populations estimates from dam/ladder/weir/census counts, comparing population estimates from census methods to survey estimates. In addition, we will begin exploring where we can develop the data to allow the conversion of redd counts to population estimates. The necessary data would include the sex ratio of returning adults and redd:female ratios.

Where the subbasin has on-going index surveys, assess the cost/information gained relationship for index surveys, census methods and probabilistic sampling. To fully explore this issue, develop a dataset that covers the range of abundance seen under the historic index surveys to examine the relationship between the three methods. From this analysis we should be able to develop a strong relationship that will allow us to index the historic surveys to the probabilistic surveys, and assess the best monitoring program for the future. This will take an unknown length of time but will probably be on the order of 5-10 years.

Subtask 2.1.3 – Test juvenile population/productivity assessment methods.

Methods 2.1.3. – Juvenile Salmonid Survey

Ideally, juvenile salmonid monitoring will be accomplished by snorkel surveys involving a single upstream pass through each pool during daylight along a 1-km survey reach. This approach will be assessed and modified as needed to adopt the following methods to the Wenatchee River basin.

For single pass snorkel surveys the number of snorkelers employed will be based on what is needed to effectively cover the pool being snorkeled on a single upstream pass. To reduce problems associated with snorkeling in shallow or fast water habitat, only pools ≥ 6 m^2 in surface area and ≥ 40 cm deep are snorkeled. Counts of the number of juvenile and adult trout (*O. mykiss*) and salmon (*O. tshawytscha*) are recorded for each pool. Trout and salmon will be categorized as fry (0 year class), juvenile (1+ years or greater), or adult based on size classes developed from local data and/or standards. Other species will be noted as present and recorded. Crewmembers either alternate the pools that they snorkel or one crewmember snorkels the entire reach. After snorkeling, the underwater visibility of each pool during the snorkel count is ranked on a scale of 0 to 3 where: 0 = not snorkelable due to an extreme amount of hiding cover or zero water visibility; 1 = high amount of hiding cover or poor water clarity; 2 = moderate amount of hiding cover or moderate water clarity neither of which were thought to impede accurate fish counts; and 3 = little hiding cover and good water clarity. Only pools with a visibility rank of two or three are used in data analysis. If all pools in a reach have visibilities < 2, then as many pools in the reach as possible will be electrofished using Smith-Root model 12-B backpack electrofishers following NMFS electrofishing guidelines for juvenile salmonid presence/absence. Electrofishing will be conducted by making a single pass upstream in each pool that meets the size and depth criteria for conducting snorkel surveys. No block nets will be used for this sampling. Electrofishing data will be used to determine the presence and percent of pools occupied by juvenile *O. mykiss* and spring chinook.

To quantify the measurement error in the snorkel data, and to provide information on temporal changes in abundance during the course of the sampling season, supervisory staff will resurvey a random sample of 10 to 20 percent of the sites surveyed in each subbasin. The goal is to limit between diver error to ± 20% or less with intensive presurvey training of field crews and regular random resurveys.

Data analysis will involve calculating the percentage of survey sites that contain at least one juvenile fish for *O. mykiss* and spring chinook and the percentage of pools per site that contain juvenile *O. mykiss* and spring chinook to quantify changes in the relative distribution interannually. Analysis from coastal watersheds indicate that snorkeling data from pools has the strongest explanatory power regarding the overall trend in juvenile steelhead and coho populations (Pers. Comm, Jeff Rodgers, ODFW Research Lab, Corvallis). We will quantify the number of juvenile *O. mykiss* and spring chinook observed per square meter for use in population trend analysis within and among individual subbasins. Confidence limits for summary estimates will be developed based on quantifying the measurement error in the snorkel data (see paragraph above) and site-to-site variability based on a variance estimator developed by the EPA EMAP Program for this application (Pers. Comm. Don Stevens, EPA Research Lab, Corvallis).

In the current application of these methods by ODFW and others to coho salmon juveniles, the small pools and non-pool habitat are not sampled. If the habitat use characteristics of over-summering juveniles is known (as it is in this case for coho salmon), then the validity of counting in pools only can be assessed. Part of the process will be to assess this approach for other salmonid species at summer low flows. Alternative sampling approaches are used for other species and life history variants, and as such, can be assessed, tested and if appropriate, incorporated. The primary goal of juvenile sampling will be to develop an index of juvenile population size and productivity. The "pool-only" approach only works when this habitat type contains the majority of the summer low-flow juveniles. In the worst case sampling scenarios (e.g., poor visibility), presence/absence data only will be developed to assess the cumulative distribution of pool use by juveniles. Nonetheless, the CDF of pool use has been shown to index the productivity of coho salmon juveniles when it is not possible to develop sufficiently precise counts. The intent of this program development is not to impose a suite of protocols on a sampling scheme, but rather to assess their ability to generate data of known accuracy and precision that meets the resource management needs of the local and regional co-managers.

Subtask 2.1.4 – Test probabilistic sampling based approaches.

Methods 2.1.4. – Sampling methods, domains and site selection

Based on current environmental monitoring programs (U.S. EPA 1998, 2000, Oregon Plan 1997, WA CMS 2001), and scientific review of proposed salmonid and habitat monitoring programs (ISRP reviews of numerous proposals across several provinces) the sampling framework adopted for testing in this project is the US Environmental Protection Agency's EMAP. While the program has been implemented regionally for water quality monitoring (U.S. EPA 2000) and salmonid population and habitat monitoring (Oregon Plan), there are a number of aspects of the sampling frame that should be tested prior to program implementation in each new ecoregion. Therefore, while an EMAP sampling framework will underlie the development of this monitoring program, concomitant testing of the sampling program design will occur.

In cooperation with co-managers and other interested parties, this project will annually refine the sampling universe for habitat and juvenile surveys based on current distribution maps. The sampling domain is defined at the upper ends of watersheds by perennial streams and at the lower end by the capability of field crews to snorkel the sample reach. Juvenile salmonids will be inventoried at all sites within the summer rearing distribution of juvenile *O. mykiss* and spring chinook in snorkelable streams below known barriers to upstream migration. Sample sites will be derived from the 1:100k EPA River Reach file.

In previous applications of EMAP to salmonid population and habitat monitoring (Jones et al. 2001, Jacobs et al. 2001), a non-uniform sampling universe was constructed. Sites were selected in a spatially balanced random fashion – sample site selection is random, but with an enforced dispersion to prevent site clustering as is common with simple random samples across space. However, because sample sites were selected from EPA reach files, the number of reaches on smaller streams was much larger than those of larger streams per unit area. To force the representation of larger streams the site selection process was biased to increase the probability of larger streams being sampled. However, the weighting functions for increasing the representation of a stream order in the sample relative to the fraction of actual stream miles of that order were not functions of local conditions (stream network geometry is a strong function of gradient, geology and precipitation). Therefore, the proposal will test the assumptions that underlie the weighting functions such that, if needed, subbasin specific weighting functions will be developed.

To balance the needs of status (more random sites) and trend (more repeat sites) monitoring, EMAP based sampling programs generally implement a rotating panel design (general recommendations from the EPA EMAP Design Group; Pers. Comm. P. Larsen, EPA, Corvallis). Thus, for a subbasin scale program 50 sites drawn on an annual basis for each would be assigned to the rotating panel design as follows:

- 3 panels with different repeat intervals
- 17 of the sites will be sampled every year
- 16 sites will be allocated to a 4 year rotating panel (sites visited once every 4 years on a staggered basis)
- 17 sites will be new sites each year

With this sampling strategy, 50 sites will be drawn the first year and 33 new sites will be drawn in subsequent years because 17 of the originally drawn sites will be repeated each year. The rotating panel strategy is essentially a bet-hedge against the distribution of indicator variance over space and time. The best estimator of status is thought to be from random sites fixed through time (drawn once, resampled annually), while the best estimator of trend captures both the spatial and temporal variance components and their interactions (drawn randomly each year). Since we have an incomplete understanding of the spatio-temporal variance structure (first and higher order terms), a rotating panel approach is a good compromise. One goal of this project will be to explicitly sample for the spatial, temporal and interaction variance components (as recently outlined by Larsen et al. 2001). Armed with a more complete picture of indicator variance the most efficient implementation scheme for site selection over space and time can be developed. Again, the motivation is to increase the information content of the monitoring data collected for the effort expended.

Similarly, there is nothing "magical" about 50 samples per subbasin since precision increases gradually with increase in sample size. For the most part, we want a good estimate of the variance of our target population. Small sample sizes give poor estimates of the variance, and with small samples, random draws can be quite a bit off from the actual population's characteristics (mean, variance, median). Fifty is a rule of thumb to get a reasonably good picture. Another reasonably good rule of thumb is that doubling precision requires a four-fold increase in sample size. So, for a given precision at 50 samples, one would need 200 samples to double the precision. However, once again, 50 samples is an initial guess that can be refined with data collection on indicator variance structure.

For the sake of brevity, the subbasin specific expansion of *Task 2.2 and 2.3* and *Methods 2.2 and 2.3* are presented in outline form only. The intention of the status monitoring program is to be as consistent as possible across subbasins within the Columbia River basin.

Task 2.2. Develop and test a status monitoring program specific to the John Day River basin ecosystem.

2.2.1. – Test habitat assessment methods.
2.2.2. – Test adult population assessment methods.
2.2.3. – Test juvenile population/productivity assessment methods.
2.2.4. – Test probabilistic sampling based approaches.

Task 2.3. Develop and test a status monitoring program specific to the Salmon River basin ecosystem.

2.3.1. – Test habitat assessment methods.
2.3.2. – Test adult population assessment methods.
2.3.3. – Test juvenile population/productivity assessment methods.
2.3.4. – Test probabilistic sampling based approaches.

Objective 3.

Implement the salmonid and habitat status and trend monitoring program developed in *Objective 2* through the cooperative agreement developed in *Objective 1.*

Task 3.1.

Implement a pilot status and trend monitoring program for salmonids and their habitat in the Wenatchee River basin.

Methods 3.1.1. – Habitat and Juvenile Salmonid Monitoring

Sample 50 randomly selected 1-km reaches in each of the four major watershed of the upper Wenatchee River basin. The sampling universe will be 5^{th} order and smaller stream from the 1:100k EPA River Reach file. Sample size was determined based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on methods for habitat and juvenile monitoring developed in *Tasks* associated with *Objective 2* (protocols and methods modified as needed from: Jones and Moore, 1999; Rodgers, 2000; Thom et al., 2000). Habitat sampling will determine current habitat conditions in each of the watersheds and allow for assessing how habitat conditions change in the future. Current habitat conditions will also be compared to habitat survey undertaken by US Forest Service. Juvenile salmonid sampling will determine the current distribution and abundance of salmonids in each of the 4 watersheds and trends in distribution and abundance of salmonids over time. In addition, trends among the watersheds can be compared over time as functions of differing degrees of resource management and human impact.

Methods 3.1.2. – Steelhead and Spring Chinook Adult Monitoring
Sample 50 randomly drawn 1-km reaches in each of the four watersheds. The sampling universe will be the range of steelhead and Chinook spawning in each of the four watersheds. Sample size is based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on protocols and methods developed in *Tasks* associated with *Objective 2* for spawning surveys. Each site will be visited once every 10 – 14 days across the entire spawning season to develop cumulative redd counts. Spawner sampling will determine the current abundance (status, ±40%) and distribution of adult steelhead and chinook in each of the four watersheds and allow the assessment of abundance and distribution change over time.

Task 3.2.
Implement a pilot status and trend monitoring program for salmonids and their habitat in the John Day River basin.

Methods 3.2.1. – Habitat and Juvenile Salmonid Monitoring
Sample 50 randomly selected 1-km reaches in each of the four major watershed of the upper John Day River basin. The sampling universe will be 5th order and smaller stream from the 1:100k EPA River Reach file. Sample size was determined based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on methods for habitat and juvenile monitoring developed in *Tasks* associated with *Objective 2* (protocols and methods modified as needed from: Jones and Moore, 1999; Rodgers, 2000; Thom et al., 2000). Habitat sampling will determine current habitat conditions in each of the watersheds and allow for assessing how habitat conditions change in the future. Current habitat conditions will also be compared to habitat survey undertaken by US Forest Service. Juvenile salmonid sampling will determine the current distribution and abundance of salmonids in each of the 4 watersheds and trends in distribution and abundance of salmonids over time. In addition, trends among the watersheds can be compared over time as functions of differing degrees of resource management and human impact.

Methods 3.2.2. – Steelhead and Spring Chinook Adult Monitoring
Sample 50 randomly drawn 1-km reaches in each of the four watersheds. The sampling universe will be the range of steelhead and Chinook spawning in each of the four watersheds. Sample size is based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on protocols and methods developed in *Tasks* associated with *Objective 2* for spawning surveys. Each site will be visited once every 10 – 14 days across the entire spawning season to develop cumulative redd counts. Spawner sampling will determine the current abundance (status, ±40%) and distribution of adult steelhead and chinook in

each of the four watersheds and allow the assessment of abundance and distribution change over time.

Task 3.3.

Implement a pilot status and trend monitoring program for salmonids and their habitat in the upper Salmon River basin.

Methods 3.3.1. – Habitat and Juvenile Salmonid Monitoring

Sample 50 randomly selected 1-km reaches in each of the four major watershed of the upper Salmon River basin. The sampling universe will be 5th order and smaller stream from the 1:100k EPA River Reach file. Sample size was determined based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on methods for habitat and juvenile monitoring developed in *Tasks* associated with *Objective 2* (protocols and methods modified as needed from: Jones and Moore, 1999; Rodgers, 2000; Thom et al., 2000). Habitat sampling will determine current habitat conditions in each of the watersheds and allow for assessing how habitat conditions change in the future. Current habitat conditions will also be compared to habitat survey undertaken by US Forest Service. Juvenile salmonid sampling will determine the current distribution and abundance of salmonids in each of the 4 watersheds and trends in distribution and abundance of salmonids over time. In addition, trends among the watersheds can be compared over time as functions of differing degrees of resource management and human impact.

Methods 3.3.2. – Steelhead and Spring Chinook Adult Monitoring

Sample 50 randomly drawn 1-km reaches in each of the four watersheds. The sampling universe will be the range of steelhead and Chinook spawning in each of the four watersheds. Sample size is based on the minimum number of sites necessary to quantify current conditions (status) and detect trends in conditions over time. Sampling will be based on protocols and methods developed in *Tasks* associated with *Objective 2* for spawning surveys. Each site will be visited once every 10 – 14 days across the entire spawning season to develop cumulative redd counts. Spawner sampling will determine the current abundance (status, ±40%) and distribution of adult steelhead and chinook in each of the four watersheds and allow the assessment of abundance and distribution change over time.

Watershed-scale Habitat Action Effectiveness Monitoring

Habitat restoration action effectiveness monitoring can be conducted at multiple spatial scales, depending on the objectives of the work. For example, one can assess the effect of a management action on a specific ESU (which may encompass several populations), a specific population (may include several sub-populations), at the sub-population level (may encompass a watershed within a basin), or at the reach scale. Clearly, the objectives and hence the indicators measured dictate the spatial scale at which action effectiveness monitoring is conducted. For example, if the objective is to assess the effects of nutrient enhancement on egg-smolt survival of a specific sub-population of spring chinook, then the spatial scale covered by the study must include the entire area inhabited by the eggs, fry, parr, and smolts. If, on the other hand, the objective is to assess the effects of a sediment reduction project on egg-fry survival of a local group of spring chinook (*i.e.*, chinook within a specific reach of stream), then the study area would only encompass the reach of stream used by spawners of that local group.

Although in theory there might be no limit to the scale at which effectiveness monitoring can be applied, in practice there is a limit. This is because as the spatial scale increases, the likelihood of overlapping multiple treatments (*i.e.,* management actions) increases. For example, at the spatial scale representing an ESU or population, there may be 10s to 100s of management actions within that area. Multiple treatment effects make it very difficult to assess the effects of specific actions on an ESU (see Hillman and Giorgi 2002). Even though it may be impossible to assess specific treatment effects at larger spatial scales, it does not preclude one from conducting effectiveness monitoring at this scale. Indeed, one can assess the combined effects of the management actions on the ESU or population.

If the biological indicator of interest is a life-stage specific survival term, then the fundamental scale of the monitoring program should be equal to the area occupied by a specific sub-population. Here, a sub-population is defined as the smallest geographic unit where juvenile life-stage survival can plausibly be assumed to be independent of other sub-populations. Thus, one cannot measure independent fry-to-parr, parr-to-smolt, and recruit-per-spawner survival rates at finer spatial scales because of mixing and migration. For egg-fry survival, the spatial scale could be smaller because eggs and alevins are more confined in space than are fry and parr, which tend to move both upstream and downstream from spawning locations.

Because of the conflict between spatial scale and multiple treatment effects, and thus the ability to assess specific management actions, there may be times when it is not possible to effectively analyze the effects of individual management actions on life-stage specific survival specific sub-populations. This can, for example, occur if multiple actions impact parr-to-smolt survival rates for a particular sub-population. In this case, it will be necessary to measure other indicator(s) to assess the effectiveness of specific management actions. Other biological indicators identified in the BiOp include distribution, abundance, growth, and condition. In addition, the BiOp calls for the monitoring of physical/environmental attributes. These too can be used to assess the effects of management actions. Therefore, to establish the linkages between management actions and biological indicators as called for in the BiOp one will need to measure physical/environmental indicators in concert with biological indicators. These studies often can be conducted at scales small enough to avoid treatment effects from multiple management actions. They can also help infer which action or actions had the greatest affect on life-stage specific survival at the sub-population scale.

Thus, to capture the aggregate impact of multiple habitat restoration projects on population demographic characteristics, the minimal spatial scale of this effectiveness monitoring program will be major watersheds that correspond to identified population segments (*i.e.,* as defined by the IC-TRT). The actions within each watershed will be assessed for their local environmental and physical impact through reach scale habitat condition assessments, but their biological impact will be assessed on the scale of the entire watershed as indicated by integrative response variables such as juvenile fish productivity and fish conditions as well as several representative water quality indicators known to integrate over an entire watershed such as temperature.

Experimental Design

Classification of watersheds

Prior to conducting action effectiveness research, it will be necessary to classify the ecologic and geologic characteristics of the landscape supporting distinct sub-populations (as defined above). A potential hierarchical classification system is that proposed in Hillman and Giorgi (2002). That system includes descriptions of processes at the regional, drainage basin, valley segment, and channel segment scales, including standardized protocols. The value of watershed classification arises from the potential to define control sites for project-based monitoring based on their similarity to treatment sites, using the variables described in this system. The process by which matching is done, and its necessity, is described below.

Detecting changes in survival due to habitat actions

The following guidelines for detecting survival changes are based on a couple of straight-forward considerations. First, the main driver for effectiveness monitoring is changes in survival rates. Second, as noted above, below the sub-population scale it makes little sense to try to measure survival rates. To make a difference in adult abundance over time (or λ, recruits per spawner, etc.), changes in life-stage survival rates must eventually translate into changes in survival or growth rates for adults. Any tributary action that only affects a portion of the sub-population will have a proportionately small effect on population growth rates. Although juveniles are generally thought to migrate downstream on net (e.g., Bjornn 1978), they are highly mobile. Therefore, almost any action, to be effective at increasing adult numbers, must affect most or all of the target sub-population.

To estimate life-stage specific survival rates, one often needs to estimate life-stage specific abundance (mark-recapture studies usually avoid this requirement; Table 1.). Adult counts for most populations are conducted at weirs or by counting redds, and (at least for chinook) are believed to cover most of the spawning reaches for most stocks. In combination with annual, sub-population-specific return-at-age estimates, these can be used to estimate recruits per spawner. For juveniles, one would tag parr in rearing areas each year, but probably not for the entire length of the area. Tagging more than 1,000-3,000 parr per population does little to increase the precision of parr-to-smolt survival estimates. To assess entire population units, systematic parr and smolt emigrant abundance estimates are currently available for some populations. Typically, fish are screw-trapped in the fall and spring and estimates of detection probabilities are made simultaneously.

Table 1. Population variables to be monitored for tributary habitat status and effectiveness research.

Life stage	Monitoring variable	Sampling frequency (all measured annually)
Adults	Redd or weir counts	Multiple counts within spawning season

	Age class of spawners	Multiple counts within spawning season
	Hatchery fish spawning wild	Multiple counts within spawning season
Juveniles		
	Parr density/size	Single snorkeling sessions during summer/fall
	Parr PIT tagging/size	Single tagging sessions during summer/fall
	Resident parr abundance (mark-recapture)	Single tagging sessions during summer/fall
	Emigrant parr & smolt abundance/size	Screw trap sampling during fall and spring out-migration, with mark-recapture to estimate trap efficiency

Detecting changes in local fish distribution

Different action types probably will have differing effects on local fish distributions (Table 2). Population indicators can be divided into two different categories, since the intensity (and hence the costs) of the categories will be quite different – changes in presence/absence due to actions will be substantially less expensive than changes in juvenile densities. The best approach to fish distribution monitoring for effectiveness research will be to select reaches above, within, and below habitat actions (treatments), and comparable control sites – monitoring the same locations each year in the same manner. How extensive this effort will be depends, in turn, on how many action sites or reaches are located in the target watershed. This approach will suffice to detect changes in juvenile (parr) distribution as a result of barrier removals and other actions that change fish distributions.

Table 2. Action types and assessments as to effects on presence-absence and density.

Action Type	**Change in presence-absence**	**Increase in current (non-zero) density**
Instream flows	No, unless low flow is very low	Maybe
Nutrient additions	No	Maybe, if juveniles leave because of limited food supply
Barrier removal	Yes	No, unless current barriers are partially passable
Diversion screens	No	No
Sediment reduction	Maybe, if treated area is so heavily embedded that spawning is impossible	Maybe – removing sediment may increase spawning usage
Riparian buffers	No, unless area is currently uninhabitable due to lack of cover	Maybe – treatment may attract juveniles to improved habitat
Instream structures	No, unless area is currently uninhabitable due to lack of structures	Maybe – treatment may attract juveniles to improved habitat
Water quality improvements	No, unless temperature or chemicals render area uninhabitable	Maybe – treatment may attract juveniles to more hospitable habitat

Detecting changes in physical/environmental conditions

Table 3. contains physical/environmental indicator variables for effectiveness monitoring. Flow and water temperature would be sampled continuously at fixed gauging stations located in the lower reaches of each population. In some cases, where actions are expected to have substantial effects on these variables, one would sample upstream and downstream from treatment and control reaches as well. Similar spatial density would probably be needed for other water quality measures. For the remaining variables in Table 3., one would do treatment and control reach sampling similar to the juvenile sampling. The detailed habitat surveys would be conducted at the same times and locations as the surveys for juveniles.

Table 3. Physical/environmental indicator variables to be monitored for tributary habitat status and effectiveness research. Table is modified from Hillman and Giorgi (2002).

General characteristics	Specific indicators	Suggested protocols	Sampling frequency	Spatial density/locations
Temperature	MWMT and MDMT	Schuett-Hames et al. (1999a); Zaroban (2000)	Continuous	Lower end of treatment and control reaches
Sed/turbidity	Turbidity	OPSW (1999)	Seasonal (4 times/yr)	As above
	Depth fines	Platts et al. (1983); Schuett-Hames (1999b)	Annual	Three subsamples within each spawning area (pool tailout or riffle)within a site
Contaminant/ nutrients	pH	OPSW (1999)	Seasonal (4 times/yr)	Lower end of treatment and control reaches
	DO	OPSW (1999)	As above	As above
	Nitrogen	OPSW (1999)	As above	As above
	Phosphorus	OPSW (1999)	As above	As above
Artificial barriers	Road crossings	Parker (2000); WDFW (2000)	Annual	Total number for entire reach
	Diversion dams	Bain & Stevenson (1999); WDFW (2000)	Annual	As above
	Fishways	WDFW (2000)	Annual	As above
Substrate	Dominant substrate	Bevenger & King (1995); Bunte & Abt (2001)	Annual	Measured at 11 equally space transects in each site
	Embeddedness	MacDonald et al. (1991)	Annual	Three subsamples within riffles used for spawning and rearing within a site
Large wood	Pieces per mile	Overton et al. (1997); BURPTAC (1999)	Annual	Total number for entire reach
Pools	Pools per mile	Overton et al. (1997); Platts et al. (1983)	Annual	As above
	Pool quality	Platts et al. (1983)	Annual	Measure each pool within survey sites
Off-channel habitat	Side channels & backwaters	WFPB (1995); Reeves et al. (2001)	Annual	Total number for entire reach
Channel condition	Width/depth ratio	BURPTAC (1999)	Annual	Measured at 11 equally space transects in each site
	Wetted width	Bain & Stevenson (1999)	Annual	As above
	Bank full width	Bain & Stevenson (1999)	Annual	As above
	Bank stability	Platts et al. (1987); BURPTAC (1999)	Annual	As above
Streamflows	Streamflow	Bain & Stevenson (1999);	Continuous	In lower reach for each

		MacDonald (1991)		major tributary
Watershed condition	Watershed road density	WFC (1998); Reeves et al. (2001)	Annual	Entire watershed
	Riparian-road index	WFC (1998)	Annual	Entire watershed
	Equivalent clearcut area	USFS (1974); King (1989)	Annual	Entire watershed
	Percent veg altered	Platts et al. (1987)	Annual	Measured within each sampling site

Data and analytical products

Data for each watersheds will consist of the following:

1) Classification variables, probably updated no more than once;
2) Water quantity and quality measured in lower reaches of each population and perhaps upstream and downstream from some project sites;
3) Annual physical/environmental indicators from Table 3. for treatment and control reaches;
4) Annual redd or weir counts for spawning adults (multiple counts of entire spawning reach where feasible, peak index counts otherwise), with return-at-age information for each year;
5) Annual estimates of hatchery origin fish on spawning grounds, and outplants of hatchery juveniles;
6) Annual parr density surveys for treatment and control reaches;
7) Parr PIT tagging of 1,000-3,000 parr tagged each year.
8) Annual estimates of parr and smolt emigration.
9) Integrator variables for water quality (e.g., temperature).

In addition to the biological and environmental data, a critical part of the effort will be compiling a detailed inventory of past, current, and planned habitat projects. The inventory is required to select treatment and control monitoring sites, to assess how extensive the required juvenile distribution and detailed habitat monitoring effort will be, and will also be useful for other programs (e.g., subbasin planning). These data are equivalent to the classification variables in scope and use in that they contribute to the biological context in which all actions are sited. These data will be collected at the same time to facilitate data base development

Analytical framework to detect watershed scale impacts of restoration actions

We want to be able to answer a variety of questions at different spatial and temporal scales:

Q1) Do subbasins or sub-populations in aggregate help move an entire ESU toward recovery goals?

Q2) Did habitat projects in aggregate within a sub-population increase recruits per spawner, life-stage survival rates, etc.?

Q3) Is an individual habitat project in a given reach effective in changing fish distributions or environmental conditions?

Our approach manifests an "Observational Studies" approach to project effectiveness. Techniques for observational studies are commonly applied to tests of drug effectiveness or tests of environmental toxicology and correlated human response. As such, there already are tools for the design and analysis of experiments of this type (see Rosenbaum, 1995).

Unfortunately, it is uncommon for the details and limitation of observational studies to be incorporated explicitly into work plans for field studies of the type we are describing. For example, it is common for people to monitor a couple of indicators in populations of treatments and controls and simply perform a t-test or ANOVA to identify differences between those populations. This is inadequate for our purposes. The ISRP said as much in its recent review of the Clearwater Subbasin Plan (ISRP, 2003) when they distinguished randomized treatments and controls from the non-random selection in observational studies:

> *Large scale observational studies that involve "treatment-control", "before-after" or "before-after-control-impact (BACI)" designs fall under Tier 1 or 2 trend monitoring and do not establish cause and effect relationships as in Tier 3 research monitoring.* (ISRP, 2002)

This clearly points to the statistical challenges presented by non-randomization of treatments. It may be too conservative to treat observational studies as inadequate for our purposes. In fact, Cochran defines observational studies as empirical studies where:

> *"...the objective is to elucidate cause-and-effect relationships...(where)...it is not feasible to use controlled experimentation, in the sense of being able to impose the procedures or treatments ... or to assign subjects at random to different procedures."* (Cochran, 1965)

So the potential to infer cause and effect from properly designed and analyzed observational studies exists. Having said that, however, the word "properly" places a heavy responsibility squarely on the design of these studies to incorporate the analytical features adequate to generate the required cause-and-effect inferences.

Luckily, there are strategies for dealing with these design issues. In particular, the non-random assignment of treatments can result in some feature of the treated area being responsible for differences from the control areas that have nothing to do with the treatment itself – the problem of hidden bias. A familiar example is the correlation of smoking and heart attacks. If we were to look at 500 smokers and 500 non-smokers and evaluate the number of heart attack sufferers in those two populations we might see a significant correlation between smoking and heart disease. However, on that data alone we cannot exclude other correlated hypotheses. For example, it is possible that the smokers were on average more obese, in which case heart disease may be correlated strongly with obesity, but poorly with smoking, independent of body condition – obesity is biasing the correlation.

The formal process of initiating an observational study involves an extensive pre-treatment or pre-analysis assessment of the "treatment" and "control" data. Until proper hypothesis generation, matching and hidden bias assessment are done, all of the problems with non-randomly distributed samples are present, and the results of any analysis highly suspect. Observational studies statistical approaches differ markedly from standard inferential statistics at this point: it is essential to generate as many alternative hypotheses as possible and to collect all of the classification variables that might be correlated with each hypothesis; since there is no randomization of treatment and control application across a single population, proper contrast due to treatment can only be established by proper matching of treatment and control samples (pre- or post-hoc); and finally, as a result of the non-random nature of the samples, bias (hidden) may be present in the data and must be assessed. However, it is a relatively straightforward process of correlation analysis to establish that treatments in our studies are free from hidden bias. If bias is present in a proposed matching scheme for "treatment" and "control" samples it can be dealt with in several manners, the most effective being re-matching to minimize the bias. Once hidden bias is removed one can then apply standard statistical approaches that are familiar to randomized experiments and draw similar quality inferences (Rosenbaum, 1995).

Since hidden bias reduction is critical to the successful analysis of an observational study, the process merits further discussion. One of the strategies for eliminating hidden bias is to stratify treatment and control comparisons with a long vector of correlated variables ($\mathbf{x}_{[j]}$). If one can show that $\mathbf{x}_{[j]}$ is the same in treatment and control groups, or indeed even that the likelihood of elements in $\mathbf{x}_{[j]}$ being the same ($\lambda(\mathbf{x}_{[j]})$) is itself the same in treatments and controls, then one is able to employ standard statistical approaches to evaluating the consequences of treatments (Rosenbaum, 1995). In fact, even if $\mathbf{x}_{[j]}$ is of high dimension with continuous variables, and so is unlikely to be exactly equivalent in treatments and controls, there are approaches to determine confidence intervals on $\mathbf{x}_{[j]}$ and rules for when one can and cannot apply standard analytical approaches for randomized treatments to observational studies (Rosenbaum, 1995).

These features of observational studies will be incorporated into the study designs for effectiveness research in this program. Indeed, the utility of $\mathbf{x}_{[j]}$ in validating inferences has, in part, motivated the long list of classification variables that is a required components of this program. In the study design, we will use common values of $\mathbf{x}_{[j]}$ to identify suitable controls for treatment sites. In the response design we will capitalize on changes in other indicators to discriminate the differences between treatments and controls.

Objective 4.

Implement a watershed scale habitat restoration action effectiveness monitoring approach with known accuracy and precision through field-testing of protocols and sampling design.

Task 4.1.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the Wenatchee River basin.

4.1.1. – Develop landscape scale stratification/covariate data layer.

4.1.2. – Monitor physical/environmental indicators at each project location within target watershed.

4.1.3. – Monitoring integration response variables at base of each target watershed.

4.1.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

Task 4.2.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the John Day River basin.

4.2.1. – Develop landscape scale stratification/covariate data layer.
4.2.2. – Monitor physical/environmental indicators at each project location within target watershed.
4.2.3. – Monitoring integration response variables at base of each target watershed.
4.2.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

Task 4.3.

Implement a watershed scale habitat restoration action effectiveness monitoring program for salmonids and their habitat in the Salmon River basin.

4.3.1. – Develop landscape scale stratification/covariate data layer.
4.3.2. – Monitor physical/environmental indicators at each project location within target watershed.
4.3.3. – Monitoring integration response variables at base of each target watershed.
4.3.4. – Coordinate implementation of status, trend and effectiveness monitoring program.

1. Develop GIS data layers for land use including the locations of the status monitoring sites, the major human uses of the environment, the location of monitored projects, and the changes in the key landscape-scale status variables through time. ($150/yr total)

a. Data layer development
   i. Complile existing data layers
   ii. Generate new data layers
      1. From DEMs generate stream network, valley form
      2. From remote sense data generate vegetation, LULC layers

b. Landscape scale fish-habitat association tool development
   i. Utility of various remote sense products and landscape scale analysis
   ii. Fish-habitat association models on landscape scale
   iii. Productivity potential assessment
   iv. Historic landscape reconstruction

Subbasin specific aspects of the Status and Trends Monitoring program:

-Wenatchee River Basin
   a. Many existing data layers, requires coordination, compliation

-John Day River Basin
   a. Many existing layers compiles (e.g., SWAM)
   b. Potential for historic reconstruction
   c. Coordinate with ongoing landscape scale programs (USBR, NMFS, OSU)

-Upper Salmon River Basin
   a. Many existing data layers compiled (e.g., SWAM)
   b. Coordinate with ongoing landscape scale programs (USBR, NMFS)

2. For a significant portion of each subbasin, monitor key environmental variables associated with restoration activity in each of the eight classes of effects that are identified in the Action Agencies' RME workplan. This monitoring program should incorporate, wherever possible, either a pre- and post-project research design or an action/reference site paired design that will identify and test causal relationships between the key environmental variables and the structured salmonid population. This monitoring scheme is identified in the RME workplan as a top-down action effectiveness monitoring program. (($750k/yr total)
   a. On the scale of watersheds, assess the impact of total suite of habitat restoration actions.
   b. Monitor the physical/environmental indicators at each action site w/in watershed, and overall potential for biological benefit at base of watershed with integrator indicators (smolts, temp, other water quality metrics)
   c. **(move to 4)** Integrate monitoring program with assessment framework
      i. Not an explicit experiment, so analysis must consider multiple routes to determining impact.
      ii. Construction of logical argument to support effectiveness assessment of suites of actions.
      iii. At monitoring sites, within and between watersheds w/in subbasin, compare environmental indicators for difference (magnitude and distribution.
      iv. Comparison of watershed integration indicators between watersheds as function of #s and types of actions
      v. Comparison of indicators (all) within watersheds to subbasin condition
      vi. Comparisons via correlation models
      vii. Comparisons via linear models (check with Bailey and Li on their methods for grazing exclusion experiment methods)

Subbasin specific aspects of the Status and Trends Monitoring program:

-Wenatchee River Basin
   a. Upper watershed is dominated by preservation/conservation actions – test assumption that lower river habitat modifications represent major limitations to basinwide productivity. Limiting factors are: temperature, off-channel habitat, bank habitat complexity. Alternative hypothesis that upper watershed actions are having an impact needs to be assessed in parallel.
   b. Target watersheds for comparisons of ongoing activity
      i. Chiwawa, Nason, Lake Wenatchee and above, Peshastin
      ii. Trapping at each watershed mouth underway (needs some support)
      iii. Some preservation and restoration projects underway or planned, build in site specific physical/environmental monitoring wherever possible.
      iv. Develop survival estimates for upper watershed juvenile rearing with tag/detect program.
   c. In lower river (confluence to Tumwater) major channel restoration program developing for implementation in 1-2 yrs.
      i. Establish baseline as "before" condition

ii. Channel characterization surveys
iii. Reach classification surveys
iv. Snorkel subset of reaches (stratified by classification) for juvenile use

d. Assessment framework
    i. Compare upper basin action site indicators to subbasin scale indicators.
    ii. Compare rearing juvenile survival as fish move through system, and as mainstem restorations are undertaken.

-John Day River Basin

a. Test assumption of key limiting factors associated with water quality
b. Target watersheds: NF and MF above US 395 bridge, SF (all)
    i. Each can be assessed with smolt trap and water quality indicators (e.g., temp, nutrients, toxins) at mouth.
    ii. Each watershed has known program of habitat restoration actions targeting temperature, sediment, nutrients.
    iii. Monitor at 500m reach for physical/environmental indicators w/in each project (~20 per watershed)
c. Assessment framework
    i. Compare action site indicators to subbasin EMAP indicators
    ii. Compare action watershed productivity to basinwide productivity metrics.

-Upper Salmon River Basin

a. Specific limiting factor that should be assessed???
    i. Forest practices?
    ii. Water qual/quan?
    iii. Hatchery fish?
b. Pick watersheds and trap and monitor all actions w/in???

3. Coordinate the development and implementation of the integrated status and effectiveness monitoring program. ($750k/yr total)

a. Pointless to undertake this program development w/o buy-in and participation of subbasin comanagers and participating agencies.
b. Fundamental to implementing above tasks will be sufficient staffing support for local infrastructure development and participation.
    i. 1.5-2.0 FTEs per subbasin to be distributed as needed
    ii. 1.5 FTEs at NWFSC for oversight and analytical lead/development
c. Subbasin specific RME program advisory groups
    i. Wenatchee River Basin: RTT subgroup
    ii. John Day River Basin: Form from at least – ODFW, CTWSR, ODEQ, USFS, USFWS, NMFS, OSU.

Upper Salmon River Basin: Form from at least – IDFG, USFS, NP, CTSB, USFWS, NMFS.

Evaluation and Long-term Program Design

This proposal represents the effort required to implement subbasin-scale pilot status and effectiveness monitoring projects. However, the program must also contain an evaluative component capable of assessing the quality and utility of the data gathered by the pilot projects, as well as the mechanism by which the program is scaled up to meet full implementation requirements of a Columbia River basinwide monitoring project.

Objective 5.

Develop an evaluation framework for the status, trend and watershed scale effectiveness monitoring program.

Task 5.1.

Compile and evaluate the annual assessments of population and habitat status.

Methods 5.1.1. – Compile status and trend monitoring data.

This project does not explicitly contain a data management element, but is linked to a proposed data management development effort (proposal #35048) that targets spatially explicit status and trend data for salmonid populations and habitat condition indicators. As such, data compilation, quality checking, and metadata development will occur in parallel to the data collection efforts.

Methods 5.1.2. – Evaluate status and trend monitoring data.

The intent of the project is to implement a quantitative monitoring and evaluation plan. The sampling protocols are to be implemented and tested to assess their ability to capture status and trend aspects of anadromous salmonid habitat and populations with known measurement error. The individual protocols are implemented within a statistically rigorous sampling scheme such that the data generated is of known spatial representation, with known accuracy and precision. The status and trend evaluations arise directly from the sampling scheme, as the estimators of the first and second moments of the data are given by the sample weights and distributions in time and space. Nonetheless, while the reduction of the monitoring data may be reasonably straightforward, the evaluation of the program itself, *i.e.,* its ability to generate data that meets regional decision-making performance standards, will be more complex. In fact, such an assessment will be impossible in many cases, as no regionally agreed upon standards for performance of status monitoring programs exist. However, the status and trend data from this proposed monitoring program will be used to suggest design and performance criteria for population and habitat monitoring programs.

Task 5.2.

Compile and evaluate the annual assessments of watershed scale habitat action effectiveness.

Methods 5.2.1. – Compile project effectiveness monitoring data.

This project does not explicitly contain a data management element, but is linked to a proposed data management development effort (proposal #35048) that targets spatially explicit project effectiveness monitoring data for salmonid populations and habitat condition indicators. As such, data compilation, quality checking, and metadata development will occur in parallel to the data collection efforts.

Methods 5.1.2. – Evaluate watershed-scale habitat action effectiveness monitoring data. The quantitative framework for watershed-scale habitat action effectiveness evaluations was described in *Objective 4*. What should be apparent from the description of the analytical approaches described above is that large matrices of response variables and descriptive covariates must be compiled, linked and manipulated in a spatially explicit fashion. As such, the evaluation framework will depend heavily on the parallel development of a GIS based database system to support the statistical analysis of large complex data structures. For example, the requirements of observational studies statistics for optimizing multidimensional pair-wise matching of "treatment" and "control" sites based on continuously varying independent variables will require a flexible, dynamically searchable database of all Tier 1 and Tier 2 physical and environmental habitat indicators. Annual assessments of the watershed-scale effectiveness monitoring program and its data will be performed by updating and verifying the statistical models for detecting biological responses within and between watersheds, as well as the stratification process by which site are grouped.

Objective 6.

Develop and implement a long-range status, trend, and watershed scale effectiveness monitoring program.

Task 6.1.

Expand the proposed program to additional subbasins and watersheds as needed to meet regional and programmatic monitoring requirements, in particular, the complete implementation of the RME program of the NMFS 2000 FCRPS Biological Opinion.

Methods 6.1.1. – Develop a framework for programmatic guidance.
As the pilot studies are expanded beyond the initial watersheds and subbasins, a framework for guiding the process must be established. Develop a regional oversight process for compiling subbasin specific monitoring needs, planning program direction and soliciting independent assessment of the plans and the progress towards their implementation.

Status Monitoring Critical Uncertainties

The primary goal of this proposed status and trend monitoring and evaluation effort is to design and implement a system of statistically rigorous data collection schemes to answer questions fundamental to the management and recovery of anadromous salmonids. In spite of tremendous past efforts many of the most important questions remain unanswered due to basic uncertainties in these fishes' population processes, both with respect to trends in abundance as well as the factors that regulate salmonid population dynamics. Some of these uncertainties arise from a basic lack of biological information, and some from general areas of weakness in regional monitoring programs. In either case, management decisions such as recovery plans will be compromised due to a fundamental lack of supporting information. For example, the quality of population status data, and life-stage specific distribution information is much lower for steelhead than for other anadromous salmonids. As such, the quality of management plans will be uneven between populations, ESUs and species of anadromous salmonids across the Columbia River basin. The objective of the following tasks is to address two key status monitoring uncertainties identified as part of the implementation plan for the NMFS 2000 FCRPS BiOp.

Objective7.

Address status monitoring critical uncertainties. These additional monitoring efforts are to be distributed across the entire anadromous portion of the Columbia River basin to address key status monitoring needs.

Task 7.1.

Intensify population status monitoring programs to assess the abundance and spatial extent of steelhead spawning adults and rearing juveniles.

Methods 7.1.1. – Identify geographic gaps in steelhead status monitoring data

In consultation with IC-TRT and basin co-managers, expand key on-going status monitoring efforts to capture critical missing populations or geographic areas.

Methods 7.1.2. – Expand current status monitoring programs for steelhead adults and juveniles.

Expand steelhead status monitoring programs to develop more accurate abundance estimates and increased spatial coverage of adult spawning populations. In addition, bolster current monitoring programs to better define the spatio-temporal distribution of rearing juveniles during their freshwater phase.

Task 7.2.

Intensify the assessment of the extent to which anadromous salmonids of hatchery origin spawn naturally in the wild.

Methods 7.2.1. – Identify geographic gaps in monitoring of wild spawning hatchery fish.

In consultation with the IC-TRT and basin co-managers, expand key on-going status monitoring efforts to capture critical missing populations or geographic areas.

Methods 7.2.2. – Expand current status monitoring programs to detect hatchery fish in natural spawning areas.

Quantify the extent to which hatchery origin fish may be spawning naturally in the wild as indicated by the spatial extent of wild spawning hatchery fish, the fraction of natural spawners hatchery fish represent, and their range of spawning behavior or activity.

g. Facilities and equipment

Staff to support and supervise this project will be based at the NOAA Fisheries' Northwest Fisheries Science Center in Seattle, WA. The NWFSC supports research efforts across the region with a large staff of laboratory and field fisheries biologists, as well as a research staff specializing in mathematical and statistical analysis of population and environmental data. In addition, the NWFSC has strong IT and IM support for the development and maintenance of information and data management systems.

h. References

Reference (include web address if available online)	Submitted w/form (y/n)
Alverts, B., Horton, A. and Stone, B. (1997). Results of FY 1996: Implementation Monitoring Program for Management of Habitat for Late-Succession and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl. United States Forrest Service.	N
Botkin, D. B., Peterson, D. L. and Calhoun, J. M., Ed's, (2000). The scientific basis for validation monitoring of salmon for conservation and restoration plans. Olympic Natural Resources Center Technical Report. University of Washington, Olympic Natural Resources Center, Forks, Washington, USA.	N
Columbia Basin Fish and Wildlife Authority (CBFWA) (2001). Provincial Review Process and Sub basin Planning: Sub basin summaries and Workplan. http://www.cbfwa.org/files/province/gorge/subsum.htm	N
Federal Caucus, 2000. Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery Strategy. Vol. 1 & 2. http://www.salmonrecovery.gov/strategy_documents.shtml	N
Holmes, E. E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Science USA 98:5072-77.	N
Holmes, E. E. and W. F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology, in press.	N
Independent Scientific Advisory Board (ISAB), (2001). Model Synthesis Report: An analysis of decision support tools used in Columbia River Basin salmon management. March 2, 2001. ISAB 2001-1a. For the Northwest Power Planning Council and the National Marine Fisheries Service.	N
Jacobs S., J. Firman, and G. Susac 2001. Status of Oregon coastal stocks of anadromous salmonids, 1999-2000; Monitoring Program Report Number OPSW-ODFW-2001-3, Oregon Department of Fish and Wildlife, Portland, Oregon.	N
Jones, K. K. and K. M. S. Moore. 1999. Habitat assessment in coastal basins in Oregon: implications for coho salmon production and habitat restoration. Pages 329-340 In Sustainable Fisheries Management. E. E.	N

Reference (include web address if available online)	Submitted w/form (y/n)
Knudsen, C. R. Steward, D. D. McDonald, J. E. Williams, and D. W. Riser Eds. CRC Press New York 724 p.	
Jones, K.K., R.L. Flitcroft, and B.A. Thom. 2001. Spatial patterns of aquatic habitat in Oregon. Pages 266–280 In First International Symposium on GIS in Fisheries Science. T. Nishida, Editor.	N
Jordan, C. and 15 co-authors 2002. Mainstem/Systemwide Province Stock Status Program Summary. Guidelines for Conducting Population and Environmental Status Monitoring. February 22, 2002. Prepared for the Northwest Power Planning Council. http://www.cbfwa.org/files/province/systemwide/subsum/020515StockStatus.pdf	N
Kaufmann P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck. 1999. Quantifying Physical Habitat in Wadeable Streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.	N
Larsen, D.P., T.M. Kincaid, S.E. Jacobs, and N.S. Urquhart. 2001. Designs for evaluating local and regional scale trends. BioScience 51(12):1069-1078.	N
Moore, K.M.S., K.K. Jones, and J.M. Dambacher. 1997. Methods for stream habitat surveys. Oregon Department of Fish and Wildlife, Information Report 97-4, Portland, Oregon.	N
National Marine Fisheries Service (NMFS). 2000a. Federal Columbia River Power System Biological Opinion: Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. NMFS-NWR, Seattle, WA.	N
National Marine Fisheries Service (NMFS). 2000b. Recovery Planning Guidance for Technical Recovery Teams. 1 September, 2000 DRAFT. NMFS-NWR, Seattle, WA.	N
Northwest Power Planning Council. 2000. 2000 Columbia River Basin Fish and Wildlife Program, a multi-species approach for decision-making, November 30, 2000, Council document 2000-19. Portland, Oregon. http://www.nwcouncil.org/library/2000/2000-19/index.htm	N
Oregon Plan. 1997. Coastal Salmon Restoration Initiative. Salem, OR. http://www.oregon-plan.org/Final.html	N
Recovery Science Review Panel (RSRP) (2001). Report for the meeting held December 4-6, 2000. http://www.nwfsc.noaa.gov/cbd/trt.htm	N

Reference (include web address if available online)	Submitted w/form (y/n)
Rodgers, 2000; Rodgers, J.D. 2000. Abundance of Juvenile Coho Salmon in Oregon Coastal Streams, 1998 and 1999. Monitoring Program Report Number OPSW-ODFW-2000-1, Oregon Department of Fish and Wildlife, Portland, Oregon. (http://osu.orst.edu/dept/pacrim/pdf's/snkrep99.pdf)	N
Thom, B.A., K.K. Jones and R.L. Flitcroft. 1999. Stream Habitat Conditions in Western Oregon, 1998. Monitoring Program Report 1999-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, Oregon.	N
Thom B., K. Jones, P. Kavanagh and K. Reis. 2000. Stream Habitat Conditions in Western Oregon, 1999. Monitoring Program Report Number OPSW-ODFW-2000-5, Oregon Department of Fish and Wildlife, Portland, Oregon.	N
Thom, B. A., P. S. Kavanagh, and K. K. Jones. 2001. Reference Site Selection and Survey Results, 2000. Monitoring Program Report Number OPSW-ODFW-2001-6, Oregon Department of Fish and Wildlife, Portland, Oregon.	N
U.S. EPA. 1998. Environmental Monitoring and Assessment Program (EMAP): Research Plan 1997. EPA/620/R-98/002. U.S. Environmental Protection Agency, Washington, D.C.	N
U.S. EPA. 2000. Ecological Assessment of Streams and Rivers in the Western United States: A Cooperative Effort Between the U.S. EPA and Western States and Tribal Nations. U.S. Environmental Protection Agency, Corvallis, Oregon	N
WA CMS. 2001. Washington State Comprehensive Monitoring Strategy. http://www.wa.gov/iac/SalmonMonitoring.html	N
Zar, J.H. 1984. Biostatistical Analysis. 2nd ed. Prentice Hall, New Jersey.	N

Section 10 of 10. Key personnel

Christopher E. Jordan, Ph.D. 0.1 FTE
Mathematical Biology and Systems Monitoring, Program Manager
NMFS Northwest Fisheries Science Center
2725 Montlake Blvd. E.
Seattle, WA 98112

Education:

University of Washington	Ph.D.	1994	Zoology
University of Chicago	B.A.	1985	Biology

Positions Held:

Program Manager	NOAA/NMFS/NWFSC, Seattle,	2002 - present
Operations Research Analyst	NOAA/NMFS/NWFSC, Seattle	1999 - 2002
Research Assistant Professor	Washington State Univ., Pullman	1999 - present
Assistant Professor	University of Colorado, Boulder	1995 - 1999
Research Associate	University of Chicago, Chicago	1994 - 1995
Research/Teaching Assistant	University of Washington, Seattle	1987 - 1994

Mathematical and Biological Publications:

Jordan, C.E. 1992. A model of rapid starting intermediate Reynolds number swimming: Undulatory locomotion in the chaetognath Sagitta elegans. *J. exp. Biol.* **163**, 119-137.

Daniel, T.L., C.E. Jordan, and D. Grunbaum. 1992. Hydromechanics of animal locomotion. In: *Mechanics and Energetics of Animal Locomotion, Advances in Comparative and Environmental Physiology, Vol. 11.*, pp. 17-49. ed. R.McN. Alexander. Springer Verlag, Berlin.

Jordan, C.E. 1996. Coupling internal and external mechanics to predict swimming behavior: a general approach? *Amer. Zool.*, **36**(6):710-722.

Steinberg, E.K. and C.E. Jordan. 1997. Using genetics to learn about the ecology of threatened species: the allure and the illusion of measuring genetic structure in natural populations. In: Conservation Biology. eds, P. Fiedler and P. Kareiva. Chapman Hall, New York.

Katz, S.L. and C.E. Jordan. 1997. A case for building integrated models of aquatic locomotion that couple internal and external forces. In: Proceedings of the 10th International Symposium on Unmanned Untethered Submersible Technology: Bioengineering. AUSI, Durham, NH.

Jordan, C.E. 1998. Scale effects in the kinematics and dynamics of swimming leeches. (**76**(10):1869-1877, Can. J. Zool.)

McClure, M. M., Sanderson, B. L., Holmes, E. E. & Jordan, C. E., (2003). A large-scale, multi-species risk assessment: Anadromous salmon in the Columbia River Basin. Ecol. Apps. In Press

Roni, P., C.E. Jordan, M.C. Liermann, and A.E. Steel. Monitoring design: important considerations for developing monitoring of aquatic restoration. In review

****

KEY PERSONNEL FOR MAJOR SUBCONTRACTING RESPONSIBILITIES

****

ROBERT M. BUGERT

Governor's Salmon Recovery Office

1133 North Western Avenue

Wenatchee, WA 98801-1229

Education:

Graduate, Washington Agriculture and Forestry Education Foundation, Class XI.
M. S. Fisheries Resources, University of Idaho, Moscow. 1985.
B. S. Wildlife Biology, Washington State University, Pullman. 1977.

Experience:

1998 to present
Eastern Washington Coordinator, Governor's Salmon Recovery Office.

Policy and technical advisor to the Governor=s Office on salmon recovery and the Endangered Species Act (ESA). Assist local governments and stakeholders in development of regional salmon recovery plans. Facilitate Habitat Conservation Plan (HCP) negotiations between the federal government and irrigation districts, conservation districts, and county governments. Serve as liaison between executive and legislative branches of state government. Serve as chair of the Snake River and Upper Columbia Regional Technical Teams.

1995 to 1998
Technical Facilitator, Mid-Columbia Public Utility Districts, Wenatchee, Washington.

Facilitated technical negotiations among agency, tribal, and utility scientists in a multi-species HCP for five major hydroelectric dams on the Columbia River. Served as technical advisor on salmon issues to watershed councils and irrigation districts for HCP development. Established means to provide financial and technical incentives to private landowners to protect salmonid habitats. Developed consensus strategy documents for both habitat and hatchery management in the Columbia River upstream of the Yakima River confluence.

1991 to 1995
Fishery Biologist, Washington Department of Fish and Wildlife, Wenatchee, Washington.

Project leader of four large-scale hatchery research programs in Columbia River. Project leader of six hatchery support programs. Agency technical representative on salmon issues to ESA Recovery Team, Northwest Power Planning Council, and several interagency groups. Served as a technical liaison to National Marine Fisheries Service on Sections 7 and 10 of ESA.

1985 to 1991
Fishery Biologist, Washington Department of Fisheries, Dayton, Washington.

Research project leader for artificial and natural production of salmon on lower Snake River. Secured funding, developed experimental design, and lead research team. Primary focus was to study (1) effects of hatcheries on wild salmon population dynamics and genetic resources, and (2) barging salmonids through Snake River dams. Assisted landowners with upland and riverine restoration projects. Served as agency technical representative to ESA Biological Review Team.

BRUCE A. MCINTOSH, Ph.D.
ODFW Oregon Plan Monitoring Coordinator
Oregon Department of Fish and Wildlife, 28655 Highway 34, Corvallis, OR 97333

Education and Experience

B.S., Wildlife Biology-University of Montana, 1982
M.S., Forest Ecology-Oregon State University, 1992

Ph.D., Forest Ecology-Oregon State University, 1995

2000 – present	Oregon Plan Monitoring Coordinator, Oregon Department of Fish and Wildlife and Assistant Professor (Courtesy), Departments of Fisheries and Wildlife and Forest Science, Oregon State University
1999 – 2000	Assistant Professor, Dept of Forest Science, Oregon State University
1996 – 1999	Research Associate, Dept of Forest Science, OSU
1992 – 1996	Faculty Research Assistant, Dept of Forest Science, OSU

Principal areas of research:

Assessment of the structure, function, and dynamics of aquatic ecosystems

Evaluation of historical changes in aquatic ecosystem structure and function and the influence of anthropogenic and natural disturbance on these changes

Multi-scale methods to assess aquatic condition and community structure of watersheds

Freshwater ecology of fish assemblages of the Pacific Northwest

The use of remote sensing techniques for across scale assessments and watershed monitoring

Selected Publications:

Torgersen, C.E., R.N. Faux, B.A. McIntosh, N.J. Poage, and D.J. Norton. In press. Airborne Thermal Remote Sensing for Water Temperature Assessment in Rivers and Streams. Remote Sensing of Environment.

Faux, R.N., and B.A. McIntosh. 2000. Stream temperature assessment using forward-looking infrared (FLIR). Conservation Biology in Practice, 1(10): 38-39.

McIntosh, B.A., J.R. Sedell, R.F. Thurow, S.E. Clarke, and G.L. Chandler. 2000. Historical changes in stream habitats in the Columbia River basin. Ecological Applications, 10(5): 1478-1496.

Torgersen, C.E., D.M. Price, B.A. McIntosh, and H.W. Li. 1999. Multiscale thermal refugia and stream habitat associations of □hinook salmon in northeastern Oregon. Ecological Applications, 9(1): 301-319.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of eastern Oregon and Washington. Northwest Science, 68(Special Issue): 36-53.

James B. Scott, Jr.
Chief Fish Scientist
Science Division, Fish Program
Washington Department of Fish and Wildlife

EDUCATION

M.S., Fisheries, University of Washington 1982
B.S., Fisheries, University of Washington 1980

PROJECT RESPONSIBILITIES

Mr. Scott will serve as the principal contact and coordinator for WDFW contributions to the project.

EXPERIENCE

Mr. Scott joined the Washington Department of Fish and Wildlife (WDFW) in 1999 to lead the newly created Science Division. His primary area of expertise is simulation and analytical models of biological systems. This expertise has been applied in a variety of applications in domestic and international forums. He served as co-chair of the Pacific Salmon Commission Chinook Technical Committee from 1991 through 2001, and was a technical advisor for the renegotiation off the Pacific Salmon Treaty in 1999. Since joining WDFW, his work has focused on developing procedures to evaluate the risks and benefits of artificial production and providing the technical basis for recovery goals for listed species. As manager of the Science Division, comprised of over 130 FTEs, he has the responsibility of assuring that the production and management of fish resources by WDFW is grounded on a sound scientific basis.

•

Example Publications:

Scott, J.B., C.R. Steward, and Q.J. Stober. 1983. The effects of urban nonpoint source pollution upon stream fish population dynamics. TAFS 115: 555-567.

Scott, J.B., Jr. 1990. Design of fishery sampling programs. In. P. Knudsen (editor), "14th Northeast Pacific Pink and Chum Workshop", pages 10-13. Washington State Department of Fisheries.

Puget Sound Salmon Stock Review Group. 1992. Assessment of the status of five stocks of Puget Sound chinook and coho as required under the PFMC definition of overfishing. Pacific Fishery Management Council. 113pp. (co-author)

Ken MacDonald
Fisheries Program Manager, Okanogan-Wenatchee National Forest
US Forest Service
215 Melody Ln
Wenatchee, WA 98801

Education and Experience

B.A., Fisheries	Oregon State University, 1977
B.A., Forestry	Oregon State University, 1982

20+ years of habitat management and monitoring of fish populations for the USFS.

Congratulations!