APPENDIX A

Definitions

“95% CI” means the range in which a true population mean (average) will fall for 95% of all samples possibly drawn from the population.

“Action item” means a specific task to be undertaken by ODFW.

“Adaptive management” means a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

“AIC” means Akaike Information Criterion; a measure of the relative goodness of fit for a statistical model.

“Alevin” means a salmonid fry with a visual yolk-sac.

"Anadromous" means fish which migrate from saltwater to freshwater for spawning.

“Aquatic habitat" means the waters which support fish or other organisms which live in water and which includes the adjacent land area and vegetation (riparian habitat) that provides shade, food, and/or protection for those organisms.

"Brood" means a group of fish that are produced by parents during a single year of spawning.

"Broodstock" means a group of fish that are held and eventually artificially spawned to provide a source of fertilized eggs for hatchery programs.

"Brood year" means the year in which the adults spawn.

“Brood harvest rate” means the proportion of recruits that were harvested by fishers.

“cfs” means cubic feet per second (a measure of stream flow).

"CH" means Chinook salmon (spring and fall races).

"CHF" means fall Chinook salmon.

"CHS" means spring Chinook salmon.

“Cohort” means fish that originated from the same parental spawning year.

“Conservation status criterion” means a measurable point, or range of points, that is indicative of a significant deterioration in population status.

"Conservation" means managing for sustainability of native fish so that present and future generations may enjoy their ecological, economic, recreational, and aesthetic benefits.

“Covariate” means a variable that is possibly predictive of the outcome under study.

“Co-variation” means a correlated variation of two or more variables.

“CWT” means a coded wire tag placed located in the snout of a fish.

“Desired status” means taking full advantage of the productive capacity of natural habitats, in order to provide substantial ecological, economic, and cultural benefits.

“Desired status criterion” means a point of population status that was identified as desirable as a result of the planning process.

“DIC” means Deviance Information Criterion; a measure of the relative goodness of fit for a statistical model.

"Disease" means problems caused by infectious agents, such as parasites or pests, and by other conditions that impair the performance of the body or one of its parts.

"Enhancement" means management activities including rehabilitation and supplementation that increase fish production beyond the existing levels.

“Empirical” means information gained by means of observation during surveys or experiments.

“Exploitation rate” means the age-specific proportion of recruits harvested in the ocean fisheries or the proportion of maturing adults harvested in a near-shore terminal fishery or a freshwater fishery.

“Fishery” means a grouped activity related to the catching of fish.

"Fish Hatchery" means a facility at which adult broodstock are held, or where eggs are collected and incubated, or where eggs are hatched, or where fish are reared.

“Freshwater escapement” means the number of fish that entered freshwater (includes estuaries).

"Fry" means young salmon which have recently emerged from the gravel.

"Genotype" means the kinds of and the combination of genes possessed by an individual.

"Hatchery fish" means a fish incubated or reared under artificial conditions for at least a portion of its life.

"Hatchery Program" means a program in which a specified hatchery population is planted in a specified geographical location.

“Huntley Park” means the sampling location for CHF migrating in the Rogue River (RM 8)

“Jacks” mean age 2 mature salmon.

"Lost Creek Dam" means the same as William Jess Dam.

"Lost Creek Lake" means the reservoir impounded by William Jess Dam.

“Management Action” means a specific task to be undertaken by ODFW

“Management Strategy” means the broad concept referring to an overall scheme.

"Marine species" means those fish found in the ocean or the saline or brackish water of estuaries or bays along the coast, but not generally found in freshwater streams.

“Maximum sustained yield” means the largest catch or yield that can continuously be taken from a population given average environmental conditions over the period of record.

"Mean” means average.

“Median” means the mid-value (50% higher and 50% lower) of the observations.

“Metric” means a measurable quantity of an attribute.

"Mitigation" means to lessen the impact of activities or events that cause fish or habitat loss.

“Model” means a mathematical characterization of a biological or physical process(s).

“Morphology” means the form and structure of an organism or an environmental feature.

“MSY” means maximum sustained yield (see above).

"Native fish" means indigenous to Oregon, not introduced. This includes both naturally produced and hatchery produced fish.

"Naturally produced" means fish that reproduce and complete their full life cycle in natural habitats.

"Natural spawners" means fish, regardless of parental origin, that spawn in the natural environment.

“NFCP” means ODFW’s Native Fish Conservation Policy.

“NP” means naturally produced.

“NP CHS” means naturally produced spring Chinook salmon.

“NP CHF” means naturally produced fall Chinook salmon.

"ODFW" means the Oregon Department of Fish and Wildlife.

"ODEQ" means the Oregon Department of Environmental Quality.

"Optimum" means the level of fish abundance that results in the greatest ecological, economic, recreational, and aesthetic benefits.

"*P*" means the probability if the test statistic really were distributed as it would be under the relevant hypothesis, of observing a test statistic as extreme as, or more extreme than, the one actually observed. The smaller the *P* value, the more strongly the test rejects the hypothesis being tested. A *P* value of .05 or less rejects the hypothesis "at the 5% level" that is, the statistical assumptions used imply that only 5% of the time would produce a finding this extreme if the hypothesis were true.

“Persistence” means continuation despite problems or difficulties.

“PFMC” means the Pacific Fishery Management Council.

"Policy" means mandatory direction or constraints that provide the framework for programs of governmental agencies.

"Population" means a group of fish originating and reproducing in a particular area at a particular time which do not interbreed to any substantial degree with any other group reproducing in a different area or in the same area at a different time.

"Production" means the number or pounds of fish raised in a hatchery or resulting from natural spawning and rearing in freshwater, estuarine, or ocean habitats.

“PVA” means a population viability assessment.

“QET” means a quasi-extinction threshold; below which a population is projected to become extinct.

"Recruits" means the estimated number of age 3-6 NP CHF that would have spawned naturally in the absence of any fishing related mortality.

"Recruitment" means the addition of recruits to a population of fish.

"Risk" means the extent to which, a management practice may reduce population productivity or cause an undesirable change in genetic characteristics of a population.

“RM” means river (or stream) mile as measured from the mouth.

“Salmon-steelhead cards” mean cards on which anglers record harvested fish.

"SE" means standard error; a statistical measure of uncertainty.

"Serious depletion" means a significant likelihood that the species management unit will become threatened or endangered under either state law or the federal Endangered Species Act.

"Smolt" means a juvenile salmon or trout that is capable of initiating a seaward migration and is capable of living in the sea.

“SMU" means species management unit (see below).

“S_{MSY}” means the number of spawners estimated for attainment of maximum sustained yield.

“Spawning escapement” means the number of fish that spawned naturally.

"Species" means any group or population that interbreeds and is substantially reproductively isolated.

"Species management unit” means a collection of populations from a common geographic region that share similar genetic and ecological characteristics.

“Standard deviation” means a statistical measure of the dispersion of a set of data from its mean.

“Stochastic model” means a mathematical model involving random variable(s) in order to estimate probability distributions of potential outcomes.

“Stratum” means a group of fish populations, with a Species Management Unit, characterized by a primary commonality in life history.

"Sustainable" means persistence over time, that is to say the ability of a population or a species management unit to maintain temporal, spatial, genetic, and ecological coherence while withstanding demographic, environmental, and genetic variation and catastrophic events from natural and human induced causes.

"USACE" means the United States Army Corps of Engineers.

"USGS" means the United States Geological Survey.

“Viability” means continued existence with full functioning attributes.

"Wild" means fish that reproduce and complete their full life cycle in natural habitats (same definition as “naturally produced”).

"William Jess Dam" means the same as Lost Creek Dam.

APPENDIX B

Regulatory Responsibilities of Governmental Agencies

Local Government

Cities and counties are responsible for the administration of land-use planning. Under Oregon's statewide land-use planning program, administered by the Department of Land Conservation and Development (DLCD), all cities and counties are required to adopt comprehensive plans that meet mandatory state land-use standards. The standards are 19 statewide planning goals that deal with land use, development, housing, transportation, and the conservation of natural resources. Comprehensive plans approved by the Land Conservation and Development Commission (LCDC) become the controlling document for land use in the area covered by that plan.

Several statewide planning goals require the protection of natural resources by cities and counties through adoption of land-use planning ordinances. Most notable is Goal #5, which covers open spaces, scenic and historic areas, and natural resources. Other applicable statewide planning goals include Goal #6, which covers air, water and land resources quality, Goal #8, which covers recreational needs, Goal #16, which covers estuarine resources, and Goal #19, which covers ocean resources.

Natural resource related land-use activities that may be regulated by cities and counties, through land-use planning, include riparian and wetland protection, stormwater management, floodway/floodplain development, and removal-fill activities in waters of the State.

State Government

ODFW goals and policies for commercial and sport fishing regulations, fish management, and the Native Fish Conservation Policy and Fish Hatchery Management Policy are adopted as Oregon Administrative Rules (OAR). These policies along with the Oregon Plan for Salmon and Watersheds provide guidance on the development of fish management options for water bodies throughout the state.

Fish management authority and associated activities conducted by ODFW are provided and directed by statute, rule, and policy. ODFW is authorized by Oregon Revised Statute (ORS) to manage the fish and wildlife resources of the state (ORS chapter 496). Within the Oregon Administrative Rules, Division 007 rules provide directives associated with fish management and hatchery operations. Specific Division 007 policies include the Native Fish Conservation Policy (OAR 635-007-0502), General Fish Management Goals (OAR 635-007-0510), Hatchery Program Management Plans (OAR 635-007-0545), and Control of Fish Disease (OAR 635-007-0550). Additional guiding policies are found within OAR Division 415 and 412 rules for Fish and Wildlife Habitat Mitigation and Fish Passage and within Division 500 rules for fish management plans.

Regulatory responsibilities for the preponderance of activities that may affect aquatic ecosystems are executed by a variety of state agencies under the umbrella of the Oregon Plan for Salmon and Watersheds.

The Oregon Department of Environmental Quality (DEQ) is responsible for protecting and enhancing Oregon's water and air quality, for cleaning up spills and releases of hazardous materials, and for managing the proper disposal of hazardous and solid wastes. In addition to local programs, the Environmental Protection Agency (EPA) delegates authority to DEQ to operate federal environmental programs within the state such as the Federal Clean Air, Clean Water, and Resource Conservation and Recovery Acts.

The Oregon Water Resources Department (OWRD) is charged with administration of the laws governing surface and ground water resources. The Department's core functions are to protect existing water rights, facilitate voluntary flow restoration in streams, increase the understanding of the demands on the state's water resources, provide accurate and accessible water resource data, and facilitate water supply solutions.

The Department of State Lands (DSL) is responsible for administering the removal-fill law, which protects Oregon´s waterways and wetlands from uncontrolled alteration. DSL is the lead state agency for the protection and maintenance of wetlands resources; and management of coastal resources seaward of the mean high tide line.

The Oregon Department of Forestry (ODF) responsibilities include implementation of the Oregon Forest Practices Act, which provides for timber harvest using techniques that are consistent with conservation and environmental protection. ODF also manages state-owned forest land in Oregon.

The Oregon Department of Geology and Mineral Industries (DOGAMI) is lead regulator for geologic resources (oil; gas; geothermal energy; metallic and industrial minerals; and sand, gravel, and crushed stone). The Mineral Land Regulation and Reclamation Program is the lead coordinating agency for state mining regulation.

The Oregon Parks and Recreation Department (OPRD) administers the Oregon Scenic Waterways Program. Approval must be obtained from OPRD for activities such as cutting of trees, mining, construction of roads, railroads, utilities, buildings, or other structures within a one-quarter mile of the bank of a designated scenic waterway. Portions of both the Rogue and Illinois Rivers are designated as scenic waterways. The OPRD, through its ocean shore rules, administers a permit program for ocean shore alterations.

The Oregon Department of Agriculture (ODA) Natural Resources Division works to conserve, protect, and develop natural resources on public and private lands so agriculture will continue to be productive and economically viable in Oregon. Primary program areas include: water quality, confined animal feeding operations, smoke management, land use, soil & water conservation districts, and plant conservation biology. The ODA Plant Division oversees statewide noxious weed control efforts.

The Oregon State Marine Board (OSMB) is Oregon's recreational boating agency. The OSMB registers outfitters and guides and licenses ocean charter boats. The OSMB establishes statewide boating regulations and contracts with county sheriffs and the Oregon State Police to enforce marine laws. The OSMB also provides grants and engineering services to local governments (cities, counties, park districts, port districts) to develop and maintain accessible boating facilities and protect water quality.

Oregon State Police (OSP) Fish and Wildlife Enforcement Services Division ensures compliance with the laws and regulations that protect and enhance the long term health and equitable utilization of Oregon's fish and wildlife resources and the habitats upon which they depend.

The Oregon Watershed Enhancement Board (OWEB) promotes and funds voluntary actions that strive to enhance Oregon's watersheds. OWEB programs support efforts to restore salmon runs, improve water quality, and strengthen ecosystems that are critical to healthy watersheds and sustainable communities. OWEB administers a grant program funded from the Oregon Lottery. The grant program supports voluntary efforts by Oregonians seeking to create and maintain healthy watersheds.

Regulatory Responsibilities – Federal Government

The Bureau of Land Management (BLM) administers public lands within a framework of numerous laws. The most comprehensive of these is the Federal Land Policy and Management Act of 1976. Other applicable laws include the National Environmental Policy Act of 1969, Multiple-Use Sustained-Yield Act of 1960, Mining Law of 1872, Taylor Grazing Act of 1934, and the Oregon and California Act of 1937.

The United States Forest Service (USFS) manages national forest lands for a number of multiple uses within the framework of the National Forest Management Act of 1976. Other applicable laws include the Multiple-Use Sustained-Yield Act of 1960, National Environmental Policy Act of 1969, and Mining Law of 1872.

Substantial portions of the Rogue River Basin are managed by the BLM and the USFS. Land management activities such as logging and road construction are designed to meet forest practices rules and water quality standards outlined by the Oregon Forest Practices Act. A portion of the Rogue River was designated a national Wild and Scenic River in 1968. The BLM and USFS regulate commercial and recreational boat traffic within the Wild and Scenic section of the Rogue River.

The Environmental Protection Agency (EPA) administers the Clean Water Act. The Clean Water Act gives EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. The Act makes it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under provisions of the Act.

The National Marine Fisheries Service (NOAA Fisheries) is responsible for the management, conservation and protection of living marine resources within the Exclusive Economic Zone (waters three to 200 miles offshore) as provided by the Magnuson-Stevens Act. Under the Marine Mammal Protection Act and the Endangered Species Act, NOAA Fisheries is responsible for the recovery of protected marine species, which includes species of anadromous fish species.

The Pacific Fishery Management Council (PMFC) is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976. Fishery Management Councils advise NOAA Fisheries on issues that relate to the management of ocean fisheries within the Exclusive Economic Zone. PFMC is responsible for fisheries off the coasts of California, Oregon, and Washington.

The United States Fish and Wildlife Service (USFWS) administers protection programs for native endangered and threatened species under the Endangered Species Act. The USFWS also administers permits for activities such as depredation control under the Migratory Bird Act.

The Natural Resources Conservation Service (NRCS) provides technical and financial assistance to help agricultural producers, and other entities, conserve land and water resources. NRCS works through conservation districts, and other entities, to help landowners, as well as Federal, State, tribal, and local governments and community groups, conserve natural resources on private lands.

The U.S. Army Corps of Engineers (USACE) regulatory authority extends to structures in navigable waterways under the Rivers and Harbors Act of 1899 and the discharge of dredge and fill material under Section 404 of the Federal Water Pollution Control Act Amendments of 1972. In addition, the USACE regulates stream flows under the Flood Control Acts of 1936 and 1958. Included in these legislative acts were directives to survey for flood control potential in the Rogue River Basin. Subsequent legislation authorized the construction of three dams in the basin (United States Congress 1962), two of which have been built and are operational.

APPENDIX C

Development of Spawner and Freshwater Escapement Estimates Rogue River Basin Populations

As described in the conservation plan, there appear to be five populations of CHF present in the Rogue River Basin (*see* **SPECIES MANAGEMENT UNIT AND CONSTITUENT POPULATIONS**, page 7 in the conservation plan). The populations can be generally termed as Upper Rogue, Middle Rogue, Lower Rogue, Applegate, and Illinois. Data sources related to the abundance of adult CHF within these populations varied markedly. An overview of the sources of available data follows. Only those data sets which covered at least five consecutive years are described. Also described is the relevance of the data to the development of this conservation plan.

Databases Related to CHF Abundance

Lower Rogue population: Spawners (live and dead CHF) were counted in portions of various tributary streams during 1986-2010. This database was directly relevant to the purpose of this conservation plan because spawner abundance could be estimated for the entire population, criteria could be developed in relation to desired status and conservation status, and monitoring is ongoing and expected to continue for the foreseeable future.

Middle Rogue population: Carcasses were counted within two survey areas located on the mainstem of the Rogue River during 1974-2004. The areas surveyed included Valley of the Rogue State Park - the city of Rogue River (RM 113-111) and Lathrop's Landing - Robertson Bridge (RM 97-87). This database was judged to not be directly relevant to the purpose of this conservation plan because the data could not be used to estimate spawner abundance for the entire population, and monitoring has been terminated and is not expected to be implemented again within the foreseeable future. As a result of these factors, it was judged there was minimal value in trying to craft criteria for desired status or conservation status.

Upper Rogue population: Fish passage at Gold Ray Dam (RM 125) was estimated at a counting station during 1942-2009. In August 2010, the fish counting station became inoperable with the removal of Gold Ray Dam. Substitution of spawning surveys to estimate CHF spawner abundance is not possible because of the spatial and temporal overlap in CHS and CHF spawning (ODFW 1991). With the loss of the fish counting station, it was judged there was minimal value in trying to craft criteria for desired status or conservation status.

Illinois population: Spawners (live and dead CHF) were counted within portions of three tributary streams (Mendenhall Creek, Elk Creek, and Sucker Creek) during 1996-2004. This database was judged to not be directly relevant to the purpose of this conservation plan because the data could not be used to estimate spawner abundance for the entire population, and monitoring has been terminated and is not expected to be implemented again within the foreseeable future. In addition, ODFW staff judged that CHF spawn primarily in the mainstem, and in the East and West Forks. It is currently unknown whether spawner counts in the smaller tributaries may be representative of spawning escapement throughout the entire basin. As a result of these factors, it was judged there was minimal value in trying to craft criteria for desired status or conservation status.

Applegate population: Carcasses were counted within three survey areas located on the mainstem of the Applegate River, and in Slate Creek, during 1974-2004. The areas surveyed in the Applegate River included the town of Applegate - Williams Creek (RM 25-20), the town of Murphy - Hog Ranch (RM 13-11), and Highway 199 - the mouth (RM 4-0). The Slate Creek survey covered the lowest 5.0 miles of Slate Creek. This database was judged to not be directly relevant to the purpose of this conservation plan because the data could not be used to estimate spawner abundance for the entire population. Monitoring has been terminated and is not expected to be implemented again within the foreseeable future. As a result, it was judged there was minimal value in trying to craft criteria for desired status or conservation status.

Aggregate populations: Migrating adults were captured during 1976-2010 with a 300’ beach seine fished at Huntley Park (RM 8) three days weekly during July 15-October 28 (ODFW 1992). Each day, sampling begins early in the morning and continues until the seine has been fished 15 times. This sampling effort was standardized in 1978 and tagging studies indicated that all of the CHF populations in the Rogue River Basin are susceptible to capture (ODFW 1992). A more detailed description of the utility of this data follows.

The Oregon Game Commission (now ODFW) began beach seining near the mouth of the Rogue River in 1974 in order to capture adult salmonids that entered the Rogue River. Initially, the sampling was designed to collect fish in order to obtain life history information and to estimate freshwater escapement through the use of mark-recapture methods. Mark-recapture efforts were terminated after 1976 when it became apparent that mortality rates of tagged Chinook salmon resulted in biased estimates of freshwater escapement (Cramer 1979). Instead, catch per unit of seining effort was used as an index of abundance. This approach continued through the 1980s, although it became apparent that unusually high flows affected the efficacy of sampling with the beach seine at the Huntley Park site during 1983 and 1984.

Establishment of a run of hatchery coho salmon in the early 1980s afforded an opportunity to generate annual estimates of seining efficiency. Available data indicated that few coho salmon died during upstream migration, few hatchery fish strayed to spawn naturally, and, at the time, there was no directed freshwater fishery for coho salmon. Seining efficiency on coho salmon of hatchery origin was estimated, compared to flow at time of seine capture, and a catch efficiency model was developed (ODFW 1989). This flow-based model was used to estimate freshwater escapement for each run of anadromous salmonids, including CHF (ODFW 1989; ODFW 1992; ODFW 1994).

In 1992, ODFW determined that the flow-based model significantly underestimated the number of CHF that returned to the Rogue River. During some years, known numbers of CHF exceeded the estimate produced by the flow-based model. Known numbers of CHF included: (1) those that passed the fish counting station at Gold Ray Dam, (2) those recovered as carcasses during spawning surveys, and (3) those estimated to be harvested by anglers based on returns of salmon-steelhead cards. In light of these results, ODFW subsequently termed estimates derived from the flow-based model as the “Huntley Park Index” of CHF freshwater escapement.

Methods Devised to Estimate CHF Passage at Huntley Park

ODFW developed two methods to estimate the number of CHF that passed Huntley Park. Both methods entailed expansion of the annual passage index at Huntley Park. The first method used the results of mark-recapture efforts during 2000-2002 to calibrate the passage index. The second method used CHF passage estimates at Gold Ray Dam to calibrate the passage index. Both methods resulted in very similar passage estimates at Huntley Park and a description of each method follows.

Calibration of Huntley Park Index with mark-recapture estimates: ODFW has tried twice (once during 1975-76 and once during 2000-2002) to estimate CHF escapement in the Rogue River based on the Petersen mark-recapture method. Freshwater returns were estimated to be about 63,000 fish in 1975 and about 93,000 fish in 1976 (Appendix Table C-1). However, these estimates were judged to be inflated because of delayed mortality among tagged fish (Smith et al. 1978). Increased mortality of tagged CHF was likely a significant bias because non-handled CHF died at high rates during years of warm water temperature (ODFW 1992).

Instances of significant prespawning mortality decreased markedly after the mid-1980s as water release strategies at Lost Creek Dam were modified to increase flow in the Rogue River during critical periods of CHF migration (ODFW 1992). The only instance of significant prespawning mortality occurred during the drought year of 2001 (Satterthwaite 2002). The decrease in CHF prespawning mortality led ODFW to attempt another series of mark-recapture efforts with CHF during 2000-2002. Resultant Petersen mark-recapture estimates of the number of CHF that passed Huntley Park during these years ranged between 126,000 and 405,000 fish (Appendix Table C-1).

Appendix Table C-1. Petersen mark-recapture estimates of the number of fall Chinook salmon that entered the Rogue River, 1975-2002 and associated data relevant to the calibration of the Huntley Park Index of freshwater escapement. River physical factors are reported as mean daily maximum values during August at Agness (RM 30). Standardized sampling at Huntley Park began in 1978.

	Mark-recapture	Huntley	River physical factors	
Year	estimate (95% CI)	Index	Flow	Temperature
1975	63,235 (47,160 - 87,655)	37,175	1,716 cfs	--
1976	92,977 (61,807 - 147,043)	23,469	2,149 cfs	71°F
2000	126,085 (88,540 - 208,919)	40,047	2,317 cfs	73°F
2001	404,660 (192,880 - 616,440)	42,577	1,762 cfs	74°F
2002	203,267 (150,057 - 290,622)	80,545	2,027 cfs	72°F

To some degree, all of the mark-recapture estimates listed in Appendix Table C-1 are inflated because of delayed mortality among tagged fish. Bias related to tagging mortality was judged to be differentially high in 2001 because of low flow and extensive prespawning mortality (Satterthwaite 2002). Consequently, the 2001 estimate was excluded from further consideration. Tagging related mortality was assumed to be 10% in the other years, resulting in adjusted mark-recapture estimates of 113,476 in 2000 and 182,940 in 2002. Subsequent comparisons indicated that the escapement estimates exceeded the Huntley Passage Indexes by 2.70-fold in 2000 and 2.27- fold in 2002. The average (2.485) of these values was used to calibrate (expand) the Huntley Passage Index for the period of record. Calibrated values were then considered to be numerical estimates of the number of CHF that passed Huntley Park. Resultant estimates will be presented later in this section.

Calibration of Huntley Park Index with Gold Ray Dam counts: ODFW has estimated fish passage at Gold Ray Dam since 1942. All passing fish were counted during 1942-1947. During

1948-92, fish were counted eight hours daily, five days weekly. Partial counts were designed to estimate biweekly passage with an average error of less than 10% (Li 1948). Since 1993, passage has been estimated with video recordings; a procedure which is assumed to have minimal uncertainty. Chinook salmon that pass the counting station by 15 August are classified as CHS, while later migrants are classified as CHF (ODFW 2000).

ODFW tagged numerous CHF in the lower Rogue during 1974-78 and looked for tags on carcasses found during spawning surveys. Most tags were recovered in the Middle Rogue, Applegate, and Lower Rogue population areas. However, five tags were recovered upstream of Gold Ray Dam (Upper Rogue population area). All of these early-run CHF had been captured and tagged at Huntley Park between 15 July and August 4. The other tag recoveries indicated that later migrating CHF eventually spawned in other population areas farther downstream in the Rogue River Basin (ODFW 1992). Early-run fish are defined as those CHF that pass Huntley Park before 4 August.

Application of radio-tags to a few CHF caught at Huntley Park in 2008 (ODFW 2009) afforded the opportunity to examine the assumption that early-run CHF migrate upstream to spawning areas above Gold Ray Dam. There were three early-run CHF tagged at Huntley Park that passed Gold Ray Dam. One passed on August 11 and was classified as a CHS. The other two passed later and were thus classified as CHF. In addition, there were another three CHF that were tagged at Huntley Park after August 4 and were subsequently detected on spawning grounds downstream of Gold Ray Dam.

The Oregon Game Commission also tagged large numbers of CHF near the mouth of the Rogue River in 1970 and in 1971 during a research project directed at summer steelhead (Everest 1973). Efforts to recover tagged CHF were limited to very few spawning surveys, but 36 tagged CHF were trapped as they attempted to pass the fish counting station at Gold Ray Dam. The mean date of tagging at the river’s mouth was 11 August (95% CI = ±4 days). These results, coupled with the 1974-78 tag recoveries, indicate that early-run CHF in the Rogue River primarily spawn upstream of Gold Ray Dam. Assuming that is the case, then an appropriate expansion factor could be developed for the Huntley Park Index because all passing fish are counted at the counting station.

Based on the counts the counts at Gold Ray Dam, the early-run component of the Huntley Passage Index accounted for an average of 40% (95% CI for arc-sine transformed data = 17-64%) of the early-run CHF that actually passed Huntley Park during 1992-2008. Data from years prior to 1992 were not included because of concern that the population of CHF in the upper Rogue was still increasing relative to CHF in the remainder of the basin (ODFW 2000). Because of variations in CHF migration timing at Huntley Park, this approach would not be appropriate if there were data from only a few years. However, with 17 years (1992-2008) of data, it was judged that variations in CHF migration timing would likely be mostly cancelled provided that annual variations in CHF migration timing were random in nature. Application of a 40% adjustment factor (2.5-fold expansion factor) produced the Huntley Park passage estimates presented in Appendix Table C-2.

Appendix Table C-2. Four metrics related to the abundance of fall Chinook salmon in the Rogue River Basin, 1974-2010. Known fish are the sum of (1) passage estimates at Gold Ray Dam, (2) harvest estimates from salmon-steelhead tags, and (3) the number of carcasses recovered in five survey areas in the Applegate and Middle Rogue population areas. The carcass surveys covered 24 miles of high quality spawning habitat. Total spawning habitat in the basin estimated to be about 540 miles, with about 300 miles is considered to be used consistently by a significant number of spawners.

	Total	Huntley	Passage at Huntley Park	
Year	known[a]	Index[b]	Method 1[c]	Method 2[d]
1974	--	42,656	106,021	106,660
1975	--	37,175	92,383	92,940
1976	--	23,469	58,329	58,680
1977	12,697	32,038	79,615	80,095
1978	18,501	74,575	185,321	186,438
1979	13,239	69,730	173,281	174,325
1980	6,497	33,478	83,194	83,695
1981	13,552	41,420	102,942	103,563
1982	10,568	55,735	138,506	139,340
1983	9,314	21,464	53,336	53,658
1984	8,336	18,212	45,257	45,530
1985	20,282	36,109	89,722	90,263
1986	39,760	98,314	244,291	245,763
1987	51,204	65,133	161,857	162,833
1988	61,078	33,930	84,319	85,423
1989	24,787	38,767	96,337	96,918
1990	9,472	10,187	25,315	25,468
1991	10,749	7,544	18,747	18,860
1992	13,403	31,288	77,751	78,220
1993	22,515	19,002	47,220	47,505
1994	30,740	33,114	82,290	82,786
1995	28,580	35,444	88,079	88,610
1996	20,283	27,004	67,105	67,509
1997	10,056	24,625	61,193	61,562
1998	12,435	19,967	49,618	49,917
1999	9,500	23,710	58,920	59,275
2000	21,624	42,047	104,489	105,118
2001	29,095	42,577	105,805	106,442
2002	42,491	80,545	200,157	201,363
2003	57,760	94,231	234,167	235,577
2004	--	63,561	157,950	158,902
2005	--	25,821	64,167	64,553
2006	--	17,972	44,660	44,929
2007	--	20,366	50,740	50,914
2008	--	17,336	43,080	43,340
2009	--	30,453	75,676	76,132
2010	--	26,633	66,184	66,582

[a] *Carcasses were not surveyed after 2003 and only three areas were surveyed during 1974-76.*
[b] *Index values for 1974-77 were adjusted for non-standardized sampling (ODFW 1992).*
[c] *Huntley Park Index calibrated with mark-recapture estimates from 2000 and 2002.*
[d] *Huntley Park Index calibrated with 1992-2009 passage estimates at Gold Ray Dam.*

In summary, the Gold Ray Dam counts provide an accurate abundance estimate of the Upper Rogue population and tag recoveries indicated that this population passes Huntley Park by August

5. A comparison of the Huntley Park Index, calculated only for the period July 15-August 5, with the Gold Ray dam counts resulted in the conclusion that CHF passage at Huntley Park is best estimated with the application of a 2.5X expansion factor (0.40/Huntley Park Index).

Estimation of Life History Parameters

Aggregate populations: Scale interpretations were used to estimate the origin and age composition of CHF that entered the Rogue River during 1974-1988 (ODFW 1992). Scales were also used to estimate CHF age composition for the 2007-2011 returns. The age composition of the 1989-2006 returns was estimated based on length-at-age criteria developed from scale samples obtained from the 2007-2011 returns. Annual proportions of hatchery fish within the 1989-2011 returns were estimated by expanding the number of fin-clipped fish caught at Huntley Park, by the mark rates among cohorts released from hatcheries in the Rogue River Basin. Fin-clipped fish were assigned to specific brood years based on their length. Final estimates of CHF passage at Huntley Park can be found in Appendix Table E-1.

All spawners were assumed to be naturally produced fish. During 1991-2004, ODFW recovered about 80,000 CHF carcasses during spawner surveys conducted throughout the Rogue River Basin. Only 54 of those fish were marked with adipose fin clips and expansions for the proportions of smolts indicated that hatchery fish composed about 0.2% of the spawners, which was judged to be insignificant.

Lower Rogue population: For the 2009-2010 returns, the proportion of hatchery fish among spawners was estimated based on recoveries of fin-clipped fish and the proportion of fin-clipped fish among adults that returned to Indian Creek Hatchery. As no age composition estimates were available, the age composition of wild spawners in the Lower Rogue population area was assumed to equal that of wild CHF that passed Huntley Park. For the 1986-2008 returns, the proportion of hatchery fish among spawners was estimated by expansion of recovered CWTs based on the proportion of cohorts marked with CWTs before release from the hatcheries.

Surveyors found 46 CWTs among the 7,370 CHF carcasses recovered during the 1986-2008 surveys. All of the CWTs recovered during 1992-2005 and all of these marked CHF originated from smolts released at Indian Creek Hatchery. Each recovered CWT was expanded for the proportion of CWTs, among all CHF smolts released, within the specific year of release. The resultant estimates were used to estimate the proportions of hatchery fish among the 1986-2008 spawners. Results suggested that hatchery fish composed an average of 4% of the 1992-2008 spawners. With no CWTs found among carcasses recovered in 1986-1991, it was assumed that hatchery fish composed 1% of the spawners during those years. This assumption was based on the number of smolts released annually at Indian Creek Hatchery as compared to those brood years that produced the adults that spawned in 1991-2010.

Estimation of Freshwater Harvest

Aggregate populations: Freshwater harvest (includes the estuary) was estimated from salmon-steelhead cards (punchcards) returned to ODFW by anglers. ODFW (1992) reported estimates of total harvest for 1956-1984. Estimates for later years were obtained from ODFW records. Harvest estimates from salmon-steelhead cards do not include jacks; which are almost all age 2 fish (ODFW 1992). Harvest of jacks was estimated based on their proportion among CHF that passed

Huntley Park (i.e., it was assumed that the freshwater fishery did not selectively harvest CHF of different ages).

Estimates of CHF harvest were segregated into areas upstream and downstream of Huntley Park. Angler harvest downstream of Huntley Park was assumed to equal the salmon-steelhead card estimates applicable to the Rogue River downstream of Elephant Rock (RM 3). Estimates for this area were only available for 1993 and later years. During this period, the area downstream of Elephant Rock accounted for an average of 53% (95% CI = 48-58% as estimated from arcsine transformed data). The mean estimate of harvest distribution was applied to years prior to 1993 in order to estimate angler harvest downstream of Elephant Rock.

Lower Rogue population: Freshwater harvest was assumed to equal the harvest downstream of Elephant Rock.

Estimation of Spawning Escapement

Aggregate populations: Spawning escapement in the Rogue River Basin was estimated as:

Passage estimates at Huntley Park - (prespawning mortality + angler harvest)

CHF in the Rogue River are susceptible to high rates of prespawning mortality during years of low flow and warm water temperatures. Rates of prespawning mortality were estimated during 1978-1986 (ODFW 1992) and during 2001 (Satterthwaite 2002). Prespawning mortality rates in all other years were assumed to equal 2% because there were no anecdotal reports of significant prespawning mortality in years after 1986 (2001 excepted).

Lower Rogue Population: The estimation methods are described in **APPENDIX D** (*see* **Chetco, Winchuck, and Lower Rogue Populations:,** page 181).

Estimation of Ocean Fishery Impacts

Annual exploitation rates in the ocean fisheries were assumed to equal those estimated for fall Chinook salmon of Klamath River Basin origin, as reported by the Pacific Fishery Management Council (PFMC 2010). Ocean exploitation rates on age 5 and age 6 fish were assumed to equal those on age 4 fish. These assumptions had to be made because there were no consistent releases of CWT marked CHF from hatcheries within the Rogue River Basin and consequently it was not possible to directly estimate exploitation rates in the ocean fisheries.

The assumption of equal ocean exploitation rates on age 3 and age 4 fish of Rogue and Klamath origin appeared reasonable because (1) Rogue and Klamath CHF exhibit indistinguishable landing patterns in the ocean fisheries (Appendix Table C-3) and (2) freshwater returns of CHF in the Rogue and Klamath rivers are positively correlated (*see* **Comparisons to Other Populations:,** page 69 in the conservation plan). Weitkamp (2010) also documented very similar ocean landing distributions of Chinook salmon released from hatcheries in the Southern Oregon - Northern California ecoregion.

Estimation of Ocean Abundance

Cohort reconstructions (Ricker 1975) were employed to estimate the number of NP CHF that resided in the ocean during spring prior to onset of any fishing mortality. Estimation procedures began with age 6 fish and ended with age 3 fish and were analogous to those employed by Hankin and Healy (1986) and Mohr (2006). Estimates of cohort abundance began with age 6 fish because all NP CHF of Rogue River Basin origin matured at ages 2-6. The abundance of younger cohorts were estimated as the sum of (1) the number of fish that resided in the ocean during the succeeding year, (2) natural mortality, (3) harvest in the ocean fisheries, and (4) the number of fish that returned to the river.

Appendix Table C-3. Comparisons of landing distributions of CWT-marked fall Chinook salmon released from hatcheries in the Rogue and Klamath River basins, 1987-2003 brood years. Data incorporated in the analyses include only those CWT groups released after the month of August. Comparisons were made with paired t-tests of arcsine transformed data. Data from Irongate and Trinity River hatcheries in the Klamath River Basin were pooled because no difference in landing distributions could be detected (paired t-test *P* = 0.52).

Landing distribution metric	Mean		***P*** **for difference**
	Rogue	**Klamath**	
Proportion landed in California+Oregon	**0.99**	**0.99**	**0.76**
Proportion landed in Oregon	**0.43**	**0.45**	**0.38**

For each cohort, we used the equation:

$$N_i = \frac{\dfrac{N_i + 1}{1 - A_i} + E_i}{1 - u_i}$$

where

N_i = number of age i fish resident in the ocean prior to fishing during year t,
N_{i+1} = number of age i+1 fish resident in the ocean during the next year,
A_i = rate of natural mortality for age i cohorts resident in the ocean between years t and t+1,
u_i = exploitation rate of age i fish in the ocean during year t, and
E_i = freshwater return of age i fish during year t.

Estimation of Recruitment

For each cohort (brood year), recruitment was estimated as the sum of the estimated freshwater returns of age 3-6 CHF under a scenario of no ocean fishing mortality (as termed “adult equivalents” by Mohr (2006)).

References

Cramer, S.P. 1979. Rogue Basin Fisheries Evaluation Program, annual report. Oregon Department of Fish and Wildlife, Fish Research Project, DACW 57-77-C-0027, March, Annual Progress Report, Portland.

Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, Oregon.

Fustish, C.A., S.E. Jacobs, B.P. McPherson, and P.A. Frazier. 1988. Effects of Applegate Dam on the biology of anadromous salmonids in the Applegate River. Phase I Completion Report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Portland.

Hankin, D.G., and M.C. Healey. 1986. Dependence of exploitation rates for maximum yield and stock collapse on age and sex structure of Chinook salmon (*Oncorhynchus tshawytscha*) stocks. Canadian Journal of Fisheries and Aquatic Sciences 43:1746-1759.

Li, J.C.R. 1948. A sampling plan for estimating the number of fish crossing Gold Ray Dam on the Rogue River. Unpublished report to the Oregon State Game Commission, Portland.

Mohr, M.S. 2006. The cohort reconstruction model for Klamath River fall Chinook salmon. Unpublished document. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

ODFW (Oregon Department of Fish and Wildlife). 1989. Effects of Lost Creek Dam on coho salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1991. Effects of Lost Creek Dam on the distribution and time of chinook salmon spawning in the Rogue River upstream of Gold Ray Dam. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Special Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1992. Effects of Lost Creek Dam on fall chinook salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2009. Efficacy of radio-tagging spring Chinook salmon in the Rogue River. Oregon Department of Fish and Wildlife, Salem.

PFMC (Pacific Fishery Management Council). 2010. Preseason report I. Stock abundance analysis for 2010 ocean salmon fisheries. Pacific Fishery Management Council, Portland, Oregon.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Satterthwaite, T.D. 2002. Effects of reservoir releases on adult salmon during a drought year. Supplemental Report Number 1. Lost Creek Dam Evaluation Project. Oregon Department of Fish and Wildlife, Portland.

Smith, A.K., B.P.McPherson, S.P. Cramer, and J.T. Martin. 1978. Rogue Basin Fisheries Evaluation Program, adult salmonid studies. Oregon Department of Fish and Wildlife, Fish Research Project, DACW 57-75-C-0109, Annual Progress Report, Portland.

Weitkamp, L.A. 2010. Marine distributions of Chinook salmon from the west coast of North America determined by coded wire tag recoveries. Transactions of the American Fisheries Society 139:147–170.

APPENDIX D

Development of Spawner Escapement Estimates
Coastal Populations and Lower Rogue Population

Visual counts of live and dead CHF made during walking surveys along small streams were the only available data directly related to spawner abundance, with the exception of the Chetco population area. During some years, visual counts of live and dead CHF were made from boats for portions of the mainstem of the Chetco River. In addition, a telemetry project estimated CHF spawner escapement in the Chetco River during 1995 and 1996.

Estimation of Spawning Escapement

The oldest records of CHF spawning surveys in the coastal population areas date back to the late 1950s and early 1960s. During the 1960s through the mid-1980s, spawning surveys were conducted in one (usually) stream segment within each of the following population areas: Lower Rogue, Pistol, Chetco, and Winchuck. These surveys were usually conducted only once or twice each year. During the mid-1980s, the number of spawning surveys increased significantly and surveys began in the Euchre Creek and Hunter Creek population areas. Survey frequency also increased and surveys of individual stream segments were generally conducted between three and ten times over the course of the CHF spawning period. However, the choices of which stream segments to be surveyed within each basin varied among years. Survey choices were probably chosen based on accessibility and some previous knowledge of where substantial numbers of CHF tended to spawn.

The annual goal of each survey was to obtain a peak count of spawners (live and dead CHF) within the specific survey area and to express the peak count in terms of CHF spawners per mile. Estimation of a peak count of spawners can be used to estimate the total number fall Chinook salmon present by employing an expansion factor of 2.82 (personal communication dated April 7, 2009, Ethan Clemons, ODFW, Newport).

Surveyors segregated observed CHF based on body length. Fish longer than 24 inches were classified as “adults”, while smaller fish were classified as “jacks”. Estimation procedures that follow below pertain only to adults. For the coastal populations, jacks were subsequently incorporated into the final estimates of spawning escapement based on age composition estimates for CHF that spawned in the Chetco River Basin. For the Lower Rogue populations, jacks were subsequently incorporated into the final estimates of spawning escapement based on age composition estimates for CHF that passed Huntley Park.

The spawning period of CHF in each population area extends over a period of about 2.5 months. During review of the data, it became apparent that surveys conducted at low frequencies likely missed the true peak period of CHF spawning. A filter criterion was chosen in order to generate spawner density estimates that were less affected by low survey rates. Various options were considered with a final choice of a minimum of four surveys conducted over the course of CHF spawning during any single spawning season. Only those surveys which met the filter criterion were included within the following analyses.

Analyses of Peak Densities for Adult Spawners: As previously conveyed, there were temporal and spatial variations for spawning surveys conducted within the various population areas. The first analytical step was to use paired t-tests (Zar 1999) to test for differences in adult CHF densities between the various surveys within each population area. Analysis of variance could not be used because of the temporal and spatial variations in survey selections. Results indicated that CHF spawner densities differed significantly (P <0.05) between many of the surveys within individual population areas. These findings lead to rejection of the hypothesis that spawner densities did not differ significantly between different stream segments within population areas. Consequently, survey results could not be pooled and alternative estimation methods had to be developed. Given the high degree of uncertainty associated with these methods, a research project is needed to independently test the propriety of the estimation methods described in the following sections (*see* **Research Needs**, page 142 in the conservation plan).

Estimation of Effective Spawning Habitat: The distribution of CHF spawning habitat was needed to estimate the total number of spawners within each population area. Initial estimates of total CHF habitat were obtained from ODFW's Fish Habitat Distribution database. These databases were subsequently modified before analysis. First, the downstream terminus of spawning within each population area was identified by local ODFW staff. Second, the upstream terminus of spawning within each stream within each population area was identified by local ODFW staff. Third, the database was modified to account for marginal spawning habitat that is likely used only on a sporadic basis. Inconsistent spawning habitat was considered to be that CHF would not be expected to spawn in more than 50% of the years and that minimum densities during spawning would be at least two CHF per mile.

A filter was devised to better classify areas with consistent CHF spawning. Criteria generated to filter out areas of inconsistent CHF spawning consisted of (1) stream gradient exceeds 4% in reaches immediately downstream of the perceived upstream terminus of CHF spawning, or (2) stream gradient averages greater than 3.5% in areas immediately downstream of the upstream terminus of perceived CHF spawning, or (3) there is no upstream passage by adult CHF of any point where gradient exceeds 6% within a reach that is at least 100 meters in length.

Euchre Population: There were four spawning surveys with data that met the filter criterion. Two surveys were located in the mainstem of Euchre Creek, while two were located in a tributary stream (Appendix Table D-1). Paired t-tests indicated that spawner densities in the mainstem surveys were significantly greater (both $P < 0.05$) than those in the uppermost Cedar Creek survey. Consequently, peak spawner numbers were separately estimated for the tributaries and the mainstem. Spawner densities throughout the entire mainstem were assumed to equal the average of the two mainstem surveys. Results from paired t-tests were used to predict peak spawner densities for those years when some of the surveys were not conducted.

Appendix Table D-1. Summary of CHF spawning surveys completed in the Euchre Creek population area, 1986-2011. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and do not include jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Euchre Creek (RM 3.3-4.5)	1.26	24	4.0
Euchre Creek (RM 4.5-5.7)	1.18	16	8.9
Cedar Creek (RM 0-0.6)	0.60	3	1.1
Cedar Creek (RM 0.8-1.9)	1.11	14	3.5

Effective CHF spawning habitat in the Euchre population area was estimated to be 12.52 miles with 8.60 miles in Euchre Creek and 3.92 miles in tributary streams. These estimates were used, with spawner densities averaged separately for the mainstem and the tributaries, to estimate annual peak spawner densities for the entirety of Euchre Creek population area. The 2.82 expansion factor was then used to estimate the total number of adults that spawned annually in the population area during 1986-2011.

The estimated number of adult spawners was then separated into wild and hatchery fish based on coded-wire tag (CWT) recoveries in the population area. During 1986-2010, there were seven CWT recoveries among the 120 CHF carcasses recovered during surveys. All of the CWTs originated from smolts released in Elk River, except that one originated from a smolt release in Hunter Creek. Each recovered CWT was expanded for the proportion of CWTs, among all CHF smolts released, within the specific year of release. The pooled findings suggested that hatchery fish accounted for 50% of the CHF that spawned in Euchre Creek during 1986-2010. This estimate was applied to all years of estimated age 3-6 spawner escapements (Appendix Table E-3).

The last step was to estimate the age composition of CHF that spawned in the Euchre population area. Because there are no age estimates for CHF spawners in the Euchre population area, it was assumed that the age composition of CHF spawners were equal to the estimated age composition of CHF that spawned in the Chetco River Basin.

Hunter Population: There were three spawning surveys with data that met the filter criterion. Two surveys were located in the mainstem of Hunter Creek, while one survey was located in a tributary stream (Appendix Table D-2). Paired t-tests indicated that spawner densities in the tributary survey was significantly greater ($P < 0.05$) than those in one of the mainstem surveys. Consequently, peak spawner numbers were separately estimated for the tributaries and the mainstem. Spawner densities throughout the entire mainstem were assumed to equal the average of the two mainstem surveys. Results from paired t-tests were used to predict peak spawner densities for those years when some of the individual surveys were not conducted.

Appendix Table D-2. Summary of CHF spawning surveys completed in the Hunter Creek population area, 1989-2011. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and do not include jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Hunter Creek (RM 3.3-4.2)	0.90	22	14.7
Hunter Creek (RM 5.5-6.6)	1.09	17	42.2
Little South Fork (RM 0.0-0.6)	0.59	20	28.1

Effective CHF spawning habitat in the Hunter population area was estimated to be 9.10 miles with 8.51 miles in Hunter Creek and 0.59 miles in tributary streams. These estimates were used, with spawner densities averaged separately for the mainstem and the tributary, to estimate annual peak spawner densities in the entirety of Hunter Creek population area. The 2.82 expansion factor was then used to estimate the total number of adults that spawned annually in the population area during 1989-2011.

The estimated number of adult spawners was then separated into wild and hatchery fish based on CWT recoveries in the population area. During 1989-2009, there were 92 CWT recoveries among the 657 CHF carcasses recovered during surveys. All CWTs except one were recovered during 1993-1999 and all originated from smolts released in Hunter Creek or Pistol River, except that 11 originated from smolts released at Indian Creek Hatchery. Each recovered CWT was expanded for the proportion of CWTs, among all CHF smolts released, within the specific year of release. The resultant estimates were used to estimate the proportion of hatchery fish among the 1993-1999 spawners. With the paucity of CWT recoveries in other years, it was assumed that hatchery fish composed 4% of the spawners in 1989-1992 and 2% of the spawners in 2000-2009. These assumptions were based on the number of smolts released annually at Indian Creek Hatchery, and in the Hunter and Pistol population areas, as compared to those brood years that produced the adults that spawned in 1993-1999. This estimate was applied to all years of estimated age 3-6 spawner escapements (Appendix Table E-3). For the 2010-2011 return years, estimates of spawner composition (% hatchery) were generated based on the proportion of fin-marked fish among recovered carcasses, because all of the hatchery fish originating from nearby releases should be 100% fin-marked; beginning in 2010.

The last step was to estimate the age composition of CHF that spawned in the Hunter population area. Because there are no age estimates for CHF spawners in the Hunter population area, it was assumed that the age composition of CHF spawners were equal to the estimated age composition of CHF that spawned in the Chetco River Basin.

Pistol Population: There were three spawning surveys with data that met the filter criterion. All three surveys were located tributary streams; two in Deep Creek and one in the South Fork of the Pistol River (Appendix Table D-3). Paired t-tests indicated that spawner densities in the Deep Creek surveys differed significantly (both $P < 0.05$) from spawner densities in the South Fork. Consequently, peak spawner numbers were separately estimated for the small tributaries (like Deep Creek) and for the larger tributaries and the mainstem. Spawner densities in the South Fork survey area were assumed to reflect spawner densities in other large tributaries and also in the mainstem. Results from the paired t-tests were used to predict peak spawner densities for those years when some of the individual surveys were not conducted.

Appendix Table D-3. Summary of CHF spawning surveys completed in the Pistol River population area, 1987-2011. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and do not include jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Deep Creek (RM 0.0-0.5)	0.48	25	56.9
Deep Creek (RM 0.5-0.8)	0.34	25	46.9
South Fork (RM 2.4-3.8)	1.40	13	16.1

Effective CHF spawning habitat in the Pistol population area was estimated to be 24.25 miles with 20.49 miles in the mainstem and the large tributaries (North Fork, East Fork, and South Fork) and 3.76 miles in small tributary streams. These estimates were used, with spawner densities averaged separately for the large streams and the small tributaries, to estimate annual peak spawner densities for the entirety of Euchre Creek population area. The 2.82 expansion factor was then used to estimate the total number of adult spawners in the population area during 1987-2011.

The estimated number of adult spawners was then separated into wild and hatchery fish based on CWT recoveries in the population area. During 1987-2009, there were 47 CWT recoveries among the 642 CHF carcasses recovered during surveys. All CWTs were recovered during 1993-1999 and all originated from smolts released in Hunter Creek or Pistol River, except that one originated from smolts released at Elk River Hatchery. Each recovered CWT was expanded for the proportion of CWTs, among all CHF smolts released, within the specific year of release. The resultant estimates were used to estimate the proportions of hatchery fish among the 1993-99 spawners. With the paucity of CWT recoveries in other years, it was assumed that hatchery fish composed 18% of the spawners in 1989-1992 and 2% of the spawners in 2000-2009. These assumptions were based on the number of smolts released annually in the Pistol and Hunter population areas as compared to those brood years that produced the adults that spawned in 1993-1999. For the 2010-2011 return years, estimates of spawner composition (% hatchery) were generated based on the proportion of fin-marked fish among recovered carcasses, because all of the hatchery fish originating from nearby releases should be 100% fin-marked; beginning in 2010. Final estimates of age 3-6 CHF spawning escapement in the Pistol population area can be found in Appendix Table E-3.

The last step was to estimate the age composition of CHF that spawned in the Pistol population area. Because there are no age estimates for CHF spawners in the Pistol population area, it was assumed that the age composition of CHF spawners were equal to the estimated age composition of CHF that spawned in the Chetco River Basin.

Chetco, Winchuck, and Lower Rogue Populations: Greater numbers of spawning surveys were completed during 1986-2011 in the Chetco, Winchuck, and Lower Rogue population areas as compared to the Euchre, Hunter, and Pistol population areas. Surveys were conducted only in tributary streams.

The first step toward generating estimates of annual spawner abundances was to infer peak counts within those locations that were not surveyed. Thus, inference was needed for all years, for the period of record, at sites that were never surveyed and was also needed at sites where surveys were not conducted on particular years due to changes in survey choices or funding shortfalls (Appendix Table D-4). Once spatial and temporal inferences were made, then a total annual peak counts within each population area was obtained by simply summing the observed and inferred peak counts over all tributaries within an entire population area across all years. Total annual peak counts were then subsequently converted into total spawner abundances based on the estimated amount of effective spawning habitat in each tributary and the expansion factor of 2.82.

Appendix Table D-4. Summary of CHF spawning surveys completed in Chetco, Winchuck, and Lower Rogue population area, 1986-2011.

	Chetco	Winchuck	Lower Rogue
Number of spawning surveys	6	8	7
Number of completed surveys	118(76%)	103(50%)	136(75%)

Environmental Covariates: There were sufficient data to determine if there was some environmental variable(s) that could account for the variations in spawner densities (Isaak and Thurow 2006; Moir et al. 2009). A myriad of environmental variables could have theoretically been selected. However, habitat surveys have yet to be completed for any of the population areas in the SMU. Instead, variables likely related to CHF habitat were estimated from a GIS stream network that was developed using information on (1) topography from a 10-meter Digital Elevation Model and (2) mean annual precipitation. Within this stream network, reaches on the order of 50-200 meters in length were defined dynamically by changes in gradient and form the units for subsequent calculations (Agrawal et al. 2005). For each reach, four variables were calculated: mean gradient, valley width, width of the active channel, and mean annual discharge at the base of the reach. Mean annual discharge was estimated as a function of mean annual precipitation and catchment area in the coastal basins using the PRISM model (Dailey et al. 1994). The PRISM model predicts climate variables by interpolating observations over the period 1961-1990 and accounting for topographical effects such as elevation and aspect.

Covariates were examined over the entire spatial extent where the peak counts were observed and where inferences were needed. Four geomorphic covariates were available in the GIS layer that can be used for this purpose. One of these (“Active Channel Width”) was strongly correlated with two other features and was therefore not included in subsequent analyses in order to attenuate the effects of colinearity on parameter identifiably. The three remaining geomorphic covariates were mean annual discharge, valley width, and gradient (these variables are subsequently labeled “MAD”, “Width”, and “Grad”, respectively). It is important to note that there were 21 sites (Appendix Table D-4) with unique combinations of these geomorphic covariates. Since a site’s geomorphic covariates do not vary over the period of record, different observations of peak counts over time within a particular site must be treated as repeated measures that are nested within the site. Treating each peak count obtained over time within a site as an independent observation ($N' = 136 + 118 + 103 = 357$) incorrectly inflates the degrees of freedom for statistical inference of the relationship between the geomorphic covariates and peak count.

Peak counts within a site can vary over time for two distinct reasons. The first reason is that the number of spawning CHF is different every year. The second reason is that CHF access to different kinds of spawning sites may change annually because of changes in stream flow (Gallagher and Gard 1999). To address the latter hypothesis, mean flow of the Chetco River during November-December was developed as a forth covariate. Unlike the geomorphic covariates that vary over space but are fixed through time, flow is measured at a single location (USGS gage for the Chetco River) and varies across years.

Statistical Models: Observed peak spawner counts were treated as a Poisson random variable. All environmental covariates affect the Poisson rate parameter (λ) on a log scale. We used the log of the survey length as a Poisson offset. We modeled extra-Poisson variation with two random effects. The first random effect is a zero-centered normal deviate that varies across time and populations. This term models extra-Poisson variance that can be attributed to change in each population’s spawner abundance through time. This term is essential for inferring interannual variation within each of the three populations. The second random effect is a zero-centered normal deviate that varies across sites. This deviate models extra-Poisson variance within each site that is not explained by the site-level covariates. We included a fixed-effects to model overall differences in abundances between the three populations (i.e. each population has a unique intercept).

Six different models were formulated with different combinations of the four covariates. A 7th model did not include the random site effect. The most complex model (*Equation 1*) is:

$$\ln(\lambda_{i,t,p}) = \ln(L_{i,t,p}) + \alpha_{1,t,p} + \alpha_{2,i} + \beta_1 * Pop_{p,1} + \beta_2 * Pop_{p,2} + \beta_3 * Pop_{p,3} + \ldots$$

$$\beta_4 * MAD_{i,p} + \beta_5 * Grad_{i,p} + \beta_6 * Width_{i,p} + \beta_7 * Grad_{i,p}^2 + \ldots$$
$$\beta_8 * Flow_t + \beta_9 * Flow_t * MAD_{i,p} + \beta_{10} * Flow_t * Grad_{i,p}$$

where observed counts (*y*) at site *i*, year *t*, and population *p*, are

$$y_{i,t,p} \sim Poisson(\lambda_{i,t,p})$$

the alphas are the random effects mentioned above, and Pop is a 3 by 3 identity matrix. We noted the necessity of including flow as a main effect even though our scientific interest is focused on the interactions involving flow. The simpler models are described in Appendix Table D-5 as the full model given above minus particular terms.

Appendix Table D-5. Summary of models fitted to the observed peak counts of age 3-6 fall chinook salmon in tributary streams in the Chetco, Winchuck, and Lower Rogue population areas (DIC means Deviance Information Criterion).

Model	DIC	Rank
Full	5139	1
Full - Flow*Grad	5139	1
Full - Flow *MAD	5188	5
Full - Width	5139	1
Full - Flow*Grad - Flow*MAD	5262	6
Full - Grad^2	5140	1
Full - site random effect, α_2	5521	7

All models were fit with Bayesian techniques. All covariates were standardized and coefficients were given the relatively noninformative priors: Normal(mu=0,sd=31.6).

Some analyses were repeated with a hierarchical noninformative priors: Normal(mu=0, sd=sig~U(0,6))

The first formulation of the prior probabilities resulted in very similar posterior estimates as obtained under the second prior probability. Thirty thousand posterior samples for each model parameter were obtained from two Markov Chain Monte Carlo (MCMC) simulations implemented in Winbugs. MCMCs were initiated at random starting points and allowed “burn-in” for 5000 iterations. Subsequent samples were “thinned” to every 23rd MCMC iteration. Visual assessments and Gelman-Rubin statistics confirmed that the Markov chains reached equilibrium and were well mixed. Deviance Information Criterion (DIC) was computed for each model.

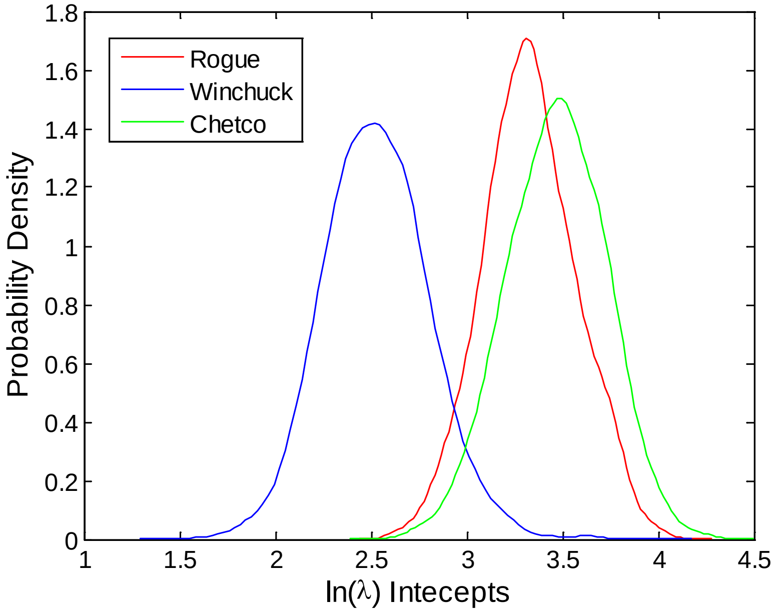
Statistical Results: Deviance Information Criterion (DIC) indicated that there was a 4-way tie for the best model of the peak count data (Appendix Table D-5). Since Bayesian multimodel inferences is an area of active and controversial research[•], we decided not to attempt any model averaging. Instead, we decided to simply use the full model to infer peak counts. Although we acknowledge that this is a philosophically unsatisfying position, we note that the there extremely small difference in the predictions obtained from the four best models. Thus, we do not believe that there is practical significance to our decision to ignore these competing models. Point estimates of the parameters in the full model are shown in Appendix Table D-6.

[•] http://warnercnr.colostate.edu/~anderson/PDF_files/commentonlb.pdf

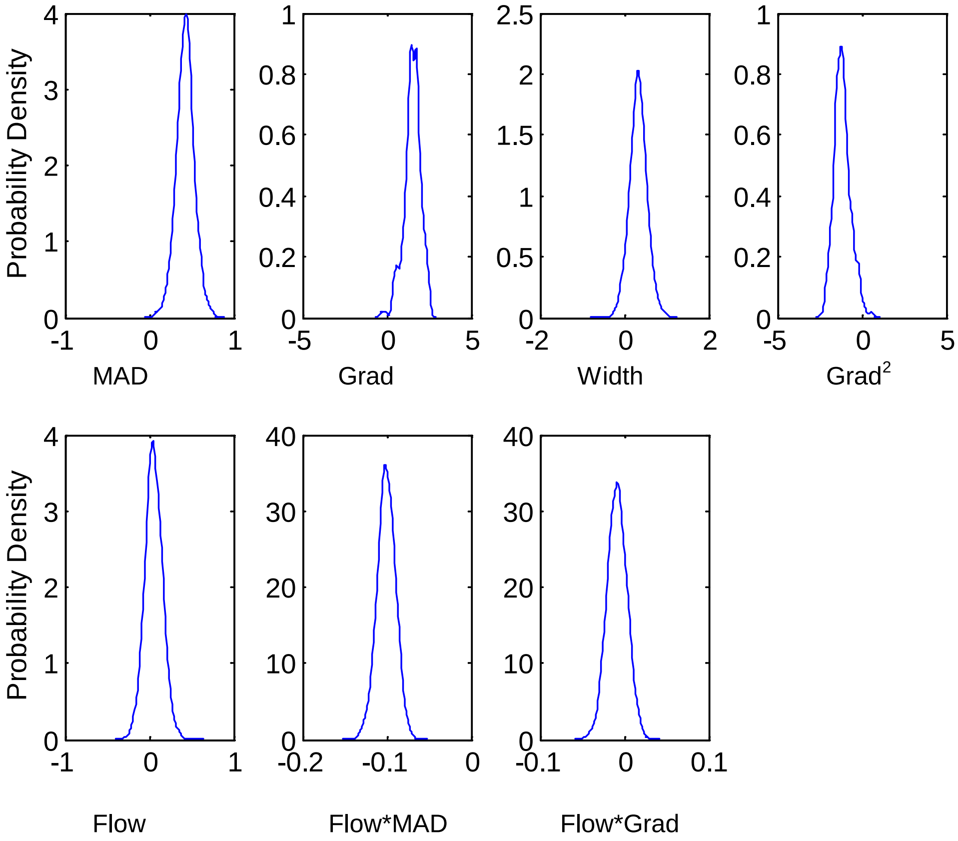
Appendix Table D-6. Point estimates of parameters in *Equation 1*.

		α_1					α_2			β	
	Rogue	Winchuck	Chetco		Site#	Rogue	Winchuck	Chetco		β1	3.326
1986	-0.124	-0.076	0.391		1	0.105	0.132	0.413		β2	2.531
1987	0.696	0.365	0.016		2	-0.085	0.325	0.126		β3	3.454
1988	0.315	0.173	0.822		3	-0.005	0.171	0.052		β4	0.442
1989	-0.570	-0.877	0.884		4	0.078	0.328	0.189		β5	1.601
1990	-2.161	-0.908	-0.511		5	0.066	-0.115	-0.341		β6	0.360
1991	-1.966	0.140	0.579		6	0.143	-0.036	-0.446		β7	-1.209
1992	-0.075	0.105	0.096		7	-0.291	-0.394	na		β8	0.054
1993	-2.629	0.602	0.794		8	na	-0.404	na		β9	-0.100
1994	-1.252	0.906	0.808							β10	-0.008
1995	-0.526	-0.156	0.728								
1996	-0.198	0.498	0.402								
1997	-0.928	0.243	0.361								
1998	-0.251	0.381	0.066								
1999	-0.305	0.579	-0.752								
2000	0.762	0.205	0.046								
2001	1.280	-0.377	0.306								
2002	2.381	0.448	0.463								
2003	2.199	0.152	-0.675								
2004	1.489	-0.315	-0.210								
2005	0.696	-1.404	-1.326								
2006	-0.264	-1.445	-1.689								
2007	-1.204	-0.724	-1.822								
2008	-0.566	-0.565	-0.884								
2009	0.891	1.048	0.414								
2010	1.357	0.824	0.101								
2011	0.998	0.219	0.512								

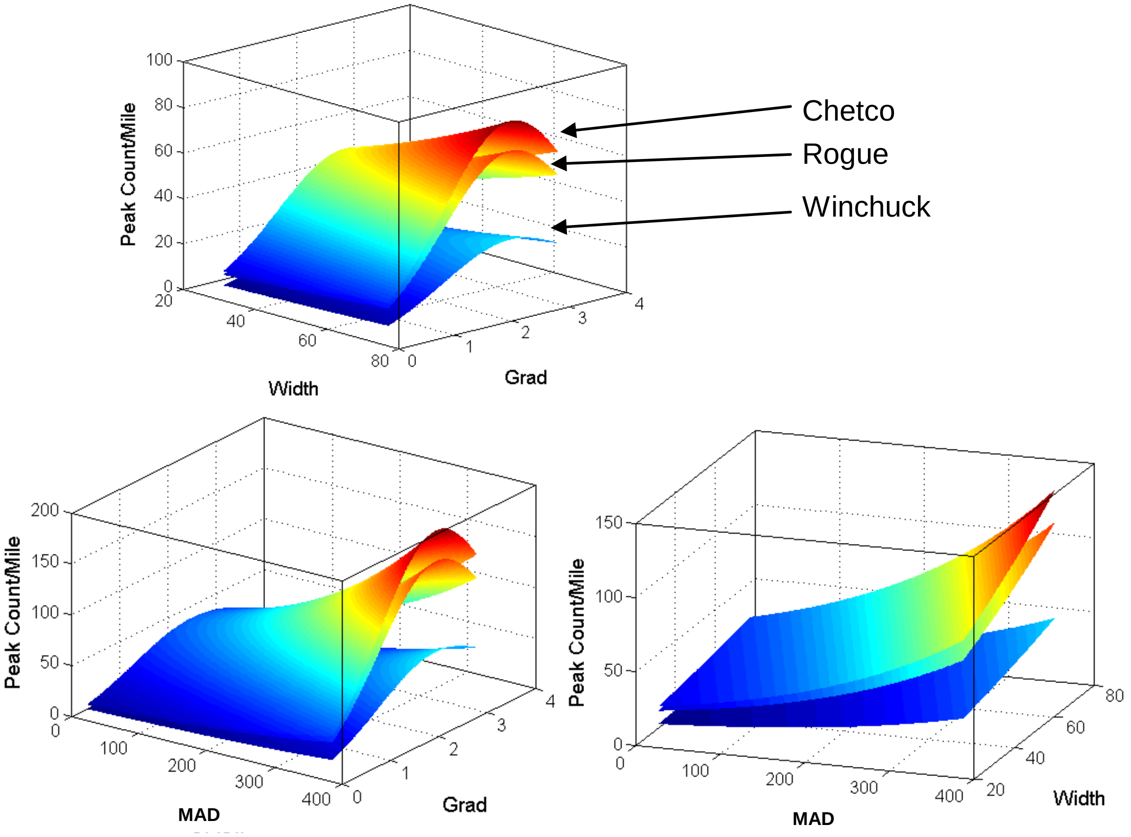
Posterior samples for each parameter were converted to a probability density using the kernel smoothing density estimator, *ksdensity* available in MATLAB R2012a (Appendix Figure D-1 and Appendix Figure D-2). The mean of the posterior estimates of beta 1-7 (*Equation 1*; Appendix Table D-6) were used to display the relationships among coefficients on expected peak counts per mile (Appendix Figure D-3).



Appendix Figure D-1. Posterior probability densities for population-level fixed effects (beta 1-3 in *Equation 1*) on a log scale.



Appendix Figure D-2. Posterior probability densities for coefficients (beta 4-10 in *Equation 1*) on a log scale.



Appendix Figure D-3. Modeled peak count per mile for three populations as a function of three geomorphic variables assuming average flow rate.

Lower Rogue Population: There were seven spawning surveys with data that met the criterion developed to filter out years when surveys likely missed a true peak density of spawners. All of the surveys were located in tributary streams (Appendix Table D-7). Paired t-tests indicated that annual spawner densities differed significantly ($P < 0.05$) between many of the survey areas. Consequently, parameter estimates of *Equation 1* (Appendix Table D-6) were used to infer peak counts during years when an individual survey was not conducted.

Appendix Table D-7. Summary of CHF spawning surveys completed in the Lower Rogue population area, 1986-2010. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and exclude jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Saunders Creek (RM 0.0-0.6)	0.58	16	19.9
Jim Hunt Creek (RM 0.0-0.7)	0.76	26	69.1
Lobster Creek (RM 6.2-7.1)	0.98	26	163.6
Lobster Creek (RM 9.1-9.6)	0.50	9	193.5
SF Lobster Creek (RM 4.3-5.5)	1.15	15	89.9
Quosatana Creek (RM 0.6-2.4)	1.79	23	78.4
Shasta Costa Creek (RM 0.2-1.3)	1.07	21	21.5

Effective CHF spawning habitat in the Lower Rogue population area was estimated to be 75.8 miles with 48.4 miles in the mainstem, 0.5 miles in Indian Creek, 1.1 miles in Saunders Creek, 0.8 miles in Jim Hunt Creek, 10.5 miles in Lobster Creek, 5.6 miles in the South Fork of Lobster Creek, 0.3 miles in Boulder Creek, 2.9 miles in Quosatana Creek, 1.2 miles in Silver Creek, 0.4 miles in Tom Fry Creek, 1.6 miles in Shasta Costa Creek, and 2.6 miles in Foster Creek. These lengths were used as the Poisson offsets ("*L*" in *Equation 1*) while parameterizing the statistical model of peak counts.

The values for MAD, Width, and Grad were obtained from the GIS database for all segments of the CHF spawning habitat in each spawning tributary. Since the statistical model (*Equation 1*) was fitted using standardized covariates, it was necessary to transform the GIS variables at inference sites to this scale. The fitted full model given in Appendix Table D-6 was then used to estimate peak counts at each of these tributary segments through time. Temporal variation in peak counts at a given site is partially achieved by including the different values of Flow for each year. However, the primary mechanism for inferring interannual variation in peak counts comes from the α_1 term in *Equation 1* (Appendix Table D-6). This term was specifically included in *Equation 1* to model interannual variation for each population. The 2.82 expansion factor was then used to estimate the total number of adult spawners in the tributaries during 1986-2011.

Estimation of spawning escapement in the mainstem of the Rogue River was based on very limited data. Aerial counts of CHF redds were made in the lower 40 miles during 1953 (one count in early November), 1954 (three counts in November), 1974 (five counts in early November through the middle of December), and in 1975 (five counts in early November through early December). The peak counts made during years of multiple surveys ranged between 140 and 343 redds.

However, from the late 1970s through the 1990s, ODFW staff observed that very few CHF spawned in the lower 40 miles of the mainstem of the Rogue River. In contrast, ODFW staff observed numerous CHF spawning in the mainstem during the large returns in the early 2000s. Given the seemingly sporadic nature of spawning in the lowest portion of the mainstem, it was assumed that only 2% of the CHF spawned in the mainstem of the Rogue River. This assumption produced average annual estimates for mainstem spawning of about 65 CHF during 1986-2000 and 2005-2009 and about 470 CHF during 2001-2005. Final estimates of CHF spawning escapement in the Lower Rogue population area can be found in Appendix Table E**-2**.

Winchuck Population: There were eight spawning surveys with data that met the filter criterion. All of the surveys were located in tributary streams (Appendix Table D-8). Paired t-tests indicated that spawner densities differed significantly ($P < 0.05$) among many of the surveys. Consequently, parameter estimates of *Equation 1* (Appendix Table D-6) were used to infer peak counts during years when an individual survey was not conducted.

Effective CHF spawning habitat in the Winchuck population area was estimated to be 34.43 miles with 10.90 miles in the mainstem, 6.12 miles in the East Fork, 5.17 miles in the South Fork, 5.74 miles in Wheeler Creek, 3.26 miles in Fourth of July Creek, 2.36 miles in Bear Creek, 0.42 miles in Salmon Creek, 0.33 miles in Sankey Creek, and 0.13 miles in Willow Creek. These lengths were used as the Poisson offsets ("*L*" in *Equation 1*) while parameterizing the statistical model of peak counts.

Appendix Table D-8. Summary of CHF spawning surveys completed in the Winchuck River population area, 1987-2011. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and do not include jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Bear Creek (RM 0.0-0.7)	0.74	26	18.2
Bear Creek (RM 0.7-1.2)	0.50	25	23.8
East Fork (RM 0.3-1.4)	1.03	6	15.3
East Fork (RM 2.2-3.0)	0.82	5	10.0
Wheeler Creek (RM 0.0-0.7)	0.68	9	11.6
Wheeler Creek (RM 2.0-2.8)	0.80	15	12.6
Fourth of July Creek (RM 0.0-0.5)	0.52	12	8.2
Fourth of July Creek (RM 0.5-1.9)	1.41	5	13.8

The values for MAD, Width, and Grad were obtained from the GIS database for all segments of the CHF spawning habitat in each spawning tributary. Since the statistical model (*Equation 1*) was fitted using standardized covariates, it was necessary to transform the GIS variables at inference sites to this scale. The fitted full model shown in Appendix Table D-6 was then used to estimate peak counts at each of these tributary segments through time. Temporal variation in peak counts at a given site is partially achieved by including the different values of Flow for each year. However, the primary mechanism for inferring interannual variation in peak counts comes from the α_1 term in *Equation 1* (Appendix Table D-6). This term was specifically included in *Equation 1* to model interannual variation for each population. The 2.82 expansion factor was then used to estimate the total number of adult spawners in the tributaries during 1978-2010.

Estimation of spawning escapement in the mainstem of the Winchuck River was based on very limited data. There was only one day when a spawning survey was conducted in a portion of the mainstem. A comparison to peak counts made during the same week in five tributary streams indicated that the spawner density in the mainstem was 0.22 (95% CI = ± 0.08) was that of the large tributaries. This proportion was used to estimate the number of adult CHF that spawned in the mainstem.

The estimated number of adult spawners was then separated into wild and hatchery fish based on CWT recoveries in the population area. During 1987-2009, there were 23 CWT recoveries among the 503 CHF carcasses recovered during surveys. All CWTs except six were recovered during 1992-1996 and all originated from CWTs released as smolts in the Chetco or Winchuck river basins, except that one originated from smolts released at Elk River Hatchery. Each recovered CWT was expanded for the proportion of CWTs, among all CHF smolts released, within the specific year of release. The resultant estimates were used to estimate the proportions of hatchery fish among the 1992-96 spawners. With the paucity of CWT recoveries in other years, it was assumed that hatchery fish composed 17% of the spawners in 1987-1991 and 6% of the spawners in 1997-2009. These assumptions were based on the number of smolts released annually in the Chetco and Winchuck population areas as compared to those brood years that produced the adults that spawned in 1992-1996. For the 2010-2011 return years, estimates of spawner composition (% hatchery) were generated based on the proportion of fin-marked fish among recovered carcasses, because all of the hatchery fish originating from nearby releases should be 100% fin-marked; beginning in 2010. Final estimates of age 3-6 CHF spawning escapement in the Winchuck population area can be found in Appendix Table E-2.

The last step was to estimate the age composition of CHF that spawned in the Winchuck population area. Because there are no age estimates for CHF spawners in the Winchuck population area, it was assumed that the age composition of CHF spawners were equal to the estimated age composition of CHF that spawned in the Chetco River Basin.

Chetco Population: There were seven spawning surveys with data that met the filter criterion. All of the surveys were located in tributary streams (Appendix Table D-9). Paired t-tests indicated that spawner densities differed significantly ($P < 0.05$) among many of the surveys. Consequently, parameter estimates of *Equation 1* (Appendix Table D-6) were used to infer peak counts during years when an individual survey was not conducted.

Appendix Table D-9. Summary of CHF spawning surveys completed in the Chetco River population area, 1986-2010. Summary includes only those surveys that met the filter criterion. Spawner densities are raw survey observations and do not include jacks.

Spawning survey	Length (miles)	Years(*N*)	Mean peak density (adults/mile)
Jack Creek (RM 0.0-0.4)	0.44	8	64.8
Jack Creek (RM 0.5-3.5)	3.00	17	20.3
North Fork (RM 0.0-1.5)	1.48	21	56.2
Mill Creek (RM 0.0-1.1)	1.05	19	41.1
Wilson Creek (RM 0.0-0.3)	0.29	16	58.0
Emily Creek (RM 0.0-1.2)	1.21	26	78.4
Panther Creek (RM 0.0-0.4)	0.42	19	37.5

Effective CHF spawning habitat in the Chetco population area was estimated to be 53.82 miles with 28.95 miles in the mainstem, 0.50 miles in Joe Hall Creek, 5.41 miles in Jack Creek, 0.64 miles in Hamilton Creek, 0.34 miles in Jordan Creek, 6.75 miles in the North Fork, 1.23 miles in Mill Creek, 1.92 miles in Emily Creek, 0.29 miles in Wilson Creek, 0.43 miles in Panther Creek, 1.90 miles in the South Fork, 3.12 miles in Quail Prairie Creek, 1.10 miles in Eagle Creek, and 1.23 miles in Mislatnah Creek. These lengths were used as the Poisson offsets ("*L*" in *Equation 1*) while parameterizing the statistical model of peak counts.

The values for MAD, Width, and Grad were obtained from the GIS database for all segments of the CHF spawning habitat in each spawning tributary. Since the statistical model (*Equation 1*) was fitted using standardized covariates, it was necessary to transform the GIS variables at inference sites to this scale. The fitted full model shown in Appendix Table D-6 was then used to estimate peak counts at each of these tributary segments through time. Temporal variation in peak counts at a given site is partially achieved by including the different values of Flow for each year. However, the primary mechanism for inferring interannual variation in peak counts comes from the α_1 term in *Equation 1* (Appendix Table D-6). This term was specifically included in *Equation 1* to model interannual variation for each population. The 2.82 expansion factor was then used to estimate the total number of adult spawners in the tributaries during 1986-2011.

Estimation of spawning escapement in the mainstem of the Chetco River was based on very limited data. ODFW conducted surveys of the mainstem on a sporadic basis during the late 1980s through 2010 and none of these surveys met the filter criterion. While the primary purpose of these surveys was to collect life history information from spawners, hundreds of live and dead

CHF were often seen by samplers. Based on a radio-telemetry project conducted in 1995-1996 (Trask 1998), it was assumed that 40% of the adult CHF spawned in the mainstem of the Chetco River.

Final estimates of age 3-6 CHF spawning escapement in the Chetco population area can be found in Appendix Table E-2. Spawning escapement of age 3-6 CHF in 1995 and 1996 was estimated to be 10,785 and 7,676 adults respectively. In comparison, spawning escapement estimates of age 3-6 CHF, derived from a radio-telemetry project conducted in 1995-1996, were estimated to be 11,143 and 6,519 adults respectively (Trask 1998).

Estimation of Spawner Origin (Chetco Population): A differential spawning distribution of wild and hatchery fish complicated the development of the estimates of spawning escapement. As described below, hatchery fish primarily spawned in the lowest portion of the basin. In addition, most of the spawning surveys were conducted in the lowest portion of the Chetco River Basin. Scales collected from spawners were used to estimate the age composition and origin of CHF that spawned in the Chetco River Basin. Scales from wild and hatchery fish can be differentiated because wild fish of Chetco origin have significantly fewer freshwater circuli as compared to hatchery fish released in the Chetco River Basin (Downey et al. 1988; personal communication dated February 9, 2009, from Lisa Borgerson, ODFW, Corvallis).

Surveyors collected scale samples from about 6,000 dead CHF that spawned in the Chetco River Basin during 1986-2010. The number of scale samples collected annually varied markedly, ranging between 42 and 1,029. In addition, the temporal and spatial distribution of the samples varied markedly. Scale samples were needed to differentiate wild and hatchery fish because of the low mark rate among hatchery smolts released in the Chetco River Basin. In order to appropriately develop methods to estimate the age and origin of spawners, the following hypotheses were tested:

H_O: there was no difference in the spawning time between hatchery and NP CHF
H_O: there was no difference in the spawning distribution between hatchery and NP CHF

There was sufficient data to test the hypothesis that the mean date of spawning did not differ significantly between hatchery and NP CHF. To test the hypothesis, mean dates of carcass recoveries were compared within six survey areas. Results indicated that there were significant differences in the mean date of carcass recovery for three of nineteen comparisons (Appendix Table D-10). In the three instances with significant differences, hatchery fish spawned later than naturally produced fish (twice) and hatchery fish spawned earlier than naturally produced fish (once). These results indicate hatchery and naturally produced fish spawned at similar times in the Chetco River Basin. Based on this conclusion, there was no need to account for temporal differences in CHF spawning time during the development of escapement estimates for naturally produced fish and hatchery fish.

Similarly, there was sufficient data to test the hypothesis that there were no spatial differences in the spawning distribution of wild and hatchery CHF. To test this hypothesis, proportions of hatchery fish among spawners in disparate areas of the basin was compared with contingency

Appendix Table D-10. Comparisons of mean date of carcass recovery for hatchery and naturally produced fall Chinook salmon in the Chetco River Basin. Comparisons include only those years when sampling occurred over a broad area of the basin and when at least ten fish of each type were recovered within each survey area. Fish origin was identified by scale analyses. A t-test, assuming equal variances, was used to estimate *P* values of significance.

	Mean date of carcass recovery		
Year	**Natural ± 95%CI**	**Hatchery ± 95%CI**	***P* for difference**
	Jack Creek		
1995	**Dec. 25 ± 2.3 days**	**Dec. 22 ± 2.3 days**	**0.252**
2001	**Dec. 15 ± 2.7 days**	**Dec. 21 ± 3.5 days**	**0.018**
	North Fork		
1989	**Dec. 24 ± 2.3 days**	**Dec. 23 ± 2.6 days**	**0.890**
1995	**Dec. 23 ± 3.0 days**	**Dec. 23 ± 3.3 days**	**0.766**
2001	**Dec. 28 ± 1.7 days**	**Dec. 26 ± 2.4 days**	**0.105**
	Mill Creek		
1995	**Dec. 27 ± 2.3 days**	**Dec. 28 ± 2.3 days**	**0.887**
2001	**Dec. 19 ± 4.0 days**	**Dec. 10 ± 10.4 days**	**0.044**
	Emily Creek		
1989	**Dec. 24 ± 8.3 days**	**Dec. 28 ± 6.3 days**	**0.472**
1995	**Dec. 27 ± 1.2 days**	**Dec. 28 ± 1.9 days**	**0.894**
2001	**Dec. 16 ± 2.6 days**	**Dec. 15 ± 3.9 days**	**0.707**
	Mainstem Chetco (RM 4-9[a])		
1989	**Dec. 29 ± 1.2 days**	**Dec. 29 ± 2.6 days**	**0.983**
1995	**Dec. 26 ± 3.5 days**	**Dec. 26 ± 10.9 days**	**0.922**
2001	**Dec. 16 ± 3.6 days**	**Dec. 14 ± 7.4 days**	**0.668**
2008	**Dec. 14 ± 3.6 days**	**Dec. 12 ± 7.4 days**	**0.482**
2009	**Dec. 29 ± 3.3 days**	**Dec. 23 ± 9.4 days**	**0.183**
	Mainstem Chetco (RM 9-18[b])		
1995	**Dec. 23 ± 2.2 days**	**Dec. 31 ± 4.1 days**	**0.005**
2001	**Dec. 15 ± 1.6 days**	**Dec. 19 ± 4.0 days**	**0.107**
2008	**Dec. 12 ± 2.4 days**	**Dec. 15 ± 7.8 days**	**0.219**
2009	**Dec. 18 ± 1.8 days**	**Dec. 16 ± 5.8 days**	**0.430**

[a] *Social Security Bar - Loeb State Park.*
[b] *Loeb State Park - South Fork.*

tables and where differences were detected, a Tukey-type multiple comparison (Zar 1999) was employed to test for differences among singular samples. A summary of the available data can be found in Appendix Table D-11. Analyses were limited only to those data sets with at a minimum of 50 fish in each sample.

Appendix Table D-11. Origin of fall Chinook salmon recovered as carcasses during spawning surveys completed in the Chetco population area. Data is only shown for those instances where sample sizes exceeded 14 fish. No data is available prior to 1987.

	Proportion hatchery fish among spawners(*N*)					
	Jack	**North**	**Mill**	**Emily**	**Chetco River**	
Year	**Creek**	**Fork**	**Creek**	**Creek**	**RM 4-9**[a]	**RM 9-18**[b]
1987	**--**	**--**	**0.42(67)**	**--**	**--**	**0.15(68)**
1988	**--**	**--**	**--**	**0.47(19)**	**--**	**0.38(37)**
1989	**0.52(25)**	**0.42(108)**	**--**	**0.35(20)**	**--**	**0.20(201)**
1990	**--**	**--**	**--**	**0.50(30)**	**--**	**--**
1991	**--**	**0.60(25)**	**--**	**--**	**--**	**0.45(76)**
1992	**--**	**--**	**--**	**0.68(31)**	**--**	**0.12(17)**
1993	**0.73(26)**	**0.61(117)**	**0.51(37)**	**0.47(15)**	**--**	**0.21(29)**
1994	**--**	**0.18(39)**	**--**	**--**	**--**	**--**
1995	**0.70(104)**	**0.44(250)**	**0.46(92)**	**0.21(94)**	**0.13(79)**	**0.12(241)**
1996	**0.82(175)**	**0.58(133)**	**0.78(59)**	**0.52(195)**	**--**	**--**
1997	**0.69(32)**	**0.57(21)**	**0.66(41)**	**0.32(19)**	**--**	**--**
1998	**0.59(61)**	**0.28(36)**	**0.41(22)**	**0.45(31)**	**--**	**0.20(35)**
1999	**0.65(20)**	**0.23(22)**	**--**	**--**	**--**	**0.16(31)**
2000	**0.35(40)**	**0.32(99)**	**--**	**0.28(50)**	**--**	**0.06(52)**
2001	**0.44(98)**	**0.36(112)**	**0.23(39)**	**0.27(78)**	**0.22(55)**	**0.09(118)**
2002	**--**	**0.33(90)**	**--**	**0.12(32)**	**--**	**--**
2003	**--**	**0.18(24)**	**--**	**0.06(16)**	**--**	**--**
2004	**0.33(33)**	**0.37(35)**	**--**	**0.08(26)**	**--**	**--**
2005	**--**	**--**	**--**	**--**	**--**	**--**
2006	**--**	**--**	**--**	**--**	**--**	**--**
2007	**--**	**--**	**--**	**--**	**--**	**--**
2008	**0.62(16)**	**0.38(26)**	**--**	**0.12(17)**	**0.26(65)**	**0.11(97)**
2009	**0.13(15)**	**0.12(26)**	**--**	**0.10(49)**	**0.15(65)**	**0.08(160)**
2010	**--**	**0.19(48)**	**--**	**0.10(50)**	**0.11(174)**	**0.08(253)**
2011	**0.41(51)**	**0.24(96)**	**0.37(51)**	**0.10(30)**	**0.27(128)**	**0.08(271)**
Mile[c]	**4.3**	**5.8**	**6.7**	**9.2**	**4.8**	**13.6**

[a] *Social Security Bar - Loeb State Park.*
[b] *Loeb State Park - South Fork.*
[c] *Chetco river mile at tributary confluence or mean river mile for mainstem surveys.*

There were two years, 1995 and 2001, with sufficient data to test for differences in spawner composition among the spatially distinct survey areas. Contingency table analyses indicated that spawner composition varied significantly among the survey areas in 1995 (Chi-square = 153.2, $v = 5$, $P < 0.001$) and also in 2001 (Chi-square = 37.4, $v = 4$, $P < 0.001$). Because significant differences were detected, a Tukey-type multiple comparison was employed to test for differences among singular samples (Appendix Table D-12).

The findings indicated that the proportion of hatchery fish among spawners was greater in tributary streams as compared to the mainstem of the Chetco River. In addition, the findings suggested that within tributaries, the proportion of hatchery fish among spawners decreased with distance upstream from the mouth of the Chetco River. In addition, the findings suggested that there is a possibility that the proportion of hatchery fish among mainstem spawners also decreased with distance upstream. Scales collected from spawners during 2008-2010 also

Appendix Table D-12. Summary of Tukey-type multiple comparisons of the proportions of hatchery fish among CHF carcasses recovered during spawning surveys completed in the Chetco population area. The proportion of hatchery fish differed significantly ($P < 0.05$) between survey areas that do not share the same subscript lines.

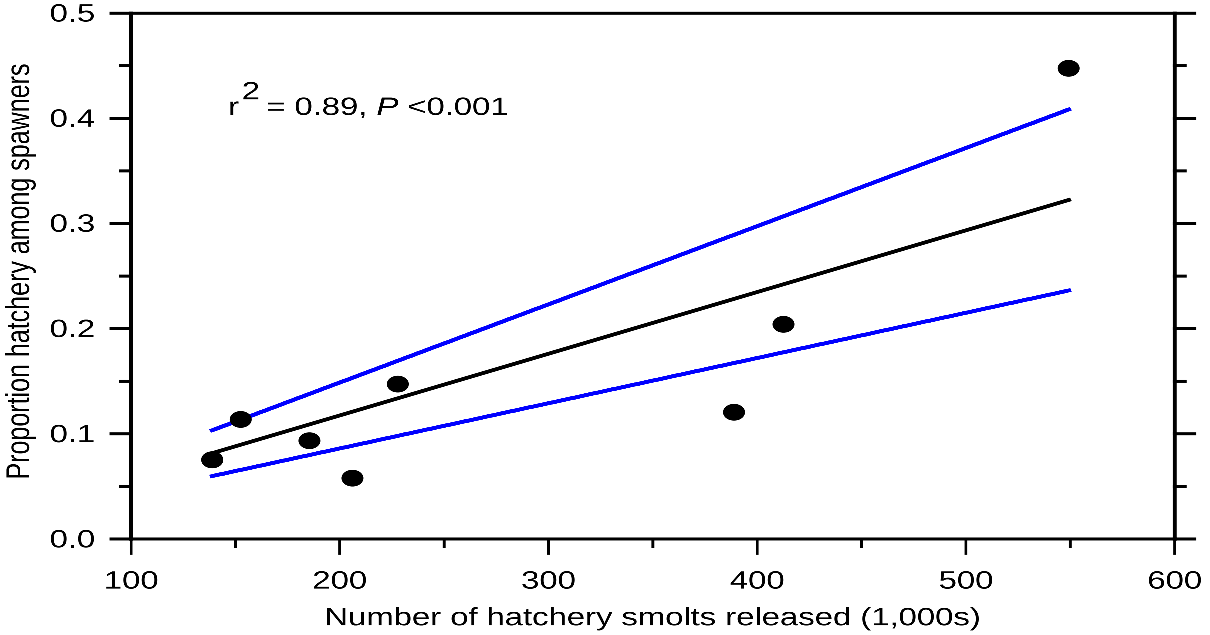
Proportion hatchery fish among spawners						
1995	Jack	Mill	N. Fork	Emily	Chetco(RM 4-9)	Chetco(RM 9-18)
2001	Jack	N. Fork	Emily	Chetco(RM 4-9)	Chetco RM(9-18)	

suggested that the proportion of hatchery among mainstem spawners was greater in the downstream survey area as compared to the upstream survey area (z = 2.37, $P < 0.05$ for 2008; z = 1.99, $P < 0.05$ for 2009; but z = 1.20, $P > 0.05$ for 2010). The differential spawning distribution of hatchery and naturally produced fish, in conjunction with spatially biased surveys and inconsistent sampling among years, meant that some type of indirect method was required to separately estimate the number for each type of fish that spawned annually in the Chetco population area.

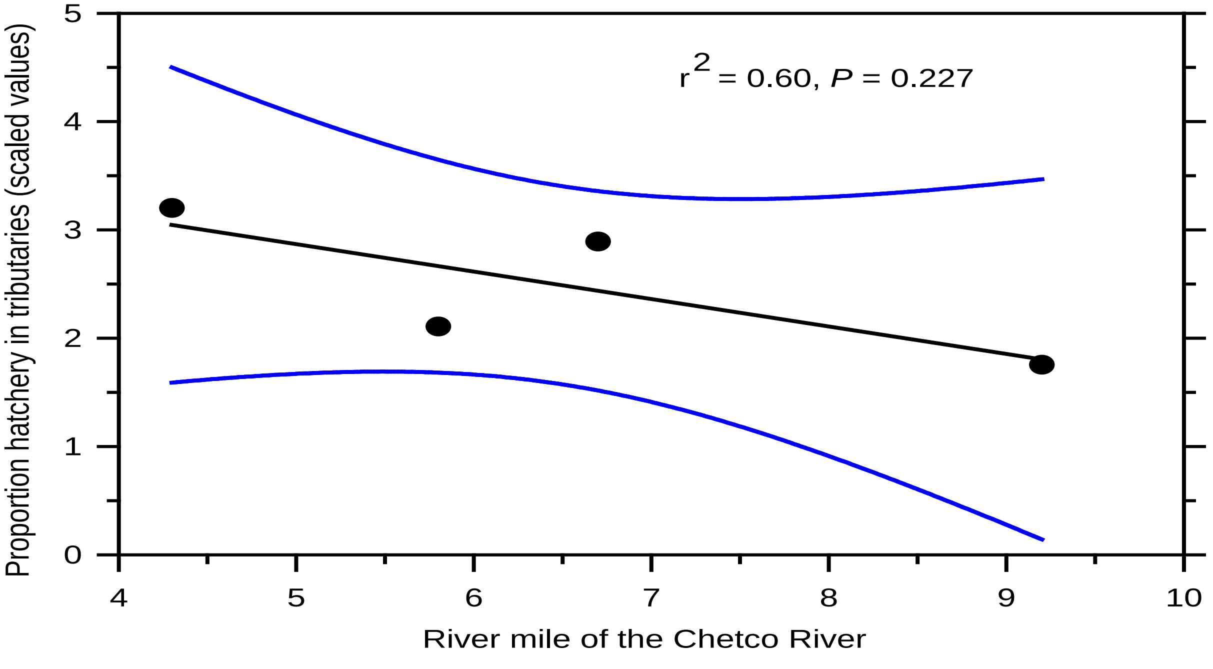
Results from the 1995-1996 radio-tag (Trask 1998) indicated that of the NP CHF that spawned in the mainstem of the Chetco River, about one half of the fish spawned in the survey area between Loeb State Park and the South Fork (RM 9-18). Data from all of the years of surveys in this area indicated that the proportion of hatchery fish among the spawners was significantly related to the number of hatchery smolts released in earlier years (Figure D-4). This relationship was used to estimate spawner composition in the mainstem of the Chetco River for all years; with the assumption that the proportion of hatchery fish in the RM 9-18 survey area reflected the proportion of hatchery fish among all adults that spawned in the mainstem of the Chetco River.

The next estimation step was to determine proportion of hatchery fish among CHF that spawned in tributary streams of the Chetco River. There was some spawner composition data for four tributaries of the 13 tributaries where CHF are known to spawn. These four tributaries are relatively low in the basin, so some predictive method was needed to account for those fish that spawned in tributaries farther upstream in the basin. A spatial relationship for spawner composition served this purpose.

To negate the influence of substantial variations in the number of hatchery fish released during the period of record, spawner composition estimates for the tributary streams (Appendix Table D-11) were scaled to the annual estimates of spawner composition in the mainstem of the Chetco River. These scaled values were then plotted versus river mile (Figure D-5). While a linear regression was not significant at $P \leq 0.05$, there was a good chance that the regression would have been significant had there been data available for tributaries that entered the Chetco River upstream of RM 9. For example, the South Fork enters the Chetco River at RM 18 and none of the 25 scale samples collected from CHF that spawned in the South Fork were classified as hatchery fish. To make the regression useful, for the purposes of predicting spawner composition within all tributary streams, the regression was modified by transforming, to natural logarithms, river mile of the tributaries. The predicted scalar values for all 13 of the tributary streams, in conjunction with the predicted values for the mainstem of the Chetco River, were used to estimate the proportion of hatchery fish within all of these areas during 1986-2011.



Appendix Figure D-4. Relationship between the proportion of hatchery fish among fall Chinook salmon carcasses recovered in the Chetco River (RM 9-18) and the average number of hatchery smolts released two-four years earlier. The black line is the regression equation and the blue lines represent the 95% confidence interval.



Appendix Figure D-5. Relationship between tributary location and the scaled values of the proportion of hatchery fish among fall Chinook salmon that spawned in the tributaries. Proportion estimates were scaled to the estimated spawner composition within the Chetco River (RM 9-18). The black line is the regression equation and the blue lines represent the 95% confidence interval.

Estimation of Spawner Ages: Ages of CHF in the Chetco population area were estimated from scale samples collected from carcasses found during spawning surveys. The number of samples collected annually varied greatly among years as did the spatial distribution of the annual collections. It was assumed that variations in spatial distribution of the collections did not bias age composition estimates. It was also assumed that CHF of all body sizes were sampled at similar rates. This latter assumption is somewhat erroneous and is dependent on stream size and turbidity (Solazzi 1984).

During 1987-2011, there were only four years when scales were collected from more than 300 NP CHF and only two years when scales were collected from more than 300 CHF of hatchery origin (Appendix Table D-13). During many years, sample sizes for wild and hatchery CHF did not exceed 100 fish of each type. As it was important to estimate spawner escapement specific to each brood year, data from years with at least 100 samples were assumed to be reflective of the age composition of the spawners. For years with less than 100 samples, the age composition of the spawners was assumed to be the average of those years with at least 100 spawners. This assumption meant that average age composition was assumed for 13 of 25 years for wild CHF and 18 of 25 years for CHF of hatchery origin. Estimates of mean age composition of CHF spawners can be found in Appendix Table D-14.

Appendix Table D-13. Age of fall Chinook salmon recovered during spawning surveys within the Chetco population area, 1987-2011. Ages and origin were determined from scale interpretations.

	Number of wild fish						Number of hatchery fish					
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1987	8	19	85	11	1	124	19	31	9	2	1	62
1988	5	6	23	18	3	55	4	6	28	2	0	40
1989	24	16	139	68	4	251	15	17	73	15	0	120
1990	2	5	3	6	2	18	0	0	5	2	0	7
1991	4	5	44	10	0	63	5	5	90	14	0	114
1992	1	3	12	10	3	29	0	0	7	5	0	12
1993	11	50	45	11	0	117	6	42	86	15	0	149
1994	5	7	49	9	0	70	3	4	9	4	0	20
1995	18	50	368	199	5	640	22	85	169	56	2	334
1996	11	23	204	37	0	275	3	37	347	11	0	398
1997	0	7	34	13	0	54	6	9	53	11	1	80
1998	2	6	66	36	1	111	0	9	31	42	1	83
1999	4	10	36	16	3	69	1	3	22	1	0	27
2000	7	59	101	19	1	187	9	31	25	10	0	75
2001	21	52	280	13	1	367	3	21	102	10	0	136
2002	2	14	68	14	0	98	8	9	15	3	0	35
2003	0	0	32	14	0	46	2	0	6	0	0	8
2004	9	18	25	32	1	85	0	7	22	4	0	33
2005	0	1	1	2	0	4	0	0	1	0	0	1
2006	0	2	4	4	0	10	0	0	0	1	0	1
2007	0	4	6	2	1	13	0	0	1	0	0	1
2008	57	8	90	21	0	176	8	6	30	3	0	47
2009	7	120	82	66	2	277	0	7	10	10	0	27
2010	14	37	418	58	1	528	0	4	19	3	0	26
2011	13	73	307	111	0	504	10	17	80	13	0	120

Appendix Table D-14. Mean age composition (*p*) of fall Chinook salmon recovered during spawning surveys within the Chetco population area, 1987-2011. Means were estimated from data only for those years when sample sizes for each fish type exceeded 100. Confidence intervals were estimated with arcsine transformed data.

Age 2(95%CI)	Age 3(95%CI)	Age 4(95%CI)	Age 5(95%CI)	Age 6(95%CI)
WILD				
0.054(0.025-0.094)	**0.148(0.082-0.230)**	**0.599(0.508-0.686**	**0.159(0.107-0.219)**	**0.003(0.001-0.006)**
HATCHERY				
0.050(0.019-0.092)	**0.150(0.080-0.237)**	**0.688(0.559-0.804)**	**0.099(0.059-0.148)**	**0.001(0.000-0.002)**

Estimates of age composition for NP CHF spawners are available only for the Chetco population. Consequently, it was assumed that the ages of NP CHF in the other coastal populations were the same as estimated for Chetco NP CHF. Given the high degree of uncertainty associated with this assumption, a research project is needed to test the propriety of the assumption (*see* **Research Needs**, page 142 in the conservation plan).

Estimation of Freshwater Harvest

Freshwater harvest (includes the estuaries) was estimated from salmon-steelhead cards (punchcards) returned to ODFW by anglers. Harvest estimates from salmon-steelhead cards do not include jacks. The harvest of jacks in each population area was estimated based on their proportion among CHF that spawned in the Chetco population area and it was assumed that the freshwater fisheries did not selectively harvest CHF of different ages. The proportion of hatchery fish in the harvest within each population area was assumed to be the same as the proportion of hatchery fish among spawners within each population area.

Estimation of Ocean Fishery Impacts

Because there was no other option, ocean exploitation rates of age 3 and age 4 fish were assumed to equal those on fall Chinook salmon of Klamath River Basin origin, as reported by the Pacific Fishery Management Council (PFMC 2010). Ocean exploitation rates on age 5 and age 6 fish were assumed to equal those on age 4 fish. The propriety of the assumption of equal ocean exploitation rates on age 3 and age 4 fish of Chetco and Klamath origin is somewhat questionable because Chetco and Klamath CHF exhibit somewhat different landing patterns in the ocean fisheries (Appendix Table D-15). There was no opportunity to directly estimate ocean exploitation rates of Chetco River origin because there was no means by which to directly estimate freshwater escapement of CWT-marked hatchery fish. Given the high degree of uncertainty associated with the allied assumption of equal age-specific harvest rates, a research project is needed to produce improved estimates of ocean harvest rates for CHF that originate from the coastal stratum of the SMU (*see* **Research Needs**, page 142 in the conservation plan).

Estimation of Ocean Abundance

A cohort reconstruction analysis (Ricker 1975) was employed to estimate the number of NP CHF that resided in the ocean during spring prior to onset of any fishing mortality. Estimation procedures began with age 6 fish and ended with age 2 fish and were analogous to those

Appendix Table D-15. Comparisons of landing distributions of CWT-marked fall Chinook salmon released in the Chetco and Klamath River basins, 1978-2003 brood years. Data incorporated in the analyses include only those CWT groups released after the month of August. Comparisons were made with paired t-tests of arcsine transformed data. Data from Irongate and Trinity River hatcheries in the Klamath River Basin were pooled because no difference in landing distributions could be detected (paired t-test *P* = 0.52).

	Mean		***P*** **for**
Landing distribution metric	**Chetco**	**Klamath**	**difference**
Proportion landed in California + Oregon	**0.96**	**0.99**	**<0.01**
Proportion landed in Oregon	**0.65**	**0.47**	**<0.01**

employed by Hankin and Healy (1986). Estimates of cohort abundance began with age 6 fish because all NP CHF of Rogue River Basin origin matured at ages 2-6. The abundance of younger cohorts were estimated as the sum of (1) the number of fish that resided in the ocean during the succeeding year, (2) natural mortality, (3) harvest in the ocean fisheries, and (4) the number of fish that returned to the river. For each cohort, we used the equation:

$$N_i = \frac{\frac{N_i + 1}{1 - A_i} + E_i}{1 - u_i}$$

where

N_i = number of age i fish resident in the ocean prior to fishing during year t,

N_{i+1} = number of age i+1 fish resident in the ocean during the next year,

A_i = rate of natural mortality for age i cohorts resident in the ocean between years t and t+1,

u_i = exploitation rate of age i fish in the ocean during year t, and

E_i = freshwater return of age i fish during year t.

Estimation of Harvest in the Chetco Terminal Fishery

Estimation of NP CHF harvest in the late-season (October-November) fishery off the mouth of the Chetco River required indirect methods. Recoveries of CWTs indicated that there were significant contributions from (1) other CHF populations in southern Oregon and (2) other CH populations in the Central Valley of California. These findings indicated that immature CH of non-local origin contributed to the terminal fishery. Consequently, an alternative method had to be developed to estimate composition of the harvest. This method employed a cohort reconstruction analysis for hatchery fish of Chetco origin in order to estimate the number of maturing hatchery fish annually landed in the terminal fishery and the proportion of CWT-marked fish of Chetco origin landed in the terminal fishery in relation to CWT-marked fish of Chetco origin landed in all the ocean fisheries.

In the cohort analysis, the terminal fishery harvest of hatchery fish was initially assumed to be zero. This initial analysis produced age-specific estimates of harvest during the general ocean season (May-September) based on estimated exploitation rates of Klamath CHF. Next, the proportion of CWT-marked fish landed in the terminal fishery was incorporated into the cohort analysis, under the assumption that all of these fish would have matured during the year of landing. Because the proportion of hatchery fish landed in the terminal fishery did not equate to the proportion of CWT-marked fish in the terminal fish, successive iterations were needed until both metrics were of equal value. After the last iteration, the cohort analysis included an estimate of the number of hatchery fish annually landed in the terminal fishery. The number of wild fish landed in the terminal fishery was estimated based on the proportion of hatchery fish among natural spawners. Final results suggested that, for those years when at least 50 CWT-marked hatchery fish were harvested in the terminal fishery, fish of Chetco River origin accounted for an average of 49% (95% CI = 27-77% as estimated from arcsine transformed data) of the harvest. This mean estimate of harvest composition was used to estimate the numbers of NP CHF, of Chetco River origin, that were annually harvested in the terminal fishery. Given the high degree of uncertainty associated with this estimate, a research project is needed to produce improved estimates of population composition of CHF harvested in the Chetco terminal fishery (*see* **Research Needs**, page 142 in the conservation plan).

Recoveries of CWT-marked CHF smolts released in natal population areas indicated that NP CHF produced in the Winchuck, Pistol, and Hunter population areas also contributed to the terminal fishery off the mouth of the Chetco River. The proportion of these fish harvested in the terminal fishery, in relation to the total harvest of cohorts in all of the ocean fisheries was compared to estimates derived from counterparts of Chetco origin. Results suggested that per maturing adult, Winchuck CHF contribute to the terminal fishery at a rate of 0.77 of Chetco CHF, Pistol CHF contribute to the terminal fishery at a rate of 0.24 of Chetco CHF, and Hunter CHF contribute to the terminal fishery at a rate of 0.09 of Chetco CHF (Appendix Table D-16). These estimates seem to be reasonable, given the spatial distribution of the population areas. The estimated scalar values, in conjunction with estimated exploitation rates of Chetco CHF, were used to estimate the annual exploitation rates of Winchuck, Pistol, and Hunter CHF in the terminal fishery off the mouth of the Chetco River. Given the high degree of uncertainty associated with this estimate, a research project is needed to produce improved estimates of population composition of CHF harvested in the Chetco terminal fishery (*see* **Research Needs**, page 142 in the conservation plan).

Appendix Table D-16. Population comparisons of the proportions of CWT-marked fall Chinook salmon of hatchery origin harvested in the terminal fishery, in relation to total ocean harvest. Estimates include only those hatchery fish of natal origin and only broods with total ocean harvest of at least 50 fish.

	p harvested in the terminal fishery			
Brood year	**Chetco**	**Winchuck**	**Pistol**	**Hunter**
1989	**0.177**	**--**	**0.036**	**--**
1991	**0.611**	**0.490**	**0.192**	**--**
1992	**0.284**	**0.210**	**0.088**	**0.052**
1993	**0.508**	**--**	**0.057**	**0.017**
1994	**0.486**	**--**	**--**	**0.027**

Estimation of Recruitment

For each cohort (brood year), recruitment was estimated as the sum of the estimated freshwater returns of age 3-6 CHF under a scenario of no ocean fishing mortality (as termed “adult equivalents” by Mohr (2006)).

References

Agrawal, A., R. Schick, E. Bjorkstedt, R. G. Szerlong, M. Goslin, B. Spence, T. Williams, and K. Burnett. 2005. Predicting the potential for historical coho, Chinook and steelhead habitat in northern California. U. S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-379.

Daly, C., R. P. Neilson, and D. L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology 33:140–158.

Downey, T.W., G.L. Susac, and J.W. Nicholas. 1988. Research and development of Oregon's coastal chinook stocks. ODFW Fish Research Project NA-87-ABD-00019, Annual Progress Report, Portland.

Gallagher, S.P., and M.F. Gard. 1999. Relationship between Chinook salmon (*Oncorhynchus tshawytscha*) redd densities and PHABSIM-predicted habitat in the Merced and Lower American rivers, California. Canadian Journal of Fisheries and Aquatic Sciences 56:570-577.

Hankin, D.G., and M.C. Healey. 1986. Dependence of exploitation rates for maximum yield and stock collapse on age and sex structure of Chinook salmon (*Oncorhynchus tshawytscha*) stocks. Canadian Journal of Fisheries and Aquatic Sciences 43:1746-1759.

Isaak, D.J., and R.F. Thurow. 2006. Network-scale spatial and temporal variation in Chinook salmon (*Oncorhynchus tshawytscha*) redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63:285–296.

Mohr, M.S. 2006. The cohort reconstruction model for Klamath River fall Chinook salmon. Unpublished document. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Moir, H.J., C.N. Gibbins, J.M. Buffington, J.H. Webb, C. Soulsby, and M.J. Brewer. 2009. A new method to identify the fluvial regimes used by spawning salmonids. Canadian Journal of Fisheries and Aquatic Sciences 66: 1404–1408.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Solazzi, M.F. 1984. Relationships between visual counts of coho, chinook, and chum salmon from spawning fish surveys and the actual number of fish present. Oregon Department of Fish and Wildlife, Information Reports (Fish) 84-7, Portland.

Trask, S. 1998. 1995-96 ChF Mark Recapture Project, Chetco River. Final Contractor’s Report submitted to the Oregon Department of Fish and Wildlife. Document available from ODFW office in Gold Beach.

Zar, J.H. 1999. Biostatistical analysis, 4th edition. Prentice-Hall, Inc., Upper Saddle River, New Jersey.

APPENDIX E

Data and Estimates Used During Plan Development

Appendix Table E-1. Estimated number of adult fall Chinook salmon that passed Huntley Park and the estimated age composition of naturally produced fish, 1974-2011. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX C**.

Return	Passage estimate			Proportion of return				
year	Natural	Hatchery	Total	Age 2	Age 3	Age 4	Age 5	Age 6
1974	106,021	0	106,021	0.189	0.271	0.461	0.070	0.009
1975	92,383	0	92,383	0.118	0.195	0.567	0.113	0.008
1976	58,329	0	58,329	0.414	0.174	0.343	0.069	0.000
1977	79,615	0	79,615	0.676	0.167	0.129	0.028	0.000
1978	185,321	0	185,321	0.162	0.377	0.405	0.056	0.000
1979	173,281	0	173,281	0.054	0.101	0.802	0.044	0.000
1980	83,010	184	83,194	0.343	0.110	0.284	0.262	0.000
1981	101,429	1,513	102,942	0.258	0.486	0.175	0.073	0.010
1982	134,684	3,822	138,506	0.274	0.266	0.432	0.027	0.001
1983	45,441	7,895	53,336	0.148	0.487	0.336	0.030	0.000
1984	42,255	3,002	45,257	0.231	0.374	0.360	0.029	0.005
1985	84,141	5,582	89,722	0.581	0.110	0.261	0.048	0.000
1986	229,858	14,433	244,291	0.373	0.497	0.113	0.016	0.001
1987	147,944	13,914	161,857	0.210	0.398	0.364	0.028	0.000
1988	79,078	5,241	84,319	0.144	0.198	0.606	0.052	0.000
1989	89,144	7,193	96,337	0.170	0.323	0.421	0.070	0.016
1990	23,915	1,400	25,315	0.183	0.370	0.395	0.051	0.000
1991	18,364	383	18,747	0.184	0.476	0.309	0.031	0.000
1992	76,456	1,295	77,751	0.415	0.232	0.277	0.069	0.008
1993	46,668	552	47,220	0.228	0.598	0.128	0.040	0.006
1994	80,707	1,584	82,290	0.164	0.435	0.357	0.043	0.001
1995	82,745	5,334	88,079	0.224	0.510	0.215	0.046	0.005
1996	64,445	2,660	67,105	0.243	0.380	0.338	0.036	0.003
1997	58,860	2,333	61,193	0.302	0.386	0.241	0.061	0.010
1998	47,732	1,886	49,618	0.142	0.577	0.257	0.024	0.000
1999	56,350	2,570	58,920	0.333	0.264	0.287	0.093	0.023
2000	100,701	3,787	104,489	0.128	0.581	0.216	0.070	0.004
2001	103,026	2,778	105,805	0.259	0.274	0.314	0.134	0.020
2002	196,948	3,209	200,157	0.217	0.318	0.313	0.119	0.033
2003	224,139	10,027	234,167	0.086	0.287	0.425	0.173	0.029
2004	152,081	5,869	157,950	0.130	0.197	0.446	0.188	0.040
2005	61,323	2,843	64,167	0.079	0.281	0.455	0.158	0.026
2006	41,845	2,815	44,660	0.162	0.254	0.428	0.134	0.023
2007	46,778	4,264	51,041	0.070	0.326	0.343	0.256	0.005
2008	39,495	3,751	43,246	0.384	0.181	0.336	0.099	0.000
2009	73,883	2,369	76,252	0.185	0.419	0.342	0.055	0.000
2010	63,849	2,335	66,184	0.223	0.348	0.390	0.038	0.002
2011	97,875	3,044	109,919	0.308	0.242	0.397	0.052	0.001

Appendix Table E-2. Estimated number of age 3-6 fall Chinook salmon that spawned in the Lower Rogue, Chetco, and Winchuck population areas, 1986-2011. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Return	Lower Rogue		Chetco		Winchuck	
year	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
1986	3,706	37	4,471	2,513		
1987	8,089	82	2,673	2,168	1,089	219
1988	5,454	55	5,617	5,246	911	183
1989	2,629	27	6,204	4,968	274	55
1990	530	5	1,659	1,118	269	54
1991	623	25	5,142	3,116	770	155
1992	3,697	149	3,437	1,773	823	165
1993	310	12	7,100	3,198	1,306	200
1994	1,112	45	8,025	2,677	1,905	363
1995	2,137	86	7,949	2,166	722	120
1996	2,579	104	6,442	1,530	1,865	147
1997	1,571	44	5,579	1,230	1,104	43
1998	2,797	79	4,383	869	1,417	56
1999	3,001	85	1,916	312	1,511	59
2000	9,494	268	4,191	670	961	38
2001	13,335	377	5,712	894	642	25
2002	40,576	1,147	6,672	1,030	1,441	57
2003	34,921	988	2,112	325	1,043	41
2004	18,274	517	3,306	519	609	24
2005	6,990	198	1,146	182	248	10
2006	2,599	73	819	118	250	10
2007	1,143	32	685	96	441	17
2008	2,224	63	1,731	243	499	20
2009	10,297	275	6,487	603	2,339	92
2010	14,149	446	4,786	633	2,180	76
2011	11,715	115	6,591	1,214	1,021	36

Appendix Table E-3. Estimated number of age 3-6 fall Chinook salmon that spawned in the Hunter and Pistol population areas, 1986-2011. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Return	Hunter		Pistol		Euchre	
year	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
1986					9	8
1987			345	76	79	75
1988			896	197	147	138
1989	163	7	169	37	57	54
1990	262	11	230	51	20	19
1991	163	7	252	55	79	75
1992	80	3	390	86	31	29
1993	635	171	283	73	136	128
1994	490	121	1,624	417	180	170
1995	1,265	634	736	189	91	85
1996	794	125	2,296	590	101	96
1997	1,137	452	1,995	513	30	28
1998	841	161	996	111	193	182
1999	965	59	1,541	73	247	233
2000	214	4	1,907	39	16	15
2001	1,534	31	1,175	24	193	182
2002	883	18	1,730	35	125	118
2003	796	16	1,279	26	19	17
2004	181	4	4,164	85	35	33
2005	584	12	1,076	22	78	73
2006	251	5	1,228	25	31	29
2007	344	7	1,612	33	34	32
2008	511	10	839	17	11	11
2009	313	6	2,440	50	45	42
2010	377	29	814	63	93	87
2011	830	22	952	25	90	85

[a] *Spawner composition could not be estimated for individual years (49% hatchery fish in all years).*

Appendix Table E-4. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Upper Rogue population area, 1984-2004 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean harvest	River return[a]	River harvest[a]	Brood harvest rate	Recruits	Parent spawners[b]
1972	3,325	2,085	104	0.622	4,523	--
1973	4,318	1,925	125	0.698	5,260	--
1974	7,571	5,134	215	0.603	10,606	1,873
1975	19,020	12,278	520	0.614	23,341	2,039
1976	5,336	3,296	42	0.620	6,460	1,553
1977	2,690	1,833	34	0.598	3,831	1,678
1978	5,348	6,223	136	0.468	9,452	4,924
1979	10,723	4,018	132	0.730	22,403	2,927
1980	5,910	4,763	199	0.562	18,800	1,830
1981	1,464	4,103	252	0.295	4,826	3,402
1982	2,753	3,396	170	0.463	5,120	3,198
1983	9,305	15,807	1,006	0.395	19,148	3,192
1984	10,460	17,685	1,819	0.410	21,991	2,392
1985	4,820	8,244	930	0.411	10,146	3,071
1986	3,851	6,151	787	0.430	7,538	7,744
1987	2,424	4,555	593	0.398	5,257	7,758
1988	420	4,945	636	0.176	4,428	9,390
1989	560	4,093	509	0.207	3,801	5,426
1990	1,402	13,420	1,734	0.189	11,299	2,941
1991	1,167	11,622	1,467	0.185	10,511	2,483
1992	1,556	15,059	1,631	0.175	14,017	3,889
1993	505	9,947	984	0.130	6,597	5,099
1994	301	7,007	577	0.111	4,125	9,539
1995	474	7,107	500	0.121	5,843	10,968
1996	1,377	7,014	511	0.212	7,207	8,491
1997	3,189	15,852	1,148	0.215	16,942	3,338
1998	5,422	17,378	1,156	0.275	20,370	4,535
1999	7,111	25,046	1,639	0.259	27,112	2,337
2000	7,599	20,589	1,252	0.301	22,804	8,606
2001	3,097	10,457	668	0.265	10,825	9,897
2002	1,049	8,910	654	0.160	7,708	14,792
2003	731	4,697	371	0.190	4,584	22,009
2004	602	4,988	379	0.164	4,333	12,649

[a] *Includes estuary.*

[b] *Passage estimates of age 3-6 NP CHF at Gold Ray Dam.*

Appendix Table E-5. Estimates of population and harvest metrics for aggregated populations of naturally produced fall Chinook salmon in the Rogue River Basin, 1972-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX C**.

Brood year	Ocean harvest	River return[a]	River harvest[a]		Total river harvest	Brood harvest rate	Recruits	Parent Spawners[b]
			Below Huntley	Above Huntley				
1972	64,832	41,380	1,125	989	2,115	0.668	100,232	--
1973	98,268	32,036	1,246	1,095	2,341	0.882	114,121	--
1974	212,244	97,548	1,712	1,505	3,218	0.744	289,621	82,518
1975	479,073	233,165	1,572	1,382	2,954	0.732	658,090	78,840
1976	105,752	48,979	444	390	834	0.756	141,072	32,474
1977	60,128	30,961	433	380	813	0.722	84,397	23,486
1978	176,491	110,628	1,642	1,444	3,086	0.630	285,148	134,691
1979	182,635	53,266	942	828	1,769	0.489	377,237	29,875
1980	73,955	42,684	1,198	1,053	2,252	0.320	238,336	23,206
1981	19,258	43,052	1,572	1,382	2,954	0.365	60,935	65,448
1982	45,547	40,631	1,157	1,017	2,173	0.578	82,591	92,768
1983	120,683	179,001	5,409	4,754	10,163	0.450	290,726	37,696
1984	84,580	122,570	9,563	8,406	17,968	0.509	201,344	31,683
1985	51,980	59,010	4,616	4,058	8,674	0.565	107,284	33,414
1986	27,551	42,414	2,981	2,620	5,601	0.486	68,221	140,969
1987	17,434	22,151	2,071	1,831	3,902	0.576	37,061	109,293
1988	3,721	34,422	2,578	2,337	4,915	0.228	37,919	58,733
1989	3,751	29,509	1,892	1,883	3,775	0.229	32,910	68,177
1990	8,882	67,132	6,456	6,666	13,122	0.292	75,470	17,403
1991	6,890	60,663	4,884	3,841	8,725	0.232	67,192	12,581
1992	9,291	73,109	5,536	3,671	9,207	0.226	82,007	42,112
1993	4,353	43,522	2,429	2,019	4,448	0.185	47,566	29,866
1994	3,294	42,572	1,909	1,418	3,327	0.145	45,622	60,887
1995	4,810	55,370	2,598	1,874	4,472	0.155	59,722	59,464
1996	11,699	59,517	2,623	2,430	5,054	0.241	69,616	44,949
1997	27,674	126,338	5,523	5,139	10,662	0.255	150,542	38,785
1998	50,222	139,168	4,503	5,952	10,455	0.330	183,635	38,864
1999	65,609	194,007	6,007	7,682	13,688	0.311	254,879	35,293
2000	68,144	147,337	4,559	5,743	10,302	0.372	210,998	82,935
2001	22,469	65,713	2,066	2,448	4,514	0.312	86,379	63,555
2002	9,134	49,755	2,629	1,650	4,279	0.230	58,211	144,954
2003	6,902	32,407	1,864	955	2,819	0.250	38,938	191,999
2004	5,004	34,601	1,917	1,101	3,017	0.205	39,173	124,571
2005	124	38,319	3,400	1,383	4,783	0.128	38,442	53,208
2006	1,987	66,201	5,301	2,355	7,656	0.140	68,654	32,873

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-6. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Lower Rogue population area, 1984-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean harvest	River return[a]	River harvest[a]	Brood harvest rate	Recruits	Parent spawners[b]
1984	5,906	8,872	718	0.463	14,314	--
1985	2,000	2,883	254	0.478	4,715	--
1986	955	1,453	100	0.461	2,288	3,744
1987	927	997	82	0.588	1,715	8,171
1988	234	2,265	137	0.149	2,483	5,509
1989	81	1,664	77	0.091	1,738	2,656
1990	168	935	84	0.233	1,084	535
1991	236	1,429	114	0.213	1,645	648
1992	432	2,908	214	0.195	3,313	3,846
1993	224	2,139	122	0.148	2,337	322
1994	242	2,276	103	0.138	2,495	1,156
1995	529	4,500	211	0.149	4,963	2,223
1996	2,154	7,981	333	0.255	9,769	2,683
1997	5,501	20,056	803	0.255	24,704	1,615
1998	9,529	29,505	906	0.274	38,015	2,876
1999	10,136	38,001	1,139	0.238	47,431	3,086
2000	9,284	22,307	702	0.323	30,913	9,762
2001	2,574	8,244	239	0.266	10,584	13,713
2002	406	3,975	198	0.139	4,356	41,723
2003	324	1,678	113	0.222	1,969	35,908
2004	490	2,514	173	0.227	2,924	18,791
2005	33	6,217	539	0.091	6,250	7,187
2006	465	14,126	863	0.090	14,716	2,673

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-7. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Euchre population area, 1983-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean harvest	River return[a]	River harvest[a]	Brood harvest rate	Recruits	Parent spawners[b]
1983	165	88	2	0.735	228	--
1984	147	127	3	0.579	257	--
1985	63	67	1	0.518	122	--
1986	65	32	1	0.766	86	17
1987	54	61	1	0.510	106	154
1988	9	50	0	0.149	57	285
1989	26	96	0	0.220	119	112
1990	35	208	0	0.147	240	40
1991	20	100	0	0.166	119	154
1992	24	93	0	0.208	115	61
1993	22	93	0	0.198	111	264
1994	25	166	0	0.132	189	350
1995	18	170	0	0.097	188	176
1996	5	60	0	0.070	64	197
1997	39	180	0	0.180	214	58
1998	23	121	0	0.162	143	375
1999	12	37	0	0.245	47	479
2000	34	40	0	0.494	70	30
2001	29	62	0	0.333	88	376
2002	6	40	0	0.140	46	242
2003	8	29	0	0.208	37	36
2004	5	26	0	0.168	30	68
2005	0	25	0	0.019	26	151
2006	6	116	0	0.054	123	61

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-8. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Hunter population area, 1986-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean Harvest May-Sept	Ocean Harvest Oct-Nov	River[a] return	River[a] harvest	Brood harvest rate	Recruits	Parent spawners[b]
1986	371	0	208	0	0.683	543	--
1987	129	0	165	0	0.468	275	--
1988	32	0	149	0	0.184	178	--
1989	102	0	381	0	0.217	474	170
1990	237	4	1,017	0	0.197	1,227	272
1991	220	7	954	0	0.195	1,165	170
1992	247	8	924	1	0.222	1,153	83
1993	183	9	1,078	1	0.155	1,245	806
1994	105	7	888	5	0.118	993	610
1995	76	8	702	13	0.123	783	1,899
1996	39	4	362	10	0.131	402	919
1997	303	11	1,463	16	0.189	1,745	1,589
1998	238	5	1,004	7	0.203	1,230	1,002
1999	200	7	682	10	0.247	880	1,025
2000	233	5	367	7	0.427	574	218
2001	215	11	446	12	0.367	648	1,565
2002	52	8	313	3	0.170	369	901
2003	106	7	340	2	0.259	444	812
2004	100	5	514	8	0.186	606	185
2005	2	1	176	5	0.044	178	596
2006	42	2	650	10	0.078	699	257

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-9. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Pistol population area, 1984-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean Harvest May-Sept	Ocean Harvest Oct-Nov	River[a] return	River[a] harvest	Brood harvest rate	Recruits	Parent spawners[b]
1984	313	13	237	10	0.647	520	--
1985	312	0	196	10	0.699	460	--
1986	407	0	216	11	0.726	575	--
1987	252	1	280	9	0.539	484	421
1988	47	3	334	2	0.136	379	1,093
1989	149	4	483	0	0.249	614	206
1990	287	15	1,410	5	0.182	1,680	281
1991	276	20	1,067	8	0.228	1,334	307
1992	614	54	2,205	10	0.241	2,821	476
1993	285	40	1,818	7	0.158	2,106	355
1994	152	28	1,258	13	0.135	1,425	2,041
1995	167	38	1,278	34	0.162	1,475	925
1996	176	42	1,420	28	0.151	1,630	2,886
1997	350	42	1,873	37	0.193	2,226	2,508
1998	468	20	1,673	24	0.241	2,122	1,107
1999	1,094	43	1,846	37	0.407	2,882	1,615
2000	2,175	75	3,129	44	0.439	5,230	1,946
2001	649	80	1,698	37	0.326	2,348	1,199
2002	272	87	1,286	24	0.236	1,625	1,765
2003	403	84	1,435	18	0.266	1,902	1,305
2004	305	34	1,552	30	0.200	1,838	4,249
2005	4	3	906	17	0.026	913	1,098
2006	63	16	2,010	48	0.060	2,095	1,253

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-10. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Chetco population area, 1983-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean Harvest		River[a] return	River[a] harvest	Brood harvest rate	Recruits	Parent spawners[b]
	May-Sept	Oct-Nov					
1983	8,093	247	4,808	945	0.661	14,056	--
1984	10,481	204	7,127	1,236	0.657	18,148	--
1985	7,343	0	6,345	1,216	0.631	13,575	--
1986	6,278	0	3,387	965	0.741	9,769	6,985
1987	4,719	0	5,309	1,121	0.610	9,576	4,841
1988	711	149	4,882	984	0.304	6,062	10,863
1989	1,461	42	5,857	745	0.282	7,980	11,172
1990	2,479	242	12,621	1,605	0.269	16,055	2,777
1991	1,833	567	8,229	1,151	0.324	10,949	8,258
1992	2,092	710	7,534	892	0.347	10,654	5,211
1993	1,127	479	6,441	860	0.292	8,450	10,298
1994	512	366	4,730	712	0.275	5,787	10,702
1995	334	233	2,371	448	0.324	3,133	10,115
1996	547	461	3,606	695	0.365	4,660	7,973
1997	1,759	744	8,230	1,251	0.341	11,005	6,809
1998	1,741	272	7,345	1,370	0.354	9,566	5,252
1999	1,484	332	4,014	1,103	0.479	6,097	2,228
2000	2,198	294	3,262	565	0.529	5,777	4,860
2001	940	427	1,943	469	0.552	3,329	6,606
2002	271	433	1,381	531	0.578	2,134	7,702
2003	477	308	1,360	421	0.514	2,348	2,437
2004	799	232	3,512	484	0.308	4,916	3,825
2005	27	15	2,878	251	0.095	3,089	1,328
2006	474	437	9,449	1,184	0.190	11,035	936

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-11. Estimates of population and harvest metrics for naturally produced fall Chinook salmon in the Winchuck population area, 1984-2006 brood years. Statistical measures of uncertainty could not be developed for the estimates. Estimation methods are described in **APPENDIX D**.

Brood year	Ocean Harvest May-Sept	Ocean Harvest Oct-Nov	River[a] return	River[a] harvest	Brood harvest rate	Recruits	Parent spawners[b]
1984	968	21	925	81	0.593	1,807	--
1985	548	0	451	68	0.670	919	--
1986	836	0	404	73	0.816	1,114	808
1987	723	7	777	92	0.600	1,370	1,307
1988	136	27	916	106	0.253	1,065	1,094
1989	278	19	1,091	46	0.252	1,358	330
1990	365	58	2,134	71	0.196	2,521	323
1991	266	68	1,093	56	0.279	1,400	925
1992	519	154	1,796	89	0.314	2,426	989
1993	288	109	1,498	155	0.298	1,853	1,506
1994	205	110	1,499	171	0.270	1,799	2,268
1995	157	129	1,260	114	0.260	1,541	843
1996	105	95	912	77	0.250	1,108	2,012
1997	251	83	1,142	92	0.295	1,446	1,147
1998	408	57	1,456	151	0.326	1,891	1,472
1999	384	92	1,085	101	0.375	1,540	1,571
2000	417	65	681	59	0.479	1,131	999
2001	190	75	371	56	0.525	611	667
2002	87	90	344	62	0.464	514	1,498
2003	166	93	465	33	0.411	711	1,084
2004	243	54	1,083	50	0.261	1,333	633
2005	12	22	1,006	16	0.047	1,039	258
2006	122	138	3,151	108	0.107	3,416	260

[a] *Includes estuary.*

[b] *Age 3-6; includes hatchery fish.*

Appendix Table E-12. Estimated mean annual survival rates of coded-wire tagged juvenile spring Chinook salmon released at Cole M. Rivers Hatchery during September and October, 1980-2004 brood years. Estimates of these smolt survival rates were used as a proxy for variable ocean conditions and were assumed to co-vary in relation to the ocean survival rates of naturally produced fall Chinook salmon that migrated into the ocean from streams in the Rogue Species Management Unit. Normalized data was included as a covariate in the analyses that resulted in the stock-recruitment relationships reported in this conservation plan. Estimates could not be developed for other years because of lacking data.

Brood year	Ocean survival rate[a]	Normalized survival rate
1980	0.0824	0.6143
1981	0.0646	0.1623
1982	0.0930	0.8837
1983	0.1449	2.2027
1984	0.0597	0.0369
1985	0.1144	1.4275
1986	0.0283	-0.7619
1987	0.0179	-1.0257
1988	0.0237	-0.8771
1989	0.0272	-0.7885
1990	0.0374	-0.5291
1991	0.1062	1.2174
1992	0.0859	0.7032
1993	0.0623	0.1039
1994	0.0107	-1.2084
1995	0.0544	-0.0986
1996	0.0104	-1.2169
1997	0.0914	0.8434
1998	0.1155	1.4550
1999	0.0778	0.4972
2000	0.0735	0.3869
2001	0.0400	-0.4638
2002	0.0095	-1.2391
2003	0.0142	-1.1188
2004	0.0108	-1.2063

[a] *Estimated survival to age 2 in the ocean before the onset of any fishing mortality.*

Appendix Table E-13. Indicators of critical freshwater environmental conditions experienced by naturally produced fall Chinook salmon in the Rogue River Basin, 1969-2009. Normalized estimates were used as covariates in the analyses of the stock-recruitment relationships reported in this conservation plan.

	July-Aug flow[a]		Peak flow[b]		Oct-Nov[c] flow	
Year	Mean	Normalized	Mean	Normalized	Mean	Normalized
1969/70	1,404	-1.309	59,200	0.931	107	-1.100
1970/71	1,130	-1.765	87,100	1.994	409	0.392
1971/72	2,191	0.004	82,500	1.818	253	-0.378
1972/73	1,799	-0.650	13,400	-0.814	96	-1.153
1973/74	932	-2.094	96,400	2.348	992	3.276
1974/75	2,045	-0.240	56,000	0.809	80	-1.231
1975/76	2,149	-0.068	26,800	-0.303	273	-0.278
1976/77	1,985	-0.341	1,950	-1.250	53	-1.367
1977/78	916	-2.121	44,600	0.375	363	0.165
1978/79	2,216	0.044	18,600	-0.616	76	-1.253
1979/80	2,130	-0.099	38,400	0.138	283	-0.231
1980/81	2,069	-0.200	16,100	-0.711	75	-1.259
1981/82	1,970	-0.365	78,700	1.674	612	1.396
1982/83	2,621	0.720	73,300	1.468	521	0.947
1983/84	2,966	1.294	32,500	-0.086	767	2.162
1984/85	3,409	2.031	19,000	-0.601	806	2.358
1985/86	2,405	0.359	32,400	-0.090	268	-0.303
1986/87	2,328	0.231	22,600	-0.463	307	-0.112
1987/88	2,282	0.155	16,400	-0.700	249	-0.397
1988/89	1,844	-0.575	25,300	-0.361	393	0.317
1989/90	2,464	0.458	13,700	-0.803	312	-0.084
1990/91	1,983	-0.344	18,300	-0.627	291	-0.189
1991/92	2,166	-0.039	7,590	-1.035	279	-0.247
1992/93	1,534	-1.092	20,800	-0.532	234	-0.472
1993/94	2,895	1.175	4,950	-1.136	306	-0.113
1994/95	1,441	-1.246	16,800	-0.684	237	-0.458
1995/96	2,767	0.963	28,700	-0.231	314	-0.077
1996/97	2,528	0.564	90,800	2.135	485	0.771
1997/98	2,707	0.862	39,000	0.161	369	0.194
1998/99	3,157	1.612	43,400	0.329	638	1.524
1999/00	3,419	2.048	21,200	-0.517	265	-0.320
2000/01	2,376	0.312	3,010	-1.210	272	-0.286
2001/02	1,434	-1.258	13,000	-0.829	94	-1.162
2002/03	1,911	-0.463	34,800	0.001	305	-0.118
2003/04	2,042	-0.245	20,770	-0.533	266	-0.312
2004/05	2,040	-0.248	24,600	-0.387	308	-0.106
2005/06	2,273	0.140	78,200	1.655	333	0.019
2006/07	2,627	0.729	29,400	-0.204	282	-0.236
2007/08	2,029	-0.267	22,400	-0.471	328	-0.006
2008/09	2,988	1.331	18,000	-0.639	274	-0.273

[a] *Mean flow (cfs) at Agness when juveniles reared in freshwater.*

[b] *Greatest mean daily flow (cfs) at Grants Pass when eggs and alevins incubated in the gravel.*

[c] *Mean flow (cfs) at Applegate town when adults migrated and spawned in the Applegate River.*

Appendix Table E-14. Indicators of critical freshwater environmental conditions experienced by naturally produced fall Chinook salmon in the coastal river basins, 1969-2009. Normalized estimates were used as covariates in the analyses of the stock-recruitment relationships reported in this conservation plan. All data originated from the USGS Chetco River gage.

	Nov-Dec flow[a]		Peak flow[b]		May-June[c] flow		July-Aug[d] flow	
Year	**Mean**	**Normalized**	**Mean**	**Normalized**	**Mean**	**Normalized**	**Mean**	**Normalized**
1969/70	4,191	-0.073	44,800	0.654	759	-0.270	118	-0.664
1970/71	6,415	0.791	65,800	2.180	677	-0.442	205	0.937
1971/72	4,485	0.041	54,500	1.359	545	-0.717	128	-0.480
1972/73	2,769	-0.625	14,100	-1.578	344	-1.138	98	-1.039
1973/74	9,139	1.849	29,000	-0.495	352	-1.120	111	-0.805
1974/75	1,780	-1.009	38,900	0.225	998	0.230	124	-0.558
1975/76	3,597	-0.303	25,700	-0.735	364	-1.096	187	0.603
1976/77	175	-1.633	15,200	-1.498	529	-0.750	110	-0.824
1977/78	7,658	1.274	46,100	0.748	1,046	0.329	213	1.074
1978/79	999	-1.312	36,900	0.079	1,438	1.149	131	-0.428
1979/80	4,379	0.000	27,400	-0.611	544	-0.720	131	-0.427
1980/81	4,820	0.172	53,800	1.308	708	-0.377	154	-0.015
1981/82	9,850	2.125	51,800	1.162	809	-0.166	123	-0.572
1982/83	5,803	0.553	46,300	0.763	929	0.084	376	4.086
1983/84	7,572	1.240	44,600	0.639	1,554	1.391	174	0.365
1984/85	5,865	0.577	14,900	-1.520	936	0.100	160	0.114
1985/86	2,471	-0.741	36,900	0.079	816	-0.152	122	-0.598
1986/87	2,763	-0.627	26,600	-0.669	353	-1.120	97	-1.066
1987/88	3,516	-0.335	36,600	0.057	1,537	1.355	194	0.728
1988/89	3,797	-0.226	17,600	-1.324	604	-0.593	160	0.112
1989/90	915	-1.345	49,300	0.981	1,734	1.767	226	1.317
1990/91	1,115	-1.267	23,400	-0.902	607	-0.587	121	-0.619
1991/92	1,140	-1.258	23,000	-0.931	443	-0.931	115	-0.733
1992/93	3,180	-0.465	42,100	0.457	2,294	2.937	224	1.280
1993/94	1,628	-1.068	20,000	-1.149	776	-0.235	134	-0.373
1994/95	3,757	-0.241	40,200	0.319	1,140	0.526	210	1.022
1995/96	9,873	2.134	33,600	-0.161	2,036	2.398	156	0.033
1996/97	9,548	2.008	34,000	-0.131	729	-0.332	137	-0.320
1997/98	3,441	-0.364	25,900	-0.720	591	-0.621	136	-0.347
1998/99	5,631	0.487	28,000	-0.568	857	-0.066	140	-0.259
1999/00	2,975	-0.545	43,700	0.574	971	0.172	153	-0.028
2000/01	1,413	-1.152	9,800	-1.886	583	-0.637	127	-0.504
2001/02	4,979	0.233	28,800	-0.509	379	-1.064	101	-0.986
2002/03	4,678	0.116	36,800	0.072	926	0.078	135	-0.349
2003/04	3,993	-0.150	45,500	0.704	384	-1.053	123	-0.585
2004/05	2,742	-0.635	48,200	0.901	1,717	1.732	269	2.112
2005/06	6,498	0.823	58,300	1.635	1,018	0.271	188	0.618
2006/07	7,414	1.179	45,900	0.734	678	-0.440	142	-0.230
2007/08	4,369	-0.004	17,200	-1.353	608	-0.587	105	-0.909
2008/09	3,797	-0.226	51,100	1.112	1,221	0.695	117	-0.684

[a] *Mean flow (cfs) when adults migrated and most spawned.*

[b] *Greatest mean daily flow (cfs) when eggs and alevins incubated in the gravel.*

[c] *Mean flow (cfs) when fry reared in freshwater.*

[d] *Mean flow (cfs) when presmolts reared in freshwater.*

APPENDIX F

Population Models

For each population, we assessed the relationship between the abundance of spawners on a given year and the resulting number of adult progeny (recruits) produced by those spawners. This spawner-recruit analysis yields information about trans-generational population dynamics that is subsequently used to assess extinction risk in population viability analysis (PVA). This appendix begins by describing spawner-recruit analysis and then goes on to describe how results from this analysis are used in a PVA.

Spawner-Recruit Relationships

In **APPENDIX C** and **APPENDIX D**, we described the development of (1) annual estimates of spawner abundance for each population and (2) estimates of the number of recruits that were produced by those spawners. We now assess the shape and strength of a relationship between our estimates of spawners and recruits. A simple straight linear relationship between spawners and recruits is biologically unrealistic because, among other reasons, it suggests that there is no upper limit to the number of recruits that can be produced. Thus, a nonlinear relationship between spawners and recruits is needed. We considered the two most common relationships commonly used by fish scientists; the Ricker (1954) and Beverton-Holt (1957) curves.

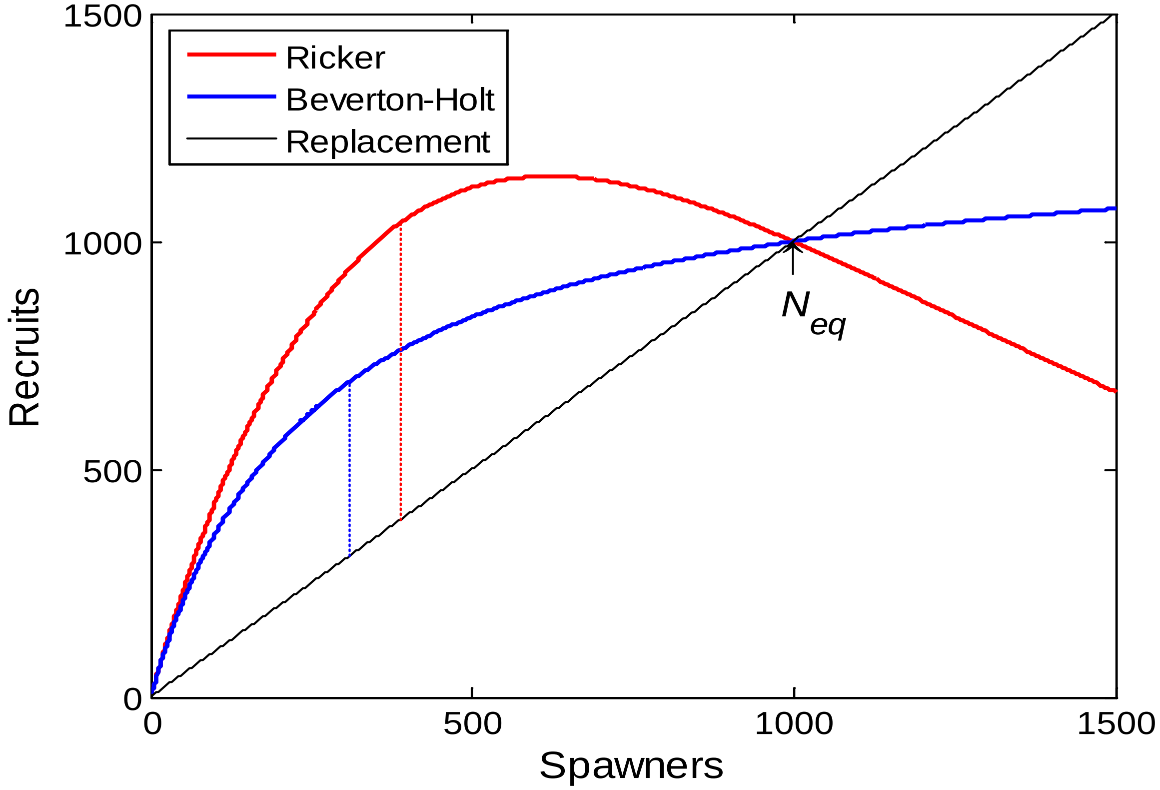
The Ricker function

$$R = \alpha S e^{-\beta_{RK} S} \qquad \textit{Equation 1}$$

and the Beverton-Holt function

$$R = \frac{\alpha S}{1 + \dfrac{\alpha}{\beta_{BH}} S} \qquad \textit{Equation 2}$$

Both functions model recruit abundance (*R*) as a two-parameter function of spawner abundance (*S*). In both equations, α represents “intrinsic productivity,” which is the number of recruits produced per spawner as spawner abundance approaches zero. This value therefore represent the reproductive output when animals are uninhibited by density-dependent effects, and is an important component of population resiliency. The meaning of the β parameter is different in the two functions, and so we denote this difference by using subscripts in equations 1 and 2 above. In a Ricker function, β_{RK} indicates the rate of decline in recruit abundance (*R*) as spawner abundance (*S*) increases. There are different algebraic ways of writing the Beverton-Holt function (*see* Equations 7-9 below), but as it is written in Equation 2, the β_{BH} parameter represents the asymptote of recruit abundances as *S* increases. The Ricker and Beverton-Holt functions are plotted in Appendix Figure F-1. Both functions in Appendix Figure F-1 assume



Appendix Figure F-1. Ricker and Beverton-Holt functions. The Ricker function (red) assumes that recruitment drops at very high spawner abundances while the Beverton-Holt function (blue) assumes that recruitment asymptotes as spawner abundance increases. The maximum sustained yield occurs at the spawner abundance (S_{MSY}) with the maximum vertical distance (dotted) between the model (colored) and population replacement (black). In the absence of fishing mortality, spawner abundance will reach equilibrium at N_{eq}.

$\alpha = 5$. Values of β were selected for each function so that they cross the replacement line (spawners = recruits) corresponding to 1000 spawners and recruits[•]. The point where the function crosses the replacement line is denoted N_{eq}. If there was no harvest, then all recruits would become spawners, and abundance of spawners would be in equilibrium at N_{eq}.

Maximum sustained yield is a mathematical concept that can be derived from spawner-recruit relationships. It is the maximum number of animals that can be harvested such that the abundance of animals escaping harvest should produce an equally harvestable surplus of recruits. Graphically, the number of spawners that produces MSY (S_{MSY}) is the point on the x-axis of a spawner-recruit plot where there is maximum vertical distance between recruits and the replacement line (Appendix Figure F-1). Attempts to manage fish abundances to attain MSY have been implicated in the overfishing and collapse of many fisheries (Larkin 1977; Finley 2011). Although we do not advocate MSY-based fish management, we nonetheless compute S_{MSY}

[•] Solve Equation 1 and Equation 2 for R=S, call the result Neq, then rearrange for β to obtain:

$$\beta_{RK} = \frac{\log(\alpha)}{N_{eq}}, \beta_{BH} = \frac{N_{eq}\alpha}{\alpha - 1}$$

because we define critical conservation abundance at the 75th percentile of our estimate of half of S_{MSY} (*see* next section). For the Ricker and Beverton-Holt functions, S_{MSY} is respectively:

$$S_{MSY} = \frac{\ln(\alpha)}{\beta_{RK}}\left(0.5 - 0.07\ln(\alpha)\right) \qquad \text{Equation 3}$$

$$S_{MSY} = \beta_{BH}\sqrt{\frac{1}{\alpha}} - \frac{\beta_{BH}}{\alpha}\ , \qquad \text{Equation 4}$$

Statistical Fits of Spawner-Recruit Relationships: We used Bayesian methods to fit spawner-recruit functions for two reasons. First, as noted above, the spawner-recruit relationship is used to drive trans-generational population dynamics in the PVAs. An important aspect of any PVA is incorporation of statistical uncertainty in underlying parameters. Bayesian methods yield probability densities for the parameters of the spawner-recruit functions whereas non-Bayesian (i.e. “frequentist”) methods do not. Thus, Bayes’ method provides results that can be directly used to simulate parameter uncertainty in a PVA, which is one reason why Bayesian methods are appealing to conservation biologists (Wade 2002).

The second reason we used Bayesian methods to fit spawner-recruit relationships derives from our desire to characterize uncertainty in our estimate of S_{MSY}. Fifty percent of S_{MSY} has been used as a critically low abundance for triggering conservation action (AHSAC 2011). However, since S_{MSY} is never known perfectly, we define critically low abundance as 50% of the 75th percentile of the estimate of S_{MSY}. This definition of a critically low abundance explicitly acknowledges uncertainty in S_{MSY}, and reduces the conservation risk associated with overestimating the true value of S_{MSY}. Stated another way, when ambiguity in the data increases, fish managers should respond more conservatively. Since S_{MSY} is computed from α and β parameters (*see* Equations 3 and 4), our assessment of statistical uncertainty in S_{MSY} depends on uncertainty in both of those parameters as well as their covariance. Quantifying uncertainty in S_{MSY} is therefore a very complex problem. Indeed, an exact analytical solution is not known to science. However, the Bayesian statistical paradigm offers a method for numerically estimating uncertainty in S_{MSY}. S_{MSY} can be computed on the fly as Markov Chain Monte Carlo (MCMC) methods sample from parameter posterior distributions (Haddon 2011). This yields a probability density of S_{MSY}, which, unlike results of frequentist methods, can be used to make probability statements about the value of S_{MSY}.

We modeled recruits as a lognormally distributed random variable. Specifically, we let

$$\log(R) \sim \text{Normal}(\mu,\tau) \qquad \textit{Distribution 1}$$

and, for the Ricker function, we get

$$\mu = \log(\alpha)+\log(S) - \beta_{RK}{*}S. \qquad \textit{Equation 5}$$

If environmental covariates are included in the Ricker function, then we have:

$$\mu = \log(\alpha)+\log(S) - \beta_{RK}{*}S + \gamma_1\text{Env}_1 + \gamma_2\text{Env}_2. \qquad \textit{Equation 6}$$

We had difficulty getting Beverton-Holt models to converge, so we tried several parameterizations of the Beverton-Holt function. Specifically, we explored:

$$\mu = \log(\alpha)+\log(S) - \log(1+ \alpha/\beta_{BH}{*}S\ )\ \ \{\text{logarithmic version of Equation 2}\} \qquad \textit{Equation 7}$$

$$\mu = \log(S) - \log(1/\exp(\alpha) + S/\exp(\beta_{BH})) \qquad \textit{Equation 8}$$

$$\mu = \log(a)+\log(S) - \log(b + S). \qquad \textit{Equation 9}$$

As in Equation 6, we included environmental covariates to the Beverton-Holt function by simply including them as additive terms.

We used WinBUGS to carry out MCMC fitting of our spawner-recruit functions. Here, we follow WinBUGS distributional notation and note that τ in Dist. 1 is the precision of the normal distribution, where $\tau = 1/\sigma^2$. We first transform τ to the more familiar standard deviation, σ, and then let

$\sigma \sim \text{Uniform}(0,6)$. *Distribution 2*

We also tried the more common:

$\tau \sim \text{Gamma}(0.005, 0.005)$ *Distribution 3*

and found that the choice of prior parameterizations had little effect of our posterior results. For the intrinsic productivity parameter of both Ricker and Beverton-Holt functions, we specified noninformative priors with:

$\alpha \sim \text{Uniform}(0,10)$. *Distribution 4*

The prior distribution we used for β_{RK} is

$\beta_{RK} \sim \text{Normal}(\mu = 0.0000001, \tau = 0.005)$, *Distribution 5*

but we also explored the effects of assuming

$\beta_{RK} \sim \text{Uniform}(0.00001, 0.005)$. *Distribution 6*

We tried a host of different prior distributions for Beverton-Holt functions given in equations 7-9 because of the difficulty we experienced getting good convergence. Specifically, we tried normal, lognormal, and uniform priors in conjunction with several different noninformative parameterizations of these distributions. We did not obtain satisfactory fits and good evidence to support the use of Beverton-Holt functions for any of the populations we modeled. Thus, all of the spawner-recruit models presented in this conservation plan were derived from Ricker's function.

We always ran two Markov chains, and typically allowed them "burn-in" for 5000 iterations. We obtained a total of 3500 samples from each chain, after thinning the chains out to every 31st iteration. We plotted the "trace" of the resulting samples and computed Gelman-Rubin statistics to verify that the chains had properly mixed. For many models, including all those assuming a Beverton-Holt function, we did not obtain good evidence of convergence. If we were not able to remedy convergence problem by adjusting the length of the burn-in and making minor adjustments to the prior distribution values and/or starting values, then we concluded that the model was not well suited to the data and we abandoned further attempts to fit the model.

We looked at the resulting parameter estimates to ensure that there were not any biologically unrealistic values. For example, if non-informative normal priors are used for the parameters in *Equation 9* (a Beverton-Holt function), then we frequently obtained huge uncertainty intervals that include negative values. Since the parameters of *Equation 9* represent non-negative entities, we did not entertain results with negative estimates. Using such the results of such models in our PVA (below) would have carried absurd assumptions into our estimates of extinction risk. As noted above, we were unable to obtain satisfactory results for any population using the Beverton-Holt function.

We included environmental covariates in the spawner-recruit modeling for two reasons. First, it provides an opportunity to possibly better quantify, the effects of primary factors that have been previously shown to limit recruitment within NP CHF populations of the Rogue SMU. Second, scatterplots of our spawner and recruit data look nothing like the recruitment functions we attempted to fit. Including environmental covariates provides a means of getting better parameter estimates if the covariates can significantly account for some of the apparent randomness in the spawner-recruit data. Covariates were z-transformed so that values approximately come from a standard normal distribution in order to improve convergence performance. Descriptions of the chosen covariates, and the rationale associated with those choices, can be found in the conservation plan (*see* **Spawner Abundance:**, page 60 and **Spawner Abundance:**, page 88).

We computed a Deviance Information Criterion (DIC) for each model. DIC is a Bayesian analogue of Akaike Information Criterion (AIC), which represents the tradeoff between model fit and complexity (Spiegelhalter et al. 2002). Much like AIC, a practical rule of thumb is that models receiving DIC scores within 1-2 of the "best" (i.e. smallest DIC) deserve consideration, whereas scores 2-7 greater than the "best" have considerably less support (Appendix Table F-1).

Appendix Table F-1. Deviance Information Criterion scores for Ricker spawner-recruit models fitted to the populations of naturally produced fall Chinook salmon in the Rogue Species Management Unit. No reliable models could be developed for the Lower Rogue population. The model with the lowest DIC is marked with an asterisk, along with models with similar (<2 difference) DICs.

	Deviance Information Criterion scores					
Covariate	Rogue[a]	Chetco	Winchuck	Pistol	Hunter	Euchre
None	53.9	33.4	31.5*	38.4*	36.4	43.1*
Survival rate[b]	45.0*	31.0*	32.7*	36.9*	27.9*	41.6*
PK flow[c]	55.8	34.3	33.7	40.6	37.7	43.0*
JA flow[d]	51.7	35.7	31.3*	40.5	38.2	43.4*
ON flow[e]	55.3	n/a	n/a	n/a	n/a	n/a
MJ flow[f]	n/a	35.4	31.2*	40.5	37.1	45.0
Two covariates[g]	46.4*	33.2	34.3	39.1	30.0	43.2*
Two covariates[h]	45.6*	32.5*	30.7*	38.2*	26.0*	42.7*
Two covariates[i]	n/a	33.4	31.6*	38.2*	25.7*	43.4*

[a] Rogue aggregate populations.
[b] Survival rate to age 2 for CWT-marked CHS (Appendix Table E-12).
[c] Peak flow during incubation (Appendix Tables E-12 (Rogue) and E-14 (Chetco)).
[d] Jul-Aug rearing flow (Appendix Tables E-13 (Rogue) and E-14 (Chetco)).
[e] Oct-Nov spawning flow (Appendix Table E-13 (Rogue)).
[f] May-June rearing flow (Appendix Table E-14 (Chetco)).
[g] Survival rate and peak flow as covariates.
[h] Survival rate and Jul-Aug flow as covariates.
[i] Survival rate and May-June flow as covariates.

Candidate Models

Multiple candidate models were developed for each NP CHF population in the Rogue SMU and it was not possible to identify a single "best" model for each population (Appendix Table F-1). However, a generalized inference could be made by examination of the entire suite of developed models. Based on a difference of at least 2.0 among DIC scores, candidate models with smolt survival rates, summer flow during juvenile rearing, and spring flow during juvenile rearing could not be differentiated from each other; yet often appeared to be better as compared to candidate models with other covariates or no covariates (Appendix Table F-1). Models that could not be differentiated from each other are described in Appendix Tables F-2 through F-6.

Table F-2. Parameter values of the best fit Ricker stock-recruitment models built for the aggregated populations of naturally produced fall Chinook salmon in the Rogue River Basin, 1980-2004 brood years. Data included in the models are listed in Appendix Tables E-5, E-12, and E-13.

Rogue1 Model

lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate

Parameter	Coefficient	95% confidence interval
Ricker α	4.07	2.11 – 6.28
Ricker β	1.57 x 10^{-5}	9.76 x 10^{-6} - 2.24 x 10^{-5}
e1[a]	0.37	0.14 - 0.61

Rogue2 Model

lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*peak flow

Parameter	Coefficient	95% confidence interval
Ricker α	3.92	2.03 – 6.16
Ricker β	1.56 x 10^{-5}	0.88 x 10^{-5} - 2.17 x 10^{-5}
e1[a]	0.38	0.15 - 0.61
e2[b]	-0.10	-0.38 - -0.17

Rogue3 Model

lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*summer flow

Parameter	Coefficient	95% confidence interval
Ricker α	3.93	2.03 – 6.01
Ricker β	1.56 x 10^{-5}	0.95 x 10^{-5} - 2.20 x 10^{-5}
e1[a]	0.32	0.08 - 0.57
e2[c]	0.16	-0.12 - 0.43

[a] *Survival rate (p) to age 2 for CWT-marked spring Chinook salmon cohorts of hatchery origin.*

[b] *Peak flow (cfs) at Grants Pass during egg and alevin incubation.*

[c] *Mean flow (cfs) at Grants Pass during July-August of juvenile rearing in freshwater.*

Table F-3. Parameter values of the best fit Ricker stock-recruitment models built for naturally produced fall Chinook salmon in the Chetco River population area, 1986-2004 brood years. Data included in the analysis are listed in Appendix Tables E-10, E-12, and E-14.

Chetco1 Model

$$\ln\text{Recruits} = \ln\alpha + \ln\text{Spawners} - \beta{*}\text{Spawners} + e1{*}\text{survival rate}$$

Parameter	Coefficient	95% confidence interval
Ricker α	3.67	1.70 - 6.21
Ricker β	1.87×10^{-4}	1.02×10^{-4} - 2.73×10^{-4}
e1[a]	0.22	-0.01 - 0.45

Chetco2 Model

$$\ln\text{Recruits} = \ln\alpha + \ln\text{Spawners} - \beta{*}\text{Spawners} + e1{*}\text{survival rate} + e2{*}\text{summer flow}$$

Parameter	Coefficient	95% confidence interval
Ricker α	3.73	1.60 - 6.23
Ricker β	1.90×10^{-4}	1.02×10^{-4} - 2.77×10^{-4}
e1[a]	0.23	0.00 - 0.47
e2[b]	0.11	-0.18 - 0.41

[a] *Survival rate (p) to age 2 for CWT-marked spring Chinook salmon cohorts of hatchery origin.*

[b] *Peak flow (cfs) of the Chetco River during egg and alevin incubation.*

Table F-4. Parameter values of the best fit Ricker stock-recruitment models built for naturally produced fall Chinook salmon in the Winchuck population area, 1984-2004 brood years. Data included in the analysis are listed in Appendix Tables E-11, E-12, and E-14.

Winchuck1 Model (lnRecruits = lnα + lnSpawners - β*Spawners)

Parameter	Coefficient	95% confidence interval
Ricker α	4.56	2.09 - 7.36
Ricker β	1.05×10^{-3}	0.57×10^{-3} - 1.53×10^{-3}

Winchuck2 Model (lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate)

Ricker α	4.47	2.13 - 7.54
Ricker β	1.04×10^{-3}	0.56×10^{-3} - 1.56×10^{-3}
e1[a]	0.11	-0.12 - 0.35

Winchuck3 Model (lnRecruits = lnα + lnSpawners - β*Spawners + e1*summer flow)

Ricker α	4.46	1.94 - 7.16
Ricker β	1.05×10^{-3}	0.58×10^{-3} - 1.53×10^{-3}
e1[b]	0.20	-0.10 - 0.48

Winchuck4 Model (lnRecruits = lnα + lnSpawners - β*Spawners + e1*spring flow)

Ricker α	4.23	1.74 - 6.84
Ricker β	1.02×10^{-3}	0.56×10^{-3} - 1.54×10^{-3}
e1[c]	0.14	-0.05 - 0.35

Winchuck5 Model
lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*summer flow

Ricker α	4.32	2.11 - 6.95
Ricker β	1.02×10^{-3}	0.56×10^{-3} - 1.49×10^{-3}
e1[a]	0.16	-0.07 - 0.38
e2[b]	0.25	-0.03 - 0.54

Winchuck6 Model
lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*summer flow

Parameter	Coefficient	95% confidence interval
Ricker α	4.15	1.79 - 6.69
Ricker β	1.00×10^{-3}	0.52×10^{-3} - 1.48×10^{-3}
e1[a]	0.12	-0.09 - 0.36
e2[c]	0.15	-0.05 - 0.35

[a] *Survival rate (p) to age 2 for CWT-marked spring Chinook salmon cohorts of hatchery origin.*
[b] *Mean flow (cfs) of the Chetco River during July-August of juvenile rearing in freshwater.*
[c] *Mean flow (cfs) of the Chetco River during May-June of juvenile rearing in freshwater.*

Table F-5. Parameter values of the best fit Ricker stock-recruitment models built for naturally produced fall Chinook salmon in the Pistol population area, 1987-2004 brood years. Data included in the analysis are listed in Appendix Tables E-9, E-12, and E-14.

Pistol1 Model

$\ln Recruits = \ln\alpha + \ln Spawners - \beta * Spawners$

Parameter	Coefficient	95% confidence interval
Ricker α	4.17	2.22 - 6.53
Ricker β	6.32×10^{-4}	3.31×10^{-4} - 9.42×10^{-4}

Pistol2 Model

$\ln Recruits = \ln\alpha + \ln Spawners - \beta * Spawners + e1 * survival\ rate$

Parameter	Coefficient	95% confidence interval
Ricker α	3.63	1.91 - 5.60
Ricker β	5.43×10^{-4}	2.22×10^{-4} - 8.29×10^{-4}
e1[a]	0.27	-0.02 - 0.55

Pistol3 Model

$\ln Recruits = \ln\alpha + \ln Spawners - \beta * Spawners + e1 * survival\ rate + e2 * summer\ flow$

Parameter	Coefficient	95% confidence interval
Ricker α	3.68	1.92 - 5.76
Ricker β	5.49×10^{-4}	2.35×10^{-4} - 8.61×10^{-4}
e1[a]	0.27	-0.04 - 0.57
e2[b]	0.03	-0.35 - 0.43

Pistol4 Model

$\ln Recruits = \ln\alpha + \ln Spawners - \beta * Spawners + e1 * survival\ rate + e2 * spring\ flow$

Parameter	Coefficient	95% confidence interval
Ricker α	3.62	1.84 - 5.66
Ricker β	5.44×10^{-4}	2.33×10^{-4} - 8.56×10^{-4}
e1[a]	0.27	-0.03 - 0.57
e2[c]	0.03	-0.21 - 0.29

[a] *Survival rate (p) to age 2 for CWT-marked spring Chinook salmon cohorts of hatchery origin.*
[b] *Mean flow (cfs) of the Chetco River during July-August of juvenile rearing in freshwater.*
[c] *Mean flow (cfs) of the Chetco River during May-June of juvenile rearing in freshwater.*

Table F-6. Parameter values of the best fit Ricker stock-recruitment models built for naturally produced fall Chinook salmon in the Hunter population area, 1989-2004 brood years. Data included in the analysis are listed in Appendix Tables E-8, E-12, and E-14.

Hunter1 Model

lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*summer flow

Parameter	Coefficient	95% confidence interval
Ricker α	4.35	2.54 - 6.50
Ricker β	1.45×10^{-3}	0.97×10^{-3} - 1.96×10^{-3}
e1[a]	0.45	0.21 - 0.69
e2[b]	0.27	-0.08 - 0.61

Hunter2 Model

lnRecruits = lnα + lnSpawners - β*Spawners + e1*survival rate + e2*spring flow

Parameter	Coefficient	95% confidence interval
Ricker α	4.62	2.60 - 6.74
Ricker β	1.57×10^{-3}	1.09×10^{-3} - 2.04×10^{-3}
e1[a]	0.41	0.17 - 0.62
e2[c]	0.18	-0.03 - 0.38

[a] *Survival rate (p) to age 2 for CWT-marked spring Chinook salmon cohorts of hatchery origin.*
[b] *Mean flow (cfs) of the Chetco River during July-August of juvenile rearing in freshwater.*
[c] *Mean flow (cfs) of the Chetco River during May-June of juvenile rearing in freshwater.*

Population Viability Analysis

Population viability analysis (PVA) is a quantitative assessment of a population's risk of extinction (Morris and Doak 2002). Extinction risk can be characterized as either (1) mean time to extinction or (2) probability of extinction over some time horizon, typically 100 years. Here, we adopt the latter meaning of extinction risk. Since we are interested in the probability of extinction over 100 years, we require principled, empirically-based method of simulating population dynamics through time. The purpose of this section of the Appendix is to describe how results from the spawner-recruit assessments are used to drive a PVA simulator.

A spawner-recruit curve is a model of trans-generational dynamics, and can therefore simulate population dynamics through time. However, to function as proper PVA, assumptions about (1) statistical uncertainty, (2) harvest, and (3) critically low abundance are needed. These three components of the PVA are addressed below.

Statistical Uncertainty: A deterministic spawner-recruit curve describes the number of recruits *expected* from some number of spawner. Clearly, however, observations of recruitment do not perfectly match this expectation. Rather, there is considerable deviation from this expectation every year. If these deviations are not incorporated into a simulation of a spawner-recruit relationship, then the simulated populations will converge on a stable age distribution and a stable spawner size (N_{eq} in Appendix Figure F-1). It is the principled incorporation of statistical uncertainty that distinguishes a PVA from other forms of population projection. To incorporate stochasticity, we simply compute the variance of the residuals in a spawner-recruit curve and then incorporate those deviations into the simulation. We also compute the lag-1 autocorrelation of the spawner-recruit residuals so that observed trends above or below the spawner-recruit curve are included in our simulations. With estimates of the variance and lag-1 autocorrelation on hand, a 100-year time series of simulated spawner-recruit residuals (or “environmental deviates”) was computed using the formula:

$$\varepsilon_t = \rho\varepsilon_{t-1} + \sqrt{\sigma^2}\sqrt{1-\rho^2}\,N(0,1) \qquad \textit{Equation 10}$$

where ρ is the estimate of the lag-1 autocorrelation of the residuals, σ^2 is the variance of the residuals and $N(0,1)$ is a standard normal deviate. At each time-step of the PVA, the corresponding ε_t was added to the expected number of recruits for a given number of spawners. This adds stochasitcity to the otherwise deterministic spawner-recruit function. Note that this procedure assumes a homoscedastic distribution of random deviates.

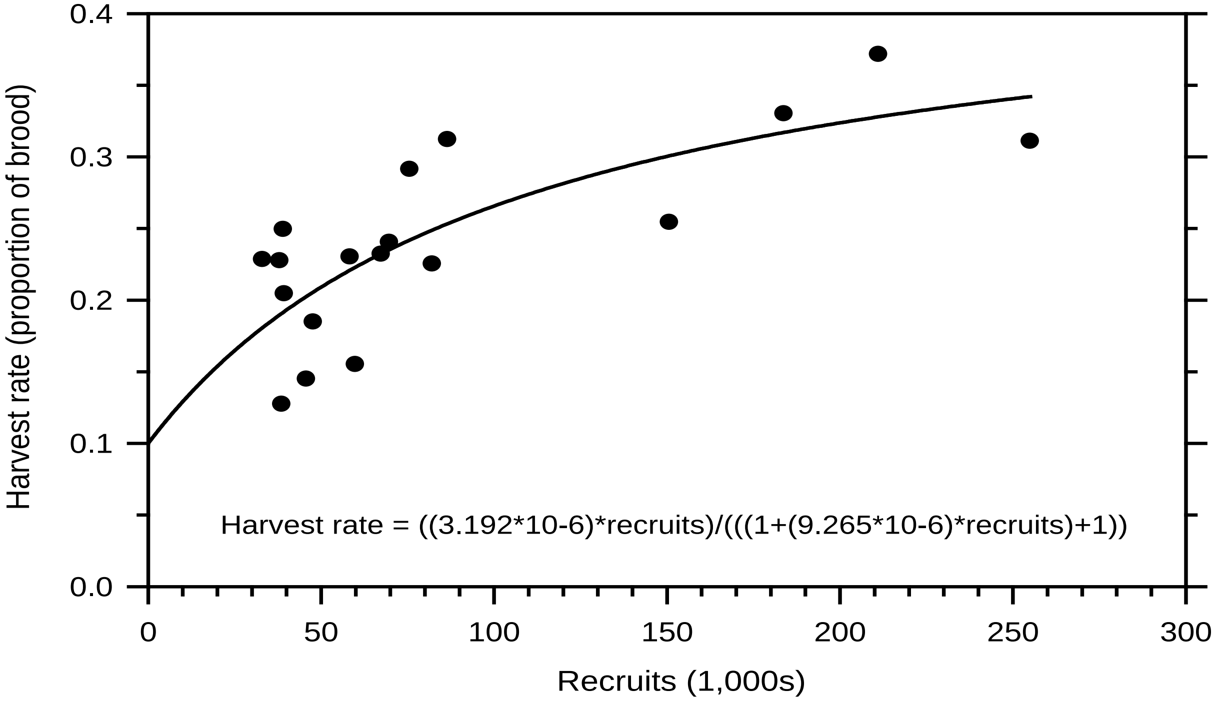
As noted in the section above on statistically fitting spawner-recruit relationships, it is important for the PVA to incorporate uncertainty in parameter estimates. Indeed, a motivation for using Bayesian methods to fit the spawner-recruit curves is that it permits us to make probability statements about different spawner-recruit parameter values. For each population, we randomly drew values of the spawner-recruit curve from their posterior probability distributions 1000 times. For each of these draws, residuals variance and autocorrelation were recomputed, and then the PVA was repeated 50 times. Thus, the PVA was repeated a total of 50,000 times for each population. The frequency of extinction events (*see* section on critically low abundance, below) among these 50,000 replicates is extinction risk as reported in the conservation plan.

Harvest: Chinook return to the spawning grounds at different ages, and these differences must be captured in the PVA. If **a** is a vector of the probabilities of spawning at different ages, then **a***R is a vector containing the number of fish that will return to the spawning grounds at different ages. The values for **a** represent the observed mean age composition of age 2-6 NP CHF spawners for the period of record (**a** = 0.207, 0.366, 0.324, 0.091, 0.011 for the Rogue populations and **a** = 0.072, 0.183, 0.572, 0.168, 0.004) for the coastal populations). Thus, under a scenario of no harvest for the Rogue populations, if brood year 1 produces 1000 recruits (*R*), then the model estimates that 366 of these fish will return to spawn three years later. These fish would spawn with 414 two-year olds if brood year 2 produces 2000 recruits; again under the assumption of no harvest. The total number of spawners in a given simulated year is obtained by summing the products of recruits produced in previous years and the probabilities of spawning at different ages; and then removing harvested fish. Specifically, spawner abundance on a given year (S_t) is:

$$S_t = \sum_{i=1}^{6} R_{t-i}\,a_i\,(1-H) \qquad \textit{Equation 11}$$

where *H* is the estimated brood harvest rate. Note that *H* and **a** were needed to construct the original spawner-recruit dataset. Harvested fish were included in the number of recruits in the original spawner-recruit dataset. *Equation 11* removes the same number of fish before they spawn, which reflects the real-world harvest process.

For each coastal population, simulations were completed at specific harvest rates of 0.25 and 0.40. Selection of these harvest rates reflected conservative (0.25) and liberal (0.40) harvest management strategies observed since the late 1980s; when ocean exploitation rates on Rogue SMU populations decreased in response to management efforts implemented to meet spawning escapement goals for CHF in the Klamath River Basin (*see* **Fisheries**, page 65 in conservation plan). In contrast, simulations of the Rogue populations incorporated brood harvest rates that were estimated from each simulated value of population abundance. This procedure was implemented because brood harvest rates of NP CHF in the ocean fisheries are dependent on the stock size of Klamath CHF, and the abundance of Klamath CHF and Rogue NP CHF are correlated (*see* **Comparisons to Other Populations**, page 69 in the conservation plan). A function for brood harvest rates was incorporated into the PVA for NP CHF produced in the Rogue River Basin (Appendix Figure F-2).



Appendix Figure F-2. Harvest rate function used in the population viability assessment of naturally produced fall Chinook salmon within aggregated populations of the Rogue River Basin. The employed function was estimated for data from the 1988-2005 brood years. This temporal period covers the current approach to management of the ocean fisheries based on the abundance of fall Chinook salmon of Klamath River Basin origin. The function also assumes a baseline harvest rate of 0.10 to account for freshwater

References

AHSAC (Ad Hoc Salmon Amendment Committee). 2011. Final environmental assessment and initial regulatory impact review for Pacific coast salmon plan amendment 16: classifying stocks, revising status determination criteria, establishing annual catch limits and accountability measures, and de minimis fishing provisions. Pacific Fisheries Management Council, Portland.

Beverton, R.J.H., and S.J. Holt. 1957. On the dynamics of exploited fish populations. United Kingdom Ministry of Agriculture and Fisheries. Fisheries Investigations (series 2) 19:1-533.

Finley, C. 2011. All the Fish in the Sea: Maximum Sustained Yield and the Failure of Fisheries Management. The University of Chicago Press, Chicago, Illinois.

Haddon, M. 2011. Modelling and Quantitative Methods in Fisheries. Second Edition. Chapman and Hall/CRC, Boca Raton, Florida.

Larkin, P.A. 1977. An epitaph for the concept of maximum sustained yield. Transactions of the American Fisheries Society 106:1-11.

Morris, W.F. and D.F. Doak. 2002. Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis. Sinauer Associates, Inc, Sunderland, Maryland.

Ricker, W.E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 11: 559-623.

Spiegelhalter, D.J., N.G. Best, B.P. Carlin, and A. van der Linde. 2002. Bayesian measures of model complexity and fit. Journal of the Royal Statistical Society, Series B 64:583-639.

Wade, P.A. 2002. Bayesian population viability analysis. In Bessinger, S.R. and D.R. McCullough (Eds.) Populaiton Viability Analysis. The University of Chicago Press, Chicago, Illinois.

APPENDIX G

Potential Actions Considered for Populations in the Rogue Stratum

List includes only those factors that limit, or may limit, attainment of desired biological status (*see* **Rogue Stratum**, page 46 in conservation plan)

DESIRED STATUS ELEMENT: ADULT ABUNDANCE (≥55,000 age 3-6 NP CHF passage at Huntley Park)

Limiting Factor A1 - peak flow during egg and sac-fry incubation

Potential management actions:

A1(a). ODFW annually recommends that the USACE reduce peak flows during the period of November through March as much as possible under current reservoir management strategies implemented for Lost Creek and Applegate lakes. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a CHF management plan.

A1(b). ODFW annually recommends that the USACE increase the reduction of peak flows during the period of November through March. **Primary Implications:** This action would usually require that the USACE manage Lost Creek and Applegate lakes at levels significantly below the rule curves and also would require the annual releases of reservoir storage that exceed the amounts authorized for a “normal” year.

A1(c). ODFW annually recommends a specific maximum target for flows in the upper portions of the Rogue and Applegate rivers. **Primary Implications:** This action would decrease flexibility of USACE reservoir regulators if a reservoir level reaches the rule curve and cause the reservoir to be evacuated at greater rates, leading to a potential increase in fry dewatering in downstream areas. In addition, this action may lead to the perception that no regulatory actions should be employed when flows are not expected to reach a specific maximum target.

A1(d). ODFW encourages the construction of stormwater retention (preferred) or detention basins for proposed developments that would significantly increase the area of impervious surfaces. **Primary Implications:** This action would require ODFW outreach efforts to educate the general public and local government agencies.

A1(e). Take no action. Floods are good for maintaining ecosystem functions.

Limiting Factor A2 - water temperature during egg and sac-fry incubation

Potential management actions:

A2(a). ODFW annually recommends that the USACE release the coldest water possible from Applegate Lake during November through February. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a fish management plan.

A2(b). ODFW requests that the USACE determine, through water temperature modeling, if the operations at Applegate Lake can be modified to further decrease the temperature of water released during the period of November through February. **Primary Implications:** Development of water temperature models will be needed to accomplish this assessment.

A2(c). Take no action.

Limiting Factor A3 - flow prior to spawning

Potential management actions:

A3(a). ODFW annually recommends that the USACE manage reservoir releases at Lost Creek and Applegate lakes to optimize CHF spawning distribution. **Primary Implications:** This action would increase the abundance of CHF spawners within CHS spawning habitat in the Rogue River.

A3(b). ODFW annually recommends that the USACE manage reservoir releases at Applegate Lake to optimize CHF spawning distribution. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a fish management plan.

A3(c). Take no action.

Limiting Factor A4 - flow during egg and sac-fry incubation

Potential management actions:

A4(a). ODFW annually recommends that the USACE manage reservoir releases at Applegate Lake in order to minimize the number of redds that would be dewatered during the season of reservoir filling. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a fish management plan.

A4(b). Take no action.

Limiting Factor A5 - flow decreases during juvenile rearing

Potential management actions:

A5(a). ODFW annually recommends that the USACE manage reservoir releases at Applegate Lake to reach current criteria designed to minimize the potential for dewatering of juvenile NP CHF. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a fish management plan.

A5(b). Take no action.

Limiting Factor A6 - water temperature during adult migration

Potential management actions:

A6(a). ODFW annually recommends that the USACE manage reservoir releases to maximize survival by decreasing disease-related losses of adult CHF. **Primary Implications:** This action would often result in increased mortality among adult CHS, unless more reservoir storage (in excess of the current fish allocation) is authorized by the United States Congress.

A6(b). The same as described in option A6(a), except ODFW annually recommends that the USACE manage reservoir releases with CHF protection being of secondary priority as compared to CHS protection. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in a fish management plan.

A6(c). The same as described in option A6(a), except ODFW annually recommends that the USACE manage reservoir releases to cap expected disease-related losses of adult CHF at a maximum of 20%. **Primary Implications:** This action would sometimes produce increased mortality among adult NP CHS, unless more reservoir storage (in excess of the current fish allocation) is authorized by the United States Congress.

A6(d). During those years when disease-related losses of adult CHF are forecasted to reach or exceed 40%, ODFW recommends that the additional release of reservoir storage from Lost Creek

Lake. This additional water would be used to decrease CHF mortality rates. **Primary Implications:** Implementation of this request, by the USACE, would sometimes result in the release of more than 180,000 acre-feet of reservoir storage. The authorizing document (U.S. Congress) that guides reservoir management strategies calls for a release of only 180,000 acre-feet during a “normal” year.

A6(e). ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat. **Primary Implications:** Mature riparian habitat helps reduce water temperatures by the shading of streams.

A6(f). Take no action.

Limiting Factor A7 - water temperature during juvenile rearing

Potential management actions:

A7(a). ODFW annually recommends that the USACE manage reservoir releases from Lost Creek Lake to increase survival of rearing juveniles by releasing storage that is not needed to decrease disease-related losses of adult CHS and adult. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF.

A7(b). Analogous to option A7(a), except ODFW annually recommends that the USACE manage reservoir releases to maximize juvenile survival rates. **Primary Implications:** This alternative will produce increased mortality among adult CHS and CHF, or more reservoir storage, in excess of the current fish allocation, will be needed to protect both races of Chinook salmon.

A7(c). ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat. **Primary Implications:** Mature riparian habitat helps reduce water temperatures by the shading of streams.

A7(d). ODFW initiates or supports efforts designed to restore mature riparian habitat. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU.

A7(e). ODFW initiates or supports efforts designed to promote the natural development of mature riparian habitat in natural bar or floodplain areas. **Primary Implications:** This action may limit activities that impact vegetational succession of gravel bar features, including the means to access streams.

A7(f). Take no action.

Limiting Factor A8 - amount of spawning and rearing habitat

Potential management actions:

A8(a). ODFW supports the removal of artificial barriers to the upstream migration of adult CHF and pursues improvement of upstream passage at those barriers that cannot be removed. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU.

A8(b). ODFW pursues the means to obtain high quality water that would be used to allow for adult migration and spawning in Little Butte Creek during the period of October 15 through November 15. **Primary Implications:** This action would likely require at least 10,000 acre-feet of water that is currently not available. It is likely that such a volume can only become available if it originates from storage in a reservoir that has yet to be planned.

A8(c). ODFW pursues the means to obtain high quality water that would be used to allow for adult migration and spawning in Bear Creek during the period of October 15 through November 15.

Primary Implications: This action would likely require at least 10,000 acre-feet of water that is currently not available. It is likely that such a volume can only become available if it originates from storage in a reservoir that has yet to be planned.

A8(d). ODFW collects and transfers adult NP CHF into potential spawning habitat upstream of Applegate Dam. **Primary Implications:** This area was probably used by few, if any, before construction of Applegate Dam.

A8(e). In all population areas within the Rogue River Basin, ODFW collects and transfers excess broodstock of hatchery origin into potential spawning habitat not accessible to naturally migrating adults. **Primary Implications:** This action would introduce genetically different hatchery fish into non-historical NP CHF habitat.

A8(f). In the Lower Rogue population area, ODFW collects and transfers excess broodstock of hatchery origin into potential spawning habitat not accessible to naturally migrating adults. **Primary Implications:** This action would introduce hatchery fish into non-historical NP CHF habitat.

A8(g). Take no action.

Limiting Factor A9 - quality of spawning habitat

Potential management actions:

A9(a). ODFW requests that the USACE act to restore and maintain, at historic levels, gravel quality and quantity in spawning areas between Applegate Lake and the Little Applegate River. **Primary Implications:** This area was rarely used by spawning CHF prior to the construction and operation of Applegate Dam.

A9(b). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A9(c). Take no action.

Limiting Factor A10 - quality of rearing habitat

Potential management actions:

A10(a). ODFW develops an outreach effort designed to encourage landowners to maintain riparian habitat. **Primary Implications:** The primary benefits of this action are maintenance of channel shading and streambank stability.

A10(b). ODFW supports local government's participation in Oregon's Phase II Municipal Stormwater Program; which is administered through ODEQ. This program is designed to reduce the amount of stormwater pollutants discharged into streams. **Primary Implications:** This action would require ODFW outreach efforts to educate the public and local government.

A10(c). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A10(f). Take no action.

Limiting Factor A11 - juvenile mortality at water diversions

Potential management actions:

A11(a). ODFW continues to support improvements at diversion sites in order to increase the survival rates of juvenile salmonids. **Primary Implications:** This action has been employed by ODFW, and would include support for the reconstruction or removal of structures that inadequately protect downstream migrants.

A11(b). Take no action.

Limiting Factor A13 - predation on juveniles and adults

Potential management actions:

A12(a). ODFW encourages fishing-related mortality for non-native fish (Umpqua pikeminnows). **Primary Implications:** None.

A12(b). ODFW annually recommends that the USACE manage reservoir releases to increase survival of resident juveniles by releasing storage that is not needed to decrease disease-related losses of adult CHS and adult CHF. **Primary Implications:** This action has been employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF. Umpqua pikeminnow consumption of juvenile Chinook salmon would decrease because decreased water temperatures in downstream areas would decrease pikeminnow metabolic rates and growth rates.

A12(c). ODFW reduces the number of steelhead smolts released in the Applegate River to decrease predation on NP CHF fry. **Primary Implications:** Reductions in contribution rates to the half-pounder and winter steelhead fisheries.

A12(d). ODFW initiates a program to decrease cormorant predation on juvenile Chinook salmon passing through the estuary. **Primary Implications:** These animals are currently protected under the Federal Migratory Bird Treaty Act. However, the United States Fish and Wildlife Service has authorized some states to take steps designed to limit cormorant populations.

A12(e). ODFW supports a program designed to harass pinnipeds in the Rogue River estuary in order to try to decrease predation mortality on juvenile and adult fall Chinook salmon by attempting to limit future increases of pinniped numbers in the estuary through harassment techniques. **Primary Implications:** These animals are currently protected under the Federal Marine Mammals Act and thus lethal measures of pinniped control cannot currently be employed, and pinniped relocations have not proved effective in other areas.

A12(f). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW supports a program designed to harass pinnipeds in the Rogue River estuary in order to try to decrease predation mortality on juvenile and adult fall Chinook salmon. **Primary Implications:** These animals are currently protected under the Federal Marine Mammals Act and thus lethal measures of pinniped control cannot currently be employed, and pinniped relocations have not proved effective in other areas.

A12(g). ODFW initiates or supports efforts designed to decrease the chance that non-native species would be introduced into streams and estuaries. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU. This action would also help decrease the chance for introductions of non-native competitors and disease organisms.

A12(h). Take no action.

Limiting Factor A13 – fishing mortality in the ocean

Potential management actions:

A13(a). During years when freshwater returns are forecasted to trigger conservation criteria for adult abundance within the Rogue aggregate populations, ODFW recommends additional harvest restrictions for fisheries operating in the Klamath Zone Management Area. Fisheries operating (3-200 miles offshore) in this area are managed by NOAA Fisheries, with input from the Pacific Fisheries Management Council. **Primary Implications:** Allowable harvest in this area is currently primarily based on projected impacts to CHF produced in the Klamath River Basin.

A13(b). During years when freshwater returns are forecasted to trigger conservation criteria for adult abundance within the Rogue aggregate populations, ODFW proposes additional harvest restrictions inside the three mile coastal zone; where the state of Oregon establishes fishery regulations. **Primary Implications:** Differences in ocean fishery regulations complicates rules for fishers and increases difficulty of enforcement.

A13(c). Take no action.

Limiting Factor A14 – fishing mortality in freshwater

Potential management actions:

A14(a). ODFW manages freshwater fisheries in order to attain spawner escapement goals related to estimates of MSY for affected populations of NP CHF. **Primary Implications:** Such regulations need to be developed in concert with regulations for any special late-season near-shore (within the three mile coastal zone) fisheries.

A14(b). ODFW employs regional (zone) regulations during those years when NP CHF spawning escapement is forecasted to meet or exceed spawner escapement goals related to conservation criteria for singular or aggregate populations. **Primary Implications:** This action assumes that it is in the public interest to minimize the complexity of freshwater fishery regulations.

A14(c). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes regulations to ensure, if possible, NP CHF spawning escapement exceeds conservation criteria. **Primary Implications:** Reductions to allowable harvest would be achieved through changes to (1) the timing and duration of the harvest season, and/or (2) changes to daily or annual limits for harvest.

A14(d). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW requests increased enforcement of fishery regulations.

A14(e). Take no action.

Limiting Factor A15 - spawning escapement

Potential management actions are the same as those described under **Limiting Factors A1-A14**.

DESIRED STATUS ELEMENT: AGE COMPOSITION
(≥10% age 5+6 among adults passing Huntley Park)

Limiting Factor B1 - juvenile abundance

Potential management actions:

Juvenile NP CHF that grow at slower rates in freshwater mature at older ages and growth rates are partially dependent on juvenile density. Actions employed to increase NP CHF fry production and NP CHF fry survival rates will thus also act to increase the age of maturity. ODFW employs management actions designed, as described under **Limiting Factors A1-14**, to increase the production of juvenile NP CHF.

Limiting Factor B2 - age-selective fishing mortality in the ocean

Potential management actions:

B2(a). During years when freshwater returns are forecasted to trigger conservation criteria for adults within the Rogue aggregate populations, ODFW proposes a maximum size limit for NP CHF harvested in the river fisheries. **Primary Implications:** None.

B2(b). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW recommends additional harvest restrictions for fisheries operating in the Klamath Zone Management Area. Fisheries operating (3-200 miles offshore) in this area are managed by NOAA Fisheries, with input from the Pacific Fisheries Management Council. **Primary Implications:** Allowable harvest in this area is currently primarily based on projected impacts to CHF produced in the Klamath River Basin.

B2(c). Take no action.

DESIRED STATUS ELEMENT: RUN COMPOSITION
(≥8% October migrants among adults passing Huntley Park)

Limiting Factor C1 - juvenile abundance

Potential management actions:

The proportion of NP CHF that pass Huntley Park in October is primarily influenced by the production of fish in the Illinois and Lower Rogue population areas relative to the production of fish in the Upper Rogue, Middle Rogue, and Applegate population areas. Actions employed to increase NP CHF fry production and NP CHF fry survival rates will thus also act to increase the abundance of adult CHF that pass Huntley Park in October. ODFW employs management actions designed, as described under **Limiting Factors A1-14**, to increase the production of juvenile NP CHF in the Illinois and Lower Rogue population areas.

Limiting Factor C2 - time-selective fishing mortality in freshwater

Potential management actions:

Late-run (October migrants) CHF are selectively harvested by recreational fisheries in the Rogue River. The spawning escapement of these fish is affected by angler harvest during October-December in the Rogue River downstream of the mouth of the Illinois River. Thus, changes in harvest regulations can increase the spawner escapement of late-run CHF. Options for relevant potential management actions were previously described (*see* **Limiting Factor A14**) but would only be employed for the period of October-December in areas downstream of the mouth of the Illinois River.

DESIRED STATUS ELEMENT: SPAWNER COMPOSITION

(≤5% hatchery fish among spawners)
Upper Rogue, Middle Rogue, Applegate, + Illinois Populations

Limiting Factor D1 – abundance of naturally spawning hatchery fish

Potential management actions:

D1(a). Manage CHF in the Upper Rogue, Middle Rogue, Applegate, and Illinois population areas for NP CHF. **Primary Implications:** No CHF of hatchery origin would be released in these population areas, except for a short-term recovery action in the case of a catastrophic NP CHF mortality event.

D1(b). Take no action.

DESIRED STATUS ELEMENT: SPAWNER COMPOSITION
(≤10% hatchery fish among spawners)
Lower Rogue Population

Limiting Factor E1 – abundance of naturally spawning hatchery fish

Potential management actions:

E1(a). If desired status is not attained, ODFW decreases the number of juvenile CHF released from Indian Creek Hatchery until attainment of desired status. Current releases average 75,000 smolts annually. **Primary Implications:** This action would result in decreased fishery yields.

E1(b). Revise broodstock collection practices in the Lower Rogue population area to increase age at maturity of progeny by developing length-specific goals for adult fish to be included in the broodstock. Older adults would be selectively bred at the hatchery to compensate for age-selective harvest in the ocean and freshwater fisheries. **Primary Implications:** This action would likely (1) increase harvest in the ocean fisheries, (2) decrease harvest in the freshwater fishery, and (3) decrease the number of hatchery fish that spawn naturally. This action also runs counter to the prevailing concept of random mating of hatchery brood stocks. Broodstock collection currently reflects the run timing and age classes represented in the natural population.

E1(c). ODFW continues to implement the Hatchery and Genetic Management Plan completed for Indian Creek Hatchery in 2006.

APPENDIX H

Potential Actions Considered for Populations in the Coastal Stratum

List includes only those factors that limit, or may limit, attainment of desired biological status (*see* **Coastal Stratum**, page 72 in conservation plan)

DESIRED STATUS ELEMENT: SPAWNER ABUNDANCE (criteria vary by population area)

Limiting Factor A1 - amount of freshwater rearing habitat

Potential management actions:

A1(a). ODFW initiates or supports the removal of artificial barriers to the upstream migration of adult CHF and pursues improvement of upstream passage at those artificial barriers that cannot be removed. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU.

A1(b). ODFW initiates or supports the modification of natural barriers that block the upstream migration of adult CHF. **Primary Implications:** This action would result in adult CHF migrating into areas of non-historical use.

A1(c). ODFW initiates or supports the modification of natural barriers that periodically limit the upstream migration of adult CHF. **Primary Implications:** This action would somewhat increase the amount of CHF spawning habitat and rearing habitat for juvenile CHF.

A1(d). In all population areas, ODFW collects and transfers excess broodstock of hatchery origin into potential spawning habitat not accessible to naturally migrating adults. **Primary Implications:** This action would introduce genetically different hatchery fish into non-historical NP CHF habitat.

A1(e). In population areas with adult collection facilities for hatchery fish, ODFW transfers excess broodstock of hatchery origin into potential spawning habitat not accessible to naturally migrating adults. **Primary Implications:** This action would introduce hatchery fish into non-historical NP CHF habitat.

A1(f). In population areas with significant amounts of unappropriated stream flow during summer, ODFW files for increased instream flow rights. **Primary Implications:** This action would be effective for the maintenance of instream flow only in the Chetco River during June and in the Winchuck River during July. In addition, this action may require initiation and completion of new flow studies, and those updated studies must demonstrate that additional instream flow is necessary to protect fish resources.

A1(g). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A1(h). ODFW initiates or supports efforts to increase summer flow through the purchase, lease, transfer, or cancellation of water rights. **Primary Implications:** This action is already employed by State of Oregon agencies, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU.

A1(i). ODFW initiates or supports efforts to limit further appropriation of surface water from areas where instream water rights are not met. **Primary Implications:** This action will limit the availability of any additional surface water for rural residential uses.

A1(j). ODFW initiates or supports efforts to increase summer flow through the construction of reservoirs at sites identified by OWRD in the Chetco and Winchuck river basins (OAR 690-517-0030) **Primary Implications:** This action may negatively affect native fishes including winter steelhead, cutthroat trout, and Pacific lamprey.

A1(k). Take no action.

Limiting Factor A2 - amount of rearing habitat in estuaries

Potential management actions:

A2(a). ODFW initiates or supports the restoration of filled, diked, or otherwise impacted areas in estuaries in order to increase the area and depth of wetted areas accessible to juvenile CHF. **Primary Implications:** This action requires the identification and mapping of previously filled estuarine areas.

A2(b). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A2(c). Take no action.

Limiting Factor A3 - summer water temperature in streams and estuaries

Potential management actions:

A3(a). ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat. **Primary Implications:** Mature riparian habitat helps reduce water temperatures by the shading of streams and the upper portions of estuarine areas.

A3(b). ODFW initiates or supports efforts designed to restore mature riparian habitat. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU.

A3(c). ODFW initiates or supports efforts designed to promote development of mature riparian habitat in natural bar or floodplain areas. **Primary Implications:** This action may limit activities that impact vegetational succession of gravel bar features, including the means to access streams.

A3(d). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A3(e). Take no action.

Limiting Factor A4 - water quality in estuaries during juvenile residence

Potential management actions:

A4(a). ODFW initiates or supports efforts designed to decrease the amount of phosphorus and nitrogen that eventually enter estuaries. **Primary Implications:** Efforts to restore mature riparian areas and to improve channel complexity would help achieve this action by increased nutrient spiraling rates.

A4(b). ODFW shall work with regulatory and planning agencies, land management agencies, private developers, public interest groups, and the public to utilize habitat protection and mitigation opportunities provided by applicable federal, state, and local environmental laws and land use regulations. **Primary Implications:** This action is already employed by ODFW in furtherance of Wildlife Policy (ORS 496.012) and Food Fish Management Policy (ORS 506.109), via implementation of Fish and Wildlife Habitat Mitigation Policy (OAR 635-415-0000 through OAR 635-415-0025).

A4(c). ODFW initiates or supports efforts designed to control European beach grass in areas proximal to estuaries. **Primary Implications:** Non-native European beach grass increases beach/foredune stabilization, and thus may result in higher elevations for sand bars and less tidal exchange in small south coast estuaries during summer.

A4(d). ODFW initiates or supports efforts designed to increase levels of dissolved oxygen in estuaries found to be oxygen deficient. **Primary Implications:** This action item could be accomplished by installation and operation of aerators.

A4(e). Take no action.

Limiting Factor A5 - juvenile growth in streams and estuaries

Potential management actions:

A5(a). ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat. **Primary Implications:** Mature riparian habitat helps reduce water temperatures by the shading of streams and estuarine areas. Decreased water temperatures during summer will increase the scope of growth for resident juveniles.

A5(b). ODFW develops a program designed to enhance primary and secondary production in streams that meet Oregon Water Quality standards related to nutrient levels. **Primary Implications:** This action would entail the transportation and placement of salmon carcasses as close as practical to headwater areas. The availability of salmon carcasses would be dependent on the availability of hatchery fish that are excess to broodstock needs.

A5(c). ODFW supports efforts designed to decrease the chance that non-native species would be introduced into streams and estuaries. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU. This action would also help decrease the chance for introductions of non-native predators and disease organisms.

A5(d). ODFW initiates or supports efforts designed to enhance the volume of macroinvertebrate habitat through the installation of large woody debris in streams and estuaries. **Primary Implications:** Landowner agreement will be needed to complete this action in most locations.

A5(e). ODFW initiates or supports efforts designed to enhance the volume of macroinvertebrate habitat through the installation of artificial structures in estuaries. **Primary Implications:** This action item should be completed in two phases. In the first phase, only small structures would be installed within wetted areas near the upstream end of estuaries. In the second phase, large structures would be installed only after the completion of thorough water quality assessments throughout the estuary. The water quality assessments will allow for the identification of optimal rearing habitat. Landowner agreement will be needed to complete this action in most estuarine locations.

A5(f). Take no action.

Limiting Factor A6 - predation on juveniles

Potential management actions:

A6(a). ODFW initiates or supports efforts designed to decrease the chance that non-native species would be introduced into streams and estuaries. **Primary Implications:** This action is already employed by ODFW, but has yet to be incorporated in an ODFW fish management plan for CHF in the Rogue SMU. This action would also help decrease the chance for introductions of non-native competitors and disease organisms.

A6(b). ODFW reduces the number of steelhead smolts released in the Chetco River. **Primary Implications:** Reductions in contribution rates to the winter steelhead fishery.

A6(c). ODFW releases juvenile CHF of hatchery origin no earlier than October in order to minimize the attraction of predators into areas inhabited by juvenile NP CHF. **Primary Implications:** Changes in release timing may affect survival rates of hatchery smolts.

A6(d). ODFW initiates or supports efforts designed to restore the amount of hiding cover for juvenile CHF resident in estuaries through the installation of woody debris. **Primary Implications:** This action item should be completed in two phases. In the first phase, only small woody debris should be installed within wetted areas near the upstream end of estuaries. In the second phase, large woody debris should be installed only after the completion of thorough water quality assessments throughout the estuary. The water quality assessments will allow for the identification of optimal rearing habitat. Landowner agreement will be needed to complete this action in most estuarine locations.

A6(e). ODFW initiates or supports efforts designed to restore the amount of hiding cover for juvenile CHF resident in estuaries through the installation of artificial structures during late spring. **Primary Implications:** This action item should be completed in two phases. In the first phase, only small structures would be installed within wetted areas near the upstream end of estuaries. In the second phase, large structures would be installed only after the completion of thorough water quality assessments throughout the estuary. The water quality assessments will allow for the identification of optimal rearing habitat. Landowner agreement will be needed to complete this action in most estuarine locations.

A6(f). Take no action.

Limiting Factor A7 – fishing mortality in the ocean

Potential management actions:

A7(a). During years when freshwater returns are forecasted to trigger conservation criteria within the Chetco population area, ODFW recommends additional harvest restrictions for fisheries operating in the Klamath Zone Management Area even though this population will not be proposed as an indicator stock for the purposes of federal management of the ocean fisheries. Fisheries operating (3-200 miles offshore) in this area are managed by NOAA Fisheries, with input from the Pacific Fisheries Management Council. **Primary Implications:** Allowable harvest in this area is currently primarily based on projected impacts to CHF produced in the Klamath River Basin.

A7(b). During years when freshwater returns are forecasted to trigger conservation criteria for spawner abundance within the Chetco population area, ODFW proposes additional harvest restrictions inside the three mile coastal zone, where the state of Oregon establishes fishery regulations, during the period of harvest covered by regulations adopted by NOAA. **Primary Implications:** Differences in ocean fishery regulations complicates rules for fishers and increases difficulty of enforcement.

A7(c). ODFW manages special late-season, near-shore fisheries (within the three mile coastal zone) to (1) ensure attainment of spawner escapement goals linked to estimates of MSY for proximal populations of NP CHF and (2) provide additional harvest opportunities when forecasted spawner escapements exceed those linked to estimates of MSY. **Primary Implications:** This type of fishery currently only operates of the mouths of the Chetco and Winchuck Rivers.

A7(d). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes regulations for special late-season, near-shore fisheries to ensure, if possible, that NP CHF spawning escapement exceeds conservation criteria for proximal populations. **Primary Implications:** This type of fishery currently only operates of the mouths of the Chetco and Winchuck Rivers.

A7(e). ODFW establishes a task force to be charged with the development of an allocation schedule for the sharing of allowable harvest between freshwater fisheries and any special late-season near-shore (within the three mile coastal zone) fisheries. **Primary Implications:** The task force should be composed of representatives of local public interest groups.

A7(f). ODFW terminates special late-season near-shore (within the three mile coastal zone) fisheries. **Primary Implications:** Implementation of this action would reduce fishery opportunities and yields during years when spawner escapements are forecasted to exceed estimates of MSY.

A7(g). Take no action.

Limiting Factor A8 – fishing mortality in freshwater

Potential management actions:

A8(a). ODFW manages freshwater fisheries in order to attain spawner escapement goals related to estimates of MSYs for affected populations of NP CHF. **Primary Implications:** Such regulations will need to be developed in concert with regulations for any special late-season near-shore (within the three mile coastal zone) fisheries.

A8(b). ODFW employs regional (zone) regulations during those years when NP CHF spawning escapement is forecasted to meet or exceed spawner escapement goals related to conservation criteria for singular or aggregate populations. **Primary Implications:** This action assumes that it is in the public interest to minimize the complexity of freshwater fishery regulations.

A8(c). During years when freshwater returns are forecasted to trigger conservation criteria for any single NP CHF population, ODFW proposes regulations to ensure, if possible, NP CHF spawning escapement exceeds conservation criteria. **Primary Implications:** Reductions to allowable harvest would be achieved through changes to (1) the timing and duration of the harvest season, and/or (2) areas open to harvest. This action is designed to complement action A7(d).

A8(d). During years when freshwater returns are forecasted to trigger conservation criteria for any single NP CHF population, ODFW requests increased enforcement of fishery regulations.

A8(e). ODFW establishes a task force to be charged with the development of an allocation schedule for the sharing of allowable harvest between freshwater fisheries and any special late-season near-shore (within the three mile coastal zone) fisheries. **Primary Implications:** This task force should be composed of representatives of local public interest groups.

A8(f). Take no action.

Limiting Factor A9 - spawning escapement

Potential management actions are the same as those described under **Limiting Factors A1-A8**.

DESIRED STATUS ELEMENT: AGE COMPOSITION
(≥16% age 5+6 among NP spawners in the Chetco population area)

Limiting Factor B1 - fishing mortality in the ocean and freshwater

Potential management actions:

B1(a). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes a maximum size limit for NP CHF harvested in the terminal fishery off the mouth of the Chetco River and in the river fishery. **Primary Implications:** None.

B1(b). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW recommends additional harvest restrictions for fisheries operating in the Klamath Zone Management Area. Fisheries operating (3-200 miles offshore) in this area are managed by NOAA Fisheries, with input from the Pacific Fisheries Management Council. **Primary Implications:** Allowable harvest in this area is currently primarily based on projected impacts to CHF produced in the Klamath River Basin.

B1(c). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes additional harvest restrictions inside the three mile coastal zone during the period of harvest covered by regulations adopted by NOAA; where the state of Oregon establishes fishery regulations. **Primary Implications:** Differences in ocean fishery regulations complicates rules for fishers and increases difficulty of enforcement.

B1(d). Take no action.

DESIRED STATUS ELEMENT: SPAWNER COMPOSITION
(≤18% hatchery fish among Chetco spawners)

Limiting Factor C1 – abundance of naturally spawning hatchery fish

Potential management actions:

C1(a). If desired status is not attained, ODFW decreases the number of juvenile CHF released in the Chetco River until attainment of desired status. Current releases average 150,000 smolts annually. **Primary Implications:** This action would result in decreased fishery yields.

C1(b). In the Chetco River Basin, ODFW establishes an acclimation and collection facility designed to capture returning adult CHF of hatchery origin. **Primary Implications:** Depending on facility location, this action may result in decreased yields of hatchery fish in the freshwater fishery.

C1(c). Revise broodstock collection practices in the Chetco River to increase age at maturity of progeny by developing length-specific goals for adult fish to be included in the broodstock. Older adults would be selectively bred in order to compensate for age-selective harvest in the ocean fisheries. **Primary Implications:** This action would likely (1) increase harvest in the ocean fisheries, (2) decrease harvest in the freshwater fishery, and (3) decrease the number of hatchery fish that spawn naturally. This action also runs counter to the prevailing concept of random mating among hatchery brood stocks. Broodstock collection currently reflects the run timing and age classes represented in the natural population that returns to freshwater.

C1(d). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes mark selective regulations for (1) the terminal fishery off the mouth of the Chetco River and (2) the freshwater fishery in the Chetco River. **Primary Implications:** Some post-release mortality can be expected for naturally produced (unmarked) fish.

C1(e). Take no action. **Primary Implications:** ODFW would only continue to implement the Hatchery and Genetic Management Plan completed in 2006 for CHF of Chetco River origin.

DESIRED STATUS ELEMENT: SPAWNER COMPOSITION
(≤10% hatchery fish among Winchuck spawners)

Limiting Factor D1 – abundance of naturally spawning hatchery fish

Potential management actions:

D1(a). If desired status is not attained, ODFW decreases the number of juvenile CHF released in the Chetco River until attainment of desired status. Current releases average 150,000 smolts annually. **Primary Implications:** This action would result in decreased fishery yields in the Chetco fisheries.

D1(b). Manage CHF in the Winchuck population area for NP CHF. **Primary Implications:** No CHF of hatchery origin would be released in these population areas, except for (1) educational purposes or (2) a short-term recovery action in the case of a catastrophic NP CHF mortality event.

D1(c). During years when spawner escapement are forecasted to trigger conservation criteria, ODFW proposes mark selective regulations for (1) the terminal fishery off the mouth of the Chetco River and (2) the freshwater fishery in the Winchuck River. **Primary Implications:** Some post-release mortality can be expected for naturally produced (unmarked) fish.

D1(d). Take no action. **Primary Implications:** ODFW would only continue to implement the Hatchery and Genetic Management Plan completed in 2006 for CHF of Chetco River origin.

DESIRED STATUS ELEMENT: SPAWNER COMPOSITION
(≤5% hatchery fish among spawners in the Hunter and Pistol population areas)

Limiting Factor E1 – abundance of naturally spawning hatchery fish

Potential management actions:

E1(a). Manage CHF in the Hunter and Pistol population areas for NP CHF. **Primary Implications:** No CHF of hatchery origin would be released in these population areas, except for (1) educational purposes or (2) a short-term recovery action in the case of a catastrophic NP CHF mortality event.

E1(b). During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes mark selective regulations for the freshwater fisheries in Hunter Creek and/or

Pistol River. **Primary Implications:** Some post-release mortality can be expected for naturally produced (unmarked) fish.

E1(c). Take no action. **Primary Implications:** ODFW would only continue to implement the Hatchery and Genetic Management Plans completed in 2006 for CHF of Chetco River and Lower Rogue origin.

APPENDIX I

Alternative Suites of Management Actions
Rogue Population Stratum

FORMULATED SUITES OF MANAGEMENT ACTIONS

Alternative 1

a. Establish juvenile production in areas not accessible to adult CHF (includes hatchery fish)
b. Design reservoir management strategies for emphasis on CHF rather than NP CHS
c. Adopt less complex regulations for freshwater fisheries

Alternative 2

a. Increase NP CHF habitat by removal of artificial barriers
b. Design reservoir management strategies to limit adult CHF mortality to less than 20%

Alternative 3

a. Increase NP CHF habitat by removal of artificial barriers
b. Design reservoir management strategies to limit adult CHF mortality to less than 20%
c. Increase control of predators

Alternative 4

a. Increase NP CHF habitat by removal of artificial barriers
b. Maintain NP CHS production as highest priority for reservoir management strategies
c. Adopt less complex regulations for freshwater fisheries

Alternative 5

a. Increase NP CHF habitat by removal of artificial barriers
b. Maintain NP CHS production as highest priority for reservoir management strategies
c. Increase control of predators
d. Adopt less complex regulations for freshwater fisheries

MANAGEMENT ACTIONS COMMON TO ALL ALTERNATIVES

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

A3(b) Recommend increased outflow from Applegate Lake during adult migration
A8(a) Support removal of artificial barriers and improvements to fish passage facilities

Management Actions Related to Habitat Quality

A1(a) Recommend reduced peak flows at USACE reservoirs during egg and sac-fry incubation
A2(a) Recommend release of cold water from Applegate Lake during egg and sac-fry incubation
A2(b) Request water temperature modeling for Applegate Lake
A4(a) Recommend outflows at Applegate Lake to minimize redd dewatering
A5(a) Recommend ramping rates at Applegate Lake to minimize fry dewatering
A7(a) Recommend reservoir releases so as to increase smolt survival rates
A7(c) Develop outreach effort to encourage restoration and maintenance of riparian zones
A7(d) Support efforts to restore mature riparian habitat
A7(e) Support natural development of mature riparian habitat in floodplain areas
A9(a) Request restoration and maintenance of spawning habitat below Applegate Lake
A9(b) Utilize laws and regulations to protect habitat and craft mitigation opportunities
A10(a) Develop outreach effort to encourage restoration and maintenance of riparian zones
A10(b) Support Oregon’s stormwater program
A10(c) Utilize laws and regulations to protect habitat and craft mitigation opportunities
A11(a) Support fish screening improvements at water diversion sites

Management Actions Related to Biological Factors

A12(a) Encourage fishing related mortality on non-native Umpqua pikeminnows
A12(b) Recommend reservoir releases to decrease pikeminnow predation
A12(g) Support efforts to decrease introductions of non-native species

Management Actions Related to Fisheries

A13(a) Recommend greater restrictions for NOAA-managed ocean fisheries when adult abundance is forecasted to trigger the conservation criterion for the Rogue aggregate populations
A13(b) Propose greater restrictions for Oregon-managed ocean fisheries when adult abundance is forecasted to trigger the conservation criterion for the Rogue aggregate populations
A14(c) Manage freshwater fisheries to exceed conservation criteria for spawner escapement

Management Actions Related to Hatchery Fish

E1(c). Implement the Hatchery and Genetic Management Plan for Indian Creek Hatchery.

ALTERNATIVE 1

a. Establish juvenile production in areas not accessible to adult CHF (includes hatchery fish)
b. Design reservoir management strategies for emphasis on CHF rather than NP CHS
c. Adopt less complex regulations for freshwater fisheries

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

(also employs actions common to all alternatives)

A8(b) Pursue obtaining water necessary to enhance upstream migration in Little Butte Creek
A8(c) Pursue obtaining water necessary to enhance upstream migration in Bear Creek
A8(e) Collect and transport excess hatchery broodstock upstream into inaccessible spawning habitat

Management Actions Related to Habitat Quality

(also employs actions common to all alternatives)

A6(a) Recommend reservoir releases to maximize survival of migrating CHF adults

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A14(b) Adopt regional (zone) regulations for freshwater fisheries except when spawning escapement is forecasted to trigger conservation criteria.

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

A8(e) Collect and transport excess hatchery broodstock upstream of inaccessible spawning habitat

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Reservoir storage, already allocated for other purposes, must be obtained from irrigation districts to increase the spawning distribution of CHF in the Little Butte and Bear Creek subbasins.

2. Transportation of hatchery fish would introduce genetically different fish into non-historical CHF habitat, except in the Lower Rogue population area (hatchery program currently in place)

3. Crafting of reservoir release strategies to maximize survival of adult CHF will result in less reservoir storage currently used to optimize survival rates of depressed NP CHS in the Rogue River. As a result, implementation of this action would result in marked increases in freshwater mortality rates of NP CHS.

4. Current NP CHF habitat probably exceeds historical CHF habitat for multiple reasons.

ALTERNATIVE 2

a. Increase NP CHF habitat by removal of artificial barriers
b. Design reservoir management strategies to limit adult CHF mortality to less than 20%

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(also employs actions common to all alternatives)
A6(c) Recommend reservoir releases so as to limit adult CHF mortality to less than 20%

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)
A14(a) Manage freshwater fisheries to meet MSY goals for spawner escapement
B2(a) Propose maximum size limit when age composition is forecasted to trigger the conservation criterion for the Rogue aggregate populations
B2(b) Propose greater restrictions for NOAA-managed ocean fisheries when age composition is forecasted to trigger the conservation criterion for the Rogue aggregate populations

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)
D1(a) Manage for naturally produced CHF in all population areas except Lower Rogue
E1(a) Reduce release of CHF smolts if desired status is not attained for spawner composition
E1(b) Revise broodstock collection to produce hatchery fish that mature at more natural ages.

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Crafting of reservoir release strategies to limit adult CHF mortality to less than 20% will sometimes increase (during years of low water yield) mortality rates of depressed NP CHS in the Rogue River.

2. Current NP CHF habitat probably exceeds historical CHF habitat for multiple reasons.

ALTERNATIVE 3

a. Increase NP CHF habitat by removal of artificial barriers
b. Design reservoir management strategies to limit adult CHF mortality to less than 20%
c. Increase control of predators

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(also employs actions common to all alternatives)

A6(c) Recommend reservoir releases so as to limit adult CHF mortality to less than 20%

Management Actions Related to Biological Factors

(also employs actions common to all alternatives)

A12(d). Initiate a program designed to decrease cormorant predation on juvenile CHF
A12(e). Support a program designed to harass predatory pinnipeds in the Rogue River estuary

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A14(b) Adopt regional (zone) regulations for freshwater fisheries except when spawning escapement is forecasted to trigger conservation criteria.
B2(a) Propose maximum size limit when age composition is forecasted to trigger conservation criteria for the Rogue aggregate populations

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

E1(b) Revise broodstock collection to produce hatchery fish that mature at more natural ages.

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Crafting of reservoir release strategies to limit adult CHF mortality to less than 20% will sometimes increase (during years of low water yield) mortality rates of depressed NP CHS in the Rogue River.

2. Current NP CHF habitat probably exceeds historical CHF habitat for multiple reasons.

3. Cormorants and pinnipeds are currently protected from lethal measures by federal law. However, the United States Fish and Wildlife Service has authorized some states to take steps designed to limit cormorant populations. A pinniped harassment program is currently in place.

ALTERNATIVE 4

a. Increase NP CHF habitat by removal of artificial barriers
b. Maintain NP CHS production as highest priority for reservoir management strategies
c. Adopt less complex regulations for freshwater fisheries

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(also employs actions common to all alternatives)

A6(b). Recommend reservoir releases with enhancement of NP CHS as a greater priority as compared to enhancement of NP CHF
A6(d). Recommend additional reservoir releases when disease-related losses of adult CHF are forecasted to reach or exceed 40%.

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A14(b) Adopt regional (zone) regulations for freshwater fisheries except when spawning escapement is forecasted to trigger conservation criteria.

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

D1(a) Manage for naturally produced CHF in all population areas except Lower Rogue
E1(a) Reduce release of CHF smolts if desired status is not attained for spawner composition
E1(b) Revise broodstock collection to produce hatchery fish that mature at more natural ages.

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Crafting of reservoir release strategies to prioritize production of the depressed NP CHS population in the Rogue River is currently employed by ODFW; as directed by the Rogue Spring Chinook salmon conservation plan adopted by Oregon’s Fish and Wildlife Commission in 2007. Implementation of this alternative will result in increased mortality rates of adult CHF as additional reservoir storage is purchased for consumptive purposes; but is intended to ensure that CHF disease losses do not exceed 40% in any given year.

2. Current NP CHF habitat probably exceeds historical CHF habitat for multiple reasons.

ALTERNATIVE 5

a. Increase NP CHF habitat by removal of artificial barriers
b. Maintain NP CHS production as highest priority for reservoir management strategies
c. Increase control of predators
d. Adopt less complex regulations for freshwater fisheries

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX G**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(also employs actions common to all alternatives)

A6(b). Recommend reservoir releases with enhancement of NP CHS as a greater priority as compared to enhancement of NP CHF.
A6(d). Recommend additional reservoir releases when disease-related losses of adult CHF are forecasted to reach or exceed 40%.

Management Actions Related to Biological Factors

(also employs actions common to all alternatives)

*A12(d). Initiate a program designed to decrease cormorant predation on juvenile CHF
*A12(e). Support a program designed to harass predatory pinnipeds in the Rogue River estuary

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A14(b) Adopt regional (zone) regulations for freshwater fisheries except when spawning escapement is forecasted to trigger conservation criteria.

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

D1(a) Manage for naturally produced CHF in all population areas except Lower Rogue
E1(a) Reduce release of CHF smolts if desired status is not attained for spawner composition
E1(b) Revise broodstock collection to produce hatchery fish that mature at more natural ages.

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Crafting of reservoir release strategies to prioritize production of the depressed NP CHS population in the Rogue River is currently employed by ODFW; as directed by the Rogue Spring Chinook salmon conservation plan adopted by Oregon's Fish and Wildlife Commission in 2007. Implementation of this alternative will result in increased mortality rates of adult CHF as additional reservoir storage is purchased for consumptive purposes; but is intended to ensure that CHF disease losses do not exceed 40% in any given year.

2. Current NP CHF habitat probably exceeds historical CHF habitat for multiple reasons.

3. Cormorants and pinnipeds are currently protected from lethal measures by federal law. However, the United States Fish and Wildlife Service has authorized some states to take steps designed to limit cormorant populations. A pinniped harassment program is currently in place.

APPENDIX J

Alternative Suites of Management Actions
Coastal Population Stratum

FORMULATED SUITES OF MANAGEMENT ACTIONS

Alternative 1

a. Establish juvenile production in areas not accessible to adult CHF (includes hatchery fish)
b. Management emphasizes freshwater and late-season ocean fisheries in near-shore areas
c. Manage populations for NP and hatchery CHF

Alternative 2

a. Increase NP CHF habitat by removal of artificial barriers
b. Management emphasizes freshwater and late-season ocean fisheries in near-shore areas
c. Focus management on NP CHF

Alternative 3

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Maintain current management priorities for each type of directed fishery
c. Focus management on NP CHF

Alternative 4

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Maintain current management priorities for each type of directed fishery
c. Focus management on NP CHF

Alternative 5

a. Increase NP CHF habitat by removal of artificial barriers
b. Adopt less complex regulations for freshwater fisheries (Chetco River excepted)
c. Focus management on NP CHF

Alternative 6

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Adopt less complex regulations for freshwater fisheries (Chetco River excepted)
c. Focus management on NP CHF

MANAGEMENT ACTIONS COMMON TO ALL ALTERNATIVES

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

A1(a) Support removal of artificial barriers and improvements to fish passage facilities
A1(f) File for water rights to maintain summer flows in the Chetco and Winchuck rivers
A1(g) Utilize laws and regulations to protect habitat and craft mitigation opportunities
A1(h) Support efforts to increase summer flow in streams
A1(i) Support efforts to limit further appropriation of surface water
A2(a) Support restoration efforts to increase area and depth of estuaries
A2(b) Protect estuary habitat and pursue mitigation opportunities

Management Actions Related to Habitat Quality

A3(a) Develop landowner education program for maintenance of riparian zones
A3(b) Support efforts to restore mature riparian habitat
A3(c) Support efforts to restore mature riparian habitat in floodplain areas
A3(d) Utilize laws and regulations to protect habitat and craft mitigation opportunities
A4(a) Support efforts to decrease nutrient volumes in estuaries
A4(b) Utilize laws and regulations to protect habitat and craft mitigation opportunities
A4(c) Support efforts to control European beach grass
A4(d) Support efforts designed to increase levels of dissolved oxygen in estuaries

Management Actions Related to Biological Factors

A5(a) Support efforts to restore mature riparian habitat
A5(b) Develop program to increase stream productivity
A5(c**)** Support efforts to decrease introductions of potential competitors
A5(d) Support installation of wood in streams and estuaries for macroinvertebrate habitat
A5(e) Support installation of artificial structures in estuaries for macroinvertebrate habitat
A6(a**)** Support efforts to decrease introductions of potential predators
A6(c**)** Release hatchery CHF smolts after September to decrease competition with wild fish
A6(d) Support installation of wood to increase hiding cover in estuaries
A6(e) Support installation of artificial structures to increase hiding cover in estuaries

Management Actions Related to Fisheries

A7(a) Recommend greater restrictions for NOAA-managed ocean fisheries when adult abundance is forecasted to trigger the conservation criterion for the Chetco population
A7(b) Propose greater restrictions for Oregon-managed ocean fisheries when adult abundance is forecasted to trigger the conservation criterion for the Chetco population
A7(c) Manage late-season ocean fisheries to meet MSY goals for spawner escapement in proximal population areas
A7(d) Manage late-season ocean fisheries to exceed conservation criteria for spawner escapement in proximal population areas
A7(e) Establish task force to devise harvest allocations for freshwater and late-season ocean fisheries
A8(c) Manage freshwater fisheries to exceed conservation criteria for spawner escapement
A8(e) Establish task force to devise harvest allocations for freshwater and late-season ocean fisheries

Management Actions Related to Hatchery Fish

A6(c**)** Release hatchery CHF smolts after September to decrease competition with NP CHF

ALTERNATIVE 1

a. Establish juvenile production in areas not accessible to adult CHF (includes hatchery fish)
b. Management emphasizes freshwater and late-season ocean fisheries in near-shore areas
c. Manage populations for NP and hatchery CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(also employs actions common to all alternatives)

A1(b) Support modification of natural barriers that block adult migration
A1(c) Support modification of natural barriers that periodically block adult migration
A1(j) Support reservoir construction to increase summer flow

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(b) Adopt regional (zone) regulations for freshwater fisheries except when spawning escapement is forecasted to trigger conservation criteria.
C1(d), D1(c), E1(b) Propose mark-selective fisheries when spawner escapement is forecasted to trigger conservation criteria

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

C1(b) Establish an acclimation and collection facility in the Chetco River Basin
C1(e), D1(c), E1(b) Propose mark-selective fisheries when spawner escapement is forecasted to trigger conservation criteria

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Modification of barriers would introduce NP CHF into non-historical habitat generally utilized by other species of native fish.

2. Assumes that greater societal benefits accrue by harvesting CHF in streams and in ocean areas proximal to natal streams.

3. Allows for small-scale releases of CHF hatchery smolts in all population areas.

ALTERNATIVE 2

a. Increase NP CHF habitat by removal of artificial barriers
b. Management emphasizes freshwater and late-season ocean fisheries in near-shore areas
c. Management focus on NP CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(also employs actions common to all alternatives)

A6(b) Reduce release of winter steelhead smolts

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(a) Manage freshwater fisheries to meet MSY goals for spawner escapement
A8(d) Request additional enforcement when spawner escapement is forecasted to trigger conservation criteria
B1(a) Propose maximum size limit when age composition is forecasted to trigger the conservation criterion for the Chetco population
B1(b) Propose greater restrictions for NOAA-managed ocean fisheries when age composition is forecasted to trigger the conservation criterion for the Chetco population

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

A6(b) Reduce release of winter steelhead smolts
C1(a) Reduce CHF smolt releases if Chetco spawner composition does not meet desired status
C1(b) Establish an acclimation and collection facility in the Chetco River Basin
C1(c) Revise broodstock collection to produce hatchery fish that mature at more natural ages.
D1(a) Reduce CHF smolt releases if Winchuck spawner composition does not meet desired status
D1(b) Manage for naturally produced CHF in the Winchuck population area
E1(a) Manage for naturally produced CHF in the Hunter and Pistol population areas

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. No modifications of natural barriers to the upstream migration of adult CHF.

2. Assumes societal benefits would increase with additional limitations to the ocean fisheries.

3. Within independent populations, CHF hatchery programs would be limited only to the Chetco River Basin; except for educational purposes and restoration efforts following catastrophic events.

ALTERNATIVE 3

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Maintain current management priorities for each type of directed fishery
c. Focus management on NP CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(also employs actions common to all alternatives)

A1(c) Support modification of natural barriers that periodically block adult migration

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(b) Adopt regional (zone) regulations for freshwater fisheries except when spawner escapement is forecasted to trigger conservation criteria

C1(d), D1(c), E1(b) Propose mark-selective fisheries when spawner escapement is forecasted to trigger conservation criteria

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

C1(b) Establish an acclimation and collection facility in the Chetco River Basin

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Partial or periodic natural barriers would be modified to provide unrestricted passage for adult CHF.

2. Assumes societal benefits would not increase with additional limitations to the ocean fisheries.

3. Allows for small-scale releases of CHF hatchery smolts in all population areas.

ALTERNATIVE 4

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Maintain current management priorities for each type of directed fishery
c. Focus management on NP CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(also employs actions common to all alternatives)

A1(c) Support modification of natural barriers that periodically block adult migration

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(also employs actions common to all alternatives)

A6(b) Reduce release of winter steelhead smolts

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(a) Manage freshwater fisheries to meet MSY goals for spawner escapement
A8(d) Request additional enforcement when spawner escapement is forecasted to trigger conservation criteria
B1(a) Propose maximum size limits when age composition is forecasted to trigger conservation criteria for the Chetco population

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

A6(b) Reduce release of winter steelhead smolts
C1(a) Reduce CHF smolt releases if Chetco spawner composition does not meet desired status
C1(b) Establish an acclimation and collection facility in the Chetco River Basin
C1(c) Revise broodstock collection to produce hatchery fish that mature at more natural ages.
D1(a) Reduce CHF smolt releases if Winchuck spawner composition does not meet desired status
D1(b) Manage for naturally produced CHF in the Winchuck population area
E1(a) Manage for naturally produced CHF in the Hunter and Pistol population areas

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Partial or periodic natural barriers would be modified to provide unrestricted passage for adult CHF.

2. Assumes societal benefits would not increase with additional limitations to the ocean fisheries.

3. Within independent populations, CHF hatchery programs would be limited only to the Chetco River Basin populations; except for educational purposes and restoration efforts following catastrophic events.

ALTERNATIVE 5

a. Increase NP CHF habitat by removal of artificial barriers
b. Adopt less complex regulations for freshwater fisheries (Chetco River excepted)
c. Focus management on NP CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(employs actions common to all alternatives)

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(b) Adopt regional (zone) regulations for freshwater fisheries (Chetco River excepted) except when spawner escapement is forecasted to trigger conservation criteria
A8(d) Request additional enforcement when spawner escapement is forecasted to trigger conservation criteria

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

C1(a) Reduce CHF smolt releases if Chetco spawner composition does not meet desired status
C1(b) Establish an acclimation and collection facility in the Chetco River Basin
C1(c) Revise broodstock collection to produce hatchery fish that mature at more natural ages.
D1(a) Reduce CHF smolt releases if Winchuck spawner composition does not meet desired status
D1(b) Manage for naturally produced CHF in the Winchuck population area
E1(a) Manage for naturally produced CHF in the Hunter and Pistol population areas

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Assumes societal benefits would increase with additional limitations to the ocean fisheries.

2. Regulations for freshwater fisheries would be simplified except for the Chetco River fishery. Regulations for the Chetco River would remain more variable because of (1) the need for temporal closures related to water quality and (2) the need to identify harvest allocations for freshwater and late-season ocean fisheries.

3. Within independent populations, CHF hatchery programs would be limited only to the Chetco River Basin populations; except for educational purposes and restoration efforts following catastrophic events.

ALTERNATIVE 6

a. Increase NP CHF habitat by removal of artificial barriers and partial natural barriers
b. Adopt less complex regulations for freshwater fisheries (Chetco River excepted)
c. Focus management on NP CHF

MANAGEMENT SUITE

Coded management actions are described in **APPENDIX H**

Management Actions Related to Habitat Quantity

(also employs actions common to all alternatives)

A1(c) Support modification of natural barriers that periodically block adult migration

Management Actions Related to Habitat Quality

(employs actions common to all alternatives)

Management Actions Related to Biological Factors

(employs actions common to all alternatives)

Management Actions Related to Fisheries

(also employs actions common to all alternatives)

A8(b) Adopt regional (zone) regulations for freshwater fisheries (Chetco River excepted) except when spawner escapement is forecasted to trigger conservation criteria
A8(d) Request additional enforcement when spawner escapement is forecasted to trigger conservation criteria

Management Actions Related to Hatchery Fish

(also employs actions common to all alternatives)

C1(a) Reduce CHF smolt releases if Chetco spawner composition does not meet desired status
C1(b) Establish an acclimation and collection facility in the Chetco River Basin
C1(c) Revise broodstock collection to produce hatchery fish that mature at more natural ages
D1(b) Manage for naturally produced CHF in the Winchuck population area
E1(a) Manage for naturally produced CHF in the Hunter and Pistol population areas

PRIMARY IMPLICATIONS OF THE ALTERNATIVE

1. Partial or periodic natural barriers modified to provide unrestricted passage for adult CHF.

2. Assumes societal benefits would increase with additional limitations to the ocean fisheries.

3. Regulations for freshwater fisheries would be simplified except for the Chetco River fishery. Regulations for the Chetco River would remain more variable because of (1) the need for temporal closures related to water quality and (2) the need to identify harvest allocations for freshwater and late-season ocean fisheries.

4. Within independent populations, CHF hatchery programs would be limited only to the Chetco River Basin, except for educational purposes and restoration efforts following catastrophic events.

APPENDIX K

Management Application of Conservation Criteria for Spawner Escapements

Spawner escapements that fall below, or are forecasted to fall below, conservation criteria will dictate a response by fish managers. A change in management strategies will then follow (see **CRITERIA INDICATING DETERIORATION IN STATUS**, page 133 in conservation plan). However, if effective forecasting methods can be devised, fish managers will have the opportunity to decrease the chance that spawner abundance will fall below conservation criteria or, at least, minimize the difference between conservation criteria and the resultant observed status of a population. The purpose of this appendix is two-fold: (1) detail managerial ability to forecast NP CHF spawner escapements and (2) present the implications of forecasting ability in relation to options related to the temporal component of conservation criteria.

Development of Forecasting Methods

Pre-season forecasts of salmon stock sizes are typically based on the observed abundance of siblings from the same brood during the previous year. As Chinook salmon mature at a variety of ages, age composition estimates are needed to assign mature fish to specific brood years. As annual estimates of age composition were available on a consistent basis for only the aggregated Rogue populations, and were available for only some years for the Chetco population, alternative methods may be needed to develop forecasting tools needed for the management of the Lower Rogue and coastal populations.

Methods: Sibling regressions were developed to estimate the ocean abundance of age 3-6 NP CHF before the onset of any ocean fishing mortality. In each case, the sibling regressions were forced through the origin; analogous to the methods employed to forecast CH stock sizes in the local geographical area (PFMC 2011; PFMC 2012). Two types of possible models were considered:
Model 1. Spawners in year i-1 (X) and siblings alive in ocean during spring of year i (Y).
Model 2. Age 2+3 spawners (summed) in years i-1and i-2 (X) and age 4 siblings alive in ocean during year i. Age 3+4 spawners (summed) in years i-1and i-2 (X) and age 5 siblings alive in ocean during year i. Analogous to method 1, age 2 spawners in year i-1 (X) and age 3 siblings alive in ocean during year i (Y) and age 5 spawners in year i-1 (X) and age 6 siblings alive in ocean during year i (Y).

Sibling regressions were used to hindcast the pre-fishing ocean abundance of age i NP CHF for each year within the period of record. Next, annual exploitation rates on age i Klamath CHF (PFMC 2012) were used to hindcast the post-fishing ocean abundance of age i NP CHF. Next, mean (period of record), population-specific, maturation probabilities were used to hindcast the numbers of maturing age i NP CHF. Next, observed rates of fishing mortality (Chetco terminal fishery and freshwater fishery) were used to hindcast age i NP CHF spawning escapements. Finally, hindcasted estimates of summed age 3-6 were regressed on observed (empirical) estimates to assess which model type was a more effective method for pre-season forecasting of NP CHF abundance.

Results: Based on the regression analyses, significant ($P < 0.05$) forecasting models were developed for the Rogue aggregate, Lower Rogue, Chetco, and Winchuck populations; but could not be developed for the Pistol and Hunter populations (Appendix Table K-1). There was no indication that the type 2 models resulted in better forecasts of NP CHF spawner escapements (Appendix Table K-1), because the regression intercepts were always greater for the type 2 models as compared to the type 1 models (Appendix Table K-1). However, the results indicate that the reliability of forecasts, for any single year, appear questionable because in all cases, the values of the regression intercepts are close to (Chetco excepted) the numerical component of the conservation criteria for NP CHF spawner escapements (*see* **CRITERIA INDICATING DETERIORATION IN STATUS**, page 133 in the conservation plan). These findings indicate that the temporal component of the conservation criteria, for NP CHF spawner escapements, should cover multiple years as compared to single years.

Appendix Table K-1. Relationships of hindcasted (Y) and estimated (X) numbers of age 3-6 NP CHF spawning escapements for independent populations in the Rogue Species Management Unit.

Model	*N*	Equation (SEs)	*P*	r^2[a]
		Rogue Aggregate[b]		
1	36	Y = 24,588(7,595)+0.4771(0.0902)*X	<0.001	0.44
2	35	Y = 32,591(8,299)+0.4916(0.0984)*X	<0.001	0.41
		Lower Rogue		
1	24	Y = 1,481(1,296)+0.6841(0.1006)*X	<0.001	0.66
2	23	Y = 2,051(1,258)+0.5864(0.0963)*X	<0.001	0.62
		Chetco		
1	23	Y = 215(916)+0.7825(0.1939)*X	<0.001	0.41
2	22	Y = 491(836)+0.7384(0.1698)*X	<0.001	0.46
		Winchuck		
1	23	Y = 163(230)+0.6187(0.1929)*X	0.004	0.30
2	22	Y = 197(227)+0.6418(0.1904)*X	0.003	0.32
		Pistol		
1	23	Y = 785(290)+0.0751(0.1862)*X	0.691	-0.04
2	22	Y = 961(323)+0.0513(0.2030)*X	0.803	-0.05
		Hunter		
1	21	Y = 355(116)+0.0853(0.1629)*X	0.607	-0.04
2	20	Y = 450(118)+0.1268(0.1619)*X	0.444	-0.02

[a] Adjusted for sample size.
[b] Passage at Huntley Park.

Forecast Efficacy in Relation to Development of Conservation Criteria

Pre-season forecasts of salmon stock sizes are typically based on the estimated abundance of spawning adults during the previous year and the annual estimates of spawning abundance are usually based on fairly intensive sampling of important populations. However, with the exception of the Rogue aggregate populations, there is currently only limited sampling conducted within the individual population areas to estimate CHF spawner escapements and age composition of the spawners. Such sampling limitations raise concerns about the propriety of pre-season forecasts for NP CHF populations in the Rogue SMU.

Pre-season forecasts that predict the number of NP CHF expected to eventually spawn will be used to determine if conservation status criteria will likely be reached. In addition, pre-season forecasts will be used to quantify the number of NP CHF that can be harvested in the late-season terminal fishery that operates off the mouths of the Chetco and Winchuck rivers. During any given year, implementation of fishery management regulations will generically result in one of three scenarios: (1) predicted = observed, (2) observed returns are greater than predicted returns, or (3) predicted returns are greater than observed returns. Comparisons of predicted and observed returns during the periods of record for each NP CHF population, based on the forecasting methods described in the previous section, were used to assess the efficacy of conservation criteria that could cover varied periods of one-three years.

Relevant comparisons of predicted and observed NP CHF spawner escapements are listed in Appendix Tables K-2 through K-7. Some explanatory information follows in relation to these tables.
1. Years listed in the tables include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.
2. Predicted values for spawner escapements were generated based on the number of cohorts estimated to have spawned during the previous one - three years using the type 1 models presented in the previous section.
3. Conservation "shortfall" is estimated as the numerical component of conservation status criterion - actual estimated number of spawners.
4. Estimates of "harvest adjustment" convey the management changes (harvest reductions) required in order for the predicted values of spawning escapement to meet the numerical component of the conservation criteria (predicted spawning escapement - harvest adjustment = conservation criterion).

Results indicated that, in every case, multiple year coverage periods for conservation status criteria are of greater accuracy as compared to coverage periods of a single year (Appendix Tables K-2 through K-7). In addition, coverage periods of three years are of greater accuracy as compared to coverage periods of two years (Appendix Tables K-2 through K-7). The advisory committee and ODFW considered these results in relation to the following items:
1. The highest priority was to ensure sustainability for all independent NP CHF populations in the Rogue SMU.
2. Management actions taken during periods of low population abundance should result in significant increases in NP CHF spawning escapement. This matter was deemed important because annual exploitation rates (freshwater harvest/freshwater returns) in the freshwater fisheries can exceed 25% for the Chetco, 20% for the Winchuck, and 25% for the Rogue aggregate populations while average freshwater exploitation rates for the Lower Rogue, Hunter, and Pistol populations do not exceed 5% (*see* **Lower Rogue Population**, page 20, **Hunter Creek Population**, page 33, and **Pistol River Population**, page 35) in the conservation plan.
3. The numerical components of the conservation criteria incorporate a conservation buffer (75% percentile estimate of S_{MSY} based on modeling results) or greater (specific to only the Hunter population).

4. Variations in survey efficiency provide additional conservation buffer because poor survey conditions (high flow and/or high turbidity) result in lower spawner counts than would be been observed under good survey conditions.
5. Female NP CHF mature primarily at three ages (3-5) in the SMU populations.
6. Harvest opportunities are lost, changes to fishery regulations are not needed, and management credibility becomes an issue, when a pre-season forecast under-predicts the actual spawning escapement.

After the consideration of the above factors, ODFW and the advisory committee concluded that the conservation criteria for spawning escapement should cover a period of two years for NP CHF populations with potentially high (>20%) freshwater exploitation rates during low return years (Rogue aggregate, Chetco, and Winchuck populations) and that the conservation coverage period should be three years for NP CHF populations harvested at low rates (≤5%) in the freshwater fisheries (Lower Rogue, Hunter, and Pistol populations.

Appendix Table K-2. Assessment of three temporal options for application of the conservation criterion of no less than 20,400 naturally produced fall Chinook salmon passing Huntley Park (Rogue aggregate populations) during 1975-2010. Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	**Predicted**	**Estimated**	**shortfall**	**adjustment**[a]
One Year Coverage Period (Year i)				
1990	**43,577**	**19,531**	**869**	**0**
1991	**20,377**	**14,991**	**5,409**	**23**
Two Year Coverage Period (Average for Year i-1 and Year i)				
1991	**19,954**	**17,261**	**3,139**	**-446**
1992	**18,729**	**29,865**	**0**	**-1,671**
Three Year Coverage Period (Average for Years i-2 through Year i)				
No three year average fell below 20,400 spawners				

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

Appendix Table K-3. Assessment of three temporal options for application of the conservation criterion of no less than 1,500 naturally produced fall Chinook salmon spawning in the Lower Rogue population area during the period of record (1988-2010). Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	Predicted	Estimated	shortfall	adjustment[a]
One Year Coverage Period (Year i)				
1990	1,448	530	970	52
1991	513	623	877	987
1992	855	3,697	0	645
1993	5,658	310	1,190	0
1994	474	1,112	388	1,026
1995	1,179	2,137	0	321
2007	2,202	1,143	357	0
2008	837	2,224	0	663
Two Year Coverage Period (Average for Year i-1 and Year i)				
1991	521	576	924	979
1992	739	2,160	0	761
1994	392	711	789	1,108
1995	1,145	1,624	0	355
2008	990	1,684	0	510
Three Year Coverage Period (Average for Years i-2 through Year i)				
1991	669	1,261	239	831
1994	867	1,706	0	633
1995	2,016	1,186	314	0

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

Appendix Table K-4. Assessment of three temporal options for application of the conservation criterion of no less than 1,440 naturally produced fall Chinook salmon spawning in the Chetco population area during the period of record (1988-2010). Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	Predicted	Estimated	shortfall	adjustment[a]
One Year Coverage Period (Year i)				
2005	1,700	1,328	112	0
2006	650	936	504	790
2007	601	781	659	839
2008	743	1,974	0	697
Two Year Coverage Period (Average for Year i-1 and Year i)				
2006	989	1,132	308	451
2007	769	859	581	671
2008	762	1,378	62	678
Three Year Coverage Period (Average for Years i-2 through Year i)				
2007	955	1,015	425	485
2008	820	1,231	209	620

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

Appendix Table K-5. Assessment of three temporal options for application of the conservation criterion of no less than 300 naturally produced fall Chinook salmon spawning in the Winchuck population area during the period of record (1988-2010). Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	Predicted	Estimated	shortfall	adjustment[a]
One Year Coverage Period (Year i)				
1989	526	274	26	0
1990	96	269	31	204
1991	257	770	0	43
2005	343	248	52	0
2006	158	250	501	142
2007	202	441	0	98
Two Year Coverage Period (Average for Year i-1 and Year i)				
1990	185	272	28	115
1991	263	519	0	37
2006	203	249	51	97
2007	226	345	6	74
Three Year Coverage Period (Average for Years i-2 through Year i)				
1991	267	438	0	33
2007	233	313	0	67

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

Appendix Table K-6. Assessment of three temporal options for application of the conservation criterion of no less than 540 naturally produced fall Chinook salmon spawning in the Pistol population area during the period of record (1989-2010). Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	Predicted	Estimated	shortfall	adjustment[a]
One Year Coverage Period (Year i)				
1989	123	169	361	407
1990	47	230	300	483
1991	159	252	278	371
1992	195	390	140	335
1993	269	283	247	261
1994	423	1,624	0	107
1996	269	2,269	0	261
1999	302	1,541	0	228
Two Year Coverage Period (Average for Year i-1 and Year i)				
1989	177	200	330	353
1990	108	200	330	422
1991	195	241	289	335
1992	223	321	209	307
1993	329	336	194	201
1994	353	953	0	177
1996	503	1,516	0	27
Three Year Coverage Period (Average for Years i-2 through Year i)				
1990	149	210	320	381
1991	186	217	313	344
1992	226	291	239	304
1993	304	308	222	226
1994	365	766	0	165

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

Appendix Table K-7. Assessment of three temporal options for application of the conservation criterion of no less than 300 naturally produced fall Chinook salmon spawning in the Hunter population area during the period of record (1991-2010). Listed years include only those years when either the predicted or observed values fell below the numerical component of conservation criteria related to NP CHF spawning escapement.

	Age 3-6 spawners		Conservation	Harvest
Year	Predicted	Estimated	shortfall	adjustment[a]
One Year Coverage Period (Year i)				
1991	182	163	137	118
1992	126	80	220	174
1993	57	635	0	243
1999	263	965	0	37
2000	689	214	86	0
2001	252	1,534	0	48
2004	451	181	119	0
2005	119	560	0	181
2006	427	237	63	0
2007	156	324	0	144
2008	241	491	0	59
Two Year Coverage Period (Average for Year i-1 and Year i)				
1991	222	212	88	78
1992	144	121	179	156
1993	68	358	0	232
2005	150	371	0	150
2007	197	281	19	103
2008	283	408	0	17
Three Year Coverage Period (Average for Years i-2 through Year i)				
1991	202	196	104	98
1992	183	168	132	117
1993	100	293	7	200
2008	268	351	0	32

[a] *Harvest reduction target needed to meet numerical portion of the conservation status criterion, for those years when predicted values were lower than the conservation criterion.*

References

PFMC (Pacific Fishery Management Council). 2011. Preseason report I. Stock abundance analysis and environmental assessment Part 1 for 2011 ocean salmon fishery regulations. Pacific Fishery Management Council, Portland, Oregon.

PFMC (Pacific Fishery Management Council). 2012. Preseason report I. Stock abundance analysis and environmental assessment Part 1 for 2012 ocean salmon fishery regulations. Pacific Fishery Management Council, Portland, Oregon.