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Mainstem/Systemwide Province Stock Status Program Summary

Guidelines for Conducting Population and Environmental Status Monitoring

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Northwest Power Planning Council

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Stock Status Program Summary

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Stock Status Program Summary

I. PROGRAM DESCRIPTION

A. <u>Purpose of Program</u> – Why have a System-wide status monitoring program?

Goal of a status monitoring program

The goal of population and environmental status monitoring, for example as proposed under the Federal Columbia River Power System Biological Opinion (FCRPS BO Action 180; NMFS, 2000), is to provide the necessary data for resolving a wide range of uncertainties, determine population status, establish the baseline for determining causal relationships between habitat attributes and population response, and facilitate the assessment of the overall impact of management actions. The utility of a monitoring program is ultimately driven by the clarity and relevance of the questions that the program is designed to answer. Ideally a monitoring program developed to address population and environmental status monitoring in the Columbia River Basin would be used to evaluate recovery measures based on the *quantities* of fish populations (e.g., abundance and growth rate) needed to support ecological and cultural values and the structural *qualities* of populations (e.g., life history diversity, genetic diversity) that allow them to sustain themselves (and these values) in a fluctuating environment.

A system-wide status monitoring program is inherently a regional responsibility. Under current Biological Opinions and resource management plans there is a hierarchy of monitoring requirements, for example: (i) FCRPS BO Implementation status monitoring requirements that will be funded as a high priority by the Action Agencies, (ii) CBFWA status monitoring needs, (iii) Recovery Planning status monitoring of ESA listed populations that may be outside of the scope of the CBFWA funding responsibilities, and (iv) an even broader level program that meets the monitoring needs of all populations for all regional federal and state agencies. This hierarchy should be developed collaboratively, developing these levels in a stepped construction of a program over time based on costs, available funds, and pilot studies that show the value and application of more intensive monitoring. It is important to note that overall funding could be a region wide responsibility beyond the CBFWA. It is also important to note that there are other types of RME such as action effectiveness research, critical uncertainties hypothesis testing and project implementation monitoring that are essential to a resource management program, but outside of the scope of a status monitoring program.

At present there are a number of 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 addition, there is no clear plan to guarantee that data of any utility will be gathered to monitor 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.

Thus, the primary objective of a status monitoring plan for the 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. The primary complication arises from the enormous spatial scale of the sampling area and the resulting difficulty in identifying true replicate sampling sites. 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 statistically rigorous sampling program informed by our knowledge of demographic and habitat processes.

Utility of a status monitoring program

An inventory, or determination of stock status, of native fish in the mainstem rivers is critical to understanding and evaluating the effects of watershed changes, exotic species invasions, and the manipulations of conditions intended to increase the survival of anadromous fishes. Studies in other river systems have shown that restoration efforts in watersheds influence water quality and fish communities further downstream, and vice versa (Stanford and Ward 1992). Exotic species, such as American shad, smallmouth bass, and walleye have invaded the Columbia and Snake rivers, possibly displacing native species and altering community relationships. Also, impoundment of the Columbia River during the last 60 years has produced changes in the seasonal hydrograph and changes in primary and secondary production (Ebel et al. 1989, ISG 1996), that in turn have changed the physical and biotic environment for native resident fish species in the mainstem Columbia River. Ongoing actions in the mainstem Columbia River, such as seasonal spill, channel dredging, and shoreline development, continue to alter the habitats and populations of native species. Further, restoration activities in various subbasins within the Columbia River Basin will also affect mainstem conditions for native fishes.

Native fish assemblages in the Columbia River Basin have been affected by a combination of species introductions, excessive harvest, and extensive habitat degradation both before and following hydroelectric development in the basin (Li et al. 1987; ISG 1996, ISG 2000). The construction and operation of hydroelectric dams in the basin have resulted in a loss of highly productive riverine habitat, altered temperature and discharge patterns (Quinn and Adams 1996, Coutant 1999), continual export of very fine organic matter and dissolved nutrients, simplification of the channel, and loss of floodplain inundation (ISG 2000). These and other anthropogenic disturbances have allowed non-native fishes, such as American shad *Alosa sapidissima*, smallmouth bass *Micropterus dolomieui*, and walleye *Stizostedion vitreum* to establish robust populations (Beamesderfer and Rieman 1991) and resulted in a loss of native biodiversity and biotic integrity (Li et al.1987, ISG 2000). Approximately 60% of the native fish species in the basin are resident in the Columbia and Snake Rivers (Li et al. 1987).

The NWPPC's Fish and Wildlife Program recognizes the need to ensure that biodiversity is maintained within the basin to protect the integrity and sustainability of ecosystems (section 7.1) and to conserve the genetic diversity of resident native fish (section 10.2B). However, the status of the native fish fauna (particularly non-salmonid species) and consequently the structure and genetic diversity of resident fish assemblages, remains largely unknown. Native resident taxa include, for example, various species of sculpins, minnows, sandrollers, and suckers. Notable exceptions to this are the northern pikeminnow *Ptychocheilus oregonensis* that are major predators on juvenile salmonids and support a large fishery (Beamesderfer et al. 1996), and white sturgeon *Acipenser transmontanus* that support important commercial, tribal, and recreational fisheries (Miller et al. 1995, Beamesderfer et al. 1995). In a recent review of the NWPPC's Fish and Wildlife Program, the Independent Scientific Review Panel (ISRP) noted that measures in Section 10 imply a logical sequence beginning with an evaluation of the status of native fish populations (ISRP 1997, p. 29). The ISRP specifically recommend that the NWPPC require a systematic basin-wide inventory of remaining native resident fish populations so that restoration opportunities can be identified and prioritized.

The Independent Science Group (ISG) has stated that returning the Columbia River to a more normative state is necessary to restore Columbia River salmonids (ISG 2000). However, to document trends towards or away from a normative ecosystem, baseline conditions must be established. Projects that will provide baseline information on the relative abundance of native fishes in the Columbia River are needed, and will also provide information for identifying degradations and improvements in the biological integrity of the native fish assemblage. The Fish and Wildlife program recognizes the need to explore methods to assess trends in system health (section 2.1A.1). Native fish assemblages are routinely sampled in other regions to monitor changes in ecosystem quality over time and to assess responses of fish assemblages to management and other human activities (Fausch et al. 1984, Angermeir and Karr 1986, Hughes and Gammon 1987, Fausch et al. 1990, Lyons et al. 1996).

The NWPPC's Fish & Wildlife Program (Section 10.2) implicitly describes the need for a basin-wide inventory of native resident fish populations and their status. The Report of the Independent Scientific Review Panel (ISRP 1997) specifically recommended that the "*Council require a basin-wide systematic inventory of remaining native resident fish populations and their status, upon which opportunities for restoration and rebuilding native resident fish populations can be identified and prioritized"* (Recommendation III.B.13). The importance of understanding and monitoring community level responses to adaptive management strategies has been further emphasized in a recent NWPPC planning document entitled "Development of a Regional Framework for Fish and Wildlife Restoration in the Columbia River Basin, A Proposed Scientific Foundation for the Restoration of Fish and Wildlife in the Columbia River Basin" (NWPPC 1998).

B. <u>Scope of Program</u> – What are the specific objectives of a system-wide monitoring program?

The NMFS 2000 FCRPS Biological Opinion provides a useful hierarchical framework structured around three tiers for a comprehensive monitoring and evaluation program. Tier 1 monitoring forms the basis of the program as a broadscale assessment of ecosystem status. The component data layers are used for: subbasin scale association models between fish presence and environmental covariates; identification of subbasins or watersheds that may serve as references or controls for Tier 3 monitoring; forming the basis of a probabilistic status sampling program for Tier 2 monitoring. Tier 2 monitoring is statistically based sampling on an annual basis to determine, given trade-offs between cost, precision and accuracy, the status of fish populations and their habitat. The data collected by this type of monitoring will be used to assess fish abundance and trend by population; determine stage specific survival rates; assess the status of watershed health; and associate watershed condition with population status and processes. Tier 3 monitoring assesses, in the form of explicitly posed experiments, the effectiveness of specific recovery actions. This type of monitoring is implemented at the spatio-temporal scale of the recovery actions, comparing the impact of the action as measured by fish based response variables to reference or control conditions.

A status monitoring program for salmonid fishes in the Columbia River basin must be designed to address the following list of questions. Each of these questions is framed in a general fashion to allow for geographic, logistical and biological constraints. For example, the spatial scale for many of the questions is either population, subbasin or ESU, depending on the most appropriate or convenient scale at which to collect the required response variate. That is to say, Snake River steelhead are best enumerated at Lower Granite Dam for the entire ESU while John Day River steelhead are best enumerated through sampling for redds across potential spawning habitat. Policy and technical representatives of the management entities must first work together to specify both the level of acceptable risk (uncertainty) for making management decisions and the cost they are willing to bear for a monitoring program. Within those constraints, the accuracy and precision of all measurements must be specified in order to design the data collection scheme and to allow the development of confidence intervals for analyses based on these data.

Tier 1 (ecosystem status) questions:

What is the distribution of adult salmonid fishes?

measured variate(s): presence/absence of adult salmonid fishes
spatial scale: Columbia River system, ESU
accuracy and precision: census
temporal scale: sampling on 3 – 5 year cycle

What is the ecosystem status for Columbia River Basin (CRB) fish populations?

measured variate(s): Geology/Soils, Land classification, Stream network, DEM, Road, Land ownership
spatial scale: Columbia River system, ESU
accuracy and precision: census
temporal scale: sampling on 5+ year cycle

Tier 2 (population and habitat status monitoring) questions:

What is the size of CRB fish populations?

measured variate(s): numbers of adults, spawners or redds
spatial scale: population, sub basin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the annualized growth rate of CRB fish populations?

measured variate(s): numbers of adults, spawners or redds
spatial scale: population, sub basin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: trend in annual samples over at least 10 year period

What is the freshwater productivity (e.g., smolt/female) of CRB fish populations?

measured variate(s): index of juvenile population
spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the age-structure of CRB fish populations?

measured variate(s): age of returning adults

spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the fraction of potential natural spawners that are of hatchery origin?
measured variate(s): fraction of escapement that is of hatchery origin
spatial scale: population, subbasin, ESU
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the biological condition of CRB fish spawning and rearing habitat?
measured variate(s): macroinvertebrate, amphibian and fish assemblages
spatial scale: subbasin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the chemical water quality in CRB fish spawning and rearing habitat?
measured variate(s): DO, pH, Conductivity, Nutrients, Solids, Pesticide and heavy metal conc., Temp.
spatial scale: subbasin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

What is the physical habitat condition of CRB fish spawning and rearing habitat?
measured variate(s): Channel Form, Valley Form, Valley Width Index, Geomorphic channel units, Channel Substrate, Canopy cover, Large woody debris, Riparian vegetation, Land use, Number of diversions or dams, Assessment of erosion processes, Channel modification, Instream flow
spatial scale: sub basin, watershed
accuracy and precision: unbiased estimate with known sampling and measurement error
temporal scale: annual samples

The need for, and benefits of, a systematic monitoring program are recognized by a broad spectrum of federal, state, and tribal fish and wildlife recovery and restoration plans (NMFS 2000a, NMFS 2000b, CRITFC 1995, Roger *et al. 2000*). Despite this broad agreement, actually implementing an effective status monitoring program has proven nearly impossible. The following policy, technical, and on-the-ground challenges are some of the obstacles which must be overcome.

1. Policy Challenges
    - Unspecified level of acceptable uncertainty for decision making
    - Cooperation of necessary private, local, state, tribal, and federal jurisdictions is difficult to achieve
    - Entities have different scopes of responsibility and authority
    - Entities often have no mandate for supporting regional programs
    - Different entities and programs operate at different spatial and temporal scales
    - Perceived high cost
    - Insufficient technical feedback to policy makers

2. Technical Challenges
    - Existing monitoring efforts are not cataloged
    - No concise, clearly described basin-wide monitoring program presently exists
    - A manual of field data collection methods is needed to guide diverse field crews

- Specific monitoring responsibilities need to be assigned to, and accepted by, multiple entities
- Data management technology is evolving rapidly and the various entities are at different stages of ability and have different levels of available resources.

3. On-the-Ground Challenges
   - Coordinating field crews from multiple agencies is operationally difficult
   - No common protocols exist for collecting field data
   - Field crews often do not have time for data entry and QA/QC activities

II. ACCOMPLISHMENTS/RESULTS

A. Current Status Monitoring Programs and Results

Tier 1

Anadromous salmonid fishes and their habitat

NWPPC Subbasin Assessments gather some, but not all, Tier 1 data. However, these assessments are not meant to be ongoing and periodic, rather one-time data gathering efforts to support subbasin planning.

Resident salmonid fishes and their habitat

NWPPC subbasin assessments gather some, but not all, Tier 1 data. However, these assessments are not meant to be ongoing and periodic, rather one-time data gathering efforts to support subbasin planning.

Non-salmonid fishes and their habitat

It is not clear that any status monitoring programs are occurring at the tier 1 level for non-salmonid fishes and their habitat within the Columbia River basin.

Tier 2

Anadromous salmonid fishes and their habitat

There are numerous state and tribal monitoring programs targeting salmonid fishes, and to some extent their habitat, distributed across the Columbia River basin. For a summary of these programs see the attached spreadsheet of the status of status monitoring programs. While there are a number of status monitoring programs, there is little coordination of these programs across administrative boundaries, and as such, the resulting status monitoring data may not be adequate to address regional, or basin-wide management needs.

Resident salmonid fishes and their habitat

There are numerous state and tribal monitoring programs targeting salmonid fishes, and to some extent their habitat, distributed across the Columbia River basin. For a summary of these programs see the attached spreadsheet of the status of status monitoring programs. While there are a number of status monitoring programs, there is little coordination of these programs across administrative boundaries, and as such, the resulting status monitoring data may not be adequate to address regional, or basin-wide management needs. The USFWS has begun to develop a coordinated recovery monitoring and evaluation program, through bull trout recovery plan efforts, to address many of these issues and to efficiently guide limited resources for status monitoring.

Non-salmonid fishes and their habitat
The relative abundance of few species, aside from salmonids, is known within the Columbia River system. Predators on juvenile salmonids have been sampled since the early 1980s, although projects have had different objectives and thus sampling protocols have varied. An index of northern pikeminnow abundance was estimated in lower Columbia River reservoirs (1990), lower Snake River reservoirs (1991), downstream from Bonneville Dam (1992), and in mid-Columbia River reservoirs (1993; Ward et al. 1995). Northern pikeminnow indexing has continued in selected reaches as part of the evaluation of the Northern Pikeminnow Management Program (Zimmerman and Ward 1999). Some information on smallmouth bass abundance is also provided through this indexing program (e.g., Ward and Zimmerman 1999). Studies that have examined the stock status of white sturgeon, that constitute a popular recreational fishery and important commercial and tribal fisheries, have also been conducted in various portions of the mainstem Columbia River (Beamesderfer et al. 1995, DeVore et al. 1995). However, trends in the abundance of most resident fish species within the basin cannot be estimated, due to the lack of standardized methods for estimating population status and the lack of consistent time series data. For example, there is limited monitoring of lamprey populations in the Lower Columbia River and Umatilla River. This is a species of important ecological significance that lacks a comprehensive monitoring and evaluation plan (see Mainstem/Systemwide Lamprey Program Summary). The USFWS BiOP and Kootenai River sturgeon recovery plan call for monitoring of all stages of natural recruitment, preservation of Kootenai River sturgeon stocking program, and the evaluation of the feasibility of establishing self-sustaining rocky substrate for sturgeon hatching and rearing in the Kootenai River.

B. Adaptive Management Implications of a Status Monitoring Program

Adaptive management depends on data. A system-wide status monitoring for listed salmonid fishes is a critical component for recovery planning. Currently no such program exists. Therefore, for effective management of these natural resources, a system-wide comprehensive monitoring program that tracks the long-term status and trend of fish populations and the characteristics of freshwater habitat necessary for spawning, rearing and migrating is needed.

There have been a number of proposed, draft, or calls for, regional monitoring programs (Roger *et al.* 2000, Botkin *et al.* 2000, ISAB 2001, RSRP 2001, ISRP 1997, NWPPC 1998, Bisbal 2001), and independently the states and tribes of the Columbia River Basin have initiated fish and habitat monitoring programs (*e.g.,* Oregon Plan, Washington Comprehensive Monitoring Strategy). However, the entire Columbia River Basin has not seen the development and implementation of a comprehensive monitoring program to track the status and trend of fish populations and their habitat.

C. Benefits to Fish and Wildlife of a Status Monitoring Program

The mainstem Columbia River is inherently related to the biota and water quality of tributaries that flow into it. Anadromous salmonids and lamprey produced in the tributaries, whether migrating juveniles or returning adults, will be subjected to the physical and biological conditions in mainstem reservoirs. Further, some resident salmonids contained within streams tributary to the mainstem Columbia River (e.g., Bull trout *Salvelinus confluentus*), may occasionally use the mainstem Columbia River for foraging or migrating to other tributaries. Thus, conditions in mainstem reservoirs may influence the utility of watershed restoration to increase and stabilize salmonid production and native resident fish populations within subbasins of the Columbia River. Improvements in water quality in streams tributaries will affect the water quality and biota of the reservoirs. As management actions are taken to return the Columbia River ecosystem to a more normative state, the effects of upriver actions will be reflected by the status of biota resident in the mainstem. Trends in resident fish populations towards, or away from, a more normative condition in the mainstem river cannot currently be assessed, and the efficacy of watershed restoration cannot be viewed in the context of improved or degraded mainstem conditions.

Projects that determine the stock status of resident fishes in the mainstem Columbia River would also complement existing information regarding the habitat requirements and other factors affecting the white sturgeon population in Bonneville Reservoir (Project #: 198605000) by providing a biological context to the physical habitat descriptions provided by Parsely and Beckman (1994) and by describing the fish assemblage that white sturgeon are contained within. White sturgeon live within a complex biological and physical system that, in addition to hydroelectric development, has been drastically altered by introductions of nonnative species (Li et al. 1987). The current status and population dynamics of native and introduced resident fishes (e.g., common carp *Cyprinius carpio*, smallmouth bass *Micropterus dolomieu*, walleye *Stizostideon vitreum*, etc.) that prey upon (Miller and Beckman 1996) and compete with white sturgeons is unknown.

D. Project funding to date

Program has not previously existed. See attached spreadsheet of monitoring efforts across the Columbia River Basin.

E. Reports and Technical Papers

Program has not previously existed. See attached spreadsheet of monitoring efforts across the Columbia River Basin.

III. RELATIONSHIP OF PROGRAM TO USFWS/NMFS BIOLOGICAL OPINIONS -- RPAS

2000 Federal Columbia River Power System Biological Opinion, NMFS

At an absolute minimum the anadromous salmonid status 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 Rive Basin (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 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 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.

Resident Fish Biological Opinion, USFWS
2000 USFWS Biological Opinion for the FCRPS on bull trout and Kootenai River white sturgeon (KWS)

The USFWS BiOp for operations of the FCRPS calls for a focused and intensive program to monitor the spawning, recruitment, and environmental conditions of sturgeon in the Kootenai River from the vicinity of Bonners Ferry, ID, downstream to Kootenay Lake, British Columbia. The USFWS BiOP and Kootenai River sturgeon recovery plan call for monitoring of all stages of natural recruitment and preservation of Kootenai River sturgeon stocking program. In particular, design and conduct studies to determine the effects of Libby Dam operations and other threats on sturgeon life history, and causes of sturgeon mortality. In addition, evaluate the feasibility of establishing self-sustaining rocky substrate for sturgeon hatching and rearing in the Kootenai River. Most of BPA's responsibilities for KWS under the USFWS are satisfied through the Fish and Wildlife Program's funding process for the Mountain Columbia province.

The USFWS BiOp for operations of the FCRPS calls for a focused and intensive program regarding research, monitoring and evaluation (RME) efforts relative to the impact of FCRPS operations on bull trout. Requirements unique to each FCRPS project could be addressed by the federal agency that owns and operates the project (i.e., the Corps and Bureau of Reclamation), with the BPA/Council FWP funding several efforts through the appropriate provincial review process.

The following is background and support for RME efforts needed to promote recovery of listed bull trout and support Biological Opinion implementation.

Bull trout in the coterminous United States were listed as threatened, under the Endangered Species Act, on November 1, 1999 (64 FR 58910). Earlier rulemakings had listed distinct population segments (DPSs) of bull trout as threatened in the Columbia River, Klamath River, and Jarbidge River basins (63 FR 31647, 63 FR 42757, 64 FR 17110). Although bull trout continue to occur in scattered subpopulations in the Columbia, Klamath, Jarbidge, and St. Mary-Belly rivers, bull trout distribution, abundance, and habitat quality have declined over their entire range.

Numerous factors played a role in the decision to list bull trout as threatened. These included the impacts of dams, forest management practices, livestock grazing, road construction and maintenance, mining, residential development, and introduced non-native species. The existence of dams in the Columbia River DPS, specifically those in the Federal Columbia River Power System (FCRPS), was a particularly important factor in the listing decision. Existing dams can be passage and migratory barriers for bull trout. These structures may isolate bull trout subpopulations, eliminate individuals from subpopulations, reduce or eliminate genetic exchange between subpopulations, and separate spawning areas from productive overwintering and foraging areas. Dams have fragmented bull trout habitat and resulted in numerous isolated populations. Individuals that pass downstream, over or through dams, are often lost from upstream populations. Dams have converted historic rearing habitats for migratory fish in the large river systems into reservoirs with conditions that are frequently unsuitable for bull trout. Bull trout passage is prevented or inhibited at hydroelectric, flood-control, or irrigation dams in many of the major rivers in the Columbia River basin.

Much of the bull trout information in tributary streams is limited in the Columbia River basin and much of what we know has been collected incidental to salmon and steelhead work. Critical information on the effects of FCRPS operations will require developing an understanding of bull trout abundance, life history, and migration behavior in key tributary streams where bull trout occur as well as their connectivity to the mainstem. This information is necessary to assess accurately trends in population abundance, distribution and the response of bull trout to FCRPS recovery actions. Numerous population studies are presently being funded under the FWP, the USFWS, and other programs.

The FCRPS may impact bull trout directly (as indicated by passage issues identified under Measure 8 of the Columbia Basin discussion) or indirectly (as indicated by prey issues identified under Measure 3 of the Lower Columbia River discussion). The USFWS is anticipating support on RME on the status, abundance, trends in distribution, and growth rates of bull trout populations, specifically through marking experiments and life cycle assessments. Much of this work would focus in the tributaries and would include RME on life history patterns and the relationship between migratory and resident forms. We also are expecting support for RME on population movements into and out of tributaries as well as within mainstem areas. To assess the impacts of the FCRPS in mainstem areas, RME is needed on bull trout passage at dams, the use of reservoirs by bull trout and water quality issues associated with the operation of the FCRPS. Within all areas of research, RME comparing relatively strong and weak populations of bull trout (for example, Umatilla and Deschutes rivers and Grande Ronde and Imnaha rivers), is needed to assess the measurable impacts of the FCRPS on bull trout stocks, and to determine the potential impacts of the FCRPS on bull trout stocks which have little or no direct connection to the mainstem. There are numerous tributaries (i.e. the Umatilla River) where we have very little information on bull trout movement but where the mainstem may be critical to the full expression of the trout's life history.

In the lower mainstem areas of the Columbia and Snake rivers, the initial focus of bull trout monitoring under the Action Agencies' BiOp Implementation Plans is on detecting and measuring bull trout use of the mainstem dams and reservoirs of the FCRPS. Some fluvial/adfluvial bull trout are known to use the mainstem. This is particularly true for parts of Bonneville reservoir (e.g., Drano Lake), in which bull trout from Oregon's Hood River have been observed. Some bull trout from the Umatilla and Tucannon rivers are also known/believed to use the mainstems, and smolt traps in the Snake River at Lewiston, ID, (head of Lower Granite reservoir) have caught a single bull trout in some years. However, these traps are designed for capturing surface oriented salmon on their seaward migration. More extensive radio telemetry studies will be needed to track bull trout at greater depths than possible with present technology. On rare occasions bull trout have been documented in the juvenile or adult salmon passage facilities at some mainstem dams. Presently, it is unknown to what extent bull trout use the mainstem because observations programs are targeted at migrated adult salmon (e.g., no adult counts between Jan 1 to March 15). To observe, detect and quantify indirect impacts and their influence on the population status of bull trout, tributary work is absolutely necessary. Ultimately, to determine the impact of the FCRPS we need to measure the annual population growth rates of bull trout, which will require monitoring and evaluation of the tributary populations. A long term commitment to these RME activities is needed to gather this information to assess impacts of the FCRPS as tributary populations recover. An infrastructure for RME of bull trout, like that established for salmon in the Columbia Basin, has not been established or supported in the past.

IV. FUTURE NEEDS

A. Project Recommendations – Funding of existing programs

A single comprehensive status monitoring program for native fishes and their habitat does not currently exist. However, there are numerous state, tribal and federal status monitoring programs that could strongly benefit from cohesive guidance and coordination. The following actions build on these existing monitoring efforts and would significantly move toward a coordinated monitoring program in the next three years.

1. Policy Actions:
   - Obtain policy-level support from resource managers to develop and participate in a regional monitoring program

- Form an ad hoc policy group to identify monitoring priorities and protocols to meet the monitoring needs of the FWP, recovery plans under the ESA, and tribal restoration plans. Inform the data management program of these priorities.

2. Technical Actions:
   - Develop a statistically sound monitoring program to meet ESA, FWP, and tribal needs:
   - Catalog of existing monitoring efforts and identify those which also contribute to regional monitoring needs.
   - Develop a field manual of standard monitoring protocols, including QA/QC procedures.
   - Develop tools and applications to facilitate implementation of the protocols and procedures by local field crews.

3. On-the-Ground Actions:
   - Assign, with policy group concurrence, specific monitoring responsibilities to action agencies and resource managers.
   - Develop new monitoring efforts to fill gaps in existing monitoring efforts.
   - Provide training in standard monitoring procedures to field crews.

A rough needs assessment of status monitoring programs for native fish populations and their habitat across the Columbia River Basin indicates the following: there has been considerable work on the status of spawning populations of anadromous salmonids across the basin; less work on other life stages or other species; and almost no consistent fish habitat status monitoring. Therefore, the priorities of a basin-wide status monitoring program must address: the lack of consistent protocols for all types of sampling; the lack of juvenile fish data for much of the basin; the lack of population status data for non-anadromous salmonids across the basin; and finally, the lack of habitat status data across the basin.

B. <u>Needed Future Actions</u> – Guidelines for the development of a system-wide status monitoring program

A comprehensive status monitoring program addresses 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., spatial/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.

Lacking any regionally developed guidelines for the development and implementation of a Columbia River Basin native fish and habitat monitoring program, the structure presented in the Federal Columbia River Power System Biological Opinion (NMFS 2000a) will be adopted herein for the purposes of example. To meet the varied needs of a Research Monitoring and Evaluation program the NMFS 2000 FCRPS BO specifies a three tiered structure. In this proposed structure there are two tiers of status monitoring, each at different spatio-temporal scales, and a single tier of effectiveness monitoring. In general, three different elements are tracked within each tier: adult salmonids, juvenile salmonids and environmental conditions. The three tiers are linked by their objectives and their interdependence with respect to sampling design and data evaluation. This monitoring program targets anadromous salmonids, however, it can easily be applied to all fishes and their habitat in the Columbia River Basin. Below, the goals of each tier of monitoring are discussed, followed by guidelines for meeting these goals.

The USFWS Draft Recovery Plan for bull trout will call for comprehensive monitoring and evaluation of bull trout throughout their range (with emphasis both in the tributaries and mainstem). This plan will also aide in assessing the impacts of the FCRPS and its operations on bull trout. The proposed monitoring and evaluation system will have differences from NMFS proposed three tier monitoring system primarily due to a number of life history forms (fluvial, ad-fluvial, anadromous, and resident populations) of bull trout, but the design can be quite complimentary. The bull trout monitoring and evaluation program will address: 1) large scale or ecosystem level assessments; 2) population status monitoring; and 3) monitoring of recovery measures effectiveness. However, the bull trout program will operate at different spatial scales, which should correspond to recovery criteria associated with population distributions and trends at the core population, recovery unit and Distinct Population Segment (DPS) levels (Lohr et al. 2001). As in NMFS tier one; the bull trout goals would be to identify the entire geographic range used by bull trout (all life history forms including resident and migratory). The bull trout presence/ absence data should be collected in a rigorous manner, along the lines of the statistical protocols described in the AFS bull trout presence/ absence protocol document (AFS 2002). Given that the bull trout DPS covers the entire Columbia River basin, a number of challenging sampling issues have been identified (USFWS 2002 – Bull Trout Recovery Monitoring and Evaluation Workshop proceedings). Therefore, the design of the sampling frame may require a different construct than that for anadromous salmon. As we proceed with a comprehensive monitoring and evaluation program we need to look for efficiencies between anadromous salmon and resident fish populations. However, we need to design programs that will address the needs of the different life history strategies for these two types of ESA listed fish populations in the Columbia River basin.

One of the immediate needs for bull trout in the Mainstem/Systemwide province is to detect and estimate bull trout use of the mainstem reservoirs. Dam passage by bull trout is being monitored through Corps and BPA-funded juvenile and adult salmon passage programs. Use of Bonneville Pool by bull trout from the Hood River and use of the lower Snake River by bull trout from the Tucannon River are being studied by BPA-funded projects in those areas. Bull trout, if any, that use other mainstem FCRPS areas would be extremely difficult to monitor. Other status monitoring for bull trout may be identified in the forthcoming bull trout recovery plan.

The geographic area for the range of Kootenai River sturgeon is much smaller than for bull trout or anadromous salmon. Therefore, the range of the ecological assessment will be less challenging than that for bull trout. The focus for Kootenai River sturgeon status monitoring will be more focused. The future needs for sturgeon will focus on the following needs. The USFWS BiOP and Kootenai River sturgeon recovery plan call for monitoring of all stages of natural recruitment and preservation of the Kootenai River sturgeon stocking program. In particular, design and conduct studies to determine the effects of Libby Dam operations and other threats on sturgeon life history, and causes of sturgeon mortality. In addition, evaluate the feasibility of establishing self-sustaining rocky substrate for sturgeon hatching and rearing in the Kootenai River between river kilometer 229 and 245. Based on the results of the evaluation, implement appropriate action to restore sturgeon spawning and rearing habitat.

Needs for Kootenai River White Sturgeon are being addressed through Mountain Columbia provincial review and through non-FWP programs. There are no Mainstem/Systemwide needs for this species.

Tier 1-- Ecosystem Assessment

Goals are to:

(i) Identify the entire geographic range used by anadromous salmonids

- broadscale assessment of populations to detect changes in population distribution.
  - required for adult salmonids
  - desirable, but difficult, for juvenile salmonids.

(ii) Identify associations between salmonid presence and habitat attributes

- broadscale assessment of the following habitat covariates
  - Geology/Soils, Land classification, Streamnetwork (1:12k) DEM (10m), delineate Hydrologic Units (4^{th}-8^{th}), Roads, Land ownership

(iii) Ground-truth and update fish distribution and habitat databases.

- all data to be collected as a census

Tier 1 data forms the basis for a broadscale assessment of ecosystem health. The component data layers are used for: subbasin scale association models between fish presence and environmental covariates; to identify subbasins of watersheds that may serve as references or controls for Tier 3 monitoring; to form the basis of a probabilistic status sampling program for Tier 2 monitoring.

Tier 1 monitoring cannot address questions of population or environmental status or trend, nor can it be used to assess the effectiveness of specific restoration actions. However, Tier 1 monitoring is essential for the development of rigorous Tier 2 & 3 monitoring programs. In many cases the first round of Tier 1 monitoring may already be complete. For example, data collected for NWPPC subbasin assessments, the SWAM & EDT subbasin assessments, as well as other state/tribal/local watershed assessments. Thus, existing data may provide sufficient coverage when compiled in a consistent manner to fill the need for an initial Tier 1 assessment of the entire FCRPS BO region. Subsequent round of Tier 1 monitoring will occur with a periodicity appropriate for the variable of interest. For example, land classification, roads, and land ownership should be updates on a 10yr cycle, while DEMs, stream networks and geology/soils only as necessary. Fish presence/absence data should be updated on a 5yr cycle unless a major range expansion/contraction event is occurring, in which case a 3-year cycle may be more appropriate.

Tier 2—Status Monitoring

Goals in freshwater habitat are to:

(i) Estimate population growth rate and adult abundance.
- determined in a statistically rigorous manner through a probabilistically based sampling scheme

(ii) Estimate juvenile abundance and juveniles survival rates.
- determined in a statistically rigorous manner through a probabilistically based sampling scheme

(iii) Identify associations between population growth rates or life stage survival and environmental attributes and parentage (wild/hatchery).
- sample key salmonid habitat indicators in the following covariate classes through a probabilistically based sampling design
  - biological condition, water chemical quality, physical habitat
  - through coordinated sampling of habitat variables and population status data develop predictive fish-habitat association models

Goals in the estuary are to:

(i) Estimate survival and abundance during residence.

(ii) Establish associations these and environmental attributes, parentage, and passage history.

Tier 2 monitoring is statistically based sampling on an annual basis to determine, given trade-offs between cost, precision and accuracy, the status of fish populations and their habitat. The data collected by this type of monitoring will be used to assess fish abundance and trend by population; determine stage specific survival rates; assess the status of watershed health; and associate watershed condition with population status and processes.

The primary feature motivating the design of the Tier 2 monitoring program is the requirement that the data collected be representative on the spatial scale of subbasins and the temporal scale of a year. The requirement of a statistically based sampling program forming the backbone of the Tier 2 monitoring program arises simply from the consideration of monetary cost. That is to say, status data for any of the identified indicators collected on a subbasin scale without sampling, but still maintaining the accuracy and precision standards, is equivalent to that gathered by means of a statistically based sampling program. For example, if the spawning habitat of a subbasin is so spatially limited that it a census is easily accomplished, there is no need for sampling. A more complete description of a spatially balanced sampling protocol that captures fish population and habitat status on the subbasin scale is presented in the

Tier 2 monitoring overlaps in concept with Tier 1 monitoring since they both assess fish populations and habitat condition; however, critical differences result from the differences in sampling design. Tier 1 monitoring is the snapshot view required to develop the sampling program for Tier 2 monitoring. Therefore, Tier 1 data layers are coarse-scale assessments that do not capture interannual variation and spatial variation in covariate magnitude, while Tier 2 data layers are specifically designed to be equally representative over time and space, capturing annual variation in abundance at the population to subbasin scale.

The most critical component of Tier 2 monitoring, setting it distinctly apart from Tier 1 and 3, is its basis on a spatially balanced probabilistic sampling scheme. The three primary sources of variance in population and habitat metrics are: interannual variation, spatial variation, and their interaction. Therefore, to develop estimators of population and habitat status with known accuracy and precision the sampling design must be optimized for the characteristic scales of the problem.

All population and habitat estimators are inherently periodic, with at minimum annual periods. To best capture the temporal variance components, a census in time will be conducted on estimators on an annualized basis.

The fundamental spatial scale of the problem is the size of a distinct demographic unit. Since in most cases the boundaries of demographic populations are not known, the sampling program must capture the status of at least one population. When the sampling area includes more than one population, it must capture the multiple populations in their entirety.

To capture the status variance that results from the interaction of the time and space components, sampling sites must be randomly drawn in space, but balance correlated and random effects in time, e.g., rotating panels.

Tier 3 – Project Effectiveness Monitoring
Tier 3 monitoring assesses, in the form of explicitly posed experiments, the effectiveness of specific recovery actions. This type of monitoring is implemented at the spatio-temporal scale of the recovery action, comparing the impact of the action as measured by fish based response variables to control or reference conditions. Within the context of the 2000 FCRPS BO, Tier 3 monitoring has several overarching goals. Principally, there is a need to assess whether individual management actions improve fish survival or condition. Effectiveness is defined here as an increase -- as a result of management actions -- in listed salmonid life-stage or life-cycle survival or fish condition. Since the increase must be attributable to the management actions, as distinct from other phenomena, the actions themselves as well as the monitoring efforts must be designed as discrete, controlled experiments. In addition, Action 9 of the 2000 FCRPS BO also calls for Tier 3 monitoring to be designed to answer critical uncertainties about general population responses to classes of actions. Therefore, the monitoring plans must maintain some coherence in design between different actions. Acknowledging the important differences that will exist between actions, if only because of location differences, comparisons between actions will only be possible if monitoring is performed in as comprehensive and detailed a manner as possible. Treating each action as a monitored, controlled experiment is the only way to ensure that the data will reveal mechanistic connections between the actions and the fish population response—an explicit objective in section 9.6.5.3.1 of the 2000 FCRPS BO.

For the most part however, Tier 3 monitoring will not be explicitly addressed under the Mainstem and System-wide Provincial Review. Tier 3 monitoring of tributary restoration projects occur on a much finer spatial scale that considered appropriate for a system-wide perspective. Nonetheless, mainstem and estuarine restoration actions are within the scope of this province, and as such, if constructed as experiments should be considered under this context. Specific guidelines for Tier 3 monitoring under the 2000 FCRPS BO are under development separately, but will be referenced on the Action Agencies and NWPPC's web pages as they become available.

Guidelines for the implementation of a comprehensive status monitoring program

The region has not yet adopted guidelines for systematically acquiring the data necessary to satisfy the goals of ecosystem, population and environmental status monitoring as expressed in the 2000 FCRPS BO and elsewhere. However, in order to accomplish these status monitoring goals, there are specific data needs, accuracy and precision constraints on certain data, as well as a distinct need for integrated data management. The following sections briefly outline the guidelines required to implement a rigorous status monitoring program for native fish populations and their habitats. If implemented in this fashion, the status monitoring program will meet the region's identified resource management data needs, as well as satisfying the 2000 FCRPS BO.

Tier 1-- Landscape-level Ecosystem Attributes
Because much of the data that are critical for assessing environmental status are more appropriately collected at a watershed to subbasin scale, broad-scale habitat and population censuses will be needed every 3 – 5 years. These landscape-level ecosystem attributes are in two general classes: environmental/habitat condition and species presence/absence. To capture the first data class the Action Agencies shall acquire and digitize aerial or satellite imagery of the entire Columbia River basin once every 3 to 5 years. Presence/absence data shall be collected every 3 – 5 years to track major changes in geographic extent, as well as to form the sampling universe on which Tier 2 protocols are based. Landscape-level data collection will allow a more detailed assessment of land use and land cover variables than is currently available for the region. This assessment, in turn, will allow the association of potentially important watershed-level characteristics with salmon population status. In addition, the repeated assessment of the variables through time will allow changes in environmental characteristics to be associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

<u>Guidelines: Tier 1 Ecosystem status attributes:</u>

1. Clearly identify the appropriate geographic scales (e.g. subbasin, watershed) and resolution (e.g., 1:24k, 4m pixels) at which the status indicators are measured.
2. Identify the indicators that will be directly measured (e.g. fish presence/absence, DEM) to estimate ecosystem status.
3. Describe the method used for determining derived indicators (land classification, stream network).
4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.

Indicators with a required census period and accuracy at the subbasin scale:

Population geographic extent

Presence/absence of adult salmonid fishes, 1:24k stream-network, 3 – 5yrs

Environmental attributes

Geology/soils, once, updating only as required
Land classification, 10yrs
Stream network, 1:24k, 10yrs
DEM, 10m, 10yrs
Roads, 1:24k, 10yrs
Passage barriers, 1:24k, 10yrs
Land ownership, 1:24k, 10yrs

Protocol references for sampling methods and precision estimates for the above indicators:

Pacific Northwest Ecosystem Research Consortium,
http://www.orst.edu/dept/pnw-erc/

Tier 2 -- Population Status Monitoring-Adults:
In order to determine and track the status of a population, spawner escapement and removals en route to the spawning ground must to be estimated. Removals may be caused by passage mortality or in-river harvest. Different species offer different opportunities for estimating spawner escapement. In the Columbia River Basin, redds counts have generally been adopted as acceptable for tributary spawning chinook. In contrast, steelhead redds are difficult to observe during spawning periods when flows are high, and are not particularly useful for estimating escapement using traditional peak count methods. However, new methods recently developed by the Oregon Department of Fish and Wildlife Corvallis Research Lab indicate that cumulative steelhead redd counts may be a very reliable method for estimating adult steelhead abundance (Jacobs et al. 2001). For mainstem spawning species like fall chinook, counting redds in large, deep rivers is not very reliable, so dam counts usually must suffice. Recent work by the USFS Rocky Mountain Research Lab has begun to address the measurement error associated with a variety of types of redd count methods (Dunham et al. 2001, Thurow 2000).

Defining the goals of the proposed monitoring effort is a fundamental first step. Usually, the analytical processes that use the monitoring data dictate the data requirements. For example, spawner-recruit models require annual estimates of return-at-age. In formulating these guidelines we did not restrict data needs to BO driven analyses, but attempt to satisfy broader applications as well. In addition, we recognize that future models for population viability and other BO applications may change, requiring additional data (e.g., annual age structure).

<u>Guidelines: Tier 2 Population Status-Adult Life Stage:</u>

1. Clearly identify the demographic scale (e.g. population, ESU, deme; wild/natural or hatchery origin) for which abundance estimates will be produced.
2. Demonstrate that the target unit is readily distinguishable from other sympatric population units (e.g. spawning location, timing, etc.).
3. Identify the performance measure or indicator that will be monitored/enumerated (e.g. redds, carcasses, weir counts, dam counts etc.) in order to estimate spawner escapement. If different methods (e.g., weir counts and redd counts) are used to enumerate the same population, specify.
4. Describe the method used for enumerating the indices, e.g., aerial or ground surveys, peak or cumulative (repeated) counts, and the error associated with the method.

5. Specify any expansion factors (e.g. spawners/redd, expansions beyond index areas) or other adjustments (e.g. harvest removals, passage mortality) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.
6. Provide estimates of the annual age structure of the sampled population, and how this is estimated.
7. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating spawner escapement, or total numbers of returning adults.

Indicators and required precision (Coefficient of Variation: CV = 100 x sd/mean) at the subbasin scale for annual measurements:

Adults, Spawners, or Redds, measured with known bias and at most CV = 15%.
Age structure of spawning population measured with known bias and at most CV = 10%.
Sex ratio of spawning population measured with known bias and at most CV = 10%.
Hatchery fraction of naturally spawning fish measured with known bias and at most CV = 10%.

Protocol references for sampling methods and precision estimates for the above indicators:

Oregon Plan reports 1998, 2000
Jacobs and Nickelson 1998

Tier 2 -- Population Status Monitoring-Juveniles:

The status of juvenile salmonids in tributary habitats is a critical indicator of population productivity. Not only does a juvenile population status metric contribute to the assessment of adult population status by providing a second, somewhat independent indicator of overall population processes, juvenile population status alone allows an assessment of freshwater survival and productivity independent of the ocean phase. Therefore, some measure of juvenile production should be made for each species in each subbasin. In some cases a complete enumeration will be possible due to the presence of a trap, weir or counting facility. In other cases, enumeration will be possible due to the potential for calibrating a probabilistic sampling program, and in the remaining cases, only an index of the resident juvenile population will be possible. Nonetheless, juvenile sampling is a key component of the comprehensive nature of the system-wide status monitoring program. Wherever juvenile counts are done via spatially balanced sampling (as opposed to sampling at pour points via screw traps), habitat surveys must also be conducted. A critical uncertainty that the status monitoring program is designed to address is the link between habitat characteristics and population processes; only by gathering coincident data sets will this uncertainty begin to be resolved.

Therefore, the juvenile status component of the monitoring program seeks to generate at a minimum a trend in the juvenile production index at the subbasin scale, but when even possible should generate the status of the juvenile population by demographic unit. If multiple life-stage counts can be made, or if sampled non-migrant fish can be staged, a more detailed population process understanding will be possible. The logistics of juvenile population surveys are immediately apparent. Species or life-history types with minimal tributary resident times will be the most problematical, potentially being resolved at no less than the subbasin scale. However, for species and life-history variant with at least a summer season of tributary residence, snorkeling and snorkeling + electrofishing techniques have been shown to be rather precise (Hankin and Reeves 1988, Rodgers 2001).

Guidelines: Tier 2 Population Status-Juvenile Life Stage:

1. Clearly identify the demographic unit (e.g., population, ESU, deme; wild/natural or hatchery origin) over which sampling will take place.
2. Clearly identify the spatial scale represented by each samples (e.g., reach, watershed, basin).
3. Identify the performance measure or indicator that will be monitored (e.g. summer/winter juveniles, outmigrating smolts). If different methods are used to enumerate the same population, specify.
4. Describe the method used for enumerating the indices, e.g., snorkel surveys, electrofishing, smolt trap, and the error associated with the method.
5. Specify any expansion factors (e.g. aerial expansions, trap efficiency) or other adjustments (e.g., daylight trapping only) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.
6. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating juvenile abundance or an index of juvenile abundance.

Indicators and required precision (Coefficient of Variation: CV = 100 x sd/mean) at the subbasin scale for annual measurements:

Instream juveniles measured with known bias and at most CV = 15%.
Outmigrating juveniles measured with known bias and at most CV = 15%
Age/size classes of sampled juveniles measured with known bias and at most CV = 15%.
Condition of sampled juveniles measured with known bias and at most CV = 15%.

Protocol references for sampling methods and precision estimates for the above indicators:

Hankin and Reeves 1984, 1988
Rodgers 2001

Tier 2 -- Habitat Status Monitoring:
The goal of habitat or environmental status monitoring is to quantify and characterize landscape, riparian and stream habitat conditions that influence the productivity of native salmonids at the appropriate geographic scales. Information derived from these analyses will be used to describe the current environmental conditions that support native salmonids and to develop associations between environmental conditions and populations trends.

Guidelines: Tier 2 Habitat Status Monitoring:

1. Clearly identify the appropriate geographic scales (e.g. province, ecoregion, subbasin) that status estimates will be developed for.
2. Identify the indicators that will be monitored/enumerated (e.g. land cover, habitat types, stream temperature, summer base flow, etc.) to estimate environmental status.
3. Describe the method used for enumerating the indicator value.

4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.
5. Describe the known or probable relationships between environmental attributes and salmonid productivity.
6. What is the status of environmental attributes potentially affecting salmonid populations?
7. How do these attributes change through time?
8. Assess the associations between environmental attributes and salmonid population status.

Habitat variables selected for Tier 2 monitoring are either linked to measures of salmonid population health by preliminary statistical analyses or relate to indices of stream condition. Tier 2 habitat factors will emphasize variables that may be improved by management actions and are likely to have a direct impact on salmonid survival.

Indicators and required precision (Coefficient of Variation: CV = 100 x sd/mean) at the subbasin scale for annual measurements:

<u>Biological Condition</u>
Macroinvertebrate assemblage with known bias and at most CV = 15%.
Fish and amphibian assemblage with known bias and at most CV = 15%.

<u>Chemical Water Quality</u>
Dissolved oxygen with known bias and at most CV = 15%.
pH with known bias and at most CV = 15%.
Conductivity with known bias and at most CV = 15%.
Nutrients (N and P) with known bias and at most CV = 15%.
Solids with known bias and at most CV = 15%.
Pesticide and heavy metal contamination with known bias and at most CV = 15%.
Stream temperature with known bias and at most CV = 15%.

<u>Physical Habitat</u>
Channel Form with known bias and at most CV = 25%.
Valley Form with known bias and at most CV = 25%.
Valley Width Index with known bias and at most CV = 25%.
Geomorphic channel units with known bias and at most CV = 25%.
Channel Substrate with known bias and at most CV = 25%.
Canopy cover with known bias and at most CV = 10%
Large woody debris with known bias and at most CV = 25%.
Riparian vegetation with known bias and at most CV = 25%.
Land use with known bias and at most CV = 25%.
Number of diversions or dams with known bias and at most CV = 25%.
Qualitative or quantitative assessment of erosion processes with known bias and at most CV = 25%.
Channel modification with known bias and at most CV = 25%.
Instream flow with known bias and at most CV = 25%.

Protocol references for sampling methods and precision estimates for the above indicators:

Kaufmann P.R. et al. Quantifying Physical Habitat in Wadeable Streams.
Thom, B.A. et al.. Stream Habitat Conditions in Western Oregon.
ODEQ Habitat sampling protocol manual.
ODFW Habitat sampling protocol manual.

Statistically based sampling design for status monitoring
For the system-wide status monitoring program to be both accurate and cost effective, data must be gathered using a rigorous, unbiased sampling design. Sampling designs for spatially explicit situations such as habitat surveys are potentially quite complex. The requisite sampling scheme must provide information on the status and trends in abundance, geographic distribution, and productivity of salmonid populations and their habitat at the population to subbasin scale. However, and more importantly, the sampling design must estimate the above quantities with no bias and a known precision. The primary concern is one of selecting sites across a large spatial area without inflating the variance or biasing the estimate. The traditional sampling approach, simple random samples, has the potential in a landscape-scale sampling to inflate variance and bias the estimators because the samples can end up clumped in space. The next generation of sampling schemes, stratified random sampling, addresses the spatial distribution of sites if the strata are themselves spatially distributed, but has the potential to introduce hidden biases if the strata are not correctly chosen. In addition, stratification always requires more samples to maintain power across strata. For landscape-scale sampling the ideal system thus has built in spatial distribution -- sampling on a grid rather than randomly across space.

For grid-based sampling, the question becomes one of grid shape and site selection. Randomly selected points on the grid will generate the least biased estimators, but can suffer the same problem as simple random samples if the grid units are too small relative to the area of interest. However, there are many grid-based site selection techniques that provide probabilistic samples that generate unbiased estimates of status and trend. The US Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) is an example of a spatially balanced environmental monitoring site selection process especially designed for aquatic systems. The state of Oregon has successfully implemented an EMAP based sampling program for coastal coho salmon (Moore 2002). The monitoring program as implemented in Oregon is spatially explicit, unbiased, and has to statistical power to detect trends. The sample design is sufficiently flexible to use on the scale of multiple large river basins and can be used to estimate the numbers of adult salmon returning each year, the distribution and rearing density of juvenile salmon, productivity and relative condition of stream biota, and freshwater habitat conditions. In addition, the EMAP site selection approach supports sampling at varying spatial extents. All grids are interpenetrating so that a lower density grid is a subset of all higher density grids. Therefore, the link between Tier 2 and Tier 3 monitoring programs can be explicitly imbedded in the status monitoring program. Tier 3 projects are finer scale monitoring efforts that if coordinated with status monitoring through common indicators and site selection protocols can both supply status information, as well as be compared to status sites to reveal restoration action efficacy.

Data and information management system
The best prospects for scientifically based natural resource management and listed species

recovery depend strongly on information systems. In particular, monitoring and evaluation data is of critical importance. Currently the region's information management system is an ad-hoc distributed information system that lacks essential components, and more importantly, coherent organization, standards, protocols, shared responsibility or structure. Because natural resource management is so highly dependent on information, and there is currently no overall 'regional information system umbrella' it is recommended that regional information system development be initiated as soon as possible.

The problem needs to be managed within a formal information system development at an enterprise level, as described, for example in the Federal Enterprise Architecture Framework. A formal approach would systematically develop awareness of the problem, build consensus on the approach, assess the extent and details, undertake renovation and rebuilding of existing information infrastructure, test the solutions and deploy the preferred solutions.

While this structured approach would produce its own recommendations it is likely that a viable solution will involve the development of a Distributed Database Management System (DDBMS). A DDBMS provides the tools and protocols to connect multiple users and databases into a coherent information system. It provides considerable advances over the informal resources currently available through the Internet or Intranets. Users would have the benefit of using common protocols for: information sharing, data inventory, data transfer and interchange, metadata, data recovery, data collection, data distribution, confidentiality, and version control. It is these, and potentially other common elements that distinguish a DDBMS from the current ad-hoc use of the Internet. A critical element is the concept of transparency, that users, to the maximum extent possible should be able to use the new system without needing expert knowledge in computer networking and data transformation. Data-warehouse approaches may also be beneficial for at least part the regional information needs and should be evaluated.

Therefore, the programmatic recommendations for monitoring and the development of an evaluation data management system are the following. Develop the system within an overall information system architecture - a critical and currently missing part of the region's information system. Where possible use of the many potential data centers already exist. Facilitate information portals communicating via the World Wide Web and Internet. Information would be geo-spatially referenced for use in geographic information and database management systems and document.

Information system development objectives:
Develop a system for the efficient and effective collection, management and distribution of information relating to fish and related wildlife restoration and management in the Columbia River Basin. The system must meet information needs in relation to the Endangered Species Act, Northwest Power Act, Treaty trust responsibilities and other relevant requirements. This system should meet the following objectives:

Meet monitoring and evaluation and scientific research needs and satisfy identified management, environmental and biological objectives of recovery and management efforts;

- Ensure access to biological data relating to fish and wildlife populations in the Columbia Basin, attributes of aquatic, terrestrial and marine habitats, and ecological functions and attributes of species and habitats;

- Include data pedigree and metadata and clearly distinguish primary data and derived information;
- Develop and use common protocols and techniques for data collection, development, storage and distribution;
- Promote the free exchange of information and development of a systems view of the Columbia River Basin;
- Provide security for data, systems and participants where necessary;
- Overcome existing information management system deficiencies;
- Ensure that information system development supports integration: laterally, with other institutions and individuals sharing a need for the information; and vertically, to roll data to different levels of resolution and scale;
- Provide for real time input of data from remote *in situ* data collection devices;
- Design, develop, test, implement and operate a coordinated, distributed, scalable information system; and,
- Obtain and maintain commitments, and develop a working process for, cooperation and standards.

V. REFERENCES

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