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Mainstem/Systemwide Habitat Summary

October 24, 2002

Prepared for the
Northwest Power Planning Council

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DRAFT: This document has not yet been reviewed or approved by the Northwest Power Planning Council

Mainstem/Systemwide Habitat Program Summary

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Program Description

Purpose

The purpose of the Mainstem Habitat Program follows the fundamental vision for the Columbia Basin as discussed in the Northwest Power Planning Council's "Columbia River Basin Fish and Wildlife Program" (NWPPC 2000). The vision for the Program is "a Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife, mitigating across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem and providing the benefits from fish and wildlife valued by the people of the region." The plan to achieve this vision is based on protecting and restoring the natural ecological functions, habitats, and biological diversity of the Columbia River Basin. Thus, the Fish and Wildlife Program is habitat-based, rebuilding healthy, naturally producing fish and wildlife populations by protecting, mitigating, and restoring habitats and the biological systems within them, including anadromous fish migration corridors.

The goal of this habitat program is to protect or restore physical habitat conditions in the mainstem Columbia and Snake rivers that will support the life history requirements of native anadromous and resident fish and wildlife species. In many areas of the basin, the original physical habitat conditions have been permanently lost. Modification of hydrosystem configuration and operation can be used to re-create or improve physical habitat in some areas. In other areas, offsite mitigation will be required. Monitoring and evaluation of actions taken to create, restore or improve habitat is an important part of this program, to determine the relative success of those actions.

The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) have also recommended a range of mainstem habitat measures to improve conditions for species listed under the Endangered Species Act (ESA). The NMFS 2000 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2000a) and the USFWS Biological Opinion on the Effects to Listed Species from Operations of the Federal Columbia River Power System (USFWS 2000) outline these measures as well as additional recommendations. Existing conditions, technical background, effects of the FCRPS on mainstem habitat conditions, and measures and recommendations relative to listed species from these Biological Opinions are discussed later in this document.

Scope

The geographic scope of this document includes the mainstem Columbia and Snake rivers from the estuary upstream, throughout all of the ecological provinces described in the Fish and Wildlife Program. For the Columbia River mainstem, the upstream extent of coverage includes the Upper Columbia subbasin in the Intermountain Province, and terminates at the international boundary between the United States and Canada. For the Snake River mainstem, the upstream extent of coverage includes the Snake Headwater subbasin in the Upper Snake Province, and terminates at Jackson Lake in Wyoming. Mainstem habitat issues are discussed for anadromous fish, resident fish, wildlife, and ecological values such as riparian zone conditions. Only brief discussions will be presented for white sturgeon, lamprey, and water quality, since there are specific programs within the Mainstem and Systemwide Province for those subject areas. In addition, estuarine fish habitat issues in saline or brackish water are covered in the Estuary and Marine Survival Program, and will be discussed only briefly under this Program.

NWPPC Fish and Wildlife Program- Habitat Strategies

Historically, the mainstem Columbia and Snake rivers were among the most productive spawning and rearing habitats for anadromous and resident salmonids and provided essential resting and feeding habitat for mainstem resident and migrating fish. Thus, protection and restoration of mainstem habitat conditions is a critical piece of the habitat-based Fish and Wildlife Program.

The primary habitat strategy discussed in the Fish and Wildlife Program includes identification of current habitat conditions and the biological potential of the habitat, followed by protection or restoration of the habitat to the extent described in the biological objectives (Fish and Wildlife Program - Appendix D). Specific plans have been developed for the mainstem Columbia and Snake rivers within each of the ecological provinces that include an assessment of the current physical and biological conditions, and that then address the habitat improvements that are needed. This document attempts to review current habitat conditions and specific habitat projects associated with the ecological provinces, and to describe additional mainstem habitat projects not included in other provincial reviews as well as limiting factors and needs associated with the mainstem.

Several fundamental habitat strategies were described in the Fish and Wildlife Program that should be used to guide protection and restoration efforts in the mainstem Columbia and Snake rivers. **"*Mainstem habitat that supports existing populations that are relatively healthy and productive should be protected*."** This is also a basin-level environmental characteristic objective discussed in Appendix D. An example is fall Chinook spawning and rearing habitat in the Hanford Reach. Although the quantity and quality of spawning and rearing habitat in this area has been compromised by hydrosystem operations, a "relatively" healthy population of fall Chinook continues to persist. **"*Adjacent habitats should also be expanded that have some likelihood of sustaining healthy populations*."** An example might be upstream and downstream mainstem dam tailrace areas where pool elevations or seasonal streamflow patterns could be adjusted to provide spawning habitat. An action such as this would help to expand and spread mainstem fall Chinook production over a larger area and buffer against periodic reductions in habitat (i.e. low streamflow years) during some years in some areas. **"*The estuary is also an important ecological feature that is negatively affected by upriver management actions, and there are indications that substantial improvements are possible and that these improvements may benefit most of the anadromous fish populations*".** Protection and restoration of ecosystem functions in the estuary and near-shore ocean discharge plume are discussed as a basin-level environmental characteristic objective in Appendix D. The lower Columbia River and estuary are important habitats for most anadromous fish as well as for other species such as white sturgeon. Habitat protection and restoration in these areas have the potential to affect a large number of species as well as individuals.

Hydrosystem Operations and Mainstem Aquatic Habitats

The Fish and Wildlife Program discusses ***"…the provision of conditions within the hydrosystem for adult and juvenile fish that most closely approximate the natural physical and biological conditions, provide adequate levels of survival to support fish population recovery based in subbasin plans, support expression of life history diversity, and assure that flow and spill operations are optimized to produce the greatest biological benefits with the least adverse effects on resident fish…".*** Development and operation of the hydrosystem has had major impacts on various fish species and their habitats. Habitat impacts include: 1) Dams and the reservoirs behind them reduce water velocity, increase water depth, and retain sediments functionally reducing or eliminating spawning and rearing habitat in the mainstem, as well as affecting juvenile and adult migration speed; 2) The impoundment, storage, and release of water changes the pattern of streamflows and water temperatures through and below the dams and reservoirs, and changes the characteristics of the estuary; 3) Operation of the hydrosystem can cause abrupt and frequent changes in streamflows that disrupt the stability of riparian zones and habitat and leave juvenile fish stranded in isolated pools or on the substrate; 4) The construction of a series of reservoirs in the Columbia and Snake rivers has artificially modified the habitat from a free-flowing riverine condition to a largely lacustrine environment, creating habitat conditions that favor both exotic and native resident predators, and eliminating the majority of habitat for stream-type fish species. These impacts affect not only anadromous fish, but also other fish species such as white sturgeon and bull trout, and many wildlife species.

The Northwest Power Act requires the Council's Fish and Wildlife Program to adopt measures to "protect, mitigate, and enhance" all fish and wildlife affected by the operation of the hydrosystem, and to include measures that provide for improved survival of fish at hydroelectric facilities and for flows of sufficient quality and quantity to improve production, migration and survival. In order to accomplish this, the Council has adopted several hydrosystem strategies. Strategies that relate to mainstem habitat include:

- Provision of conditions in the hydrosystem for adult and juvenile fish that most closely approximate natural physical and biological conditions.

Operation of the hydrosystem should protect, and where possible, expand, mainstem spawning and rearing areas.

- Management of the hydrosystem so that patterns of flow more closely approximate the natural hydrographic patterns, and assure any changes in water management are premised upon, and proportionate to, fish and wildlife benefits.

A basin-level environmental characteristic objective discussed in Appendix D describes allowing ***"patterns of water flow to move more than at present toward the natural hydrographic pattern in terms of quantity, quality and fluctuation."***

- Protect and restore freshwater habitat for all life history stages of the key species. Protect and increase ecological connectivity between aquatic areas, riparian zones, floodplains and uplands.

This is a basin-level environmental characteristic objective discussed in Appendix D. The intent of this objective is to increase the connections between rivers and their floodplains, side channels, and riparian zones. Riparian areas should be managed to protect aquatic conditions and form a transition to floodplain terrestrial areas and side channels. In addition, the functions of key alluvial river reaches should be protected and restored.

- Mainstem coordination plan.

The Fish and Wildlife Program mandates development of a mainstem coordination plan, similar to the individual subbasin plans which have been developed for most of the basin. The plan is intended to develop standards for systemwide coordination including operational requirements to protect mainstem spawning and rearing areas, and to protect resident fish and wildlife.

- Assure that hydroelectric relicensing and future development provides protection for fish and wildlife.

Hydrosystem Operations and Mainstem Wildlife Habitat

Many wildlife species have also been affected by the development and operation of the hydrosystem. The most obvious and direct impact has been the inundation and loss of large areas of historic mainstem habitat. In addition, reservoir levels have substantially altered the trees, shrubs, and grasses of the riparian zone that would normally occur at the water's edge. Fluctuating streamflows also compromise the integrity of the riparian zone. When functional, riparian habitat can provide nesting and feeding habitat, as well as cover for up to 80% of all wildlife species (Thomas et al. 1979).

The Fish and Wildlife Program has been structured as an ecosystem-based approach, treating a given habitat as an ecosystem that includes both fish and wildlife. As a result, issues relating to mainstem wildlife habitat are included in this document. The Program mandates completion of the current mitigation program for construction and inundation losses and includes wildlife mitigation for all operational losses as an integrated part of habitat protection and restoration. Mitigation programs should provide protection of habitat through fee-title acquisition, conservation easement, lease, or management plans for the life of the project.

RELATIONSHIP OF PROGRAM TO NMFS FCRPS BIOLOGICAL OPINION

Construction and operation of the FCRPS has caused permanent, basin-wide changes to mainstem habitat attributes required by a number of anadromous and resident fish species. The following section is limited to those species discussed in the NMFS FCRPS Biological Opinion that are dependent on mainstem Columbia or Snake river habitat for some portion of their life cycle excluding upstream or downstream migration.

Hydrosystem Effects on Mainstem Habitat

Columbia River basin anadromous salmonids have been dramatically affected by the development and operation of the FCRPS. Storage dams have eliminated spawning and rearing habitat and have altered the natural hydrograph of the Snake and Columbia rivers, decreasing spring and summer flows and increasing fall and winter flows. Power operations cause flow levels and river elevations to fluctuate, affecting fish movement through reservoirs and riparian ecology, and stranding fish in shallow areas. The dams also have converted the once-swift river into a series of slow-moving reservoirs, slowing the smolts' journey to the ocean and creating habitat for predators. Water velocities throughout the migration corridor now depend far more on volume runoff than before development of the mainstem reservoirs.

Mainstem habitats of the Columbia and Snake rivers have been affected by impoundments that have inundated large amounts of spawning and rearing habitat. Historically, fall chinook salmon spawned in the mainstem Columbia River near The Dalles, Oregon, upstream to the Pend Oreille River in Washington and the Kootenai River in Idaho. In the Snake River, fall chinook spawned from the mouth, upstream to Shoshone Falls. Current mainstem production areas are mostly confined to the Hanford Reach of the mid-Columbia River and to the Hells Canyon Reach of the Snake River, with minor spawning populations elsewhere in the mid-Columbia, below the lower Snake River dams, and below Bonneville Dam. Hanford Reach is the only known mainstem spawning area for steelhead. Chum salmon habitat in the lower Columbia may also have been inundated by Bonneville Reservoir. In addition, the only remaining mainstem chum salmon spawning habitat is heavily influenced by operations at Bonneville Dam. Mainstem habitat in the Columbia and Snake rivers has been reduced, for the most part, to a single channel, floodplains have been reduced in size, off-channel habitat features have been lost or disconnected from the main channel, and the amount of large woody debris (large snags/log structures) in rivers has been reduced. Most of the remaining habitats are affected by flow fluctuations associated with power production and reservoir management.

Background – Listed Species

Snake River (SR) Fall Chinook Salmon

The most productive areas of the Snake River basin are now inaccessible or inundated as a result of hydrosystem development. The upper reaches of the mainstem Snake River were the primary areas used by fall chinook salmon, with only limited spawning activity reported downstream from river kilometer (rkm) 439. The construction of Brownlee Dam (1958; rkm 459), Oxbow Dam (1961; rkm 439), and Hells Canyon Dam (1967; rkm 397) eliminated the primary production areas of SR fall chinook salmon. There are now 12 dams on the mainstem Snake River and they have substantially reduced the distribution and abundance of fall chinook salmon (Irving and Bjornn 1981).

Fall chinook salmon are known to spawn in the tailraces of Lower Granite, Little Goose, and Ice Harbor dams. The effects of FCRPS flow management on the quality and use of this spawning habitat (water depth and velocity, area, access to habitat, availability of suitable substrate) is unknown. Fall chinook also spawn in Hells Canyon, between Hells Canyon Dam and Lower Granite Pool. Flows in the Hells Canyon Reach are shaped by the Idaho Power Company's Hells Canyon complex of dams, which are not federal projects. As a result, this Reach is not addressed in the Biological Opinion.

Juvenile SR fall chinook salmon are subyearling migrants, moving downstream during June through September and rearing during at least part of this period. Most juveniles rear in the free-flowing Snake River above Lower Granite Reservoir. Juveniles in the lower Snake River reservoirs are either pelagic-oriented or found over sandy, mostly unvegetated substrate (Curet 1993).

Lower Columbia River (LCR) Chinook Salmon

Columbia River (CR) Chum Salmon

Hydrosystem operations also influence physical habitat conditions (velocity, water depth) necessary for spawning, incubation, and rearing in mainstem areas below Bonneville Dam. Average daily flows and flow fluctuations can affect the areal extent of available spawning habitat, cover or dewater redds, and strand juvenile and adult salmon. Flow levels can also affect the connectivity of juvenile and adult tributary habitat to the mainstem. Both LCR chinook salmon and CR chum salmon have been observed spawning near the Ives Island area located along the Washington shoreline approximately 2 miles downstream from Bonneville Dam. CR chum salmon have also been observed spawning at the location of several spring seeps near the Interstate 205 bridge across the Columbia River.

LCR chinook salmon are tule-type fish, distinguished from upriver or lower river brights by their body color (brownish tinge) and shape as well as early run timing. They were observed there for the first time during October 1999 (Hymer 1999b). Field biologists reported a peak count of 45 redds on October 19th (ODFW and WDFW 1999).

CR chum salmon spawn in tributaries and in mainstem spawning areas below Bonneville Dam during late October through December, typically after local precipitation begins and baseflows increase in the mainstem. Most fish spawn on the Washington side of the Columbia River (Johnson et al. 1997). CR chum salmon were first observed in the Ives Island area during 1967 (ODFW, WDFW, and USFWS 1999). Targeted censuses began in 1998, when the species was proposed for listing.

Both the hydraulic connection between the backwater area that separates Ives and Pierce islands (and the mainstem Columbia River) from the Washington shoreline and the areal extent of submerged spawning habitat for LCR chinook and CR chum salmon are strongly affected by FCRPS flow management and tides. According to USFWS, ODFW, and WDFW field biologists, a Bonneville outflow of at least 125 kcfs is needed to create and sustain the hydraulic connection, with a higher flow needed to counteract any temporary drop in river elevation (e.g., during the lower low of a spring-tide cycle) (FPAC 1999). The slough that separated Hamilton Island from the Washington shoreline was directly upstream from a primary spawning area for LCR chinook and CR chum salmon. This slough was bisected by a dike and backfilled with materials excavated from the construction site for Powerhouse II beginning in the mid-1970s (Harza 2000).

Operation of the FCRPS will affect the biological requirements for spawning habitat of both LCR chinook salmon and CR chum salmon in the Ives Island area below Bonneville Dam. The Action Agencies can use reservoir storage from the upper Columbia and Snake river basins to augment mainstem flows below Bonneville Dam, creating access to, and increasing the spatial extent of, shallow-water spawning habitat. Under the proposed action, the likelihood of meeting a minimum spawning flow of 125 kcfs at Bonneville Dam during September and October is 20% or less, and during November and December is 90% or less (NMFS 2000a). Short-term fluctuations in flow in the Ives Island area, especially below 125 kcfs, can also strand adult fall chinook and chum salmon and interrupt spawning.

Flow through the Ives Island area is important not just during the fall spawning period but also through incubation, rearing, and emergence. Seining data collected by the Oregon and Washington departments of fish and wildlife show that the body size (fork length) of subyearling chinook salmon captured in the Ives Island area during winter/spring 1999 and 2000 increased progressively during the period January through July (USFWS 2000b). Since tule fall chinook salmon were only observed spawning in this area during fall 1999, most of these observations are likely to pertain to Ives Island brights (UCR summer/fall-run chinook salmon). However, it is likely that tule fall chinook also rear in the Ives Island area before emigration. In contrast, the seining data show that CR chum salmon leave the area soon after emergence (USFWS 2000). Emigrating chum smolts and any juvenile chinook that rear in the area are subject to stranding and death due to desiccation or bird predation under some Bonneville operations for power production (load-following) that are characterized by fluctuating flows. Juvenile fall chinook salmon emerging from the Ives Island area are also likely to rear in the mainstem lower Columbia River.

Measures to Avoid Jeopardy

Measures to avoid jeopardy to listed species are described in the Biological Opinion in the form of reasonable and prudent alternatives or RPA's. These RPA's are intended to establish a course of action for FCRPS and BOR operations that avoids both jeopardy to the listed stocks and destruction or adverse modification of critical habitat and, thus, meets the performance standards and associated performance measures established in the Biological Opinion.

Specific RPA's that are relevant to mainstem habitat actions or conditions are presented in the following discussion.

9.6.1 Hydro Measures

Operational and structural fish passage improvements at FCRPS projects are proposed to increase the survival of listed fish. This section describes specific hydro measures that NMFS determined based on the best scientific information. These hydrosystem measures are expected to reduce juvenile and adult salmonid mortality attributable to passage through the hydrosystem. RPA's that are relevant to mainstem habitat issues were listed in the ***Water Management*** section (***9.6.1.2***) of Hydro Measures. The relevant subsection was ***9.6.1.2.1, Flow Management Objectives in Mainstem Columbia and Lower Snake Rivers.***

Action 14: The Action Agencies shall operate FCRPS dams and reservoirs with the intent of meeting the flow objectives (Table 9.6-1) on both a seasonal and weekly average basis for the benefit of migrating juvenile salmon.

This flow-management program uses three strategies:

- Limit the winter/spring drawdown of storage reservoirs to increase spring flows and the probability of reservoir refill.
- Draft from storage reservoirs during the summer to increase summer flows.
- Provide minimum flows in the fall and winter months to support mainstem spawning and incubation below Bonneville Dam.

Table 1. Seasonal flow objectives (kcfs) and planning dates for the mainstem Columbia and Snake rivers.

	Spring		Summer	
Location	**Dates**	**Objective**	**Dates**	**Objective**
Snake River at Lower Granite Dam	4/03 - 6/20	85 - 100	6/21 - 8/31	50 - 55
Columbia River at McNary Dam	4/10 - 6/30	220 - 260	7/01 - 8/31	200
Columbia River at Priest Rapids Dam	4/10 - 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1- emergence	125–160	NA	NA

The third habitat strategy has recently been integrated into the overall flow management objective to provide habitat for mainstem spawning chum and fall chinook. It includes subsequent flows to protect the redds from dewatering through their emergence in the spring, to the extent possible without impacting refill probabilities of FCRPS storage projects and spring flow objectives.

Action 15: The Action Agencies shall operate the FCRPS to provide flows to support chum salmon spawning in the Ives Island area below Bonneville Dam.

A spawning operation will be implemented as described below if the best hydrologic data available by early October indicate that precipitation, runoff, and reservoir storage are likely to support the operation from the start of spawning (late October or early November) until the end of emergence (generally through the start of the spring flow augmentation season in April). The spawning operation cannot adversely affect implementation of this RPA or the parties' ability to comply with the Vernita Bar agreement. That agreement protects natural production of unlisted fall chinook in the Columbia River Hanford Reach. If these conditions cannot be met, the Action Agencies will work with NMFS and regional salmon managers to identify operations that would benefit salmon while maintaining these other fish protection measures. Such operations may include intentional flows below what is necessary for mainstem spawning to discourage redds from being established in the area.

Real-time operating decisions will be made through the in-season management process described in Section 9.4 of the Biological Opinion. The Technical Management Team will recommend a managed daily average discharge level as information on natural flows and reservoir storage becomes available.

For details on the operation of the FCRPS for Columbia River mainstem spawning chum salmon, refer to this Action item in the Biological Opinion.

Hydropower operators have shaped flows to nighttime hours to keep spawning below targeted elevations in the mid-Columbia River. However, the effect of shaping nighttime flows on limiting the spawning behavior of chum salmon has not been documented. Evaluation of the effect of shaping higher flows to nighttime hours on chum spawning behavior should be conducted. The Action Agencies should evaluate the effect when nighttime flows exceed the recommended flow range until such effects are better documented.

Several states noted that fluctuations in discharge from Bonneville Dam result in stranding of juveniles in the Ives Island complex. The extent and effect of these flow fluctuations is being assessed through an ongoing research program, and a preliminary recommendation for a ramping rate has been proposed. Continued evaluation of the need for an operation to limit juvenile stranding is required. When adequate information is developed, the appropriate operation shall be specified in the annual and 5-year hydro operations plan.

Action 16: The Action Agencies shall operate the FCRPS to provide access for chum salmon spawning in Hamilton and Hardy creeks.

During years when there is insufficient water in storage to maintain a mainstem spawning flow of at least 125 kcfs throughout the spawning season, enough flow will be provided during the chum spawning season at times to allow access to tributary creeks. Under these conditions, the Technical Management Team will develop a recommended operation through the in-season management process.

9.6.2 Habitat Actions

The habitat strategy is intended to accelerate efforts to improve survival in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, Federal agencies commit in the Basinwide Recovery Strategy to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The Basinwide Recovery Strategy identifies these short-term actions, timelines, and responsible Federal agencies. This biological opinion identifies the Action Agencies' contribution to the Basinwide Recovery Strategy. Where costs are stated in this biological opinion, they are estimates meant to help define the scale and pace of the action, not specific amounts the Action Agencies must actually spend to comply.

Over the long term, the habitat strategy has three overarching objectives:

1) protect existing high quality habitat,
2) restore degraded habitats on a priority basis and connect them to other functioning habitats,
3) prevent further degradation of tributary and estuary habitats and water quality.

9.6.2.1 Actions Related to Tributary Habitat

When related to the basic habitat needs of listed anadromous fish, tributary habitat efforts have the following objectives:

- Water quantity—increase tributary water flow to improve fish spawning, rearing, and migration.
- Water quality—comply with water quality standards, first in spawning and rearing areas, then in migratory corridors.
- Passage and diversion improvements—address in-stream obstructions and diversions that interfere with or harm listed species.
- Watershed health—manage both riparian and upland habitat, consistent with the needs of the species.
- Mainstem habitat—improve mainstem habitat on an experimental basis and evaluate the results.
- Estuary improvement—improve and restore habitat conditions in the Columbia River estuary.

Action 155: BPA, working with BOR, the Corps, EPA, and USGS, shall develop a program to:

1) Identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships, and identify research needs;
2) Develop improvement plans for all mainstem reaches; and
3) Initiate improvements in three mainstem reaches.

Results shall be reported annually.

Large-scale water development over the last 65 years has inundated and significantly degraded mainstem habitat. Populations such as fall chinook that were once highly productive spawned in the mainstem and in the lower reaches of major tributaries. Studies in other river systems in the Northwest indicate that mainstem habitat improvements can result in greater population and habitat diversity, complexity, and productivity. However, no systematic assessment of habitat modifications from dam construction has been done, nor have potential restoration sites and specific benefits to salmon and steelhead been identified. BPA, working with the Corps, will take immediate steps to begin to address these uncertainties by collecting baseline data, improving mainstem reaches in ways that mimic the range and diversity of historic habitat conditions as much as possible, and monitoring and evaluating the results. Results will be reported annually. After 5 years, NMFS and the Action Agencies, in consultation with NWPPC and others, will determine whether to make changes in this program.

Action 156: The Action Agencies and NMFS shall study the feasibility (including both biological benefits and ecological risks) of habitat modification to improve spawning conditions for chum salmon in the Ives Island area.

The objectives of the study will be to determine whether it would be beneficial to increase the frequency of access to spawning habitat or the areal extent of spawning habitat by means other than flow augmentation. The feasibility study will evaluate actions to alter the hydraulic control points that limit flow in the Ives Island area to provide the same areal extent and quality of sustainable spawning habitat (including characteristics such as upwelling through the gravels currently present at the site) at lower levels of Bonneville discharge; reconstruct spawning channels to increase the extent of habitat available at a given level of Bonneville discharge; and maintain hydraulic connections between tributary habitats and the mainstem Columbia River to allow entry for adults and emergence channels for juveniles.

Action 157: BPA shall fund actions to improve and restore tributary and mainstem habitat for CR chum salmon in the reach between The Dalles Dam and the mouth of the Columbia River.

The purpose of this action is to compensate for effects of FCRPS water management in the Ives Island area, which appreciably diminish the value of critical spawning habitat for the survival and recovery of CR chum salmon. The FCRPS has been a relatively important factor for decline of this ESU. Bonneville and The Dalles dams limit access to potential spawning habitat further upstream and Bonneville Reservoir drowned known historical habitat in Bonneville pool. Spawning is currently known in only two areas: the Grays River system in the Columbia River estuary and the Hardy/Hamilton creeks/Ives Island complex, downstream of Bonneville Dam.

Although most of the existing subbasin populations and the ESU as a whole are on a slightly positive growth trajectory (ESU-level lambda = 1.035), RPA water management operations will continue to limit the areal extent of spawning habitat in Bonneville pool and the Ives Island complex in most water years. Therefore, BPA will:

1) fund surveys of existing and potential tributary and mainstem habitat in the Columbia River between The Dalles Dam and the mouth of the Columbia River for suitable protection and restoration projects;
2) develop and implement an effective habitat improvement plan;
3) protect, via purchase, easement, or other means, existing or potential spawning habitat in this reach and adjacent tributaries (i.e., protect, restore, and/or create potentially productive spawning areas).

The overall goal of this effort will be to ensure the survival and recovery of CR chum salmon by ensuring the availability of diverse, productive spawning habitats over a wide range of water years.

9.6.2.2 Actions Related to Estuarine Habitat

Although the ***Estuary and Marine Survival*** section of the ***Mainstem and Systemwide Program*** addresses estuary and marine issues including habitat, many of the actions recommended in the NMFS Biological Opinion are directed at the *lower Columbia River* and estuary. As such, this section includes actions that are relevant to mainstem habitat. Refer to the Biological Opinion for details.

9.6.5 Research, Monitoring, and Evaluation Plan

The research, monitoring, and evaluation plan outlined in the Biological Opinion is extensive and has many components. Portions of the plan address habitat action implementation and species response throughout the basin. The plan is extensive and will not be reviewed in this document. For details of the plan relevant to mainstem habitat, this section of the Biological Opinion should be consulted. A listing of relevant RPA's from this section is presented below.

9.6.5.3.3 Habitat, Tier 3—Effectiveness Monitoring

Because offsite mitigation is required as part of this RPA, and habitat performance measures will be assessed, habitat effectiveness monitoring is necessary. Objectives for this monitoring should be set at a subbasin or smaller scale. Habitat research areas should be identified by assessments and should include management or project actions of greatest potential significance to salmonid productivity in that region. The subbasin assessment template should provide the background context to identify specific monitoring objectives for each region.

In addition, critical information can be gained by initiating experimental studies on readily identifiable general classes of habitat improvement actions. Monitoring and evaluation studies should be initiated in the first 2 years to take advantage of selected opportunities to gain information on the effectiveness of these types of actions in terms of physical standards and juvenile survival criteria or standards (e.g., egg-to-parr survival, egg-to-smolt survival). Study design and selection should take into account the relative change in survival expected in a particular setting, the existence of baseline information, and the ability to detect improvements over the range of life history patterns (e.g., upstream and downstream rearing areas).

Action 183: Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points. Management actions falling in this category include the following:

- Attainment of minimum instream flows
- Compliance with water quality standards
    - Alteration of grazing practices
    - Reduction of sediment through road closures
- Enhanced levels of marine-derived nutrients
- Improved riparian conditions
    - Alteration of grazing practices
    - Active stream restoration

Conservation Recommendations

Section 11 of the Biological Opinion discusses NMFS' obligation to develop conservation recommendations under Section 7 (a)(1) of the ESA, which directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and listed species. Conservation recommendations are discretionary measures suggested to minimize or avoid the potential adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the Federal agencies in complying with the obligations under Section 7(a)(1) of the ESA. NMFS believes that the following conservation recommendations are consistent with these obligations and, therefore, supports their implementation by the Action Agencies.

11.1 Create Spawning Habitat For LCR Chinook Salmon In Ives Island Area Below Bonneville Dam

As described in Section 6, the Action Agencies can augment lower Columbia River flows with upper basin reservoir storage to create spawning habitat for tule chinook salmon in the Ives Island area. Starting the flow augmentation program described in Section 9.6.1.2.1 to benefit CR chum salmon approximately 4 weeks earlier will give LCR fall chinook salmon access to this habitat. However, NMFS is concerned about whether the hydrosystem can sustain this operation during a low or average water year without an adverse effect on the ability to meet flow objectives specified in Section 9.6.1.2.1. NMFS, therefore, recommends that the Action Agencies provide flow augmentation for access to spawning habitat in the Ives Island area as early as the first week in October, if the hydroregulation studies completed by mid-September indicate that the operation will not add significant risk to operations designed to meet spawning and incubation requirements for chum salmon or spring and summer flow objectives for juvenile migrants.

Magnuson-Stevens Fishery Conservation And Management Act

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Act to establish new requirements for essential fish habitat (EFH) descriptions in Federal fishery management plans and to require Federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Act, Section 3)." The Secretary of Commerce has designated EFH for the Federally managed groundfish, coastal pelagics, and Pacific salmon fisheries (PFMC 1998a,b, PFMC 1999) as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. That is, EFH provides the properly functioning habitat conditions necessary for the long-term survival of the species over the full range of environmental variation.

The Magnuson-Stevens Act consultation requirements apply to all actions that may adversely affect EFH, regardless of their location. Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside EFH, such as upstream and upslope activities that may have an adverse effect on EFH.

Essential Fish Habitat In The Columbia River Basin

PFMC has recommended to the Secretary of Commerce an EFH designation for the Pacific salmon fishery that includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassable barriers identified by PFMC (1999). Chief Joseph Dam, Dworshak Dam, and the Hells Canyon Complex (Hells Canyon, Oxbow, and Browne dams) are among the listed manmade barriers that represent the upstream extent of the Pacific salmon fishery EFH. Salmon EFH excludes areas upstream of longstanding, naturally impassable barriers (e.g., natural waterfalls in existence for several hundred years). In the estuarine and marine areas, the designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception (PFMC 1999).

Flow Objectives for Salmon and Steelhead

The Action Agencies recommend that mainstem flow operations be based on the 1995 RPA as supplemented by the 1998 FCRPS Biological Opinion. System operators will continue to confer with NMFS and the regional fisheries co-managers to determine how to best manage in-season conditions relative to the seasonal average flow objectives.

For fall chinook and chum salmon spawning below Bonneville Dam, the FCRPS would be operated to use storage to augment natural flows, attempting to provide a flow level of 125 kcfs during early November through early April while maintaining the 1995 RPA requirement for storage projects to be at their upper (flood control) rule curve elevation on April 10 of each year. As natural conditions permit, a conservative stepwise approach would allow higher flows during late fall and early winter.

Effects of Proposed Action

General Considerations

As described previously in the Biological Opinion, the activities proposed for the configuration and operation of the FCRPS are likely to continue to reduce the function of already impaired EFH and retard the long-term progress of the impaired habitat toward properly functioning conditions. Direct effects of the FCRPS on EFH include blockage of habitat and habitat alteration.

By providing a storage capacity for almost 40% of the average annual runoff of the Columbia River above Bonneville Dam and operating to meet electrical generation, flood control, and irrigation demands, reservoir operations have changed streamflow conditions affecting turbidity and sediment transport, estuary conditions, and the extent and characteristics of the Columbia River plume. Reservoir operations on the mainstem Columbia and Snake rivers have altered the natural runoff pattern in the basin by increasing fall and winter flows, decreasing spring and summer flows, and effectively increasing the cross-sectional area of the river, resulting in downstream migration delays. Reduced flows result in substantial modification of the rivers' thermal regime and water quality by increasing water temperatures and altering water chemistry.

The effects of water regulation and impoundments effectively transform an ecosystem dependent on moving water (lotic habitat) into one dependent on still water (lentic habitat). This results in substantial changes in the distribution, abundance, and diversity of organisms and in the carrying capacity of the habitat, as well as changed predator-prey dynamics. Because reservoirs have low water velocity, changes in water temperature, dissolved oxygen levels, turbidity, water chemistry, and aquatic habitat may result. Thermal and chemical stratification are likely to occur, with potentially significant effects on associated aquatic life, in and downstream of the reservoir. Specific downstream effects are likely to depend on site, water quality, size of impoundment, and facility design.

Mainstem Essential Fish Habitat

Mainstem EFH provides the migratory corridor for juvenile salmonids and returning adults. In the Columbia River basin, dams built to provide hydropower, and reservoirs built for water storage and flood control may adversely affect salmon EFH. Potential adverse effects include impaired fish passage (including blockages and diversions); altered water temperature, water quality, water quantity, and flow patterns; interrupted transport of the nutrients, large woody debris, and sediment that affect river, wetland, riparian, and estuarine systems; increased competition with non-native species; and increased predation and disease.

Hydrologic effects of dams include water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. These altered flow regimes can affect the migratory behavior of juvenile salmonids. Water-level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and sometimes strand fish or allow desiccation of spawning redds. Drawdowns reduce available habitat area and concentrate organisms, potentially increasing predation and transmission of disease (Spence et al. 1996). Drawdown in the fall for flood control produces high flows during spawning. The high flows allow fish to spawn in areas that may not have water during the winter and spring, resulting in loss of the redds.

Conclusion

NMFS believes that the proposed action may adversely affect designated EFH for groundfish and coastal pelagics, as well as designated EFH for chinook and coho salmon.

EFH Conservation Recommendations

Conservation measures are discretionary measures suggested to avoid, minimize, or otherwise offset adverse modification of EFH, or to develop additional information. The RPA detailed in Section 9 of the Biological Opinion, along with the reasonable and prudent measures and the terms and conditions that implement them, are applicable to designated groundfish and coastal pelagics EFH and designated Pacific salmon EFH.

Because listed fish in the Columbia River are in such precarious condition, the habitat strategy is intended to accelerate efforts to help fish in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, in the Basinwide Recovery Strategy, Federal agencies commit to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration.

Over the long term, the habitat strategy has three overarching objectives:

1. protect existing high quality habitat,
2. restore degraded habitats on a priority basis and connect them to other functioning habitats, and
3. prevent further degradation of tributary and estuarine habitats and water quality.

Estuarine protection and restoration must play a vital role in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin.

Conservation recommendations (action items) outlined in the "Magnuson-Stevens Fishery Conservation And Management Act" chapter of the Biological Opinion are exactly the same as the RPA's described in Section 9.6.2.2 of the Biological Opinion, "Actions Related to Estuarine Habitat". No conservation recommendations were outlined to deal specifically with the freshwater portion of essential fish habitat as mandated by the Magnuson-Stevens Fishery Conservation And Management Act. The Act requires Federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH for Pacific salmon includes estuary/marine habitat as well as freshwater habitat, and applies to fall chinook and coho salmon regardless of whether they are listed under the ESA.

RELATIONSHIP OF PROGRAM TO USFWS FCRPS BIOLOGICAL OPINION

The USFWS biological opinion addresses the effect of operation and maintenance of the FCRPS on both the threatened bull trout and endangered Kootenai white sturgeon. Since the scope of this mainstem habitat program includes only the mainstem Columbia and Snake rivers, and the distribution of the Kootenai white sturgeon does not include the mainstem Columbia and Snake rivers, this discussion is confined to bull trout. The USFWS opinion concludes that the proposed action will not jeopardize the continued existence of bull trout. The Service has worked with the action agencies to develop a comprehensive list of activities known as reasonable and prudent measures, and terms and conditions to avoid jeopardy and minimize impacts to the species.

Hydrosystem Effects on Mainstem Habitat

Historically, bull trout have been captured in the Columbia River (Gray and Dauble, 1977), and recent captures of bull trout in the mainstem suggest that bull trout use of the Columbia River is a feasible hypothesis. Therefore, habitat loss and increased competition and predation from introduced species may be adversely affecting remnant populations. Dam and reservoir construction and operation have altered major portions of bull trout habitat throughout the Columbia River Basin. Dams without fish passage create barriers to fluvial and adfluvial bull trout which isolates populations, and dams and reservoirs alter the natural hydrograph, thereby affecting forage, water temperature, and water quality (USFWS 1998). Migratory corridors tie seasonal habitat together for anadromous, adfluvial, and fluvial forms, and allow for dispersal of resident forms for recolonization of rebounding habitats (USDA 1993). General effects of the operation of the FCRPS on bull trout habitat include:

1) inundation of fish spawning and rearing habitat;
2) modification of the streamflow and water temperature regime;
3) dewatering of shallow water zones during power operations;
4) loss of native riparian habitats;

5) water level fluctuations interfering with establishment of riparian vegetation along reaches affected by power peaking operations; and
6) establishment of non-native riparian vegetation along affected reaches.

Power Peaking

When they are present in the Lower Columbia River, bull trout can be adversely impacted by rapid elevation fluctuations in both reservoirs and unimpounded river reaches below projects resulting from power peaking operations. Sudden increases or decreases in flows can dewater streambanks, strand or displace juvenile fish, disrupt adult fish populations, and reduce availability of aquatic insects and small fish for food (BA 1999). Smaller bull trout may be susceptible to entrapment or stranding due to flow fluctuations. Flow fluctuations could potentially strand or entrap juvenile bull trout if they are present in the Lower Columbia River. Additional information is needed to determine the size of bull trout when they are present in the Lower Columbia River.

Inundated Habitat

The construction of the hydroelectric projects on the mainstem Columbia River has resulted in significant changes to the aquatic habitat and the biological community. Hydroelectric projects have created reservoir systems upstream of the dams, changing what was once a free-flowing riverine (lotic) system into a slow-moving lacustrine (lentic) system. Dam construction has inundated, impeded, or blocked access to spawning areas (Fulton 1968; Gordon 1964; Raymond 1988). Other effects of inundated habitat have included changes in the biological community within the system due to modifications of the aquatic habitat.

Background – Listed Species

The Service initially listed the bull trout (*Salvelinus confluentus)* as five distinct population segments (DPS) within the conterminous United States (USFWS 1999; USFWS 1998). Bull trout of the Columbia River DPS occur within the action area.

Bull trout, a char in the salmon family, were commonly known as Dolly Varden until recognized as a separate species by the American Fisheries Society in 1980. Bull trout reach sexual maturity at between three and five years of age. They spawn in gravel and cobble pockets in streams during late summer and early fall. Spawning areas are often associated with springs or areas where stream flow is influenced by cold ground water.

Bull trout are known to exhibit two life-history forms or strategies: resident and migratory. Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear from one to four years before migrating to either a lake (adfluvial), a river (fluvial), or in certain coastal areas to salt water (anadromous) where they grow to maturity. These diverse life histories are important to the stability and viability of bull trout populations (Rieman and McIntyre, 1993).

Bull Trout Status and Distribution within the Columbia River DPS

The area covered by the Columbia River distinct population segment (DPS) includes the entire Columbia River and eleven of its tributaries. Generally, bull trout populations in the Columbia River DPS are declining. Because the bull trout populations in the Columbia River DPS have been isolated and fragmented by a number of factors including construction of the FCRPS, conservation activities will be necessary to improve the connectivity between populations, and to restore habitat in population strongholds. Connectivity should be enhanced between strongholds and spawning/rearing reaches. Migratory bull trout ensure interchange of genetic material between populations, thereby ensuring genetic variability. Unfortunately, migratory bull trout have been restricted and/or eliminated due to migration barriers, stream habitat alterations, including seasonal or permanent obstructions, detrimental changes in water quality, increased temperatures, and the alteration of natural stream flow patterns.

Lower Columbia River

The present distribution of bull trout in the Lower Columbia River basin is less than their historic range (Buchanan et al. 1997). Subpopulations of bull trout have been isolated by large-scale hydroelectric facilities and large expanses of fragmented habitat. Although fish may pass Bonneville, The Dalles, John Day, and McNary dams in both upstream and downstream directions, the extent to which bull trout use the Columbia River and these fish passage facilities designed for anadromous fishes is relatively unknown. Bull trout have been caught in the mainstem downstream from Bonneville Dam, and in both the Bonneville and The Dalles reservoirs in the northern pikeminnow reward program fishery (Wachtel 2000). In addition, several fish tagged in the Hood River, Oregon river reach have been recaptured at Drano Lake, Washington, the Bonneville pool backwater of the Little White Salmon River (ODFW, unpublished).

Lower Snake River

The only subpopulation of bull trout associated with the four Lower Snake River reservoirs spawns and rears in the Tucannon River basin. Both resident and migratory forms occur here. Evidence suggests that migratory bull trout from the Tucannon River utilize the mainstem Snake River on a seasonal basis (Buchanan et. al. 1997 citing Ward; WDFW, 1997). Kleist in litt. (1993) reported several observations of adult bull trout passing Lower Monumental and Little Goose dams. From 1994 to 1996, there were 27 bull trout passing the adult fish counting station (mainly in April and May) at Little Goose Dam (Richards, WDFW, personal communication, 2000). At least six bull trout passed counters at Lower Monumental and Little Goose dams in 1991 and 1992 (Kleist 1993). Kleist also observed one bull trout in 1993 just downstream of the count window at Lower Monumental Dam. These were likely migratory fish from the Tucannon River. However, one bull trout was observed at Lower Granite dam in 1998 (Hurson, USCOE, personal communication, 2000) that may indicate fluvial fish are migrating to other upstream subpopulations.

Several subpopulations of bull trout occur upstream of the reservoir influence of Lower Granite Dam, and migrants from these groups have the capability of freely moving to and from Lower Granite Reservoir. Buchanan et al. (1997) suggested that some migrants from the Grande Ronde still utilize the Snake River. Recent observations of radio-tagged bull trout from the Grande Ronde River verified the use of the Snake River by those fish as far down as RM 146, just upstream from Asotin, WA (Shappart, ODFW, personal communication 2000). In the lower reaches of the Imnaha River, large migrant sized bull trout are incidentally caught by steelhead anglers each year, and ODFW believes these fish are migrants that use the Snake River seasonally (Knox, ODFW, personal communication 2000). The most compelling evidence is data from the Idaho Fish and Game smolt trap at Lewiston. It indicates the capture of an occasional bull trout (Basham, in litt. 2000), but the catch rates have been no more than 1 bull trout annually.

Summary of the Effects of the Proposed Action

The Service anticipated indeterminate levels of harassment, harm or killing of bull trout to occur in the mainstem Lower Columbia and Snake rivers. These effects are primarily the result of changes in pool water level elevations affecting food and habitat availability.

In the FWS biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species. Critical habitat has not been designated for bull trout; therefore, none will be affected.

Reasonable and Prudent Measures

Lower Columbia River

The Service recommended the following basic research and habitat-related reasonable and prudent measures (RPM) to minimize the take of bull trout in the Lower Columbia River:

1) Determine the extent of bull trout use of the Lower Columbia River affected by the FCRPS. This would include the river reach from the Pacific Ocean to the upstream extent of the McNary Dam reservoir.

Presently, information regarding bull trout use of the Lower Columbia River is limited. However, existing information indicates that bull trout are present in Bonneville Pool and in several tributaries of the Lower Columbia River. The potential increase in bull trout populations in tributaries is likely to result in their increasing use of the Lower Columbia River reservoirs.

2) If it is determined, in consultation with the Service, that there is a significant bull trout population in the Lower Columbia River based upon results of these studies, then a study shall be conducted to determine the effect of flow fluctuations on stranding or entrapment of bull trout or their prey in FCRPS reservoirs and free flowing reaches of river downstream from FCRPS projects.

Lower Snake River

The Service recommended the following basic research and RPM to minimize the take of bull trout in the Lower Snake River:

1) The action agencies shall determine the presence of, and use by, bull trout in the mainstem Snake River, and shall implement monitoring and studies to provide critical information on bull trout distribution, timing, and usage of the Lower Snake River dams and reservoir system. If this information indicates consideration of modifications to facilities or operations, the Service will work with the action agencies to implement those measures.

No specific habitat-related RPMs were recommended.

Terms and Conditions

Lower Columbia River
The Service recommended terms and conditions to minimize the take of bull trout in the Lower Columbia River area. The terms and conditions established to implement RPM #1 were intended to determine the existing and future extent of bull trout populations using the Lower Columbia River reservoirs and tributary streams. No specific habitat studies were recommended.

Implementation of RPM #2 discussed above, would not be required unless studies indicated substantial numbers of bull trout to be using the Lower Columbia River and reservoirs or attempting to pass the dams. If implementation of RPM #2 is eventually required, the following terms and conditions would apply:

1) Initiate studies to determine the effect of flow fluctuations on river or reservoir water surface elevations and on stranding or entrapment of bull trout and other aquatic life related to the prey base of bull trout.
2) Initiate studies to determine use and suitability of bull trout habitat for all life history stages in the Lower Columbia River.

Lower Snake River
The Service recommended terms and conditions to minimize the take of bull trout in the Lower Snake River area. The terms and conditions established to implement RPM #1 were intended to determine the existing and future extent of bull trout populations using the Lower Snake River area. In addition, the Corps was directed to investigate the presence in, and use of, the mainstem Snake River by bull trout migrating from the Tucannon River.

EXISTING AND PAST EFFORTS

Fish and wildlife habitat projects in or along the mainstem Columbia and Snake rivers have been funded through both the NWPPC's Columbia Basin Fish and Wildlife Program, as well as through other funding sources. Many of these projects are considered "system-wide" in nature, while others focus on specific geographic locations. This section discusses work conducted both in the mainstem subbasins within individual Provinces, as well as work conducted that spans province boundaries. Summaries of mainstem habitat-related projects both within, and outside the Fish & Wildlife program are presented in this section. A complete accounting of wildlife habitat projects related to hydrosystem mitigation has not been provided. For a comprehensive list of Fish and Wildlife Program funded wildlife mitigation projects, contact the Bonneville Power Administration, Office of Environment, Fish and Wildlife.

Columbia River Mainstem Aquatic Habitat Projects - Fish & Wildlife Program

Project 1999003001 - ***Evaluate Spawning for Fall Chinook and Chum salmon just Below the Four Lowermost Columbia River Mainstem Dams***

The primary goal of this project is to restore, protect, and enhance the fall chinook and chum salmon populations that spawn downstream from the Columbia River mainstem dams. The objectives of the project are three-fold: 1) Document the existence of fall chinook and/or chum salmon populations spawning downstream from Bonneville, The Dalles, John Day, and McNary dams, and estimate the size of the populations; 2) Profile the stocks for important population characteristics including spawning time, genetic make-up, emergence timing, emigration size and timing, and juvenile to adult survival rates, and relate these population characteristics to river flows and water temperatures; 3) Determine physical habitat use and preference for fall chinook and chum salmon, and describe the relationship between streamflow/backwater effects and the quantity, quality, and location of physical habitat.

Fundamental life history and habitat characteristics were described for both fall chinook and chum salmon. Evidence of fall chinook spawning below The Dalles and John Day dams and fall chinook and chum spawning below Bonneville Dam was documented. Locations of shallow and deep water redds were recorded using GPS, and a GIS map of the known spawning area was developed. Population estimates were produced for fall chinook and chum salmon spawning in the Ives/Pierce Island complex below Bonneville Dam. Fall chinook and chum emergence and emigration timing from the Ives/Pierce Island complex was also determined. The physical and biological aspects of chum/chinook stranding/entrapment as a result of flow fluctuations in the Ives/Pierce Island complex were described. In-season hydrosystem management recommendations were provided to the salmon managers and hydrosystem operators regarding spawning habitat conditions and flows required for chum and fall chinook salmon to complete incubation and emergence. Extensive in-season analysis was conducted to determine flows required to protect alevins and juveniles from elevated total dissolved gas levels and stranding.

Population estimates were made for other areas where chum were present in Washington Columbia River non-index areas. At least one survey for chum was completed on each of the 33 Washington tributaries. Chum were found in only 7 of the 33 areas surveyed. The largest population between the Grays River and Hamilton/Hardy/Ives Island index populations was the Wood's Landing/Rivershore seeps population near the I-205 Bridge. A total of 33 Oregon Columbia River tributaries were surveyed for the presence of adult chum salmon with only one chum observed. .

Earlier spawning Lower Columbia River (tule) fall chinook were also documented using the Ives/Pierce Island complex. In addition, over 100 upriver bright fall chinook redds were documented and mapped in deep water near Ives and Pierce Islands. Substrate type at the redds was characterized and velocity measurements were collected at selected redd sites. CWT's were applied to 10,000 juvenile fall chinook captured in the Ives/Pierce Island complex during 2001.

Piezometers were successfully installed within the study area, and resulting water temperature data indicated a gradient between the hyporheic zone and the river. Temperature data from piezometers was used to estimate emergence and emigration timing for chinook and chum in the Ives/Pierce Island complex.

Microhabitat parameters (depth, velocity, substrate, slope) were measured for spawning fall chinook and chum salmon, and geographic locations of important hydraulic features and river bathymetry were recorded and entered into a GIS. A 2-dimensional hydraulic model was calibrated to provide hydraulic and physical data over a range of river flows for habitat modeling. Models are under development to provide spawning, rearing, and incubation flows for fall chinook and chum salmon downstream from Bonneville Dam.

Project 199902500 - *Lower Columbia River Wetlands Restoration and Evaluation Program*

This program, has the following goals: 1) Restore 200 acres of wetland and associated upland habitat, and monitor and evaluate restoration success; 2) Convert vegetation on 200 acres from invasive species (reed canary grass) to a more native plant community; 3) Convert 10 existing acres of seasonal open water to 25 acres of seasonal open water; 4) Convert 55 acres of upland meadow to palustrine emergent wetlands; 5) Improve vegetative condition on remaining 120 acres palustrine emergent wetlands; 6) Develop a restoration and management model that can be implemented in other Pacific Northwest watersheds; and 7) Document the contribution of restored wetlands to biodiversity.

Project 199902600 - *Sandy River Delta Riparian Restoration*

The goal of this project is to restore a 600-acre block of "gallery" Columbia River bottomland riparian forest (dense, unbroken stands of black cottonwood, willow, and ash).

Project 199301500 - *Vernita Bar Redd Surveys*

This project was funded in 1992 and 1993 to help determine the relationship between river operations and placement of fall chinook salmon redds on Vernita Bar in the Hanford Reach downstream from Priest Rapids Dam.

Project 199406900 - *Development of a Conceptual Spawning Habitat Model for Fall Chinook Salmon*

The objective of this project is to use Hanford Reach fall chinook salmon and their habitat as an analog to determine the features of mainstem alluvial rivers that are important for adult fall chinook salmon. The project has shown that fall chinook salmon spawning habitat is a function of the geomorphic features of river channels that promote the exchange of surface water and ground water within the river bed. This suggests that the carrying capacity, or potential escapement, of the Hanford Reach is less than would be predicted using traditional metrics of spawning habitat. Currently the project is attempting to determine the spawning capacity of the Hanford Reach for fall chinook salmon. Relevant lessons learned from the Reach are also being applied to the Snake River in an effort to more precisely determine the amount of spawning habitat available there.

Significant findings have been presented in several journal articles, including Geist and Dauble (1998), Geist et al. (2000), Geist (2000), and Dauble and Geist (2000).

Project 199701400 - *Evaluation of Juvenile Fall Chinook Stranding on The Hanford Reach*

The goal of this study was to describe the relationship between river operations, specifically power peaking and fluctuating flows, and the stranding or entrapment of juvenile fall chinook salmon and resident fish. Hourly flows from Priest Rapids Dam fluctuate rapidly due to changes in hydroelectric generation (power peaking). These rapid fluctuations in river flow are known to cause stranding of newly emerged and rearing fall chinook on gently sloped banks, and entrapment during early life stages in potholes formed by the receding water. Since inception in 1997, this project has had the following basic objectives: Evaluate the effect of flow fluctuations in the Hanford Reach of the Columbia River on 1) rearing juvenile fall chinook, 2) resident fish, and 3) the benthic macro-invertebrate community. Preliminary results indicated significant numbers of fish were being stranded or entrapped in isolated pools as a result of power peaking operations from the seven mid-Columbia dams. Results from this project will contribute to development of a long term agreement and operations plan to reduce juvenile chinook mortality in the Hanford Reach during their emergence and rearing period, and to develop a monitoring program to determine implementation dates for the plan and critical time periods of maximum susceptibility.

Project 19944300 - *Lake Roosevelt Monitoring Program*

The two primary goals of this program include monitoring and evaluation of the performance of fish released into Lake Roosevelt by the Spokane Tribal and Sherman Creek hatcheries, and development of a fisheries management plan, which prescribes mitigation actions and hydro operations that will maximize ecosystem diversity, complexity, and sustainability. In order to develop an achievable fisheries management plan, a better understanding of this unique non-native Lake Roosevelt ecosystem is required. As a result, a model is being developed to predict the effect of single actions on the ecosystem and fishery of the lake.

Project 199700400 - *Joint Stock Assessment Project*

The Joint Stock Assessment Project (JSAP) area (blocked area) is composed of 32 unique water bodies covering 9.3 million acres. The project boundary is defined as all water bodies upstream of Chief Joseph Dam within the State of Washington. Prior to hydropower development, the area was a productive, stable ecosystem (Scholz et al. 1985) which contained healthy, native, self-sustaining populations of resident fish, wildlife, and anadromous fish. The JSAP has been designed to function as a tool for fish managers in the blocked area. This tool will focus on understanding the dynamics of fish and their habitats throughout the area and recommend management actions based on the best available science and the condition of the entire areas' ecosystem. The JSAP allows managers to view the Blocked Area as a system by compiling previously collected data, organizing available data, identifying areas needing data, performing necessary research, and recommending management actions. In 1993, managers identified a need for a coordinated approach to fish management in the blocked area. This coordinated approach included a baseline stock inventory of the resident fish species inhabiting the area.

Columbia and Snake River Mainstem Aquatic Habitat Projects - Fish & Wildlife Program

Project 199800402 - ***Assessment of the Impacts of Development and Operation of the Columbia River Hydroelectric System on Mainstem Riverine Processes & Salmon Habitats***

This project had three primary goals: 1) Identify the amount of mainstem salmon spawning and juvenile rearing habitat lost to development and operations of the Columbia River hydroelectric system; 2) Identify the types of ecological modifications that have occurred; and 3) Suggest areas or actions with particular potential for restoration of riverine habitat. The project conducted a quantitative assessment of salmon and steelhead habitats lost because of hydroelectric development. A workshop was also held to compile a list of restoration options, including risks and benefits of implementing those options, for mainstem habitats in the Columbia and Snake rivers. Two restoration strategies were tested: 1) Drawdown of John Day reservoir on the lower Columbia River, and 2) Removal of the four lower Snake River dams. Collectively, the results of these studies represent significant progress toward defining locations in the Columbia and Snake rivers with greatest potential for restoration of mainstem riverine processes and salmon habitats. Most data products are presented in a GIS format to facilitate information exchange among fisheries scientists and resource managers.

Project 199102900 - ***Identification Of The Spawning, Rearing, And Migratory Requirements Of Fall Chinook Salmon In The Columbia River Basin***

This project and the sub-projects listed below, have conducted research in both the mainstem Columbia and Snake rivers. When the project started in 1991, the primary focus was on Snake River fall chinook salmon. Spawning surveys were conducted in the Snake River, and juvenile behavior, rearing, and emigration were studied. Spawning surveys continued in the Snake River in subsequent years, and juvenile studies expanded to include Hanford Reach naturally produced juvenile fall chinook. Habitat studies were conducted in both the Columbia and Snake rivers.

The project title changed in 1998 to "*Post-release Attributes and Survival of Hatchery and Natural Fall Chinook Salmon in the Columbia River Basin"*, and the emphasis of the research was on juvenile fall chinook life history, survival, and habitat use.

Following are summaries of sub-projects conducted through 1997 under the original project title.

Sub-Project - ***Fall Chinook Salmon Spawning Ground Surveys in the Snake River Upstream of Lower Granite Dam***

Spawning ground surveys and redd searches were conducted from 1991 to 1996 as part of an effort to determine the number, timing, location, and spawning habitat characteristics of fall chinook salmon, *Oncorhynchus tshawytscha,* spawning each year in the Snake River between the head of Lower Granite Reservoir and Hells Canyon Dam. Methods included counts from helicopter surveys, underwater searches, and ground observations.

Sub-Project - ***Fall chinook salmon spawning habitat availability in the free-flowing Reach of the Snake River***

Research was conducted between 1991 and 1993 to determine the relation between Hells Canyon Complex discharge and the availability of fall chinook spawning habitat at selected index sites in the Hells Canyon Reach of the Snake River. Conclusions included; 1) Estimates of fall chinook spawning habitat can be made in the Snake River using hydraulic and habitat models, and 2) Fall chinook spawning habitat in the free-flowing reach of the Snake River is underseeded.

Sub-Project - ***Fall Chinook Salmon Spawning Downstream of Lower Snake River Hydroelectric Projects***

Historically, fall chinook salmon spawned in the mainstem Snake River from its confluence with the Columbia River to its headwaters near Shoshone Falls, Idaho, a distance of approximately 1,000 km (Gilbert and Evermann 1892); Fulton 1968; Figure 1). Since 1975, following construction of the Hells Canyon Dam and the four lower Snake River hydroelectric dams, mainstem spawning was apparently restricted to the Hells Canyon Reach (river km 236-397; Horner and Bjornn 1979). All other riverine habitat, except for a short distance downstream of mainstem hydroelectric projects, was blocked or inundated.

Anecdotal evidence existed that fall chinook salmon spawned in the tailrace area downstream of two lower Snake River dams. For example, Bennett et al. (1983, 1993) captured subyearling chinook salmon in Little Goose reservoir before collection of downstream migrants in the juvenile collection facility at Lower Granite Dam. Salmon embryos, believed to be fall chinook salmon, were discovered downstream of Lower Monumental Dam during dredging operations in February 1992 (Kenney 1992). High fallback rates and holding patterns of adults during the spawning season (Mendel et al. 1992, 1994), also provided evidence that fall chinook salmon spawned downstream of some lower Snake River hydroelectric facilities.

The objective of this study was to search for and characterize fall chinook salmon spawning sites in areas immediately downstream of the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). This information was needed to minimize impacts of in-channel construction activities on fall chinook salmon and has important implications related to future operation of lower Snake River hydroelectric projects, including assessment of reservoir drawdown. Results indicated some fall chinook spawning occurred downstream from Ice Harbor, Little Goose, and Lower Granite dams.

Sub-Project - ***Evaluation of Substrate Quality For Incubation of Fall Chinook Salmon Embryos in the Snake River***

Recovery efforts for fall chinook salmon are limited by the lack of understanding of life history requirements. Successful natural reproduction of Snake River fall chinook salmon could be limited by the quality of spawning gravel. Fall chinook salmon spawn in the free-flowing reach of the Snake River between river kilometers (RKMs) 235 and 398 (Garcia et al. 1994).

A complex mixture of sediment sizes in combination with certain hydraulic conditions are required to provide an ideal spawning environment for chinook salmon (Reiser and Bjornn 1979) although the mixture of sediment sizes for optimum salmon survival is not clear (Platts et al. 1979). High concentrations of fine sediments can create detrimental effects during salmonid egg and fry development (Meehan and Swanston 1977). Excessive amounts of fine sediment in the spawning substrate can decrease permeability and water velocity to incubating embryos (Lotspeich and Everest 1981). Decreased flow through the substrate reduces oxygen availability to embryos and slows removal of metabolic wastes that may be toxic to embryos (Iwamoto et al. 1978). Also, entrapment of fry occurs when fine sediments are lodged in substrate interstices that prevent emergence (Phillips 1975).

The purpose of this project was to describe the composition of gravel in the Snake River between Rkms 245.1 and 398, and to assess effects of the substrate composition on the incubation success of fall chinook salmon. The objectives were to: (1) review the literature on quality of spawning substrate of Pacific salmon and substrate sampling techniques with emphasis on chinook salmon, (2) characterize the spawning substrate at 12 previously identified fall chinook salmon spawning locations, and (2) estimate incubation success of fall chinook salmon embryos in artificial redds using substrate representative of the 12 study locations.

Results were similar to those reported from other laboratory and field experiments in that as percent fines increase in the sediment, fry survival decreases. Substrate samples showed that spawning gravel in the Snake River has relatively low amounts of fine sediment above the Imnaha River, and significantly higher amounts of fines below the Grand Ronde River.

Sub-Project - ***Nearshore habitat use by subyearling chinook salmon in the Columbia and Snake rivers***

This study began in 1992 with the goal of identifying and describing the characteristics of rearing habitats used by naturally produced subyearling chinook salmon in riverine reaches and mainstem reservoirs in the Columbia and Snake rivers. Research in the Columbia River was conducted in the Hanford Reach and McNary Pool. Research in the Snake River was conducted in the Hells Canyon Reach. Studies continued in 1994 with the additional goal of investigating nearshore habitat use by non-native piscivores.

Sub-Project - ***Nearshore Movement and Feeding Behaviors of Juvenile Fall Chinook Salmon in the Columbia River***

The goal of this research, initiated in 1994, was to build upon previous juvenile fall chinook studies by focusing more closely on nearshore movements, behavior and habitat use. Studies were conducted in the Hanford Reach of the Columbia River to use available fall chinook salmon as surrogate experimental animals rather than the endangered Snake River fall chinook salmon. Objectives were to: 1) document and compare rate and direction of juvenile fall chinook salmon die1 movements in nearshore habitats throughout the rearing season; 2) describe the use and avoidance of various microhabitats found in nearshore areas by juvenile fall chinook salmon; and 3) identify the peak times of juvenile fall chinook salmon feeding, resting, and movement in nearshore areas. Studies continued in 1995 with the added objective of investigating the effect of differing flow and substrate composition in nearshore areas on juvenile fall chinook salmon movement patterns.

Project 199102900 - ***Post-release Attributes and Survival of Hatchery and Natural Fall Chinook Salmon in the Columbia River Basin***

The focus of this project and the sub-projects listed below shifted in 1998 to research on juvenile fall chinook life history, survival, and habitat use, hence, the new project title. Research was conducted in both the mainstem Columbia and Snake rivers. Activities in the Columbia River have included habitat evaluations for juvenile fall chinook salmon in both McNary Reservoir and the Hanford Reach. Evaluations identified subyearling chinook salmon rearing areas for further study, estimated spatial and temporal utilization of habitats by subyearling chinook salmon, and described characteristics of these habitats. Changes in rearing habitat were quantified as a function of river flow for the Hanford Reach and showed that there is less available habitat at higher discharges. Power peaking operations at Priest Rapids Dam can subject juvenile salmon to stranding or entrapment. The area that is alternately watered and de-watered as a result of those operations was quantified for different operational scenarios. Investigations in McNary Reservoir showed that fall chinook salmon do not prefer riprap habitats. This finding may indicate much of the riprapped shorelines of mainstem reservoirs are unsuitable for rearing. Hydroacoustic assessments of migrating fall chinook salmon have been made in McNary and John Day reservoirs to determine if fish distributions are related to water velocities. The zooplankton community that fall chinook may use as food has been described as well. Travel time analyses were conducted for fall chinook salmon traveling through John Day Reservoir, as well as determining which portion of the juvenile outmigration contributes the most adults. Current activities include estimating the survival of juvenile Hanford Reach fall chinook salmon to determine factors that influence survival and for comparing survival estimates to those of ESA listed Snake River fall chinook salmon.

Sub-Project - ***Nearshore Habitat Use by Subyearling Fall Chinook Salmon in the Snake River***

Past studies of habitat use by subyearling fall chinook salmon conducted in the Snake River have primarily used beach seining in the free-flowing reaches (Key et al. 1994a; Key et al. 1994b) and reservoirs (Bennett et al. 1992; Curet 1993). Beach seining is limited by the range of velocities and substrates that can be effectively sampled, and therefore can bias estimates of habitat use. Deep, rocky, and swift habitats must be sampled with gear other than beach seines. Electrofishing was used in 1998 to sample a wider range of habitats than had been sampled in the past. The objective of this study was to better define subyearling fall chinook salmon rearing habitat in the Snake River, and to compare habitats used to those used by fall chinook salmon in the Hanford Reach of the Columbia River.

Results of this study suggested that subyearling fall chinook salmon habitat use is similar between the free-flowing Snake River and the Hanford Reach of the Columbia River. Habitat variables such as gradient and velocity seemed to be most important in determining fish presence. Substrate and embeddedness did not seem to be important criteria for habitat selection, except for avoidance of bedrock cliffs and man-made boulder areas.

Sub-Project - *Modeling Flow-Dependent Changes in Juvenile Fall Chinook Salmon Rearing Habitat and Entrapment Areas in the Hanford Reach of the Columbia River*

Each year the Hanford Reach produces an estimated 25-30 million natural juvenile salmon which rear along shallow main-stem shorelines for 2-4 months before migrating seaward during the summer (P.G. Wagner, Washington Department of Fish and Wildlife, personal communication). Upstream hydroelectric dams regulate flows through the Hanford Reach with Priest Rapids Dam at the head of the Reach exerting the greatest local influence. Changes in discharge at Priest Rapids Dam to meet power demand, termed power peaking, can cause tail-water elevations to fluctuate in excess of three vertical meters within hours (U.S. Geological Survey, gage station 12472800, unpublished data). These fluctuations can potentially change the amount of rearing habitat available to juvenile fall chinook salmon on a daily and hourly basis. The repeated drying and rewetting of shoreline substrates resulting from flow fluctuations may also limit the production of macroinvertebrates, which juvenile fall chinook salmon use as food (Becker 1973; Dauble et al. 1980; Cushman 1985; Gislason 1985). Sharp decreases in flow also strand and entrap fall chinook salmon when water rapidly recedes from low-gradient shoreline habitats (Wagner et al. 1999), which can result in significant mortality of young salmon.

Since the production of juvenile fall chinook salmon in the Hanford Reach is partially dependent upon rearing habitat quality and quantity, it is important to understand the influences of annual and daily variations in discharge. The objective of this study was to quantify the effects of flow fluctuations on the amount of juvenile fall chinook salmon rearing habitat and entrapment areas.

Water velocity was found to be an important factor influencing the habitat selection of juvenile chinook salmon. The water velocities used by Hanford Reach fall chinook salmon were similar to those reported for chinook salmon in large rivers (Glova and Duncan 1985; Garland and Tiffan 1999) and smaller streams (Everest and Chapman 1972; Rubin et al. 1991

Water depth by itself, was not found to be an important variable in this study. Instead, fall chinook salmon presence was associated with lateral slope, which incorporates water depth. Areas of low velocity and lateral slope near shore are typically warmer than the main channel and may maximize growth of juvenile fall chinook salmon.

The amount of fall chinook salmon rearing area in the Hanford Reach increased as flow decreased due to shallower nearshore slopes and reduced water velocities. In contrast, at higher flows water velocities were generally greater and the shorelines were located on steeper banks due to fuller river channels. In addition, many of the islands that provided rearing area at low flows were submerged at higher discharges.

The greatest detriment to juvenile fall chinook salmon in the Hanford Reach caused by fluctuating flows is stranding and entrapment. Because fall chinook salmon are shoreline oriented, they are susceptible to stranding on shallow slopes or being entrapped in pools when waters rapidly recede following a decrease in flow.

Historically, fall chinook salmon reared under a natural hydrograph that most likely exhibited little diel fluctuation. Although the general shape of the hydrograph is still similar today, hydroelectric power peaking has introduced hourly and daily fluctuations that can affect the rearing potential of fall chinook salmon in the Hanford Reach. While the specific effects of habitat changes on the rearing population remain largely unexplored, the negative consequences of stranding and entrapment are apparent (Wagner et al. 1999). As such, hydro and fishery managers should, to the extent practicable, minimize flow fluctuations in the Hanford Reach.

Sub-Project - *Subyearling Fall Chinook Salmon Use of Shoreline Riprap Habitats in a Reservoir of the Columbia River*

This project responded to a need to determine the effect of riprap habitats on rearing habitat for subyearling fall chinook salmon so informed decisions could be made on future shoreline modification projects, as well as restoration efforts.

The objectives of this study were to: 1) determine if subyearling fall chinook salmon use riprap and natural shoreline habitats differently; 2) describe the physical characteristics of riprap and natural habitats; and 3) determine whether the presence of potential predators is associated with subyearling fall chinook salmon habitat selection. Studies were conducted in Lake Wallula, the reservoir upstream from McNary Dam.

The research determined that the abundance of subyearling fall chinook salmon in Lake Wallula was much greater in natural shoreline habitats than in man-made riprap habitats. Substrate size was the most obvious difference between natural and riprap habitats. Rocks used for riprap are large and densely spaced to stabilize banks and prevent erosion. This type of substrate structure is not naturally occurring in alluvial river reaches such as the Hanford Reach, Columbia River. Where boulders occurred naturally in the study area, they were widely spaced and heavily embedded with silt, and made up a small percentage of the natural substrate available. Boulders in natural habitats were used less by subyearling fall chinook salmon than all other substrates.

The project concluded that the production of fall chinook salmon would be greatest in unimpounded alluvial habitats to which these fish are adapted. The riprap habitats that constitute a large portion of shorelines in Columbia and Snake river reservoirs are very different from natural riverine habitats that support subyearling fall chinook salmon. The physical habitat characteristics of riprap such as large unembedded substrates, deep water near shore, and steep lateral slopes, reduce the rearing potential for subyearling fall chinook salmon in Lake Wallula and probably other reservoirs with riprap habitat.

Subyearling fall chinook salmon rearing in, or migrating through, this type of habitat may also be at a greater risk of predation.

Snake River Mainstem Aquatic Habitat Projects - Fish & Wildlife Program

Project 199810003 - ***Spawning Distribution of Fall Chinook Salmon in the Snake River, Progress toward determining the spawning distribution of supplemented fall chinook salmon in the Snake River basin upriver of Lower Granite Dam in 1999***

Data were collected during 1999 on the spawning distribution of hatchery fall chinook salmon that were released upriver of Lower Granite Dam. Yearling fish were released at three locations that were phased in over a three-year period. Multiple release sites were used with the intent to distribute spawning throughout the existing habitat, and this project was designed to determine if this actually occurred. Returning fish were trapped at Lower Granite Dam, their origin was identified (all fish were externally marked), and radio tags were used to follow the fish to where they spawned. Mostly female fish were targeted so that spawning locations could be determined by observing redds, although some male fish (adults and one-ocean males) were also targeted to obtain information on the movements of both sexes and all age groups. In 1999, a total of 73 fall chinook salmon were radio-tagged, and tagging and tracking proceeded as planned. A preliminary analysis of the data collected in 1998 showed that roughly 80% of the yearling fish released at Pittsburg Landing spawned in the upper half of the Hells Canyon Reach. This suggested the release strategy may produce the desired spawning distribution for this release site. Preliminary data from the Captain John site showed adult fish from subyearling releases entered the Grande Ronde River, whereas returns from yearling and subyearling releases at the Pittsburg Landing site did not.

Sub-Project - ***Fall chinook salmon spawning ground surveys in the Snake River basin upriver of Lower Granite Dam, 1999***

Aerial searches for fall chinook salmon redds were conducted in 1999 upriver of Lower Granite Dam in portions of the Snake, Grande Ronde, Imnaha, and Salmon rivers, all of the Clearwater River, and some tributaries of the Clearwater River. In addition, underwater searches were conducted in the Snake River using submersible cameras. A total of 579 redds were counted, and of those, 373 were observed in the Snake River (273 during aerial searches, and 100 using submersible cameras), 181 in the Clearwater River, one in the North Fork Clearwater River, two in the South Fork Clearwater River, 13 in the Grande Ronde River, and nine in the Imnaha River. The total redd count in 1999 was the highest recorded in recent years (303 were counted in 1998, and 189 in 1997), and corresponded with an increase in the number of adult fall chinook salmon counted at Lower Granite Dam (1,917 in 1999 vs. 962 in 1998). Techniques to guide underwater searches using GPS technology were tested by Idaho Power Company (IPC) biologists, and may be employed by both USFWS and IPC crews next year

Project 199106700 - *Idaho water rental: Fish and wildlife impacts*
The BPA funded Idaho Water Rental Project began in 1991 and ended in calendar year 2000. The purpose of the project was to estimate impacts to resident fish habitat in the Snake River and tributaries upstream of Brownlee Reservoir resulting from the release of 427,000 acre feet of water for salmon flow augmentation.

Project 19980002 - ***Snake River Native Salmonid Assessment***
This is an ongoing research project funded by BPA and implemented by IDFG. The project was initiated in August 1998 to assess the current status of native salmonids in the middle and upper Snake River provinces in Idaho (Phase I), identify factors limiting populations of native salmonids (Phase II), and develop and implement recovery strategies and plans (Phase III). The inventory phase is being used to assess presence/absence and abundance of native salmonids in all major watersheds of the middle and upper Snake River provinces, and concurrent habitat measurements are being used to conduct a preliminary examination of factors that influence presence/absence and abundance. Genetic samples are also being collected to assess the purity of populations and the degree of genetic variability among and within populations of native salmonids. Based on these findings, major limiting factors will be investigated during the second phase of the project. Recovery strategies for individual or groups of subbasins will be developed to address the factors most important in limiting the patterns of distribution and abundance of native salmonids.

Project 199201000 - *Habitat Protection and Restoration Project*
Riparian areas on the Fort Hall Indian Reservation have been negatively affected by lateral scouring and down cutting of stream banks caused by years of unrestricted grazing and rapid flooding and drafting of American Falls Reservoir. Negative impacts from lateral scouring and down cutting include siltation of spawning gravels, loss of object cover and pool depth, increasing width:depth ratios of stream channels, and resulting increases in water temperature. The primary goal of the restoration project has been to facilitate recovery of native fish and wildlife populations to near historic levels on the Fort Hall Indian Reservation.

Enhancement and restoration techniques have included the use of instream structures to provide cover for fishes and direct flow from unstable streambanks (i.e., rock and wood wing dams and barbs), sloping of streambanks, revegetation with native riparian species, placement of evergreen revetments, and fencing sensitive riparian areas.

Initial restoration/enhancement project efforts were based on creating cover through the use of instream structures. Recently, project priorities have shifted to protecting streambanks and allowing natural processes to heal riparian areas and stream channels (wide shallow channels to narrow deep channels). Riparian plantings and revetments have been successful and continue to be a part of restoration efforts (Taki and Arthaud 1993; Arthaud and Taki 1994; Arthaud *et al*. 1995; Arthaud *et al.* 1996; Moser and Colter 1997; Moser 1998; Moser 1999). In addition to protecting sensitive streambanks, revetments provide cover for juvenile and adult salmonids. Willow plantings have become more successful each year with modification and refinement of techniques.

Mainstem Wildlife Habitat Projects - Fish & Wildlife Program

Funding for wildlife projects has included evaluations of the impacts of the hydropower system on wildlife populations and habitat, and planning for land acquisitions including but not limited to purchases along the Mainstem Columbia River.

Project 198801200 - *Wildlife Impact Assessment: Bonneville, McNary, The Dalles, and John Day Project*

This project estimated the net affects on wildlife from hydroelectric development and operation of The Dalles, John Day, and McNary dams, and recommended protection, mitigation, and enhancement goals for target wildlife species. A total of 26,570 ha and 48,442 Habitat Units were estimated lost as a result of constructing these four mainstem dams.

Status Review of Wildlife Mitigation at Columbia Basin Hydroelectric Projects, Columbia Mainstem & Lower Snake Facilities (BPA 1984)

This effort reviewed the status of past, present, and proposed future wildlife planning and mitigation programs at existing hydroelectric projects in the Columbia River Basin. It was intended that this evaluation would form the basis for determining any remedial measures or additional project analyses.

Projects 199009200, *Conforth Ranch Management Plan*, and 199009201, *Conforth Ranch Land Purchase*, resulted in the purchase of 1,119 ha near Umatilla, Oregon as partial mitigation for construction of McNary Dam.

Idaho Department of Fish and Game

The Idaho Department of Fish and Game (IDFG) has received BPA funding to enact mitigation projects since 1997. Some of these projects have been in partnership with the Shoshone-Bannock Tribes and Teton Regional Land Trust.

Table 2. Upper Snake Subbasin BPA-funded Wildlife Mitigation Projects

Project Name	Year Implemented	Manager(s)	Acres	Habitat Units
Menan acquisition	1997	IDFG&SBT	140	317
Beaver Dick acquisition	1997	IDFG&SBT	310	901
Deer Parks	1999	IDFG&SBT	2,556	6,918

Mitigation Acquisitions

The Deer Parks Complex includes three Wildlife Mitigation Units. The Menan and Beaver Dick properties were acquired in 1997 and the Deer Parks (Boyle Ranch) property was acquired in 1999. The Bonneville Power Administration provided funds to BLM to purchase the lands. The Deer Parks Complex is managed cooperatively by BLM, IDFG, and SBT.

The properties that comprise the Deer Parks Complex were acquired for the purpose of partial mitigation for the loss of wildlife habitat caused by construction of the Palisades Project dam and reservoir. Using Bonneville Power Administration (BPA) funding, the wildlife mitigation units were acquired from willing sellers by U.S.D.I. Bureau of Land Management (BLM), with the agreement that the Idaho Department of Fish and Game (IDFG) and The Shoshone-Bannock Tribes (SBT) would cooperatively manage them.

The Deer Parks Complex is located along and near the Snake River and Henry's Fork Snake River about 20 miles north of Idaho Falls, Idaho in Jefferson and Madison counties. The mitigation units lie in the Snake River Plain at an elevation of 4,790 feet on the Snake River. Most of the terrain has gentle relief and slopes gradually away from the river, rising to about 4,830 feet. An exception to the otherwise gentle topography is the North Menan Butte, which rises nearly 800 feet above the surrounding landscape and is partially within the Deer Parks mitigation unit.

The **Deer Parks Wildlife Mitigation Unit** is located along the mainstem Snake River in Jefferson County about three miles north of Menan, Idaho. The 2,556-acre property includes about two miles of river frontage, wetlands, shrub-steppe uplands, pasture and cropland. It abuts BLM land on three sides. A paved county road is adjacent to the property. There is no levee system along the river in this reach and the low-lying portions of the property flood most years.

The **Menan Wildlife Mitigation Unit** is located along the mainstem Snake River in Jefferson County adjacent to the Deer Parks unit. The 142-acre property includes river frontage, wetlands, former pasture and former cropland and floods most years.

The **Beaver Dick Wildlife Mitigation Unit** is located along the Henry's Fork Snake River in Madison County about 5 miles west of Rexburg, Idaho. The 310-acre property includes one mile of river frontage, wetlands and former pasture. It also floods most years.

Mainstem Aquatic Habitat Projects Outside the Fish & Wildlife Program

The Bi-State Water Quality Program, States of Oregon and Washington, 1989
In 1989, the States of Oregon and Washington recognized that more information was needed about the health of the lower Columbia River. While much activity was ongoing in the Columbia Basin, the emphasis generally focused above Bonneville Dam. Not much attention had been paid to the lower 146 miles of the Columbia River. A nomination to the National Estuary Program was being discussed, but data was lacking to confirm the degradation that would warrant participation in the program. To address that need, the Lower Columbia River Bi-State Water Quality Program (Bi-State Program) was created in 1990 and continued until 1996. Its study area was the lower part of the river from Bonneville Dam to the Pacific Ocean, a stretch of 146 river miles.

The Bi-State Program was a public/private partnership jointly administered by the Washington Department of Ecology and the Oregon Department of Environmental Quality and assisted by a Bi-State Steering Committee. Steering Committee members came from the many groups with active interests in the health of the river: environmentalists, industry representatives, private citizens, public ports, local governments, fishing interests, Native American tribes, the Northwest Power Planning Council, and state and federal agencies dealing with environmental and natural resource issues. The citizens of Oregon and Washington, the Northwest Pulp and Paper Association, and the region's public ports financially supported the program. Private contractors and state and federal agencies conducted the studies. During its six-year existence, the Bi-State Program invested over $5 million in its work.

The Bi-State Program assessed the health of the river by looking at how well the "beneficial uses" of the river are being met. Beneficial uses are defined in state laws and regulations and include water supply, agriculture, fish and wildlife, recreation, and commercial uses. The program focused on those beneficial uses that relate to the health of humans, fish, and wildlife. These studies generated over 50 technical reports, which are summarized in an integrated technical report called ***The Health of the River 1990-1996***. Based on this work, the Bi-State Program identified four major problems in the study area that warranted further study and action:

- Toxic contaminants in sediment and fish tissue that affect the health of humans, fish, and wildlife.
- Habitat loss or modification that affects fish and wildlife resources.
- Water quality problems that affect the beneficial uses in parts of the estuary.
- An overall decline in fish and wildlife health, including that of a number of threatened and endangered species.

The findings of the Bi-State Program supported nomination of the lower Columbia River estuary in the National Estuary Program. The U.S. Environmental Protection Agency announced the Columbia River as one of the waterways accepted into the program in July 1995.

SSHIAP (Salmon Steelhead Habitat Inventory Assessment Program)

Washington Department of Fish and Wildlife

The SSHIAP program combines data from multiple sources in a comprehensive GIS based data system for salmon and steelhead habitat in the Lower Columbia region. All fish bearing streams within the Lower Columbia region (WRIA's 24 through 30) are included in this assessment. Estuary habitat is also included in this assessment, and encompasses estuary area from the mouth of the Columbia River to Bonneville dam. SSHIAP core attribute variables include:

1. Fish passage barriers
2. Hydro modifications (anthropogenic features such as dikes, rip rap, etc.)
3. Fish Distribution
4. Habitat type (large trib, small trib, Rosgen type, Confinement)

Other data including but not limited to flow, stream widths, land use, and historical conditions will be added where available. All data will be 'attached' to a gradient-segmented 24K hydro layer. From this, multiple habitat variables will be accessible via the internet. Also, multiple habitat queries can be performed to access specific stream/stock/habitat information. Hardcopy maps will also be available. The intention of SSHIAP is to assist in the prioritization of restoration-type projects, as well as provide a centralized visual data storage in a dynamic updateable system available to all agencies and the general public.

IDEQ Beneficial Use Reconnaissance Program (BURP) Monitoring

In 1993, the Idaho Department of Environmental Quality (IDEQ) embarked on a pilot program aimed at integrating biological and chemical monitoring with physical habitat structure assessment to characterize stream integrity and the quality of water. This program was developed in order to meet the Clean Water Act requirements of monitoring and assessing biological assemblages as well as developing biocriteria. Because of the success of the 1993 pilot, IDEQ expanded the project statewide in 1994. Since 1994, the project has remained statewide.

Table 3. BURP monitoring sites and TMDL schedule in the Upper Mid Snake River Subbasin.

HUC Code	HUC Name	# BURP Sites	Date SBA Completed	Date TMDL Completed
17040212	Mid-Snake River	104	1996	1997
17040212	Upper Snake-Rock	104	1998	1999
17040213	Salmon Falls	56	2004	2005
17040219	Big Wood	162	2000	2001
17040220	Camas	39	2002	2003
17040221	Little Wood	32	2002	2003
17050101	C. J. Strike Reservoir	22	2003	2004

Bonneville Reservoir substrate characterization, 2001

U.S. Geological Survey

A cooperative effort between the USGS Coastal and Marine Geology Program and the USGS Biologic Resource Division, Columbia River Research Laboratory to map the surficial sediment distribution and sediment thickness within the Bonneville Reservoir was conducted during 2001 (Darren Gallion, USGS, personal communication). The goal of this study is to define benthic habitats and to assess sediment accumulation and its effects to the larger scale sediment budget of the Columbia River and adjacent coastal ocean. The study area encompassed roughly 70 km of the Columbia River from the Bonneville Dam to The Dalles. The USGS Cruise E1-01-CR was conducted within the Bonneville Reservoir, August 3 - 21, 2001. Funding for this study was provided by the USGS.

The geophysical data were acquired using a Benthos (Datasonics) SIS-1000 system (comprised of a sidescan-sonar (~100 kHz) and sub-bottom profiler (2 - 7 kHz swept FM (CHIRP))), and an Edgetech DF-1000 100/500 kHz dual-frequency sidescan-sonar system.

The SIS-1000 was utilized to acquire sub-bottom data only; the sidescan-sonar portion of the system was not operational. These data were logged digitally, processed and mosaic in the field generating a base from which the sample locations were chosen. Grab sample, video, and still photographs were acquired using the SEABOSS system and utilized to ground-truth the sidescan-sonar data. Sub-bottom data were only acquired in half of the reservoir; Bonneville Dam to Hood River and data in near shore and backwater areas are needed to complete the side-scan mosaic for this reservoir.

Aquatic macrophyte bed mapping, Bonneville Reservoir, 2001

U.S. Geological Survey

Initial efforts to document the extent of Eurasian watermilfoil (*Myriophyllum spicatum)* in Bonneville Reservoir were initiated by the USGS Columbia River Research Laboratory during 2001 (Tim Counihan, USGS, personal communication). From August through October, 2001, the USGS surveyed Bonneville Reservoir for aquatic macrophytes, including Eurasian watermilfoil. Aquatic macrophyte beds were sampled using a modified-rake sampler to collect specimens at each macrophyte bed. Species were identified to family. Percent composition of each species was estimated. Using a boat, the USGS collected samples and surveyed the Washington shoreline from Bonneville Dam's forebay boat restricted zone (BRZ) at river kilometer (rkm) 235.1 to The Dalles Dam tailrace BRZ at rkm 307.8. The Oregon shoreline from The Dalles Dam tailrace BRZ at rkm 307.8 downstream to Crates Point at rkm 299.6, and from the Hood River bridge at rkm 273.2 to Ruthton Point at rkm 266.6 was also surveyed.

Locations and boundaries of macrophyte beds were recorded using a global positioning system, and downloaded to Arcview geographic information system software. Using locations of aquatic macrophyte bed boundaries and the shoreline, the USGS has created polygons representing each macrophyte bed. The goal of this project is to develop a model that will predict the probability of Eurasian water milfoil occurrence by combining information on the location and extent of Eurasian water milfoil with substrate and water depth and velocity and other pertinent data. The model will provide a means to identify factors promoting the establishment of this invasive aquatic plant. Preliminary results from this study suggest that Eurasian water milfoil is abundant in this reservoir. Seed money for this project was provided by the USGS.

Miscellaneous Projects and Efforts

The Army Corps of Engineers (USACE 1977) provided a description of shoreline features (i.e. substrates and riparian vegetation) and some habitat inventory information (i.e. potential rearing areas) for Bonneville Reservoir in their Reach Inventory series (USACE 1977). This information is contained in a mosaic of post-impoundment aerial photographs containing written descriptions of features.

The Washington Department of Fish and Wildlife is working on Western Pond Turtle recovery in habitat near the mouth of the Klickitat River and near Dog Mountain. Western Pond Turtles have been listed as threatened by Washington State.

The Washington Department of Fisheries entered a petition with the FERC in 1976 to establish a minimum discharge of approximately 1,982 m_3/s at Priest Rapids Dam during spawning and incubation of fall chinook salmon. The State of Oregon, the National Marine Fisheries Service (NMFS), and certain treaty Indian Tribes joined in the petition. An agreement was reached to conduct studies over a four-year period. The studies focused on chinook spawning at Vernita Bar (approximately 6.4 km below Priest Rapids Dam), an important spawning area for fall chinook salmon. Studies revealed that after eggs were deposited in redds, a minimum flow level was needed to maintain coverage of the redds until the fry emerge the following spring. In 1988 a long term (1998-2005) Vernita Bar Settlement Agreement was reached. The Agreement establishes procedures to be used in the determination of river flows out of Priest Rapids Dam that are associated with 1) the initiation of spawning, 2) a critical minimum flow needed for continued submergence of the redds, and 3) an emergence date which marks the end of the period identified for coverage of the redds. The particular maximum flow level that occurs during spawning varies from year to year, depending upon the water supply in the basin. However, the Agreement calls for maintaining flows out of Priest Rapids Dam at or below 1,982 m^3/s in the daytime (assumed spawning time) to discourage spawning at higher elevations and for maintaining flows during incubation to minimize dewatering of redds. During incubation, minimum flow is set at the highest flow that occurred during spawning.

Many projects have also been funded by the U. S. Department of Energy and conducted by the PNNL. Most of these projects have been completed in support of Hanford-related activities. A summary of these studies can be found in Becker (1990). Lukas (2001) compiled a review of over 150 different reports related to salmon and steelhead issues, data, studies or monitoring efforts conducted or funded by Grant PUD. This review is a guide to past studies conducted through the Mid-Columbia Proceeding; however, not all studies reviewed are a direct result of the Mid-Columbia Proceeding. Many are voluntary efforts funded by Grant PUD (often with co-funding from Chelan and Douglas PUDs).

Washington Department of Ecology (WDOE) conducts ongoing streamflow and water quality monitoring and management on the mainstem Columbia River in the Columbia Upper Middle Mainstem Subbasin. Instream flows for the mainstem Columbia River were first established in 1980 under the Instream Resources Protection Program (codified in Chapter 173-563 WAC). From 1980 to 1997, any water rights issued were made subject to interruption should Columbia River Instream Flows not be met. In response to the federal protection of salmonids in the Columbia and Snake River Systems through Endangered Species Act listings in December of 1991, the WDOE issued an order in 1992 placing a moratorium on further allocation of water from the Columbia River. Legislative action in 1997 eliminated Columbia River instream flows and the moratorium for all future water resource decisions. However, streamflow monitoring continues for the management of hundreds of water use authorizations with priority dates between 1980 and 1997. In water year 2001, enforcement and other management actions were taken by the WDOE as, for the first time, instream flows were not met. Monitoring and management of streamflows will continue as the water rights with priority dates between 1980 and 1997 will continue to be subject to the 1980 instream flow specification.

Bennett *et al*. (1983) showed variation in fish abundance among similar habitats in different Snake River reservoirs. For example, the abundance of chiselmouth and northern pikeminnow was considerably higher at an embayment station in Lower Monumental Reservoir than in embayment habitat in either Little Goose or Ice Harbor reservoirs. In addition, many observations of fishes and their associated habitats were made and reported by Bennett et al. Most of this research was funded by the ACOE and can be found in their reports.

Several studies have described the substrata in the lower Snake River reservoirs. Bennett and Shrier (1986) conducted the first known substrate analyses in Lower Granite Reservoir. They used a Ponar dredge to characterize the substrate at six stations. Substrate sizes were significantly different between shallow and deep waters, although silt was the predominant substrate class at each of the six study locations. Clay content of the substrate generally increased with distance downstream. Organic content was less than 5%.

In 1987, Bennett *et al*. (1988) surveyed the substrata in five shallow water areas of Lower Granite Reservoir by both systematic diving and Ponar dredge. Larger substrata were found near Wawawai (RM 109) in the lower portion of the reservoir than at other up-reservoir locations. A high degree of embeddedness was found for substrates less than 6 inches in diameter. Organic content ranged from 5.2% to 8.8% and overlapping confidence intervals suggested little difference in organic content among shallow water stations throughout Lower Granite Reservoir.

Bennett *et al.* (1998) recently completed the most comprehensive survey of substrata in three of the lower Snake River reservoirs. Eighty-one Van Veen dredge samples were collected in total, three each at shallow, mid-depth, and deep locations in each of three sites in Lower Granite, Little Goose, and Lower Monumental reservoirs. Generally, the percentages of fine sediments (silts, clay, and organic material) increased from upstream to downstream in each of the reservoirs. Upstream sample locations were generally higher in sands, although coarse and fine gravels were collected from a shallow water site at RM 117 in Lower Granite Reservoir. Substrata from the three depths were generally similar throughout the three reservoirs. Silt and sand accounted for most of the substrate composition. Substrates were not otherwise classified in Lower Monumental or Ice Harbor reservoirs. Tailwater substrata, including the degree of embeddedness, are likely similar in composition to the more upstream tailwaters. Greater occurrence of fines, especially in down-reservoir areas such as gulch and embayment habitat, would be expected due to greater age and depositional history of these impoundments.

Dauble and Geist (1992) described substrata within the Snake River arm of Lower Granite Reservoir (upper reservoir) and the tailwater below Lower Granite Dam in Little Goose Reservoir during the 1992 experimental drawdown. Cobble substrate was highly embedded with sand and fines based on visual observations of exposed shoreline areas in upper Lower Granite Reservoir.

Asherin and Claar (1976) inventoried the riparian habitats and associated wildlife along the Lower Snake River for the Corps of Engineers. They found a total of 49 different vegetative and land forms along the Lower Snake River. A total of 345 different species of plants were found within the Lower Snake River summary area (Ashern and Claar 1976; ACOE 1976).

The ACOE acquired a total of 28,355 acres to mitigate wildlife impacts under the LSRCP authorizations. A total of 21,141 acres were purchased out side of the Lower Snake River canyon as off-site mitigation.

Mainstem Wildlife Habitat Projects Outside the Fish & Wildlife Program

Revised Columbia White-Tailed Deer Recovery Plan

The Revised Columbia White-Tailed Deer Recovery Plan, completed in 1976 by the U.S. Fish and Wildlife Service, outlined methods of re-establishing white-tailed deer near the Columbia River. Land use practices since 1972 via an interim management plan have encouraged the regrowth and reestablishment of permanent cover on many areas of the refuge with a history of heavy grazing. Continuous evaluation of deer responses to land use changes is necessary so that the proper balance between short grass/forb pastures and dense cover is maintained.

The Columbia white-tailed deer (CWTD) was Federally listed as an Endangered Species in 1968. In 1972 the Service acquired approximately 4,800 acres of CWTD habitat and established the CWTD National Wildlife Refuge with headquarters near Cathlamet, Washington. The primary objective of the refuge is to protect CWTD and their habitat. In addition to direct land management, the Service is also involved in CWTD conservation by providing planning guidance, project review, consultations, and technical expertise to developers, local governments, public land management agencies and others.

Gem State Wildlife Habitat Area

The Gem State Wildlife Habitat Area (GSWHA) is made up of 71 acres of riparian habitat, most of which is the offsite mitigation area for losses resulting from the development of the Gem State Hydroelectric facility by the City of Idaho Falls. It is managed by the Idaho Department of Fish and Game. The parcel is located on the Snake River below the confluence of the Henry's Fork and the South Fork of the Snake River). The Gem State offsite mitigation area was purchased by the City of Idaho Falls and transferred to the Idaho Department of Fish and Game for management. GSWHA is managed primarily as wildlife habitat. GSWHA is also managed to provide public access for hunting fishing, trapping, and wildlife viewing (IDFG, 1998).

The area is located on river terraces and consists of only one soil type, Annis silty clay loam. The elevation is about 4,780 feet above sea level. No water rights are associated with the area and there has been no agricultural development. However, past use did included livestock grazing. Grazing was removed to enhance wildlife habitat when the City acquired the property.

The GSWHA provides habitat for a variety or songbirds, waterfowl, and raptors, including roost and perch sites for bald eagles. Small mammals, furbearers, deer, elk, and moose also use the area. The removal of grazing from the property and a project to reopen a remnant river channel to allow water flows to raise the water table are expected to improve habitat for wildlife. Trees, including cottonwoods, shrubs and understory vegetation are expected to improve because of the elimination of grazing and because of an increase in available water provided by a raised water table.

Market Lake Wildlife Management Area

The 5,071 acre Market Lake Wildlife Management Area (MLWMA), in Jefferson County is located 2 miles north of the city of Roberts, and 17 miles north of Idaho Falls. The MLWMA was established in 1956 to restore a portion of the historic Market Lake basin for migrating and nesting waterfowl, and to provide an area for waterfowl hunting. The MLWMA is managed by the Idaho Department of Fish and Game.

The original Market Lake was a 12 square mile flood plain of the adjacent Snake River. The vast flocks of waterfowl that visited Market Lake during the spring and fall migrations attracted "market" hunters who harvested the birds and gave the area its name. In 1956 when the MLWMA was established, only 30 acres of the original wetlands remained. Federal Aid per the Pittman-Robertson Act was used in acquiring property to create the MLWMA and also is used to manage the MLWMA.

The MLWMA has four major habitat types; marsh/wetland meadow, desert uplands, Snake River riparian, and cropland. The wetland complexes are surrounded by low rises of sand to sandy loam soils and igneous rock ledges. The 1,700 acres of wetlands receive the majority of their water from springs located throughout the MLWMA.

The MLWMA is used by 250 wildlife species and is an important migration and staging area for waterfowl species in the Pacific Flyway. Approximately 50,000 snow geese, 4,000 tundra swans, 100 trumpeter swans, 2,000 Canada geese and 250,000 ducks feed, rest, and stage at the wetland complex made up of the MLWMA, Mud Lake WMA, and Camas National Wildlife Refuge, during spring migration. The largest concentration of waterfowl occurs in March and April.

In 1998, the MLWMA was given Globally Important Bird Area status in the American Bird Conservancy's United States Important Bird Areas program. Specifically, the MLWMA provides habitat for greater than 1% of the biogeographic population of snow geese during spring migration, and greater than 1% of the world's breeding population of white-faced ibis. It also provides habitat for a nationally significant population of tundra swans in the spring. Species with special status designations and species for which there is concern for their long term well being, which use the MLWMA include the bald eagle, peregrine falcon, sage grouse, sharp-tailed grouse, and white pelican.

Miscellaneous Projects and Efforts

The vegetative communities and land forms adjacent to the Columbia River in the mainstem subbasin of the Columbia Plateau Province during the mid-1970s were identified, delineated, and quantified for The Dalles and John Day reservoirs (Tabor 1976), McNary Reservoir (Asherin and Claar 1976), and the Hanford Reach and Priest Rapids Reservoir (Payne et al. 1975). McKern (1976) and Tabor (1976) reported on an *Inventory of Riparian Habitats and Associated Wildlife along Columbia and Snake Rivers*. This effort included inventories of riparian habitats and associated wildlife under existing conditions to establish baseline data. The study area included the Columbia River from the mouth to the Canadian border. In a *Study of Impacts of Project Modification and River Regulation on Riparian Habitats and Associated Wildlife Along the Columbia River,* Tabor et al. (1981) determined the effects of river regulation for maximum power production on key riparian habitats and wildlife. The study area included the Columbia River from Vancouver, WA (river km 171) to Grand Coulee Dam.

The USACE and ODFW have cooperated in management of USACE lands along John Day Reservoir for wildlife. Approximately 9.1 ha in the vicinity of Rufus Bar was transferred from the USACE to ODFW in the late 1970s for wildlife management. ODFW has initiated some habitat improvement for waterfowl and upland game on this small parcel of land. Management practices include protection of land from cattle grazing, providing a pond, and providing winter forage for waterfowl and upland birds (Scherzinger 1983; Torland 1983). ODFW currently has an agreement with the USACE until year 2004 to manage an additional 94 ha in the Rufus Bar area. The area is managed as a refuge or sanctuary with protection provided by ODFW. No active improvements have been made to the area (Scherzinger 1983; Torland 1983).

The USACE (2000) completed the report *Salmon Recovery Through John Day Reservoir*. This includes a reconnaissance-level assessment of the potential consequences anticipated to occur to wildlife from four alternatives proposed to draw down John Day Reservoir.

Historical views of the fish and wildlife populations and their habitats in the Hanford area include Rickard and Watson (1985), *Four Decades of Environmental Change and Their Influence upon Native Wildlife and Fish on the Mid-Columbia River, Washington, USA*, and Rickard and Poole (1989), *Terrestrial Wildlife of the Hanford Site: Past and Future*. Fitzner and Hanson (1979) conducted bald eagle counts at Hanford. The PNNL has conducted a number of additional wildlife studies in the Hanford area. Downs et al. (1993), Frest and Johannes (1993), Neitzel and Frest (1993), and Cadwell (1995) are examples.

The PNNL has also conducted wildlife surveys along Priest Rapids Reservoir. Rogers et al. (1988; 1989) conducted an *Ecological Baseline Study of the Yakima Firing Center Proposed Land Acquisition*. This included surveys of fish and wildlife along a reach of Priest Rapids Reservoir proposed for inclusion in the YTC.

Grant PUD has purchased over 8,100 ha of land specifically for the benefit of wildlife and wildlife habitat to balance the lands lost to inundation. In addition, project lands still under direct Grant PUD control (not including immediate hydroproject sites) provide significant wildlife and habitat benefits. Grant PUD also developed and implemented a Land Use Plan on April 20, 1992.

WDFW is mitigating (compensating) off-site for shrub-steppe and riparian habitat losses associated with Grand Coulee and Chief Joseph Dams (the Northwest Power Planning Council has designated shrub-steppe/riparian habitats as high priorities). Mitigation projects are located within the Crab, Yakima, Okanogan, or Upper Columbia Subbasins, but are being credited against construction and inundation losses incurred in the Lake Roosevelt Subbasin.

MAINSTEM HABITAT LIMITING FACTORS

Primary limiting factors for fish, wildlife, and associated habitats in the Mainstem Columbia and Snake rivers generally fall into three categories: 1) as or resulting from hydrosystem development, 2) operation of the hydrosystem, and 3) anthropogenic activities such as floodplain and industrial development, urban and suburban development, transportation, agricultural activities and various forest practices. The NWPPC's Columbia Basin Fish and Wildlife Program asserts these factors be addressed. The factors mentioned below can largely be applied to the entire basin although some are site specific. Additional details for some site-specific limiting factors may be found in other subbasin summaries especially if tributaries are involved. For some reaches within the basin a formal limiting factors analysis has not been completed which is the case in the Upper Middle Mainstem Subbasin.

Anadromous and Resident Fish

Anadromous species that use mainstem habitat for some portion of their life cycle (excluding upstream and downstream migration) include fall chinook salmon, chum salmon and steelhead. Fall chinook salmon spawn and rear in many mainstem areas across the basin. Mainstem chum salmon spawning and rearing is confined primarily to small areas downstream from Bonneville Dam, and is usually associated with ground water activity. Very little is known regarding specific mainstem spawning and rearing locations for steelhead. Other anadromous salmonids migrate through the mainstem but do not utilize it from a functional habitat basis. White Sturgeon and Pacific Lamprey spawn and rear in the mainstem Columbia and Snake rivers but are not addressed within this program. They have been designated as separate programs within the Mainstem/Systemwide Province. Some native resident species (e.g. mountain whitefish, bull trout, sand roller) use mainstem habitats for all or parts of their life cycles, although no formal limiting factors analysis has been conducted. As a result, this discussion is directed primarily towards the effects of construction and operation of the hydrosystem on fall chinook and chum salmon.

- Hydroelectric development has transformed most fast-moving mainstem riverine habitats into slow-moving reservoir impoundments. Construction of the hydrosystem inundated or altered most of the historic fall chinook spawning and rearing habitat in the mainstem Columbia and Snake rivers. Island complexes, channel bars and other features associated with wide alluvial floodplains were largely lost. Currently, the unimpounded Hanford Reach is the primary mainstem area where these types of features can be observed. Consequently, the Reach provides the majority of mainstem spawning and rearing habitat for fall chinook.
- It is generally accepted that hydropower development on the lower Snake River and Columbia River is the primary cause of decline and continued suppression of Snake River salmon and steelhead (IDFG 1998; CBFWA 1991; NPPC 1992; NMFS 1995

and 1997; NRC 1995; Williams et al. 1998). However, less agreement exists about whether the hydropower system is the primary factor limiting recovery (Marmorek et al. 1998). This limiting factor keeps yearly effective population size low and increases genetic and demographic risk of localized extinction.

- System-wide control of Columbia Snake river discharge and impoundment limits production of mainstem spawning anadromous salmonids and possibly other species. Limitations on production of fall chinook salmon occur downstream from most mainstem hydroelectric projects. In addition, spawning habitat and year class success for white sturgeon are directly related to river discharge in the McNary, John Day, and The Dalles dam tailraces (Parsley and Beckman 1994).
- Alternate watering and de-watering of areas characterized by groundwater/surface water interaction is negatively effecting spawning and rearing habitat in critical areas for ESA listed Columbia River chum salmon.
- Power peaking or load following operations at Columbia and Snake river hydroelectric projects can result in drastic, short term changes in water surface elevations and velocity profiles at downstream areas. For example, power peaking operations at Wanapum and Priest Rapids dams have resulted in water surface elevation changes of up to three vertical meters in a matter of hours. This type of operation has resulted in the stranding and entrapment of juvenile fall chinook salmon and resident fish in the Hanford Reach, and both fall chinook and chum salmon downstream from Bonneville Dam. Similar water level fluctuations occur at other projects within the FCRPS, although they have not been extensively studied. Direct and indirect mortality associated with these events can be significant (Wagner et al. 1999), and in the case of Hanford Reach fall chinook salmon, has a direct impact on the production potential. The effects of these fluctuations on resident fish and wildlife have not been quantified.
- Fluctuations in river flows change the amount of rearing habitat available to juvenile fall chinook salmon (Tiffan et al. In press). The consequences of daily changes in rearing habitat on fish survival, displacement, predation risk, and bioenergetic costs are unknown at this time but warrant further attention.
- The repeated drying and rewetting of shoreline substrates resulting from flow fluctuations limits the production of macroinvertebrates which juvenile fall chinook salmon use as food (Becker 1973; Dauble et al. 1980; Cushman 1985; Gislason 1985).
- Flow regulation also affects connections among groundwater, floodplains, and surface water (Stanford et al. 1996), or convergence zones (hyporheic habitats) where biodiversity and bioproduction are frequently high (Stanford and Ward 1993). Water movement through the hyporheic zone has also been shown to be associated with fall chinook spawning site selection (Geist 2000).
- The relative magnitude and frequency of high flow events acts to modify and maintain channel form within a dynamic equilibrium, but only within constraints of existing geological features. For example, major floods are less frequent because of upstream flood-control projects constructed since the 1940s. This change is significant because rivers that flood frequently maintain different species and food webs from systems that are more ecologically benign (Stanford et al. 1996).

- It is unknown whether hydropower development and flow management practices have altered the physical habitat and species assemblages that form trophic relationships with fall chinook salmon and other species.
- The series of reservoirs along the Columbia and Snake rivers has created a situation where sediment deposited by side tributaries is not carried away. This results in an increased material buildup. Without the influence of scouring flood events, vegetation encroachment in shallow water areas can be severe and side channels are not regularly inundated and maintained. In the reference period, water volumes varied seasonally, while water volumes today are much more temporally uniform.
- There is a limited amount of low gradient floodplain and side-channel habitat available within the lower Columbia subbasin. Most of the historic off-channel and floodplain habitat has been disconnected from the river by diking and hardening the channels. These areas were known to be historic rearing areas for many species including fall chinook. Many of the diked sections are now developed, urbanized, or industrialized. Loss of these off-channel habitats limits rearing and over-wintering habitat for juvenile salmonids, resident species, and wildlife.
- Water withdrawals for both industrial and domestic uses reduce instream flows and subsequently the habitat available for many fish and wildlife species. The effects can be more evident in the upper basins.
- In the Snake River, the release of upstream storage for flow augmentation, primarily to speed passage of salmonid smolts through reservoirs, can affect the spawning and growth of resident fish.
- The broad scale limiting factor for native fish species in the Snake River upstream from the Hells Canyon Complex is population fragmentation due to habitat degradation and dam construction. Lack of fish passage at dams in this area of the Snake River has fragmented habitats, resulting in a loss of connectivity, and genetically isolated populations that once mixed freely. Lack of passage has also blocked access to spawning areas needed by white sturgeon (Lukens 1981; Cochnauer 1983), anadromous fish, and other fish species (Lance et al. 2001).

Wildlife

The development and operation of the hydropower system resulted in widespread changes in riparian, riverine, and upland habitats. A tremendous amount of habitat has been lost or significantly altered, primarily as a result of inundation from reservoirs. Wildlife loss assessments conducted in the late 1980s documented losses associated with each hydropower facility. Effects of hydropower development and operations on wildlife and wildlife habitat may be direct or indirect (secondary). Direct effects include stream channelization, inundation of habitat, degradation of habitat from water level fluctuations (e.g., draining and filling of wetlands, rip-rapped shorelines, and erosion), and construction and maintenance of power transmission corridors. Secondary effects include the building of numerous roads and railways, the expansion of irrigation which has resulted in extensive habitat conversion, and increased access to and harassment of wildlife.

- Specific effects of construction and operation of the hydropower system include limiting the availability of secure nesting and brood-rearing habitat for Canada geese, breeding ducks, and colonial nesting birds. Islands provide protection for nesting birds from terrestrial predators, and to some extent, disturbance by humans. Many islands historically used by birds are now inundated. Existing islands are eroding rapidly, especially in John Day Reservoir, thus reducing their size and the number of nests on islands with maximum nest density (McCabe 1976).
- Water fluctuations cause some islands to be connected to shore during periods of low water (e.g. Snake River Islands sector of Deer Flat NWR), allowing access by terrestrial predators. Fluctuations can also cause significant loss of nests established early in the season when average daily flows are lower. Some brooding sites are a great distance from nesting sites, and mortality of young birds can be very high while traveling from nesting islands to distant brooding habitat, especially during windy conditions.
- Mule deer also use islands as a location to give birth. Does likely select islands because of the security from land predators, primarily coyotes. The small number of islands remaining, the apparent loss of size (possibly existence) of some islands to erosion, the formation of land bridges to some islands during low water levels, and the inundation of some islands during periods of high water levels limit this type of use by mule deer.
- Water level fluctuations and waves can also decrease beaver and muskrat production. An additional effect on beaver populations is alternate flooding and exposing of dens. Only 19 of 43 den sites surveyed by Tabor et al. (1981) between The Dalles and Priest Rapids dams were considered suitable if predicted dam operations were achieved.
- Water level fluctuations may play a significant role in short and long-term survivability of rare plant taxa found exclusively along riparian shorelines. For example, in the Hanford Reach and downstream from Bonneville Dam at Pierce Island, persistent sepal yellow-cress, *Rorippa columbiae*, a State-threatened species found throughout the moist near-shore cobble substrate, is often inundated by river flows during times when flowering typically occurs. Little is known concerning long-term survival of this plant, and recruitment under extended periods of inundation (PNNL, unpublished data).
- Fluctuating water levels that occur in shallow areas with highly variable bathymetry contribute to avian botulism outbreaks when terrestrial and aquatic invertebrates die as land areas are repeatedly flooded and desiccated in warm ambient conditions (Locke and Friend 1987; Levine1965).
- Hydropower operations that produce atypically high discharges can displace spawned-out salmon carcasses from the open shoreline into the permanent and dense shoreline vegetation. The dense vegetation may act to conceal those carcasses from predators such as the bald eagle, and may effectively reduce a primary food item that is especially important for wintering juvenile eagles along the Hanford Reach (Brett Tiller, PNNL, unpublished data).

- Prior to the construction of dams in the middle Snake River, alluvial soils associated with the river valley supported diverse riparian habitat filled with trees and/ or shrubs. Riparian forests in these areas often consisted of large mature trees more than 100 years old, providing wildlife with abundant cover and important structural elements like snags. Many of these areas were flooded with the filling of reservoirs, and riparian zones have been slow to reestablish at the new water level as a result of poor soils, riprapped banks, and water level fluctuations. Currently, less than 50% of the historic area along the lower and middle Snake River supports riparian forests.
- Birds (and other wildlife) dependent on riparian or upland areas are also affected by hydropower development and operations. Filling of reservoirs inundated riparian and upland (shrub-steppe and steppe) habitats, and short-term water level fluctuations that result from power production at dams reduce the quantity and quality of riparian habitat on reservoir shorelines. In addition, most species of upland game birds nest on the ground, and their nests are sometimes subject to inundation and failure.
- Extensive riprap along much of the lower Snake River where roads and railways exist has severely limited the habitat availability to riparian based communities.
- Dry-land farming and extensive livestock grazing of open rangeland have been responsible for the elimination and degradation of the riparian zone throughout much of the basin.
- Wildlife habitat loss has occurred through inundation of Columbia River bottomland habitat upstream from Bonneville Dam and other mainstem dams. In the overstory, the cottonwood/willow riparian community provided a mosaic of rich habitat types that were utilized by a diverse assemblage of species. This riparian habitat along the mainstem Columbia was the critical link between drainages for a number of species (i.e., black-tail deer, western gray squirrels, neotropical birds).
- Shallow water habitats created by flooding and seasonal drying of lowland backwater areas along the Columbia River have been severely affected by impoundment of Bonneville Reservoir and other mainstem reservoirs. These seasonal environments historically were rich in amphibian species (i.e. spotted frog and western toad) that are now essentially missing from the Columbia River lowlands. Conversely these habitats have created habitat for nonnative bullfrogs which are a major threat to native species.
- The western pond turtle was considered to have been present throughout the lower Columbia River system from The Dalles to the Portland/Vancouver area. It is currently found in a few select upland ponds adjacent to the Columbia River. Recent review of pre-impoundment aerial photographs from the Columbia River indicate a significant loss of wetland habitat considered important to healthy populations of this species.
- Wildlife abundance has also been adversely affected by irrigated agriculture through the reduction of habitat diversity as monocultures are created. The development of the Columbia Basin Irrigation Project has converted vast acreage of former shrub-steppe habitat to irrigated farming, but also created a connected system of waterways and seepage areas unsuitable for farming. These areas

generally are degraded and in need of restoration, but may be suitable to replace some functions of lost mainstem riparian zones.

MAINSTEM FISH AND WILDLIFE HABITAT NEEDS

Fish and wildlife habitat needs are associated with limiting factors that have not yet been addressed. The specific needs discussed in this section include proposed actions and guidelines for fish and wildlife recovery in the Mainstem Columbia and Snake rivers. Some of the needs are proposed for 'system-wide' implementation where other needs are proposed for specific or multiple geographic locations within the system.

Anadromous and Resident Fish Habitat Needs - Systemwide

Wy-Kan-Ush-Mi Wa-Kish-Wit: Spirit of the Salmon - ***The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes, 1995***

The ***Spirit of the Salmon***, provides a framework to restore the Columbia River salmon, simply stated: put the fish back into the rivers. According to ***Spirit of the Salmon***, past attempts to maintain or restore declining salmon numbers all assumed that technology alone, could "fix" the damage caused by disregard for the underlying, interconnected processes of nature which gave rise to and sustained the great salmon runs of the Columbia Basin. Simple solutions could not replace the complexity of nature; naturally these attempts failed. The ***Spirit of the Salmon*** provides the following recommendations related to the mainstem:

- Begin improving in-channel stream conditions for anadromous fish by improving or eliminating land-use practices that degrade watershed quality.
- Protect and increase instream flows by limiting additional consumptive water withdrawals, by using the most efficient irrigation methods, by preventing soil compaction and riparian vegetation removal and wetland destruction, and, where necessary, restoring soil, restoring riparian vegetation, and re-creating wetlands.
- Use streamflow, spill, drawdowns, peak efficiency turbine operation, new turbine technology, and predator control projects to improve inriver juvenile salmon survival; avoid fluctuations caused by power peaking operations.

Fall Chinook

- Quantify the spatial and temporal relationships among life history driven habitat requirements for fall chinook salmon. Specifically, evaluate the relationship and relative importance of habitat patches and identify locations of critical habitat that support all life history stages (e.g., spawning, rearing, adult holding).
- Continue investigations into the level of fall chinook spawning activity in the mainstem Columbia River downstream from The Dalles, John Day, and McNary dams.

- Investigate the level of spawning activity, availability of spawning habitat, and the effect of streamflow and streamflow fluctuations on spawning habitat for fall chinook in the mainstem Columbia River upstream from McNary Dam, and in the Snake River between the mouth and Hells Canyon.
- Investigate the effect of adjusting downstream pool elevations on tailrace spawning habitat at mainstem Columbia and Snake river hydroelectric projects.
- Estimate the quantity and production potential of fall chinook rearing habitat in McNary, John Day, The Dalles, and Bonneville reservoirs.
- Determine whether fall chinook salmon build redds and spawn at night as well as during the day.
- The quality of mainstem reservoir rearing habitats for juvenile fall chinook compared to those of unimpounded reaches is unknown. Predation, food quantity and quality, and the amount of available rearing habitat may limit fall chinook salmon production and survival differently in these two types of habitats. Further investigation is required to determine the implications of juvenile rearing in unimpounded reaches compared to impounded reaches.

Habitat

- A systematic assessment of habitat modifications from dam construction should be done, and potential restoration sites and specific benefits to anadromous and resident fish should be identified. Mainstem reaches should be improved in ways that mimic the range and diversity of historic habitat conditions as much as possible.
- A systematic, systemwide assessment should be done of the effects of water level fluctuations on juvenile fall chinook and resident fish mortality (stranding, entrapment) and rearing habitat, invertebrate production, riparian plant communities, and wildlife use of riparian zones.
- Protect, restore, and create riparian, wetland, and floodplain areas where opportunities exist.
- Monitoring and evaluation studies should be initiated to collect information on the effectiveness of actions taken to restore or improve habitat conditions. Evaluation of changes or improvements in the physical habitat by a particular action would be a starting point, but the effects on target species in terms of survival, adult returns, expanded distribution, or other standards should also be evaluated.

Anadromous and Resident Fish Habitat Needs - Columbia River

Lower Columbia River

Chum Salmon

- Additional land acquisition and purchase of conservation easements for total protection of the Wood’s Landings and Rivershore seeps. This is essential to protect one of the only two known mainstem spawning sites for Columbia River chum salmon.

- Determine the effects of streamflows and tides on spawning habitat, and identify, record, and map chum spawning locations.
- Determine whether chum salmon build redds and spawn at night as well as during the day.
- Continue to survey the mainstem Columbia River downstream from Bonneville Dam to identify other potential chum spawning habitat including spring seeps and areas with ground water/surface water interactions for possible acquisition or restoration.
- Continue annual chum spawning ground counts (both index and non-index) to determine presence/absence, spawn timing, generate population estimates, determine carrying capacity, and determine trends in populations.
- Continue collecting chum at the Bonneville trap and collect biological and genetic data plus radio tag a portion of those fish to determine migration routes and spawning locations above Bonneville Dam.
- Continue collecting biological data from adult chum salmon to profile age, age at return, sex ratios, fecundity, and potential production.
- Continue collecting biological data from juvenile chum to estimate egg to fry survival rates, and use strontium to mark the juveniles to determine fry to adult survival rates and straying rates.
- Determine total emergence, emergence timing, rearing duration, rearing distribution, and emigration timing for chum salmon.

<u>Fall chinook</u>
- Conduct annual spawning ground surveys for Lower Columbia River and upriver bright fall chinook in the Ives/Pierce Island complex to estimate the population size, determine the carrying capacity, and collect data for age composition and CWTs to profile the stock composition.
- Determine rearing duration, rearing distribution, and emigration timing for fall chinook in the Ives/Pierce Island complex.
- Continue to apply CWT's to juvenile chinook captured in the Ives/Pierce Island complex to determine juvenile to adult survival rates, ocean and freshwater distribution, and harvest impacts.
- Determine whether fall chinook salmon build redds and spawn at night as well as during the day.

<u>Stranding Studies</u>
- Quantify the effect of Bonneville Dam flow fluctuations on stranding of salmonid species below the dam, and determine the relative impact of stranding on the total population.

<u>Habitat</u>
- Conduct surveys of the entire mainstem Columbia River downstream from Bonneville Dam to the estuary to identify areas outside the Ives/Pierce Island complex that may be used by Lower Columbia River fall chinook, bright fall chinook, or chum salmon for spawning/rearing.

- Investigate whether there is a relationship between mainstem spawning and rearing habitat for fall chinook/chum salmon, and production of adults.
- Complete physical modeling for a real-time water elevation model that incorporates ocean tides and tributary backwater effects on Bonneville discharges and associated physical habitat parameters. This is required for both habitat modeling and stranding evaluations.
- Conduct temperature profiling of river bed temperatures over large spatial areas around chum salmon spawning sites to create a spatial data layer that would indicate the extent of chum spawning habitat. Determine how river bed temperatures in spawning areas change as surface water temperature changes, and as river discharge changes. Determine the effect of these changes on spawning habitat selection by chum salmon.
- Develop a more quantitative understanding of the source and configuration of groundwater resources around chum salmon spawning areas so hydrosystem management actions don't negatively impact the potential interaction of groundwater and surface water thus restricting potential spawning habitat.
- Determine particle size distribution and hydraulic conductivity of bed sediments to quantify groundwater flux. Determine the relationship between groundwater flux and spawning habitat selection by chum salmon.
- Conduct an evaluation of the effect of hourly flow fluctuations resulting from power production at Bonneville Dam on mainstem spawning and rearing habitat.
- Continue to provide in-season recommendations for hydrosystem operation to maintain or enhance spawning, incubation, and rearing habitat for fall chinook and chum salmon.
- Complete a real-time, Internet-based tool that fish and wildlife managers and hydrosystem operators can use to evaluate the effects of hydrosystem management options on habitat for mainstem spawning fish species in areas downstream from Bonneville Dam.
- Investigate physical and/or hydraulic parameters used by spawning and rearing white sturgeon downstream from Bonneville Dam, and determine the relationship between hydrosystem operation/river discharge and physical habitat.
- Investigate physical and/or hydraulic parameters used by Columbia River smelt and cutthroat trout downstream from Bonneville Dam, and determine the relationship between hydrosystem operation/river discharge, river channel modifications and physical habitat.

Bonneville Reservoir

- Obtain high resolution bathymetric and substrate distribution information for the reservoir to enable better design of sampling strategies, for long-term monitoring of reservoir aging, to define benthic habitats, and to assess sediment accumulation and its effects on the larger scale sediment budget of the Columbia River.
- Develop a greater understanding of the physical factors associated with the proliferation of Eurasian water milfoil (*Myriophyllum spicatum*) and the effect on habitat for fish, invertebrates, and waterfowl.

- Assess the status of native species that have received little attention to date. In particular, bull trout, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.

Columbia Plateau - Hanford Reach, Columbia River

In *Return to the River*, the Independent Scientific Group (1996) emphasized the Hanford Reach of the Columbia River as a model of metapopulation dynamics and study area for "normative" river reaches that could possibly be used to revitalize drowned alluvial reaches. Based on annual escapements that have remained relatively stable over the past 10 years at about 80,000 adults (Dauble and Watson 1997), it appears that the geological template and hydrologic conditions in the Hanford Reach are compatible with life history requirements of fall chinook salmon. Understanding the processes affecting fall chinook in the Reach will ensure this population is protected.

A major uncertainty is whether steelhead successfully spawn in the Hanford Reach. There is a discrepancy in steelhead counts at the hydropower projects such that upwards of 10,000 steelhead are unaccounted for between McNary, Ice Harbor, and Priest Rapids dams (Watson 1973; PNNL, unpublished data). Some of these fish may spawn in the Hanford Reach. Understanding if production occurs in the Hanford Reach, and the type of habitat steelhead use, will assist managers in developing hydropower system operational scenarios.

The following specific needs were also identified:

- Assess the effects of hydropower system operations on salmon spawning activity in the Hanford Reach and in the tailrace areas of mainstem dams. This should include an evaluation of whether fall chinook salmon spawn in the Hanford Reach at night as well as during the day, and the relative proportion of wild and hatchery fall chinook salmon that spawn in the Reach.
- Determine the relationship between streamflows below Priest Rapids Dam and fall chinook salmon spawning habitat throughout the Reach, in order to facilitate informed decisions regarding water management during the fall spawning season.
- Assess the effects of water level fluctuations on juvenile fall chinook and resident fish mortality (stranding, entrapment) and rearing habitat, invertebrate production, riparian plant communities, and wildlife use of riparian zones in the Hanford Reach. A complete assessment should include the entire 51-mile Reach to capture the variation associated with this river segment. The consequences of daily changes in rearing habitat on juvenile fall chinook survival, premature displacement downstream, predation risk, and bioenergetic costs are presently unknown but warrant further investigation.
- Connect mainstem habitats with lower reaches of major tributaries, but only after evaluating the costs and benefits of increased migration, predation and competition of exotics, and expanded life history opportunities of anadromous fish populations.
- Apply the concepts and empirical relationships developed under the Hanford Reach fall chinook conceptual spawning habitat model to other alluvial reaches,

in order to improve estimates of production potential and identify reaches with greatest restoration potential.

- Develop a greater understanding of steelhead production (spawning and rearing) and habitat requirements in the Hanford Reach.
- Place biologically acceptable limits on flow fluctuations that are implemented through use of the Hourly Coordination Agreement which coordinates operations of the Priest Rapids, Wanapum, Rock Island, Rocky Reach, Wells, Chief Joseph and Grand Coulee dams.
- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, bull trout, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.
- Build a comprehensive GIS database for the Hanford Reach and Site as a framework for the specific needs discussed above. The accumulation of existing geographically-based information for the Reach and Site should facilitate access to existing data from a single, centralized source. Development of a 2-dimensional hydrodynamic model as part of the database would allow researchers to investigate issues associated with physical habitat such as those described above. Ongoing work, as well as existing data should be organized at a single, internet-based location.

Lake Rufus Woods

- Conduct fish habitat (quality and availability-passage) and watershed inventory assessment in the subbasin.
- Investigate the habitat and use by natural production kokanee salmon through radio tag monitoring in the Rufus Woods/Nespelem River Subbasin.
- Investigate spawning habitat suitability and availability in Lake Rufus Woods for potential re-introduction of anadromous species. Research and identify methods for solving the dissolved gas problem present below Grand Coulee Dam that effect fish populations in Lake Rufus Woods

<u>Hydropower System Development and Operations</u>

- Minimize impacts by Grand Coulee and Chief Joseph Dams operations regarding lake elevations.
- Continue to provide mitigation for losses due to Chief Joseph Dam through protection, restoration and enhancement of fish and wildlife habitat.
- Improved water flow regimes. Activities that promote improved water flow regimes in Lake Rufus Woods (reduce daily variable flows and reservoir elevations), and a return to more naturalized hydrographs within the watersheds in the basin.
- Improved fluvial habitat conditions. Activities that promote increased instream flow and water quality that are consistent with species requirements are critical to meeting fish and wildlife objectives in the subbasin. Such activities include but are not limited to upland management, riparian management, water allocation (acquisition and or conservation of consumptive water rights and

their conversion to instream water), point and non-point pollution management and total dissolved gas abatement.
- Improved lacustrine habitat conditions. Activities that promote improved fish and wildlife habitat within lacustrine habitats is important aspects in meeting fish and wildlife objectives in the basin. Actions that improve water quality, aquatic productivity, functioning littoral and pelagic zones, and wetland areas are just a few elements that are critical to improved lacustrine habitats.
- Regulation of streamflows and lake elevations within Lake Rufus Woods consistent with fish and wildlife needs, including State, Federal, and Tribal water quality standards while meeting hydropower, flood control, and irrigation needs.

Lake Roosevelt

- Conduct baseline species and habitat inventories of streams and lakes with limited current fish data.
- Increase littoral habitat of Lake Roosevelt with vegetative plantings, structure placement and nutrient additions.
- Implement littoral and deepwater habitat improvement to Lake Roosevelt and other area lakes requiring rehabilitation.
- Improved fluvial habitat conditions - Activities that promote watershed management to increase instream flows and water quality that are consistent with species requirements are critical to meeting fish and wildlife objectives in the subbasin. Such activities include but are not limited to upland management, riparian management, water allocation (acquisition and or conservation of consumptive water rights and their conversion to instream water), point and non-point pollution management and total dissolved gas abatement. Re-establishing perennial flows throughout the subbasin should be a primary fisheries focus.

Anadromous and Resident Fish Habitat Needs - Snake River

Lower Snake River

- Determine the presence of, and use by, bull trout in the mainstem Snake River, and implement monitoring and studies to provide critical information on bull trout distribution, timing, and habitat usage of the lower Snake River dams and reservoir system. If the information from these studies warrants consideration of additional modifications to facilities or operations, then implementation of these modifications should occur, as appropriate, to minimize adverse effects to bull trout.
- Determine if rearing habitats in Lower Granite reservoir and the Hells Canyon reach produce similar growth rates and survival for juvenile fall chinook salmon.
- Develop a greater understanding of the riverine habitat potential in the tailraces of Lower Snake mainstem dams under various hydrosystem operational scenarios.
- Apply the concepts and empirical relationships developed under the Hanford Reach fall chinook conceptual spawning habitat model to reaches in the Lower Snake

River, in order to improve estimates of production potential and identify reaches with greatest restoration potential.

- Develop a greater understanding of steelhead production (spawning and rearing) and habitat requirements in the Lower Snake River.
- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.

Snake River Hells Canyon

Resident Fish

- Assess the status of native species that have received little attention to date. In particular, westslope cutthroat trout, sand roller and Pacific lamprey appear to be well below historic population levels. Collect life history, distribution, abundance, and habitat use and availability by life stage, genetic and homing behavior attributes.

Bull Trout

- Collect life history, distribution, habitat, and homing behavior information of bull trout within the subbasin, and relevant core areas.

Chinook Salmon (Includes all races unless specifically noted)

- Gather improved population status information for wild, natural and hatchery chinook salmon including life history characteristics, juvenile and adult migration patterns, juvenile rearing areas, and adult holding areas.
- Determine the effect that rearing habitat fragmentation has on juvenile fall chinook salmon production potential and survival.

Summer Steelhead

Continue Natural Production Monitoring through the implementation of the following:

- Collect population status information for wild steelhead including adult spawner abundance, spawner to spawner ratios, spawning habitat and locations, and spawning timing.

Classified Wetlands

- Continue wetland inventory in watersheds throughout the subbasin.
- Acquire lands when opportunities arise for improved habitat protection, restoration, and connectivity for classified wetlands and for mitigation of lost wildlife habitat for classified wetland associated species (land purchases, land trusts, conservation easements, landowner cooperative agreements, exchanges).

- Protect, restore and create wetland and riparian habitat particularly in lower elevation riparian areas.

Lower Middle Snake River

- Acquire lands when opportunities arise for improved habitat protection, restoration, and connectivity and for mitigation of lost fish and wildlife habitat (land purchases, land trusts, conservation easements, landowner cooperative agreements, exchanges).
- Protect existing pristine and key fish and wildlife habitats directly threatened by subdivision, recreation, or extractive resource uses.

Appropriate target areas and actions should include those that will:

- Restore, protect, and create riparian, wetland and floodplain areas within the subbasin.
- Restore in-stream habitat to conditions that provide suitable holding, spawning, and rearing areas for anadromous and resident fish.
- Restore and augment streamflows at critical times using (but not limited to) water right leases, transfers, or purchases, and improved irrigation efficiency.

<u>Bull Trout</u>

- Evaluate habitat connectivity and the degree of interchange between populations throughout the subbasin.

<u>Monitoring, Evaluation and Assessment</u>

- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.
- Upgrade existing gauging stations or construct new stations to improve access to real-time streamflow and water temperature data and monitor improvement in flows and temperatures as habitat projects are completed

Upper Middle Snake River

- (USGS) A comprehensive monitoring program is needed for the middle Snake River including measures of pollutant loads and associated aquatic life as related to beneficial uses. Long-term monitoring sites are needed on the mainstem as well as major tributaries and springs. Information is needed to evaluate the progress of the middle snake TMDL and assess the status habitat, and trends of federally listed snail species as part of the USFWS Snake River snail recovery efforts.
- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, bull trout, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.

<u>IDFG</u>

- Improved flow regime that resembles a more natural hydrograph for the Snake River and tributaries throughout the subbasin. The timing, quantity and quality of the water needs to mimic the natural, historic condition. Particular flow needs include:

- Spring spawning flow requirements for white sturgeon.
- Improved low flow conditions.
- Flushing flows for channel maintenance sediment mobilization

Potential strategies include:

1) The purchase of water rights or land with water rights.
2) Changes in the state's water laws to allow the conversion of consumptive water rights into an instream beneficial use for fish and wildlife.
3) Elimination of load following activities at hydroelectric facilities.
4) Acquire storage space in subbasin reservoirs and large storage facilities upstream such as American Falls and Palisades reservoirs.

- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, bull trout, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.
- Restore riparian, streambank, channel, floodplain, and wetland conditions throughout the subbasin where habitat has been severely degraded.
- Development and implementation of biologically-based flow regimes for the Snake River and tributaries throughout the subbasin.
- A detailed, quantitative assessment of the impacts of proposed and ongoing aquifer recharge projects on fish and wildlife habitat and populations.
- Determine and establish minimum conservation pools in subbasin reservoirs to sustain aquatic and terrestrial habitat resources.
- Protect the remaining undeveloped springs along the Snake River.

Upper Snake River

- Minimum instream flow study for winter habitat and trout production in the Snake River below American Falls Reservoir, and a conceptual plan and strategy for providing that winter flow.
- Minimum fishery pool study for sustained trout production in American Falls Reservoir and a conceptual plan and strategy for providing that minimum fishery pool.
- Minimum instream flow study for winter and late summer habitat and trout production in the Snake River between American Falls Reservoir and Gem State dam, and a conceptual plan and strategy for providing those minimum flows.
- Assess the status of native species that have received little attention to date. In particular, mountain whitefish, bull trout, sand roller and Pacific lamprey. Collect life history, distribution, abundance, and habitat use and availability by life stage.

Snake River Headwaters

U.S. Fish and Wildlife Service – Idaho

Issues in this area include conversion of shrubsteppe and wetlands to agriculture, grazing, and some urban development. To return the area to its near natural status would require:

- Protect existing wetlands, and restore water regimes.
- Manage livestock grazing and restore levels of water tables. The health and complexity of riparian shrub and forest vegetation has been extensively degraded due in part to over grazing and lowering of water tables. However, restoration activities have been shown to produce relatively good results.

Wildlife Habitat Needs - Systemwide

- Wildlife species and populations need to be evaluated as to composition (occurrence), relative density, and habitat use (mapping).
- Construct a detailed GIS-based wildlife habitat map for the mainstem Columbia and Snake rivers. This would include searching available databases for existing coverages, digitizing existing wildlife information currently not available in GIS format, and identifying key areas.
- Address and mitigate hydropower impacts on loss of wildlife and wildlife habitat within the mainstem corridor, based on species-specific habitat units.
- Restore wetlands and riparian forest zones along the entire length of the Columbia River where opportunities exist for successful re-establishment of this important habitat type.
- Acquire lands when opportunities arise for improved habitat protection, restoration, and connectivity and for mitigation of lost wildlife habitat (land purchases, land trusts, conservation easements, landowner cooperative agreements, exchanges).

Waterfowl/shorebirds/water birds

- Assess the affects of water fluctuations on mudflat habitat availability and shorebird foraging and migration timing.
- Increase amount and quality of nesting cover.
- Increase amount and quality of brood rearing habitat.
- Management of waterfowl habitats to maintain quality.
- Increase the amount of moist soil habitats.

Migratory Songbirds

- Protect and manage nesting habitat to ensure reproductive success of breeding population.
- Restore nesting habitat.

Sandy River Delta Plan and EIS (1996) and Sandy River Watershed Analysis, Columbia River Gorge National Scenic Area, 1995

The Sandy River Delta Plan and EIS (1996) and Sandy River Watershed Analysis has identified the following needs:

- Restore wetland, riparian forest, shrub-scrub, upland forest, and upland meadow habitats.
- As first priorities, restore riparian forest and wetlands, with long-term objectives of re-establishing 600 acres of Columbia River bottomland riparian forest (dense stands of black cottonwood, willow and ash), and re-establishing about 200 wetland acres and associated upland habitat.
- Consider breaching levees and dikes to restore sloughs and backwater channels.

Scappoose Bay Watershed Assessment

The Scappoose Bay Watershed Assessment suggests that protection be given a higher priority than restoration, and recommends that areas identified as "refugia" be targeted for protection first. In Scappoose Bay Watershed, where refugia are primarily in private hands, either private landowners must be convinced to voluntarily increase protection standards for critical habitat, or conservation easements should be secured and/or critical habitat should be purchased.

Ecology of Bald Eagles on the Lower Columbia River, U.S. Army Corps of Engineers, 1988

The Ecology of Bald Eagles on the Lower Columbia River provides the following needs to protect and enhance bald eagles and their habitat:

- Review all dredging operations for potential effects on bald eagle populations, particularly resident breeding pairs and in Baker, Cathlamet, and Grays Bays

Revised Columbia White-Tailed Deer Recovery Plan, U.S. Fish and Wildlife Service, 1976

The Revised Columbia White-Tailed Deer Recovery Plan outlines methods of re-establishing white-tailed deer near the Columbia River. The conclusions of the Plan include needs:

- Secure the habitat of one additional subpopulation so that there are three secure and viable subpopulations.
- Secure habitat through acquisition (fee title or easement) or long-term agreements with private organizations, e.g., Columbia Land Trust and The Nature Conservancy, which own habitat.

Western pond turtle

- Western pond turtle habitat along the Columbia River needs to be improved. Key acquisitions need to take place to protect habitat, and existing habitat needs to be improved.

Wildlife Habitat Needs - Snake River

- Restore wetlands and riparian forest zones along the entire length of the Snake River where opportunities exist for successful re-establishment of this important habitat type.

Market Lake Wetland Complex ***(SE Idaho Wetland Focus Area Working Group, 2001)***

Several strategies exist for conserving existing and historic wetland areas in this complex:

- The purchase of water rights within the Snake River system and using them on the WMA may be able to supplement decreasing water levels in the marshes during the summer.
- Purchasing and installing a pumping system that will take water from the Van Leuven slough to the Snake River is another alternative. Pumping would occur when the slough backs up during times of high flows in the river so as to prevent flooding on the WMA and private property in the basin.
- Conservation actions (acquisition and restoration) within the historic Market Lake basin would allow for extensive restoration of these converted wetlands.

Fish and Wildlife Needs – Summary

Fish and wildlife habitat needs along the mainstem Columbia and Snake rivers vary by species and geographic area, however, several common fundamental themes can be observed that are the basis for most of the needs discussed above. Water regulation, consumption, and management have altered the natural hydrograph such that current conditions do not represent what most native aquatic and terrestrial species evolved with over thousands of years. Many species have not fared well within this “artificial” aquatic ecosystem, including fish and invertebrate species as well as many wildlife species which are dependent on both the aquatic ecosystem as well as the riparian zone interface between the aquatic and terrestrial systems. Most current needs are directly associated with either evaluation and restoration of habitat conditions conducive for recovery of various aquatic and terrestrial species, or mitigation for habitat conditions which have been permanently lost.

Water consumption and regulation are the underlying factors that have created the need to evaluate habitat conditions for most native species and develop restoration measures. Consumptive withdrawals for domestic or irrigation purposes have reduced water quantity and timing to the detriment of both aquatic and terrestrial species. Many of the habitat needs discussed above are associated with altered instream flows; water quantity and timing are no longer in synch with the life history patterns of many species. Assessments of species-specific instream flow needs are required to determine the necessary corrective actions. Water regulation for flood control and hydropower production have produced the most significant, system-wide habitat effects. The majority of the mainstem Columbia and Snake rivers have been changed from free-flowing riverine ecosystems to slow-moving lacustrine ecosystems. The physical habitat is no longer capable of supporting life history functions of many native species. Among the needs discussed above are such system-wide issues as the need to quantify the effect of the current lacustrine habitat on rearing conditions for fall chinook salmon, and the need for an assessment of current habitat conditions and how they affect such native resident species as bull trout, sand rollers, mountain whitefish, Pacific lamprey, and white sturgeon.

Within the remaining free-flowing sections of the Columbia and Snake rivers, longer-term water regulation for flood control and power production has reduced the spring freshet and fall flows, and increased winter flows. This artificial condition has created a need to better define the effect of reduced spring flows on such things as spawning habitat for white sturgeon, and reduced fall flows on mainstem spawning habitat for fall chinook, system-wide, as well as chum salmon in the lower Columbia River. The need for evaluations to determine the relationship between streamflows and spawning habitat is important for water management decision-makers who must balance flood control and power generation with aquatic and terrestrial resource conditions. Short-term water regulation, primarily for power production, continues to wreak havoc on both aquatic and terrestrial ecosystems and habitat. The effect of these relatively large fluctuations in both streamflow and water surface elevation, commonly on an hourly time step, are known to cause the direct mortality of both anadromous and resident fish species, as well as seriously compromising riparian habitat upon which most fish and wildlife species depend. These rapidly fluctuating water levels and the damage they cause, have created a widespread need for assessment and quantification of the effect on both fish and wildlife habitat and riparian habitat so that compromises or options can be developed that do a better job of balancing power production with the habitat needs of terrestrial and aquatic communities.

Considering that hydrosystem configuration and water management activities are the primary fundamental causes for changes in the physical habitat and the associated decline of many species and ecosystems within the Columbia and Snake rivers, it is not surprising that the needs discussed above cover the entire range of species and geographic areas. Habitat needs for native resident species such as bull trout are discussed along with system-wide habitat needs for spawning and rearing fall chinook salmon. Assessments of the effects of water management on riparian habitat and the many associated wildlife species are needed to establish guidelines on acceptable levels of reservoir and free-flowing river fluctuations. Assessments of habitat needs associated with various geographic areas include most mainstem tailrace areas for fall chinook, most mainstem reservoirs for resident fish and wildlife, a global habitat assessment for the Hanford Reach, and fish and wildlife habitat assessments in the area of the upper Snake River that has been compromised by irrigation diversions and consumptive water use.

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