Draft

Mainstem Columbia River Subbasin Summary

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Northwest Power Planning Council

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Columbia River Mainstem Subbasin Summary

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Columbia River Mainstem Subbasin Summary

INTRODUCTION

The Mainstem Columbia River Subbasin Summary was drafted to meet the interim need for a facilitated, subbasin project review by the Independent Scientific Review Panel. Termed the "Rolling Provincial Review"; this review and renewal process will establish budgets and approved activities for existing and new Bonneville Power Administration (BPA)-funded projects. This Summary is a substantial beginning towards developing the formal and final Mainstem Subbasin Plan – a comprehensive document meeting the objectives and standards set forth in the Northwest Power Planning Council's (NWPPC) revised Fish and Wildlife Program (Program) and against which future proposed projects will be assessed. These plans will be a crucial program for implementation of BPA's Endangered Species Act (ESA) responsibilities in its funding decisions.

This Subbasin Summary addresses existing assessment and planning information for the Mainstem Columbia River Subbasin within the Columbia Plateau Province. This province includes the Mainstem Columbia River from Wanapum Dam downstream to The Dalles Dam. The subbasin also covers a number of small tributaries within the province not specifically covered in other subbasin summaries. Numerous agencies, entities, and individuals contributed to the development of this subbasin summary.

It is important to note that not all mainstem fish and wildlife issues are covered in this summary. This summary is limited for the most part to issues away from dams such as habitat in and along reservoirs and free-flowing reaches within the subbasin. Similar issues in other provinces are covered in the mainstem summaries for those provinces. The Mainstem Columbia River will be addressed even more comprehensively in the System-wide/Mainstem Subbasin Summary. That summary will include specific dam-related issues such as fish passage.

SUBBASIN DESCRIPTION

General Location

The Mainstem Columbia River Subbasin of the Columbia Plateau Province is bounded at river km 669 by Wanapum Dam and at river km 308 by The Dalles Dam (Figure 1). Priest Rapids, McNary, John Day, and The Dalles dams and reservoirs are included within the subbasin, as is the free-flowing Hanford Reach immediately downstream from Priest Rapids Dam (PRD) (Table 1). Wanapum Dam is also included; however, Wanapum Reservoir is not. The subbasin also includes an area east of the Hanford Reach that includes portions of Franklin, Grant, and Adams counties, Washington.

The Columbia River flows generally southeast from Wanapum Dam in south-central Washington to the Oregon border at river km 499, then flows generally southwest along the border to The Dalles Dam. The cities of Pasco, Kennewick, and Richland, Washington (Tri- Cities) are located on the river between the Hanford Reach and the confluence with the Snake River (Figure 2).

With a population of almost 150,000 this metropolitan area is exceeded in size on the Columbia River only by Portland, Oregon. Other cities directly on the Mainstem Columbia River are small, and include Umatilla (river km 467), Boardman (river km 433), and Arlington (river km 390), Oregon. Other cities in the subbasin include Mattawa, Basin City, Mesa, Kahlotus, and Washtucna, Washington.

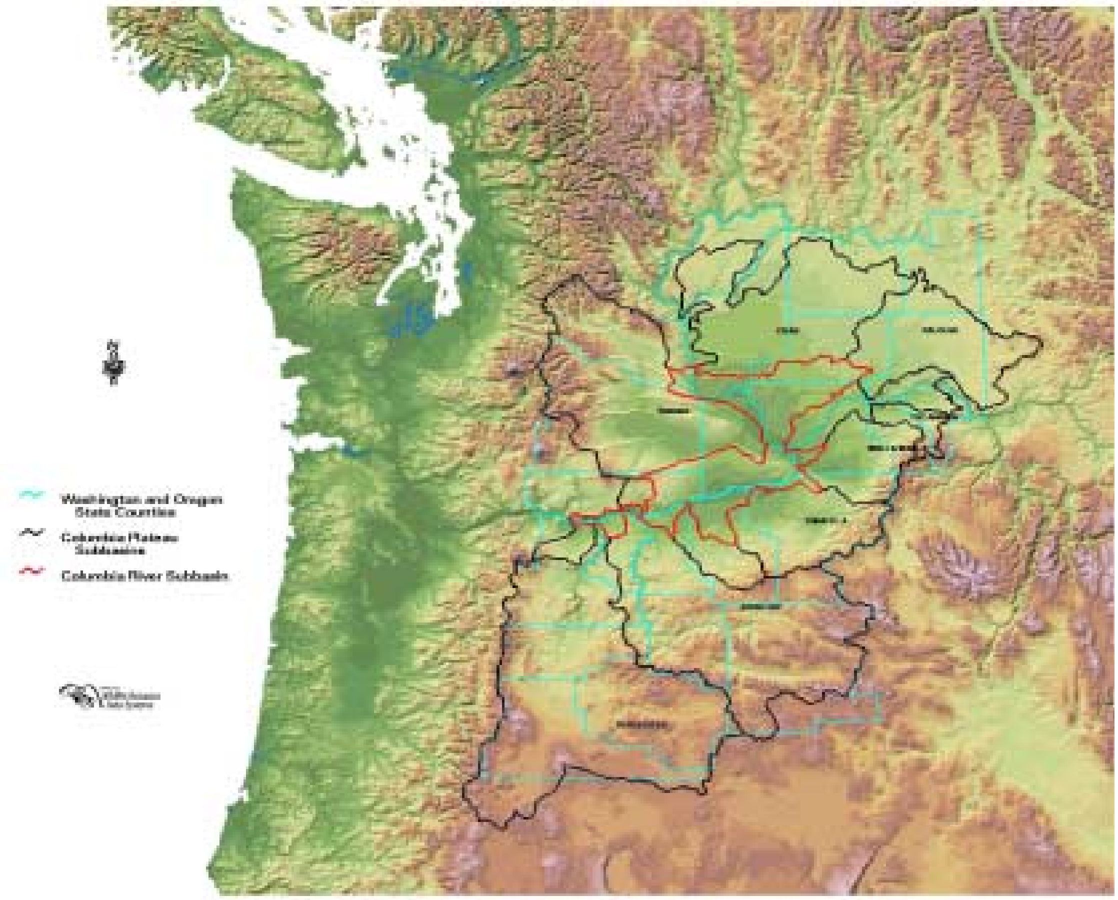


Figure 1. Location of the Mainstem Columbia River Subbasin relative to other subbasins within the Columbia Plateau Province

Table 1. Characteristics of Columbia River dams and associated reservoirs in the Mainstem Subbasin - USACE = U.S. Army Corps of Engineers; GPUD = Public Utilities District No. 2 of Grant County. Pool measurements are at normal pool.

Dam	Operator	Year completed	River km	Mean discharge (m^3/s)	Pool length (km)	Average pool width (km)	Pool surface area (ha)
Wanapum	GPUD	1964	669	3,032	61.1	0.9	5,600
Priest Rapids	GPUD	1961	639	3,035	30.0	1.1	2,800
McNary	USACE	1953	470	5,165	98.1[a]	1.6	15,700
John Day	USACE	1971	347	5,507	122.9	1.8	21,000
The Dalles	USACE	1957	308	5,536	38.5	1.4	4,500

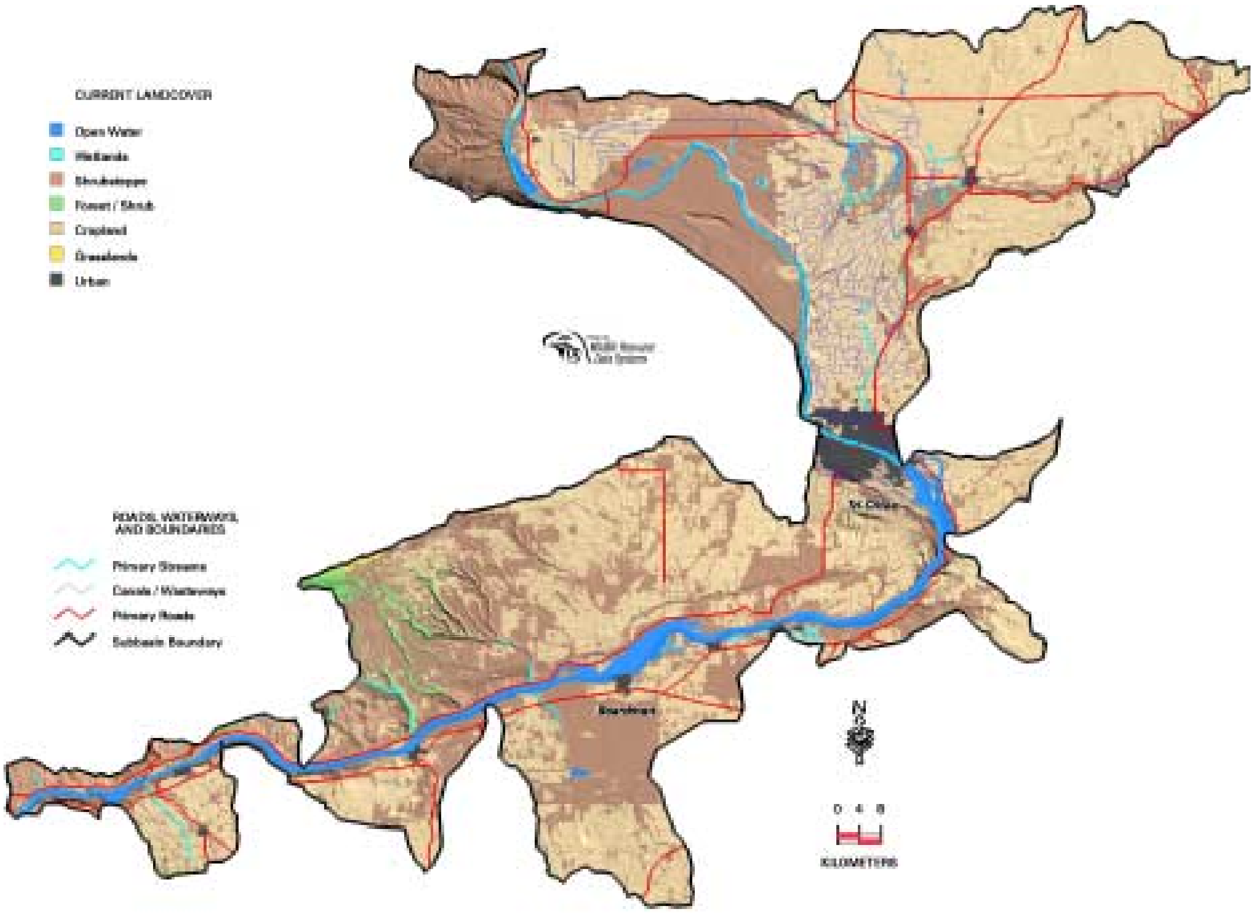
[a] The free-flowing Hanford Reach extends approximately 90 river km between Priest Rapids Dam and the head of McNary Reservoir.

Drainage Area/Hydrology

At normal pool elevations approximately 80% of the Columbia River within the subbasin is impounded (Table 1). Surface area of the impoundments totals approximately 44,000 ha. Only 90 river km within the Hanford Reach remain free flowing. Discharges at McNary and John Day dams may range from 14,000 m^3/s in spring to 2,000 m^3/s in autumn.

Priest Rapids and Wanapum dams are operated by Public Utility District No. 2 of Grant County (Grant PUD) for hydropower production, anadromous fish passage, recreation, and limited flood control. The U.S. Army Corps of Engineers (USACE) operates McNary, John Day, and The Dalles dams and reservoirs for hydropower production, anadromous fish passage, recreation, navigation, irrigation and limited flood control. John Day Reservoir is somewhat unique in that it has substantial flood control capabilities.

The Snake River is the largest tributary of the Columbia River, entering from the east at river km 523 (Figure 1). Discharge from the Snake River is generally less than 50% that of the Columbia River above the confluence. Other major tributaries within the province include the Yakima, Walla Walla, Umatilla, John Day, and Deschutes rivers (Table 2). Smaller tributaries include Crab, Willow, and Rock creeks. The Ringold, Esquatzel, and WB-10 wasteways, and Glade, Pine, and Six Prong creeks also flow into the Columbia River in this subbasin.



Columbia River Subbasin

Figure 2 Current land cover, roads, and waterways in the Mainstem Columbia River Subbasin.

Topography/Geomorphology

The topography along and near the mainstem ranges from sandy plains and plateaus to rocky slopes and ridge lines. The geologic setting is mostly volcanic in origin. A deep series of basalt layers from Miocene eruptions are up to 3,000-m thick in some areas. Faulting and lifting account for many features such as Horse Heaven Hills Plateau near the Tri-Cities and Saddle Mountain adjacent to Priest Rapids Reservoir. Elevation ranges from over 130 m near Wanapum Dam to approximately 30 m at The Dalles Dam. Mountains adjacent to or near the river have elevations as high as 900 m.

Table 2 Tributaries of the Columbia River within the Mainstem Subbasin. Location of confluence is given as Columbia River km.

Tributary	Location of confluence	Drainage area (km^2)
Crab Creek	658	13,200
Yakima River	539	9,903
Snake River	523	282,000
Walla Walla River	506	2,829
Umatilla River	465	3,685
Willow Creek	408	2.279
Rock Creek	370	--
John Day River	352	13,033
Deschutes River	330	16,894

Along John Day Reservoir, canyon walls on the Washington side of the river rise abruptly to as much as 150 m. The Oregon shore generally rises gradually along a lower terrace extending up to 1.6 km from the river, then abruptly to an elevation of 60-70 m, forming a higher terrace. High winds have resulted in the deposition of sand and the creation of dunes along these terraces. An additional area of sand deposit occurs on the east side of Priest Rapids Reservoir near the confluence of Crab Creek.

The Hanford Reach contains many riverine processes that no longer exist in Columbia River impoundments. Riparian areas in the Hanford Reach include cobble shorelines, islands that have persisted for thousands of years, floodplain lakes, and wetlands. Upland habitats adjacent to the Hanford Reach include large tracts of relatively undisturbed shrub-steppe, and the White Bluffs, a unique geologic feature that contains ancient fossils and provides unique habitat for several avian species. The subbasin extends almost 100 km east of the Hanford Reach and includes irrigated farmland within the Columbia Basin Irrigation Project, a large area of dryland farming (primarily wheat), and a large area of shrub-steppe used primarily for cattle production.

Climate

The area within the subbasin generally experiences hot dry summers with temperatures that can reach above 38^0 C during the day, then cool considerably at night. Winters may be wet and cold with strong winds and blowing snow. Summer temperatures are generally highest in July, with highs averaging 32.4^0 C at Kennewick, and 31.1^0 C at Umatilla and The Dalles Dam. Winter lows in January average -3.1^0 C at Kennewick, -3.3^0 C in Umatilla, and -1.1^0 C at The Dalles Dam. Total annual precipitation averages only 19.6 cm at Kennewick, 22.9 cm at Umatilla, and 35.5 cm at The Dalles Dam. In many areas about half the precipitation falls in winter as snow. Less than 10% of the total precipitation occurs during the summer months.

Major Land Uses

Land use and ownership in the subbasin have changed dramatically since the arrival of European settlers (Figure 2, Figure 3, & Figure 4). Roads and railroads now occupy extensive reaches of land bordering the reservoirs. The riprap revetments protecting these areas form significant portions of reservoir shorelines. An exception is Priest Rapids Reservoir, where only a minor portion of the shoreline is riprap.

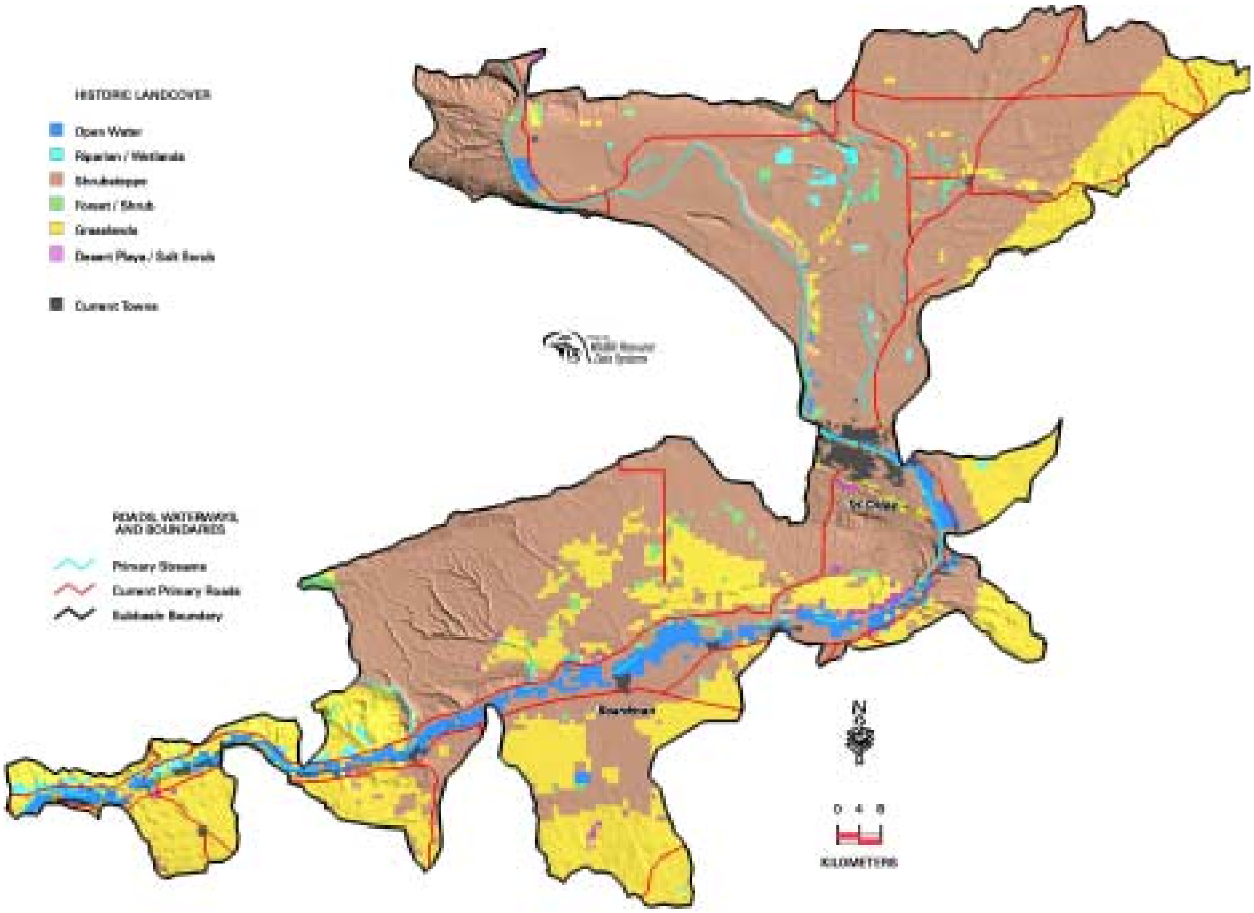
The majority of lands in the Mainstem Columbia River Subbasin are privately owned, with approximately 47% converted to agricultural uses including a variety of dryland grains and irrigated crops (Johnson and O'Neil, In Press). High-technology pivot and other irrigation methods are utilized throughout the subbasin. Wine grapes are an important crop along the Washington side of John Day Reservoir. Alfalfa, potatoes, and poplars are grown extensively along the Oregon side of the Reservoir. The Mainstem Columbia River Subbasin is one of the most highly converted regions in Oregon and Washington.

Public lands make up a small but significant portion of the remaining natural and semi-natural habitats in the subbasin (Figure 4). Most of these lands are held by the Department of Energy, Department of Defense, and the U. S. Fish and Wildlife Service (USFWS), with smaller areas managed by the State of Oregon, State of Washington, and U. S. Bureau of Land Management.

The U.S. Department of Energy owns and operates the Hanford Nuclear Reservation, which occupies almost 1,500 km^2 of land along the river between Priest Rapids Dam and the city of Richland, Washington. Access to most of this land is extremely limited. Only about 6% of the land within the reservation was used for nuclear materials production, waste storage, or waste disposal. The remaining area was left undeveloped, serving only as a security buffer for nuclear facilities. In June 2000, 667 km^2 of the Hanford Site was declared a National Monument. Saddle Mountain National Wildlife Refuge (130 km^2),Wahluke Wildlife Recreation Area (225 km^2) , and the Fitzner-Eberhardt Arid Lands Ecology (ALE) Reserve (310 km^2) are included in the new national monument.

Until recently, the Saddle Mountain National Wildlife Refuge consisted of approximately 12,220 ha of shrub-steppe upland, one 295-ha lake, and about 27 km of riparian lands along the Columbia River. The refuge was maintained for wintering waterfowl, and for wintering and nesting raptors, and was closed to all public access. In 1999, the U.S. Department of Energy and the state of Washington agreed to transfer management of the adjacent 23,000-ha Wahluke Wildlife Recreation Area to the USFWS, formally extending the boundary of the refuge.

The ALE Reserve occupies approximately 31,000 ha in the southwestern portion of the Hanford Site. The reserve is one of the largest undisturbed examples of shrub-steppe habitat in the Columbia River basin, and supports a number of rare plants and wildlife. Management of the reserve was recently transferred from the U.S. Department of Energy to the USFWS.



Columbia River Subbasin

Figure 3 Historic land cover and waterways in the Mainstem Columbia River Subbasin

The nearby US Army Yakima Training Center (YTC) occupies an additional 131,000 ha of primarily shrub-steppe habitat. The YTC is located in Kittitas and Yakima counties and is bordered on the east by the Columbia River. The YTC is used primarily for motorized, mechanized and armored infantry training.

The Umatilla National Wildlife Refuge occupies approximately 12,000 ha of marshes, sloughs, open water, cropland, and sagebrush uplands along both sides of John Day Reservoir near Irrigon, Oregon, and Paterson, Washington. The nearby Irrigon Wildlife Area is owned by the USACE and managed under agreement for wildlife habitat and wildlife oriented recreation by the Oregon Department of Fish and Wildlife (ODFW). It includes approximately 380 ha and is immediately adjacent to the Columbia River.

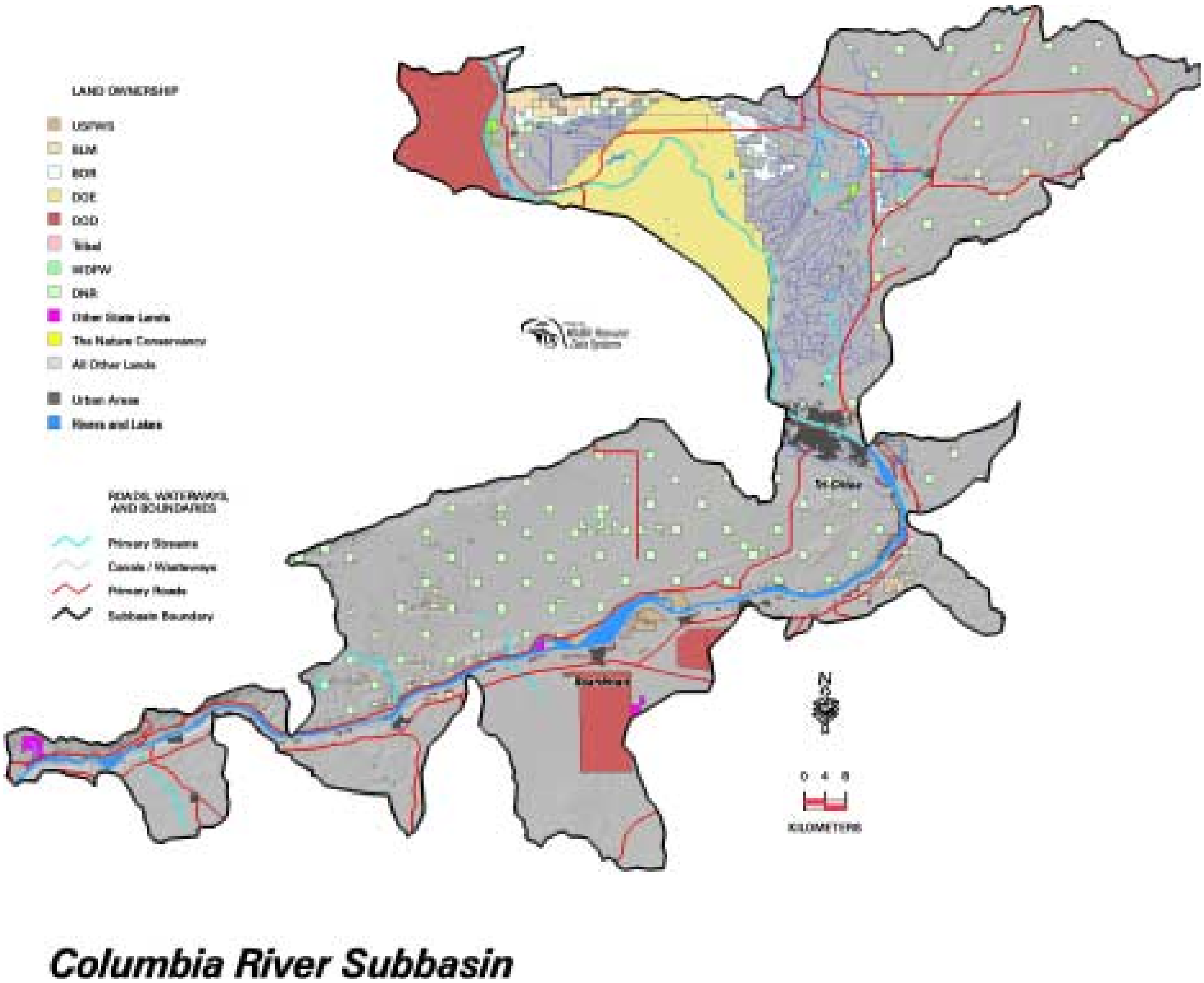


Figure 4 Land ownership in the Mainstem Columbia River Subbasin

Lands along John Day Reservoir in Oregon include a number of important holdings. The Boardman Bombing Range (a naval training facility near Boardman along the Columbia River) is a 19,000-ha facility, which includes habitat for a number of native declining bird species, and is a stronghold for the Washington ground squirrel, *Spermophilus washingtoni*. The Washington ground squirrel was recently listed in Oregon as an Endangered Species and petitioned for listing to the USFWS for federal listing as Endangered.

The Boeing Agricultural Industrial Company (BAIC) holds a 40-year agricultural and industrial lease over 40,000 ha of State of Oregon land located adjacent to the Boardman Bombing Range. BAIC subleases a portion of the property for agricultural purposes to Inland Land Company, LLC, and R.D. Offut Company--NW, which irrigate and farm the property. Approximately 10,000 ha on the BAIC leased lands still support high quality shrub-steppe and steppe habitat. Recently, water rights for existing and increased irrigation have been challenged, and settlements requiring mitigation have been negotiated that may provide an opportunity to protect the native-habitats portion of the leased lands.

The Umatilla Army Depot was established in 1941 and occupies approximately 8,000 ha in Morrow and Umatilla counties. The depot serves as a storage facility for conventional munitions and chemical warfare agents. Portions of the depot have been contaminated with explosives and metals, and a groundwater contaminant plume covers approximately 142 ha.

Water Quality

The mainstem experiences varied and somewhat unique water quality conditions. Activities at the Hanford Nuclear Reservation resulted in increased beta radioactivity and water temperatures, and lower dissolved oxygen and sulfate (Becker and Gray 1992). The last production reactor was shut down in 1971, and by the late 1980s beta radioactivity and water temperatures decreased, but nitrates had increased significantly. Water quality in the Hanford Reach is generally within Washington State standards for Class A waters. Occasional low pH values violate these standards.

Within McNary Reservoir, water quality is strongly influenced by the Snake and Yakima rivers. Flow from the Snake, Yakima, and Columbia rivers are not fully mixed until they reach McNary Dam. Below the confluence with the Snake River, the eastern and southeastern portion of the Columbia River is influenced by the Snake River, whereas the western and northwestern portion is influenced by the Yakima River. The Snake River-influenced portion experiences turbidity ranging from 5-10 NTU's during periods of little or no runoff to 200 NTU's during periods of heavy runoff. This portion of the river also experiences a high nutrient load, particularly nitrates from agriculture. The Yakima River-influenced portion experiences lower turbidity, ranging from 1-4 NTU's during periods of little or no runoff to 100 NTU's during periods of heavy runoff.

Throughout Priest Rapids, McNary, John Day, and The Dalles reservoirs, pH, dissolved oxygen, and conductivity generally meet both Washington and Oregon standards. High total dissolved gas levels during periods of high flow, and high water temperatures in late summer are the major water quality problems. Summer water temperatures often exceed the state and federal standard of 20^0 C that has been established for the Columbia River (18^0 C for Priest Rapids Reservoir).

Water is also removed from the Columbia River for irrigation. Pumping facilities are numerous, and generally small. One of the largest is part of the U.S. Bureau of Reclamation's Umatilla Basin Project. This project includes facilities to pump a maximum of 6.8 m^3/s from McNary Reservoir, and to divert an additional 3.9 m^3/s from the Oregon-bank fish ladder at McNary Dam to irrigation districts in the Umatilla River subbasin. This project was designed to decrease irrigation withdrawals from the Umatilla River. Another large pumping facility is in John Day Reservoir at the mouth of Willow Creek. A maximum of approximately 12.7 m^3/s is withdrawn as part of a permit issued in 1971 by the USACE to irrigate a portion of the land leased by the BAIC. Various groups have opposed proposed increases to the amount withdrawn.

Vegetation

The region's extremes in temperature and low level of precipitation result in sharp contrasts between riparian and upland vegetation. Riparian vegetation generally consists of deciduous trees and shrubs that grow along the wetted shoreline. Wetland vegetation in the wetted part of the shoreline is composed of a wide variety of forbs and grasses. In John Day Reservoir, riparian habitats have been broken into three categories (Rasmussen and Wright 1990): hardwood, shrub, and herb. In the hardwood community, black cottonwood *Populus trichocarpa* is the dominant species, with willow *Salix* sp., Russian olive *Elaegonus angustifolia*, and hackberry *Celtis reticulata* comprising a smaller component. Riparian shrub habitat includes willows, young hardwoods, false indigo *Amorpha* spp., and other shrubs. The riparian herb communities are generally found on sand, mud, or gravel bars. They are typically dominated by non-native mustard Brassicaceae, dock *Rumex* spp., pigweed *Chenopodium* spp., and Russian thistle *Salsola tragus*.

Most natural vegetation in upland areas of the Mainstem Subbasin is classified as steppe or shrub-steppe. The steppe, or grasslands, can be broken into three climatic, climax vegetation zones: *Artemisia-Agropyron*, *Agropyron-Poa*, and the *Festuca-Koeleria* zone (Poulton 1955). The *Artemisia-Agropyron* zone occupies the driest lower reaches of the subbasin and is dominated by big sagebrush *Artemisia tridentata*, bluebunch wheatgrass *Pseudoregnia spicatum*, and bluegrass *Poa secunda*. Epigeous cryptogams made up 13% of the groundcover in this association, the second highest percentage after bluebunch wheatgrass. The combined stress of grazing and fire have allowed rabbitbrush *Chrysothamnus nauseosus* and cheatgrass *Bromus tectorum* to invade and dominate this association, rapidly reducing the cryptogam crust.

The Agropyron-*Poa* zone is slightly wetter than the *Artemisia-Agropyron* zone (Poulton 1955). Bluebunch wheatgrass, bluegrass, and rabbitbrush dominate the *Agropyron-Poa* zone with an epigeal layer of mosses and lichens. This zone receives an average annual precipitation of approximately 37 cm, approximately 15 cm more than the *Artemisia-Agropyron* zone. Disturbance leads to increased rabbitbush and cheatgrass through the *Agropyron-Poa* zone. Agriculture is prevalent in this zone, marking the driest site in the annual cropping area of the Columbia basin (Poulton 1955).

The *Festuca*-Koeleria zone is wetter still, with prairie junegrass *Koeleria cristata*, Idaho fescue *Festuca idahoensis*, and bluebunch wheatgrass dominating the grassland areas (Poulton 1955). Black hawthorn *Crataegus douglasii* and common snowberry *Symphoricarpos albus* occur along streams and in concave areas on north-facing slopes. Cryptograms comprise 28% of the groundcover in this zone. Grazing disturbance results in an increase in Kentucky bluegrass *Poa pratensis*, brome *Bromus commutatus and B. brizaeformis*, mule’s ear *Wyethia amplexicaulis*, and St. John’s wort *Hypericum perforatum*.

Much of the shrub-steppe habitat has been eliminated or fragmented since the arrival of European settlers. Homesteads, livestock grazing, and conversion to farmland have eliminated native vegetation and facilitated invasion of non-native species such as cheatgrass, Russian thistle, and Jim Hill mustard *Sisymbrium altissimum*. Poor land use practices exacerbated problems with soil erosion as well, further reducing native vegetation. Approximately 55% of grassland habitat and 87% of shrub-steppe habitat have been lost due to irrigated and dryland agricultural conversion, or to inundation of the Columbia River and associated urban expansion (Russ Morgan, ODFW, personal communication). In the Washington portion of the basin, over

60% of the native shrub-steppe has been lost or highly fragmented (Washington Department of Fish & Wildlife, WDFW, unpublished data).

Two sites stand out relative to the current quality and extent of native steppe and shrub-steppe habitats: Hanford in Washington and the Boardman/BAIC/Horn Butte lands in Oregon. Significant portions of the Hanford Site have not experienced severe habitat degradation. The diversity and vast size of native plant communities found on the Hanford Site are unmatched in the region. Recent inventories identified a total of 17 terrestrial "element occurrences" (plant communities that are intact) on the ALE Reserve and North Slope, and an additional 6 riparian wetland element occurrences communities along the southern (western) shore of the Columbia River. The condition and size of the big sagebrush/bluebunch wheatgrass communities on the ALE Reserve, and the bitterbrush *Purshia tridentata*/Indian ricegrass *Oryzopsis hymenoides* and big sagebrush/needle-and-thread *Stipa comata* dune complex communities on the North Slope and Central Hanford are extensive and of particular regional importance. Additionally, a rich assembly of hardy, water-tolerant perennial forbs and grasses grow along the river's edge and on islands, including reed canarygrass *Phalaris arundinacea*, cattail *Typha latifolia*, and bulrush *Scirpus* spp. (Geist 1995). The dominant woody vegetation along the river includes willow, mulberry *Morus alba*, and Siberian elm *Ulmus pumila*. The riparian zone and near-shore habitat contain at least eight plants on federal or Washington State protected species lists.

Surveys and mapping efforts conducted by The Nature Conservancy of Washington and the Pacific Northwest National Laboratory document the occurrence and extent of rare plant populations and plant community types on the Hanford Site. Over 100 rare plant populations of 31 different taxa have been documented to occur on the Hanford Site (Poston et al. 2000). Five of the 31 taxa (including the two new species *Eriogonum codium* and *Lesquerella tuplashensis*) have been designated as species of concern in the Columbia River Basin Ecoregion by the USFWS.

The Boardman/BAIC/Horn Butte site contains the best remaining examples of sandy bunchgrass habitats and open sand dune habitats in the Columbia River Basin. It also has the best quality remnants of sagebrush / bluebunch wheatgrass palouse bunchgrass steppe, as well as the only high quality remnant of bitterbrush / bunchgrass steppe habitat in Oregon. It includes most of the habitat in Oregon for the Washington ground squirrel and several endemic plants. Collectively, the site includes approximately 36,000 ha of native steppe and shrub-steppe habitat.

FISH AND WILDLIFE RESOURCES

Fish and Wildlife Status

Fish

At least 51 species of fish from 14 families have been reported from the mainstem Columbia River between Wanapum and The Dalles dams (Table 3). Thirty of these species are native. Thirty-three species were found just in backwaters between McNary and Bonneville dams (USFWS 1980). Gray and Dauble (1977) list 43 species in just the Hanford Reach. Beach seine catches from April-June in the Hanford Reach are dominated by subyearling fall chinook salmon (U.S. Geological Survey, USGS, unpublished data). Other numerically important species during this time are redside shiners, carp, largescale suckers, northern pikeminnow, and peamouth. Mountain whitefish are common in the Hanford Reach and support a recreational fishery. Centrarchids and percids are more common in McNary Reservoir, although smallmouth bass are also abundant in the Hanford Reach. Tench, threespine sticklebacks, and mountain whitefish are rarely captured in Hanford beach seining activities.

Salmonids

Counts of adult salmonids passing The Dalles Dam have averaged approximately 350,000 fish in recent years (Table 4). Counts generally decrease upstream, with counts at Priest Rapids Dam averaging approximately 110,000 fish.

Historically, fall chinook salmon spawned in the Mainstem Columbia River from near The Dalles, Oregon upstream to the Pend Oreille and Kootenai rivers in Idaho (Fulton 1968). Currently, most mainstem spawning occurs in the Hanford Reach (Dauble and Watson 1997). Spawning surveys conducted since 1948 reveal a positive trend in redds visible from the air with an average of about 6,000 redds counted annually in the past 20 years (Figure 5). Spawning escapement in the Hanford Reach averaged approximately 34,000 fish from 1990-92, when run size at McNary Dam averaged 52,013 fish (WDFW and ODFW 1999).

Fall chinook salmon have also been reported to spawn in the tailraces of Wanapum and McNary dams. Information on spawning below McNary Dam is anecdotal and unverified (Don Anglin, USFWS, personal communication); however, over 400 fall chinook salmon redds were counted within 5 km downstream of Wanapum Dam during aerial surveys conducted in 1987 (Rogers et al. 1988). Preliminary data from aerial surveys in 2000 showed approximately 1,000 redds in this area (Pacific Northwest National Laboratory (PNNL), unpublished data).

Table 3 Fish species reported from the Columbia River between Wanapum and the Dalles dams. Tolerance refers to physiological resistance to organic pollution, warm water, sedimentation, and low dissolved oxygen (Zaroban et al. 1999). Status refers to listing as threatened or endangered: FE = federal endangered, FT = federal threatened, FSC = federal species of concern, OT = Oregon threatened, WC = Washington candidate.

Family, species	Origin	Tolerance	Status
Petromyzontidae			
Western brook lamprey *Lampetra richardsoni*	Native	Intermediate	--
River lamprey *L. ayresi*	Native	Intermediate	FSC
Pacific lamprey *L. tridentata*	Native	Intermediate	FSC
Acipenseridae			
White sturgeon *Acipenser transmontanus*	Native	Intermediate	--
Clupeidae			
American shad *Alosa sapidissima*	Exotic	Intermediate	--
Salmonidae			
Rainbow trout/steelhead *Oncorhynchus mykiss*	Native	Sensitive	FE, FT[a],WC
Cutthroat trout *O. clarki*	Native	Sensitive	--
Chinook salmon *O. tshawytscha*	Native	Sensitive	FE, FT[b], OT, WC
Coho salmon *O. kisutch*	Native	Sensitive	--
Sockeye salmon *O. nerka*	Native	Sensitive	FE[c], WC
Bull trout *Salvelinus confluentus*	Native	Sensitive	FT, WC
Brown trout *Salmo trutta*	Exotic	Intermediate	--
Mountain whitefish *Prosopium williamsoni*	Native	Intermediate	--
Lake whitefish *Coregonus clupeaformis*	Exotic	Intermediate	--
Cyprinidae			
Carp *Cyprinus carpio*	Exotic	Tolerant	--
Grass carp *Ctenopharyngodon idella*	Exotic	Tolerant	--
Goldfish *Carrassius auratus*	Exotic	Tolerant	--
Chiselmouth *Acrocheilus alutaceus*	Native	Intermediate	--
Redside shiner *Richardsonius balteatus*	Native	Intermediate	--
Northern pikeminnow *Ptychocheilus oregonensis*	Native	Intermediate	--
Peamouth *Mylocheilus caurinus*	Native	Intermediate	--
Longnose dace *Rhinichthys cataractae*	Native	Intermediate	--
Leopard dace *R. falcatus*	Native	Intermediate	WC
Speckled dace *R. osculus*	Native	Intermediate	--
Tench *Tinca tinca*	Exotic	Intermediate	--
Catostomidae			
Largescale sucker *Catostomus macrocheilus*	Native	Tolerant	--
Bridgelip sucker *C. columbianus*	Native	Tolerant	--
Mountain sucker *C. platyrhynchus*	Native	Intermediate	WC
Longnose sucker *C. catostomus*	Native	Intermediate	--

Family, species	Origin	Tolerance	Status
Ictaluridae			
Channel catfish *Ictalurus punctatus*	Exotic	Tolerant	--
Black bullhead *Ameiurus melas*	Exotic	Tolerant	--
Brown bullhead A. *nebulosas*	Exotic	Tolerant	--
Yellow bullhead *A. natalis*	Exotic	Tolerant	--
Poeciliidae			
Mosquitofish *Gambusia affinis*	Exotic	Tolerant	--
Gadidae			
Burbot *Lota lota*	Native	Intermediate	--
Gasterosteidae			
Three-spine stickleback *Gasterosteus aculeatus*	Native	Tolerant	--
Percopsidae			
Sandroller *Percopsis transmontana*	Native	Intermediate	--
Centrarchidae			
Largemouth bass *Micropterus salmoides*	Exotic	Tolerant	--
Smallmouth bass *M. dolomieui*	Exotic	Intermediate	--
Black crappie *Pomoxis nigromaculatus*	Exotic	Tolerant	--
White crappie *P. annularis*	Exotic	Tolerant	--
Warmouth *Lepomis gulosis*	Exotic	Tolerant	--
Bluegill *L. macrochirus*	Exotic	Tolerant	--
Pumpkinseed *L. gibbosus*	Exotic	Tolerant	--
Percidae			
Walleye *Stizostedion vitreum*	Exotic	Intermediate	--
Yellow perch *Perca flavescens*	Exotic	Intermediate	--
Cottidae			
Paiute sculpin *Cottus beldingi*	Native	Intermediate	--
Torrent sculpin *C. rhotheus*	Native	Intermediate	--
Prickly sculpin *C. asper*	Native	Intermediate	--
Reticulate sculpin *C. perplexus*	Native	Intermediate	--
Mottled sculpin *C. bairdi*	Native	Intermediate	--

[a] Middle Columbia River and Snake Basin Steelhead ESUs listed as threatened; Upper Columbia River ESU listed as endangered.
[b] Snake River Chinook Salmon ESUs listed as threatened; Upper Columbia River Spring-run ESU listed as endangered.
[c] Only the Snake River ESU is federally listed (endangered)

Table 4 Mean annual counts of anadromous salmonids and American shad at Columbia River dams, 1990-99 (WDFW and ODFW 2000).

Species, race	The Dalles	John Day	McNary	Priest Rapids
Chinook salmon				
Spring	36,500	29,356	28,548	9,051
Summer	16,199	15,459	16,138	14,070
Fall	103,218	75,636	64,830	11,038
Coho salmon	5,324	4,332	2,072	14
Sockeye salmon	32,881	34,279	35,756	40,493
Steelhead	152,747	138,044	116,317	8,208
American shad	2,396,535	1,135,900	636,257	26,217

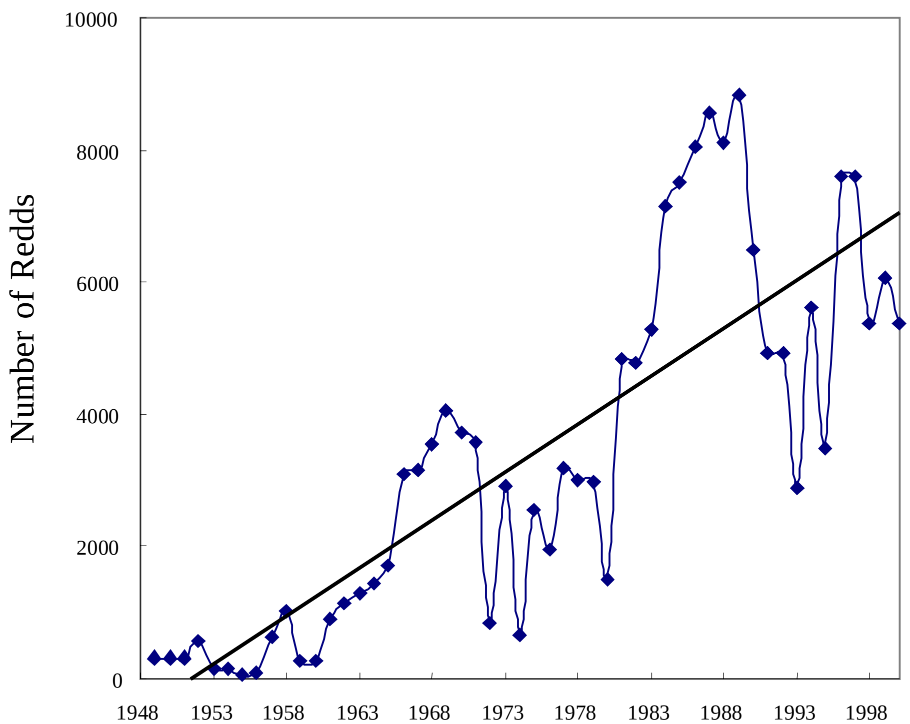


Figure 5. Fall chinook salmon redds visible from the air during annual surveys of the Hanford Reach, 1948-99.

Fall chinook salmon are somewhat unique in that they spend the entire freshwater portion of their life cycle in mainstem habitats. The Hanford Reach produces 20-30 million fry annually (WDFW, unpublished data), which emerge from March through May and rear along the shoreline and backwaters for a short period before migrating seaward during the summer (Becker 1973; Key et al. 1994; Key et al. 1996). Fall chinook salmon are the dominant salmonid during spring in nearshore areas. Fall chinook salmon also use the upper portions of McNary and John Day reservoirs for rearing, but do not prefer riprap habitats that constitute a large portion of reservoir shorelines (USGS, unpublished data). Releases from Priest Rapids and Ringold hatcheries in June artificially increase the juvenile fall chinook salmon population. Additional fall chinook salmon enter McNary Reservoir from the Snake River and include ESA-listed natural fish produced in Hells Canyon and fish from Lyons Ferry Hatchery. Juvenile fall chinook salmon begin passing McNary Dam in late June and pass John Day Dam in July using the Columbia River as a migration corridor. Many are transported by barge and trucks from these dams to below Bonneville Dam where they are released. Juvenile fall chinook travel time has been shown to be related to river flow (Berggren and Filardo 1993; Giorgi et al. 1997; Tiffan et al. 2000).

The Hanford Reach is presently designated as critical habitat for the Upper Columbia River steelhead Evolutionary Significant Unit (ESU). Steelhead are present in the Hanford Reach all year; however, most adults move into the reach from August to November, peaking in September (Watson 1973; Becker 1985). Most of the adults that return to the reach are hatchery fish. Ringold Hatchery, operated by the WDFW, has been raising and releasing into the Hanford Reach an average of 163,000 steelhead smolts since 1962. From 1981-88 and since 1998, fish reared and released into the Hanford Reach have been the Wells stock that were listed under the ESA. Prior to 1998 (other than 1981-88) most of the fish were Skamania (coastal) stock.

Whether steelhead currently spawn in the Hanford Reach is debatable. Spawning most likely would occur between February and early June, with peak spawning in mid May (Eldred 1970; Watson 1973; Becker 1985); however, little is known about the quality and quantity of steelhead spawning, rearing, and adult holding habitat in the Hanford Reach. Watson (1973) estimated that from 1962 to 1971 an average of 35,000 steelhead that annually passed McNary Dam did not pass Priest Rapids Dam on the Columbia River or Ice Harbor Dam on the Snake River. He estimated that 10,000 of these fish were potential spawners in the Hanford Reach, after taking into account reductions due to migration into the Yakima and Walla Walla rivers, sport catch, and natural mortality. Counts from 1977 to 1996 indicated an average of 20,000 steelhead that annually passed McNary Dam did not pass Ice Harbor or Priest dams, and approximately 9,000 of these could be potential spawners in the Hanford Reach (PNNL, unpublished data). Gray and Dauble (1976) collected gravid and ripe females in late April and early May and collected spent males in August within the Reach. No juvenile steelhead were collected in shoreline fyke nets, but they were obtained in shoreline areas by electroshocking. No juvenile steelhead were collected during extensive beach seining from 1997-2000 (WDFW, unpublished data).

Bull trout are rarely observed in the Columbia River; however, Gray and Dauble (1977) reported collecting bull trout at two sites within the Hanford Reach. In recent years very few bull trout have been collected during sampling in McNary Reservoir (ODFW, unpublished data). Extensive multi-gear, multi-season sampling (beach-seining, electrofishing, gill-netting, and minnow trapping) in the Priest Rapids and Wanapum tailraces, reservoirs, and forebays during 1999 resulted in the capture of only 2 bull trout (Pfeifer et al. 2000).

Harvest of salmonids in the Columbia River within the subbasin is relatively low (Table 5), and has declined dramatically from historic levels (WDFW and ODFW 2000). No commercial or recreational fisheries have targeted on spring chinook salmon since 1977, other than a small tribal fishery in winter. Summer chinook salmon have not been targeted in commercial fisheries since 1964, in treaty fisheries since 1965, or in recreational fisheries since 1973. Unlike spring and summer chinook salmon, treaty harvest of fall chinook salmon has increased over time since lows in the late 1950s after The Dalles Dam was completed. Most recreational catch occurs in the Hanford Reach. Commercial harvest of sockeye salmon ended in 1988, and recreational harvest ended in 1991. Although Indian harvest of steelhead remains substantial, commercial landing of steelhead by non-Indians has been prohibited since 1975. Recreational catch of steelhead is focused in tributaries.

Resident Predators

Primary predators of juvenile salmonids in the Columbia River include northern pikeminnow, smallmouth bass, and walleye. Beamesderfer and Rieman (1991) estimated abundance in John Day Reservoir to be approximately 85,000 northern pikeminnow and 15,000 walleye longer than 250 mm fork length, and 35,000 smallmouth bass longer than 200 mm fork length. Ward et al. (1995) estimated abundance of northern pikeminnow relative to that in John Day Reservoir to be approximately 138% in The Dalles Reservoir, 68% in McNary Reservoir (excluding the Hanford Reach), and 33% in Priest Rapids Reservoir. Zimmerman and Parker (1995) estimated abundance of smallmouth bass relative to that in John Day Reservoir to be approximately 10% in The Dalles Reservoir and 45% in McNary Reservoir.

Petersen (1994) estimated the annual loss of juvenile salmonids to predation by northern pikeminnow in John Day Reservoir to be 1.4 million, approximately 7.3% of all juvenile salmonids entering the reservoir. Rieman et al. (1991) determined that northern pikeminnow accounted for 78% of the loss of juvenile salmonids to fish predators. Ward et al. (1995) estimated predation on juvenile salmonids by northern pikeminnow relative to that in John Day Reservoir to be approximately 190% in The Dalles Reservoir, 50% in McNary Reservoir, and 17% in Priest Rapids Reservoir.

Predation on juvenile salmonids by northern pikeminnow has decreased since implementation of the Northern Pikeminnow Management Program in 1990 (Beamesderfer et al. 1996; Friesen and Ward 1999). From 1992 through 1999, annual exploitation rate of northern pikeminnow longer than 250 mm fork length has averaged approximately 11.4% in The Dalles Reservoir, 5.2% in John Day Reservoir, and 15.3% in McNary Reservoir and the Hanford Reach combined. Friesen and Ward (1999) estimate that predation by northern pikeminnow has decreased approximately 25%, with no compensation by walleye or smallmouth bass.

Table 5 Mean annual catch of anadromous salmonids, American shad, white sturgeon, and walleye between Bonneville and McNary dams, 1990-99 (WDFW and ODFW 2000).

Species, race	Commercial	Ceremonial and subsistence	Recreational
Chinook salmon			
Spring	<100	4,080	0
Summer	0	280	0
Fall	41,280	0	Unavailable
Coho salmon	1,310	0	Unavailable
Sockeye salmon	0	0	0
Steelhead	23,420	7,390	Unavailable
American shad	39,740	0	Unavailable
White sturgeon	2,500	400[a]	2,350
Walleye	538	0	6,401[b]

[a] 1992-99 only
[b] Includes fish caught and released

White Sturgeon

White sturgeon are distributed throughout Columbia River reservoirs and the Hanford Reach. In 1997, abundance in The Dalles Reservoir was estimated as 59,800 fish 70-166 cm total length, of which 8,100 were in the legal harvest slot of 110-137 cm (Ward 1999). In 1996, abundance in John Day Reservoir was estimated as 27,100 fish 70-166 cm, of which 4,040 were in the legal harvest slot (Ward 1998). In 1995, abundance in McNary Reservoir and the Hanford Reach was estimated as 5,200 fish 70-166 cm (Rien and Beiningen 1997). Density was higher in McNary Reservoir than in the Hanford Reach.

White sturgeon often experience year-class failures and poor recruitment to young of the year in mainstem reservoirs (Parsley and Beckman 1994). Although recent population estimates in John Day and The Dalles reservoirs (Ward 1998; Ward 1999) are higher than previous estimates (Beamesderfer et al. 1995), larval and juvenile fish have remained relatively scarce. White sturgeon spawning was documented for the first time in Priest Rapids Reservoir in 2000 (Grant PUD, unpublished data).

American Shad

American shad were introduced into the Columbia and Snake rivers in 1885 and 1886 from the Atlantic Coast (Hammann 1981). Adult American shad ascend the Columbia River to spawn from early May and peak in mid July, although primary spawning areas have not been identified. Juvenile American shad are very abundant in McNary and John Day reservoirs in late summer and fall. Juvenile American shad composed over 98% of trawl catches in John Day Reservoir from late August to the end of October in 1993 (Kofoot et al. 1994), and may compete for food resources with late-migrating juvenile fall chinook salmon. American shad also may interact with upstream migrating salmon and steelhead in adult fishways.

Wildlife

Riparian and wetland habitats directly influenced by the Columbia River and upland habitats along the river are important to many species of wildlife. At least 258 species of birds, 44 species of mammals, and 21 species of reptiles and amphibians have been reported from habitats along or near the Mainstem Columbia River between Wanapum and The Dalles dams. Species assemblages vary among habitats, which include open water, wetland, riparian, and upland. Assemblages also differ among reaches of the Columbia River. A number of species have been designated by state or federal agencies as endangered or threatened (Table 6). Numerous other species are considered sensitive or species of concern, or are a candidate for state or federal listing.

Birds

McKern (1976) reported 179 bird species associated with riparian areas along the Columbia River between The Dalles and Wanapum dams. Rogers et al. (1989) found 72 species of birds during surveys along Priest Rapids Reservoir. Surveys summarized by Fitzner and Gray (1991) and the Nature Conservancy (TNC 1999) found a total of 258 bird species known to breed or periodically occupy portions of the Hanford Site, including upland areas. Weiss and Mitchell (1992) identified 103 bird species associated with the riparian community of the Hanford Reach, and LaFramboise and LaFramboise (1998) report a total of 158 species from the nearby ALE Reserve. Asherin and Claar (1976) found 114 species of birds associated with McNary Reservoir. Tabor (1976) found 145 species of birds associated with John Day Resevoir and 79 species associated with The Dalles Reservoir. Eight species of birds known to occur in the subbasin are state or federally listed as threatened or endangered (Table 6). Numerous additional species are candidates for listing, or are considered sensitive or species of concern.

The Mainstem Subbasin supports one of the largest Northwest concentrations of wintering waterfowl, particularly Canada geese *Branta canadensis* and mallards *Anas platyrhynchos*. The subbasin supported 24 species of migrant/wintering waterfowl in the mid-1970's (McKern 1976), with at least 20 species using John Day Reservoir (Tabor 1976). Agricultural production of cereal grains, as well as the increase in open water since development of the hydropower system have contributed to a significant increase in migrant/wintering waterfowl numbers. In the winter of 1982-83, populations approaching 500,000 ducks and 150,000 geese were recorded at the Umatilla NWR (BPA 1984). High concentrations of waterfowl have also been noted on islands near Threemile Canyon (river km 410). ODFW's Irrigon Wildlife Area also provides important duck nesting habitat. The upper 67 km of John Day Reservoir has supported 131,000 wintering ducks and an average of 33,550 wintering Canada geese (USFWS 1997). During the 1990s the Eagle Lakes and Sugar Ranch complex north of Basin City alone wintered 125,000 ducks some years (USFWS 2001). Between 1943 and 1950 the entire Columbia River basin supported a migrant/wintering waterfowl population of 50,000 to 100,000 (USFWS 1997). In addition to large wintering concentrations of waterfowl on the Hanford Reach, approximately 200 Canada goose nests are found and monitored annually or bi-annually (PNNL, unpublished data).

Table 6 Wildlife species found in the Mainstem Subbasin designated by state or federal agencies as endangered or threatened. F = federal, O = Oregon, W = Washington, E = endangered, and T = threatened. Numerous other species are considered sensitive or species of concern.

Class, common name	Scientific name	Status
Birds		
American white pelican	*Pelecanus erythrorhynchos*	WE
Bald eagle	*Haliaeetus leucocephalus*	FT, OT, WT
Ferruginous Hawk	*Buteo regalis*	WT
Peregrine falcon	*Falco peregrinus*	OE, WE
Sage Grouse	*Centrocerus urophasianus*	WT
Sandhill crane	*Grus canadensis*	WE
Snowy plover	*Charadrius alexandrinus*	FT, WE
Upland sandpiper	*Bartramia longicauda*	WE
Mammals		
Washington ground squirrel	*Spermophilus washingtoni*	OE
Western gray squirrel	*Sciurus griseus*	WT
Pygmy rabbit	*Brachylagus idahoensis*	WE
Reptiles and Amphibians		
Western Pond Turtle	*Clemmys marmorata*	WE
Northern Leopard Frog	*Rana pipiens*	WE

All reservoirs and the Hanford Reach in the subbasin support colonies of colonial nesting birds. Most of these species are primarily dependent on fish; however, amphibians, birds, reptiles, small mammals, and invertebrates may provide important forage at times. Islands support breeding colonies of great blue herons *Aredea herodias,* black-crowned night herons *Nycticorax nycticorax*, California gulls *Larus californicus*, ring-billed gulls *L. delauarensis,* glaucous-winged gulls *L. glaucesiens,* Forster's terns *Sterna forsteri*, Caspian terns *Hydroprogne caspia*, white pelicans *Pelecanus erythrorhynchos*, and double-crested cormorants *Phalacrocorax olivaceus* (Ackerman 1994). Colonies of bank swallows *Riparia riparia* and cliff swallows *Petrochelidon pyrrhonota* are also found in the subbasin.

The Osprey *Pandion haliaetus* represents the most abundant nesting raptor whose foraging requirements are directly dependent on the fish resources of the Columbia River. Riparian forest and cliffs in this subbasin provide nesting opportunities for several other species of raptors including red-tailed hawks *Buteo jamaicensis*, Swainson's hawks *B. swainsoni*, prairie falcons *Falco mexicanus,* and American kestrels *Falco sparverius*. Riparian habitats are also used during migration by sharp-shinned hawks *Accipiter striatus* and Cooper's hawks *A. cooperii*. Northern harriers *Circus cyaneus* nest and forage in grassland, marsh, and wetland communities. Golden eagles *Aquila chrysaetos* occur throughout upland areas and nest in cliffs adjacent to the river. Wintering bald eagles are common along the Columbia River during winter. Peregrine falcons nest and winter along lower John Day Reservoir. The primary owl species found in riparian areas include the great horned owl *Bubo virginianus,* the long-eared owl *Asio otus,* and the western screech owl *Otus kennicottii*. Short-eared owls *Asio flammeus* are present in wetland and grassland habitat. Barn owls *Tyto alba* are found primarily in association with croplands. Burrowing owls *Athene cunicularia* and snowy owls *Nyctea scandiaca* occur primarily in shrub-steppe, grassland, and some cropland habitat in the subbasin.

Upland game birds found throughout the subbasin include ring-neck pheasant *Phasianus colchicus,* California quail *Lophortyx californicus,* chukar *Alectoris graeca,* mourning dove *Zenaida macroura* and common snipe *Capella gallinago*. Gray partridge *Perdix perdix* have been found along Priest Rapids Reservoir (Rogers et al. 1989).

Killdeer *Charadrius vociferous* and spotted sandpipers *Actitis macularia* are-shorebirds that commonly nest along mainstem impoundments. Additional shorebirds that nest in the subbasin include black-necked stilts *Himantopus mexicanus* and American avocets *Recurvirostra americana*. One of two migration routes for shorebirds through Washington is a portion of the Intermountain West Flyway. In general, this flyway routes birds through the interior of the American southwest, the Great Basin, The Columbia Basin, and the interior of British Columbia. Two of the sites for large concentrations of migrant shore birds along this route in eastern Washington are the Yakima and Walla Walla River deltas. Each of these two sites has supported single high counts of 1,000 or more birds during autumn migration (WDFW, unpublished data). Annual cumulative use at each of these sites is several thousand birds. The food resources provided at these sites are critical for the shore birds to accumulate adequate fat deposits to fuel single flights that may last for several days and cover 3,000 to 5,000 km.

Many species of passerine birds occur along the Columbia River. Some, including cliff swallows, bank swallows, barn swallows *Hirudo rustica,* violet-green swallows *Tachycineta thalassina*, Vaux's swifts *Chaetura vauzi,* and common nighthawks *Chordeiles minor* forage for insects over the river. Marsh habitats are particularly important to marsh wrens *Telmatodytes palustris,* common yellowthroats *Geothlypis trichas,* red-winged blackbirds *Agelaius phoeniceous,* yellow-headed blackbirds *Xanthocephalus xanthocephalus*, and other species.

A number of passerine bird species found in the subbasin have been designated by the state of Oregon as species of concern. The loggerhead shrike *Lanius excubitor* (Oregon Sensitive, Vulnerable), a sagebrush-obligate, is undergoing a significant decline in the subbasin, primarily due to habitat loss. Other designated species include the sage sparrow *Amphispiza belli*, grasshopper sparrow *Ammodramus savannarum,* and the long-billed curlew *Numenius americanus*. The sage sparrow (Oregon Sensitive, Critical) was once very abundant in the Columbia Plateau region of the Columbia Basin (Gabrielson and Jewett 1993), but is now extremely rare. It is a habitat specialist closely tied to dense upland sage flats with a healthy microbiotic crust and little or no cheatgrass. The grasshopper sparrow (Oregon Sensitive, Vulnerable) is a perennial bunchgrass obligate. The long-billed curlew (Oregon Sensitive, Vulnerable) seems to be maintaining stable numbers; however, it is listed as vulnerable in the basin due to the uncertainty of secure habitat areas in the future.

A number of raptors have also been designated by the state of Oregon. The ferruginous hawk (Oregon Sensitive, Critical) is closely tied to the remaining shrub-steppe areas of the basin that have remnant juniper stands. An estimated 12 pairs nest in the north portion of Morrow and Gilliam Counties (ODFW, unpublished data). This species is listed as threatened in Washington. There are an estimated 54 ferruginous hawk territories within the Washington portion of the subbasin. Breeding surveys from 1995-97 found only 34% to 39% occupancy (WDFW, unpublished data). The Swainson's hawk (Oregon Sensitive, Vulnerable) is fairly common in the subbasin as it seems to have adapted to the agricultural setting fairly well. The burrowing owl *Speotyto cunicularia* (Oregon Sensitive, Critical) is a species associated with grassland/shrub habitats. It tends to be distributed in a "clumped" fashion and thus, large expanses are necessary to sustain a breeding population.

The Hanford area contains significant breeding populations of nearly all steppe and shrub-steppe dependent birds, including loggerhead shrike, sage sparrow, sage thrasher *Oreoscoptes montanus*, ferruginous hawk, and other species of regional management concern (Saab and Rich 1997). These populations demonstrate the importance of the Hanford area to bird conservation in the Columbia River basin. Shrub-steppe dependent species are closely linked with big sagebrush and native grass cover, and with the exception of sage thrashers (found in high numbers only at upper elevations on the ALE Reserve) and sage grouse (known historically but not currently from Hanford) they are found throughout the area. The Hanford area has been identified as a recovery zone for the expansion of sage grouse in Washington.

Mammals

Forty-four species of mammals have been found in the subbasin (Tabor 1976, Asherin and Claar 1976, and Payne et al. 1975), two of which are listed as endangered by the State of Washington (Table 5). These species include aquatic and terrestrial furbearers, small mammals, and big game. Aquatic furbearers include muskrat *Ondatra zibethicus*, beaver *Castor canadensis*, river otter *Lutra canadensis*, and mink *Mustela vison*. Terrestrial furbearers found in or near riparian habitats include coyote *Canis latrans*, badger *Taxidea taxus*, striped skunk *Mephitis mephitis*, red fox *Vulpes vulpes*, porcupine *Erithizon dorsatum*, and raccoon *Procyon lotor*. Coyotes and raccoons are generally the most abundant of these species (USACE 2000). Other species present may include opossum *Didelphis virginiana*, and bobcat *Lynx rufus*. Numerous species of small rodents are also present, including the Washington ground squirrel (recently listed as endangered in Oregon, and has been petitioned for federal listing across its entire range), which is associated with native shrub-steppe and grassland habitats. It has a very limited distribution and occurs only in portions of the Columbia basin, including the BAIC tract, Boardman Bombing Range, and in small populations in Grant County and Franklin Counties on and near the Hanford Site (TNC 1999).

Small mammals play important, but often unappreciated roles in ecosystem functioning. They turn soil, increase water infiltration, provide habitat, and serve as prey base for carnivores such as raptors, owls and snakes. They are also highly responsive to changes in vegetation or land management. Burrowing animals, including the Washington ground squirrel and the Townsend's ground squirrel *Spermophilus townsendii*, which are associated with native shrub-steppe and grassland habitats, provide these ecosystem functions. Other small mammals that may be of concern, but of which little is known about their current distribution within the Columbia River basin, include pygmy rabbits, sagebrush vole *Lemmiscus certatus* and Merriam's shrew *Sorex merriami*. Life-histories of these animals are closely tied to shrub-steppe ecosystems.

Mule deer *Odocoileus hemionus hemionus* and black tailed deer *O. h. columbianus* are the only species of big game typically observed along impoundments downstream from the Hanford Reach. Most frequent deer use is along steep, brushy slopes of canyon walls and adjacent ridges. Mule deer are also the most abundant ungulate associated with the Hanford Reach; however, white-tailed deer *O. virginianus* have been infrequently documented there since 1994 (Brett Tiller, PNNL, unpublished data). Bighorn sheep *Ovis Canadensis* and pronghorn *Antilocapra americana* are present on uplands near the river. A rapidly expanding population of Rocky Mountain elk *Cervus elaphus nelsoni* is centered on the ALE Reserve (WDFW 2000). Cougars *Felis concolor* have been documented in riparian areas and upland communities throughout the Hanford Site (Tiller et al. 2000).

Because of a history of misperception regarding their behavior and role in natural ecosystems, as well as the difficulty in collecting information about them, bats are often under-studied and under appreciated. Historical perception not withstanding, bats are an important part of many ecosystems. They provide a measure of control on flying insects, cycle nutrients, and pollinate some plant species. Finally, because they rely on specific and limited habitats for portions of their life-cycle, and are long-lived with low reproduction rates, some bat populations may be declining in the subbasin.

Seven species of bats are known to frequent the Hanford Site. The hoary bat *Lasiurus cinereus* has been captured along streamsides on the ALE Reserve in August and September during their migration. The pallid bat *Antrozus pallidus* is common in the summer and frequently uses deserted buildings. The silver-haired bat *Lasionycteris noctivagans* is another fall migrant to the site and is primarily associated with springs throughout the shrub-steppe. Three myotis species, the Califonia myotis *Myotis Californicus*, little brown myotis *M. lucifugus* and Yuma myotis *M. yumanensis* also are common residents at Hanford. Becker (1993) also documented the presence of the Western pipistrelle *Pipistrellus hesperus*. Past surveys identified large concentrations of the spotted bat *Euderma maculatum* just north of the Hanford Site in the Moses Coulee (Neil Hedges 2000, personal communication); however, no spotted bats were found during intensive echolocation surveys conducted in 1997 and 1998 throughout the Hanford Site (TNC 1999). Townsend's big-eared bats *Plecotus townsendii* also may occur within the Mainstem Subbasin but have not been documented.

Reptiles and Amphibians

Because they are predators, often rely on specific habitats, and are sensitive to environmental degradation, amphibians and reptiles often reveal important information about the ecological condition of an area. Furthermore, there is global concern that amphibians are declining as the result of climate change and habitat alteration (Wake and Morowitz 1991; Stebbins and Cohen 1995).

McKern (1976) found 21 species of reptiles and amphibians in riparian areas along the Columbia River between The Dalles and Wanapum dams. Four species of reptile and one species of amphibian were collected along Priest Rapids Reservoir (Rogers et al. 1989). Reptiles included the side-blotched lizard *Uta stansburiana*, desert short-horned lizard *Phrynosoma douglassii*, gopher snake *Pituophis melanoleucas*, and western rattlesnake *Crotalus viridis*. The only amphibian collected was the Pacific treefrog *Hyla regilla.*

Four species of reptiles and three species of amphibians are commonly found in association with riparian and marsh habitats of impoundments downstream from McNary Dam (USACE 2000). The western painted turtle *Chrysemys picta belli* is abundant in the Irrigon Wildlife Management Area, supported by the complex of emergent marsh and open water. The introduced bullfrog *Rana catsbiana* is also common. Areas between riparian and upland habitats are important to Woodhouse's toad *Bufo woodhousei*, Great Basin spadefoot toad *Scaphiopus intermontanus*, sagebrush lizard *Sceloporus graciosus*, western yellow-bellied racer *Coluber constrictor*, and gopher snake. Populations of Great Basin spadefoot toad have been negatively impacted by the development of the hydropower system (Leonard et al. 1993).

Increased habitat for the non-native bullfrog has impacted several species of native amphibians. Bull frogs aggressively compete with native amphibians for food and breeding sites, and often consume both young and adults of other amphibian species. Bullfrogs and their tad poles are often avoided as a food source by native birds such as herons, whereas native amphibians are not.

Several other reptiles and amphibians are found in upland areas near the river. One of these is the sagebrush lizard (Oregon Sensitive, Vulnerable), a sagebrush obligate that occurs locally in the subbasin. A recent study on the Boardman Bombing Range showed that this species is dependent on bare/sandy soil areas within the sagebrush community (ODFW, unpublished data).

The Hanford area provides an important refuge for amphibian and reptile populations. Sixteen species occur at Hanford, and the site is particularly important for sensitive species such as the Woodhouse's toad, tiger salamander *Ambystoma tigrinum*, night snake *Hypsiglena torquata*, striped whipsnake *Masticophis taeniatus*, sagebrush lizard, and others that are rare or have limited distributions in Washington. The Western terrestrial garter snake *Thamnophis elegans* and tiger salamander were found for the first time in 1995 and 1998 respectively.

Invertebrates

The Hanford area retains invertebrate species that have been lost elsewhere due to habitat conversion, fragmentation, degradation and spraying of pesticides. This is most obvious in the high species diversity found in groups with major economic importance such as ladybird beetles, bees and predatory wasps. Although they receive less attention than other biological subjects, insects may ultimately prove to be the most sensitive measure of ecosystem quality and function.

Ongoing identification of insects and other invertebrates continues to add to the biodiversity totals for Hanford. To date, 1,536 species in 16 orders have been identified, of which 43 were previously undescribed, and 142 represent new records for Washington. Equally important is the great diversity found in groups like Hymenoptera, Coleoptera, Homoptera and the moth branch of the Lepidoptera. Hanford supports a diversity of insects unmatched elsewhere within the arid intermountain west.

Aquatic insects are a key element supporting the thriving salmon population in the Hanford Reach. The high biodiversity found in upland invertebrate species at Hanford is matched by the aquatic fauna. Recent surveys greatly expanded the knowledge of the invertebrate fauna of the Hanford Site, especially of the Trichoptera, Odonata, and Hemiptera existing in desert spring streams. For example, the Trichoptera fauna increased from 4 genera recorded in previous studies to 15 genera. A total of 145 taxa of aquatic invertebrates are now identified from the Hanford Reach, and 43 taxa have been identified from desert spring streams. Without this basic information it is almost impossible to know about new state records and loss of species.

Habitat Areas and Quality

Fish

Mainstem reservoirs in the Columbia Plateau Province have little storage capacity, and discharges through dams are run-of-the-river; therefore, water velocity is generally fast enough to prevent occurrence of a thermocline and oxygen depletion in deep water. The dominant shoreline type within the impoundments is usually rip-rap, followed by smaller rock or sand (Hjort et al. 1981). Shoreline gradient in rip-rapped areas is often very steep (>45^{o}). In the relatively common backwaters, banks are often eroded, and substrate is often smaller than in main reservoirs. These nearshore and backwater areas are more important to the early life history stages of most fish species than is the main river channel (Hjort et al. 1981); however, high water temperatures during the summer and freezing water temperatures during the winter may preclude year-around use by many species (USFWS 1980).

Development of the hydropower system has eliminated most mainstem riverine habitat available for spawning by anadromous salmonids. Notable exceptions are the Hanford Reach and the tailrace below Wanapum Dam. The river channel in the Hanford Reach is braided around islands, submerged rock ledges, and gravel bars, creating a complex network of pools and riffles. The channel is mostly unconfined, and much of the river bed consists of a relatively uniform layer of coarse material (Dauble and Geist 2000). The diversity of geomorphic features combined with the coarse alluvium results in a river that is interactive with the floodplain, which creates transitional habitats within the river bed (termed hyporheic zone). Physical habitat characteristics within the Hanford Reach remain suitable for use by spawning and rearing fall chinook salmon, and probably for steelhead as well.

Flows within the Hanford Reach are regulated primarily by releases from Grand Coulee Dam with re-regulation occurring at Priest Rapids Dam. Even with re-regulation from minimum flow requirements, daily fluctuations in water surface elevation can be up to 2m/day (Dauble and Geist 2000). Geist et al. (2000) found that water velocity and lateral slope were the most significant predictors of fall chinook salmon redd location over a range of discharges. Most redds were found where water velocity was between 1.4 and 2.0 m/s, water depth was 2-4 m, and lateral slope was less than 4%. However, 30 to 60% of the areas predicted to be used for spawning were not used. Geist and Dauble (1998) suggested that the patchy distribution of fall chinook salmon redds in the Hanford Reach was likely due to the relationship of ground water and surface water within the hyporheic zone. Geist (2000) found that hyporheic upwelling into spawning areas had a dissolved solids content (i.e., specific conductance) indicative of river water and was presumed to have entered highly permeable riverbed substrate at upstream locations. Rates of upwelling into spawning areas averaged 1,200 $L/m^2 \cdot /day$[1] as compared to approximately 500 $L/m^2 \cdot /day$ in non-spawning areas. These upwelling characteristics could provide cues that adult fall chinook salmon use to locate spawning habitat and suggest that suitable fall chinook salmon spawning habitat is likely more than simply depth, velocity, and substrate.

Development of the hydropower system has altered the water flows that juvenile anadromous salmonids encounter as they migrate to the ocean. Before construction of the dams, the highest flows occurred in the spring and early summer, and the migration of juvenile salmonids coincided with those high flows (Park 1969). Operation of the hydropower system has resulted in regulated flows that are lower in spring and summer relative to the historic hydrograph (Ebel et al. 1989). Increases in cross-sectional area of the river associated with impoundments further reduced water velocities in spring and summer.

Small, relatively slow swimming juvenile salmonids such as fall chinook salmon, may use portions of reservoirs for rearing. Rearing salmonids do not prefer the rip-rap habitats that constitute a high proportion of the shoreline and nearshore areas of all reservoirs other than Priest Rapids.

The operation of the hydropower system also has large effects on the spawning habitat of white sturgeon (Parsley and Beckman 1994). White sturgeon spawning and egg incubation usually occur from April through July in the swiftest water available, generally within 8 km downstream from each dam (Parsley et al. 1993). The amount of spawning habitat for white sturgeon increases as discharge increases (Parsley and Beckman 1994); however, hydropower production has reduced spring and summer discharges (Ebel et al. 1989). During years of reduced river runoff, the lack of high-quality spawning habitat in impounded reaches may preclude successful reproduction by white sturgeon.

Though hydroelectric development has reduced the availability of spawning habitat, it has increased the area suitable for young of the year and juvenile white sturgeon in impounded reaches (Parsley and Beckman 1994). Impoundment has increased water depths upstream from the dams; thus, because young sturgeon use the deeper water, the physical rearing habitat has increased. Spawning failures and low numbers of recruits to young of the year when spawning is successful have resulted in relatively few fish occupying this available habitat.

Wildlife

The Mainstem Columbia River, associated riparian zone, and surrounding terrestrial landscape historically provided high-quality habitat for a diverse assemblage of wildlife species. The most important types of habitat for many species of wildlife along the Columbia River in this subbasin are riparian (trees and shrubs), wetland (grasses and forbs), islands, shallow water, and embayments. In those parts of the subbasin not directly along the Columbia River, permanent vegetative “cover” (i.e., un-tilled land) and shallow water are extremely important for wildlife.

Areas adjacent to the Columbia River in the subbasin that are managed primarily for wildlife and wildlife habitat include the Umatilla NWR, and the Willow Creek and Irrigon Wildlife areas (John Day Reservoir); USACE lands near the mouth of Walla Walla River and near Burbank, Washington, and McNary NWR (McNary Reservoir); the Ringold unit of the Columbia Basin Wildlife Area and Saddle Mountain NWR (Hanford Reach); and the Priest Rapids unit of the Columbia Basin Wildlife Area (Priest Rapids Reservoir). Areas in the subbasin off the Columbia River that are managed primarily for wildlife and wildlife habitat include the Linda Lake unit of the Columbia Basin Wildlife Area, Windmill Wildlife Arrea, and Bailie Ranch (WDFW).

Riverine and Riparian Habitat

Riparian habitats were historically found at all elevations and on all stream gradients in the subbasin, with up to 80% of all wildlife species dependent upon these areas at some time in their lifecycle (Thomas et al. 1979). An important ecological process that affected riparian areas was natural flooding that redistributed sediments and established new sites for riparian vegetation to become established. Impoundments have generally decreased the diversity and quality of habitats, but have increased the amount of open water available for some species of wildlife including migrant/wintering waterfowl. Fluctuating water levels that result from power generation at the dams on the Columbia River have reduced the value of shoreline areas for wildlife (Tabor et al. 1981).

Riparian areas have been extensively impacted within the Columbia basin such that undisturbed riparian systems are rare (Knutson and Naef 1997). Impacts have been greatest at low elevations and in valleys where agricultural conversion, altered stream channel morphology, water impoundment, and water withdrawal have played significant roles in changing the character of streams and associated riparian areas. Losses in lower elevations include large areas once dominated by cottonwoods that contributed considerable structure to riparian habitats. The quantity of riparian and wetland habitat identified in mid-1970s inventories was small (Tabor 1976). An example is John Day Reservoir, where only 230 ha of riparian habitat and 925 ha of wetland habitat remain (USACE 2000). The implications of riparian area degradation and alteration are wide ranging for wildlife populations that utilize these habitats for breeding, nesting, foraging and resting.

Islands in the Columbia River and other parts of the subbasin are of extreme importance to several species of wildlife. Islands provide nesting habitat free of terrestrial predators for ground nesting birds such as Canada geese, ducks, pelicans, and other colonial nesting species. In John Day Reservoir, islands occupy approximately 700 ha (USACE 2000). The number and acreage of islands in the mid-1970s in other reservoirs and the Hanford Reach are given by Tabor (1976), Asherin and Claar (1976) and Payne et al. (1975).

Shallow water habitats can be very productive for submergent, emergent, and aquatic vegetation, in addition to benthic invertebrate populations.   Aquatic plants and invertebrates are important forage resources for many wildlife species. The productivity of shallow water habitats is limited in the Columbia River portion of the subbasin because of fluctuating water levels that are caused by power production at the dams. Shallow water habitats comprise approximately 3,600 ha in John Day Reservoir (USACE 2000).

Embayments, which are shallow water habitats typically connected to the Mainstem Columbia River via culverts or small channels, provide special wildlife values. In most embayments, water fluctuates less than in the river because of the elevation of the culvert or inlet channel. The magnitude of waves is also relatively low in embayments. The reduced water fluctuation and protection from wave action is beneficial to wildlife directly, and indirectly, as a result of conditions that promote diverse riparian and wetland vegetative communities. Embayments are of special importance to beaver and muskrats because of the reduced water fluctuations. Embayments also provide protected loafing and roosting areas for waterfowl and other water birds, in addition to food resources.

Abundance of embayments differs among reaches of the Columbia River. Priest Rapids Reservoir has only 2 embayments, and the Hanford Reach has only 3 embayments. McNary Reservoir appeared to have 21 embayments in the mid-1970s (Asherin and Claar 1976). Approximately 17 embayments are connected to John Day Reservoir, with the largest being Paterson Slough in the Umatilla National Wildlife Refuge (approximately 420 ha). The Dalles Pool had 19 embayments in the mid-1970s (Tabor 1976).

River deltas and mudflats occur along McNary Reservoir, particularly at the mouths of the Yakima, Snake, and Walla Walla rivers. These areas provide critical migration stop-over habitat for shorebirds, and are frequently used by waterfowl and wading birds. These extensive shallow-water areas and mudflats are critical for shorebird foraging. Because of the specialized habitat provided, the Yakima River delta was recently named an "Important Bird Area" for the state of Washington. Because these areas attract shorebirds and waterfowl, they are often used by predators as well, including peregrine falcon, bald eagle, and others. Deltas and mudflats are affected by fluctuating water levels. Mudflats may not be exposed during critical times, eliminating important food sources for this assemblage of birds.

Waterways associated with development of the Columbia Basin Irrigation Project also provide significant aquatic resources. More than 1,200 hectares of lakes and wetlands north of Basin City in the Eagle Lakes and Sugar Ranch complex provide yearlong running water and wetlands for wildlife, and have developed riparian corridors.

Upland Habitat

Land conversion from the steppe or shrub-steppe plant communities to monotypic agricultural or grazing units has been the primary cause for declines in many of the shrub-steppe obligate species that occur in the Mainstem Subbasin (Saab and Rich 1997). For example, nest production by ferruginous hawks is low in the shrub-steppe habitat within the Mainstem Subbasin because of the limited availability of medium-sized prey items such as ground squirrels (Leary 1996; Watson and Pierce 2000). Townsend's ground squirrels and Washington ground squirrels were once abundant prey items in the subbasin but habitat loss and degradation have made this species uncommon in the shrub-steppe. In addition, the bulk of reptilian species are highly dependent on the amount and quality of shrub-steppe habitat. Sandy soil is a habitat-limited component important for short-horned lizards, western spade-foot toads, and Woodhouse's toad.

The Boardman/BAIC/Horn Butte site in Oregon, and the Hanford area and YTC in Washington contain the largest remaining undisturbed steppe and shrub steppe habitat in the Columbia River Basin. These areas span a wide climatic and edaphic (soil) range resulting in equally diverse vegetation. Much of central Hanford and the North Slope receives 15-20 cm or less of precipitation per year, and has sandy or coarse textured soils. At the other extreme are the more cool and moist conditions with loamy soil at high elevation on Rattlesnake Ridge. This great range of climatic variation combined with equally diverse geologic and soil conditions has produced a remarkable diversity of potential plant community types. In addition, these areas are relatively free of non-native species and are large enough to retain characteristic populations of shrub-steppe plants and animals that are rare or have been extirpated from other areas. One of the only two remaining subpopulations of sage grouse in Washington reside primarily within the YTC (Schroeder et al. 2000). Nearby blocks of unprotected shrub-steppe include the Eagle Lakes and Sugar Ranch properties. These areas include important undisturbed habitat for several sensitive shrub-steppe species such as ferruginous hawk, Washington ground squirrel, and burrowing owl.

Cliffs and rock outcroppings within the Mainstem Subbasin provide unique habitat for many birds and reptile species. Because vast areas of shrub-steppe habitat are virtually treeless, rock outcroppings provide critical nesting habitat for raptor species including the ferruginous hawk, Swainson's hawk, red-tailed hawk, and great-horned owl. Undisturbed cliff and rock outcrops are prominent in the Eagle Lakes area. The White Bluffs of the Hanford Reach, up to 180 m high, provide habitat for cliff and bank swallows, wintering bald eagles, nesting and roosting raptors, and a variety of other wildlife. Rock outcroppings are also used by reptiles for thermoregulation. The western rattlesnake is a top predator within the shrub-steppe ecosystem and relies on rock formations for denning, over-winter survival and foraging.

Watershed Assessment

No formal watershed assessment has been conducted for the Mainstem Columbia River between The Dalles and Wanapum dams; however, many recent reports and publications have described the area and its fish and wildlife resources. Documents describing physical habitat and limnology include the *Columbia River Backwater Study*, phases 1 and 2 (USFWS 1980; 1982). These reports contain information on water temperature, dissolved oxygen, and other attributes of backwaters in The Dalles and John Day reservoirs. Hjort et al. (1981) describe and classify the types of potential habitats in John Day Reservoir.

Annual counts of anadromous salmonids and American shad at dams are published by ODFW, WDFW, the USACE, and Grant PUD. USACE reports also include daily information on discharges and water temperatures.

A description of the physical habitat and limnology, as well as a comprehensive assessment of fish and wildlife resources of Priest Rapids Reservoir, are being compiled as part of the current

FERC relicense process (Lukas 2001). The relicense process includes documentation of prior assessments for this area.

A Columbia-basin wide assessment of losses was conducted in the late 1980s to quantify impacts from federal hydropower development (Rassmussen and Wright 1990). Wildlife mitigation objectives for the Mainstem Subbasin are based partially on the results of this loss assessment. Estimated wildlife losses caused by the development of the federal hydropower system were amended into the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program. Losses were measured in Habitat Units (HUs) for selected target and indicator species and are linked to priority habitats

A comprehensive assessment of fish and wildlife resources of John Day Reservoir was prepared by the USACE (2000) as part of a reservoir drawdown study. Earlier assessments in this area were conducted by Payne et al. (1975), Asherin and Claar (1976), Tabor (1976), Tabor et al. (1981), the USACE (1995), and the USFWS (1997).

A wealth of information has been published on changes to the Columbia River from development of the hydropower system, and the resulting effects these changes have had on migration of juvenile and adult salmonids. Pertinent publications include, but are not limited to, Park (1969), Raymond (1968; 1969; 1988), Ebel et al. (1989), Rondorf et al. (1990), Berggren and Filardo (1993), Giorgi et al. (1997), and Tiffan et al. (2000).

Physical and biological attributes of the Hanford Reach have been the subject of numerous reports and publications. The PNNL has published information on a range of topics that include radio nuclide transport and fate, ground water – surface water interactions, community structure and life histories of fish and wildlife, spatial distribution of migrating juvenile salmonids, and characterization of the ecological communities within the river. An example is Gray and Dauble (1977), a checklist of fish species found in the Hanford Reach. *The Hanford Reach: What Do We Stand To Lose?* (Geist 1995), includes a description of the history and resources of the Hanford Reach, as well as the potential consequences of various management alternatives to the ecological integrity of the Reach.

The PNNL has also provided information on the Columbia River between Priest Rapids and Wanapum dams. Rogers et al. (1988; 1989) provide descriptions of the animals and major plant communities present along the western bank of the Columbia River in this area. In addition, a comprehensive assessment of the natural resources associated with the Priest Rapids Hydroelectric Project was included in the initial consultation document for relicensing (Grant PUD 2000).

Most information on resident fish throughout the mainstem is limited to their potential effects on juvenile salmonids. Assessments of resident fish populations, their diets, and their predation on juvenile salmonids are given by Mesa et al. (1990), Beamesderfer and Rieman (1991), Poe et al. (1991), Rieman et al. (1991), Tabor et al. (1993), Petersen (1994), Ward et al. (1995), Zimmerman and Parker (1995), Knutsen and Ward (1999), Ward and Zimmerman (1999), Zimmerman (1999), and Pfeifer et al. (2000).

Recent work has resulted in numerous publications concerning white sturgeon populations and habitat assessments in the Mainstem Columbia River. North et al. (1993) describe the distribution and movements of white sturgeon in reservoirs, Parsley et al. (1993) and Parsley and Beckman (1994) describe spawning and rearing habitat and habitat use by white sturgeon, and Beamesderfer et al. (1995) describe the population dynamics and ability of white sturgeon in reservoirs to sustain harvest.

A Columbia basin-wide assessment of losses was conducted in the mid 1980s to quantify impacts from federal hydropower development (BPA 1984). Wildlife mitigation objectives for the Columbia Basin Mainstem Subbasin are based partially on the results of this loss assessment. Wildlife losses caused by the construction of the federal hydropower system were amended into the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program. Losses were measured in Habitat Units (HUs) for selected target/indicator species and are linked to priority habitats.

Major Limiting Factors

Primary limiting factors for fish, wildlife, and associated habitats in the Mainstem Columbia River are generally a result of (1) hydropower system development and operation, (2) other human activities such as farming, grazing, urban and suburban development, transportation, and industrial or nuclear development, or (3) introduction and proliferation of exotic species. These factors are often interrelated and hard to separate. For example, water quality is affected by many human activities, including operation of the hydropower system. Food webs and predation on native species can be influenced by all activities. Because of these complicated relationships, the following summaries of major limiting factors are not necessarily organized by these major categories.

Fish

Hydropower System Development and Operations

An important limiting factor associated with hydropower development is downstream and upstream passage of anadromous salmonids and white sturgeon at dams. Passage problems will not be emphasized here; rather, they will be a major component of the System-wide/Mainstem Subbasin Summary. However, a specific passage issue within the Mainstem Subbasin that needs to be addressed is the discrepancy between passage counts of adult fall chinook salmon at McNary, Ice Harbor, and Priest Rapids dams. Even after taking into account potential escapement of adult fall chinook salmon into the Yakima River, sport harvest, and hatchery returns to Ringold and Priest Rapids, adult fall chinook counts over Priest Rapids Dam in 1999 and 2000 were disproportionately high relative to aerial redd surveys conducted in the Hanford Reach and tailrace of Wanapum Dam (WDFW, unpublished data). Fall back at Priest Rapids Dam is a likely explanation for this discrepancy. Fallback events deplete adult salmon of a finite energy supply that is needed to successfully reproduce (Dauble and Mueller 2000). The most recent fallback study at Priest Rapids Dam indicated a fallback rate of approximately 15% (Stuehrenberg et al. 1995); however, fall back rates of 30 to 60% would be necessary to correct adult passage counts to make them commensurate with aerial redd surveys conducted in 1999 and 2000.

Power peaking operations of the 7 Mid-Columbia projects, including Wanapum and Priest Rapids dams, can result in a change of tailrace elevations up to three vertical meters in a matter of hours. This may result in the stranding and entrapment of both juvenile fall chinook salmon and resident fish in the Hanford Reach. Mortality associated with these events can be very high (Wagner et al. 1999), and directly reduces the production potential of fall chinook salmon and other fish in the Hanford Reach. However, a protection program has limited these flow fluctuations during times of juvenile fall chinook rearing and the impact from these fluctuations is less than 2% of the rearing population (Lukas 1999, 2001).

Fluctuations in river flows also change the amount of rearing habitat available to juvenile fall chinook salmon (USGS, unpublished data). Changes in flow may stimulate the downstream movement of juvenile chinook salmon, which may increase their risk of predation if movement occurs at a time when predators are actively feeding. Changes in flow may eventually displace juvenile fall chinook salmon from the Hanford Reach into McNary Reservoir. The reservoir contains a higher proportion of rip-rap shoreline that juvenile fall chinook salmon avoid (USGS, unpublished data), and predation in reservoirs is most intense on juvenile salmonids (Gray and Rondorf 1986). In addition, displacement of fish from preferred habitats into lower quality habitats may reduce feeding potential, increase bioenergetic costs, and ultimately reduce survival. Finally, the repeated drying and rewetting of shoreline substrates resulting from flow fluctuations may limit the production of macroinvertebrates, which juvenile fall chinook salmon use as food (Becker 1973; Dauble et al. 1980; Cushman 1985; Gislason 1985).

Hydroelectric development has transformed most fast-moving mainstem riverine habitats into slow-moving reservoir impoundments. Construction of McNary, John Day, and The Dalles dams inundated 200 km of fall chinook salmon spawning habitat in the Mainstem Columbia River (Van Hyning 1973). Today, only the Hanford Reach remains unimpounded and provides the majority of mainstem spawning habitat for fall chinook salmon.

It is unknown whether hydropower development and flow management practices have altered the physical habitat and species assemblages that form key trophic relationships with fall chinook salmon. It is well established that stream flow quantity and timing are critical components of water supply, water quality, and the ecological integrity of river systems (Poff et al. 1997). Flow regimes, geology of surrounding landscapes, and longitudinal slope are important controlling variables in salmon habitats and operate at both the watershed and reach scale (Imhof et al. 1996). In the Columbia River, flow regimes are highly regulated by the hydroelectric complex and seasonal discharge is influenced by water storage and water use practices (Ebel et al. 1989). 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). The relative magnitude and frequency of high flow events also acts to modify channel form, 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). In other words, it appears that Hanford Reach fall chinook salmon and the aquatic ecosystem it supports are currently healthy but because of our limited understanding of the relationships between these fish and their ecosystem, it is not obvious that the ecosystem will continue to be healthy in the future. Given the overall importance of the Hanford Reach fall chinook salmon population, this is a relatively high risk.

Shoreline habitats in McNary, John Day, and The Dalles reservoirs are predominantly rip-rapped, which juvenile fall chinook salmon avoid (USGS, unpublished data), and are often preferred by predators. In addition, reservoirs have allowed non-native aquatic macrophytes to flourish, which may provide additional predator habitat, but their effect on juvenile salmonids is unknown. These habitat-related limitations in mainstem reservoirs further reduce the production potential and survival of fall chinook salmon.

Conversion of the majority of the Mainstem Columbia River to reservoirs has resulted in a major decrease in the abundance of mountain whitefish. Only the Hanford Reach supports a recreational fishery and mountain whitefish are rarely encountered in reservoirs (WDFW, unpublished data). The loss of production of benthic insects associated with riverine habitat in the reservoirs is the probable cause for the extremely low abundance of mountain whitefish.

The operation of the hydropower system has limited the spawning success of white sturgeon in The Dalles, John Day, McNary, and Priest Rapids reservoirs. Reduced spring and summer discharges have decreased the amount of spawning habitat available, and construction of dams inundated several rapids and falls that probably provided spawning habitat. Current spring and summer flow augmentation for juvenile salmonids may serve to increase spawning habitat available to white sturgeon; however, rearing habitat in reservoirs can support more young white sturgeon than currently present.

Changes in aquatic habitats in the Columbia River basin have also resulted in substantial declines of Pacific lampreys (Close et. al. 1995). The Columbia Basin Pacific lamprey work group (CBPLTWG 1999) identified habitat of juvenile and adult life histories as a critical uncertainty. Ongoing projects have focused on evaluating population status in tributaries (Hatch and Parker 1998) and passage requirements at mainstem dams (Mesa et al. 2000; Moursund et al 2000). However, there have been no studies to assess the relative importance of mainstem habitats on the spawning and rearing of Pacific lampreys.

Water Quality

While construction and operation of dams and reservoirs within the subbasin have not produced a significant change in average water temperature, upstream storage projects have resulted in a temperature phase shift (Jaske and Goebel 1967). Recent studies have hypothesized that the phase shift has resulted in earlier arrival of adult sockeye salmon in the upper Columbia River (Quinn et al. 1997). The migratory and spawning timing of fall chinook salmon returning to the Hanford Reach is also responsive to water temperatures (Dauble and Watson 1997). Historical records indicate that fall chinook salmon returning the mid-Columbia River may spawn as much as one month later than populations did at the beginning of the nineteenth century (DeVoto 1953). The effects of a later spawning time on the emergence timing and availability of aquatic food web resources is unknown.

The maximum water temperature criteria established by Washington for the Columbia River above Priest Rapids dam is 18^{o} C. The maximum established by Washington and Oregon for the Columbia River downstream from Priest Rapids Dam is 20°C, which is often exceeded during the warmest parts of the summer. The upper incipient lethal temperature for juvenile chinook salmon is 24°C (Brett 1952). Temperature affects swimming performance (Brett 1967), growth and energetics (Brett 1952; Elliott 1982), movement behavior (Bjornn 1971), physiological development (Ewing et al. 1979), disease susceptibility (Fryer and Pilcher 1974), and vulnerability of fish to predation (Sylvester 1972; Coutant 1973; Yocom and Edsall 1974; Deacutis 1978). The long-term consequences to fall chinook salmon of chronic exposures to sublethal temperatures that exist in the Columbia River during the summer are unknown, but may be manifested in high mortality at dams due to increased physical stress during passage. This is evidenced by the subyearling chinook salmon kills at McNary Dam in 1994 and 1998, which were temperature related. Studies have also shown that late-migrating juvenile fall chinook salmon exposed to high water temperatures have poorer survival than earlier migrants (Connor et al. 1998; Muir et al. 1998). Considering the life history of fall chinook salmon along with the environmental conditions that exist during their freshwater life cycle, high water temperatures may limit this population by reducing fish performance and long-term survival.

Because increased flow during migration is thought to increase survival of juvenile salmonids by decreasing travel times, and mortality over spillways is lower than mortalities through other routes at dams, a spill program during juvenile salmonid migration has been specified at Columbia and Snake River dams. Although spill is a relatively safe route to pass dams, it poses risks to fish because it can result in elevated levels of total dissolved gas (TDG) in their bloodstreams. The Environmental Protection Agency's recommended limit is 110% TDG saturation; however, no general agreement exists as to maximum allowable TDG, or to acceptable long-term exposures to levels over 110%. Evaluations of the effects of TDG levels are further confused by the ability of fish to avoid high levels by moving to deeper water. Nevertheless, fish may be impaired by the sublethal effects of dissolved gas.

Production of nuclear weapon materials at the Hanford Nuclear Reservation left behind a legacy of chemical and radioactive contaminants and materials that have affected and may continue to affect the Columbia River for the foreseeable future. The Washington Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy initiated a study in the mid 1990s to assess the potential impact to the Columbia River from Hanford-derived contaminants. The first phase of the study encompassed a screening assessment of the potential risks to human and environmental health from contaminants carried in the ground water into the river. Environmental levels of some contaminants appear to be elevated as a result of Hanford Site operations and from other human activities upstream of the Site (PNNL 1998). Results of the ecological assessment indicate that some contaminants pose potential hazards to some plants, herbivores, omnivores consuming riverine organisms, and carnivores in some areas. Numerous aquatic species are likely to be affected by acute or chronic toxic effects because of exposure to contaminated pore water and riverbed sediments (PNNL 1998). Contaminants that were identified as being of concern include chromium, lead, mercury, copper, zinc, cyanide, cobalt-60, technetium-99, and cesium-137 with the non-radioactive chemicals posing the highest risk.

Metals in sediment samples (Patton and Crecelius 2000), and in great blue heron excrement (B. Tiller –PNNL – unpublished data) indicate elevated concentrations occur near the Priest Rapids Dam and are not the result of Hanford Site operations. Additional data indicates elevated levels of organic contamination (PCB's) were found in fish collected near the Priest Rapids Dam. These data are planned to be released to the public shortly and may have significant ramifications to commercial and recreational fishing. The contribution of these contaminants levels from hydro-electric dam construction and operation is currently unknown.

Seepage water originating upslope of highly erode-able lands above the Hanford Reach has resulted in significant landslide activity along much of the north side of the river. For example, approximately 22.9 million cubic meters of material has been displaced in the Locke Island landslide alone, which has redirected river flow into Locke Island where substantial erosion has occurred (Bennett 1999). Accelerated erosion associated with this landslide has exposed cultural artifacts buried within Locke Island and altered fisheries habitat by changing river velocities and increasing sediment input (Mueller and Geist 1999; Bennett 1999). Specific impacts to the fisheries community are unknown.

Irrigation Withdrawals

Flow objectives of National Marine Fisheries Service Biological Opinions for the Mainstem Columbia River are rarely met during the summer, especially in moderate to low water years. Diversion of water for agricultural production, also at its peak during the summer, contributes significantly to this shortage. Low flows, and consequently lack of current, makes passage longer and more difficult for migrating juveniles, significantly affecting overall survival. Limited flows also exacerbate water quality concerns - the Mainstem Columbia River fails to meet federal and state water quality standards for temperature and pollution throughout the summer.

Intakes of unscreened diversions can suck juveniles into irrigation systems causing instant mortality. Inadequately screened or poorly designed screens can impinge fish, or require constant maintenance to function properly.

Attraction flows from irrigation pumping often create more current than exists in the reservoirs. Off-channel pumping stations can attract juveniles away from the main channel, interrupting their migration, exposing them to higher temperatures and increased predation in backwaters, and potentially drawing juveniles either into irrigation systems if unscreened or impinging them if improperly designed

Food Webs and Predation

The transformation of the Mainstem Columbia River into a series of reservoirs, except for the Hanford Reach, has altered the food webs that support juvenile salmonids and resident fish. The Hanford Reach maintains a rich community of aquatic insects that juvenile fall chinook salmon use as food. Juvenile fall chinook salmon eat primarily adult and larval midges (Diptera), caddis flies (Trichoptera), and mayflies (Ephemeroptera) (Becker 1973; Dauble et al. 1980; USGS unpublished data). In contrast, juvenile fall chinook salmon in McNary Reservoir consume primarily midges, terrestrially-derived insects, and zooplankton (Rondorf et al. 1990; USGS unpublished data). The limitation imposed by altered reservoir food bases is an increased foraging cost to consume smaller, less energetically profitable zooplankton. The caloric value of the zooplankton eaten in McNary Reservoir is about 1,000-1,500 cal/g lower than that of the insects eaten in the Hanford Reach (Cummins and Wuycheck 1971). Two factors may further limit the use of zooplankton as a food resource. First is the proliferation of *Neomysis mercedis* in mainstem reservoirs. *Neomysis mercedis* is an estuarine mysid and is related to *Mysis relicta*, which has decimated zooplankton communities in coldwater lakes and reservoirs in the western United States (Nessler and Bergersen 1991). It is unknown whether *Neomysis mercedis* eat zooplankton in Columbia River reservoirs. Second is the rapid increase in the American shad population in the last decade. Juvenile American shad are planktivorous and may compete with late-migrating fall chinook salmon for food resources. However, analysis of stomach contents of fall chinook salmon collected in John Day reservoir in 1996 showed that juvenile American shad composed the majority of their diet (USGS, unpublished data). American shad may act as fall chinook salmon prey and competitors, and although interactions between the two species remain largely unexplored, negative effects on fall chinook salmon should be cause for concern.

Predator-prey relations have been altered by development of the hydropower system in many ways. Although northern pikeminnow are a native species and have always preyed on juvenile salmonids, development of the hydropower system has increased the level of predation. Dams have slowed water velocity and decreased turbidity, effects that have increased exposure time of juvenile salmonids to predators and increased predation success. Development of the hydropower system has also resulted in extended periods of warm water, and therefore increased predator activity and consumption. Dams concentrate juvenile salmonids in forebays and tailraces, and fish in tailraces are disoriented from passage through or around turbines, spillways, or bypass systems, further increasing their vulnerability to predation. Northern pikeminnow may consume up to 8% of the total number of juvenile salmonid out-migrants annually (Beamesderfer et al. 1996).

Exotic Species

Of the 50 fish species known to inhabit the Mainstem Columbia River between The Dalles and Wanapum dams, 20 are exotic (Table 3). Of primary concern are species that may compete with or prey on native species, especially salmonids. Juvenile American shad are planktivorous and may compete with late-migrating fall chinook salmon for food resources. Smallmouth bass and walleye are both known to prey upon juvenile salmonids and other native fish. Smallmouth bass are responsible for only a small amount of the predation on juvenile salmonids in Columbia River reservoirs (Rieman et al. 1991); however, they may become more important predators when wild subyearling chinook salmon are abundant in late spring and early summer (Tabor et al. 1993). Individual walleye consume as many juvenile salmonids as individual northern pikeminnow (Rieman et al. 1991); however, abundance of walleye is far lower than abundance of northern pikeminnow (Beamesderfer and Rieman 1991). Both smallmouth bass and walleye prey upon native species such as sculpins, cyprinids, suckers, and sand rollers to a much greater extent than do northern pikeminnow (Zimmerman 1999).

Wildlife

Hydropower System Development and Operations

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. Wildlife loss assessments conducted in the late 1980s documented losses associated with each hydropower facility (Table 7).

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 hydropower operation include limiting the availability of secure nesting and brood-rearing habitat for Canada geese, breeding ducks, and colonial nesting birds. Islands provide protection of nesting birds from terrestrial predators, and to some extent, disturbance by humans. Many islands used by birds are eroding rapidly, especially in John Day Reservoir, thus reducing the size of islands and eliminating nests on islands with maximum nest density (McCabe 1976). Water fluctuations cause some islands to be connected to shore during periods of low water, allowing access by terrestrial predators. 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. Massive waves characteristic of some parts of the Columbia River kill young birds directly and reduce the productivity of shallow water areas used for feeding. At some brooding sites, low water elevation is lower than the downslope extent of plants, resulting in a wide band of un-vegetated shoreline. Adults and young birds attempting to traverse this un-vegetated area are very susceptible to predation. Conversely, at some brooding sites, plants eaten by birds are unreachable due to inundation. Water level fluctuations may also reduce the productivity and availability of critical migrant shorebird habitat at deltas.

Table 7 Loss of wildlife habitat associated with federal hydropower facilities in the lower Columbia River. From Rassmussen and Wright (1990).

Hydropower Facility	Habitat Inundated (ha)	Habitat Units Lost
Bonneville	8,400	12,317
The Dalles	780	2,230
John Day	11,115	14,398
McNary	6,276	19,397

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; Levine 1965). In 1993 and 1994 PNNL biologists noted many avian carcasses in the lower regions of the Hanford Reach, particularly near islands that are influenced by the impounded waters of McNary Reservoir (Brett Tiller, PNNL, unpublished data). The islands where dead birds were found had nesting colonies of gulls and terns and scattered nesting geese. Some gulls were found dying and exhibited signs similar to avian botulism. Although samples collected tested negative for sera antibodies to *Clostridium botulinum* and *Salmonella,* the role of water fluctuations and potentiation of life-threatening diseases is unknown.

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).
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.

Through mechanisms similar to waterfowl and nesting colonial birds, water fluctuations and waves also decrease beaver and muskrat production. An additional effect on beaver populations is alternating 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.

Mule deer in the subbasin often 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 in the subbasin, 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 limits this use of islands in the subbasin by mule deer.

Water flow fluctuations may also play a significant role in short and long-term survivability of rare plant taxa found exclusively along the riparian shorelines. For example, in the Hanford Reach, persistent sepal yellow-cress *Rorrippa columbia*, a State-threatened species found throughout the moist near-shore cobble substrate, is often inundated by river flows during times when flowering typically occurs, but little is known concerning long-term survival and recruitment under extended periods inundation (PNNL, unpublished data).

Land Management Practices

Landscape-level interpretation of the quantity and quality of the shrub-steppe and riparian habitats have shed light on the current status of these habitats within the Mainstem Subbasin. Dry-land farming and extensive livestock grazing of open range land have been responsible for the elimination and degradation of the riparian zone throughout much of the basin. Wildlife abundance has also been adversely affected by irrigated agriculture through the reduction of habitat diversity as monocultures are created. In addition, forest practices have decreased the amount of available habitat and reduced the quality of remaining habitat. 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.

Land Prices

Land prices continue to rise, making it more economically difficult to preserve remaining undeveloped lands for wildlife and fish. Opportunities to restore wildlife populations and improve habitat diminish over time as habitat loss and degradation continue.

Nutrient Cycling & Food Webs

Continued decline in populations of salmon and other fish species results in loss of overall biomass being contributed to the subbasin. This reduction has negative effects on wildlife abundance. The dramatic declines in some native wildlife species, particularly blacktail jackrabbits *Lepus californicu*s and Washington ground squirrels may have contributed to the decline of associated predators such as ferruginous hawks.

Exotic Species

The spread of non-native plant and wildlife species is a threat to wildlife habitat quality and to wildlife species themselves. For example, noxious weeds threaten the quality of deer and elk winter range. Despite the overall free-flowing patterns of Columbia River along the Hanford Reach, milfoil *Myriophylum* spp. is common in the slow-water areas and the benefits and consequences to various vertebrate wildlife is not well understood.

At locations away from the Columbia River in this subbasin, duck brooding habitat quantity and quality is limited by wetland succession (e.g., late successional stages characterized by low percent of open water) and high densities of carp. Carp compete with ducklings and other wildlife for invertebrate and submergent aquatic foods.

The bullfrog has been introduced into most suitable habitat west of the Rocky Mountains. Numerous studies have shown that bullfrogs outcompete and contribute to the decline of native amphibians due aggressive behavior, rapid growth rate and predation (Corkran and Thoms 1996). The bullfrog's preferred habitat is similar to that of many other amphibians native to the Mainstem Columbia River.

Of particular importance is the invasion of riparian habitats by invasive exotic plant species such as Russian olive. The increase in Russian-olive may indirectly affect wildlife survival by increasing populations of predators such as coyotes and black-billed magpies. Within the adjacent upland areas, the acreage of sagebrush cover is even further reduced by the spread of cheatgrass, which increases fire frequency and magnitude while lengthening the recovery period following larger events.

Human Disturbance

Urban expansion, highway traffic, free-ranging dogs, noise pollution, light pollution, etc. can disturb wildlife populations and limit wildlife usage of quality habitat areas. In both the Columbia River and "off-river" parts of the subbasin, human disturbance during brood-rearing period reduces waterfowl and colonial nesting bird production. Mammals such as beaver also suffer high mortality from being hit by trains and cars because of the proximity of highways and railroads to the shoreline of the Columbia River.
Human recreation within the shrub-steppe communities may significantly affect nesting of ferruginous hawks, bald eagles, waterfowl, and many colonial nesting birds. Bald Eagles and American white pelicans are particularly sensitive to boating activities, with juvenile eagles being more sensitive to human activities than adults (Brett Tiller, PNNL, unpublished data).

Artificial Production

Four hatcheries are located on the Mainstem Columbia River between Wanapum and The Dalles dams; however, only two release fish directly into the Columbia River. Priest Rapids Hatchery is located just below Priest Rapids Dam and is operated by WDFW. The hatchery is funded by Grant PUD and the USACE, and is operated to mitigate fishery impacts caused by Priest Rapids and Wanapum dams. Goals of the hatchery include production of (1) 100,000 lb of subyearling fall chinook salmon for on-station release, (2) 1.7 million fall chinook salmon smolts as part of John Day mitigation, and (3) fall chinook salmon eggs to be provided to other facilities for rearing.

Ringold hatchery is located on the Columbia River within the Hanford Reach, and is also operated by WDFW. The hatchery is funded by NMFS, and is used for adult collection, rearing, acclimation, and release of spring chinook salmon, acclimation and release of fall chinook salmon, and rearing, acclimation, and release of summer steelhead. Goals include production of 1.1 million spring chinook salmon smolts, production of 180,000 steelhead smolts, and final rearing of 3.5 million subyearling fall chinook salmon.

The Irrigon and Umatilla hatcheries are located on the Columbia River near Irrigon, Oregon, and are operated by ODFW. Neither release fish directly into the Columbia River. The Irrigon Hatchery is funded by the Lower Snake River Compensation Program, and serves as an egg incubation and rearing facility for summer steelhead destined for the Grande Ronde and Imnaha River systems. The hatchery is also used as a final rearing site for legal-sized rainbow trout destined for northeast Oregon waters. The Umatilla Hatchery is funded by BPA, and is used for egg incubation and rearing of spring chinook salmon, fall chinook salmon, and summer steelhead for release into the Umatilla River.

Existing and Past Efforts

Columbia Basin Fish and Wildlife Program

Most projects in or along the Mainstem Columbia River funded through the NWPPC's Columbia Basin Fish and Wildlife Program are considered "system-wide" in nature. Such projects listed here are either concentrated within the Columbia Plateau Province, or significantly affect fish and wildlife or their habitats within the province. Projects intended to evaluate or improve upstream or downstream passage of salmonids at dams are not emphasized; however, they will be a major component of the System-wide/Mainstem Subbasin Summary.

Anadromous Salmonids

Relatively few BPA-funded projects have concentrated on the effects of the hydropower system within the Hanford Reach. Project 199301500, *Vernita Bar Redd Surveys*, was funded in 1992 and 1993 to help determine the relationship between river operations and placement of fall chinook salmon redds. Project 199406900, *Development of a Conceptual Spawning Habitat Model for Fall Chinook Salmon*, is being conducted in the Hanford Reach. The objective of this project is to use the Hanford Reach fall chinook salmon and their habitat as an analog to determining the features of mainstem alluvial rivers that are important for adult fall chinook salmon. Recently the project has also been attempting to determine the spawning capacity of the Hanford Reach for fall chinook salmon. Project 199701400, *Evaluation of Juvenile Fall Chinook Stranding on The Hanford Reach*, began in 1997 to collect information on stranding and entrapment of juvenile fall chinook salmon and resident fish due to fluctuating river levels from releases at Priest Rapids Dam. Preliminary results indicated significant numbers of fish were stranded or entrapped in pools from power peaking operations of the 7 mid-Columbia dams. In 1998, a Technical Work Group and a Policy Group composed of fishery and power managers were established to review results, develop interim water management strategies to minimize stranding and entrapment, and to review study designs for future sampling efforts. Interim protection plans were established and put into effect in both 1999 and 2000, which placed constraints on flow fluctuations in the Hanford Reach to minimize negative impacts to juvenile fall chinook salmon. These plans can be viewed as a natural extension of the Vernita Bar Agreement, which serves to protect fall chinook salmon prior to emergence from redds (see *Outside the Columbia Basin Fish and Wildlife Program*). Continued monitoring and evaluation of the stranding problem in the Hanford Reach is ongoing. An additional project within the Hanford Reach, Project 199205300 – *Ringold Hatchery Water Supply*, funded the design and construction of an improved water supply for the Ringold Hatchery complex.

Other projects included work throughout the province, including both the Hanford and impounded reaches. Project 199102900, *Post-release Attributes and Survival of Hatchery and Natural Fall Chinook Salmon in the Columbia River Basin*, surveyed reservoirs to identify 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. This project is also estimating survival of Hanford Reach fall chinook salmon through the lower Columbia River. In addition, it seeks to determine mechanisms of survival, such as growth, and to compare attributes of the healthy Hanford Reach fall chinook salmon population to the depressed Snake River fall chinook salmon population. Finally, this project examined juvenile fall chinook migration rates through John Day Reservoir, physiological development, and adult returns of fish marked at McNary Dam from 1991-1994. Project 199800402, *Assess The Impacts of Development and Operation of the Columbia River Hydroelectric System on Mainstem Riverine Processes and Salmon Habitats,* assessed the extent of habitat lost and recommended areas with particular potential for restoration.

Finally, a number of projects concentrated on impounded reaches. Project 198201700, *Radio Tracking of Chinook – Bonneville to McNary*, was designed to explain the "losses" of adult fall chinook salmon between Bonneville and McNary dams. Project 199202400, *Increased Levels of Harvest and Habitat Law Enforcement and Public Awareness for Anadromous Salmonids and Resident Fish in the Columbia River Basin*, was intended to decrease the number of salmon and steelhead lost to illegal fishing between Bonneville and McNary dams. Project 199900301, *Salmon Spawning Below Lower Columbia Mainstem Dams*, provides funding to search for evidence of fall chinook salmon spawning below John Day and McNary dams, document stranding of emergent fry, and describe habitat requirements in relationship to dam operations.

Resident Predators

Work to date on resident fish has emphasized their predation on juvenile salmonids and methods to decrease this predation. Predation work began with projects 198200300, *Feeding Activity, Rate of Consumption, Daily Ration, and Prey Selection of Major Predators in John Day Pool*, and 198201200, *Abundance and Distribution of Walleye, Northern Squawfish, and Smallmouth Bass in John Day Reservoir and Tailrace*. Findings from these two projects indicated that approximately 7.3% of all juvenile salmonids entering John Day Reservoir were consumed by northern pikeminnow, and that northern pikeminnow accounted for 78% of the loss of juvenile salmonids to fish predators. Design of prey-protection measures and a Northern Pikeminnow Management Program (NPMP) were the eventual products of these two projects. The NPMP, Project 199007700, has resulted in the removal of almost two million northern pikeminnow from the Columbia and Snake rivers since 1990. The program includes an evaluation component, which has indicated that annual exploitation has averaged approximately 12%, and predation on juvenile salmonids has been reduced an estimated 25%. A separate but cooperative effort is Project 199007800, *Northern Pikeminnow Management Evaluation*.

White Sturgeon

Work to evaluate and mitigate the effects of the hydropower system on white sturgeon has been systematic and comprehensive. Efforts began with Project 198301200, *White Sturgeon Workshop*, which resulted in establishing research needs for white sturgeon. Project 198331600, *Columbia River White Sturgeon Study*, focused on the responses of young sturgeon to changes in temperature and flow, and addressed the potential for artificial propagation. Project 198506400, *Develop Work Plan for Sturgeon Research*, was the final step before funding of the comprehensive Project 198605000, *Status and Habitat Requirements of White Sturgeon Populations in the Columbia River Downstream from McNary Dam*. From 1986-92, work on this project concentrated on determining the status and habitat requirements of white sturgeon in the Columbia River. Conclusions from this work led to recommendations for further work including (1) intensified management of fisheries for impounded populations, (2) evaluations of mitigation actions for impounded populations such as transplanting juvenile white sturgeon from below Bonneville Dam and refining and evaluating hatchery technology, and (3) quantifying habitat available and evaluating constraints on enhancement. Work since 1992 has been based on these recommendations. Intensive management of fisheries is ongoing, as are annual transplants of juvenile fish. A broad recommendation for flows that will provide spawning habitat in reservoirs was developed, and a final recommendation for operation of the hydropower system that will enhance physical habitat conditions is forthcoming. Response of impounded populations to these activities is monitored.

Wildlife

Funding for wildlife projects has included evaluations of the impacts of the hydropower system on wildlife populations and habitat, planning for land acquisitions including but not limited to purchases along the Mainstem Columbia River, and specific purchases along the river. As a first step, *Status Review of Wildlife Mitigation at Columbia Basin Hydroelectric Projects, Columbia Mainstem & Lower Snake Facilities* was completed (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 analysis.

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

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. Projects 199208400, *Oregon Trust Agreement Planning Project*, 199506500, *Assessing Oregon Trust Agreement Planning Project Using Gap Analysis*, and 199305800, *Washington Wildlife Mitigation Agreement*, facilitated development, management, and review of mitigation opportunities.

The *Oregon Trust Agreement Planning Project*, was initiated in 1992 by the Oregon Wildlife Coalition to create a list of potential wildlife mitigation opportunities by priority and to attempt to determine the costs of mitigating for wildlife losses in Oregon. Using screening criteria, this project resulted in a prioritized list of 287 potential mitigation sites and cost estimates for general habitats within the mitigation area.

Assessing Oregon Trust Agreement Planning Project Using Gap Analysis was a refinement of the previous effort to identify wildlife mitigation opportunities within Oregon. The primary goal of the project was to prioritize and depict the contribution of each proposed mitigation site to target species and habitats as well as to overall biodiversity in the state and/or eco-region within which it is found. From the results of the project the Oregon Wildlife Coalition identified and ranked a short list of high priority project sites.

The Oregon Wildlife Coalition (OWC) is implementing a programmatic habitat acquisition project within the Columbia Basin in Oregon. The goals of this project, *Securing Wildlife Mitigation Sites – Oregon* (199705900) are to:

- Fund project coordination activities to identify, plan, propose, and implement mitigation projects within the Columbia Basin, including the Columbia River Mainstem Subbasin.
- Prioritize potential mitigation projects
- Permanently protect priority habitats through fee-title acquisition, perpetual conservation easement, perpetual or long-term lease, and/or acquisition of instream water rights
- Enhance acquired, eased, or leased habitats through alteration of land management practices, active restoration of habitats, control of noxious weeds and other non-native vegetation, control of public access, etc. to provide benefits to target/indicator fish and wildlife species Develop and implement a monitoring and evaluation plan with both Habitat Evaluation Procedures (HEP)-based and non-HEP based monitoring criteria

The NWPPC approved funds under the OWC's programmatic project for Project No. 20115, *Securing Wildlife Mitigation – Oregon, Irrigon*, and Project No. 20016, *Securing Wildlife Mitigation Sites – Oregon, Horn Butte*. Since funding approval in FY 1999, the Irrigon project is no longer being pursued; however, landowner negotiations are still occurring on the Horn Butte project. The Horn Butte project will involve acquisition or easement of several parcels in the Horn Butte area near Arlington, Oregon. The OWC continues to pursue project opportunities in the subbasin to mitigate for the remaining wildlife losses associated with the development and operation of the hydropower system.

The NWPPC has approved funds for project #20074, *The Eagle Lakes Ranch Acquisition and Restoration.* This project was first approved for funding in 1999 and is in the final stages of negotiation for acquisition and management by USFWS. It would fund fee purchase and restoration of a portion of a 3,000-ha shrub-steppe, basalt-cliff, and wetland complex as wildlife mitigation lands in northern Franklin County, Washington. The area is known to have several sensitive shrub-steppe species, and due to its location is a prime wintering area for waterfowl. Fee and concurrent USFWS easement purchases would allow the continued use of part of the ranch as a hunting and fishing club, protect the land from imminent development, preserve more than half as National Wildlife Refuge lands, and restore wetland and upland habitats to native vegetation.

Outside the Columbia Basin Fish and Wildlife Program

Anadromous Salmonids

In 1963, Grant PUD and the Washington Department of Fisheries entered into an agreement relating to the construction of a spawning channel to mitigate for the loss of chinook salmon spawning grounds caused by the Priest Rapids and Wanapum projects. The agreement stated that the construction of the spawning channel and compliance with the provisions of the agreement constitute full compliance with the requirements of the FERC license Article 39 with respect to losses of chinook salmon spawning grounds and mitigation for fisheries losses. Problems with pre-spawning adult mortality, disease outbreaks, high sediment loads, algae, and poor juvenile growth and survival resulted in a conversion of the spawning channel to conventional hatchery production, where spawning and fertilization are done artificially. From

1972 to 1977, part of the fall chinook broodstock were spawned in a conventional hatchery manner to increase total production. Since 1978 all fish produced at the Priest Rapids facility have come from conventional hatchery methods.

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 (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.

To comply with terms of the Agreement, Grant PUD requires the cooperation of Chelan County PUD, operator of Rock Island and Rocky Reach dams, Douglas County PUD, operator of Wells Dam, and BPA, operator of dams further upstream. Cooperation of BPA is vital to the Agreement because the storage capacity of the PUD dams is too small to provide the necessary water sources for the flows required under the Agreement. The basic water sources are Grand Coulee Dam and reservoirs further upstream. Consequently, all of the parties named are participants in the Vernita Bar Agreement.

Through the Mid-Columbia Proceeding, Grant PUD implements a variety of measures designed to improve survival of downstream migrating juvenile salmonids. The primary measures are a fish spill program, gatewell dipping (netting smolts from the gatewells and transporting them downstream below the dam), and studies to test and identify long-term dam bypass systems. In July of 2000, Grant PUD entered into a Memorandum of Agreement with the National Marine Fisheries Service, Washington Department of Fish and Wildlife, Colville Confederated Tribes, Confederated Tribes of the Umatilla Indian Reservation, Colville Indian Reservation, Yakama Nation, U.S. Fish and Wildlife Service, Columbia River Intertribal Fish Commission and American Rivers. This agreement set forth spring and summer spill requirements for both the Priest Rapids and Wanapum dams and was filed with FERC to resolve the downstream passage complaint of the Mid-Columbia Proceeding. This agreement extends throughout the current license term for the Priest Rapids Hydroelectric Project (PRP).

Before 1992, little was known about the variables that defined suitable fall chinook salmon rearing habitat in the main-stem Columbia River. The USGS has conducted habitat surveys in both the free-flowing Hanford Reach and the impounded McNary Reservoir. Variables important to rearing fall chinook salmon are water velocity, lateral shoreline slope, depth, and temperature (Key et al. 1994; 1996). Natural substrates were not important to rearing in the Hanford Reach, but fish avoided rip-rapped shorelines in McNary Reservoir. In 1998, the USGS began a more comprehensive assessment of the amount of rearing habitat available at different flows in the Hanford Reach. The habitat in a 33-km reach was described using remote sensing, hydraulic modeling, and statistical and GIS analyses. The majority of shoreline habitats in the study area were suitable for rearing fall chinook salmon, and there was more habitat at lower flows than at higher flows.

Migratory behavior in the Mainstem Columbia River has been described in terms of travel times, hydroacoustic assessments, and laboratory experiments. Juvenile salmonids have been freeze branded and PIT tagged to index passage timing and travel times to, and between, main-stem dams. Radio telemetry is currently being used at John Day and The Dalles dams to determine passage routes and survival of juvenile salmonid migrants. The distribution of migrating juvenile fall chinook salmon in relation to water velocity has been evaluated by the USGS in McNary and John Day reservoirs. The USGS has also conducted laboratory experiments to identify how water velocity affects the downstream movement of juvenile fall chinook salmon.

Numerous studies have been and are being done to estimate the survival of juvenile spring and fall chinook salmon and steelhead in the Columbia River. The NMFS is currently releasing PIT-tagged fall chinook salmon at McNary Dam to estimate survival through the lower Columbia River. The USGS is currently releasing PIT-tagged wild fall chinook salmon in the Hanford Reach to estimate survival to McNary Dam and John Day Dam. Route-specific survival is being evaluated for spring and fall chinook salmon and steelhead using radio tags at John Day and The Dalles dams by USGS.

Many projects have been conducted or funded by the USACE. Most have been directly related to adult or juvenile salmonid passage at dams and will not be summarized here; however, some studies have been directed at the impoundments rather than at the dams. Examples of these studies include various environmental impact statements for the development and operation of the Columbia River hydropower system (USACE 1995). A summary of the potential effects of the hydropower system on anadromous salmonids, and studies to evaluate and mitigate these effects is given in Mighetto and Ebel (1995).

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. An summary of these studies can be found in Becker (1990).

Lukas (2001) complied 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). A large number of monitoring or completion reports are also reviewed that give summaries of activities resulting from settlement agreements such as the Vernita Bar Agreement and the operations of Priest Rapids Hatchery.

Resident Predators

Work at PNNL has also focused on the effects of water level fluctuations on smallmouth bass. Montgomery et al. (1980) used radio telemetry and recaptures of marked fish to monitor movements of smallmouth bass in relation to water level fluctuations in the Hanford Reach. They determined that movements of smallmouth bass were influenced by water level fluctuations, and that adverse effects were related to seasonal water regimes during spawning, and to inter-seasonal fluctuations in flow levels.

White Sturgeon

White sturgeon in the Hanford Reach have also received attention from PNNL (Haynes et al. 1978). Becker (1971) described a new trematode *Cestrahelmins rivularis* from the intestine of white sturgeon. Dauble et al. (1992) described radionuclide concentrations in white sturgeon from the Hanford Reach.

Wildlife

The vegetative communities and land forms adjacent to the Columbia River in the subbasin 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 (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.

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).

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.

SUBBASIN MANAGEMENT

Existing Plans, Policies, Guidelines

Various federal and state agencies and tribes within the subbasin have developed plans to protect and manage fish and wildlife and their habitats. Several planning documents, policies, and management guidelines are briefly described below.

Federal Government

U.S. Army Corps of Engineers

The USACE operates McNary, John Day, and The Dalles dams and reservoirs for hydropower production, anadromous fish passage, recreation, navigation, irrigation and limited flood control. The USACE also owns small amounts of land along the Columbia River in the subbasin. Some of this land is managed by state fish and wildlife agencies for wildlife habitat and wildlife oriented recreation . Management of USACE lands and waters is guided by federal and state legislation, and Army and USACE policies. The USACE also reviews applications for the removal and filling of materials in waterways.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) administers the Endangered Species Act as it pertains to resident fish and wildlife. The USFWS reviews and comments on land use activities that affect fish and wildlife resources such as timber harvest, hydroelectric projects, flow alterations, and dredging and filling wetlands. The biological opinion for bull trout specifies needed actions for their recovery. The federal Migratory Bird Act also protects migratory birds and their habitats. In the Mainstem Subbasin, the USFWS also manages 70,800 ha located on the Department of Energy-owned Hanford Site as the Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge (Monument/Refuge). These lands are located within the planning framework of DOE's Hanford Comprehensive Land-Use Plan (CLUP) and Environmental Impact Statement (EIS), 9/99. The CLUP and subsequent DOE/FWS Memorandum of Agreement and Permit establish the project area as an overlay unit of the National Wildlife Refuge System (NWRS) under USFWS management. Guidance for the Monument/Refuge lands is provided by the June 9, 2000, Hanford Reach National Monument Presidential Proclamation. The Proclamation directs the DOE and FWS to protect and conserve the area's native plant communities, specifically recognizing the nationally significant scientific values provided by the area's biologically diverse shrub-steppe ecosystem. The USFWS also manages the Mid-Columbia National Wildlife Refuge Complex, which includes the Umatilla, McNary, and several (former USACE Lands) tracts along the Snake River.

National Marine Fisheries Service

The National Marine Fisheries Service administers the ESA as it pertains to anadromous fish only. At least 7 listed ESU's migrate through or spawn and rear in the mainstem: Snake River fall chinook salmon, Snake river spring/summer chinook salmon, upper Columbia River spring chinook salmon, Snake River sockeye salmon, upper Columbia River steelhead, Snake River basin steelhead, and middle Columbia River steelhead. Through Biological Opinions, Recovery Plans, and Habitat Conservation Plans for federally listed species, appropriate watershed protection and restoration measures are identified.

Under the ESA's 4(d) rule, "take" of listed species is prohibited and permits are required for handling. Special permit applications have been pursued for research and management activities in the Mainstem Subbasin. Recovery actions for listed species also require Fisheries Management and Evaluation Plans; most of which have been developed. Biological Opinions, recovery plans, and habitat conservation plans for federally listed fish and aquatic species help target and identify appropriate watershed protection and restoration measures.

The recent Federal Columbia River Power System (FCRPS) Biological Opinion and the Basinwide Salmon Recovery Strategy (All-H Paper) contain actions and strategies that are specific to the Mainstem Subbasin. Other aspects of hatchery and harvest apply as well. Action Agencies are identified that will lead fast-start efforts in specific aspects of restoration on nonfederal lands.

U.S. Bureau of Land Management

The Bureau of Land Management (BLM), in accordance with the Federal Land Policy and Management Act of 1976, is required to manage public lands to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values. The BLM is required by the Clean Water Act to ensure that activities on administered lands comply with requirements concerning the discharge or run-off of pollutants.

U.S. Department of Energy

The U.S. Department of Energy (DOE) manages the Hanford Nuclear Reservation, which borders the Hanford Reach of the Columbia River. The Hanford Site (approximately 1,500 km^2) was established in the early 1940s to provide a location where reactors could be built to produce nuclear material needed for efforts associated with World War II. Eventually nine production reactors and one commercial power reactor were constructed along the shores of the river. All but the commercial power reactor have been shut down and the DOE's mission is now focused on environmental cleanup and restoration. Commensurate with this mission, several documents have been prepared in recent years including the Hanford Site Biological Resources Management Plan (BRMaP) and the Hanford Site Land-Use Planning Document.

The BRMaP document is awaiting final approval by the DOE. The BRMaP is a comprehensive plan that views Hanford's biological resources and their management from both site- and program-wide perspectives. The plan provides a consistent approach to protect biological resources and monitor, assess, and mitigate impacts to them from site development and environmental cleanup and restoration activities. The plan's primary purposes are to support DOE's environmental cleanup and other Hanford missions; provide a mechanism for ensuring compliance with laws that relate to the management of potential impacts to biological resources; provide a framework for ensuring appropriate biological resource goals, objectives, and tools are in place to make DOE an effective steward of Hanford's biological resources; and implement an ecosystem management approach for biological resources on the Site.

The Final Hanford Comprehensive Land-Use Plan integrates appropriate biological resource data and biological resources management strategies from BRMaP to implement an ecosystem management approach to land-use planning at the Hanford Site. The overriding goal of the Land-Use Plan is to evaluate the potential environmental impacts associated with implementing a comprehensive land-use plan for the Hanford Site for at least the next 50 years.

Bonneville Power Administration

The Bonneville Power Administration has mitigation responsibility for fish and wildlife restoration under the Fish and Wildlife Program of the Northwest Power Planning Council as related to hydropower development. It is also accountable and responsible for mitigation related to federal Biological Opinions and Assessments for recovery of threatened, endangered, and sensitive species. The recently released FCRPS Biological Opinion calls for the BPA to expand habitat protection measures on non-federal lands. BPA intends to rely on the Council's program as its primary implementation tool for the FCRPS BiOp off-site mitigation requirements.

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) grants License No. 2114 for the Priest Rapids Hydroelectric Project that consists of Priest Rapids and Wanapum dams and associated reservoirs and project works. The current license will expire in 2005. Details concerning some of the provisions of the license are described below under "Public Utility District No. 2 of Grant County".

U.S. Department of Agriculture

The U.S. Department of Agriculture (USDA) oversees several conservation programs to help solve natural resource concerns. The Environmental Quality Incentives Program (EQIP), established in the 1996 Farm Bill, provides a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources. EQIP offers financial, educational, and technical help to install or implement structural, vegetative, and management practices called for in agricultural land contracts. The Conservation Reserve Program (CRP) puts sensitive croplands under permanent vegetative cover.

Tribal Government

By treaty with the United States in 1855, the Confederated Tribes of the Umatilla Indian Reservation and the Yakama Nation reserved certain rights within the subbasin in compensation for ceding lands to the federal government. These reserved rights provide the basis for a wide range of rights and interest for the protection, enhancement, management, and harvest of anadromous fish in the subbasin.

Confederated Tribes of the Umatilla Indian Reservation

The CTUIR is responsible for protecting and enhancing treaty fish and wildlife resources and habitats for present and future generations. Members of the CTUIR have federal reserved treaty fishing and hunting rights pursuant to the 1855 Treaty with the United States government. CTUIR co-manages fish and wildlife resources with state fish and wildlife managers and individually and/or jointly implements restoration and mitigation activities throughout areas of interest and influence in northeast Oregon and southeast Washington. These lands include but are not limited to the entire Umatilla subbasin in which CTUIR held aboriginal title. CTUIR fish and wildlife activities relate to all aspects of management (habitat, fish passage, hatchery actions, harvest, research, etc.). CTUIR policies and plans applicable to subbasin management include the CTUIR *Columbia Basin Salmon Policy*, *Wy-Kan-Ush-Mi Wa-Kish-Wit: Spirit of the Salmon* (Columbia River Inter-tribal Fish Commission 1995), and the CTUIR *Wildlife Mitigation Plan for the John Day and McNary Dams* (Childs 1997).

Yakama Nation

The Yakama Nation, also known as the Confederated Tribes and Bands of the Yakama Indian Nation, co-manages fish and wildlife resources with state fish and wildlife managers and individually or jointly implements restoration and mitigation activities throughout areas of interest and influence in Washington. These areas lands include but are not limited to the entire Yakima and Klickitat subbasins. As a result of treaty-reserved rights, the tribe retains substantial governmental authority over activities that affect hunting and fishing.

Columbia River Inter-Tribal Fish Commission

The tribal Columbia River Anadromous Fish Restoration Plan, or *Wy-Kan-Ush-Mi Wa-Kish-Wit*, was developed by the Nez Perce, Umatilla, Warm Springs and Yakama tribes (CRITFC 1995). Recommendations set forth in this plan for salmon recovery address three types of actions: institutional, technical, and watershed, with the over-riding goal of simply putting fish back in the river (gravel to gravel management).

State Government - Oregon

Oregon Plan

Passed into law in 1997 by Executive Order, the *Oregon Plan for Salmon and Watersheds* (www.oregon-plan.org) and the *Steelhead Supplement to the Oregon Plan* outlines a statewide approach to ESA concerns based on watershed restoration and ecosystem management to protect and improve salmon and steelhead habitat in Oregon. The Oregon Plan Monitoring Program, successfully implemented in coastal watersheds, provides the necessary approach for rigorous sampling design to answer key monitoring questions, which will be applied to the all Oregon subbasins. The Oregon Watershed Enhancement Board (OWEB) facilitates and promotes coordination among state agencies, administers a grant program, and provides technical assistance to local Watershed Councils and others to implement the Oregon Plan through watershed assessments and restoration action plans.

Oregon Department of Fish and Wildlife

The Oregon Department of Fish and Wildlife (ODFW) is responsible for protecting and enhancing Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. Management of the fish and wildlife and their habitats in and along the Mainstem Columbia River is guided by ODFW policies, collaborative efforts with the Washington Department of Fish and Wildlife and affected tribes, and federal and state legislation. Direction for ODFW fish and wildlife management and habitat protection is based on the amendments and statutes passed by the Oregon Legislature through the 2001 session. For example, Oregon Administrative Rule (OAR) 635 Division 07 – *Fish Management and Hatchery Operation* sets forth policies on general fish management goals, the Natural Production Policy, the Wild Fish Management Policy, and other fish management policies. OAR 635 Division 08 – *Department of Wildlife Lands* sets forth management goals for each State Wildlife Area, OAR Divisions 068-071 set deer and elk seasons, and OAR Division 100 – *Wildlife Diversity Plan* outlines wildlife diversity program goals and objectives, identifies species listings, establishes survival guidelines, and creates other wildlife diversity policy. OAR Division 400 – *Instream Water Rights Rules* provides guidelines for inflow measurement methodologies, establishes processes for applying for instream water rights, and sets forth other instream water rights policies. OAR Division 415 - *Fish and Wildlife Habitat Mitigation Policy* establishes mitigation requirements and recommendations, outlines mitigation goals and standards, and provides other mitigation guidelines. Another pertinent ODFW policy is the Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources.

Oregon Department of Environmental Quality

The Oregon Department of Environmental Quality is the regulatory agency responsible for implementing the 1972 federal Clean Water Act and enforcing state water quality standards for protection of aquatic life and other beneficial uses. It is instrumental in designating 303(d) water quality limited streams and in processing TMDL process.

Oregon Division of State Lands

The Oregon Division of State Lands (ODSL) regulates fill and/or removal of material from the bed or banks of streams (ORS 196.800 – 196.990) through the issuance of permits. Permit applications are reviewed by ODFW, USACE, the counties, and landowners, and may be modified or denied based on project impacts to fish populations.

State Government - Washington

Washington Department of Fish and Wildlife

The Washington Fish and Wildlife Commission is directed by the Washington State Legislature (RCW77.04.055) to establish policies to preserve, protect and perpetuate fin fish, shellfish, and wildlife and their habitats to maximize fish and wildlife recreational opportunities compatible with healthy and diverse fish and wildlife populations. The Mission of WDFW is: "Sound Stewardship of Fish and Wildlife". In pursuit of this mission, WDFW will strive to maximize fishing, hunting and non-consumptive recreational opportunities compatible with healthy, diverse fish and wildlife populations. A few of the important policies, plans, and guidelines that drive WDFW management in the mainstem Columbia River include a statewide strategy to recover salmon, a wild salmonid policy, management plans for steelhead and bull trout, and salmon, steelhead, and bull trout stock inventories.

The Wild Stock Restoration Initiative (WSRI; ESHB 1309) in 1993 initiated a commitment to salmonid protection and recovery that has led to more recent salmon recovery legislation. Recently enacted state legislation (1998-1999) designed to guide salmon recovery in the state of Washington includes the Salmon Recovery Planning Act (ESHB2496), Watershed Planning Act (ESHB2514), and Salmon Recovery Funding Act (2E2SSB 5595). Stock inventories were the initial commitment of state and tribal fishery managers to the WSRI that complemented and strengthened ongoing programs to protect salmonid stocks and habitats. The Salmon and Steelhead Inventory and Assessment Program (SSHIAP) is an integral part of WSRI and complements stock inventory work. It is a partnership-based information system that characterizes freshwater and estuary habitat conditions and distribution of salmonid stocks in Washington at the 1:24,000 scale. SSHIAP is designed to support regulatory, conservation, and analysis efforts such as Washington State Watershed Analysis, State Salmon Recovery, Habitat Conservation Planning, Ecosystem Diagnosis and Treatment, and others.

The Salmon Recovery Planning Act provides the framework for developing restoration projects. It requires a limiting factors analysis and establishes a funding program for local habitat restoration projects. It also creates the Governor's Salmon Recovery Office. As a result of this bill, an Independent Scientific Panel was created to provide scientific review for salmon recovery projects.

Washington Department of Natural Resources

The Washington Department of Natural Resources is responsible for managing state forest resources, including fire prevention and suppression and administers the state's Natural Areas Program.

Washington Department of Ecology

The Washington Department of Ecology oversees and administers key laws dealing with the integrity and use of land, air, and water including the State Environmental Policy Act, Shoreline Management Act, Floodplain Management Act, Water Pollution Control Act, and Water Resources Act. The department permits dischargers of air and water pollution, oversees toxic cleanup and has enforcement authority to administer these laws.

The department also oversees the Watershed Planning Act, which encourages voluntary planning by local governments, citizens, and tribes for water supply and use, water quality, and habitat at the Water Resource Inventory Area level. Grants are available to conduct assessments and to develop strategies to ensure adequate flows for fish and out-of-stream use. There are 40 Water resource inventory areas engaged in watershed planning across Washington state. The state has provided over $12.9 million to these groups to support these efforts.

The Washington Department of Ecology is the regulatory agency responsible for implementing the 1972 federal Clean Water Act and enforcing state water quality standards for protection of aquatic life and other beneficial uses. The department has the only state certification authority over re-licensing of major hydropower projects to ensure they meet state water quality standards. The agency is also instrumental in designating 303(d) water quality limited streams and in processing TMDL process.

Washington State Growth Management Act

Various provisions of the Washington State Growth Management Act (GMA) require local Comprehensive Plans to address planning issues of statewide importance. It is a characteristic of GMA that depending upon the issue the state purposes for local plans can be either general or very specific. Relative to natural resource lands (mineral, agricultural and forestry lands), and "critical areas" (wetlands and fish and wildlife conservation, frequently flooded, critical aquifer recharge, and geologically hazardous areas), the expression of state interest is clear and specific. These must be designated and "protected" (critical areas) or "conserved" (agriculture, minerals and forestry) by regulation (36.70A.060). Currently, Benton and Franklin counties and the cities of Kennewick, Pasco, and Richland have growth management plans that include provisions for areas along the Columbia River in their respective jurisdictions.

The "Goals, Policies, and Actions," within the plan are the primary directives for land use decision-making and long range planning. They are also the principal directives to county decision-makers and staff relative to what planning and public works actions, studies, and other projects, have to be undertaken during the plan's 20 year "horizon" in order to address current and future growth and development, and resource issues.

Local Government

Public Utility District No. 2 of Grant County

Public Utility District No. 2 of Grant County (Grant PUD) owns and operates the PRP that consists of Priest Rapids and Wanapum dams and associated reservoirs and project works. The project was authorized by Congress under Public Law 83-544 and is regulated by the Federal Energy Regulatory Commission under License No. 2114. The FERC license provides the terms and operating conditions for the project. Requirements related to fish and wildlife include Article 39, which requires that Grant PUD construct, operate, and maintain fish ladders, fish traps, fish hatcheries, or other fish facilities or fish protective devices for the purpose of conserving the fishery resources.

Future fish and wildlife programs for the PRP will be developed through the relicensing process under the statutory requirements imposed by the Federal Power Act. The process for developing these programs is currently underway and Grant PUD will be filing its relicensing application with Federal Energy Regulatory Commission (FERC) by October of 2003.

Existing Goals, Objectives, and Strategies

The Mainstem Columbia River and adjacent lands encompass an extremely large area, and include a tremendous diversity in aquatic and terrestrial habitats. However, this diversity, and the accompanying fish and wildlife populations, have suffered greatly from development of the hydropower system, increased human population, and poor land-use practices. Nevertheless, tremendous potential for protecting existing resources and restoring a number of fish and wildlife populations and their habitats exist. The over-arching goals of the subbasin pertain to the protection and restoration of these resources. Objectives and strategies designed to achieve these goals are either taken directly from documents prepared by the federal, tribal, and state entities present in the subbasin, or are a composites derived from these documents. Objectives and strategies taken directly from documents are noted as such. Specific actions to be implemented are included under some strategies; however, most specific actions are listed in the Fish and Wildlife Needs section.

Goals: Protect, enhance, and restore populations of hatchery and naturally produced anadromous salmonids and lamprey in the subbasin to viable levels that ensures they are not vulnerable to extinction, and to provide ecological, cultural, and sociological benefits.

Protect, enhance, and restore production of resident fish, including white sturgeon, in the subbasin, to viable levels that ensures they are not vulnerable to extinction, and to provide ecological, cultural, and sociological benefits.

Protect, enhance, or restore wildlife populations to sustainable levels, and provide ecological, cultural, and sociological benefits.

Goal 1. **Protect, enhance, and restore populations of hatchery and naturally produced anadromous salmonids and lamprey in the subbasin to viable levels that ensures they are not vulnerable to extinction, and to provide ecological, cultural, and sociological benefits.**

National Marine Fisheries Service Objectives

The following objectives are limited to those given in the Mainstem Habitat section of the All-H Paper (NMFS 2000):

Objectives Between 2001 and 2012, restore habitat, acquire riparian corridors, modify flow regimes, reduce non-point pollution, develop improvement plans for all reaches

Beginning in 2001, identify sampling reaches, survey conditions, describe cause-and-effect relationships, identify research needs.

Tribal Objectives and Strategies (CRITFC 1995)

Objectives: In 7 years, halt the declining trends in salmon populations above Bonneville Dam.

Within 7 years, obtain the information necessary to manage and restore Pacific lamprey.

Within 25 years, increase the total adult salmon returns above Bonneville Dam to 4 million annually and in a manner that supports tribal commercial as well as ceremonial and subsistence harvests.

Within 200 years, restore historic anadromous fish abundance.

Strategies: Provide specific minimum instream flows as measured at The Dalles Dam.

Provide cool water flow augmentation for adult fall chinook and steelhead.

Implement a comprehensive review and monitoring program for water quality and substrate parameters affecting salmon, lamprey, sturgeon, and their food sources.

Implement a biomonitoring program which: (1) identifies levels of organochlorine compounds, heavy metals, and radionuclide isotopes at various points in the Mainstem Columbia and in salmonid species and sediments, (2) documents physiological abnormalities, especially in fish reproductive organs, (3) identifies hormone protein levels in fish blood samples as an indicator of the presence of organochlorine compounds, and (4) identifies sources of contaminants.

Washington Department of Ecology Objectives

Objective: Ensure State water quality standards to protect beneficial uses are met.

Sub Objective 1: Reduce temperature pollution caused by dams to meet water quality standards. Research and pursue methods for providing cooler waters to anadromous fish at critical stages in their life cycles.

Sub Objective 2: Reduce supersaturation pollution caused by dams during high flows to meet water quality standards. Pursue identification of consistent and defensible points to measure compliance with water quality standards in the Columbia and Snake River both in the forebays and tailraces of each dam.

Hanford Reach-Specific Objectives and Strategies

Objective: By 2006, recommend a fall chinook salmon escapement level to the Hanford Reach that results in a spawning population that is well distributed throughout the Reach, and, at any one time, supports a healthy population (defined as a stable or increasing trend, with an estimated probability of persistence of 95% or better over the next 100 years) which can not only sustain production in the Reach but provide recruitment for re-establishing satellite populations (e.g., Yakima River).

Strategies: Determine carrying capacity of Hanford Reach for producing fall chinook salmon under current and future operational scenarios (e.g., McNary Reservoir drawdown). Include in this assessment the spatial and temporal relationships among the habitat requirements of all life history stages, including the role of predation (e.g., channel catfish), competition (e.g., American shad), and primary productivity in setting limits on juvenile production.

Improve annual escapement estimates of Hanford Reach fall chinook salmon by improving estimates of fall back at Priest Rapids Dam, tributary escapement, sport harvest, hatchery return, and redd counts.

Evaluate connectivity between Hanford Reach and potential satellite populations/expansion areas, including mainstem dam tailrace areas, currently inundated areas (e.g., McNary Reservoir), and tributaries (e.g., Yakima River).

Objective: By 2006, evaluate whether the Hanford Reach functions as a normative river.

Strategy: Identify indicators of ecosystem health/processes for the Hanford Reach and evaluate existing conditions relative to those indicators.

Implement a comprehensive land-use plan for the Hanford Site for at least the next 50 years.

Objective: By 2006, determine if steelhead are naturally reproducing in the Hanford Reach and if there is enhancement potential.

Strategy: Develop techniques to identify steelhead spawning and rearing locations.

Hanford Reach Flow Management Agreements (Vernita Bar Settlement Agreement and Hanford Reach Juvenile Fall Chinook Salmon Protection Plan)

Objectives: Prevent the dewatering of fall chinook salmon redds. Reduce the mortality of fall chinook salmon fry in the Hanford Reach.

Strategies: Limit spawning to lower elevations on Vernita Bar. Seek an extension of the terms and conditions of the Vernita Bar Agreement beyond its expiration that is concurrent with that of the Priest Rapids Project license.

Reduce the stranding and entrapment of fry caused by flow fluctuations at Priest Rapids Dam. Seek a long-term agreement through use of information gained through experimental implementation of the 1999, 2000 and 2001 versions of the Hanford Reach Juvenile Fall Chinook Protection Program.

Predation Management Objective and Strategy

Objective: Maintain predation on juvenile salmonids by northern pikeminnow at or below 75% of pre-1990 levels.

Strategy: Maintain annual exploitation of northern pikeminnow between 10-20%.

Lamprey Objective and Strategy

Objective: By 2006, estimate the amount of Pacific lamprey spawning and rearing that occurs in the Hanford Reach and tailraces of mainstem dams.

Strategy: Implement a research program designed to evaluate the importance of mainstem habitats on the spawning and rearing of Pacific lampreys.

Goal 2. Protect, enhance, and restore production of resident fish, including white sturgeon, in the subbasin, to viable levels that ensures they are not vulnerable to extinction, and to provide ecological, cultural, and sociological benefits.

White Sturgeon Objectives and Strategies

Objectives: Restore abundance of white sturgeon so that reservoir populations can sustain annual harvest equivalent to 5 kg/ha.

Within 25 years, increase sturgeon populations so that they can support tribal commercial harvests of 3,300 annually (CRITFC 1995).

Strategies: Configure and operate the hydropower system consistent with salmonid recovery to maximize spawning and rearing success of white sturgeon in reservoirs.

Supplement depleted populations of white sturgeon in reservoirs until changes in configuration and operation of the hydropower system are completed

Actions: Transplant naturally-produced juveniles from below Bonneville Dam into reservoirs until changes in configuration and operation of the hydropower system are completed.

If abundance of naturally-spawning white sturgeon cannot be restored to pre-impoundment levels in reservoirs, supplement populations with artificially-produced fish where risks to naturally spawning populations are minimal.

Regulate harvest of white sturgeon in reservoirs based on estimated abundance and exploitation rates that provide optimum sustainable yields.

Based upon results from ongoing sturgeon studies, develop and implement coordinated management plans for targeted sturgeon populations. The plans should estimate potential levels of natural production under present conditions, the amount of additional natural production which could be achieved with modifications to flow and other environmental conditions, and additional increases which could be sustained with propagation and transportation measures (CRITFC 1995).

Mountain Whitefish Objective and Strategies

Objective: Restore the recreational fishery opportunity which has been lost due to the extreme decline in abundance of mountain whitefish in Columbia River reservoirs.

Strategy: Establish in-lieu fisheries in presently unutilized or underutilized resident fish waters of the Columbia Basin.

Actions: Conduct evaluations in the Hanford Reach to determine the current population dynamics for mountain whitefish.

Estimate the pre impoundment productivity of mainstem Columbia River segments, which have been converted to reservoirs for mountain whitefish.

Evaluate the recreational fishery for mountain whitefish in the Hanford Reach to determine harvest rates and level of angler participation.

Estimate the pre impoundment recreational mountain whitefish fishery potential for the impounded reaches of the Columbia River.

Determine appropriate locations, required habitat alterations, and fish to be utilized for the creation of in-lieu fisheries.

Implement the actions required for the creation and maintenance of in-lieu fisheries.

Goal 3. Protect, enhance, or restore wildlife populations to sustainable levels, and provide ecological, cultural, and sociological benefits.

Overall Objectives and Strategies

Objective 1. Maintain or increase wildlife species diversity.

Strategy 1. Protect, enhance, and restore wildlife habitat in the subbasin.

Action 1.1. Determine and monitor abundance and distribution of wildlife species to identify and prioritize wildlife habitat restoration needs in the subbasin.

Action 1.2. Conduct periodic comprehensive habitat and biological surveys to identify and prioritize wildlife habitat restoration needs in the subbasin.

Action 1.3. Implement wildlife habitat restoration projects in the subbasin.

Action 1.4. Acquire or lease lands with priority habitats to permanently protect wildlife habitats in the subbasin.

Action 1.5. More actively manage lands set aside for wildlife, such as CRP and CREP, to increase species diversity on those lands.

Action 1.6. Decommission unnecessary roads to reduce harassment of wildlife and encourage more uniform use of available wildlife habitat.

Action 1.7. Manage habitat to meet state management guidelines for upland birds and game mammals.

Strategy 2. Protect federal and state threatened, endangered, and sensitive wildlife species.

Action 2.1. Increase enforcement of laws pertaining to wildlife.

Action 2.2. Provide protection for federal and state threatened, endangered, and sensitive wildlife species in all resource management plans.

Action 2.3. Enforce state and local land use regulations designed to protect wildlife habitats.

Oregon Objectives and Strategies

Oregon Wildlife Diversity Plan (ODFW 1993)

Objective 1 Protect and enhance populations of all existing native non-game species at self-sustaining levels throughout their natural geographic ranges by supporting the maintenance, improvement or expansion of habitats and by conducting other conservation actions.

Strategy 1.1 Maintain existing funding sources and develop new sources of public, long-term funding required to conserve the wildlife diversity of Oregon.

Strategy 1.2 Identify and assist in the preservation, restoration and enhancement of habitats needed to maintain Oregon's wildlife diversity and non-consumptive recreational opportunities.

Strategy 1.3 Monitor the status of non-game populations on a continuous basis as needed for appraising the need for management actions, the results of actions, and for evaluating habitat and other environmental changes.

Objective 2. Restore and maintain self-sustaining populations of non-game species extirpated from the state or regions within the state, consistent with habitat availability, public acceptance, and other uses of the lands and waters of the state.

Strategy 2.1 Identify, establish standards and implement management measures required for restoring threatened and endangered species, preventing sensitive species from having to be listed as threatened or endangered, and maintaining or enhancing other species requiring special attention.

Strategy 2.2 Reintroduce species or populations where they have been extirpated as may be feasible.

Objective 3. Provide recreational, educational, aesthetic, scientific, economic and cultural benefits derived from Oregon's diversity of wildlife.

Strategy 3.1 Develop broad public awareness and understanding of the wildlife benefits and conservation needs in Oregon.

Strategy 3.2 Increase or enhance opportunities for the public to enjoy and learn about wildlife in their natural habitats.

Strategy 3.3 Seek outside opportunities, resources and authorities and cooperate with other agencies, private conservation organizations, scientific and educational institutions, industry and the general public in meeting Program Objectives.

Strategy 3.4 Maintain and enhance intra-agency coordination through dissemination of Program information, development of shared databases and coordination of activities that affect other Department divisions and programs; identify activities within other programs which affect the Wildlife Diversity program, and develop mutual goals.

Objective 4. Address conflicts between non-game wildlife and people to minimize adverse economic, social, and biological impacts.

Strategy 4.1 Assist with non-game property damage and nuisance problems without compromising wildlife objectives, using education and self-help in place of landowner assistance wherever possible.

Strategy 4.2 Administer the Wildlife Rehabilitation Program.

Strategy 4.3 Administer the Scientific Taking Permits Program.

Strategy 4.4 Administer Wildlife Holding and other miscellaneous permits.

Strategy 4.5 Provide biological input to the Falconry Program for the establishment of raptor-capture regulations.

Strategy 4.6 Update the Wildlife Diversity Plan every five years.

Oregon Migratory Game Bird Program Strategic Management Plan (ODFW 1993)

Objective 1. Integrate state, federal, and local programs to coordinate biological surveys, research, and habitat development to obtain improved population information and secure habitats for the benefit of migratory game birds and other associated species.

Strategy 1.1 Establish an Oregon Migratory Game Bird Committee to provide management recommendations on all facets of the migratory game bird program.

Strategy 1.2 Use population and management objectives identified in Pacific Flyway Management Plans and Programs.

Strategy 1.3 Develop a statewide migratory game bird habitat acquisition, development, and enhancement plan based on flyway management plans, ODFW Regional recommendations, and other state, federal, and local agency programs.

Strategy 1.4 Implement a statewide migratory game bird biological monitoring program, including banding, breeding, production, migration, and wintering area surveys based on population information needs of the flyway and state.

Strategy 1.5 Develop a statewide program for the collection of harvest statistics.

Strategy 1.6 Prepare a priority plan for research needs based on flyway management programs.

Strategy 1.7 Annually prepare and review work plans for wildlife areas that are consistent with policies and strategies of this plan.

Strategy 1.8 Develop a migratory game bird disease contingency plan to address responsibilities and procedure to be taken in the case of disease outbreaks in the state. It will also address policies concerning "park ducks", captive-reared, and exotic game bird releases in Oregon.

Objective 2. Assist in the development and implementation of the migratory game bird management program through information exchange and training.

Strategy 2.1 Provide training for appropriate personnel on biological survey methodology, banding techniques, waterfowl identification, habitat development, disease problems, etc.

Objective 3. Provide recreational, aesthetic, educational, and cultural benefits from migratory game birds, other associated wildlife species, and their habitats.

Strategy 3.1 Provide migratory game bird harvest opportunity.

Strategy 3.2 Regulate harvest and other uses of migratory game birds at levels compatible with maintaining prescribed population levels.

Strategy 3.3 Eliminate impacts to endangered or threatened species.

Strategy 3.4 Reduce impacts to protected or sensitive species.

Strategy 3.5 Provide a variety of recreational opportunities and access, including viewing opportunities, throughout the state.

Strategy 3.6 Provide assistance in resolving migratory game bird damage complaints.

Strategy 3.7 Develop opportunities for private, public, tribal, and industry participation in migratory game bird programs including, but not limited to, conservation, educational, and scientific activities.

Strategy 3.8 Disseminate information to interested parties through periodic program activity reports, media releases, hunter education training, and other appropriate means.

Objective 4. Seek sufficient funds to accomplish programs consistent with the objectives outlined in the plan and allocate funds to programs based on management priorities.

Strategy 4.1 Use funds obtained through the sale of waterfowl stamps and art to fund all aspects of the waterfowl management program as allowable under ORS 497.151.

Strategy 4.2 Develop annual priorities and seek funding through the Federal Aid in Wildlife Restoration Act.

Strategy 4.3 Solicit funds from "Partners in Wildlife" as appropriate.

Strategy 4.4 Seek funds from a variety of conservation groups such as Ducks Unlimited and the Oregon Duck Hunter's Association.

Strategy 4.5 Solicit funds form the Access and Habitat Board as appropriate and based on criteria developed by the Board and the Fish and Wildlife Commission.

Strategy 4.6 Pursue funds from other new and traditional sources, such as corporate sponsors and private grants.

Washington Objectives and Strategies

Objective 1: Assess and monitor populations

Strategy 1: Conduct base line inventories and population assessments for species where insufficient or no population and distribution information exists such as jackrabbits, amphibians, bats, small mammals, invertebrates and others.

Strategy 2: Improve our understanding of baseline ecology of golden eagles, burrowing owls and other species in the Mainstem Subbasin and prevent further declines that would lead to a state or federal Threatened or Endangered listing

Strategy 3: Continue existing population monitoring efforts

Strategy 4: Monitor population response to protection, restoration and management efforts

Strategy 5: Determine habitat associations of shrub-steppe obligate and shrub-steppe associated species such as sage sparrows, Brewer's sparrows, and sagebrush voles at both local and landscape scales.

Objective 2: Write recovery plans for species requiring such action

Strategy 1: Utilize population, habitat and limiting factor information to develop recovery strategies.

Objective 3: Maintain current wintering waterfowl numbers and increase current levels of waterfowl production.

Strategy 1: Protect existing islands from human disturbance if needed.

Strategy 2: Create or enhance islands and embayments.

Strategy 3: Create or enhance existing brood ponds.

Objective 4: Increase Washington state sage grouse population to ≥ 1,500 birds. The population should consist of at least three distinct sub-populations: ≥500 sage grouse in Management Zone 2; ≥500 sage grouse in Management Zone 4; and ≥250 sage grouse in either Management Zone 1, 3, 5, or 6. An additional ≥250 sage grouse should also be scattered through Management Zones 1, 3, 5, or 6 [Recovery Zones 4 and 5 are within the Mainstem Subbasin] (WDFW State Management Plan for Sage Grouse, 1995).

Strategy 1: Assess potential sage grouse habitats within the Mainstem Subbasin through standardized mapping efforts used throughout the Columbia Plateau.

Strategy 2: Improve quantity, quality, and configuration of the shrubsteppe habitat necessary to support a viable population of sage grouse.

Objective: 5 Recover ferruginous hawks from threatened status by maintaining a population of at least 60 nesting pairs statewide, including at least 40 pairs in the Central Recovery Zone and at least 10 in the south Recovery Zone [The Mainstem subbasin is within the Central and South Recovery Zones] (WDFW1996).

Strategy 1: Improve our understanding of the suitability and security of ferruginous hawk nesting habitats (Goal 3.1 and Research Topics in section 7 of Recovery Plan, WDFW 1996).

Strategy 2: Assess the importance of survival rates and contaminants of adult and juvenile ferruginous hawks to low rates of nest occupancy, and relate these to hawk movements (Goal 3.1 of WDFW Recovery Plan, 1996)

Strategy 3: Improve ferruginous hawk nest occupancy.

Objective 6: Maximum fishing, hunting and non-consumptive recreational opportunities compatible with healthy, diverse fish and wildlife populations. (WDFW 1999, WDFW 2000, WDFW 2001).

Strategy 1: Monitor harvest of fish and wildlife (WDFW 1999, WDFW 2000, WDFW 2001)

Strategy 2: Use population and harvest information to predict changes (WDFW 1999, WDFW 2000, WDFW 2001).

Strategy 3: Increase access opportunities for public hunting, fishing and non-consumptive wildlife recreation.

Goal 3-1: Maintain and protect existing high quality habitat areas for the conservation of viable wildlife populations.

Objective 1: Map and periodically monitor specific types of shrub-steppe.

Strategy 1: Map shrub-steppe within the subbasin using a method that permits evaluation of habitat potential, habitat condition, and endemic features of the landscape such as slope, aspect, soil, and weather.

Strategy 2: Develop a system for monitoring changes in habitat on a regular 5-year intervals.

Objective 2: Secure key habitats through purchase, conservation easement, lease or other appropriate means (WDFW State Recovery Plan for Ferruginous Hawk 1996, Hays et al. 1999)

Strategy 1: Protect an additional ≥16,000 ha. of high quality, occupied, relatively contiguous habitat throughout Management Zones 1, 3, 5, and 6 [Recovery Zones 4 and 5 are within the Mainstem subbasin] (WDFW State Management Plan for Sage Grouse 1995).

Strategy 2: Acquire or protect wetland and riparian habitats

Strategy 3: Protect existing islands from erosion

Strategy 4: Install wave “dissipater” between bays and Columbia river.

Objective 3: Enforce existing policies, laws and guidelines designed to protect and maintain habitats.

Goal 3-2. Restore degraded areas

Objective 1: Identify areas appropriate for habitat restoration.

Strategy 1: Identify landscape connectivity needs in all habitats

Strategy 2: Develop GIS inventory of shrub-steppe (WDFW Sage Grouse Management Plan 1995)

Strategy 3: Develop prioritization plans based upon inventory information

Objective 2: Secure for restoration key habitats through purchase, easement, lease or other appropriate means

Strategy 1: Acquire for restoration key parcels for connectivity in shrub steppe ecosystems

Strategy 2: Acquire for restoration wetland and riparian habitats

Objective 3: Restore degraded terrestrial habitats:

Strategy 1: Evaluate shrub-steppe restoration activities, including the WDFW’s and ODFW’s habitat restoration efforts, the Conservation Reserve Program, and species-specific restoration activities on other public and private lands.

Strategy 2: Develop restoration guidelines for shrub-steppe habitat including grazing management, seed mixtures for re-vegetation efforts, weed control methods, and considerations for landscape configuration.

Strategy 3: Improve uplands for waterfowl nesting by controlling weeds adjacent to wetlands and increasing amount of riparian shrub cover.

Strategy 4: Restore native shrub-steppe plant communities and reduce exotic weed species by increasing native grass, forb, and shrub cover.

Strategy 5: Continue to develop, distribute, and monitor use of bio-control agents (insects, microorganisms, etc.) for exotic weed control.

Objective 4: Restore degraded wetland and riparian habitats.

Strategy 1: Create new islands or increase elevation of existing islands if appropriate

Strategy 2: Create new embayments, alter inlets/outlets to existing embayments (to reduce negative impacts of water fluctuation), or contour bottom and shoreline of embayments to maximize habitat value.

Strategy 3: Create (excavate, impound) new ponds near river shoreline

Strategy 4: Enhance existing ponds (e.g., excavate to remove emergent vegetation, remove carp)

Strategy 5: Plant desirable riparian trees, shrubs, forbs, and grasses in riparian zones.

Research, Monitoring, and Evaluation

Anadromous Salmonids

Project 199406900, *Development of a Conceptual Spawning Habitat Model for Fall Chinook Salmon*, is a research project being conducted in the Hanford Reach. The objective of this project is to use the Hanford Reach fall chinook salmon and their habitat as an analog to determining the features of mainstem alluvial rivers that are important for adult fall chinook salmon. The research 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 carry 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 of Project 199406900 have been presented in several journal articles, including Geist and Dauble (1998), Geist et al. (2000), Geist (2000), and Dauble and Geist (2000).

Project 199102900, *Post-release Attributes and Survival of Hatchery and Natural Fall Chinook Salmon in the Snake River*, conducts research in both the main-stem 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. Changes in rearing habitat were quantified as a function of river flow and showed that there is less available habitat at higher discharges. The amount of area created from power peaking operations at Priest Rapids Dam that can entrap juvenile salmon was quantified for different decreases in flow. Investigations in McNary Reservoir showed that fall chinook salmon do not prefer riprap habitats, which makes much of the riprapped shorelines of main-stem reservoirs 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-list Snake River fall chinook salmon.

Project 199701400, *Evaluation of Juvenile Fall Chinook Stranding on The Hanford Reach*, is an ongoing study aimed at reducing the mortality of juvenile fall chinook resulting from flow fluctuations from Priest Rapids Dam. Hourly flows fluctuate rapidly due to changes in hydroelectric generation (power peaking), irrigation, water storage, and flood control. 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 four 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. The results of this project will ultimately be used to develop a long term agreement and operations plan to minimize chinook mortality in the Hanford Reach during the susceptibility period and to develop a monitoring program to determine implementation dates for the plan and critical time periods of maximum susceptibility.

Project 198201300, *The Columbia River Coded Wire Tag (CWT) Recovery Project*, is an ongoing data collection and data management program by ODFW, WDFW, and Pacific States Marine Fisheries Commission (PSMFC) that supports a coastwide stock identification system for coded-wire tagged salmonid fish. Within the Subbasin, the CWT is used extensively for stock identification of hatchery and wild anadromous salmonid stocks. In particular, the tag data are used to monitor the status of both threatened and endangered stocks. In addition, the recovery data are used to assess a wide variety of studies designed to improve survival of hatchery produced salmonids. CWT recovery information also provides critical data for evaluating stock rebuilding programs. This program is conducted in conjunction with the U.S. Chinook Technical Committee's Upriver Bright Fall Chinook Spawning Escapement Sampling.

Snouts from adult fish for dissection and CWT extraction and pertinent biological data are collected from sampling the Columbia River sport and commercial fisheries, hatchery operations, and carcass recovery in the Hanford Reach area and from spawning surveys in the Priest Rapids Pool. Additionally, biological data are collected via a trap in the Priest Rapids Dam adult fishway . However, no fish are sacrificed to collect CWT's at this location.

Resident Predators

Project 199007000, *The Northern Pikeminnow Management Program*, includes an evaluation component, which has indicated that annual exploitation of northern pikeminnow has averaged approximately 12%, and predation on juvenile salmonids has been reduced approximately 25%. Northern pikeminnow are marked annually, then recoveries in program fisheries are used to estimate exploitation. A model is used to estimate changes in predation resulting from changes in size structure of northern pikeminnow populations, which are a result of the fisheries targeting on large, predator-sized fish.

A more comprehensive evaluation was implemented annually from 1990-96, but is now conducted every 3-5 years. In addition to estimating exploitation, this work includes an evaluation of compensation by smallmouth bass, walleye, and surviving northern pikeminnow. Benefits of the program would be reduced if these predators increased consumption directly, or through indirect consequences such as increased growth or survival. No evidence of changes in consumption, growth, survival, or fecundity (of northern pikeminnow) has been found to date. Sampling was last conducted in 1999, and is scheduled again for 2003.

White Sturgeon

One goal of Project 198605000, *Status and Habitat Requirements of White Sturgeon Populations in the Columbia River Downstream from McNary Dam*, is to provide a final recommendation for operation of the hydropower system that will enhance physical habitat conditions for white sturgeon. Meanwhile, activities implemented to mitigate for hydropower system operations include (1) intensive management of fisheries for impounded populations, and (2) transplanting juvenile white sturgeon from below Bonneville Dam to The Dalles and John Day reservoirs. Assessments of population status and progress toward recovery are estimated through mark-recapture evaluations once every five years in Bonneville, The Dalles, and John Day reservoirs.

Further research and monitoring activities as part of this project include indexing recruitment success in impoundments, and refining and evaluating hatchery technology. Sampling for age-0 white sturgeon is conducted in various impoundments annually to document success or failure of recruitment, and to determine relationships between recruitment and environmental variables such as flow. Artificial propagation may eventually be needed to restore populations in mid-Columbia reservoirs where little or no recruitment has been documented. Evaluations include determining the size at which young white sturgeon should be released to minimize losses to predation.

Wildlife

No BPA-funded wildlife research or monitoring activities are currently underway in the subbasin. Studies of wildlife include state-funded inventories of waterfowl, big game and other populations, ongoing inventories conducted within USFWS refuges and other federal lands, and research conducted through universities or other funding sources.

Fish and Wildlife Needs

Fish and wildlife needs generally pertain to limiting factors in the subbasin that have not been adequately addressed. Further information regarding these factors may be needed, or remedial actions to improve conditions may be warranted and feasible.

Anadromous Fish

This section includes both general discussions of some needs and a list of specific actions necessary to address limiting factors.

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. As indicated in a previous section, 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 fish use will assist managers in developing hydropower system operational scenarios.

The Columbia River hydropower system has increased the travel times of emigrating juvenile salmonids from those experienced historically. Spring and summer flows are currently augmented to reduce the travel times of in-river migrants and reduce exposure to such risks as predators, disease, and high summer temperatures. While this intuitively should increase fish survival, a clear flow-survival relationship has yet to be demonstrated and is the subject of considerable debate. The effects of flow on salmonid travel time and survival are often confounded with other behavioral, biological, and environmental factors. River flow is one of few variables that can be managed for juvenile salmonids, but much remains to be learned of its role as a limiting factor.

The bacterium *Flexibacter columnaris* has been shown to be a significant pathogen to steelhead, and coho and chinook salmon (Holt et al. 1975; Becker and Fujihara 1978). The incidence of *Flexibacter columnaris* in the main-stem Columbia River has not been rigorously monitored in recent history. Its occurrence in juvenile fall chinook salmon has been anecdotal, but may be associated with mortality events observed at dams. The USGS has detected the presence of *Flexibacter columnaris* in juvenile fall chinook salmon collected at McNary Dam in 1998 and John Day Dam in 1994. Fish at John Day Dam were collected 10 d after an estimated 100,000 fish died at McNary Dam due to thermal-related problems, and possibly *Flexibacter columnaris* infection. Little is known about the environmental and biological conditions that contribute to large-scale infections that could decrease fish performance and survival.

Hydropower System Development and Operations

- Assess the effects of hydropower system operations on salmon spawning activity in the Hanford Reach and in the tailrace areas of mainstem dams. This would include an evaluation of whether fall chinook salmon spawn in the Hanford Reach only during the day, and the relative proportion of wild and hatchery fall chinook salmon that spawn in the Hanford Reach. This has implications for an extension of the Vernita Bar Agreement which uses "reverse load factoring" to encourage fall chinook to construct redds at elevations that will not become dewatered during periods of low flow.
- Assess fall chinook salmon fall back at Priest Rapids Dam (PRD). The effects of fall back on the estimation of escapement to spawning areas above and below PRD is critical to the management of these populations. Further, the implications of fall back on the energy reserves of the adult fall chinook salmon that fall back over PRD needs to be understood in order to allow managers the ability to perform a risk assessment of the factors that may affect fall back rates (e.g., the operation of the PR hatchery channel/trap).
- 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.
- Add large woody debris, create shallow water areas, enhance alcove, slough, and side channel connections to the main channel, establish emergent aquatic plants in shallow water areas, and stabilize reservoir water levels (NMFS 2000).
- 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 supports all life history stages (e.g., spawning, rearing, adult holding).

- Estimate the quantity and production potential of available fall chinook rearing habitat in McNary, John Day, and The Dalles reservoirs.
- Estimate growth potential and survival of juvenile fall chinook salmon in the Hanford Reach and through McNary and John Day reservoirs.
- Develop indicators of ecosystem health for the Hanford Reach, and evaluate existing conditions relative to those indicators. The use of the Hanford Reach as a model for recovery actions needs to be verified. This will ensure that management decisions regarding applicability of the Reach to other systems are appropriate.
- 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.
- Limit daytime flows to a maximum of 70 kcfs during the fall chinook salmon spawning period and maintain this as a minimum flow through egg incubation and emergence.
- Limit flow fluctuations to ±20 kcfs when weekly average flows are <170 kcfs and no spill is occurring, and limit fluctuations to ±30 kcfs when weekly average flows are <170 kcfs and spill is occurring. When flows exceed 170 kcfs, maintain a minimum hourly discharge of 150 kcfs.
- Place 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 (GPUD).
- Increase understanding of habitat use of adult and juvenile Pacific lamprey in the Hanford Reach and tailraces of mainstem dams.
- Assess the effects of water level fluctuations on invertebrate production in the Hanford Reach.

Water Quality

- Develop a defensible quality methodology to assess points of compliance for measuring both temperature and dissolved gas presence in the Columbia River.
- Identify the combined effects of elevated summer water temperatures that meet or exceed regulatory criteria and exposure to acute stressors on the physiology, performance, and survival of juvenile fall chinook salmon.
- Reduce the seasonal phase shift of temperature in the mainstem if an assessment of the response of aquatic ecosystems to altered temperature regimes shows that the synchrony of spawning/emergence timing with availability of high-quality benthic invertebrates has been affected by the construction of upstream storage projects.
- Research methods to provide cool water for migrating salmonids. Assess existing and potential for cold water refugia.
- Monitor, assess, and mitigate impacts from Hanford Site development and environmental cleanup and restoration activities.

- Determine the location and effects of ground water input, tributary input, and cold water habitat by use of forward looking infrared radiometry technology.

Irrigation Withdrawals

- Evaluate the effects of all proposed water withdrawals on water quality, habitat, food webs, and predation on juvenile salmonids.

Food Webs and Predation

- Continue implementation and evaluation of the Northern Pikeminnow Management Program.
- Continue evaluation of intensive removal of predaceous northern pikeminnow. Implement evaluation of control programs for other predators including seagulls, bass, and walleyes (CRITFC 1995).
- Determine losses of juvenile fall chinook salmon in the Hanford Reach and Wanapum Dam tailrace from predation by smallmouth bass and channel catfish. This is needed to evaluate the relative importance of other losses of juvenile fall chinook (e.g., stranding).
- Evaluate relationships between exotic fish predator (smallmouth bass, walleye, and channel catfish) abundance and operation of the hydropower system. Assess feasibility of reducing predation on juvenile salmonids through changes in operations or by other means.
- Develop an energy budget for juvenile fall chinook salmon that use the Hanford Reach and Wanapum Dam tailrace.

Exotic Species

- Assess American shad – salmonid interactions. Specifically, there is a need to evaluate the effects to migrating anadromous adults from shad “clogging” adult ladders at mainstem dams (e.g., Priest Rapids). There is also no current policy among the fish management agencies to guide decisions that could result in expansion of American shad range within the Columbia River basin. Currently, American shad are restricted to the Columbia River below Priest Rapids Dam because of ladder design. There is also a need to determine if American shad create deleterious conditions to juvenile salmonids through predation and competition in the rearing environment.

Resident Fish

- Develop a defensible quality methodology to assess points of compliance for measuring both temperature and dissolved gas presence in the Columbia River
- Determine the hydropower system operation program that will maximize the productivity of white sturgeon in reservoirs while also supporting salmonid recovery in the Columbia River Basin.
- Determine appropriate stocks and mechanisms for supplementing white sturgeon populations in reservoirs.
- Develop both short term and long term strategies for white sturgeon supplementation.

- Develop, implement, and evaluate a management plan for white sturgeon in Columbia River reservoirs.
- Assess mountain whitefish abundance, productivity, and harvest in the Hanford Reach.
- Develop an estimate for the pre-impoundment productivity of each of the mainstem Columbia River reservoirs for mountain whitefish.
- Determine the potential magnitude of the recreational fishery for mountain whitefish that could have developed in the impounded reaches of the Columbia River.
- Develop an inventory of appropriate locations, including possible habitat alteration requirements, and fish stocks for use in the creation of in-lieu fisheries to replace the lost recreational opportunities for mountain whitefish.
- Develop, implement, and evaluate a management plan for mountain whitefish in-lieu fisheries in the Columbia Basin.
- Conduct comprehensive inventories of resident fish populations in each mainstem reservoir and the Hanford Reach.

Wildlife

The first group of needs address actions necessary to effectively survey, protect, or manage individual species or groups of species within the subbasin. These are followed by needs addressing actions to effectively protect or manage habitat types used by these species. The final group of needs are specific to the Hanford Reach.

Birds

Waterfowl/shorebirds/water birds

- Assess the affects of water fluctuations on mudflat habitat availability and shorebird foraging and migration timing
- Inventory all colonial nesting birds (herons, gulls, terns, etc.) along the river, map, document and institute conservation measures (e.g. protection from disturbance)
- Increase amount and quality of nesting cover
- Increase amount and quality of brood rearing habitat
- Management of waterfowl habitats to maintain quality
- Continue to monitor breeding activity (pair counts, nest surveys)
- Research waterfowl use of irrigation projects
- Maintain or improve availability of field grains
- Increase the amount of moist soil habitats
- Restore agricultural habitats for nesting and brood rearing
- Increase quality of waterfowl reserve areas

Raptors

- Management and protection of important bald eagle habitats (nesting, roosting, foraging), including primary and potential habitats
- Increased law enforcement and public awareness
- Continued research on bald eagle requirements to provide future management direction
- Continued monitoring of bald eagle populations and productivity.
- Protection of peregrine falcon habitats, especially nest sites, potential nest sites and areas of prey concentrations
- Breeding and wintering surveys of peregrine falcons
- Population surveys of occupancy and reproduction for peregrine falcons, and analyses of eggshell thickness and contamination
- Research on population dynamics, movements, and contamination of peregrine falcons

Shrub-Steppe Associated Raptors

- Improved nest occupancy and success for ferruginous hawks
- Assessment of possible affects of contaminants on survival and nest occupancy rates for ferruginous hawks and relationship of these to movements
- Improve understanding of golden eagle baseline ecology - specifically food habits and the relationship of shrub-steppe prey to nest occupancy and productivity
- Assess possible contaminant loads in golden eagles and determine year-round movements of locally breeding golden eagles from satellite telemetry.

- Monitoring to detect changes in burrowing owl populations
- Inventories of occupied burrows in areas with high burrowing owl densities
- Identification of habitat needs for burrowing owls

Migratory Songbirds

- Protect and manage nesting habitat to ensure reproductive success of breeding population
- Monitor long-term population trends
- Identify historical nesting areas
- Restore nesting habitat
- Identify key lands for conservation easements and/or acquisition

Cavity Excavators

- Provide and protect conifer forests, riparian habitats and oak woodlands habitats that include major components of large diameter trees
- Reduce road densities to reduce snag cutting
- Monitor long-term population trends
- Continue research into habitat needs and associations
- Educate forest users to the value of snags and wildlife tree habitats
- Identify key lands for conservation easements and/or acquisition

Shrub-Steppe Migratory Songbirds

- Needs for sage thrasher, loggerhead shrike, sage sparrow, and others in the subbasin include:
- Reduce (through restoration) and prevent further degradation and fragmentation of large contiguous blocks of shrub-steppe habitat
- Improved monitoring to detect changes in their populations

Sage Grouse

- Reduction (through restoration) and prevention of further degradation and fragmentation of large contiguous blocks of shrub-steppe habitat.
- Expansion of sage grouse range into currently unoccupied areas.
- Evaluation of potential habitat that is currently unoccupied
- Restoration of the shrub-steppe herbaceous species (grasses and forbs) on a landscape scale
- Restoration of sagebrush in areas where the shrub-steppe herbaceous component already exists

Mammals

Beaver

- Development and initiation of standardized, objective population monitoring systems
- Restoration of wetlands and riparian habitats

Big Game (Deer, Elk)

- Better demographic and population monitoring

Pygmy Rabbits

- Surveys for possible pygmy rabbit presence in potential habitat
- Restoration of shrub-steppe habitat with deep soils
- Black-tailed and White-tailed (*Lepus townsendii*) Jackrabbits -
- Develop monitoring to detect changes in jackrabbit populations
- Investigate apparent population decline and habitat relationships

Bats

- Protect key roost and hibernacula habitats to ensure reproductive and over wintering success
- Perform baseline studies to determine species presence and habitat associations
- Monitor long-term population trends

Amphibians and Reptiles

- Protection of habitats
- Development of effective survey and monitoring techniques
- Baseline surveys and inventories and monitoring of populations
- Protection from introduced species such as bullfrogs
- A better understanding of ecology and life histories

Invertebrates

- Protection of habitats
- Inventory, surveys and monitoring of butterfly populations
- Maintenance and restoration of habitats
- Further investigation of the ecology and life history requisites of butterflies

Habitat Areas and Quality

Forested

- Protect remaining old forest stands, particularly ponderosa pine
- Re-introduce fire in maintenance of dry forests
- Protect healthy populations of Western white pine resistant to blister rust
- Maintain large tree components
- Decrease road densities
- Reduce fragmentation of forest habitats

Riparian

- Protect high quality habitats
- Restore desirable riparian vegetation

Wetlands

- Protect high quality habitats
- Create or enhance wetland habitat through use of embayments
- Manage wetland areas to maintain fish, wildlife and cultural benefits

Shrub-Steppe

- Reduce (through restoration) and prevent further degradation and fragmentation of large contiguous blocks of shrub-steppe habitat
- Evaluate shrub-steppe restoration techniques and share information between agencies, tribes, private landowners and other groups involved in shrub-steppe restoration
- Develop and implement shrub-steppe restoration techniques that are economically feasible over large landscapes (e.g. establishing sagebrush by seed rather than by hand-planted rooted seedlings).
- Support education efforts on the value of shrub steppe habitats

Agricultural

- Habitat restoration on chronically idle or un-farmable lands
- Permanent vegetation restoration and management on canal and drain right-of-ways
- Development of wildlife habitat on edge, fence row and economically marginal lands
- Wetland restoration and management throughout the agricultural zone
- Utilization of tillage and harvest methods that allow waste grain to remain available to wildlife throughout the winter months

PNNL Recommended Actions

The Hanford Reach of the Columbia River as a model of metapopulation dynamics and study area for "normative" river reaches is also applicable for a variety of flora and fauna conditions that currently exist there. The following topics presented below are those where knowledge of the effects on selected wildlife from hydroelectric power is limited, and where opportunities exist to further assess impacts from hydroelectric operations on the nearshore flora and fauna.

- Assess effects of water flow regimes on nesting success of waterfowl and shorebirds. Specifically use existing long-term empirical datasets of nest inundation rates to correlate with the historical flow-regimes, and use existing hydrologic models to predict effects of various operating conditions.
- Evaluate potential displacement of salmon carcasses and subsequent loss of nutrients to aquatic macroinvertebrate and vertebrate communities (e.g., eagles) caused by fluctuating water levels. Specifically, monitor movements and fate of salmon carcasses along the Hanford Reach, and model overall impacts resulting from various operating conditions.
- Develop model(s) to assess potentially deleterious effects of rapid and frequent water fluctuations on native flora, especially those currently listed under the U.S. Endangered Species Act.

- Monitor levels of various organic and inorganic contamination in avian, terrestrial, and aquatic organisms and assess the contribution of these contaminants from regional sources.

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APPENDIX A

HGMP FOR PRIEST RAPIDS HATCHERY

HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Washington Department Fish and Wildlife

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of Program

Upper Columbia Fall Chinook Salmon Hatchery Program -
Priest Rapids Hatchery Complex

1.2) Population (or stock) and species

Upper Columbia River Summer- and Fall-run ESU chinook salmon (*Oncorhynchus tshawytscha*); fall-run component.

1.3) Responsible organization and individual:

Name(and title): Washington Department Fish and Wildlife
Organization: " "
Address: 600 Capitol Way North, Olympia, WA 98501-1091
Telephone: (Larry Brown, Lead Biologist) 509.664-1227
Fax: " " 509.662-6606
Email: brownlgb@dfw.wa.gov

Other organizations involved, and extent of involvement in the program:
The fall chinook salmon run size enhancement program is funded by Grant County Public Utility District (PUD) No. 2 for the purpose of mitigation for fishery impacts caused by the Priest Rapids Project (including Priest Rapids and Wanapum dams). The program is consistent with the Mid-Columbia Mainstem Conservation Plan ("MCMCP" - BAMP 1998), and the parties to this plan are involved in short and long-term production planning. In addition, fall chinook sub-yearlings are currently produced as partial mitigation for John Day Dam, as funded under a Federal Energy Regulatory Commission Settlement Agreement.

1.4) Location(s) of hatchery and associated facilities:

Broodstock Capture: Priest Rapids Hatchery Trap - located in the hatchery outfall channel emptying into the mainstem Columbia River (WRIA 36-0001), Washington at Rkm 662; and (secondarily, if necessary) Priest Rapids Dam ladder trap (same approximate location), on the mainstem Columbia River.
Broodstock Holding to Maturity*:* Priest Rapids Hatchery - located on the mainstem Columbia River (WRIA 36-0001), Washington at Rkm 662.
Fish Spawning, Incubation, Rearing: Spawning: Priest Rapids Hatchery.
Incubation*:* Priest Rapids Hatchery (transfers to Umatilla and Klickitat hatcheries).
Rearing*:* Priest Rapids Hatchery.
Rearing to release: Priest Rapids Hatchery - located on the mainstem Columbia River (WRIA 36-0001), Washington at Rkm 662.

1.5) Type of program:

The Priest Rapids fall chinook salmon artificial propagation project operated and managed by WDFW in the upper Columbia River region is an "integrated harvest" program.

1.6) Purpose (Goal) of program:

The goal of the Priest Rapids fall chinook salmon is to mitigate for the loss of fall-run chinook salmon adults that would have been produced in the region in the absence of the Priest Rapids Project. Additional fall chinook sub-yearlings are also produced as partial mitigation for John Day Dam, which is funded from sources other than the MCMCP. These goals can be met through the use of the artificial environment of the Priest Rapids fish rearing facilities to increase the number of adults that return to the region by increasing survival at life-history stages where competitive or environmental bottlenecks occur. Concurrently, a release strategy for artificial production is employed that will not create a new bottleneck in productivity through competition with the naturally produced component of the population and other naturally-produced stocks.

1.7) Specific performance objective(s) of program: (from Integrated Hatchery Operations Team, IHOT 1995):

(1) produce 100,000 pounds of sub-yearling up-river bright (URB) fall chinook (5,000,000 fish at 50 fpp) for on-station release as mitigation for the Priest Rapids Project;
(2) produce an additional 1,700,000 URB fall chinook sub-yearlings for on-station release as partial mitigation for John Day Dam;
(3) provide 100,000 to 17,500,000 fall chinook eggs surplus to on-station needs for transfer to other up-river bright fall chinook production programs, including those at Klickitat and Umatilla hatcheries.
(4) minimize interactions with other fish populations through proper rearing and release strategies;
(5) maintain stock integrity and genetic diversity of the propagated chinook stock through proper management of genetic resources;
(6) maximize survival at all fall chinook life stages using disease control and disease prevention techniques. Prevent introduction, spread or amplification of fish pathogens;
(7) conduct environmental monitoring to ensure that hatchery operations comply with water quality standards and to assist in managing fish health., and
(8) communicate effectively with other salmon producers and managers in the Columbia River Basin.

1.8) List of Performance Indicators designated by "benefits" and "risks":

Benefits:

(1) an enhanced post-release smolt-to-adult survival rate for hatchery-reared juvenile fall chinook salmon, evaluated through fishery contribution and trap recovery data;
(2) trapping of sufficient broodstock to meet programmed release numbers (a minimum of 500 females);

(3) use of broodstock collection, mating and fish cultural methods which maintain the genetic integrity of the stock; and
(4) use of fish cultural methods which lead to the release of high quality smolts.

Risks:
(1) the natural fall chinook salmon population in Hanford Reach appears to be at low risk of extinction, thereby not requiring extensive hatchery intervention to increase the abundance and viability of natural spawners;
(2) stress-related mortality of returning adults collected as broodstock (including hatchery and natural-origin fish), and increased mortality of eggs from spawned adults, resulting from high water temperatures in the reservoirs during the late summer, early fall adult migration period;
(3) the potential adverse genetic and ecological effects of the existing mainstem fall chinook salmon release program on natural salmonid populations;
(4) the risk of additional collections of natural adults for broodstock (particularly for the sub-yearling release programs) to the natural donor populations;
(5) the potential for long-term genetic deterioration is accentuated by the significant number of hatchery fish released through the program and the indefinite nature of the program; and
(6) the continued infusion and presence of hatchery-origin fall chinook on the spawning grounds makes it difficult to accurately assess the health of the natural population.

1.9) Expected size of program:

Expected releases:
The current, and future, expected size of the Priest Rapids Hatchery fall chinook hatchery program (fish production by facility) is indicated in the "Mid Columbia Hatchery Plan" (BAMP 1998). Current, annual production of fall chinook salmon at Priest Rapids Hatchery is 100,000 lbs. of marked and unmarked sub-yearling smolts (5,000,000 fish at 50 fpp). In addition, 1,700,000 sub-yearlings are currently produced at Priest Rapids as partial mitigation for John Day Dam, which is funded through the U.S. Army Corps of Engineers, and not Grant County PUD. Both these production groups will be maintained for the near future.

In future years, up-river bright fall chinook salmon releases from Priest Rapids Hatchery would increase to 6 million sub-yearling smolts (120,000 lbs. at 50 fpp), plus the production for John Day mitigation. However, current or future production at Priest Rapids Hatchery for John Day mitigation will not preclude current or future production capabilities for the Mid-Columbia Hatchery Program. Production for the MCMCP will take priority over production for compensation programs outside the Mid-Columbia Region. Priest Rapids Hatchery may be modified to meet this future, increased production objective. Modifications could probably include increased incubation and rearing capacities, although an analysis of program needs would be required prior to any changes at the facility (BAMP 1998).

Adult fish produced/harvested:
Production at Priest Rapids Hatchery has been self-sustaining in terms of adult fall chinook returns for the annual release program since 1984, and adult returns normally exceed egg take needs. The hatchery has become a net exporter of fall chinook eggs since that year (Chapman et al. 1994).

Table 1 presents the annual number of fall chinook taken from the Priest Hatchery (volunteer) trap and Priest Rapids Dam east fish ladder. Between 1987 and 1993, only 2.5 % of the fall chinook broodstock used at the hatchery have come from the fish ladder. Annual escapement of fall chinook salmon to the Priest Rapids Hatchery trap averaged 10,012 adults (range 2,497 - 17,350) (1986–1998 return year data from WDFW Hatcheries Program, September, 1999). Priest Rapids Hatchery-origin adults comprise the majority of the fish volunteering to the trap, although Hanford Reach wild fish, and URB fall chinook from other Basin hatcheries and mid-Columbia natural production areas, are also captured in the trap and are infused into the annual spawning population.

For the 1976 to 1989 broods, the average release to adult survival (including fishery contribution and escapement) of sub-yearlings released from Priest Rapids Hatchery is 0.84% (BAMP 1998). Table 2 compares estimated, mean survival rates for WDFW summer and fall chinook sub-yearling and yearling smolt releases presented in the Mid-Columbia Hatchery Plan (BAMP 1998). Smolt to adult survival rates for Priest Rapids Hatchery fall chinook have been estimated to range from 0.29 % to 2.44 % (smolt to adult overall survival estimates for brood years 1983-87 from IHOT 1995). The hatchery smolt to adult survival rate goal is 1.0 % (IHOT 1995).

Table 1. Number of fall chinook adult broodstock taken from the Priest Rapids Hatchery volunteer trap and Priest Rapids east bank fish ladder - brood years 1986-98 (data from Chapman et al. 1994 and WDFW Hatcheries Program, October 1, 1999).

Brood Year	Priest Rapids FH Trap	East Bank Ladder	Total Trapped
1986	11,114	3,702	14,816
1987	17,350	821	18,171
1988	9,598	368	9,966
1989	6,496	0	6,496
1990	3,409	70	3,479
1991	2,497	139	2,636
1992	6,093	4	6,097
1993	8,891	0	8,891
1994	13,819	0	13,819
1995	10,740	0	10,740
1996	14,280	0	14,280
1997	10,836	0	10,836
1998	15,029	0	15,029

Table 2. Release-to-adult survival rates of summer and fall chinook salmon reared as sub-yearlings and yearlings at selected hatcheries in the Mid-Columbia Region. Survival rates are expressed as un-weighted means of variable-sized release groups.

Hatchery	Age at release	Release years	Release-to-adult survival rate (%)
Priest Rapids	sub-yearling	1976 - 1989	0.835
Rocky Reach	yearling	1984 - 1989	1.366
Wells	sub-yearling	1976 - 1989	0.098
Wells	yearling	1976 - 1989	0.410

The estimated mean exploitation rate (using adult equivalents) for Priest Rapids Hatchery fall chinook was 64 % for brood year 1975-87 releases, ranging between 31 % (for the 1978 brood) and 83 % (for the 1984 brood) over that year span (Chapman et al. 1994).

The actual proportion of the total number of fall chinook spawning naturally within the mid- and upper Columbia River region that are of Priest Rapids Hatchery origin is unknown. Natural spawning in Hanford Reach from 1990-94 averaged 51,000 fish (Myers et al. 1998). As a result of large releases of ocean-type chinook in the mainstem Columbia and the Yakima River in recent years, a substantial proportion (approximately 50 %) of the adults returning to the ESU appear to be of hatchery-origin (Myers et al. 1998).

Escapement goal:
As cited in Chapman et al. (1994), Norman (1992) estimated optimum escapements for adult fall-run chinook passing McNary Dam of either 21,905 or 41,094. The Columbia River Fish Management Plan of 1993 specified an escapement goal of 45,000 up-river bright fall chinook past McNary Dam. The annual hatchery adult collection goal at Priest Rapids Hatchery is 6,102 (IHOT 1995).

1.10) Date program started or is expected to start:

Priest Rapids Hatchery began operations as a full scale hatchery in 1981. The hatchery evolved from a spawning channel constructed downstream from Priest Rapids Dam in 1963. The facility was operated only as a spawning channel from 1963-71, using summer/fall chinook adults trapped in the east ladder of Priest Rapids Dam. Artificial propagation of fall chinook at the site began in 1972, and between 1972 and 1977, part of the facility's production came from hatchery-raised chinook. Starting in 1978, all fish released from Priest Rapids have come from hatchery production (Chapman et al. 1994). As mentioned previously, production at Priest Rapids Hatchery has been self-sustaining since 1984, and no imports of fall chinook eggs or fry are needed to meet annual programmed release levels.

1.11) Expected duration of program:

The supplementation program will continue indefinitely, with the objective of mitigating for the loss of fall-run chinook salmon production caused by the Priest Rapids, Wanapum, and John Day hydroelectric dam projects.

1.12) Watersheds targeted by program:

Fall-run chinook salmon propagated and released through the Priest Rapids Hatchery program originated from natural and hatchery-origin summer/fall broodstock returning to the mid- and upper Columbia River region. The targeted watershed is the Columbia River mainstem below Priest Rapids Dam (WRIA 36-0001).

SECTION 2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

2.1) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates. Indicate whether this HGMP is consistent with these plans and commitments, and explain any discrepancies.

The Priest Rapids Hatchery program, and the HGMP describing it, are consistent with the following agreements or plans:

- The Mid-Columbia Mainstem Conservation Plan - Hatchery Plan (BAMP 1998).
- The Priest Rapids Project Settlement Agreement between Grant County Public Utilities District #2, their power purchasers, and the joint fishery parties represented by Washington Department of Fish and Wildlife and other state and federal fishery agencies and tribes.
- The Federal Energy Regulatory Commission Settlement Agreement between the U.S. Army Corps of Engineers, Bonneville Power Administration (BPA) (and their power purchasers), and the joint fishery parties represented by Washington Department of fish and Wildlife and other state and federal fishery agencies and tribes.
- Section 10 incidental take permit # 902, originally issued to WDFW by NMFS on April 8, 1994, and amended December 30, 1998.
- Section 10 direct take permit # 1094, issued to WDFW by NMFS on February 4, 1998, with several subsequent modifications.

2.2) Status of natural populations in target area.

Upper Columbia River ESU fall-run chinook salmon (target population) -
The natural population targeted for augmentation is the fall chinook stock spawning in the mainstem Columbia River above, and (predominately) downstream of Priest Rapids Dam in The Hanford Reach. The natural Hanford Reach fall chinook population is considered "healthy" based on escapement trend (WDF and WDW 1993). Natural spawning escapements (including jacks and adults) from 1983-1991 averaged 95,690 fish, with a low return of 50,733 in 1991 and a peak of 164,254 in 1986. The escapement goal of 45,000 fall chinook set as the objective past McNary Dam for natural spawn, hatchery escapements, and the Hanford Reach sport fishery has been met each year from 1983-91 (WDF and WDW 1993). The long term (1964-96) abundance trend based on total escapement for the Hanford Reach stock is positive (+3.5 % per year), with a short term (most recent 7-10 year) trend of - 9.9 % per year (Myers et al. 1998).

WDF et al. (1993) classified Hanford Reach fall chinook as of native stock and wild production. In the 1998 "Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California", NMFS indicated that summer/fall chinook salmon in the ESU including Hanford Reach fall chinook were not in danger of extinction, nor were they likely to become so in the foreseeable future (Myers et al.1998).

Other salmonid species -
Several salmonid species in the target area are listed as “endangered” or “threatened” under the ESA. Upper Columbia River ESU steelhead and Upper Columbia River ESU spring chinook are listed as “endangered”, and Columbia River population segment bull trout are listed as “threatened”. Sockeye salmon originating in the Upper Columbia region upstream of the fall chinook release area were judged as neither in danger of extinction or likely to become so in the foreseeable future by NMFS in the west coast sockeye salmon species status review (Gustafson et al. 1997). The summer-run chinook stocks that comprise the remaining components of the Upper Columbia River summer/fall chinook ESU are “depressed” in status (WDFW and WDW 1993), but were also determined as not warranting ESA-listing (Myers et al.1998).

Other ESA-listed species of significance to the fall chinook program include those that originate in other watersheds within the Columbia River Basin: Middle Columbia River ESU steelhead - “threatened”; Snake River ESU sockeye - “endangered”; Snake River ESU spring chinook - “threatened”; Snake River ESU fall chinook - “threatened”; Snake River ESU steelhead - “threatened”; Lower Columbia River ESU chinook - “threatened”; Lower Columbia River ESU chum - “threatened”; Lower Columbia River ESU steelhead - “threatened”; and Lower Columbia/Southwest Washington ESU coastal cutthroat - “threatened”.

2.2.1) Geographic and temporal spawning distribution.
Hanford Reach fall chinook spawn from late October to early December in the mainstem Columbia River area from Priest Rapids Dam downstream to the Tri-Cities, a distance of approximately 75 km. These chinook adults enter freshwater from mid-August through early November (WDF and WDW 1993; Waknitz et al. 1995).

2.2.2) Annual spawning abundance for as many years as available.

Table 3. Hanford Reach fall chinook spawning escapement estimates (return years 1983-1991 from WDF and WDW 1993).

Return Year	Escapement
1983	56,608
1984	54,377
1985	128,584
1986	164,254
1987	122,835
1988	116,169
1989	79,410
1990	56,204
1991	50,773

2.2.3) Progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for as many brood years as available.

Progeny to parent survival rates:

Smolt to adult survival rates for Priest Rapids Hatchery fall chinook has ranged from 0.29 % to 2.44 % (smolt to adult overall survival estimates for brood years 1983-87 from IHOT 1995). For the 1976 to 1989 broods, the average release to adult survival rate (including fishery contribution and escapement) of sub-yearlings released from Priest Rapids Hatchery is 0.84% (BAMP 1998). The hatchery smolt to adult survival rate goal is 1.0 % (IHOT 1995).

Survival standards established through IHOT, and actually met, for fall chinook propagated at Priest Rapids Hatchery are presented in Table 4. The numbers in parentheses indicate the years of available data.

Table 4. Survival data for fall chinook salmon propagated at Priest Rapids Hatchery (BAMP 1998).

	Prespawn survival (%)			Fertilization to release survival (%)		
	Standard	Actual	Proposed	Standard	Actual	Proposed
Fall chinook salmon						
Priest Rapids	90.0	93.3	93.0	81.0	88.2	83.0

Table 5 presents fall chinook survival data by life stage for the Priest Rapids Hatchery program.

Table 5. Priest Rapids Hatchery fall chinook survival summary by life stage (1983-1987 brood years, from IHOT 1995).

	Percent survival by life stage		
	Hatchery Goal	5-Year Average	Range
Adult (holding)	90 %	95.5 %	93.8 - 97.7 %
Green Egg to Fry	90 %	92.6 %	90.9 - 94.2 %
Fry to Smolt	90 %	96.9 %	94.9 - 98.4 %
Smolt to Adult	**1.0 %**	**1.17 %**	**0.29 - 2.44 %**

2.2.4) Annual proportions of hatchery and natural fish on natural spawning grounds for as many years as possible.

Myers et al. (1998), quoting Miller et al. 1990, reported that because of large releases of ocean-type chinook salmon in the mainstem Columbia River and the Yakima River in recent years, a substantial portion (approximately 50 %) of the adults returning to the Upper Columbia summer/fall chinook ESU appear to be of hatchery-origin. Actual annual proportions of hatchery and natural fish on natural spawning grounds are unknown.

2.2.5) Status of natural population relative to critical and viable population thresholds.

The natural fall chinook salmon population in the Hanford Reach is healthy in status (WDF et and WDW 1993). The Upper Columbia River summer/fall chinook ESU including the Hanford Reach population has been judged as not warranting listing under ESA protective provisions (Myers et al. 1998).

2.3) Relationship to harvest objectives:

The Priest Rapids fall chinook artificial propagation program is a component of the *Mid-Columbia Hatchery Program,* a part of an application for a 50-year multi-species Habitat Conservation Plan (HCP) and re-licensing agreement for the PUDs. This plan has two objectives: (1) to help recover natural populations throughout the Mid-Columbia Region so that they can be self-sustaining and harvestable, while maintaining their genetic and ecologic integrity; and (2) to compensate for a 7% mortality rate at each of the five PUD-owned mid-Columbia River mainstem dams (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) in a manner that is consistent with the first objective. Through the regional hatchery plan, the fall chinook artificial production program has been integrated with harvest management objectives to provide run size enhancement and fishery benefits. Biological risks to listed species in the Columbia Basin posed by hatchery fall chinook releases, including predation, competition, and disease transfer, are expected to be minimal.

Fisheries for summer/fall chinook in the Columbia River are managed under provisions of the Columbia River Fish Management Plan, adopted by U.S. District Court in 1988. URB fall chinook produced at Priest Rapids are harvested in directed fisheries in the mid- and lower Columbia River. In-river fisheries significantly supported by Priest Rapids production include sport fisheries in the Hanford Reach area, Buoy 10, and Zone 1; tribal fisheries from Bonneville Dam upstream; and non-Indian drift gillnet fisheries from the mouth of the Columbia River to Bonneville Dam. In-river harvest of fall-run chinook of up-river origin averaged 131,000 adults from 1987-192 (Chapman et al. 1994). Priest Rapids fall chinook are also harvested in marine area fisheries in Oregon, Washington, British Columbia, and Alaska.

The 1982-89 brood year average ocean fisheries exploitation rate for mid-Columbia River summer/fall chinook is 39 %, with a total exploitation rate of 68 % estimated for the same years (Myers et al. 1998). Chapman et al. (1994) estimated that the 1975-87 brood year mean exploitation rate for fish released from Priest Rapids Hatchery was 64 % (with adult-equivalents accounted for).

Given fishery protection measures implemented in preterminal area, mainstem Columbia River and upper river tributaries to protect ESA-listed and depressed salmonid populations, future harvest rates on fish propagated by the program and on natural populations in the target area are expected to be lower than the mean level estimated for the 1975-87 period.

2.4) Relationship to habitat protection and recovery strategies.

Fall chinook sub-yearlings are produced at Priest Rapids to mitigate for natural adult chinook salmon production to fisheries lost as the result of the construction and operation of the Priest Rapids, Wanapum, and John Day hydroelectric projects. One goal of the Mid-Columbia Habitat Program is to protect and restore critical habitats for salmon and steelhead within the Mid-Columbia Region (Bugert et al. 1997). The "Mid-Columbia Hatchery Program" (BAMP 1998) on which the fall chinook release program is based will therefore work in concert with the regional habitat restoration program.

The main fresh-water habitat problem presently facing this ESU is hydropower dams in the mainstem Columbia River, which have probably reduced returns of summer/fall chinook salmon (Chapman et al. 1994). Measures taken by the Mid-Columbia PUDs to improve natural production of anadromous fish in the region are designed to compensate for mortality in project and reservoir passage. Two strategies will be applied: (1) habitat protection and restoration, and (2) hatchery production of affected species in the mainstem mid-Columbia River and in the four major tributaries (BAMP 1998).

Habitat protection efforts, including improvements in dam passage survival rates, combined with sub-yearling fall chinook production from the Priest Rapids program, are expected to benefit natural fall chinook production over the short-term and long- term. Improvements in dam passage survival rates, and improvements in smolt to adult survival rates afforded by the fall chinook programs will be used to boost the upper river adult population to a level approaching 9,000 fish at Priest Rapids Dam (1974 - 1983 average level identified for initial compensation from BAMP 1998).

2.5) Ecological interactions

Salmonid and non-salmonid fishes or other species that could:
(1) negatively impact program;
Fall chinook are released as sub-yearling smolts in the late spring. Competition for food may play a role in the mortality of liberated fall chinook. SIWG (1984) indicated that there is a high risk that competition between hatchery-origin chinook, and coho, steelhead and other chinook stocks, will have a negative impact on the productivity of the hatchery fish. Predation in freshwater areas also may limit the productivity of the summer chinook releases. In particular, predation by northern pikeminnow poses a high risk of significant negative impact on productivity of enhanced chinook (SIWG 1984). The degree of predation risk to hatchery chinook juveniles posed by coho, steelhead, and other chinook stocks are unknown (SIWG 1984). Hatchery-reared salmon and steelhead released into spawning and rearing areas of natural species may fail to emigrate (residualize), and may negatively interact with natural fish. Steelhead residualism has been found to vary greatly, but is thought to average between 5% and 10% of the number of fish released (USFWS 1994).

(2) be negatively impacted by program;
SIWG (1984) reported that there is a high risk that enhanced chinook salmon populations would negatively affect the productivity of wild chum and sockeye in freshwater and during early marine residence through predation. The risk of negative effects to wild fish posed by hatchery chinook through competition is low or of unknown degree in freshwater and marine areas (SIWG 1984). Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of listed wild fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter wild salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation.

(3) positively impact program;
Increased numbers of other salmonid species that escape to spawn in upper Columbia River tributaries may contribute nutrients to the system upon dying that would benefit fall chinook productivity in the Hanford Reach, and for emigrating Priest Rapids fish in the lower Columbia River.

(4) be positively impacted by program.
Priest Rapids Hatchery fall chinook juveniles released through the WDFW programs may benefit co-occurring salmonid populations. A mass of emigrating hatchery fish may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring wild fish. Increased numbers of hatchery-origin fall chinook that are allowed to spawn naturally may contribute nutrients to the system upon dying that would benefit the productivity of other salmonid species.

SECTION 3. WATER SOURCE

Adult fall chinook used as broodstock are captured in the hatchery outfall channel, and held in a 206,000 ft3 adult holding pond. Eggs and fry are incubated in a 4,000 ft2 hatchery/incubation building, and fish are reared to smolt size in above-ground vinyl raceways. All of these fish propagation structures are supplied with water from one of two sources. The main supply draws river water via a 54" diameter siphon intake located on Priest Rapids Dam (Chapman et al. 1994). This line can supply the hatchery with up to 120 cfs of water from the Columbia River, which is the "home" water source for the propagated population. Six wells drilled on the hatchery site can provide a combined sustainable yield of approximately 16 cfs. Both river water and well water may be used for adult holding, incubation and rearing (IHOT 1995).

The risk of catastrophic loss is minimized through the availability of two separate water supply sources for the hatchery. The availability of gravity feed water from the Columbia River reduces the concern for water loss that may occur with power outages. High water temperatures in the reservoirs during late summer and early fall that periodically causes stress-related mortality if returning adults can be attenuated through increased infusion of well water.

SECTION 4. FACILITIES

Descriptions of the physical plants listed in this section
Attached is a plan view (from IHOT 1995) presenting the physical lay-out of Priest Rapids Hatchery. The primary fish rearing structures that comprise the Priest Rapids Hatchery include a 4,000 ft2 hatchery/incubation building, a 55 x 250 x 15 ft deep adult holding pond, twelve 80 x 8 x 3 ft above-ground vinyl raceways, and five 250 x 36 x 4 ft channel ponds (Chapman et al. 1994). The hatchery contains 80 stacks of vertical incubators giving the facility a total egg capacity of about 10 million.

For programs that directly take listed fish for use as brood stock, provide detailed information on catastrophe management, including safeguards against equipment failure, water loss, flooding, disease transmission, or other events that could lead to a high mortality of listed fish
The only portion of the Priest Rapids Hatchery operation that may lead to the direct take of listed species is the broodstock trapping program. The hatchery channel trap, which is used to collect all fall chinook as volunteers in recent years, may collect straying listed fish, but the likelihood for such take is low. Upstream migrating wild steelhead native to the upper Columbia River drainages, and possibly, Snake River system wild steelhead, may be incidentally encountered as strays during fall chinook broodstock operations occurring between early September and mid-November at Priest Rapids Hatchery. A maximum total of 10 adult steelhead are encountered each year at the trap during chinook broodstock collection (1986-95 base year estimate from Paul Pederson, WDFW, pers.comm. June 1997). The incidence of wild steelhead straying to this facility is low. The hatchery trap does not incorporate a fish weir to guide fish into the hatchery outlet channel or into the trap. All fish returning to Priest Rapids Hatchery are of hatchery-origin, recruiting to the trap as volunteers. The trapping program is therefore not a "run of the river" operation, and captures of other species besides fall chinook salmon produced at the hatchery are minimal.

As a run-of-the-river operation, the Priest Rapids Dam east ladder trap, when used for the collection of fall chinook broodstock, may lead to the direct take of listed stocks, including Upper Columbia River ESU steelhead and (potentially) bull trout. The operation of this trap during the fall chinook return period is presently authorized for steelhead stock assessment purposes under Section 10 direct take permit # 1094 and for bull trout takes under a Section 6 cooperative agreement with USFWS.

Authorized activities at Priest Rapids Dam include the handling of from 246 to 735 Upper Columbia ESU-origin steelhead each year (1986-96 average range). These ranges represent 8-10 % of the passing steelhead population. Because the sample is collected through operation of the trap in one ladder at the dam 1.5 days per week, most of the steelhead return is allowed to pass unimpeded, and no additional taking of Upper Columbia steelhead is anticipated through this sampling program. In nine years of operation, WDFW personnel have not experienced any mortalities of adult steelhead collected for this program at Priest Rapids Dam (L. Brown, WDFW, pers. comm. August

1997). Trapping and sampling at Priest Rapids in future years is not likely to lead to the immediate mortality of listed steelhead. Stress, descaling and possible injury of captured fish is possible, possibly leading to delayed mortality or a decreased potential for successful spawning. Bull trout are occasionally observed in fish counting windows on the Columbia mainstem dams, and this species may be encountered during operation of the Priest Rapids Dam steelhead trapping program (L. Brown, WDFW, pers. comm., May 1998). However, Mongillo (1992) identified the reach of the Columbia River mainstem where the dam is located as not presently harboring a bull trout population. No bull trout are expected to be encountered as volunteers at the Priest Rapids Hatchery trap.

Water loss is not considered a risk factor for fish held in either of the traps, due to availability of gravity feed water from Priest Rapids Dam. High water temperatures incident in the late summer that may harm holding fall chinook are countered through use of well water in the adult holding pond that is used to maintain the fall chinook broodstock through maturity each year.

Describe any instance where construction or operation of the physical plant results in destruction or adverse modification of critical habitat designated for the listed species

No circumstances where the construction or operation of the fall chinook hatchery program results in adverse impacts to listed fish critical habitat are envisioned. The program complies with NPDES permit effluent monitoring and discharge conditions (IHOT 1995), which act to protect the quality of receiving waters adjacent to the hatchery.

Describe any inconsistencies with standards and guidelines provided in any ESU-wide hatchery plan approved by the co-managers and NMFS

The described program is fully consistent with standards and guidelines set forth in the MCMCP's "Mid-Columbia Hatchery Plan" (BAMP 1998). The plan presents hatchery programs that have been jointly agreed to by the parties to the MCMCP, which includes WDFW, NMFS, USFWS, Chelan and Douglas PUDs, and the Tribes.

4.1) Brood stock collection

In recent years, all of the fall chinook broodstock used for the Priest Rapids Hatchery program have been obtained as volunteers to the hatchery trap in the outlet channel. Adult fall chinook salmon return to the hatchery and adjacent spawning grounds from September through November and are collected as volunteers to the channel. Adults have in the past been collected from the east ladder trap in Priest Rapids Dam, but these fish were usually surplus to the hatchery's on station production needs. There is usually a sufficient number of eggs taken to supply other hatcheries. Adults are collected throughout the entire run to ensure that the run timing for these populations is maintained.

Trapping procedures at the head of the outfall channel at Priest Rapids Hatchery include capture of fall chinook volunteering to the trap, transfer to the hatchery adult holding pond, and holding in the pond through maturity. An approximate mixed well water/river

-origin water discharge of 100 cfs attracts returning fall chinook to the hatchery outlet channel. Fish entering the outlet channel must swim approximately ½ mile up the channel before encountering the hatchery trap. Upon traveling up the channel, the fall chinook jump a finger weir, which is the trap entrance. The weir prevents the fish from backing downstream, and fish are held briefly in trap for transport by tank truck one mile to the adult holding pond. The holding pond is supplied with 100% well water to maintain the pond temperature at a low level for fish health purposes.

Although no longer used for fall chinook broodstock collection, stock assessment trapping procedures at Priest Rapids Dam include collection of migrants, and holding, anesthetizing, and handling prior to passage upstream. The trap in Priest Rapids Dam is located at the top of the right bank ladder. In order to capture fish, a gate is closed in the fish-way, and upstream-migrating fish are entrained into a *Denil* ladder, where they are either shunted to the dam forebay or into a temporary brail for sampling. The temporary brail measures 6' wide x 4.5' long x (up to) 12' deep. The trap is actively operated and fish are transferred immediately from the temporary brail to sampling tanks. Because the trap is actively operated, captured steelhead and fall chinook salmon are held for a minimal amount of time in the trap holding area. Fish are anesthetized using MS-222 in accordance with WDFW guidelines. Scales are collected from captured fish for age analysis. Fish are identified as of wild or hatchery-origin through examination for fin-clips and any observations regarding gill net or predator marks are also noted. Data collected are used to extrapolate the total up-river adult run size, hatchery and wild fish contribution to the total, and age class contribution. All fish sampled through the program are revived and passed immediately upstream.

4.2) Spawning

Fall chinook spawners at Priest Rapids Hatchery are maintained in a 206,000 ft3 holding pond through maturity. Only well water is used to supply the pond, but back-up is available in the event of a loss of power through gravity feed from Priest Rapids Dam. The maximum temperature of groundwater used at Priest is 16.0 degrees Celsius (range 1.6 - 16.0 degrees from BAMP 1998).

4.3) Incubation

The hatchery has 80 stacks of vertical incubators housed in a 4,000 ft2 hatchery/incubation building. The incubation facility is supplied with well water, but gravity feed water from Priest Rapids Dam is available as a back-up in the event of a power loss.

4.4) Rearing

Fall chinook fry are reared to sub-yearling smolt size at Priest Rapids in 80- x 8 x 3 ft above ground vinyl raceways or in 250 x 36 x 4 ft deep channel ponds. Either gravity feed or well water may be used to supply the ponds for rearing. Rearing on parent river water or acclimation for several weeks to parent river water is done to ensure strong homing to the facility.

4.5) Acclimation/release

Fingerlings are acclimated, reared to smolt size, and released at Priest Rapids Hatchery in either the vinyl raceways or channel ponds described above. Either gravity feed or well water may be used to supply the ponds for rearing, providing a mechanism for minimizing the risk of catastrophic loss due to power outages.

4.6) Other

No other physical plants associated with the fall chinook artificial production program are used.

SECTION 5. ORIGIN AND IDENTITY OF BROOD STOCK

5.1) Source

Broodstock used in the program are collected from the run at large volunteering to the hatchery trap. Fall chinook volunteering to the trap are almost entirely hatchery-origin fish, although some wild fish also recruit, as gene flow between the hatchery and the Hanford Reach natural production is thought to be significant (BAMP 1998). Fall chinook propagated through the program originated predominately from adults returning to the volunteer trap or to the east bank fish ladder at Priest Rapids Dam. During the 1970s and early 1980s, however, some eggs were transferred into the facility from outside sources in an attempt to build production (Chapman et al. 1994). These sources included eggs from the Bonneville and Kalama Falls hatcheries and the Ringold Rearing Ponds. The hatchery became self-sustaining in 1984, and the practice of importing eggs into the facility ended that year.

5.2) Supporting information

Ocean-type chinook salmon in the ESU including Priest Rapids Hatchery fish have been mixed considerably over the past five decades, not only among stock groupings, but among individual runs comprising the stock groupings as well (Myers et al. 1998). This mixing was due to the variety of methods employed to collect broodstock at dams, hatcheries, or other areas and as a result of juvenile introductions into various areas. Waknitz et al. (1995) reported that, partly as a result of hatchery practices, there were no significant genetic differences between summer- and fall-run chinook salmon in the ESU. Priest Rapids Hatchery fish are therefore not genetically distinguishable from summer-run adults returning to Wells Hatchery, the Wells Dam trap, or the Similkameen River (Waknitz et al. 1995).

The percentage of non-indigenous stocks incorporated into the hatchery programs has been low (about 3 % of the over 200 million ocean-type chinook propagated since 1941), and does not appear to have had a significant impact on the genetic integrity of the ESU considered in whole (Chapman et al. 1994; Myers et al. 1998). Of the 105 million fall-run chinook released from the Priest Rapids Hatchery since 1960, two percent (2.62 million) originated from outside of the Upper Columbia summer/fall chinook salmon ESU. Priest Rapids Hatchery-origin and lineage fish comprised 71.4 % of the total number of released over this period (1960-93 release data from Myers et al. 1998).

5.2.1) History (taken from Chapman et al. 1994)
The original stock used in the Priest Rapids spawning channel came from late-run chinook trapped at Priest Rapids Dam. Most of these fish were destined for areas in the Mid-Columbia River drainage upstream from Priest Rapids, although some of the fish trapped may have originated from Hanford Reach or other Columbia Basin areas. Before 1987, the hatchery depended heavily on fish trapped in the east bank ladder to provide broodstock. From 1972 through 1986 about 37 % of the adults held at the hatchery came from fish that attempted to pass Priest Rapids Dam. Egg transfers into the hatchery from Bonneville, Kalama Falls, and Ringold hatcheries in the late 1970s and early 1980s may also have influenced the genetics of the broodstock. When these transferred stocks returned as adults to the hatchery, their genetic material was incorporated into the hatchery stock. As mentioned previously, Priest Rapids Hatchery has been self-sustaining since 1984. In addition, since 1989, all of the adults used in the program have come from fall chinook volunteering to the hatchery trap. These broodstock collection changes have led to a decreased gene flow into the hatchery stock from upstream-bound fish, but Wells Hatchery lineage fish are still captured as volunteers to the hatchery trap. Stray hatchery and wild-origin fish from other Basin areas, including Hanford Reach, also volunteer to the hatchery trap each year and are incorporated into the broodstock.

5.2.2) Annual size
The spawning protocol mandates the use of a spawning population of at least 500 adults. The current annual broodstock collection goal for the Priest Rapids program is 6,102, equally divided by sex (IHOT 1995). Actual broodstock collection figures for the program from 1989 are presented in Table 1. Future production alternatives specified in the Mid-Columbia Hatchery Plan (BAMP 1998) will necessitate the annual collection of an additional 1,060 adults (1:1 sex ratio) to meet increased Priest Rapids Project fall chinook smolt production objectives (6.0 million sub-yearlings).

The current collection goal of 6,102 fall chinook for use as broodstock is not expected to adversely affect the population status of the natural population relative to critical and viable thresholds. The program relies on predominately hatchery-origin adults that volunteer to the hatchery trap, and the number of natural fish removed, and the impact on the viability of the naturally spawning populations, are minimal.

5.2.3) Past and proposed level of natural fish in brood stock.
From 1972 through 1986 about 37 % of the adults held at the hatchery came from fish that attempted to pass Priest Rapids Dam. Beginning in 1989, fish were no longer secured from the Priest Rapids Dam east bank ladder, significantly decreasing the number of natural fish incorporated into the hatchery broodstock. Broodstock used in the program are now secured only from hatchery and natural fall chinook adults volunteering to the Priest Rapids Hatchery trap. Chapman et al (1994) reported that wild-origin (mainly Hanford Reach) fish still recruit to the volunteer trap, at unknown levels relative to the total number collected. Fall chinook from other natural production areas in the Columbia Basin also recruit to the volunteer trap (CWT recovery data from Chapman et al. 1994).

5.2.4) Genetic or ecological differences

There are no known genotypic, phenotypic, or behavioral differences between the hatchery fall chinook stock and natural fall chinook stocks within the Upper Columbia summer/fall chinook ESU.

5.2.5) Reasons for choosing

Fall chinook salmon propagated through the program represent the indigenous Hanford Reach and mid- and upper Columbia River Basin up-river bright fall chinook populations, which are the target of the mitigation program.

5.3) Unknowns

There are no known circumstances where a lack of data leads to uncertainties about the choice of brood stock for this part of the program.

SECTION 6. BROOD STOCK COLLECTION

The following broodstock collection practices are consistent with standards and guidelines provided in the "Mid-Columbia Hatchery Plan" assembled by the Co-managers, PUDs, and NMFS (BAMP 1998).

6.1) Prioritized goals

The intent of the broodstock collection procedure applied at the hatchery is to collect enough adults to maintain the hatchery production program. The hatchery goal for annual adult collections is 6,102. Surplus eggs are supplied to other hatcheries when available (IHOT 1995). Adults are collected throughout the entire run to ensure that the run timing of the population under propagation is maintained.

Although Priest Rapids Hatchery has been self-sustaining in terms of adult fall chinook returns since 1984, egg or fish importations from other facilities may still be allowed to achieve production goals while maintaining regional genetic integrity in times of inadequate hatchery returns (IHOT 1995). Eggs from Priest Rapids Hatchery-origin adults are always given priority for station use. The other fall chinook stock grouping approved for release, but viewed as less well suited than the Priest Rapids Hatchery stock, are mainstem Columbia River up-river brights.

6.2) Supporting information

6.2.1) Proposed number of each sex.

The broodstock collection objective is to remove equal numbers of males and females.

6.2.2) Life-history stage to be collected (e.g., eggs, adults, etc.)

Adult fall chinook salmon are to be collected at the Priest Rapids Hatchery trap for use as broodstock.

6.2.3) Collection or sampling design.
The primary broodstock collection consideration is to achieve an escapement of 6,102 adults to the hatchery. Fall chinook are collected from the run at large captured in the volunteer trap from September through November. Broodstock are collected across the entire run to ensure that the run timing for the population is maintained.

Marked stray salmon from programs outside the mid-Columbia would be removed from the hatchery broodstocks, when it appears that the percentage of strays from a given program exceeds 5%. This provisional standard is based upon the NMFS Biological Opinion of system wide hatchery operations in the Columbia River (NMFS 1999), and will be revised when results from ongoing region-wide analyses of genetic introgression from straying provides more definitive direction.

Adverse effects on listed fish that may be encountered incidentally during trapping, are minimized through the following measures:

a. The Priest Rapids Hatchery trap will be continuously monitored and operated 3 days per week during the hatchery fall chinook migration (September 1 through November).
b. The hatchery trap is located in the hatchery outlet channel ½ mile upstream from its confluence with the Columbia River. A fish weir is not used to guide fish into the hatchery outlet. All fish returning to Priest Rapids Hatchery recruit to the trap as volunteers. The trapping program is therefore not a "run of the river" operation, and captures of other species besides fall chinook salmon that were produced at the hatchery are minimal.
c. Other salmonids incidentally trapped will be returned into the outlet channel to continue their migration.

6.2.4) Identity
(a) The target population is the Priest Rapids hatchery fall chinook stock. The population is included as part of the Upper Columbia Summer/Fall Chinook ESU (Myers et al. 1998). The hatchery-origin fish are genetically indistinguishable from other URB fall chinook populations present in the project area during the September-November broodstock collection period (Waknitz et al. 1995; Myers et al. 1998).
(b) Broodstock are collected from the run at large volunteering to the Priest Rapids Hatchery trap. A proportion of the fall chinook released through the program have an adipose clip/coded wire tag marking combination, enabling evaluation of the contribution of Priest Rapids hatchery fish to the annual broodstock collection

6.2.5) Holding
Fall chinook collected in the Priest Rapids Hatchery trap are transported by tank truck one mile to the adult holding pond on the main hatchery grounds where they are held for spawning. The holding pond is supplied with 100 % well water to maintain adult fish in cooler water than available from the river. The adult pre-spawning survival objective for the program is 90 %. No takes of ESA-listed fish occur through the broodstock holding operation.

6.2.6) Disposition of carcasses

Carcasses of fall chinook spawned through the programs are buried on-site at the hatchery or (for surplus fish) sold to fish buyers under contract with WDFW for receiving hatchery carcasses.

6.3) Unknowns

The effects of the broodstock collection program on the timing of spawning of the target population and on the composition of the naturally spawning population upstream and downstream of Priest Rapids Dam (e.g. hatchery versus wild origin, age class distribution, sex ratios) are unknown.

SECTION 7. MATING

7.1) Selection method

The spawning protocol mandates the use of a spawning population of at least 500 adults. Spawners are selected and mated randomly from the population maintained in the hatchery holding pond. Fish are spawned throughout the entire run to help ensure that the run timing for the stock is maintained. A portion of each day's egg-take is used for on-site hatchery production to help ensure that return timing of the seasonal run is represented and that the hatchery broodstock remains genetically similar to, and representative of, the naturally spawning up-river bright fall chinook populations.

7.2) Males

When spawning fewer than 1 million eggs in a day, the male to female ratio will be 1:1. When spawning more than 1 million eggs in a day, the ratio will not be less than 1 male to 3 females. The five year (1983-87 brood) average male to female sex ratio applied at Priest Rapids is 0.5 : 1.0 (range 0.4:1.0 - 0.7-1.0) (IHOT 1995).

7.3) Fertilization

For daily egg takes under 1.0 million, eggs from two females are spawned into a bucket, and two males are then spawned into the combined eggs. For daily egg takes greater than one million, the fertilization procedure is adjusted. Eggs from two females are spawned into one bucket, and milt from one male is introduced. These eggs are then combined with eggs spawned from two other females and also fertilized with one male, so that a single bucket contains eggs from four females. This procedure equates to a 1 male to 2 female ratio, but provides for back-up fertilization for the combined eggs if milt used from one of the males in the pooled buckets proves to be non-viable.

Fish health procedures used for disease prevention include water hardening of eggs in an iodophor at spawning and biological sampling of spawners. Generally, sixty ovarian fluid and kidney/spleen samples are collected from female spawners to test for the presence of viral pathogens. The enzyme-linked immunosorbent assay (ELISA) is conducted on kidney samples from 100 females. This assay detects the antigen for *Renibacterium salmonarium*, the causative agent of bacterial kidney disease (BKD).

7.4) Cryopreserved gametes

No cryopreserved gametes are used in the Priest Rapids Hatchery fall chinook program.

7.5) Unknowns

The effects of the mating protocol applied on within population diversity of the propagated and naturally spawning fall chinook populations are not known.

SECTION 8. REARING AND INCUBATION

INCUBATION:

8.1) Number of eggs taken and survival objective to ponding

The current annual egg take goal for the program is 7.89 million. The five year (1983-87) average egg take for the facility is 11.15 million (range 6.3-14.8 million) (IHOT 1995). The green egg survival objective to ponding is 90.0 %.

8.2) Loading density

Heath stack incubators are used to incubate the fall chinook eggs at the hatchery. Incubation conditions are consistent with on loading densities recommended by Piper et al. (1982). Water is supplied primarily from gravity flow from the Columbia River, but 17.6 cfs of well water is used to control incubation timing (BAMP 1998).

Pond management strategies are used to help optimize the quality of the rearing environment and to minimize fish stress. The "Density Index" (Piper et al. 1982) is used to estimate the maximum number of fish that can occupy a rearing unit based on the rearing unit's size. The "Flow Index" (Piper et al. 1982) is used to estimate the rearing unit's carrying capacity based on water flows (IHOT 1995).

8.3) Influent and effluent gas concentration

Influent and effluent gas concentrations, including dissolved oxygen concentrations, are within parameters optimal for chinook salmon egg and juvenile survival. Water quality goals established by IHOT (1995) for chinook salmon propagation are as follows:

	Water temperature (^oC)			Dissolved	Ammonia
Species	spawning	incubation	rearing	oxygen	(un-ionized)
Chinook salmon	5.6-12.8	5.0-11.7	8.9-12.2	>7.0 mg/l	<0.0125 mg/l

Water supplies and temperatures at Priest Rapids Hatchery are as follows:

Surface water		Groundwater	
Flow (cfs)	Temp. range (^oC)	Flow (cfs)	Temp. range (^oC)
98.9	0.3 - 20.0	17.6	1.3 - 16.0

8.4) Ponding

Fall chinook fry are transferred from Heath trays for ponding upon button-up and swim-up. Ponding generally occurs after the accumulation of 1,650-1,750 temperature units. Unfed fry are transferred to the rearing ponds in January and February. The mean weight for fry ponded at Priest Rapids Hatchery for brood years 1996-97 was 0.54 gms. The estimated fork length for fall chinook fry weighing 0.54 gms is 39 mm (WDFW Hatcheries Program length/weight conversion data for fall chinook, April, 1997).

8.5) Fish Health monitoring

At spawning, eggs are water-hardened in iodophor as a disinfectant. Formalin (37 % formaldehyde) is periodically dispensed into water supplied to the incubators and raceways to control fungus growth on eggs, and parasite loads on juvenile salmon. Treatment dosage and duration varies by life-stage and condition being treated. All fish disease control procedures are conducted consistent with the Co-manager's Fish Disease Control Policy (WDFW and WWTIT 1998).

No fish disease outbreaks have been experienced during the incubation to ponding period in the fall chinook program in recent years, and mortality levels have remained within program standards. Fall chinook reared at Priest Rapids have had reportable pathogens identified in past years (IHN virus identified in 1990-1995 period) (IHOT 1995). Fish health is continuously monitored in compliance with Co-manager Fish Health Policy standards (WDFW and WWTIT 1998).

REARING:

8.6) Number of fish ponded and survival objective to release

On average, 92.6 % of the fall chinook eggs fertilized through the Priest Rapids program survive to the fry stage for ponding (range 90.9-94.2 % for 1983-87 brood years from IHOT 1995). The program survival standard from fertilization to ponding is 90.0 %. The survival objective from fertilization to release is 81.0 %.

8.7) Density and loading.

The pond loading densities maintained at the hatchery are consistent with those recommended by Piper et al. (1982; 6 lb/gpm and 0.75 lb/ft^3) and Banks (1994; 0.125 lb/ft^3/in) (BAMP 1998). Fry are transferred from the Heath incubation trays to vinyl raceways for start feeding and continued rearing. The raceways have flow through water circulation.

8.8) Influent and effluent gas concentrations

Influent and effluent gas concentrations in rearing raceways, including dissolved oxygen concentrations, are within parameters optimal for juvenile salmonid production and survival (see section 8.3).

8.9) Length, weight, and condition factor.

The production objective for the Priest Rapids fall chinook salmon program calls for the release of sub-yearling smolts in mid-June at a size of 9.1 grams (50 fpp) (IHOT 1995). Fish averaging 9.1 gms in weight are estimated to average 93 mm fl. The coefficient of variation (CV) objective applied for Priest Rapids sub-yearling smolt releases is <10% around the mean individual fish weight. The 1984-87 brood year average CV was 7.2 % (range 4.8-9.5% from IHOT 1995). Condition factor data are not collected for sub-yearling smolt releases at Priest Rapids Hatchery.

Brood year `95 fall chinook volitionally released in June, 1996 ranged in size at release from 9.1 to 11.3 gms (93-100 mm fl). The CV of length for `95 brood year releases ranged from 6.2 - 7.8%. Brood year `96 fall chinook volitionally released in mid- to late June, 1997 ranged in size from 6.0 to 11.6 gms (82-101 mm fl). The CV of length for `96 brood year releases ranged from 6.2 - 24.1%.

8.10) Growth rate, energy reserves

Fish health and condition is monitored by fish health professionals throughout the fry to sub-yearling smolt rearing period. Weight samples indicating growth are taken from the population monthly at the hatchery.

8.11) Food type and amount fed, and estimates of feed conversion efficiency.

Commercial-grade moist or semi-moist fish feed is used in the operation, and applied at sizes appropriate for the size of the fish being fed. The daily amount fed is determined by the number of fish in the population and individual fish weight. Feed is therefore applied at a daily rate ranging from 3.0 % of the total population weight per day (fry and small fingerlings) to 1.5 % of the total population weight per day for larger fingerlings. The expected feed conversion efficiency rate is 1.2.

8.12) Health and disease monitoring.

Fish health and disease condition are continuously monitored, and disease reporting and disease control of selected pathogens are conducted in accordance with the Co-managers Fish Disease Control Policy (WDFW and WWTIT 1998). Fish health and condition is monitored on-site by fish health professionals at the hatchery throughout the rearing period. Specific fish health monitoring and disease control activities applied at Priest Rapids Hatchery include the following (detailed in IHOT 1995):On at least a monthly basis, both healthy and clinically diseased fish from each lot at the hatchery are given a health exam. The sample includes a minimum of ten fish per lot. Findings are reported on WDFW Form FH01;

I. Prior to release, fish are given a health exam. This exam may be conducted in conjunction with the routine monthly visit;

II. Whenever abnormal behavior or mortality is observed, the fish health specialist will examine the affected fish, make a diagnosis and recommend the appropriate remedial or preventative measures;

III. Juvenile fish are administered antibiotics orally when needed for the control of bacterial infections; and

IV. Only therapeutants approved by the U.S. Food and Drug Administration are used for treatments.

8.13) Smolt development indices, if applicable:

Priest Rapids Hatchery fall chinook are released in June as sub-yearling smolts. Fish size, appearance, and release time are used to indicate the readiness of the population for emigration. No smolt development indices are assessed.

8.14) Use of "natural" rearing methods:

Although not designed as one, Priest Rapids Hatchery could be considered as a program that employs "natural" rearing methods. Fish are well acclimated to the area, by use of Columbia River water during rearing, which is the water source for the natural population. Channel raceways used as rearing containers mimic the natural river environment in many respects.

8.15) Unknowns

Monitoring and evaluation measures are proposed to address data gaps that lead to uncertainty in the incubation and rearing protocols. These uncertainties include whether the release of ocean-type chinook salmon into the mainstem at the upper extent of Hanford Reach, an area of significant natural production, impose deleterious ecological and genetic effects on natural fish are of concern.

A carefully developed hatchery operation and evaluation program, such as the one developed for the "Mid-Columbia Hatchery Plan", is needed to identify hazards potentially posed by the Priest Rapids program to the propagated and adjacent natural summer/fall chinook populations, and to listed fish in the mid- and upper Columbia River region.

SECTION 9. RELEASE

9.1) Life history stage, size, and age at release:

The current production goal for Priest Rapids Hatchery is the annual release of 5.0 million sub-yearling fall chinook salmon smolts at an average size of 9.1 gms (50 fpp). Fish have been reared approximately 165 days prior to mid-June release. Table 6 presents Priest Rapids sub-yearling size at release data for brood years 1980-97.

9.2) Life history stage, size and age of natural fish of same species in release area at time of release (from Chapman et al. 1994)**.**

Naturally produced summer/fall chinook in the region emigrate seaward as sub-yearlings. All summer/fall sub-yearlings leave areas where they incubated in the mainstem Columbia within days to several weeks after they emerge from the redd. Fry emerge mostly in April and May. Natural Hanford Reach fall chinook fry emerge at a size of 38 - 39 mm fl. After emergence, some fry move downstream to rear. Others rear for a time in natal spawning areas before they move extensively.

Sub-yearling fall chinook produced in Hanford Reach leave the Reach before the end of July. Fish departing the Reach over this period range in size from 38-39 mm (April) to

83 mm (July). Most fish depart before mid-July, and many rear in McNary Dam pool before they pass McNary Dam. Studies in 1991 and 1992 indicated an estimated median arrival time of Hanford Reach-origin fall chinook at McNary Dam in late July or early August. June migrants from Hanford Reach averaged 90 - 108 mm upon reaching McNary Dam.

Summer/fall chinook sub-yearlings produced in upper Columbia tributaries and in tailraces of dams upstream from Rock Island Dam spend several weeks rearing in the dam reservoirs before they arrive at Priest Rapids Dam in August and later. Mid-July migrants passing over Wanapum and Priest Rapids dams are over 100 mm fl. This extended rearing and migration period (attributed to migrational delay caused by hydropower project construction) leads to arrival at McNary Dam in late August to late fall. Sub-yearlings produced in the Wanapum Dam tailrace may pass Priest Rapids Dam earlier, most likely in June and July. Late passage of sub-yearlings into the upper Hanford Reach probably has increased the proportion of sub-yearlings that remain in the Columbia River downstream of McNary Dam through winter. It also has substantially increased the mean size of sub-yearlings at the time of passage past Priest Rapids Dam.

Table 6. Size at release data for brood year 1980-97 fall chinook sub-yearling releases from Priest Rapids Hatchery.

Brood Year	Size at Release Range (gms)
1980	3.9-7.6
1981	4.8-6.8
1982	5.1-7.2
1983	5.4-6.1
1984	6.7-8.4
1985	7.1-7.8
1986	3.9-9.1
1987	5.9-7.4
1988	8.1-10.3
1989	7.2-8.0
1990	9.5-10.1
1991	7.6-9.3
1992	8.1-8.9
1993	8.6-10.1
1994	4.6-8.7
1995	9.1-11.3
1996	6.0-11.6

9.3) Dates of release and release protocols.

Rearing and release strategies are designed to limit the amount of ecological interactions occurring between hatchery and naturally produced fish. Fish are reared to sufficient size such that smoltification occurs within nearly the entire population, which will reduce retention in the streams after release. Rearing on parent river water or acclimation for several weeks to parent river water is done to ensure strong homing to the hatchery, thus reducing the stray rate to natural populations.

Various release strategies are used to ensure that fish migrate from the hatchery with the least amount of interaction with native populations. Priest Rapid fall chinook sub-yearlings are volitionally released into the Columbia River adjacent to the hatchery. Table 7 presents release date ranges for 1980-97 brood year sub-yearling chinook produced at Priest Rapids Hatchery. Sub-yearlings are presently allowed to volitionally migrate from the hatchery raceways and channels in mid- to late June.

Table 7. Release date ranges for brood year 1980-97 fall chinook sub-yearling liberations from Priest Rapids Hatchery (WDFW Hatcheries Program data, October, 1999).

Brood Year	Release Date Range
1980	May 20 - June 26
1981	May 18 - June 24
1982	April 26 - June 16
1983	May 24 - June 22
1984	June 11 - July 10
1985	June 5 - June 18
1986	April 1 - June 24
1987	June 8 - June 25
1988	June 6 - June 18
1989	June 12 - June 29
1990	June 7 - June 19
1991	June 14 - June 26
1992	June 12 - June 24
1993	May 4 - June 27
1994	June 12 - June 20
1995	June 13 - June 25
1996	June 14 - June 24
1997	June 12 - June 26

9.4) Location(s) or release.

Fall chinook produced through the program are released into the Columbia River (WRIA 36-0001) at Rkm 662.

9.5) Acclimation procedures.

Fall chinook are acclimated to the release site through rearing on Columbia River water supplied by gravity feed from Priest Rapids Dam. Rearing on parent river water, or acclimation for several weeks to parent river water, is done to ensure strong homing to the hatchery, thus reducing the stray rate to natural populations. Homing by returning hatchery-origin adults to the Priest Rapids Hatchery trap is optimized by releasing a mix of Columbia River water, and (cooler) well water into the hatchery outlet channel as attraction water.

9.6) Number of fish released:

Table 8 presents annual release numbers for the Priest Rapids Hatchery sub-yearling fall chinook program - brood year 1980-97.

Table 8. Priest Rapids fall chinook salmon sub-yearling smolt release numbers - brood years 1980-97 (data from WDFW Hatcheries Program, October, 1999).

Brood Year	Number Released
1980	4,832,491
1981	5,590,441
1982	10,296,700
1983	9,742,700
1984	6,988,700
1985	6,363,000
1986	7,188,800
1987	7,709,000
1988	5,404,550
1989	6,431,100
1990	5,239,700
1991	7,000,100
1992	5,451,000
1993	6,705,836
1994	6,702,000
1995	6,700,000
1996	6,644,100
1997	6,737,600

9.7) Marks used to identify hatchery adults.

A proportion of each year's release of fall chinook from Priest Rapids receives an adipose clip-coded wire tag marking combination. Approximately 4 % of the total annual release of 6.7 million fish has received this marking combination in each of the last three brood years (`95-`97). The chinook are marked with an adipose clip/coded wire tag combination to allow for assessment of brood year fishery contribution and survival rates for fish released from Priest Rapids Hatchery.

9.8) Unknowns

Uncertainties pertaining to release strategies applied through the program that should be resolved to allow for adaptive management include the following: (1) the effect of broodstock collection on natural escapement levels, (2) the demographic aspects of returning hatchery adults, (3) the potential for genetic changes from the natural population from differing selective processes associated with broodstock collection, selection, and mating; and hatchery propagation, and (4) the effects of hatchery releases upon natural juveniles.

SECTION 10. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

Staffing, and other support logistics for the Priest Rapids Hatchery fall chinook production program is provided by WDFW. Funding for the program is provided by Grant County Public Utility District Number 2 and the U.S. Army Corps of Engineers for the purpose of mitigation for lost fish production associated with the Priest Rapids Project (Priest Rapids and Wanapum dams) and John Day Dam, respectively. The current hatchery system lacks the necessary infrastructure and mechanisms to ensure adequate monitoring and evaluation needed to make the hatchery rearing program more efficient and effective (IHOT 1995). Staffing and funding should be made available and committed to allow full implementation of data collection, and monitoring and evaluation, described in this section.

10.1) Marking

As mentioned previously, approximately 4 % of the annual fall chinook production is marked with an adipose clip/coded wire tag combination to allow for assessment of fisheries contribution and survival. In addition, the Chinook Technical Committee (CTC) (US v OR proceedings) has mandated marking a survival index group of 200,000 natural origin Hanford Reach chinook juveniles annually. This marking effort is a cooperative effort achieved by WDFW and Yakama Nation biologists.

10.2) Genetic data

The ocean-type chinook salmon in the mid-Columbia Region is one of the most electrophoretically homogenous populations in the state (BAMP 1998). Ocean-type chinook in the region are genetically distinct from lower Columbia River ocean-type populations (Myers et al. 1998). Hatchery manipulations post-GCFMP, and in recent years, have lead to the mixing of summer/fall chinook from various parts within the upper Columbia River region (Chapman et al. 1994). This mixing, and/or homogenization that occurred through the GCFMP, may be responsible for the inability of electrophoretic analysis to differentiate among components of the Upper Columbia River summer/fall chinook ESU (Chapman et al. 1994). A thorough review of available genetic studies of Pacific Northwest chinook salmon populations, and presentation of baseline genetic data for the Upper Columbia summer/fall chinook salmon ESU, is included in the NMFS BRT chinook salmon status review document (Myers et al. 1998).

Marshall et al. (1995) evaluated the genetic diversity of extant chinook populations within the Upper Columbia summer/fall chinook ESU for WDFW. Findings from this agency genetic evaluation were used by NMFS to develop ESU determinations and stock status findings in the west coast chinook salmon status review. It is anticipated that genetic data will be gathered through biological sampling of Priest Rapids fall chinook in future years to update the allozyme baseline maintained by WDFW for Washington chinook populations.

10.3) Survival and fecundity

10.3.1) Average fecundity

Fecundity will be monitored through sub-sampling throughout the collection season of individual egg weights applied to the weight of green eggs taken from returning spawners and the total number of females spawned. Fall chinook females returning to Priest Rapids Hatchery have an estimated mean fecundity of 4,050 based on 1989-93 brood year egg take and adult broodstock trapping data (assumes 1.0 :1.0 sex ratio at trapping).

10.3.2) Survival

a) Collection to spawning

Fall chinook adult losses during trapping and holding will be monitored through removal and enumeration of mortalities from the Priest Rapids Hatchery trap and adult holding pond. Daily mortalities will be recorded on WDFW “Form 3" fish and egg disposition ticket forms. The adult pre-spawning survival standards for the program are 90.0 % (IHOT 1995).

b) Green eggs to eyed eggs

Egg losses during incubation will be monitored through removal and enumeration of green egg mortalities upon shocking from Heath trays at the hatchery. The green egg to fry survival standard for the program is 90.0 % (IHOT 1995).

c) Eyed eggs to release

Eyed egg and juvenile fish losses during incubation and rearing will be monitored through removal and enumeration of eyed egg mortalities from Heath trays, and daily or weekly (as necessary) removal and enumeration of fish mortalities occurring during the four to five month rearing period at the hatchery. The fry to smolt survival standard applied to the Priest Rapids program is 90.0 % (IHOT 1995).

d) Release to adult, to include contribution to:

(i) harvest

Contribution of Priest Rapids Hatchery program-origin fall chinook salmon to fisheries in the mainstem Columbia River and ocean will be monitored and evaluated through the regional coded wire tag recovery and evaluation program implemented by WDFW, the Tribes, and other fisheries management agencies in the Columbia Basin and the Pacific Northwest.

(ii) hatchery brood stock
Contribution of Priest Rapids Hatchery-origin fish to the hatchery broodstock will be monitored post-season by WDFW. Snouts from adipose-clipped fish spawned at the hatchery will be collected and transported to Olympia for tag-removal and identification of fish origin. The number or proportion of fall chinook spawned during a particular season will be determined through expansion of the total number of Priest Rapids Hatchery-origin tag recoveries to the sampling rate (assumed to be 100 % at the hatchery) and the percent of the population tagged.
(iii) natural spawning
A stream survey and carcass recovery program implemented annually by WDFW in the Hanford Reach will be used to recover marked fall chinook and to help evaluate the number of hatchery-origin fish spawning naturally in the region.

10.4) Monitoring of performance indicators in Section 1.8

The following monitoring objectives measures are included in the Mid-Columbia Hatchery Plan (BAMP 1998) to evaluate the performance of the summer/fall chinook salmon supplementation programs, including the Priest Rapids Hatchery project. Many of these measures are either being presently applied through the WDFW programs for upriver summer chinook populations, but there is not currently a similar formal hatchery evaluation program for the Priest Rapids fall chinook hatchery except for the index group marking described above. From BAMP (1998):

Monitoring and Evaluation Objectives:

Objective 1: Determine if the summer/fall chinook hatchery facilities are capable of meeting the current production objectives.

Objective 2: Determine whether the survival from release-to-adult of summer/fall chinook produced by the facilities is sufficient to achieve the number of adults needed to compensate for lost production due to hydroelectric project development.

Objective 3: Determine if actions taken to produce summer/fall chinook salmon conserve the reproductive success, genetic integrity, and long-term fitness of natural spawning summer/fall chinook populations of salmon in the region.

Objective 4: Determine whether smolts released from the rearing and acclimation facilities disperse and migrate downstream without impacting the natural population.

Monitoring and evaluation tasks that should be completed to meet the above objectives:
Objective 1: Determine if the summer/fall chinook hatchery facilities are capable of meeting the current production objectives.

Task 1-1: Determine the pre-spawning and egg-to-release survivals of fish for each population at various life stages at central rearing and acclimation ponds.

1) Monitor growth, mortality rates, and feed conversion of yearling summer and fall chinook salmon reared at the Mid-Columbia central rearing and acclimation sites.

2) Determine egg-to-fry and fry-to-smolt survival rates for summer and fall chinook salmon.

3) Maintain and compile records of cultural techniques for each life stage, such as: number of times adults handled for observation and inoculation; fish and egg condition at time of spawning; ponding, densities at splits and outplanting, feeding schedule of juveniles, and transport loading densities, tempering, and conditions.

4) Summarize results of tasks for presentation in annual and monthly reports. Make recommendations for improved smolt production at listed facilities. Any problems with operation of the facilities will also be noted.

Task 1-2: Determine if the adult traps are capable of collecting the required number of adults that represent the demographics of the donor population with minimal injuries and stress to the fish.
1) Monitor operation of the adult traps at Priest Rapids hatchery and at Priest Rapids Dam. Additional traps that may be built under the Mid-Columbia Hatchery Program will be monitored. Ensure compliance with established broodstock collection protocols for that station.

2) Monitor timing, duration, composition and magnitude of the runs at adult collection sites.

3) Maintain daily records of trap operation and maintenance, number and condition of fish trapped, and river stage. If low collection rates are a problem, trap data will be compared with fishway operations and flow data.

4) Collect biological information on trap-related mortalities. Determine, if possible, causes of mortality. If possible, use carcasses for stock profile sampling.

5) Summarize results for presentation in annual report. Provide recommendations on means to improve adult trapping, and if needed, refinements to broodstock collection protocols for each population.

Task 1-3: Monitor fish health, specifically as related to cultural practices that can be adapted to prevent fish health problems.

1) Standard hatchery fish health monitoring will be conducted (minimum of monthly checks of salmon and periodic checks of steelhead) by fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the donor populations. Significant fish mortality to unknown cause(s) will be sampled for histopathological study.

2) Incidence of viral pathogens in salmon and steelhead broodstock will be determined by sampling fish at spawning in accordance with the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State (WDFW and WWTIT 1998). Populations of particular concern may be sampled at the 100% level and may require segregation of eggs/progeny in early incubation or rearing.

3) Incidence of *Renibacterium salmonarium* (Rs, causative agent of bacterial kidney disease) in salmon broodstock will also be determined by sampling fish at spawning. Broodstock will be sampled for enzyme-linked immunosorbent assay (ELISA).

4) If required, provide recommendations to hatchery staff on means to segregate eggs/progeny based on levels of Rs antigen, protecting "low/negative" progeny from the potential horizontal transmission of Rs bacteria from "high" progeny. Progeny of any segregation study will also be tested by ELISA; at a minimum each segregation group would be sampled at release.

5) Use ELISA monitoring to help determine efficacy of gallimycin treatments to juveniles.

6) Autopsy-based condition assessments (OSI) will be used to assess hatchery-reared salmon smolts at release. If needed, perform OSI assessments at other key times during hatchery rearing.

7) Provide recommendations on fish cultural practices and satellite stations on monthly basis. Summarize results for presentation in annual report.

Objective 2: Determine whether the release-to-adult survival of fish from the Mid-Columbia Hatchery Program is sufficient to achieve the Phase A production objective of the "Mid-Columbia Hatchery Plan".

Task 2-1: Estimate the harvest contribution and escapement to the mid-Columbia summer and fall chinook salmon released from Mid-Columbia hatcheries.

1) Compile CWT recovery data from hatchery releases. Provide summary of ocean distribution, contribution, and survival, if such information is available.

2) Recover heads from marked (adipose clipped) returns to mid-Columbia FH facilities during routine spawning operations.

3) Recover heads from marked salmon carcasses during routine stream work.

4) Summarize results for presentation in annual report.

Objective 3: Determine if actions taken under Mid-Columbia Hatchery Program conserve the reproductive success, genetic integrity, and long-term fitness of natural spawning populations of salmon in the Mid-Columbia Region.

Task 3-1: Monitor the hatchery broodstock (and resultant progeny) for evidence of introgression of foreign genes, accelerated genetic drift or loss of genetic variation in the donor populations that could be caused by the hatchery program. Monitor populations in supplemented streams to establish baseline genetic stock identification profiles.

1) Develop a broodstock monitoring program for electrophoretic analysis of allele frequency variation at selected monomorphic and polymorphic loci. Collect tissue samples from each study group for electrophoretic analysis, using methods defined by Coast-wide Consortium.

2) Collect tissue samples from summer chinook salmon that enter Wells Dam adult trap, Wells FH, Dryden Dam, Tumwater Dam, and other trap locations developed in the Mid-Columbia Hatchery Program.

3) Prior to release, collect tissue samples of representative juveniles for electrophoretic analysis, using methods defined by Coast-wide Consortium. Compare genetic diversity of progeny samples to founder samples.

4) Begin archival of samples for potential DNA analysis in the future.

5) Collect and process adults from all study groups for scale sampling. Sample sizes for other populations will follow standard guidelines set by WDFW for variable escapement.

6) Take lengths of returning adults of all study groups, and determine sex ratios. Determine fecundity of females, and average egg size.

7) Provide results in annual report, or at appropriate time. If necessary, give recommendations for broodstock collections for study groups.

Task 3-2: Determine stray rates of fish released from Mid-Columbia hatcheries into other streams and facilities on the mid-Columbia River.

1) Conduct fall chinook carcass surveys for marked fish on the spawning areas of the mainstem Columbia River, particularly in the Hanford Reach. Coordinate activities with fishery management entities undertaking spawning ground surveys.

2) Determine incidence of marked fish released from one facility in recoveries at other hatcheries in the Mid-Columbia Region. Coordinate activities with hatchery managers.

Task 3-3: Mark each population subjected to ocean fisheries or mainstem Columbia River commercial or tribal fisheries with sufficient CWTs to estimate harvest contribution.

1) Mark (Ad + CWT) and release fall chinook salmon for determination of survival, ocean distribution, contribution to various fisheries, and returns to Columbia River sampling stations.

2) Place an external mark on selected production groups to allow recognition during broodstock collection.

3) Determine the statistical requirements to provide reliable estimates of escapement and harvest contribution. Determine the number of CWTs and other marks needed in relation to the number of recoveries expected.

4) If necessary, begin coordination of large-scale sampling program for CWT recoveries at hydroelectric projects, and on spawning grounds.

Task 3-4: Conduct intensive spawning and carcass surveys for summer/fall chinook on all streams in the Mid-Columbia Region that support ocean-type chinook salmon.

1) Document location and number of naturally spawning spring and summer/fall chinook salmon in these rivers. Conduct redd counts, determine spawner density, and evaluate locations of preferred areas. Determine distribution of redds by river kilometer.

2) Define annual and long-term changes in the spawning distribution of salmon in these rivers.

3) Determine if hatchery-reared adults reproduce effectively in terms of distribution with the naturally produced spawners, timing, and utilization of habitat.

Task 3-5: Begin baseline data collection for determination of Natural Cohort Replacement Rate for selected populations.

1) Enumerate escapement of marked and unmarked salmon to one or more streams. Randomly collect broodstock, as defined in the collection protocol. Estimate total number of spawners in those streams.

2) Use salmon collected for broodstock as random sample of returning population. Collect scales to determine age.

3) Use known age structure, fecundity, and sex ratio of collected adults to estimate egg deposition to those streams. Determine egg retention of marked and unmarked fish by opening carcasses of females during spawning ground surveys. Adjust estimate accordingly.

4) Develop methods for a long-term comparison of total spawner number to number of donor adults taken for broodstock.

5) Summarize results for presentation in annual report. Provide detailed description of methods for long-term analysis of natural cohort replacement ratios.

Objective 4: Determine whether smolts released from the rearing and acclimation facilities disperse and migrate downstream without impacting the natural population.

Task 4-1: Monitor fish behavior and emigration rates from the rearing/ acclimation ponds.

1) Install volitional fish counters (or PIT tag detectors) at out-falls to selected acclimation ponds.

2) Evaluate condition of summer and fall chinook salmon from satellite facilities prior to release. Evaluate smolt quality though OSI analysis, determine sexual precocity, descaling rates, condition factors.

3) Evaluate degree of smoltification at release site. Compare this information to environmental factors (water temperatures, river flows) at time of release.

4) Assess downstream migrants within migration corridor for degree of smoltification. If possible, identify fish to determine stock and release site. Determine trend in parr/smolt transformation in actively migrating smolts given a volitional and forced release.

Task 4-2: Develop a plan to observe fish behavior below and above the discharge at selected rearing/acclimation ponds.

10.5) Unknowns or uncertainties identified in Sections 5 through 9

Unknowns and uncertainties identified in previous sections will be addressed through monitoring and evaluation measures proposed above in Section 10.4.

10.6) Other relevant monitoring projects

The cooperative WDFW/YIN juvenile marking program (survival index groups) and other smolt passage monitoring programs operating in the mainstem Columbia River, will contribute additional information regarding the passage timing and survival of fall chinook produced each year through the supplementation program.

SECTION 11. RESEARCH

Research programs associated with this HGMP are described within the monitoring and evaluation sections above. Research will be directed at determination of supplementation program contribution rates, the ecological and genetic effects of the program on the natural population.

SECTION 12. ATTACHMENTS AND CITATIONS

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