Attachment 4

CONSERVATION PLAN FOR FALL CHINOOK SALMON IN THE ROGUE SPECIES MANAGEMENT UNIT

Draft Plan
September 12 2012

Oregon Department of Fish and Wildlife
3406 Cherry Avenue NE
Salem, OR 97303

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FOREWORD

The purpose of this document is to present a draft conservation plan for naturally produced fall Chinook salmon (*Oncorhynchus tshawytscha*) in the Rogue Species Management Unit of southwest Oregon. Conservation plans are to be developed for each Species Management Unit of native fish in the state of Oregon, as outlined by the Native Fish Conservation Policy. This policy was adopted by the Oregon Fish and Wildlife Commission in 2003 in order to ensure the conservation and recovery of native fish in Oregon.

The Oregon Fish and Wildlife Commission will eventually consider adoption of a final draft of this conservation plan. Prior to plan adoption, the commission will consider, and take action on, alternative suites of management strategies that receive support from various entities. After plan adoption by the commission, portions of this conservation plan will be added to Oregon Administrative Rules.

The Native Fish Conservation Policy states that the conservation of native fish is the principle obligation for fish management practices by the Oregon Department of Fish and Wildlife. The policy has three areas of emphasis: (1) avoid serious depletion of native fish, (2) actively restore and maintain native fish at population levels that provide ecological and societal benefits, and (3) ensure that opportunities for fisheries and other societal resource uses are not unnecessarily constrained when consistent with native fish conservation.

Conservation plans are intended to provide a basis for managing hatcheries, fisheries, habitat, predators, competitors, and pathogens in balance with sustainable production of naturally produced fall Chinook salmon in the Rogue Species Management Unit. The strategies and objectives within each section define the core management program and describe the fundamental direction that will be pursued. These are implemented through specific actions, which may include (but are not limited to) restoring or improving habitat, revisions to fishery regulations, and revisions to hatchery operations. A wide variety of actions are described, but not all may be implemented because of funding uncertainties. A draft of this plan will be distributed for a 45 day comment period to the public and to a wide variety of interested parties. Portions of this plan will become Oregon Administrative Rule upon adoption by the Oregon Fish and Wildlife Commission. Definitions of technical terms and acronyms can be found in **APPENDIX A**.

This conservation plan complements *The Oregon Plan for Salmon and Watersheds*, which was adopted by the Oregon Legislature in 1997. The primary funds that supported work on this conservation plan originated from the Sport Fish Restoration Program, administered by the United States Fish and Wildlife Service. This conservation plan also complements a conservation plan for the Rogue Spring Chinook Salmon SMU adopted by the Oregon Fish and Wildlife Commission in 2007.

ACKNOWLEDGMENTS

An advisory committee was formed to aid the Oregon Department of Fish and Wildlife (ODFW) with the development of this conservation plan. ODFW invited a diverse array of fishery interests to participate as public representatives during the planning process. Nine individuals subsequently participated over the entire period of plan development. A list of the advisory committee members follows:

Advisory Committee Members

Steve Beyerlin, Gold Beach, Oregon Guides and Packers
Val Early, Brookings, Friends of Cal-Ore Fish
Ted Fitzgerald, Brookings, Port of Brookings-Harbor
Maynard Flohaug, Eagle Point, Middle Rogue Chapter of Trout Unlimited
Rich Heap, Brookings, Oregon South Coast Fishermen, Inc.
Ron Schwarz, Gold Beach, Curry Anadromous Fishermen
Peter Tronquet, Medford, Native Fish Society
John Wilson, Gold Beach, Commercial Fishing and Fish Processing
Harvey Young, Brookings, Kalamiopsis Audubon Society

The advisory committee met 22 times over a period of about three years. During the first year of meetings, the advisory committee primarily reviewed and discussed information related to (1) the status of fall Chinook salmon in the Rogue Species Management Unit and (2) physical and biological factors known to, or could possibly affect, the distribution, abundance, life history, and fishery yields of fall Chinook salmon. During the second year of meetings, advisory committee efforts primarily focused on working with ODFW to develop (1) statements related to desired status and conservation status, (2) potential actions that could be employed as part of this conservation plan, and (3) alternative suites of management strategies that could be employed in order to attain desired status. In addition, the advisory committee reviewed and commented on the first draft of this conservation plan, which was subsequently released for technical review and comment.

INTRODUCTION

This document constitutes a conservation plan for naturally produced fall Chinook salmon (NP CHF) in the Rogue Species Management Unit. A Species Management Unit (SMU) is a group of populations from a common geographic area that share similar life history, genetic, and ecological characteristics. ODFW identified 33 SMUs of salmon and steelhead in the state of Oregon (ODFW 2006a). SMU designations are temporary until conservation plans are developed for each individual SMU. In the coastal area south of Cape Blanco, ODFW (2006a) designated a SMU for fall Chinook salmon (CHF) that solely covers all of the coastal river basins, including the Rogue River Basin (Figure 1).

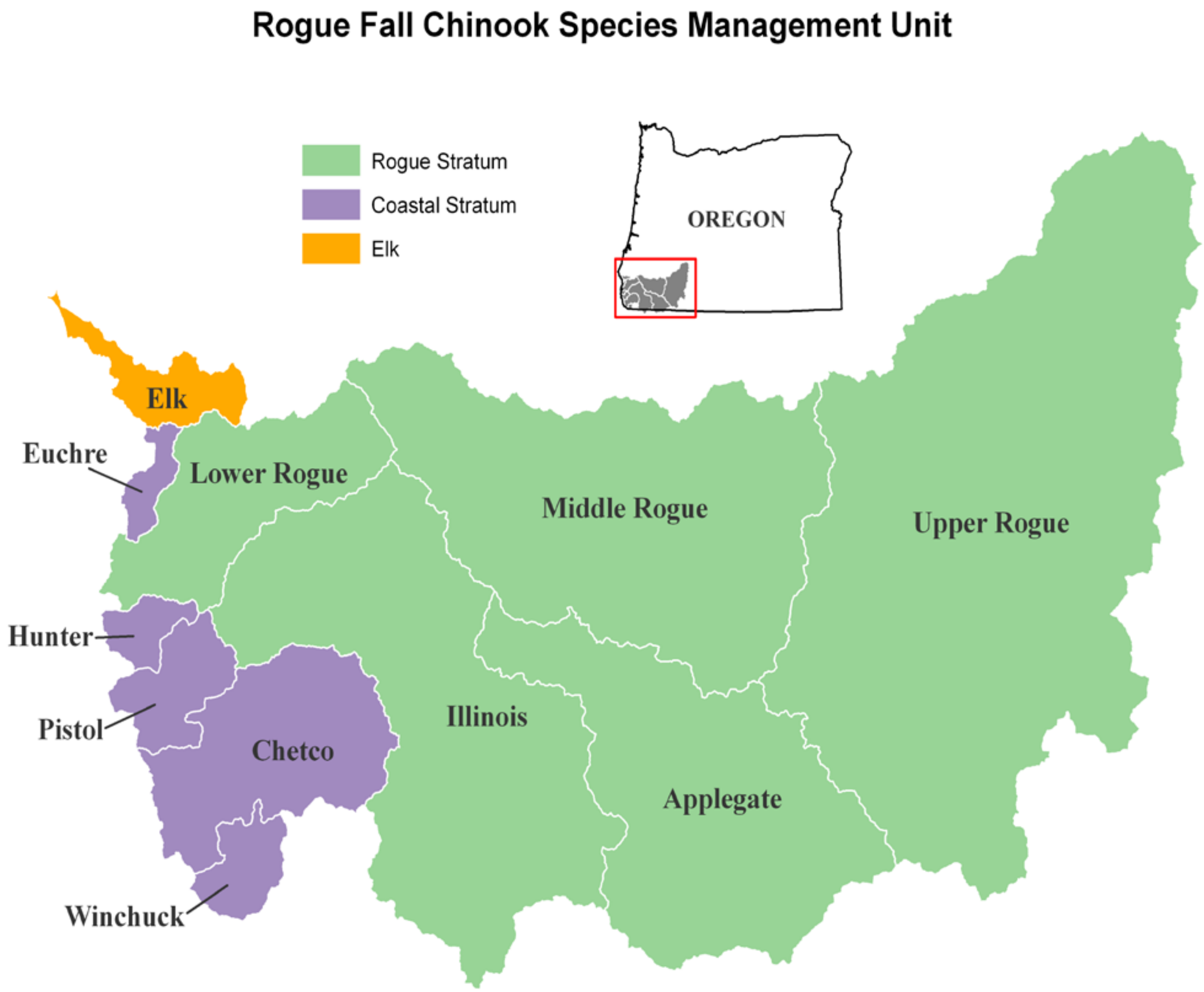

Figure 1. Provisional populations of fall Chinook salmon in the Rogue Species Management Unit as identified by ODFW (2006a).

The following sections of this document present and discuss issues that are relevant to the historical and current status of NP CHF in the SMU, define current and desired status, identify limiting factors, identify assessment needs and outline a variety of management options to be considered by the Oregon Fish and Wildlife Commission. Identification of management options is particularly important because, for the area south of Cape Blanco, ODFW currently lacks a CHF management plan and also lacks any basin plans.

RELATIONSHIP TO OTHER NATIVE FISH CONSERVATION PLANS

This conservation plan is designed to interface with, and complement, previous native fish conservation plans adopted by the Oregon Fish and Wildlife Commission within the affected geographic area. A conservation plan for the Rogue Spring Chinook Salmon Species Management Unit was adopted during 2007. No other conservation plans have been crafted for any other species/races of native fish present in the area.

Direct interface of the CHF and spring Chinook salmon (CHS) conservation plans is a prerequisite for effective management of fish resources. As outlined in the CHS conservation plan, there is only one population of CHS in the SMU and the population status declined significantly during the last 30 years as a result of the construction and operation of William Jess Dam (also known as Lost Creek Dam) in the upper portion of the Rogue River (ODFW 2007). Allied with the decline of NP CHS, is an increase in the production of NP CHF in a portion of the area historically dominated by late-run, late-spawning NP CHS. This matter is discussed in more detail later within the conservation plan (*see* **Upper Rogue Population**, page 15).

During development of this conservation plan, the public advisory committee and ODFW agreed that restoration of NP CHS in the Rogue River should be of greater priority as compared to maintenance of desired status for NP CHF in the Rogue River Basin. This decision is reflected in the two alternative suites of management strategies that received support from members of the public advisory committee and ODFW (*see* **ALTERNATIVE SUITES OF MANAGEMENT STRATEGIES**, page 117).

CONSTRAINTS

Actions proposed within this conservation plan must be in compliance with a variety of local, state, and federal laws; as well as state statutes and administrative rules, and memoranda of understanding among public agencies. Consequently, there are constraints that limit potential actions by ODFW, and those constraints need to be recognized within conservation plans adopted by the Oregon Fish and Wildlife Commission. A brief description of some of the general constraints, that need to be recognized within the plan, can be found in **APPENDIX B**.

SPECIES MANAGEMENT UNIT AND CONSTITUENT POPULATIONS

As previously described, the SMU geographical boundaries were provisionally identified as those coastal basins in Oregon south of Cape Blanco (ODFW 2006a). Chinook salmon present in these basins (Elk River Basin excepted) are included in the geographical boundaries for the Southern Oregon and Northern California Evolutionarily Significant Unit, as identified by Biological Review Teams (NOAA Fisheries 1999). In contrast, ODFW identified separate SMUs for CHS and CHF due to differences in life history strategies.

Multiple populations of NP CHF appear to be present in the Rogue SMU, under the definition that a fish population is "*a group of fish originating and reproducing in 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*" (Oregon Administrative Rule AR 635-007-0501(45)). Delineation of populations can be elucidated by three criteria: (1) detection of genetic differences, (2) detection of life history characteristics that have a genetic basis, and (3) marked spatial differences in population boundaries. Application of these criteria resulted in the identification of 10 NP CHF populations in the Rogue SMU (Table 1).

Table 1. Documented differences in population characteristics for fall Chinook salmon populations identified in the Rogue Species Management Unit. Within each characteristic category, shared letters reflect no documented differences among populations. The Applegate and Illinois populations are located in the Rogue River Basin. All other populations migrate directly to and from the ocean (coastal populations). As discussed within this section, the Elk River population is more appropriately grouped with ODFW's Coastal Fall Chinook Salmon Species Management Unit.

	Differences in characteristics		
Population	Genetic	Life History	Spatial
Upper Rogue	a	e	k
Middle Rogue		f	k,l
Lower Rogue		g	m
Illinois River		g	m,l
Applegate River	b	h	k,n
Winchuck River		i	o
Chetco River	c	i	p
Pistol River		i	q
Hunter Creek		i	r
Euchre Creek		i,j	s
Elk River	d	j	t

Assessments of microsatellite loci and mitochondrial DNA have been used to identify genetic differences between populations of Chinook salmon (Seeb et al. 2007). Such assessments have been completed for four populations of NP CHF in the Rogue SMU and the findings indicate that there are significant differences in the genetic characteristics of the Upper Rogue, Applegate, Chetco, and Elk River NP CHF populations (Renee Bellinger, Marine Fisheries Genetic Laboratory, Oregon State University, unpublished data). Genetic analyses of allozyme loci have also been completed for numerous populations of Chinook salmon in the Pacific Northwest. Analyses of these data indicated that the Elk River CHF population was most appropriately clustered with CHF populations farther to the north, as compared with CHF populations farther south (Myers et al. 1998). This result indicates that the Elk River population is more appropriately grouped with ODFW's Coastal Fall Chinook Salmon SMU rather than the Rogue Fall Chinook salmon SMU.

The life history characteristics conveyed in Table 1 have a strong genetic basis. Highly heritable traits include spawning time (Quinn et al. 2000), adult migration time (Quinn et al. 1997), and ocean distribution (Myers et al. 1998). Within the Rogue River Basin, spawning time differs significantly among the Upper Rogue, Middle Rogue, Lower Rogue, and Applegate populations (ODFW 1992; Fustish et al. 1988). Time of freshwater entry also differs significantly among NP CHF destined to spawn in the Upper Rogue, Middle Rogue, Applegate and Lower Rogue-Illinois population areas (ODFW 1992). All of the Rogue populations enter freshwater and spawn earlier than the coastal (non-Rogue) populations (Nicholas and Hankin 1988). Among the coastal populations, differences in time of freshwater entry and spawning time have yet to be detected.

During ocean residence, Chinook salmon exhibit a non-random distribution. Populations that originate from differing ecoregions of Oregon inhabit different areas of the ocean (Weitkamp (2010). Based on the distribution of ocean harvest, Chinook salmon originating from stream basins north of Cape Blanco generally rear in offshore areas from Oregon through Alaska (Nicholas and Hankin 1988). In contrast, counterparts produced in stream basins south of Cape Blanco generally rear in offshore areas from Oregon through California (Nicholas and Hankin 1988). Updated estimates confirmed that the ocean distribution of the Elk River population differed significantly from other populations in the SMU (Table 2). These results also indicate that the Elk River population is more appropriately grouped with ODFW's Coastal Fall Chinook Salmon SMU rather than the Rogue Fall Chinook salmon SMU.

Table 2. Landing distribution of Rogue Species Management Unit populations of fall Chinook salmon, and the Elk River population, harvested in the ocean fisheries, 1973-2003 brood years. Data originated from juvenile hatchery fish marked with coded-wire tags and are reported only for those brood years (*N* in table) with at least 50 fish landed in the ocean fisheries. All groups were released in the same population areas as where parents were collected. The 95% confidence intervals were estimated from arcsine transformed data. Among Chinook salmon, wild and hatchery fish that originate from the same basin exhibit very similar ocean distributions (Weitkamp 2010).

	Proportion landed in Oregon+California		
Population	Mean	(95% CI)	*N*
Middle Rogue	0.99	0.96-1.00	8
Lower Rogue	0.99	0.99-1.00	10
Winchuck River	1.00	n/a	3
Chetco River	0.96	0.92-0.98	22
Pistol River	0.91	0.43-1.00	4
Hunter Creek	0.96	0.90-0.96	3
Elk River	0.56	0.26-0.38	28

Geographical isolation is a factor that can be used to identify differences between local populations of Chinook salmon because of the proclivity of adults to home and spawn in natal streams. In those cases where populations originate from watersheds that do not share a connection to the Pacific Ocean, the degree of geographical isolation is likely related to the distance between populations. In other words, the greater the distance between river mouths, the more likely that the populations are distinctly different from each other (Eldridge et al. 2009).

Spatial distances between adjacent CHF populations are listed (Table 3) for those populations that are separated by the Pacific Ocean but significant differences have yet to be detected in relation to life history parameters that have a genetic basis. Results suggest that the NP CHF in the Winchuck River Basin are least likely to differ from adjacent populations, while NP CHF in the Euchre Creek Basin are most likely to differ from adjacent populations. However, population size in adjacent basins is also an important factor that determines if populations function independently of other populations. Classification of populations as independent or dependent is discussed later within the profile of each population.

Table 3. Spatial differences between adjacent populations of fall Chinook salmon in the Rogue Species Management Unit that are separated by the Pacific Ocean and cannot be separated by other means. Distances were estimated between locations where each stream entered the ocean. Estimates include distances between populations on the extremity of the Unit boundaries.

Populations	Distance (miles)
Smith River (CA) v Winchuck River	4
Winchuck River v Chetco River	4
Chetco River v Pistol River	18
Pistol River v Hunter Creek	8
Hunter Creek v Euchre Creek	12
Euchre Creek v Elk River	18

To summarize this section, there is information that indicates the presence of independent NP CHF populations within the SMU, but genetic assessments are needed to confirm which populations should be managed as independent populations in contrast to dependent populations (*see* **Research Needs**, page 142). There is also information that indicates NP CHF produced in the Elk River Basin should be grouped with the ODFW's coastal SMU rather than being grouped with the Rogue SMU. Consequently, the Elk River population is not included in this conservation plan. Finally, it is also possible that NP CHF in the Euchre Creek population area would be more appropriately grouped with Oregon's coastal SMU. Genetic assessments are needed to make this determination (*see* **Research Needs**, page 142).

BACKGROUND

Historical Context

Rogue River Basin Populations

Commercial fishing operations for salmon in the Rogue River began in the 1860s (Rivers 1964). The first records of salmon harvest originated from R.D. Hume's cannery, which began operations in 1877 and was the only cannery that operated in the vicinity of Gold Beach until 1915 (Rivers 1964). Cannery pack records for 1877-1891 reflect only the total number of cases packed with no differentiation of species. For 1892-1928, the pack records are segregated by Chinook salmon and coho salmon but it is not possible to differentiate the pack records for Chinook salmon by race (NP CHS versus NP CHF). However, daily catch records (numbers of fish caught per day) exist for the 1902-1914 fishery years and these records provide some indication of the probable size of the NP CHF in the Rogue River during those years.

Catch records indicate that the annual commercial harvest of NP CHF ranged from 12,000 to 41,000 fish and averaged 23,700 (95% CI = ± 7,200) fish during 1902-1914 (Table 4). Assuming that harvest rates averaged 40% annually (Mullen 1981; Lichatowich 1989), total freshwater returns probably averaged about 59,000 NP CHF annually during 1902-1914. If harvest rates had averaged only 20% annually, freshwater returns would have averaged about 119,000 NP CHF during 1902-1914. In comparison, an average of about 159,000 NP CHF (137,000 recruits + 22,000 age 2 jacks) were produced by the 1972-2006 brood years (*see* **Rogue Aggregate Populations**, page 25).

Table 4**.** Numbers of fall Chinook salmon reported harvested near the mouth of the Rogue River during 1902-1914. Daily harvest records for these years are recorded in Volume 82A, Records of R.D. Hume & Company, Special Collections Library, University of Oregon; the only commercial cannery that operated on the Rogue River during these years. Harvest estimates assume that fish landed after July 15 were fall Chinook salmon. The Rogue River was closed to the commercial harvest of salmon during 1911-1912.

Year	Harvest	Year	Harvest
1902	11,910	1908	14,739
1903	24,016	1909	14,491
1904	31,163	1910	31,922
1905	40,864	1913	16,093
1906	40,409	1914	18,546
1907	16,365		

Directed surveys of fish resources in the Rogue River Basin began in the 1940s, and were conducted by the Oregon State Game Commission (OSGC). Findings from these surveys were reported by Rivers (1964). Included in this work was the construction of a fish counting station at Gold Ray Dam, which began operation in the spring of 1942. More extensive surveys of fish populations, stream habitat, and recreational fisheries were conducted by the OSGC and the United States Fish and Wildlife Service during 1949-1954. Findings from these surveys can be found in a series of unpublished reports (USFWS 1955a; USFWS 1955b; USFWS 1955c; USFWS 1955d). Fish surveys were initiated in the Rogue River Basin during the 1940s and 1950s primarily as a result of regional interest in the construction of reservoirs for the multiple purposes of flood control, hydroelectric power, and water supply.

Interest in the construction of flood control projects intensified after a major flood event in December of 1955. The United States Army Corps of Engineers (USACE) conducted an investigation of concerns related to project development and recommended to the United States Congress that three dams be constructed in the Rogue River Basin. Primary project purposes identified by the USACE included flood control, fish enhancement, irrigation, and water supply. Secondary purposes included power generation, recreation, and water quality enhancement. Congress authorized the proposed project in 1962, including the construction of Lost Creek Dam (subsequently re-named as William Jess Dam), Applegate Dam, and Elk Creek Dam (United States Congress 1962). William Jess Dam was completed in 1977, Applegate Dam was completed in 1979, and Elk Creek Dam has yet to be completed. As none of these dams blocked CHF habitat, no CHF of hatchery origin are produced to mitigate for lost habitat.

William Jess Dam was constructed on the mainstem of the Rogue River at river mile 157 and Applegate Dam was constructed at river mile 47 on the Applegate River. Each dam is operated primarily for flood control purposes, with the reservoir levels not to exceed specified elevations on given dates (United States Congress 1962). Storage accrued during the filling of each reservoir is dedicated to specific purposes (United States Congress 1962). When Lost Creek Lake fills, 180,000 acre-feet of storage is released to meet downstream purposes, including the release of 125,000 acre-feet for fish enhancement purposes. The remaining 55,000 acre-feet of storage is dedicated to other primary uses: irrigation supply, municipal and industrial supply, and environmental enhancement. When Applegate Lake fills, 66,000 acre-feet of storage is subsequently released to meet downstream purposes, including the release of 40,000 acre-feet for fish enhancement purposes. The remaining 26,000 acre-feet of storage is dedicated to irrigation supply. Any dedicated storage that is not purchased for consumptive use is also available for downstream enhancement of fish resources (USACE 1972).

To regulate the outflow temperature, the USACE designed intake structures capable of withdrawing water from different levels in both reservoirs. Selective opening of intake ports allows for mixing of water from various temperature strata in the reservoir. Choice of outflow temperature is greatest in early summer when the reservoir is full and thermally stratified. Control of release temperature diminishes in late summer as reservoir level decreases and the highest intake ports become dewatered. Control of release temperature becomes minimal in autumn after each reservoir destratifies (Hamlin-Tillman and Haake 1990).

The authorizing document also outlined minimum outflow and maximum water temperature to be released from both Lost Creek and Applegate dams, but clearly stated these guidelines should be modified as additional information became available: "It should also be noted that project operation plans must be sufficiently flexible to permit desirable modifications in scheduled releases for fish, within the limits of storage provided therefore, if experience and further study indicates such action to be desirable for overall project benefits" (United States Congress 1962). Uncertainty related to the scheduling and efficacy of releases to meet fish allocations lead the USACE to fund two fish research projects. The Lost Creek Dam Fisheries Evaluation Project was conducted by ODFW during 1974-1996, with field sampling directed at CHF terminated in 1986. A completion report (ODFW 1992) details the findings related to work with CHF. The Applegate Dam Fisheries Evaluation Project was conducted by ODFW during 1979-1984, with field sampling directed at CHF terminated in 1984. A completion report (Fustish et al. 1988) details the findings related to work with CHF.

Findings and recommendations outlined in the CHF completion reports, along with completion reports for other races of anadromous salmonids, are used by ODFW to develop annual and seasonal recommendations for releases from Lost Creek Lake. In relation to the development of reservoir management strategies for Lost Creek Lake, ODFW’s foremost priorities have been directed towards enhancement of the depressed population of NP CHS in the Rogue River, while minimizing the chance of disease outbreaks among CHF is a secondary priority (Table 5). In relation to the development of reservoir management strategies for Applegate Lake, three of the four ODFW priorities have been directed at the enhancement of NP CHF (Table 5).

Historical records related to the production and releases of hatchery fish were reported by Rivers (1964). Hatchery programs were initiated in the Rogue River Basin as early as 1877, but were exclusively directed at CHS until at least 1910. Records for 1910-1940 suggest that juvenile CHF may have been released in the Illinois River Basin during two years and in the Applegate River Basin during four years. However, it is possible that some of these releases were CHS rather than CHF. Contemporary ODFW records indicate that no CHF hatchery programs operated in the Rogue River Basin during the 1950s and 1960s.

Coastal Populations

Historical records and documents contain minimal information that may reflect the general sizes of NP CHF populations. Federal documents published between the 1890s and the 1910s refer to commercial fisheries for Chinook salmon in the Chetco, Winchuck, and Rogue rivers; but no references could be found related to any Chinook salmon fisheries in Euchre Creek, Hunter

Table 5. Current ODFW fish management objectives as related to the operation of USACE reservoirs in the Rogue River Basin. Objectives are listed in order of priority, and have remained unchanged since 1997 (Lost Creek Lake) and since 2004 (Applegate Lake).

Lost Creek Lake Operations

1. Minimize pre-spawning mortality among adult CHS
2. Minimize dewatering losses of young salmonids
3. Minimize dewatering of CHS redds
4. Minimize early emergence by CHS fry
5. Minimize pre-spawning mortality among adult CHF
6. Increase survival rates of juvenile salmonids during the summer
7. Minimize the proportion of adult CHF that pass Gold Ray Dam
8. Minimize the effects of flow augmentation on the summer steelhead fishery in the canyon

Applegate Lake Operations

1. Increase summer rearing area for juvenile coho, juvenile steelhead, and cutthroat trout
2. Increase CHF spawning distribution
3. Minimize dewatering loss of CHF eggs and alevins
4. Extend the early rearing period for juvenile CHF

Creek, or Pistol River (Collins 1892; Wilcox 1895; Radcliffe 1919; and others). Similarly, state of Oregon annual reports for 1887-1926 (Fish and Game Protector and State Fish Commissioner reports; Fish Warden reports) referenced commercial salmon fisheries only in the Rogue, Chetco, and Winchuck rivers.

Reports of historical commercial NP CHF harvest in coastal basins, other than the Rogue River Basin, could be found for only one year. During 1895, 77,000 pounds of Chinook salmon were landed in the Chetco River (USCFF 1896). This poundage would equate to about 2,800 NP CHF assuming (1) an average fish length of 90 cm and (2) application of a length-weight relationship reported for Chinook salmon in the Rogue River (Rivers 1964). Assuming that the harvest rates were 40% annually (Mullen 1981; Lichatowich 1989), the freshwater return in 1895 was about 7,000 NP CHF. In comparison, an average of about 8,500 NP CHF (8,200 recruits + 300 age 2 jacks) were produced by the 1983-2006 brood years (*see* **Chetco River Population**, page 38).

State of Oregon focus on salmon runs in the larger streams was also apparent within the harvest regulations adopted by Oregon during the 1800s (Gharrett 1953). Between 1878 and 1900, annual regulations for commercial salmon harvest did not differ among any streams within the SMU. However, during 1901-26, regulations closed Hunter and Euchre creeks to the commercial harvest of salmon while the Rogue, Pistol, Chetco, and Winchuck rivers remained open. The commercial harvest of salmon in Hunter and Euchre creeks was restored during 1927-37, and 1937 was the last year when salmon could be harvested commercially in any of the streams in the SMU.

Spawning surveys directed at CHF in the coastal basins began in 1959 (Hutchison 1962). During the 1960s through the mid-1980s, spawning surveys were conducted only on a cursory basis. Usually there was only one survey conducted annually in each of the population areas. A review of historical records failed to reveal any releases of any hatchery CHF until the 1960s.

General Aspects of Life History

This section briefly outlines the general life strategy of NP CHF in the SMU. Specific life history attributes, which relate to potential limiting factors, are presented later in the document (*see* **PRIMARY LIMITING FACTORS**, page 45).

Rogue River Basin Populations

The life history strategy of NP CHF in the Rogue River Basin is well documented (ODFW 1992). Adult Chinook salmon may enter the Rogue River on any given day of the year. Chinook salmon that enter freshwater from February through 15 July are classified as CHS. Adult Chinook salmon that enter freshwater after 15 July are classified as CHF. Time of freshwater entry is highly dependent on the population of origin. Adults that enter freshwater early in the run spawn in areas farther upstream in the basin as compared with adults that enter freshwater later in the run. Spawning takes place from early October through the end of January. Spawning time is related to time of freshwater entry, with early-run NP CHF spawning earlier than late-run counterparts. The preponderance of spawning occurs in mainstem reaches of the Rogue and Applegate rivers.

Eggs and alevins (sac-fry) incubate in the gravel during the winter and spring. Fry emergence from the gravel begins in March and ends in late April or early May. Juveniles reside primarily in the mainstem of the Rogue River, although some rear in the larger tributary streams (Applegate and Illinois rivers) during May and June. Fry in the small tributary streams migrate downstream soon after emergence from the gravel. Few juvenile NP CHF rear in the Rogue River estuary. More than 95% of the returning adults entered the ocean as subyearling smolts during August through September at lengths of about 10-12 cm (4-5 inches), while a small proportion of juveniles spend the winter in freshwater and enter the ocean during their second year of life. Out-migration primarily as subyearling smolts is also characteristic of other CHF populations in Oregon (Nicholas and Hankin 1988).

Duration of ocean residence is highly variable. Some NP CHF rear in the ocean for less than one year, returning to freshwater as age 2 fish (almost all males and are known as “jacks”) in their second year of life. The most common life history is two or three years of ocean residence, with attainment of maturity as age 3 fish in their third year of life or as age 4 fish in their fourth year of life. Some rear in the ocean for four years and return to freshwater as age 5 fish, while a small percentage rear in the ocean for five years and mature at age 6.

Coastal Populations

The life history strategy of NP CHF in the coastal population areas differs somewhat from that of NP CHF in the Rogue River Basin. Adults enter freshwater from the early autumn through the middle of winter (Nicholas and Hankin 1988). Eggs and alevins incubate in the gravel during the winter and spring. Similar to NP CHF in the Rogue River Basin, fry emergence from the gravel begins in March (McGie 1968) and ends in late April or early May. In contrast to NP CHF in the Rogue River Basin, a significant percentage of juvenile NP CHF migrate downstream before attainment of smolt size and rear in estuaries for an extended period of time. Analyses of scales taken from returning adults indicate that almost all enter the ocean as subyearling smolts at lengths of about 10-12 cm (4-5 inches).

Similar to NP CHF produced in the Rogue River Basin, some NP CHF rear in the ocean for less than one year, returning to freshwater as age 2 jacks in their second year of life. However, NP CHF produced in the coastal population areas mature at older ages as compared with counterparts produced in the Rogue River Basin. Proportionally fewer fish mature at age three and proportionally more fish mature at age four. The most common life history is three years of ocean residence, with attainment of maturity as age 4 fish in their fourth year of life. A small percentage rear in the ocean for five years and return to freshwater as age 6 fish.

General Aspects of the Fisheries

Fall Chinook salmon produced in the Rogue SMU contribute to commercial and recreational fisheries in the ocean and also contribute to recreational fisheries in freshwater. Coastal landings of hatchery fish marked with coded-wire tags (CWT) indicate that CHF, of Rogue SMU origin, rear in the ocean primarily off the coasts of Oregon and California (*see* Table 2, page 9). Recoveries of CWTs also indicate that age 3 fish and age 4 dominate the ocean harvest, and that the ocean fisheries harvest few age 2 and age 5 fish.

The general ocean season typically operates during June through September and is managed by the federal government in cooperation with the Pacific Fisheries Management Council. In addition, there is near-shore fishery that typically operates during October and early November near the mouth of the Chetco and Winchuck rivers. This fishery is managed by the state of Oregon River and has been open most years since 1992. Generally, when this fishery is open, both commercial and sport harvest is allowed, with a quota applied to commercial harvest. During years when this fishery has been open, season length averaged 17 days. Recovery of CWTs indicate that many different populations contribute to the harvest, with about half the fish being of Chetco River origin.

Directed fisheries on maturing CHF returning to the Rogue River Basin occur only in the estuary and in the mainstem of the Rogue River. Differences in time of freshwater entry produce minor differences in freshwater harvest rates among the various populations. Populations that enter freshwater early are exposed to angler effort for longer periods of time and thus are harvested at marginally higher rates in freshwater. In contrast to CHS (ODFW 2000), there is no evidence that freshwater harvest rates differ among CHF of different ages. Maturing CHF returning to the south coastal population areas are fished almost exclusively in streams, except for the directed late season fishery off the mouths of the Chetco and Winchuck rivers.

POPULATION STATUS ASSESSMENTS

Rogue Stratum

Upper Rogue Population

The Upper Rogue population spawns in areas upstream of river mile 126 on the Rogue River (Figure 2). Of the 75 miles classified as NP CHF habitat by ODFW, tributary streams account for 53 miles and the mainstem of the Rogue River accounts for 32 miles. However, most of the population appears to spawn in the mainstem of the Rogue River, primarily between river miles 126 and 135 (ODFW 1990). Choice of the downstream boundary of the population was based on two factors. First, few NP CHF historically spawned in areas upstream of river mile 126 before

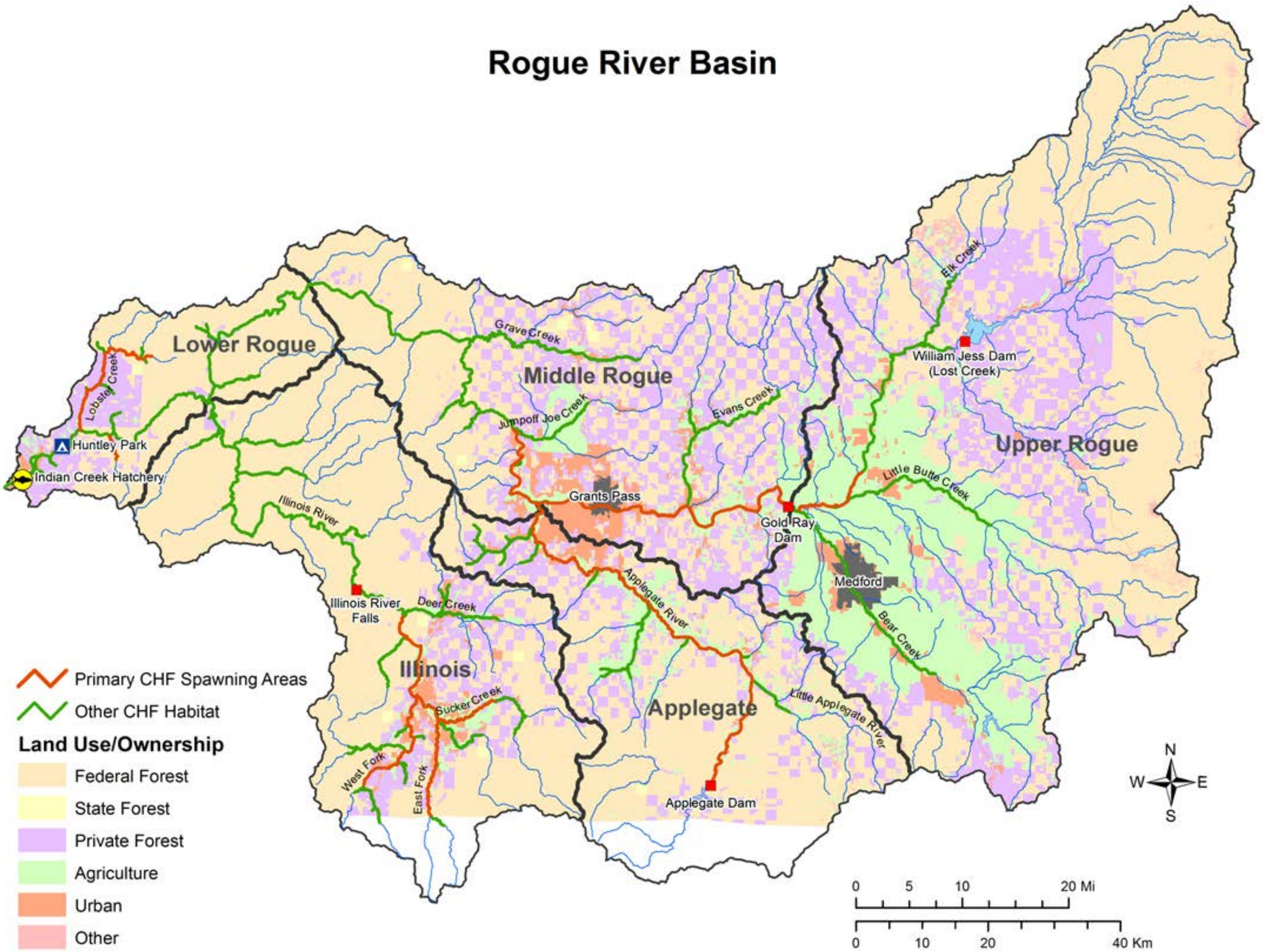

Figure 2. Spatial distribution of independent populations of fall Chinook salmon in the Rogue stratum of the Species Management Unit. The boundaries of the different population areas are shown as black lines and the Rogue River drains into the Pacific Ocean.

the construction and operation of William Jess Dam in the mid 1970s (ODFW 2000). Second, a DNA microsatellite assessment completed for samples collected in 2004 indicated that allele frequencies were not at Hardy-Weinberg equilibrium in this population, possibly suggesting relatively recent colonization from relatively few adult parents (Renee Bellinger, Marine Fisheries Genetic Laboratory, Oregon State University, unpublished data). Because Gold Ray Dam (RM 126) was not a passage barrier for adult CHF, there is no reason to suspect that removal of the dam in 2010 affected the choice of NP CHF population boundaries.

Spawning escapement in the Upper Rogue population area can be estimated from historical CHF passage estimates at Gold Ray Dam. Passage estimates directly reflect spawning escapement because CHF were not susceptible to significant prespawning mortality or fishing mortality in areas upstream of the counting station. There was no sampling conducted to estimate the age composition of passing adults.

Annual estimates of adult CHF returns to the Upper Rogue population area ranged between about 1,000 and 25,000 fish during 1942-2009. Naturally produced fish dominated the annual returns, except during the late 1980s (Figure 3). The hatchery fish originated from four broods released from Cole M. Rivers Hatchery as smolts during the early 1980s. There is a good chance that almost all of the hatchery fish returned to the hatchery rather than spawning naturally. This inference is based on research findings that indicated a 95% homing rate to the hatchery for adult CHS released as smolts from Cole M. Rivers Hatchery (Cramer et al. 1985). Application of a 95% homing rate suggests that hatchery fish compose less than 0.1% of the CHF that spawn naturally in the Upper Rogue population area.

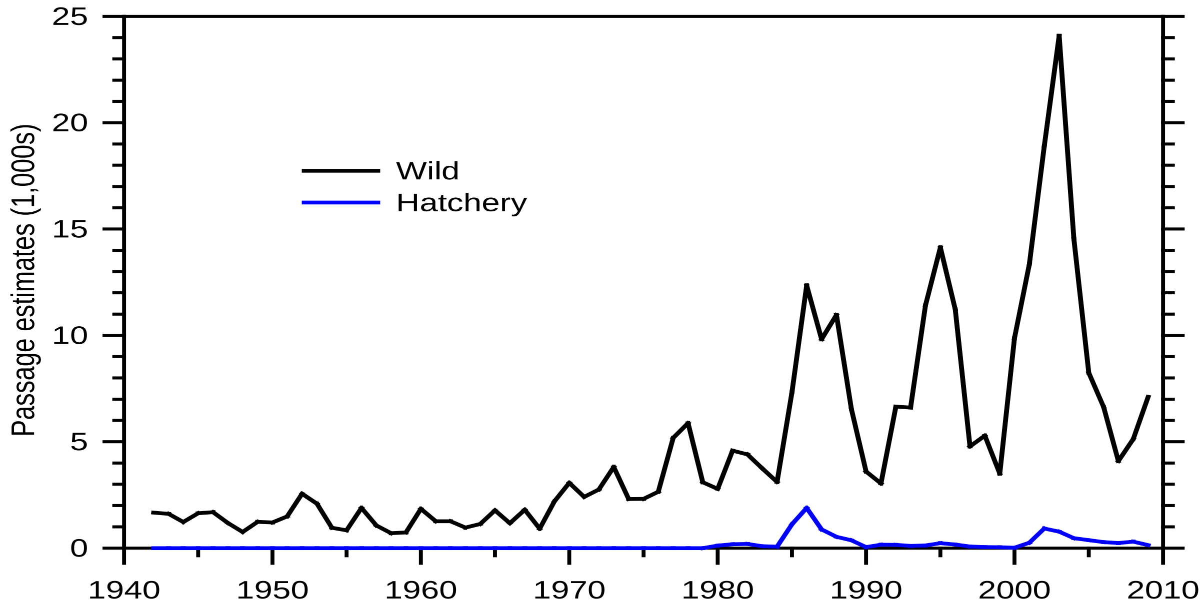

Figure 3. Estimated number of age 3-6 fall Chinook salmon that passed Gold Ray Dam, 1942-2009. No estimates are available for 2010 because the dam and fish counting station were removed before passage of any fall Chinook salmon. Confidence bounds could not be generated for these estimates.

Returns of NP CHF to the Upper Rogue population area increased markedly after 1985 (Figure 3). Passage estimates averaged 2,114 (95% CI = 1,730-2,499) NP CHF during 1942-1984 and averaged 9,168 (95% CI = 7,064-11,272) NP CHF during 1985-2009. A t-test, assuming unequal variances, indicated that the difference was significant ($P < 0.001$). Increases in adult abundance probably resulted from two primary factors: (1) a substantial decrease in ocean fishery exploitation rates beginning in the mid-1980s (*see* **Fisheries**, page 65) and (2) a change in race composition among NP CH produced in the upper portion of the Rogue River (ODFW 2007). An increase in NP CHF production, coincident with a decrease in NP CHS production, has been linked to the construction and operation of Lost Creek Dam (ODFW 2000).

The increase in NP CHF production and the allied decrease in NP CHS production is of concern to fish managers and is directly relevant to the alternative management strategies developed for this conservation plan. Management strategies and allied actions employed with the adoption of the CHS conservation plan are specifically directed at restoration of NP CHS production in the upper portion of the Rogue River (ODFW 2007). These strategies and actions call for Lost Creek Lake to be managed so that (1) reservoir outflow temperatures favor NP CHS production rather than NP CHF production and (2) reservoir outflows in autumn are managed to discourage the upstream migration of early-run NP CHF destined to spawn in habitat that historically produced NP CHS (ODFW 2007). Lost Creek Lake could be managed to instead enhance the production of NP CHF (*see* Alternatives 1-3 *in* **Rogue Stratum**, page 118). However, both the advisory committee and ODFW concluded that restoration of NP CHS production should remain a greater priority as compared to the enhancement of NP CHF production in the Upper Rogue population area (*see* **Rogue Alternative 4:**, page 119 and **Rogue Alternative 5:**, page 124).

Cohort reconstruction methods (**APPENDIX C**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 6. Several fundamental assumptions were made during derivation of these indexes, with a primary assumption of no difference between the age composition of NP CHF that returned to Upper Rogue population area and all NP CHF that entered the Rogue River.

Table 6. Summary of primary population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Upper Rogue population area, 1984-2004 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Estimates for individual brood years are listed in Appendix Table E-4.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	**10,554**	**7,623**	**4,757**	**14,017**
Ocean harvest	**2,642**	**1,390**	**560**	**3,851**
Freshwater escapement[a]	**10,391**	**8,577**	**4,988**	**15,059**
Freshwater harvest[a]	**912**	**728**	**511**	**1,252**
Recruits/spawner	**2.6**	**1.0**	**0.5**	**3.8**
Ocean harvest rate	**0.21**	**0.16**	**0.11**	**0.29**
Freshwater harvest rate[a]	**0.09**	**0.09**	**0.07**	**0.13**
Brood harvest rate	**0.23**	**0.20**	**0.16**	**0.28**

[a] *Includes estuary.*

Based on comparison of the number of NP CHF recruits produced by the Upper Rogue population and the number of NP CHF recruits produced in the entirety of the Rogue River Basin (Appendix Tables E-4 and E-5), the Upper Rogue population averaged 9% of the NP CHF produced in the Rogue River Basin (95% CI = 8-11% as estimated from arcsine transformed data). Recruit estimates included in the comparison were limited to the 1984-2004 brood years because of the increase in NP CHF production within the Upper Rogue population area after the construction and operation of Lost Creek Dam (ODFW 2000) and because of the loss of the fish counting station when Gold Ray Dam was removed in 2010.

The Upper Rogue population status can no longer be monitored because of the loss of the fish counting station at Gold Ray Dam in 2010 and no funds are available to implement other types of monitoring methods. As a result, no management criteria will be proposed for this NP CHF population. However, annual passage estimates of NP CHF at Gold Ray Dam and at Huntley Park (RM 8) were significantly related (Figure 4). This finding suggests that the Upper Rogue population would be covered, at least to some extent, by management criteria devised for pooled (aggregate) populations of NP CHF in the Rogue River Basin. A more detailed discussion of this topic is included in a succeeding section (*see* **Rogue Aggregate Populations**, page 25).

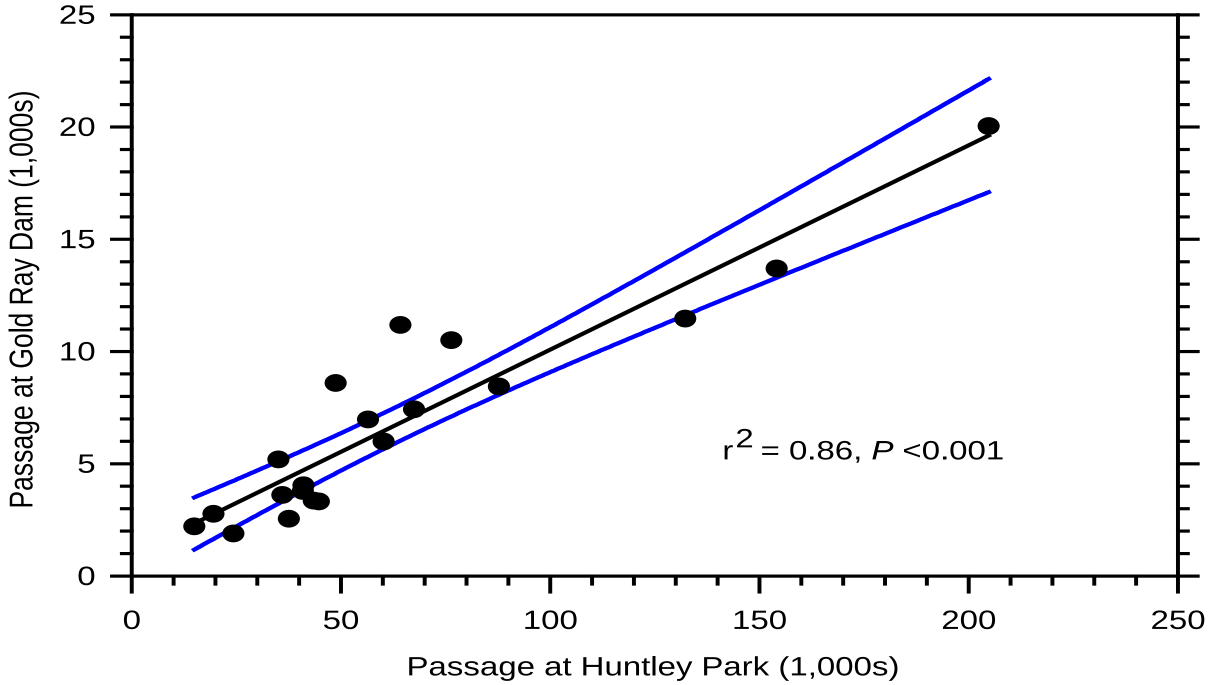

Figure 4. Relationship between annual estimates of age 3-6 naturally produced fall Chinook salmon that passed Gold Ray Dam and Huntley Park, 1990-2009. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Data prior to 1990 were not included in the analysis because of the increase in the Upper Rogue population during the 1980s (ODFW 2000).

Middle Rogue Population

The Middle Rogue population inhabits areas between river mile 48 and river mile 126 on the Rogue River (*see* Figure 2, page 16). Of the 121 miles classified as NP CHF habitat by ODFW, tributary streams account for 34 miles and the mainstem of the Rogue River accounts for 87 miles. However, the preponderance of the population appears to spawn in the mainstem of the Rogue River, primarily between river miles 86 and 126 (ODFW 1992). Choice of the downstream boundary of the population was based solely on the paucity of potential NP CHF spawning habitat within river miles 38-58. This area of sparse spawning habitat is located in the middle of an area commonly known as the Rogue River canyon.

No means could be devised to estimate CHF spawning escapement in the Middle Rogue population area. Spawned CHF carcasses were counted within two survey areas in most years from 1974 through 2004. Both surveys were located on the mainstem of the Rogue River. However, recovery efficiency, relative to the numbers of spawners within the entire population area, was not estimated during any of these years.

Few CHF of hatchery origin spawn in the Middle Rogue population area. Contemporary ODFW records indicate that hatchery fish were only released in the population area during two years in the late 1980s. During 1991-2004, surveyors recovered 29,871 spawned CHF carcasses and only four exhibited fin clips. Based on the proportion of smolts marked at the time of hatchery release, surveyors recovered an estimated 12 hatchery fish. This estimate indicated that hatchery fish composed less than 0.1% of the CHF that spawned in the Middle Rogue population area.

The Middle Rogue population is no longer monitored because of the termination of spawning surveys in 2004 and no funds are available to implement other types of monitoring methods. As a result, no management criteria will be proposed for this NP CHF population. However, annual counts of spawned NP CHF carcasses in the two survey areas were significantly related to NP CHF passage estimates at Huntley Park (Figure 5). This finding suggests that the Middle Rogue population would be covered, at least to some extent, by management criteria devised for pooled (aggregate) populations of NP CHF in the Rogue River Basin. A more detailed discussion of this topic is included in a succeeding section (*see* **Rogue Aggregate Populations**, page 25).

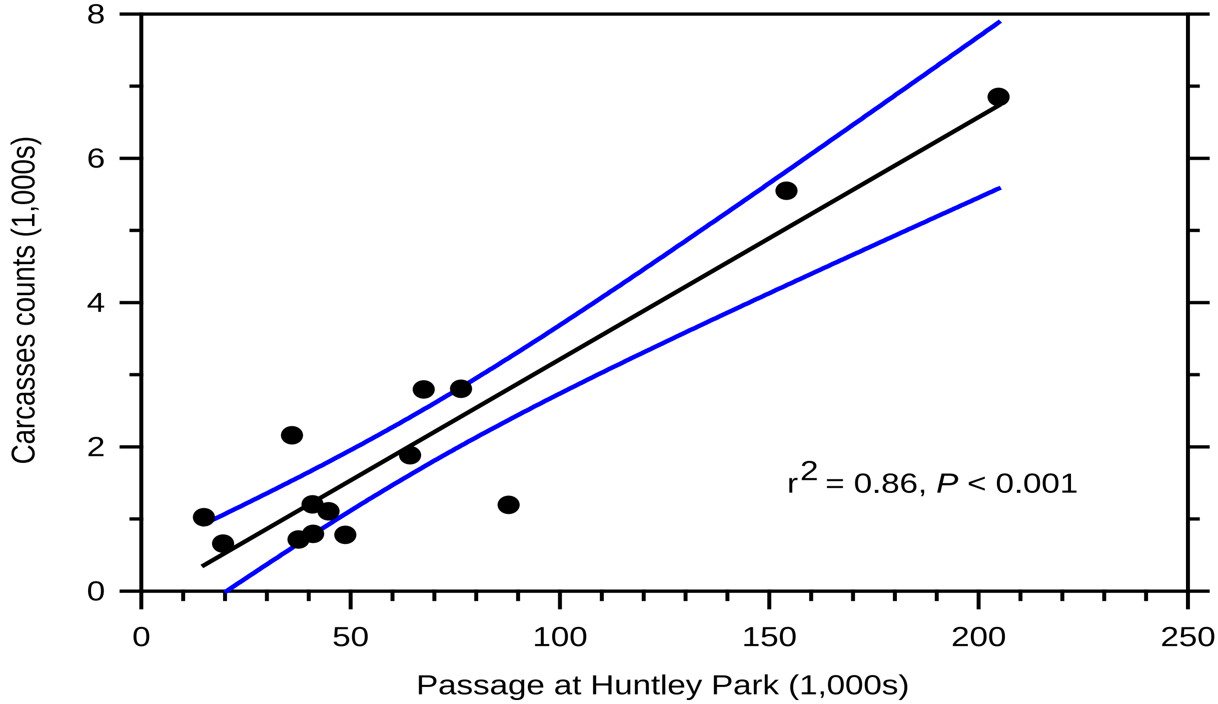

Figure 5. Relationship between annual counts of age 3-6 spawned carcasses in the Middle Rogue population area and estimates of naturally produced fall Chinook salmon that passed Huntley Park, 1990-2003. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Data prior to 1990 were not included in the analysis because of the increase in the Middle Rogue population during the 1980s (ODFW 1992). Confidence bounds could not be generated for these estimates.

Lower Rogue Population

The Lower Rogue population inhabits in areas between the estuary and river mile 48 on the Rogue River (*see* Figure 2, page 16). Of the 71 miles classified as NP CHF habitat by ODFW, tributary streams account for 28 miles and the mainstem of the Rogue River accounts for 43 miles. These estimates reflect application of a filter designed to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). During most years, the preponderance of the population appears to spawn in the larger tributary streams (primarily Lobster Creek) as compared with the mainstem of the Rogue River.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1962. However, during 1962-1985, surveys were mostly conducted only once annually on one small tributary stream. Beginning in 1986, surveys were conducted throughout the spawning season on multiple tributary streams. Using these more recent data, a method (*see* **APPENDIX D**) was devised to estimate the total spawner escapement within the population area.

Annual estimates of adult CHF that spawned in the Lower Rogue population area ranged between about 500 and 40,000 CHF during 1986-2011. Naturally produced fish dominated the annual spawning escapements (Figure 6). Spawner composition estimates averaged 3% hatchery fish (95% CI = 2-4% as estimated from arcsine transformed data) during the period of record. These estimates were derived from the brood-specific mark rates of CWTs recovered from spawned CHF carcasses. Naturally spawning hatchery fish appear to be primarily of local origin. All of the 49 CWTs recovered from spawned carcasses originated from juvenile CHF reared and released at Indian Creek Hatchery.

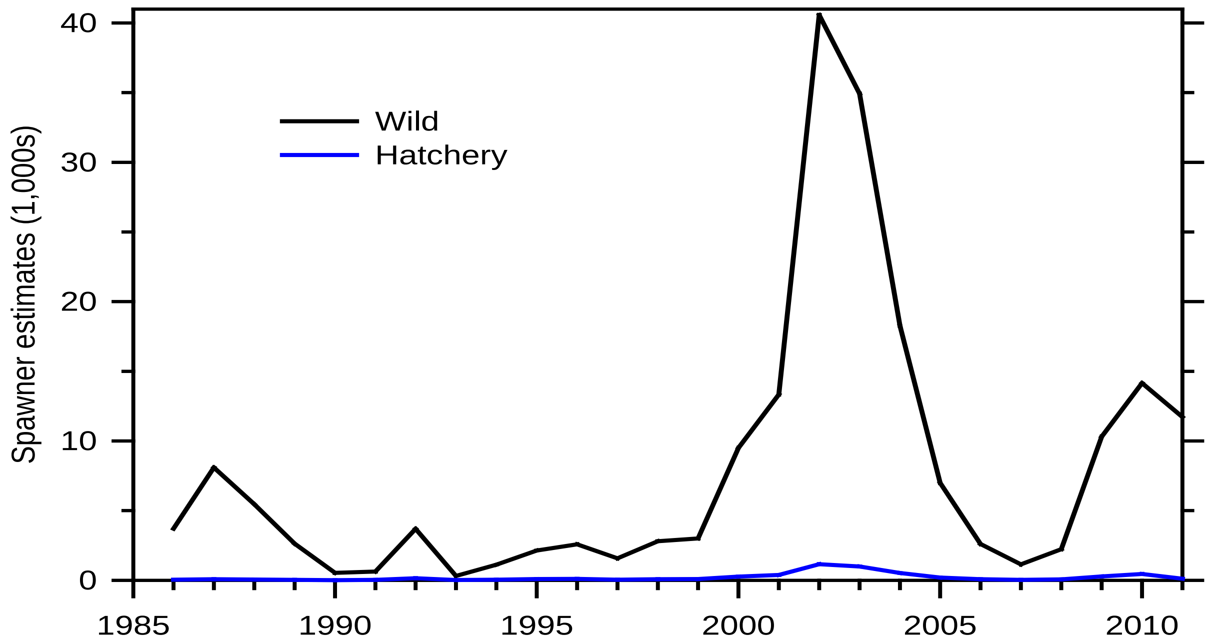

Figure 6. Estimated number of age 3-6 fall Chinook salmon that spawned in the Lower Rogue population area, 1986-2011. Annual estimates are listed in Appendix Table E-2. Confidence bounds could not be generated for these estimates.

Releases of CHF smolts at Indian Creek Hatchery began in 1986. Smolt releases have been relatively constant since 1997, averaging about 78,200 (95% CI = ±4,500) fish annually. These fish were released during July-September at sizes ranging between 10 and 35 fish per pound, depending on the release date. Releases of unfed CHF fry in the Lower Rogue population area began in 1986. During 1986-2011, releases of unfed fry averaged about 35,000 (95% CI = ±15,500) fish annually. Hatchery operations are currently guided by a hatchery genetic management plan (ODFW 2006b).

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 7. Several fundamental assumptions were made during derivation of these indexes, with a primary assumption of no difference between the age composition of NP CHF that returned to Lower Rogue population area and all NP CHF that entered the Rogue River.

Table 7. Summary of primary population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Lower Rogue population area, 1984-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1984-1985 brood years. Estimates for individual brood years are listed in Appendix Table E-6.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	10,205	4,356	2,300	13,382
Ocean harvest	2,297	490	238	2,469
Freshwater escapement[a]	8,127	2,908	1,793	8,715
Freshwater harvest[a]	358	211	113	661
Recruits/spawner	3.7	2.0	0.6	4.1
Ocean harvest rate	0.20	0.16	0.10	0.25
Freshwater harvest rate[a]	0.05	0.05	0.04	0.06
Brood harvest rate	0.25	0.23	0.15	0.27

[a] *Includes estuary.*

The Lower Rogue population accounted for an average of 8% (95% CI = 6-11% as estimated from arcsine transformed data) for the 1984-2006 broods of NP CHF produced in the Rogue River Basin. This conclusion was derived from a comparison of the number of NP CHF recruits produced in the Lower Rogue population area and the number of NP CHF recruits produced in the entirety of the Rogue River Basin (Appendix Tables E-5 and E-6).

Annual estimates of NP CHF spawning escapement in this population area were significantly related to NP CHF passage estimates at Huntley Park (Figure 7). This finding suggests that the Lower Rogue population would be covered, at least to some extent, by management criteria devised for pooled (aggregate) populations of NP CHF in the Rogue River Basin. However, spawning escapements in the Lower Rogue population area can be very low when passage estimates at Huntley Park are less than 40,000 age 3-6 NP CHF (Figure 7). Consequently, the Lower Rogue population should continue to be monitored with spawner surveys and management criteria were formulated for this population (*see* **DESIRED BIOLOGICAL STATUS**, page 106 and **CRITERIA INDICATING DETERIORATION IN STATUS**, page 133).

Applegate River Population

The Applegate River population inhabits areas between river mile 0 and river mile 47 of the Applegate River (*see* Figure 2, page 16). Of the 80 miles classified as NP CHF habitat by ODFW, tributary streams account for 33 miles and the mainstem of the Applegate River accounts for 47 miles. However, the preponderance of the population spawns in the mainstem of the Applegate River, primarily between river miles 0 and 26 (Fustish et al. 1988).

No means could be devised to estimate CHF spawning escapement in the Applegate River population area. Spawned CHF carcasses were counted within four survey areas in most years during 1977-2004. Three surveys were located on the mainstem of the Applegate River and one survey was located on a tributary. However, recovery efficiency, relative to the numbers of spawners within the entire population area, was not estimated during any of these years.

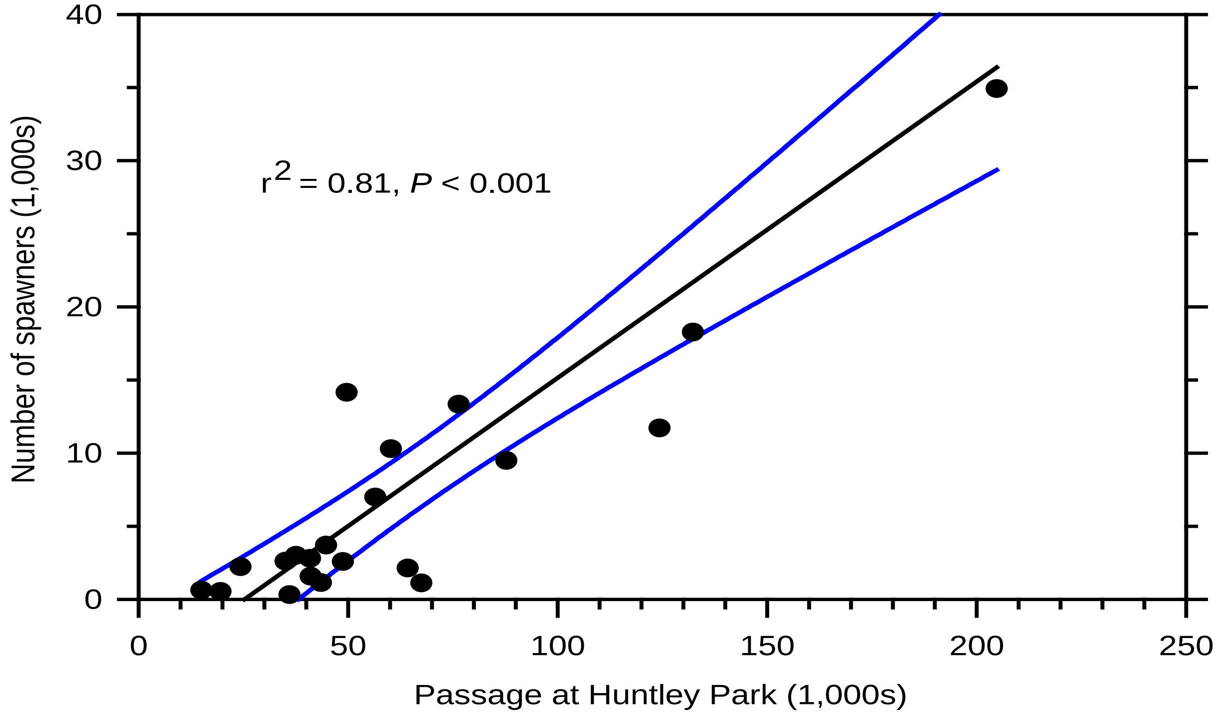

Figure 7. Relationship between annual estimates of the spawning escapement in the Lower Rogue population area and passage estimates at Huntley Park, for naturally produced age 3-6 fall Chinook salmon, 1990-2011. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Data prior to 1990 were not included in the analysis because of the increase in other Rogue populations during the 1980s (Fustish et al. 1988; ODFW 1992).

In addition, no inferences could be made, in relation to population size, from harvest estimates derived from salmon-steelhead cards because the Applegate River Basin was closed to CHF harvest during the entire period of record.

Few CHF of hatchery origin spawn in the Applegate River population area. Contemporary ODFW records indicate that hatchery fish were only released in the population area during 1981. During 1991-2004, surveyors recovered 15,555 spawned CHF carcasses; of which only two exhibited fin clips. Based on the proportion of smolts marked at the time of hatchery release, surveyors recovered an estimated 6 hatchery fish. This estimate indicated that hatchery fish composed less than 0.1% of the CHF that spawned in the Applegate River population area.

The Applegate population is no longer monitored because of the termination of spawning surveys in 2004 and no funds are available to implement other types of monitoring methods. As a result, no management criteria will be proposed for this NP CHF population. However, annual counts of spawned NP CHF carcasses in the four survey areas were significantly related to NP CHF passage estimates at Huntley Park (Figure 8). This finding suggests that the Applegate population would be covered, at least to some extent, by management criteria devised for pooled (aggregate) populations of NP CHF in the Rogue River Basin. A more detailed discussion of this topic is included in a succeeding section (*see* **Rogue Aggregate Populations**, page 25).

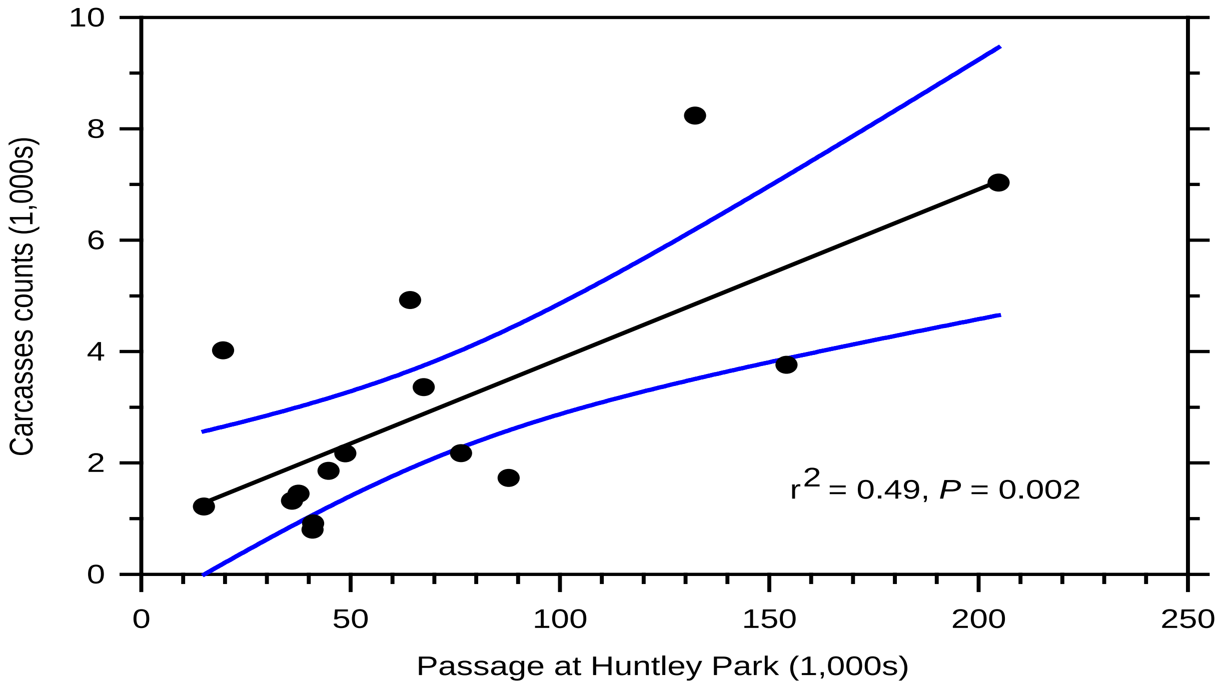

Figure 8. Relationship between annual counts of age 3-6 spawned carcasses in the Applegate population area and estimates of naturally produced fall Chinook salmon that passed Huntley Park, 1990-2004. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Data prior to 1990 were not included in the analysis because of the increase in the Middle Rogue population during the 1980s (Fustish et al. 1988).

Illinois River Population

The Illinois River population inhabits areas between river mile 0 and river mile 61 of the Illinois River (*see* Figure 2, page 16). Of the 164 miles classified as NP CHF habitat by ODFW, tributary streams account for 104 miles and the mainstem of the Illinois River accounts for 60 miles. The spawning distribution of the population is unknown, although it is suspected that the primary spawning locations are located in the mainstem near the town of Kerby and in lower portions of the East and West Forks. Prior to the construction of the fish ladder at Illinois River Falls in 1962, CHF spawned only in areas farther downstream during most years (Rivers 1964). ODFW estimates there are 58 miles of NP CHF habitat downstream of Illinois River Falls (includes mainstem and tributary streams). Based on this estimate, construction of the fish ladder in 1962 increased the amount of NP CHF habitat in the Illinois River Basin from 58 miles to 164 miles.

No means could be devised to estimate CHF spawning escapement in the Illinois population area. Spawned CHF carcasses were counted systematically during 1996-2004 within portions of three small tributary streams located in the upper portion of the Illinois River Basin. However, recovery efficiency, relative to the numbers of spawners within the entire population area, was not estimated during any of these years. In addition, no inferences could be made, in relation to population size, from harvest estimates derived from salmon-steelhead cards because the Illinois River Basin was closed to CHF harvest during the entire period of record. Given the virtual absence of appropriate data, it is important to determine, at a minimum, whether the abundance of NP CHF in the Illinois population area co-varies in relation to the other NP CHF populations in the Rogue Stratum (*see* **Research Needs**, page 142).

Few CHF of hatchery origin appear to spawn in the Illinois population area. It appears that hatchery CHF have not been released in the population for about 100 years (Rivers 1964). During 1996-2004, surveyors recovered about 350 spawned CHF carcasses; only one of which exhibited a fin clip. Based on the proportion of smolts marked at the time of hatchery release, surveyors recovered an estimated 3 hatchery fish. This estimate indicated that hatchery fish composed less than 1% of the CHF that spawned in the Illinois population area.

Rogue Aggregate Populations

Among the five populations of fall Chinook salmon that inhabit the Rogue River Basin, ODFW currently monitors spawning escapement only for the Lower Rogue population. Consequently, with the exception of the Lower Rogue population, it is not currently possible to develop management criteria for most of the populations in the Rogue population stratum. However, management criteria can be developed for aggregated populations in the stratum because ODFW monitors adult CHF that pass Huntley Park (RM 8). Primary metrics of NP CHF that can be estimated from this sampling include adult abundance, age composition, run timing, and migrant composition (*see* **APPENDIX C** for description of estimation methods). While it would be desirable to monitor each population (*see* **Monitoring Needs**, page 139 and **Research Needs**, page 142), NP CHF abundance co-varies significantly among all of the populations in the Rogue River Basin (Table 8). These relationships indicate that management criteria devised for pooled (aggregate) populations of NP

Table 8. Relationships between annual indexes of the abundance of naturally produced fall Chinook salmon in five population areas within the Rogue River Basin, 1990-2011. Coefficients of determination (r^2 adjusted for sample size) are shown in the table. All r^2 values were significant at a significance level of P <0.02. Data included in the analyses are described in the profiles for each population and the aggregated populations.

	Population			
Population	**Aggregate**	**Upper Rogue**	**Middle Rogue**	**Lower Rogue**
Upper Rogue	**0.86**	**--**		
Middle Rogue	**0.86**	**0.73**	**--**	
Lower Rogue	**0.81**	**0.66**	**0.78**	**--**
Applegate	**0.49**	**0.49**	**0.48**	**0.30**

CHF in the Rogue River Basin would cover, at least to some extent, all of the individual populations. Co-variation in the abundance of adult salmon in proximal areas has also been documented in other instances (Pyper et al. 2005; Malick et al. 2009).

Spawning escapement within the entire Rogue population stratum can be estimated based on estimates of the number of fish passing Huntley Park, reduced by harvest and prespawning mortality during the period of freshwater migration. Passage estimates were generated based on systematic sampling with a large beach seine (net) during 1974-2011. Two means were devised by which to calibrate CHF seine catches so as to estimate the number of CHF adults that annually entered freshwater. Methods to estimate freshwater escapement, freshwater harvest, and prespawning mortality are described in **APPENDIX C.**

Annual estimates of age 2-6 CHF passing Huntley Park during 1974-2011 ranged between about 18,000 and 230,000 fish and averaged about 95,000 (95% CI = ±18,000) fish. Naturally produced fish dominated the annual returns (Figure 9) and hatchery fish accounted for an average of 3% of the returns (95% CI = 2-4% as estimated from arcsine transformed data) during the period of record. These estimates were derived from the brood-specific mark rates of fin clipped CHF seined at Huntley Park.

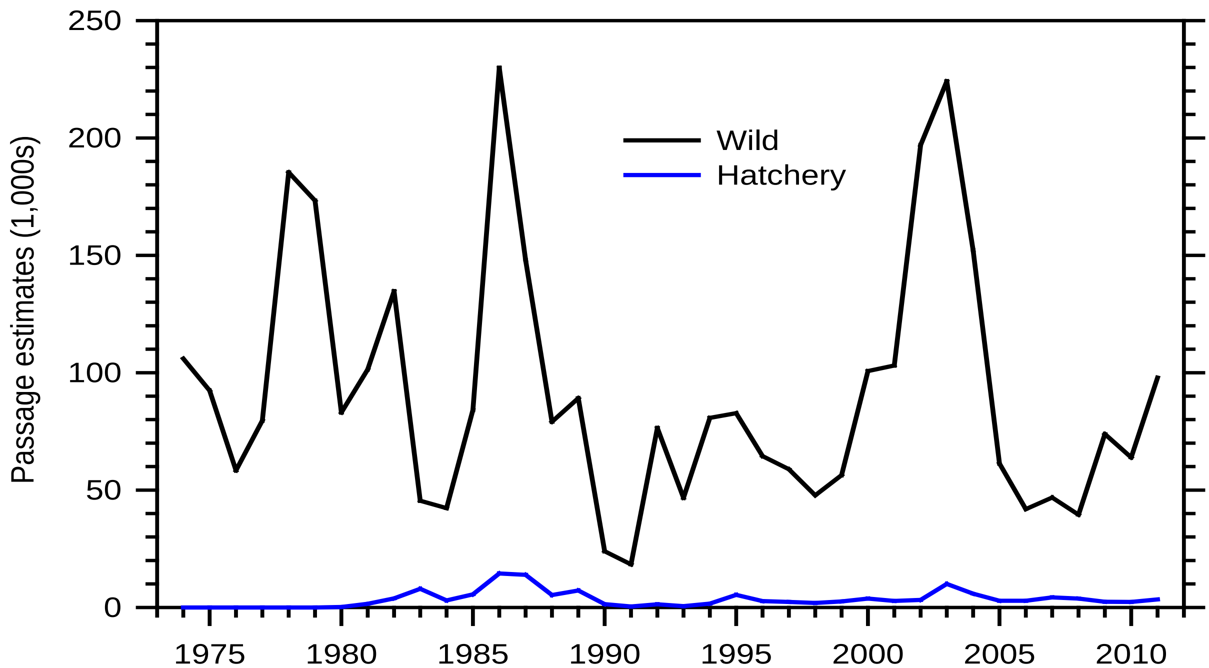

Figure 9. Estimated number of age 2-6 fall Chinook salmon that passed Huntley Park, 1974-2011. Annual estimates are listed in Appendix Table E-1. Confidence bounds could not be generated for these estimates.

Among hatchery CHF that enter the Rogue River, almost all appear to have been released as juveniles at hatchery facilities in either the Rogue or Klamath river basins. Of the 129 CWTs recovered from seined CHF at Huntley Park during 1977–2010, 71 were of Rogue River Basin origin, 56 were of Klamath River Basin origin, and 2 were of Columbia River Basin origin. While Klamath CHF accounted for 43% of the CWTs collected while seining near the mouth of the Rogue River, Klamath CHF accounted for less than 1% of the CWTs collected during carcass surveys of CHF spawning in the Rogue River Basin. Two factors may account for this difference. First, Klamath CHF may have primarily spawned in non-surveyed areas of the Rogue River Basin. Second, some Klamath CHF temporarily enter the Rogue River, re-enter the ocean, and eventually return to the Klamath River Basin (Smith et al. 1978).

Cohort reconstruction methods (**APPENDIX C**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 9. Several fundamental assumptions, described in **APPENDIX C,** were associated with the derivation of these estimates.

Table 9. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon produced in all population areas of the Rogue River Basin, 1972-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1972-1973 brood years. Estimates for individual brood years are listed in Appendix Table E-5.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	136,694	82,591	58,589	196,917
Ocean harvest	60,982	27,551	6,893	72,502
Freshwater escapement[a]	73,118	53,266	40,818	91,438
Freshwater harvest[a]	5,715	4,448	2,954	8,712
Recruits/spawner	3.2	2.1	0.7	4.4
Ocean harvest rate	0.33	0.27	0.12	0.48
Freshwater harvest rate[a]	0.07	0.07	0.02	0.09
Brood harvest rate	0.40	0.32	0.23	0.57

[a] *Includes estuary.*

Freshwater harvest of age 3-6 CHF increased after 1985 (Figure 10). Freshwater harvest estimates averaged 3,602 (95% CI = 2,602-3,521) CHF during 1956-1984 and averaged 7,357 (95% CI = 5,646-9,069) CHF during 1985-2009. A t-test, assuming unequal variances, indicated that the difference was significant ($P < 0.001$). Increases in freshwater harvest likely resulted from the increased desirability of healthier CHF to anglers as a result of improved water quality (ODFW 1992).

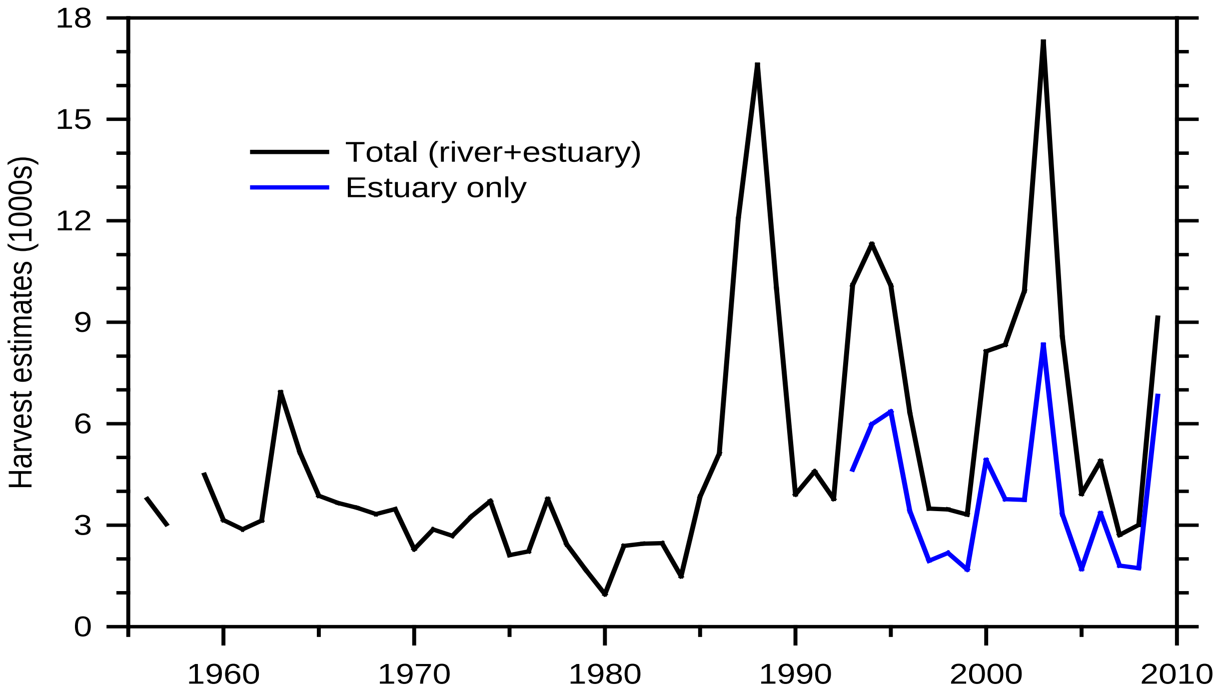

Figure 10. Freshwater harvest of age 3-6 fall Chinook salmon in the Rogue River as estimated from salmon-steelhead cards returned by anglers, 1956-2009. Estuary harvest was not estimated before 1993. Confidence bounds could not be generated for these estimates.

Fall Chinook salmon enter the Rogue River from the middle of July through late autumn, with most fish entering freshwater during August and September (Figure 11). Run timing varies among years (Figure 11) and is primarily dependent on run composition because of differences in time of freshwater entry among constituent populations; although river temperature may also have some short-term effect (Strange 2010). Adults originating from the Upper Rogue population enter freshwater first and are sequentially followed by counterparts that originate from the Middle Rogue, Applegate, Illinois, and Lower Rogue population areas (ODFW 1992). Tags applied at Huntley Park and subsequently recovered on spawned CHF indicate that the Illinois and Lower Rogue populations primarily pass Huntley Park during October (ODFW 1992).

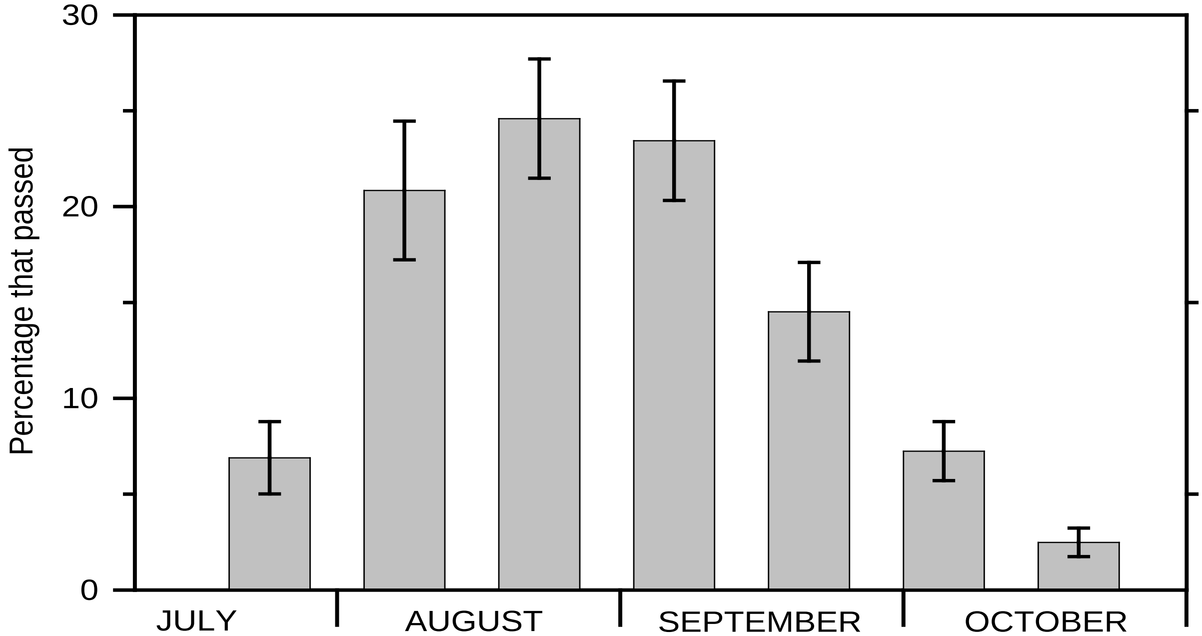

Figure 11. Mean migration timing of age 2-6 fall Chinook salmon that passed Huntley Park, 1976-2011. Brackets represent the 95% confidence intervals associated with the means, as estimated from arcsine transformed data. Some fish also pass Huntley Park after sampling terminates in late October.

Naturally produced fall Chinook salmon of Rogue River Basin origin mature at ages 2-6. During a typical return year, age 3 and age 4 fish each account for about one-third of the NP CHF that enter the Rogue River. However, the age composition of returning NP CHF varies markedly among years (Figure 12). Age 2 adults (jacks) typically compose about 20% of the run, while age 5 and age 6 adults collectively compose less than 10% of the returning NP CHF during a typical year (Figure 12).

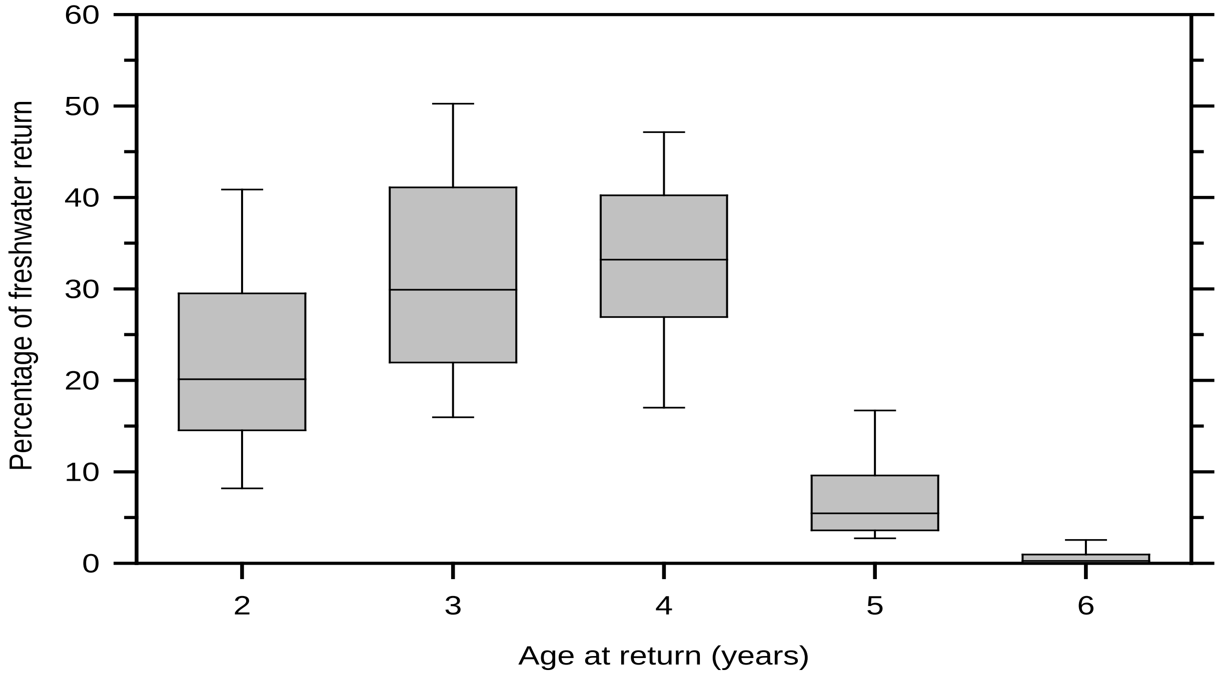

Figure 12. Median age composition of naturally produced fall Chinook salmon that passed Huntley Park, 1974-2011. Boxes represent the 25th and 75th percentiles and the brackets represent the 10th and 90th percentiles.

Coastal Stratum

Euchre Creek Population

ODFW estimates there are 12.5 miles of NP CHF habitat in the Euchre Creek Basin (Figure 13). Tributary streams account for 3.9 miles of habitat and the mainstem of the Euchre Creek accounts for 8.6 miles of habitat. These estimates reflect application of a filter designed to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). Surveys indicate that CHF spawn primarily in the mainstem of Euchre Creek as compared with the tributary streams.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1986. During succeeding years, multiple surveys were conducted throughout the spawning season. Data generated during these surveys were used to estimate spawner escapements within the population area (see **APPENDIX D**).

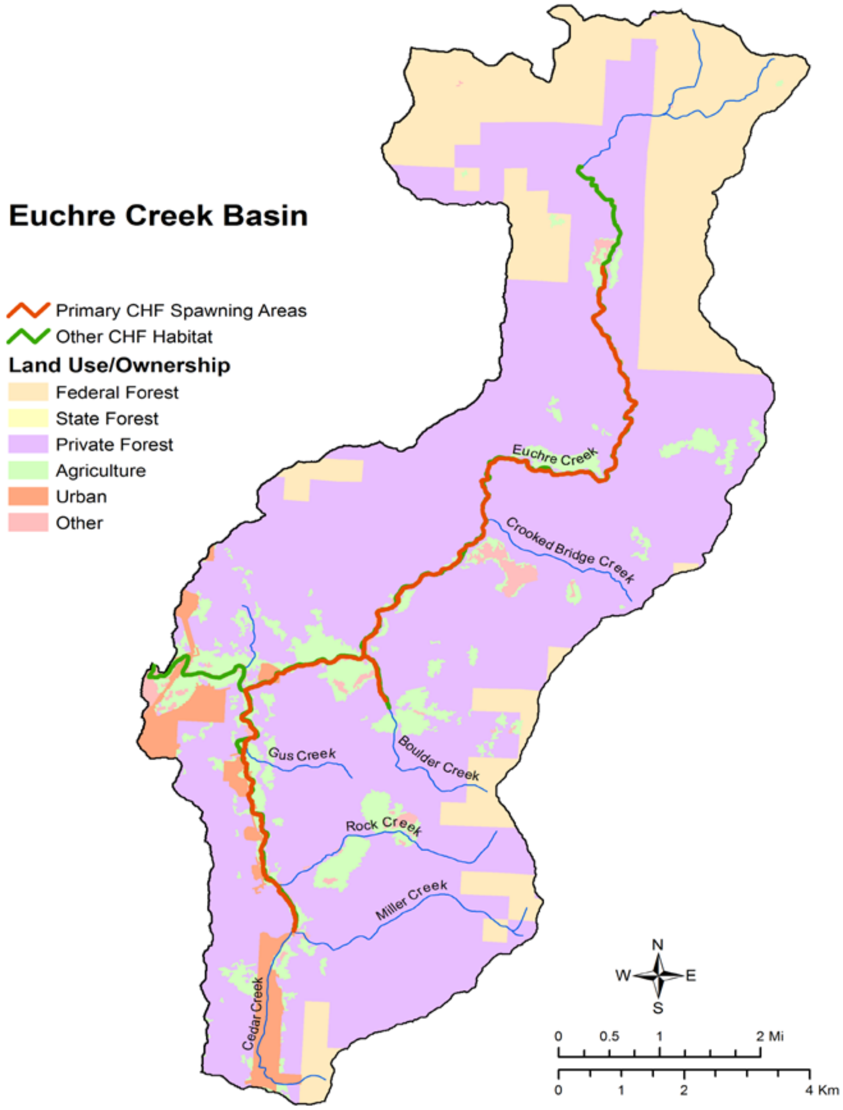

Figure 13. Map of the Euchre Creek Basin. Euchre Creek drains into the Pacific Ocean.

Annual estimates of adult CHF that spawned in the Euchre Creek population area ranged from about 20 to 500 CHF during 1986-2011 (Figure 14). Naturally spawning hatchery fish appeared to be primarily of local origin. Of the seven CWTs recovered from spawned carcasses, six originated from juvenile CHF released in nearby Elk River. No groups of CWT marked smolts have been released in Euchre Creek. As there were few CWTs recovered in individual years, data from all years had to be pooled to estimate hatchery contribution to the spawning population. With the application of brood-specific mark rates of CWTs recovered from spawned CHF carcasses, this approach resulted in an estimate of 49% hatchery fish among the spawners for all years combined.

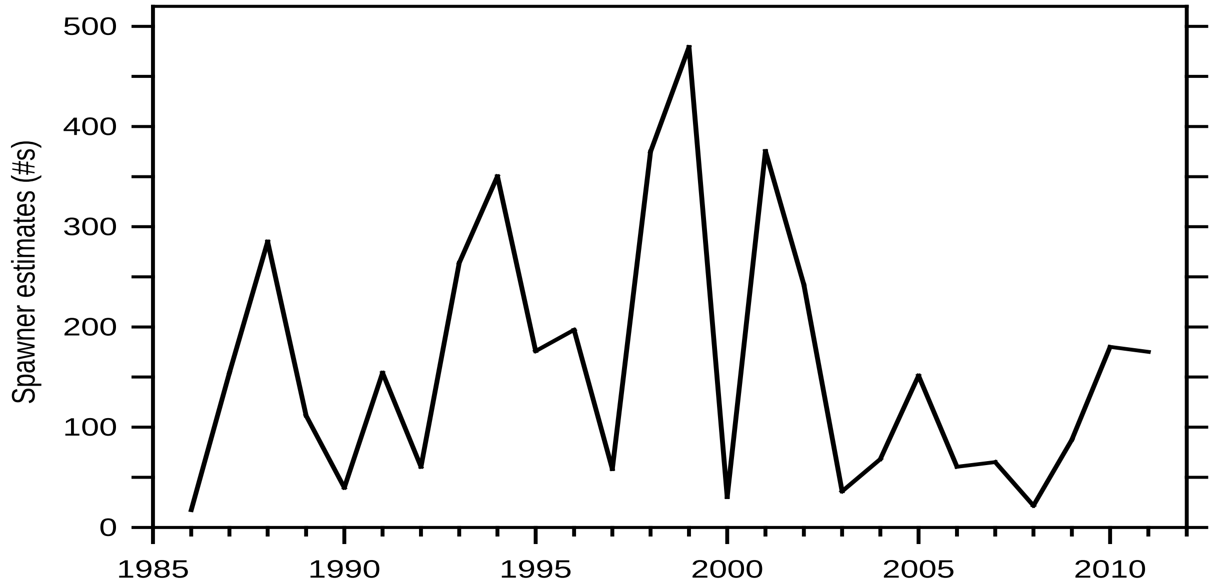

Figure 14. Estimated number of age 3-6 fall Chinook salmon that spawned in the Euchre Creek population area, 1986-2011. Hatchery fish composed about 50% of the spawners, averaged over all years. Annual estimates are listed in Appendix Table E-3. Confidence bounds could not be generated for these estimates.

Unmarked hatchery smolts, of Elk River origin, were released in the population area during 1985-1987. These releases averaged about 18,000 fish annually. In addition, unfed fry were released most years between 1985 and 2008. Releases during these years averaged 39,000 (95% CI = ±23,000) fry annually. Most of the releases originated from broodstocks collected in Elk River, but a few releases originated from broodstocks collected in the Lower Rogue population area.

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 10. Several fundamental assumptions, described in **APPENDIX D,** were associated with the derivation of these estimates.

The Euchre Creek Basin currently produces only small numbers of NP CHF. Historical information indicates that production in the basin may have never been large. Federal documents dating from the 1890s (Collins 1892; Wilcox 1895) and Oregon documents from the 1880s - 1920s (Fish and Game Protector, Fish Warden, and State Fish Commissioner) failed to mention commercial fisheries for salmon in Euchre Creek but referenced such fisheries in all of the other south coastal population areas except Hunter Creek. Similarly, harvest regulations allowed for the commercial harvest of CHF in all of the coastal population areas of the Rogue SMU during 1878-1937 with the exception that Euchre and Hunter Creeks were closed during 1901-1926 (Gharrett 1953).

Table 10. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Euchre Creek population area, 1983-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1983-1985 brood years. Estimates for individual brood years are listed in Appendix Table E-7.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	118	113	60	166
Ocean harvest	35	24	8	37
Freshwater escapement[a]	87	78	40	118
Freshwater harvest[a]	<1	0	0	0
Recruits/spawner	1.4	0.7	0.3	1.9
Ocean harvest rate[b]	0.27	0.19	0.14	0.41
Ocean harvest rate[c]	<0.01	<0.01	<0.01	<0.01
Freshwater harvest rate[a]	<0.01	0.00	0.00	<0.01
Brood harvest rate	0.27	0.19	0.14	0.41

[a] *Includes estuary.*
[b] *General season (May-September).*
[c] *Chetco terminal fishery (October-November).*

Records of recreational harvest, in conjunction with assessments of historical habitat conditions, also suggested that NP CHF production in the Euchre Creek Basin was historically low. Estimates of recreational harvest first became available in 1956 from salmon-steelhead cards (punchcards). Initially, all of the coastal population areas, except Euchre Creek, were listed on salmon-steelhead cards in 1956. Euchre Creek was not added as a harvest location until 1969. From 1969 through 1991, when Euchre Creek was open to the harvest of CHF, the harvest of CHF in Euchre Creek averaged 7% of the harvest in Hunter Creek, 6% of the harvest in the Pistol River, and 3% of the harvest in the Winchuck River.

Developmental impacts on habitat do not appear to account for the low production of NP CHF in the Euchre Creek Basin. Habitat conditions in the Hunter Creek Basin and the Pistol River Basin exhibit some degree of commonality with the Euchre Creek Basin in that all three basins (1) were logged extensively in the 1950s and 1960s, (2) exhibit high rates of sediment movement, and (3) steam channels are relatively constrained (Maguire 2001a; Maguire 2001b; Maguire 2001c). In addition, as compared to the Hunter Creek and Pistol River basins, base flow during summer is greater in Euchre Creek and the water temperature during summer is cooler (*see* **Habitat Quality**, page 77). Estuary size appears to be the most obvious factor that may account for the low NP CHF production in Euchre Creek. The wetted area of the Euchre Creek estuary is half the size of the wetted are of the Hunter Creek estuary and is only one quarter of the size of the wetted area of the Pistol River estuary. Estuary size appears to be a primary factor that limits NP CHF production in the coastal population areas (*see* **Estuary Habitat:**, page 81) and most of the Euchre Creek estuary appears to be relatively unaffected by development (Maguire 2001a).

The Euchre Creek population of NP CHF is estimated to have a very low probability of persistence (*see* **VIABILITY OF THE SPECIES MANAGEMENT UNIT**, page 111). This finding, coupled with the relatively small amount of important estuary habitat, may indicate that the population was never viable as a stand-alone population. Accordingly, within this plan, NP CHF in Euchre Creek are classified as a dependent population rather than an independent population. A genetic assessment is needed to evaluate this conclusion and such an assessment is proposed for all of the coastal NP CHF populations covered by this conservation plan (*see* **Research Needs**, page 142). Classification as a dependent population, until completion of a genetic assessment, does not affect viability of the coastal stratum of the Rogue SMU because all of the other coastal populations exhibit very high (>99%) estimates of population persistence.

Hunter Creek Population

ODFW estimates there are 9.1 miles of NP CHF habitat in the Hunter Creek Basin (Figure 15). Tributary streams account for 0.6 miles of habitat and the mainstem of the Hunter Creek accounts for 8.5 miles of habitat. These estimates reflect application of a filter designed to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). Surveys indicate that CHF spawn primarily in the mainstem of Hunter Creek as compared with the tributary streams.

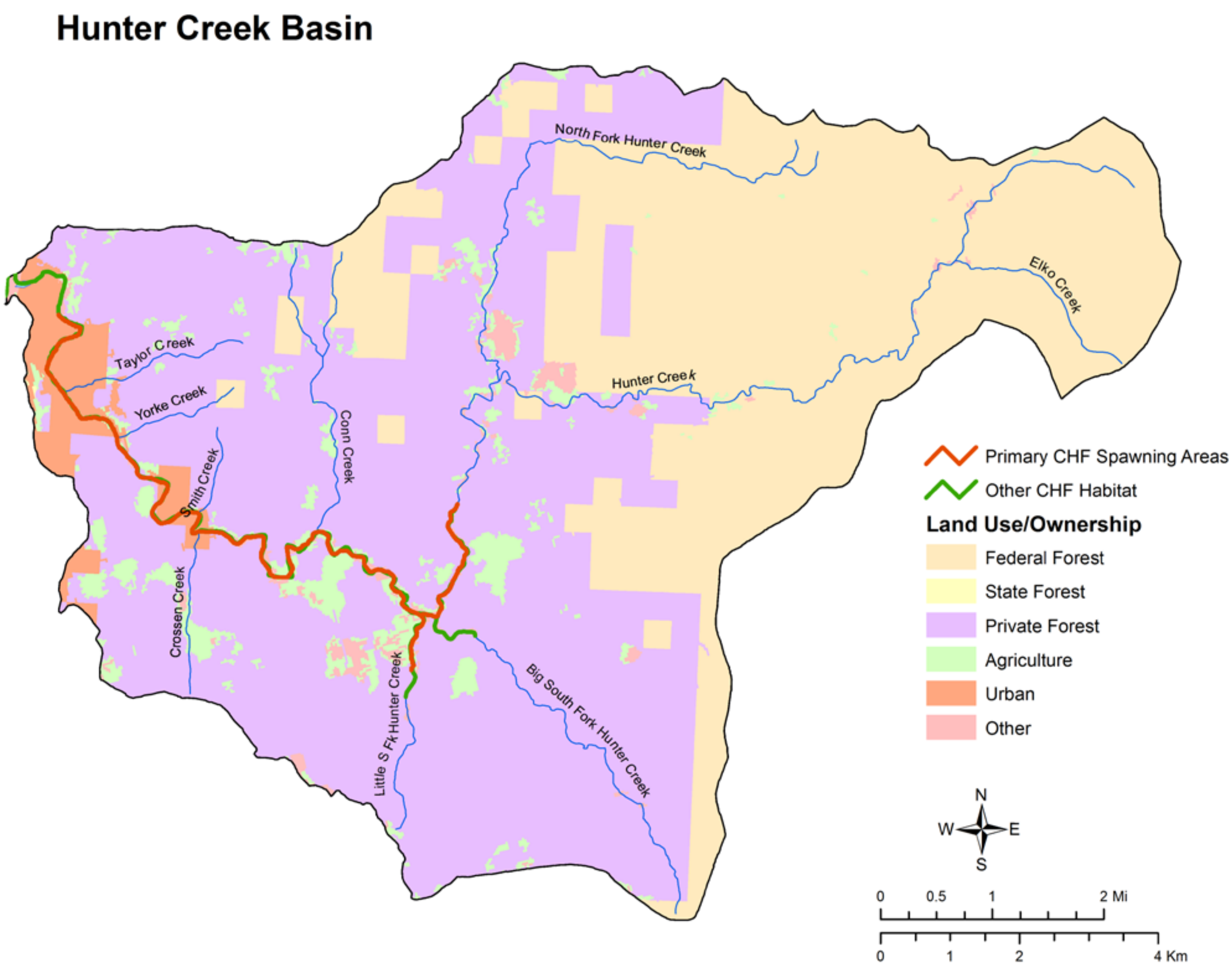

Figure 15. Map of the Hunter Creek Basin. Hunter Creek drains into the Pacific Ocean.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1986. However, during 1986-1988, surveys were conducted only once or twice annually within one survey area. Beginning in 1989, surveys were conducted throughout the spawning season in multiple survey areas. Data generated during these surveys were used to estimate spawner escapements within the population area (see **APPENDIX D**).

Annual estimates of adult CHF that spawned in the Hunter Creek population area ranged between about 80 and 1,900 CHF during 1989-2011. Naturally produced fish dominated the annual spawning escapements, except during a portion of the 1990s (Figure 16). During the period of record, spawner composition estimates averaged 6% hatchery fish (95% CI = 4-10% as estimated from arcsine transformed data). This estimate was derived from the brood-specific mark rates of CWTs recovered from spawned CHF carcasses. Naturally spawning hatchery fish were primarily of local origin. Of the 90 CWTs recovered from spawned carcasses, 47 originated from juvenile CHF released in Hunter Creek, 31 originated from CHF released in Pistol River, and 11 originated from CHF released in the Lower Rogue population area.

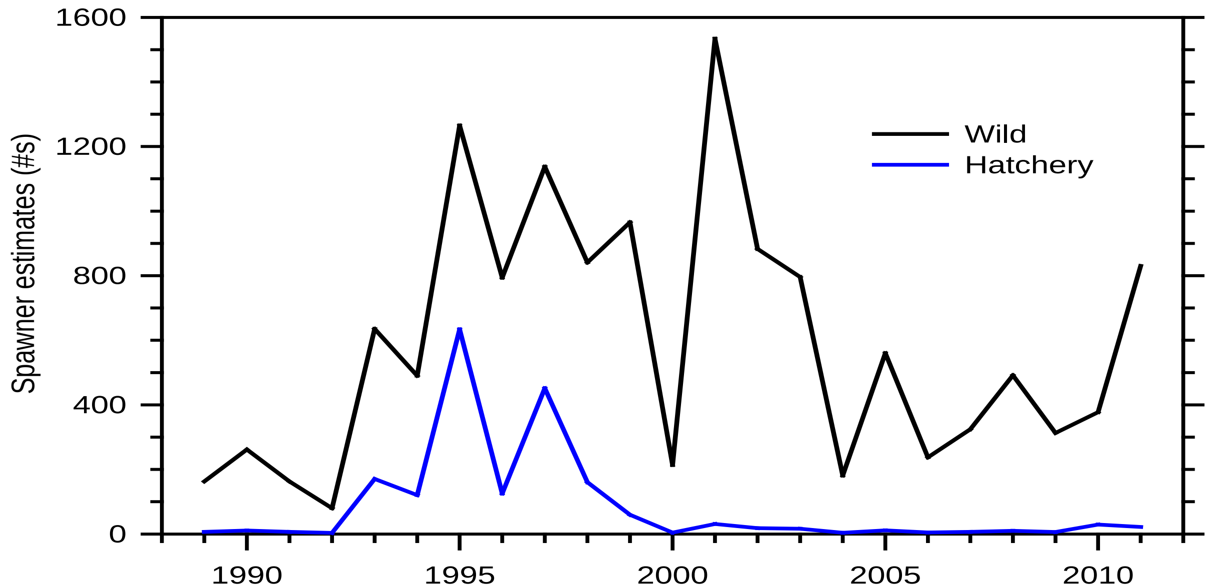

Figure 16. Estimated number of fall Chinook salmon that spawned in the Hunter Creek population area, 1989-2011. Annual estimates are listed in Appendix Table E-3. Confidence bounds could not be generated for these estimates.

Hatchery CHF smolts were released in the Hunter Creek population area during most years between 1985 and 1996. Smolt releases during this period averaged about 10,700 (95% CI = ±7,300) fish annually. These fish were released during June-November at sizes ranging between 6 and 24 fish per pound, depending on the release date. In addition, some fed fry were released during 1987-1992 and some unfed fry were released during 1993-1996. All hatchery fish originated from broodstocks collected in the Hunter Creek population area and fed juveniles were reared at Elk River Hatchery.

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 11. Several fundamental assumptions, described in **APPENDIX D,** were associated with the derivation of these estimates.

Table 11. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Hunter Creek population area, 1986-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1986-1988 brood years. Estimates for individual brood years are listed in Appendix Table E-8.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	753	648	434	1,156
Ocean harvest	159	129	77	239
Freshwater escapement[a]	609	514	333	932
Freshwater harvest[a]	5	5	0	10
Recruits/spawner	2.5	1.4	0.4	2.9
Ocean harvest rate[b]	0.22	0.19	0.13	0.23
Ocean harvest rate[c]	0.01	0.01	<0.01	0.01
Freshwater harvest rate[a]	0.01	0.01	0.00	0.01
Brood harvest rate	0.23	0.20	0.15	0.25

[a] *Includes estuary.*
[b] *General season (May-September).*
[c] *Chetco terminal fishery (October-November).*

Pistol River Population

ODFW estimates there are 24.2 miles of NP CHF habitat in the Pistol River Basin (Figure 17). Tributary streams account for 10.4 miles of habitat and the mainstem of the Pistol River accounts for 13.8 miles of habitat. These estimates reflect application of a filter designed to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). Surveys have only been conducted in tributary streams so the relative importance of the spawning areas in the mainstem remains unknown.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1959. However, during 1959-1986, surveys were mostly conducted only once annually on one small tributary stream. Beginning in 1987, surveys were conducted throughout the spawning season on multiple tributary streams. Data generated during these later surveys were used to estimate spawner escapements within the population area (see **APPENDIX D**).

Annual estimates of adult CHF that spawned in the Pistol River population area ranged between about 200 and 4,200 CHF during 1986-2011. Naturally produced fish dominated the annual spawning escapements, except during a portion of the 1990s (Figure 18). During the period of record, spawner composition estimates averaged 8% hatchery fish (95% CI = 5-12% as estimated from arcsine transformed data). This estimate was derived from the brood-specific mark rates of CWTs recovered from spawned CHF carcasses. Naturally spawning hatchery fish were primarily of local origin. Of the 46 CWTs recovered from spawned carcasses, 34 originated from juvenile CHF released in the Pistol River and 10 originated from CHF released in Hunter Creek.

Hatchery CHF smolts were released in the Pistol River population area during most years between 1985 and 1995. Smolt releases during this period averaged about 24,000 (95% CI =

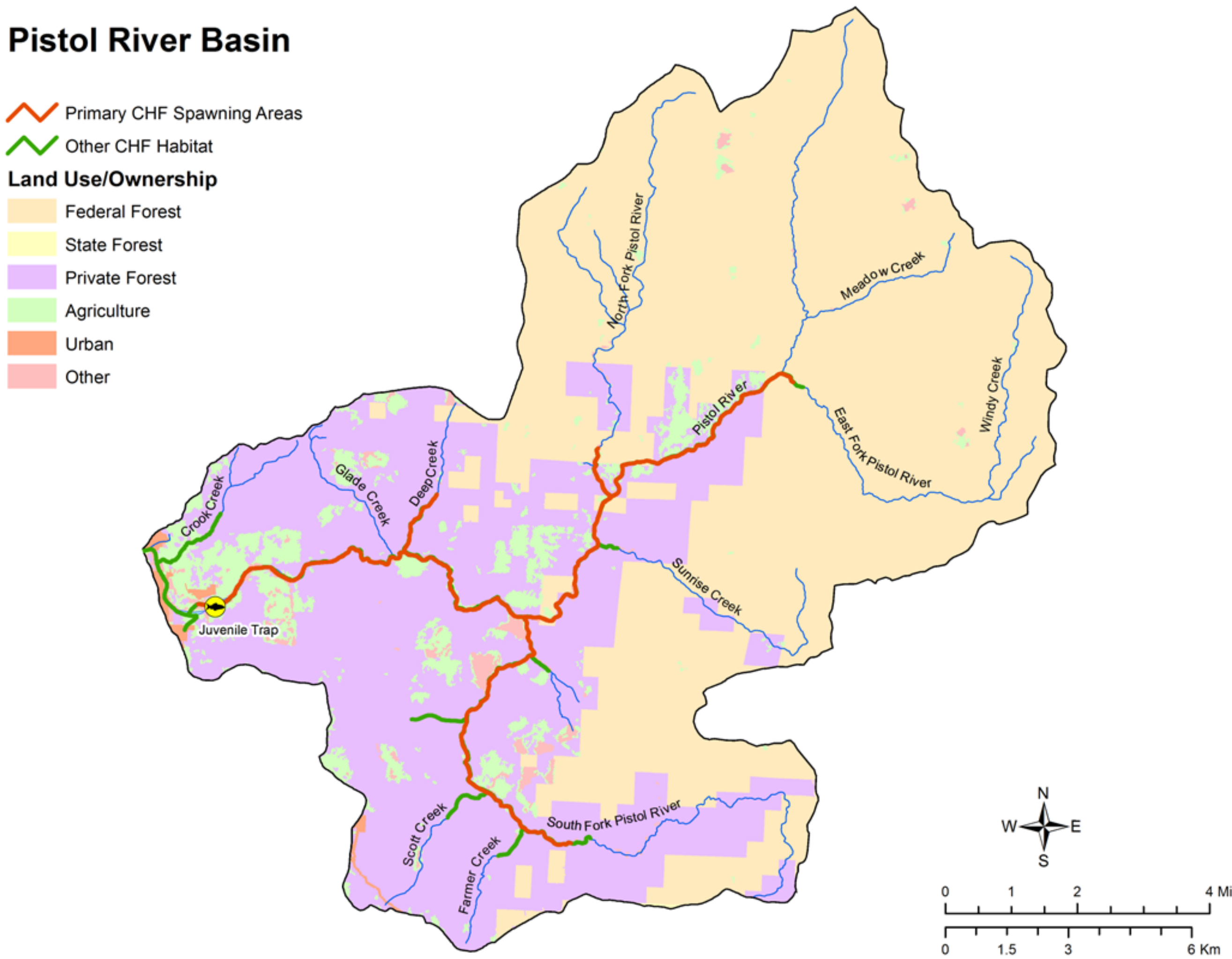

Figure 17. Map of the Pistol River Basin. The Pistol River drains into the Pacific Ocean.

±12,900) fish annually. These fish were released during July-December at sizes ranging between 8 and 50 fish per pound, depending on the release date. In addition, some fed fry were released during 1988-1990 and some unfed fry were released during 1989 and 1994. All hatchery fish released in the system originated from broodstocks collected in the Pistol River population area, except the 1989 release of unfed fry originated from broodstock collected in the Chetco River population area. Fed juveniles were reared at Elk River Hatchery.

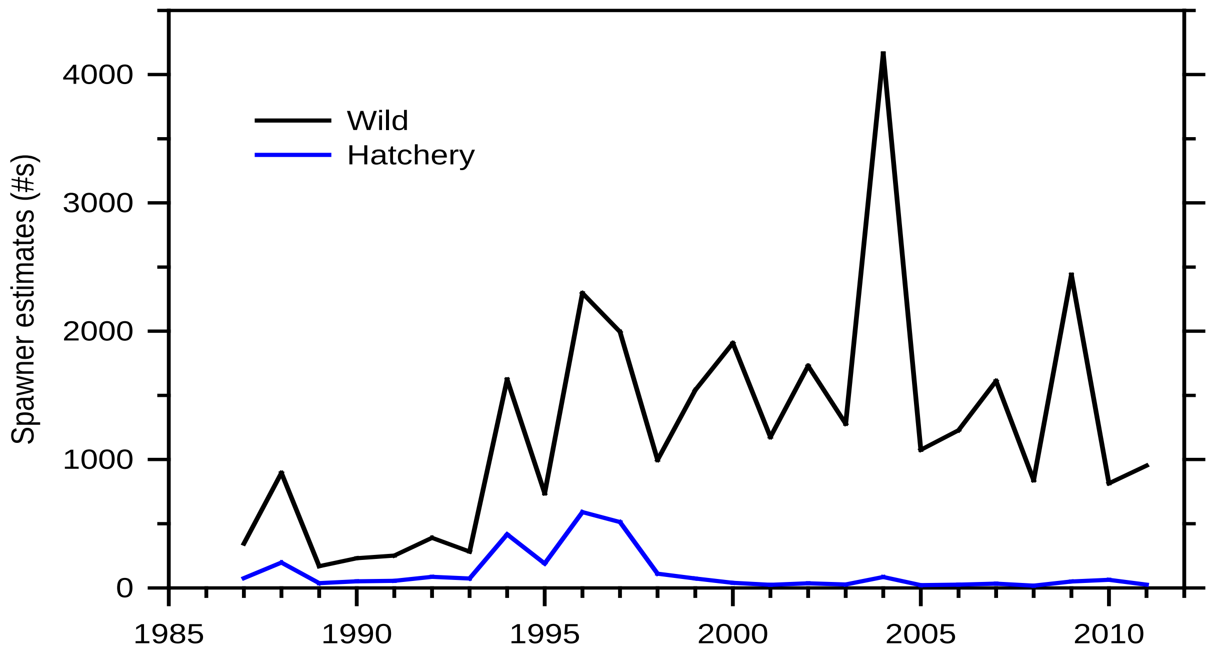

Figure 18. Estimated number of age 3-6 fall Chinook salmon that spawned in the Pistol River population area, 1987-2011. Annual estimates are listed in Appendix Table E-3. Confidence bounds could not be generated for these estimates.

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 12. Several fundamental assumptions, described in **APPENDIX D,** were associated with the derivation of these estimates.

Table 12. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Pistol River population area, 1984-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1984-1985 brood years. Estimates for individual brood years are listed in Appendix Table E-9.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	**1,681**	**1,630**	**689**	**2,118**
Ocean harvest	**433**	**325**	**208**	**468**
Freshwater escapement[a]	**1,287**	**1,410**	**589**	**1,788**
Freshwater harvest[a]	**20**	**17**	**9**	**33**
Recruits/spawner	**2.2**	**1.6**	**0.9**	**2.8**
Ocean harvest rate[b]	**0.26**	**0.21**	**0.13**	**0.35**
Ocean harvest rate[c]	**0.02**	**0.02**	**0.01**	**0.02**
Freshwater harvest rate[a]	**0.01**	**0.02**	**0.01**	**0.02**
Brood harvest rate	**0.29**	**0.24**	**0.16**	**0.39**

[a] *Includes estuary.*
[b] *General season (May-September).*
[c] *Chetco terminal fishery (October-November).*

Another important population metric is available for NP CHF produced in the Pistol population area. During 1993-2002, ODFW operated a juvenile fish trap just upstream of the Pistol River estuary. Weekly releases of marked fish upstream of the trap were used to estimate the number of subyearling migrants that entered the estuary. Estimates include only NP CHF because hatchery fish were not stocked in the Pistol River population area during those years.

Annual estimates of juvenile NP CHF production ranged between 50,000 and 290,000 migrants (Figure 19) and averaged 165,000 (95% CI = ±60,000) migrants for the period of record. Estimated migrant-recruit survival rates for NP CHF in the Pistol River population area averaged 1.6% (95% CI = 1.0-2.4% as estimated from arcsine transformed data) for the 1992-2001 brood years. In comparison, Bradford (1995) estimated marine survival rates of 1.1-1.5% for three populations of wild "ocean-type" Chinook salmon that reared 2-6 months in freshwater. It should be noted that estimates of migrant production in the Pistol River may not directly relate to the number of smolts that eventually entered the ocean. Many of the migrants that entered the Pistol River estuary were less than 9 cm in length. Analyses of scales taken from returning adults indicate that NP CHF smolts, produced in the Rogue SMU, must reach a minimum size of at least 9 cm in order to survive after ocean entry (*see* **Juvenile Size at Time of Migration**, page 83).

Figure 19. Estimated number of naturally produced juvenile fall Chinook salmon that annually migrated downstream into the estuary of the Pistol River, 1993-2002. Confidence bounds could not be generated for these estimates.

Chetco River Population

ODFW estimates there are 53.8 miles of NP CHF habitat in the Chetco River Basin (Figure 20). Tributary streams account for 24.8 miles of habitat and the mainstem of the Chetco River accounts for 29.0 miles of habitat. These estimates reflect application of a filter designed to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). Spawning surveys and a telemetry study completed in 1995-1996 indicate that CHF primarily spawn in areas downstream of Panther Creek (RM 19 on the Chetco River).

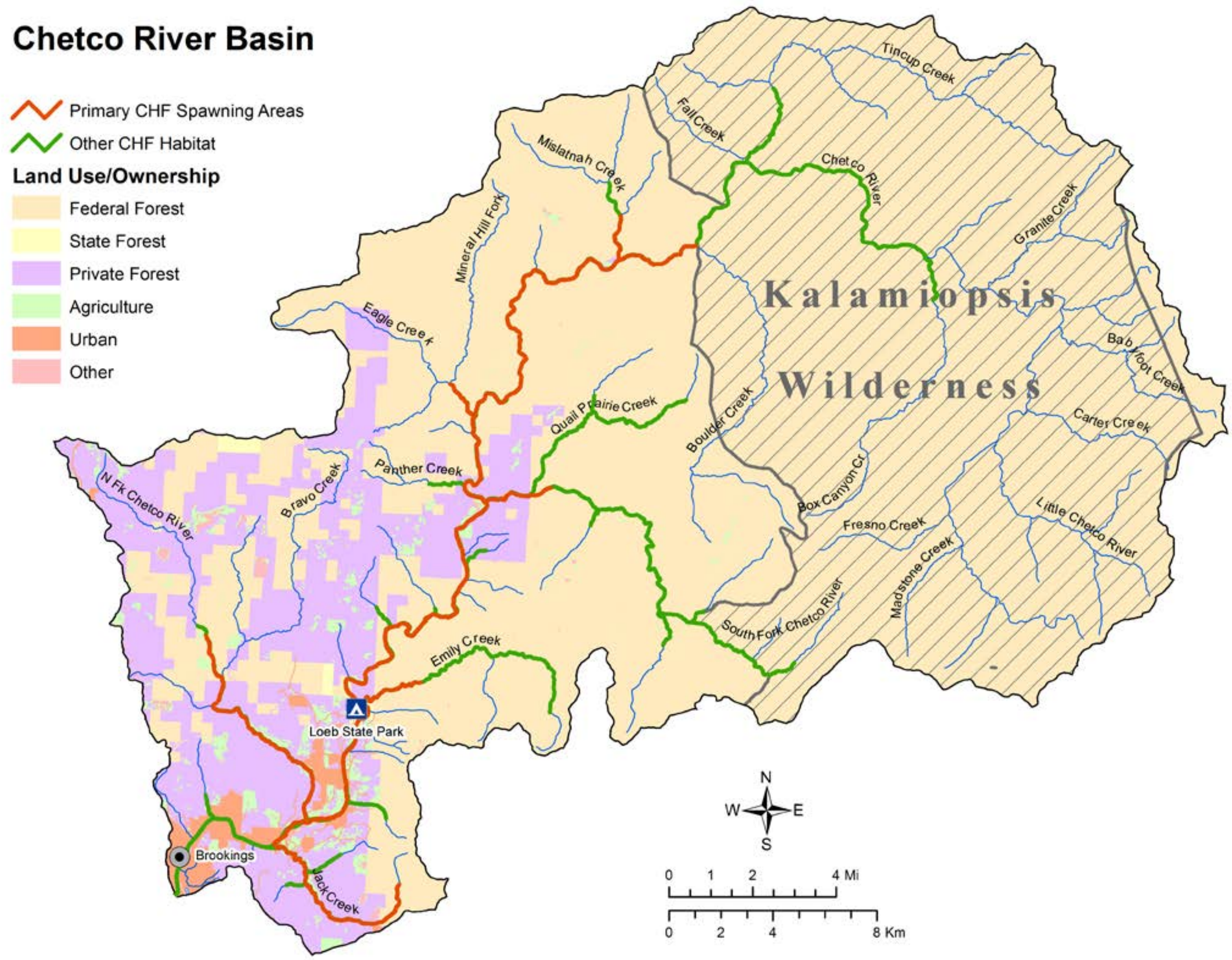

Figure 20. Map of the Chetco River Basin. The Chetco River drains into the Pacific Ocean.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1966. However, during 1966-1985, surveys were mostly conducted only once annually on one small tributary stream. Beginning in 1986, surveys were conducted throughout the spawning season on multiple tributary streams. Data generated during later surveys were used to estimate spawner escapements within the population area (see **APPENDIX D**).

Annual estimates of adult CHF that spawned in the Chetco River population area ranged between about 800 and 11,000 CHF during 1986-2011. Naturally produced fish dominated the spawning escapements, with the exception of the early 1990s (Figure 21). During the period of record, spawner composition estimates averaged 22% hatchery fish (95% CI = 17-26% as estimated from arcsine transformed data). This estimate was derived from the brood-specific mark rates of CWTs recovered from spawned CHF carcasses. Naturally spawning hatchery fish appear to be primarily of local origin. Of the 154 CWTs recovered from spawned carcasses, 148 originated from juvenile CHF released in the Chetco River and six originated from CHF released in the Winchuck River.

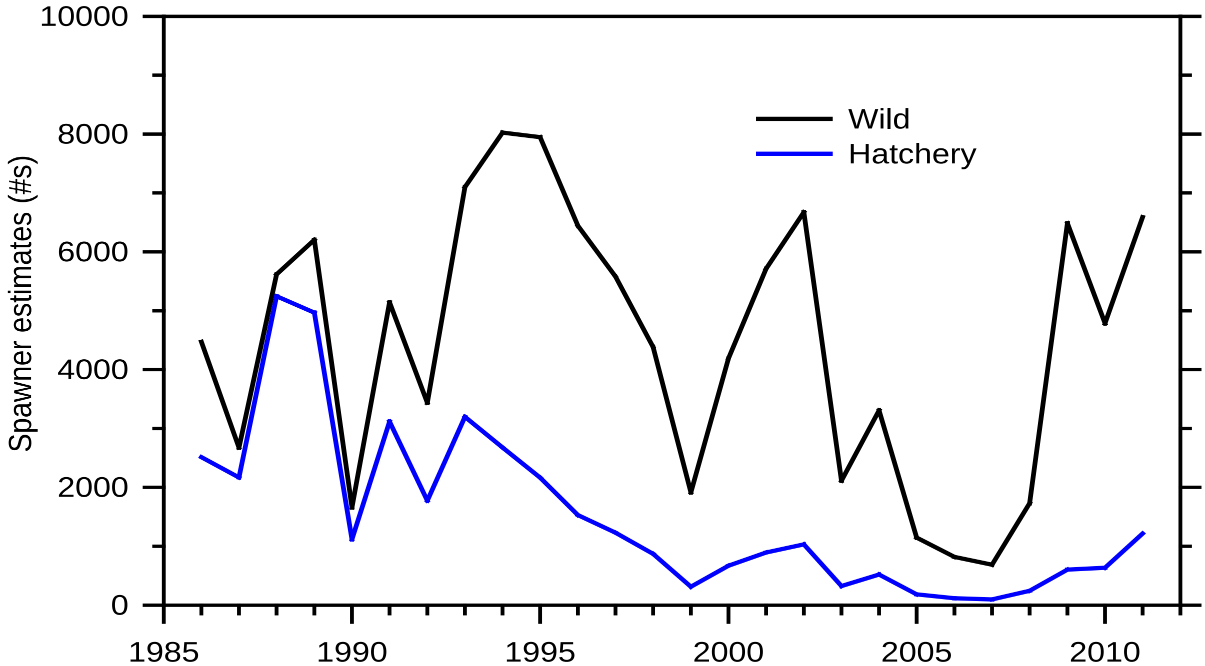

Figure 21. Estimated number of age 3-6 fall Chinook salmon that spawned in the Chetco River population area, 1986-2011. Annual estimates are listed in Appendix Table E-2. Confidence bounds could not be generated for these estimates.

Hatchery CHF smolts were released in the Chetco River population area each year; beginning in 1969. Smolt releases averaged about 322,000 (95% CI = ±55,000) fish annually during 1969-1997 and about 153,000 (95% CI = ±7,000) fish annually during 1998-2011. These fish were released during September-November at sizes ranging between 5 and 50 fish per pound, depending on the release date. In addition, some fed fry were released during 1987-1992 and some unfed fry were released annually beginning in 1985. Unfed fry releases averaged about 265,000 (95% CI = ±149,000) fish annually during 1985-1992. Annual releases of unfed fry decreased to 1,000 fish or less after 1992. All juvenile hatchery fish released in the system originated from broodstocks collected in the Chetco River population area and fed juveniles were reared at Elk River Hatchery.

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 13. Several fundamental assumptions, described in **APPENDIX D,** were associated with the derivation of these estimates.

Naturally produced fall Chinook salmon of Chetco River Basin origin mature at ages 2-6. During a typical return year, age 4 fish dominate the NP CHF that spawn in the Chetco population area. However, the age composition of spawning NP CHF varies markedly among years (Figure 22). Age 2 adults (jacks) typically compose less than 5% of the spawners, while age 3 and age 5+6 adults typically compose about 10-15% of the spawners (Figure 22).

Table 13. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Chetco River population area, 1983-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1983-1985 brood years. Estimates for individual brood years are listed in Appendix Table E-10.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	8,256	8,215	4,788	10,977
Ocean harvest	2,724	1,710	895	2,761
Freshwater escapement[a]	5,276	4,845	3,324	7,236
Freshwater harvest[a]	884	918	548	1,168
Recruits/spawner	1.9	1.3	0.6	2.0
Ocean harvest rate[b]	0.25	0.17	0.12	0.33
Ocean harvest rate[c]	0.05	0.05	0.01	0.07
Freshwater harvest rate[a]	0.12	0.11	0.10	0.14
Brood harvest rate	0.42	0.35	0.30	0.56

[a] *Includes estuary.*
[b] *General season (May-September).*
[c] *Chetco terminal fishery (October-November).*

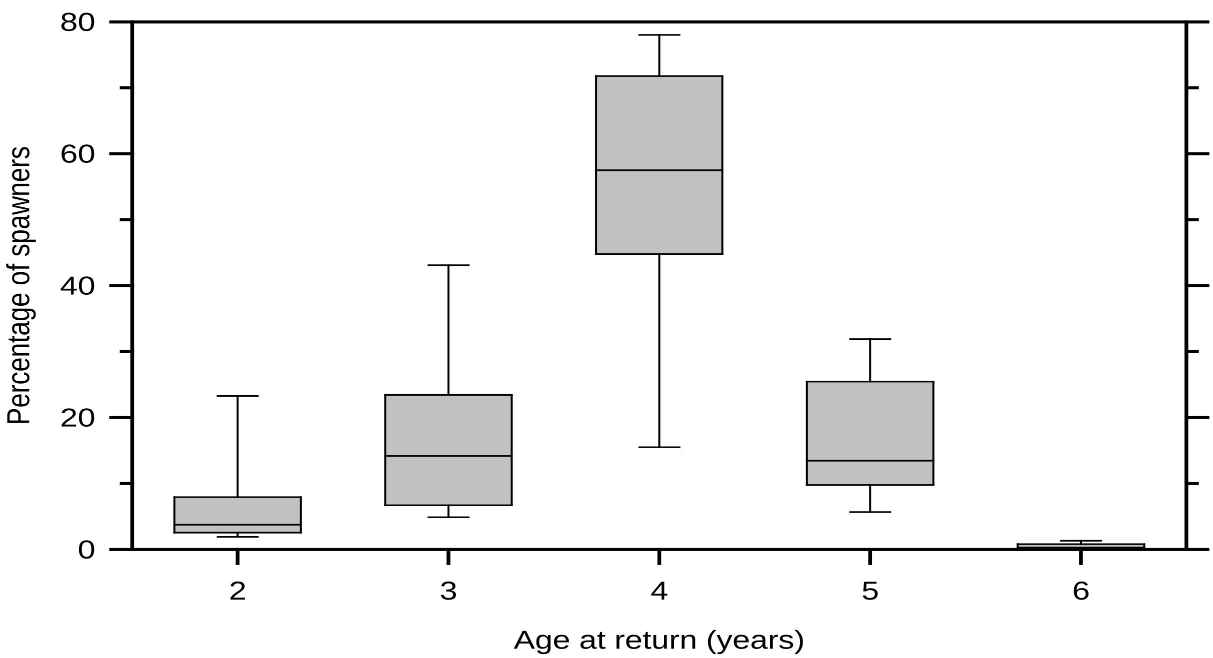

Figure 22. Median age composition of naturally produced fall Chinook salmon that spawned in the Chetco River Basin, 1987-2011. Boxes represent the 25th and 75th percentiles and the brackets represent the 10th and 90th percentiles. Data includes only those years when scales were sampled from at least 100 fish.

Winchuck River Population

ODFW estimates there are 34.3 miles of NP CHF habitat in the Winchuck River Basin (Figure 23). Tributary streams account for 23.5 miles of habitat and the mainstem of the Winchuck River accounts for 10.8 miles of habitat. These estimates reflect application of a filter designed

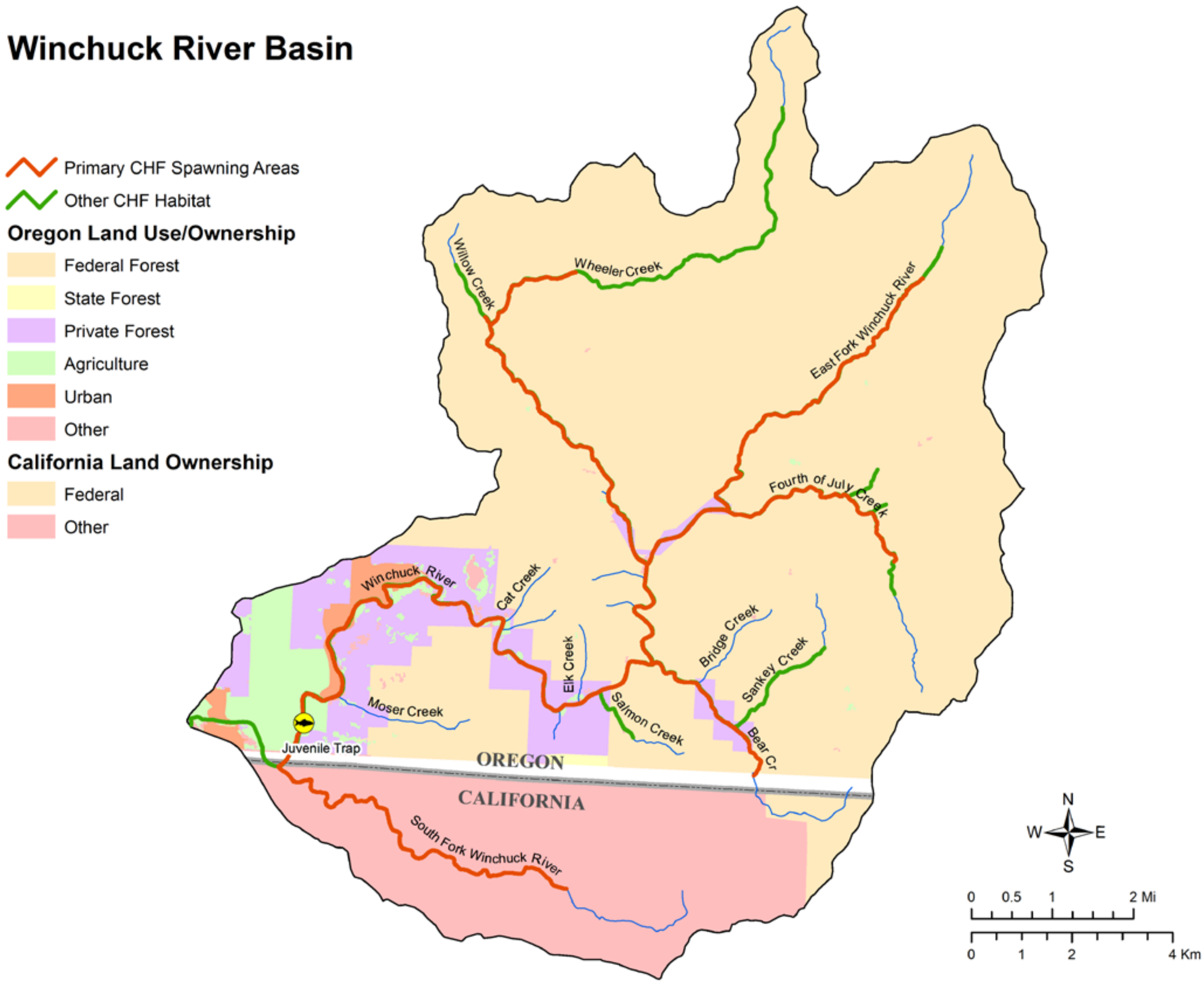

Figure 23. Map of the Winchuck River Basin. The Winchuck River drains into the Pacific Ocean.

to exclude marginal habitat located at the upstream terminus of spawning streams (*see* **APPENDIX D** for the filter description). Surveys indicate that CHF primarily spawn tributary streams as compared with the mainstem of the Winchuck River.

The first CHF spawner survey in the population area, documented by location and dates, was conducted during 1973. However, during 1973-1986, surveys were mostly conducted only once annually on one small tributary stream. Beginning in 1987, surveys were conducted throughout the spawning season on multiple tributary streams. Data generated during these later surveys were used to estimate spawner escapements within the population area (see **APPENDIX D**).

Annual estimates of adult CHF that spawned in the Winchuck River population area ranged between about 250 and 2,400 CHF during 1987-2011. Naturally produced fish dominated the annual spawning escapements (Figure 24). During the period of record, spawner composition estimates averaged 8% hatchery fish (95% CI = 5-10%) as estimated from arcsine transformed data). This estimate was derived from the brood-specific mark rates of CWTs recovered from spawned CHF carcasses. Naturally spawning hatchery fish appear to be primarily of local origin. Of the 23 CWTs recovered from spawned carcasses, 16 originated from juvenile CHF

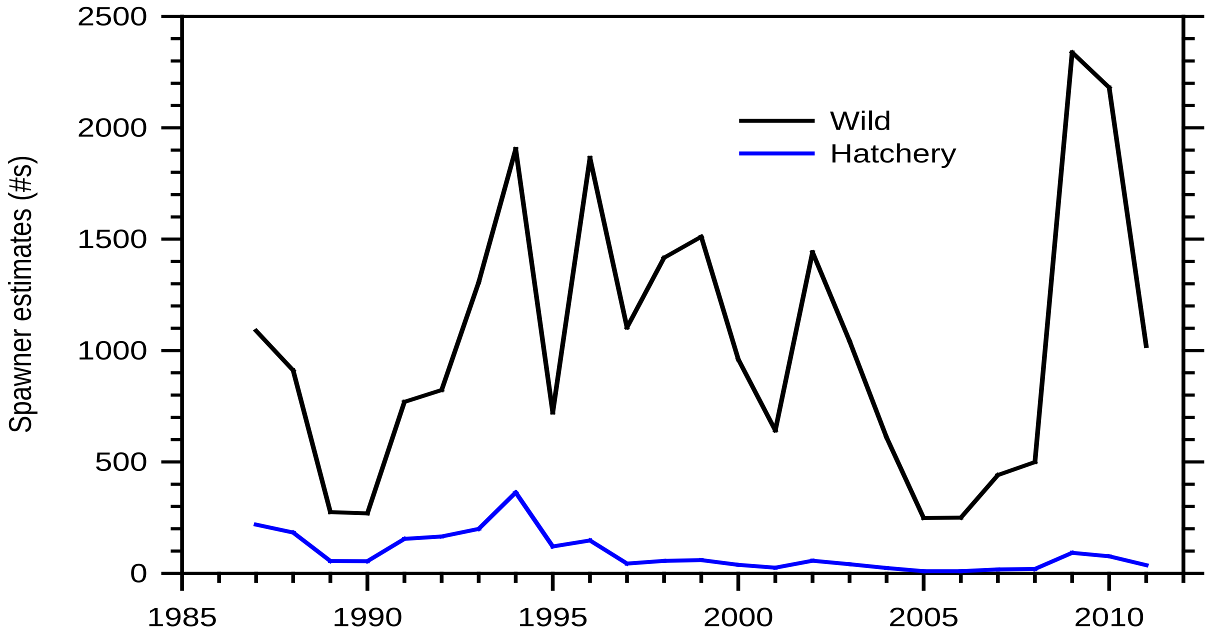

Figure 24. Estimated number of age 3-6 fall Chinook salmon that spawned in the Winchuck River population area, 1987-2011. Annual estimates are listed in Appendix Table E-2. Confidence bounds could not be generated for these estimates.

released in the Winchuck River and six originated from CHF released in the Chetco River. Hatchery CHF smolts were released in the Winchuck River population area during most years between 1986 and 1992. Smolt releases averaged about 15,900 (95% CI = ±12,400) fish annually. These fish were released during June-October at sizes ranging between 9 and 50 fish per pound, depending on the release date. In addition, some fed fry were released during 1988-1992 and some unfed fry were released during 1986-1991. All hatchery fish released in the system originated from broodstocks collected in the Winchuck River population area; except two releases of unfed fry originated from broodstock collected in the Chetco River population area. Fed fry were reared at Elk River Hatchery.

Cohort reconstruction methods (**APPENDIX D**) were used to estimate metrics that provide indications of (1) population size and productivity and (2) harvest within the ocean and freshwater fisheries. Summaries of these metrics are presented in Table 14. Several primary assumptions, described in **APPENDIX D,** were associated with the derivation of these estimates.

Another important population metric is available for NP CHF produced in the Winchuck population area. During 1991-2011, Oregon South Coast Fishermen and ODFW operated a juvenile fish trap just upstream of the mouth of the South Fork of the Winchuck River. Weekly releases of marked fish upstream of the trap were used to estimate the number of subyearling migrants that passed the trap site. Estimates include only NP CHF because hatchery fish were not stocked in the Pistol River population area during those years.

Annual estimates of juvenile NP CHF production in areas upstream of the South Fork of the Winchuck River ranged between 47,000 and 368,000 migrants (Figure 25) and averaged 135,000 (95% CI = ±37,000) migrants for the period of record (1991-2010 brood years). Estimated migrant-recruit survival rates for NP CHF in the Winchuck River population area, upstream of the South Fork, averaged 1.1% (95% CI = 0.7-1.6% as estimated from arcsine transformed data)

Table 14. Summary of population and harvest metrics estimated for age 3-6 naturally produced fall Chinook salmon in the Winchuck River population area, 1984-2006 brood years. Harvest rates are reported as number of fish harvested divided by the number of recruits, for completed broods. Spawner escapements could not be estimated for the 1985-1986 brood years. Estimates for individual brood years are listed in Appendix Table E-11.

Metric	Mean	Median	25% Quartile	75% Quartile
Recruits	1,474	1,370	1,076	1,805
Ocean harvest	402	334	261	481
Freshwater escapement[a]	1,110	1,083	705	1,407
Freshwater harvest[a]	84	77	57	105
Recruits/spawner	2.4	1.3	1.0	2.2
Ocean harvest rate[b]	0.25	0.19	0.13	0.29
Ocean harvest rate[c]	0.05	0.05	0.02	0.06
Freshwater harvest rate[a]	0.06	0.06	0.04	0.08
Brood harvest rate	0.36	0.30	0.25	0.48

[a] *Includes estuary.*
[b] *General season (May-September).*
[c] *Chetco terminal fishery (October-November).*

for the 1990-2004 brood years. In comparison, Bradford (1995) estimated marine survival rates of 1.1-1.5% for three populations of wild "ocean-type" Chinook salmon that reared 2-6 months in freshwater. It should be noted that estimates of migrant production in the Winchuck River may not directly relate to the number of smolts that eventually entered the ocean. Many of the migrants that entered the Winchuck River estuary were less than 9 cm in length. Analyses of scales taken from returning adults indicate that NP CHF smolts, produced in the Rogue SMU, must reach a minimum size of at least 9 cm in order to survive after ocean entry (*see* **Juvenile Size at Time of Migration**, page 83).

Figure 25. Estimated number of naturally produced juvenile fall Chinook salmon that annually migrated downstream of mile 2.0 in the Winchuck River, 1991-2011. Estimates of statistical confidence could not be derived from the data.

Species Management Unit Summary

The SMU produced an average of about 124,000 NP CHF recruits during the most recent 10 year period for completed broods (Table 15). Populations in the Rogue stratum accounted for 92% for the production. Most of these fish were produced in the Middle Rogue, Applegate, and Illinois population areas. The largest population in the coastal stratum was the Chetco, which accounted for about 5% of the NP CHF produced in the SMU (Table 15).

During the last 10 years, hatchery fish accounted for an estimated 1.4% of the CHF that spawned in the Rogue SMU (Table 15). Hatchery fish accounted for less than 1% of the CHF that spawned in the Rogue stratum and accounted for about 9% of the CHF that spawned in the coastal stratum.

Table 15. Estimated mean abundance and mean spawner composition of naturally produced fall Chinook salmon in the Rogue Species Management Unit, for the most recent 10 years of estimates.

Population(s)	Recruits[a]	% Hatchery[b]
Middle Rogue, Applegate, and Illinois[c]	81,700[d]	0.3%[e]
Upper Rogue	13,300	0.1%
Lower Rogue	18,200	3%
Rogue Stratum	113,100	0.7%
Euchre	80	49%
Hunter	740	3%
Pistol	2,300	2%
Chetco	5,900	13%
Winchuck	1,400	4%
Coastal Stratum	10,400	9%
Species Management Unit	123,600	1.4%

[a] *Number of naturally produced fish, 1997-2006 brood years.*
[b] *Among spawners, 2002-2011.*
[c] *Pooled values. No estimates for individual populations.*
[d] *Estimated as stratum total - (Upper Rogue + Lower Rogue).*
[e] *Assumed mean of the three populations (see population profiles).*

PRIMARY LIMITING FACTORS

There are a number of historic and current factors that may limit size and distribution of populations of NP CHF in the Rogue SMU and which probably also influence the life history strategies expressed by individual populations. Both types (current and historic) of possible limiting factors were considered in the following assessment. This assessment was crafted based on the following sources of information, listed in order of priority usage: (1) published research reports specific to NP CHF populations and allied habitat in the SMU, (2) analysis of unpublished data retrieved from ODFW files, (3) published research reports on CH populations and allied habitat outside of the SMU, and (4) the professional judgment of ODFW fish biologists who have worked with NP CHF populations in the Rogue SMU for at least 20 years. Possible limiting factors are organized under four categories (habitat volume, habitat quality, biological factors, and fishing) and are classified according to whether or not factors can be managed through directed actions (Table 16). Factors that cannot be managed are excluded from the remaining discussion of potential limiting factors.

Table 16. Parameters identified as factors that potentially impact the abundance and life history of naturally produced fall Chinook salmon in the Rogue Species Management Unit. Factors listed in italics are judged to be very difficult to manage.

Habitat Volume	**Biological Factors**
Amount of ocean rearing habitat	*Predators in the ocean*
Amount of estuary rearing habitat	*Competitors in the ocean*
Amount of spawning habitat	Predators in estuaries
Amount of freshwater rearing habitat	Competitors in estuaries
Migration barriers	Forage supply in estuaries
	Predators in freshwater
Habitat Quality	Competitors in freshwater
Current patterns in the ocean	Forage supply in freshwater
Water temperature in the ocean	Disease
Water quality in estuaries	Spawner abundance
Water temperature in freshwater	Genetics
Water quality in streams	
Stream flow	**Fishing**
Changes in stream flow	Direct mortality
Spawning gravel	Indirect mortality
Morphology of stream channels	
Riparian areas	
Water diversions	
Physical structures	

Rogue Stratum

Habitat Volume

Spawning Habitat: ODFW estimates there are about 511 miles of habitat accessible to adult NP CHF in the Rogue River Basin. Only a portion of this habitat is of primary importance in relation to NP CHF production. No empirical estimates of NP CHF spawning distribution are available for any of the population areas. However, some inferences can be made in relation to general observations made by ODFW staff.

Within the Upper Rogue, Middle Rogue, and Applegate population areas, spawner use is greatest in the main stem Rogue and Applegate rivers; relatively few adults spawn in the tributaries. In the Illinois population area, spawner use is greatest in the Illinois River upstream of the Illinois River canyon and also in the East and West Forks; fewer adults spawn in other tributaries. In the Lower Rogue population area, spawner use is greatest in tributaries of the Rogue River, especially Lobster Creek. These general observations were used to estimate the mileage of primary and secondary spawning habitat within each of the population areas and results suggest that primary spawning areas account for about 233 miles (43%) of the total spawning habitat available to NP CHF in the Rogue River Basin (Table 17). Based on this assessment, most of the primary spawning areas appear to be in the Middle Rogue, Applegate, and Illinois population areas.

Table 17. Classification of spawning habitat for fall Chinook salmon in the Rogue River Basin based on generalized ODFW observations. Estimates are rounded to the nearest mile and include newly formed spawning habitat that resulted from the removal of Savage Rapids and Gold Ray dams. No estimates of statistical confidence could be generated from the classification approach.

	Spawning habitat (miles)		
Population Area	**Primary**	**Secondary**	**Total**
Upper Rogue	12[a]	63	75
Middle Rogue	42[b]	76	118
Applegate	50[c]	33	83
Illinois	59[d]	100	159
Lower Rogue	27[e]	49	76

[a] *Mainstem of the Rogue River, Bear Creek - Dodge Bridge.*
[b] *Mainstem of the Rogue River, Gold Ray Dam - Jumpoff Joe Creek.*
[c] *Mainstem of the Applegate River.*
[d] *Mainstem of the Illinois River (Briggs Creek - Forks), East Fork, and West Fork.*
[e] *Tributaries of the Rogue River.*

Estimates of gravel resources can also provide some general index of the amount of potential NP CHF spawning habitat in the Rogue River Basin. As systematic habitat surveys have yet to be conducted in the basin (Jones et al. 2011), the only source of information originates from visual estimates completed during surveys conducted in July-September of 1944. Surveyors estimated the area of those graveled locations judged to be covered by water during autumn and winter (USFWS 1955c). Some inferences can be made in relation to these visual estimates of spawning gravel resources, especially if the gravel estimates are segregated by classification scheme for NP CHF spawning habitat as described in the preceding paragraph.

Within primary NP CHF spawning areas of the Rogue River Basin, the amount of spawning gravel appears to be greatest in the Applegate population area and is probably lowest in the Lower Rogue population area (Table 18). There are significant amounts of gravel in spawning areas of secondary importance (Table 18), but NP CHF use of these areas is limited to some degree by stream flow during the spawning period; as described later in this section. The large amounts of gravel estimated during the 1944 surveys typify streams in the Klamath Mountains physiographic province (Wallick et al. 2009 and Jones et al. 2011)), and indicate that gravel abundance is probably generally not a primary factor that limits NP CHF production in the Rogue River Basin.

In relation to gravel abundance, there are three means by which the amount of NP CHF spawning habitat can be affected by development. First, dams can block the recruitment of gravel into downstream areas. Second, gravel volumes in streams can diminish if recruitment rates are insufficient to compensate for the amount of gravel extracted from the stream channel. Third, construction of temporary gravel dams (“push-up dams”) can destabilize gravel bars and

Table 18. Estimates of potential spawning gravel in the Rogue River Basin based on surveys conducted in the 1944. Estimates are rounded to the nearest 100 square yards and are segregated into primary and secondary areas of spawning importance for fall Chinook salmon. Estimates include all areas judged to be accessible to adult salmon and steelhead. Confidence bounds could not be generated for these estimates.

	Spawning gravel (square yards)		
Population Area	**Primary**	**Secondary**	**Total**
Upper Rogue	87,800[a]	54,800[b]	142,600
Middle Rogue	109,200[c]	13,500[d]	122,700
Applegate	169,500[e]	28,200[f]	197,800
Illinois	104,800[g]	30,000[h]	134,800
Lower Rogue	i	28,500[j]	--

[a] *Rogue River (Bear Creek - Dodge Bridge).*
[b] *Includes Little Butte Creek and Bear Creek.*
[c] *Rogue River (Gold Ray Dam - Mule Creek).*
[d] *Includes Evans Creek and Grave Creek.*
[e] *Applegate River (Applegate Dam - mouth).*
[f] *Includes Little Applegate River; Williams, Cheney, and Slate creeks.*
[g] *Includes Illinois River (Briggs Creek - Forks), East Fork, and West Fork.*
[h] *Includes Sucker Creek, Althouse Creek, and Elk Creek.*
[i] *Tributary streams were not surveyed.*
[j] *Rogue River (Mule Creek - mouth).*

limit the size of potential NP CHF spawning areas, particularly during low flow years. At the present time, there are more than 20 push-up dams constructed annually or periodically in the Rogue River Basin and almost all are located in the Applegate and Illinois River basins (Rogue Basin Fish Access Team, unpublished data). All of these impacts are manageable to some degree. Dams can be removed or gravel can be artificially introduced in areas downstream of dams (Tetra Tech 2009) in order to mitigate for the loss of gravel recruitment. Gravel extraction can be limited to areas outside of the active channels of streams and push-up dams can be replaced by water pumps or infiltration galleries.

The volume of spawning habitat is also affected by stream flow just before, and during, NP CHF spawning. The upstream migration of adult NP CHF in tributary streams can be limited in years of low flow during autumn. Limitations in tributary entry and migration are most evident in streams of the Rogue River Valley because NP CHF spawn earlier (peak in mid- to late October) in those areas as compared with counterparts spawning in nearby coastal areas. Entry of NP CHF in small spawning tributaries is dependent on increases in flow, which usually occur in the middle of autumn (Figure 26). Stream flow during autumn and early winter is primarily a function of precipitation as few water diversions occur during this period. As a result, there are minimal management opportunities for modification of stream flow during the period of NP CHF migration in tributary streams, except for the Applegate River.

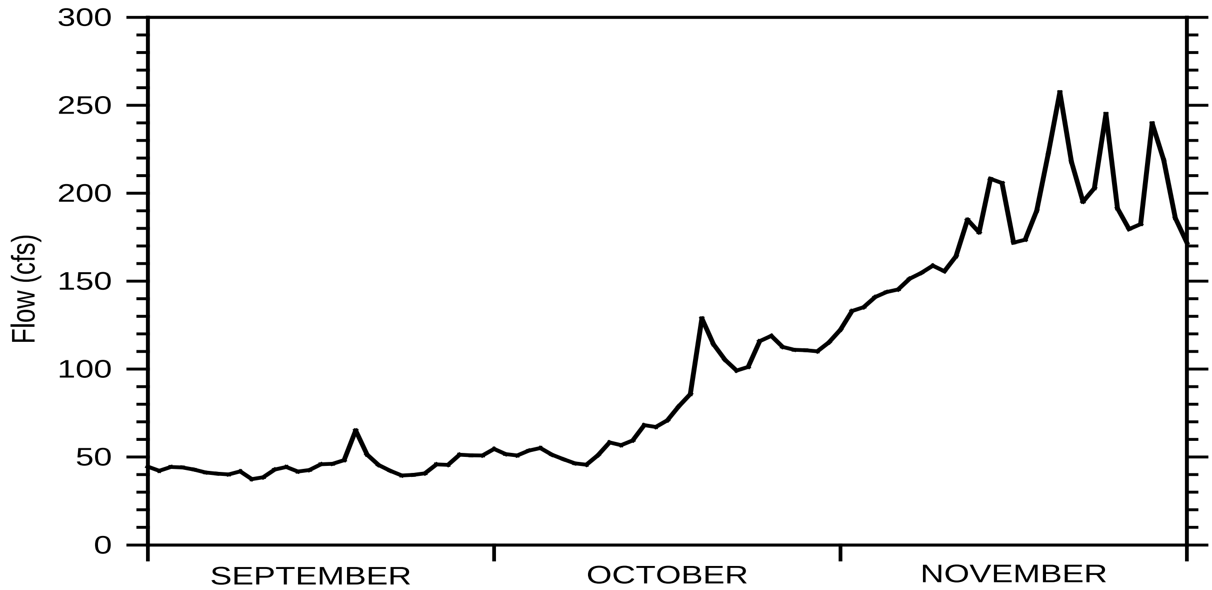

Figure 26. Mean daily flow of Little Butte Creek at river mile 3.0 during autumn, 2006-2011. Little Butte Creek is located in the Upper Rogue population area and flow is basically unregulated during autumn.

USACE operation of Applegate Dam (RM 47) affects flow in the Applegate River during autumn. Fish enhancement is a primary authorized purpose (United States Congress 1962) and the USACE releases reservoir storage in autumn to aid the upstream migration of adult NP CHF (Figure 27). This operational strategy has been successful in increasing the spawning distribution of NP CHF in the Applegate River. Prior to reservoir construction and operation, an average of 10% of the NP CHF spawned upstream of Murphy (RM 13). After reservoir operation, an average of 33% of the CHF spawned upstream of Murphy. The upstream shift in spawning distribution was significant at $P < 0.005$ (Fustish et al. 1988) and reflects an increase in the amount of CHF spawning habitat in the Applegate River.

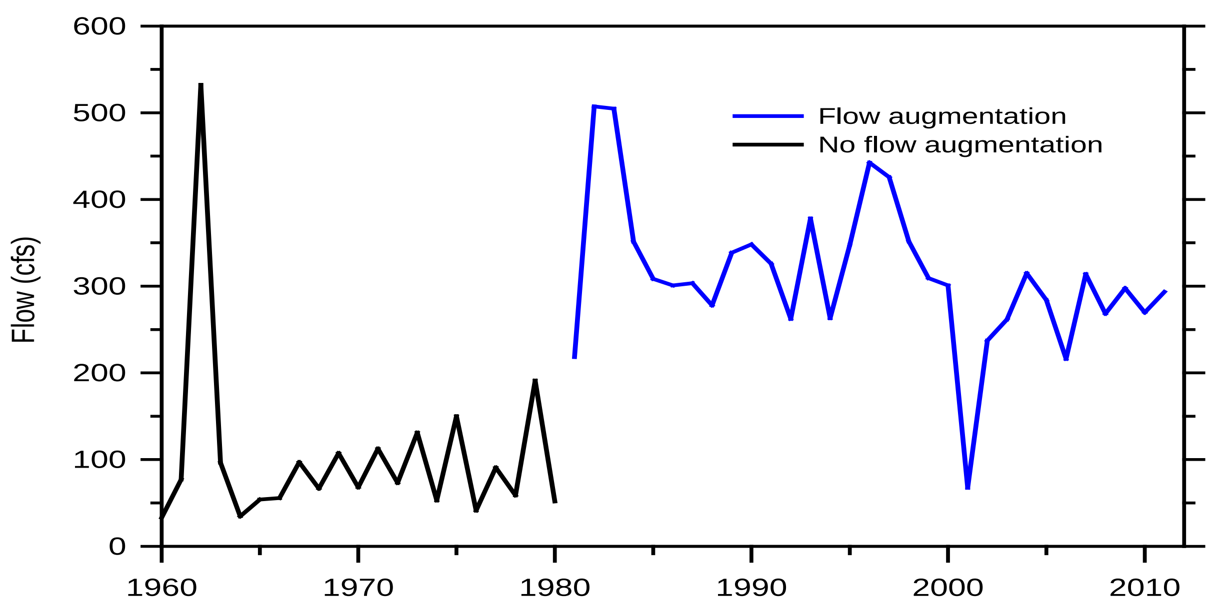

Figure 27. Mean flow of the Applegate River at Applegate (RM 27) in October, 1960-2011.

Migration Barriers: Applegate Dam appears to be the only major complete barrier to upstream migration of adult NP CHF. However, few, if any, adults would have reached this location without flow augmentation from Applegate Lake. There are numerous other structures that likely act as partial barriers to adult NP CHF migration during periods of low flow. Most of these structures are small dams located on Evans Creek, Little Butte Creek, and in the Illinois River Basin (Rogue Basin Fish Access Team, unpublished data). Upstream passage of adults at small dams is hindered by low flows while passage is more successful at greater flows. As low flow just before and during upstream migration is the primary factor that limits the amount of spawning habitat in the Rogue River Basin, removal of artificial barriers will result in only relatively minor increases in NP CHF production. In contrast, removal of Applegate Dam would instead decrease the amount of CHF spawning habitat.

One natural site is no longer a barrier to the upstream migration of adult NP CHF. Prior to the construction of the fish ladder at Illinois River Falls in 1962, CHF spawned only in areas farther downstream during most years (Rivers 1964). Laddering of the falls increased the spawning distribution of NP CHF by about 100 miles in the Illinois population area.

Freshwater Rearing Habitat: The volume of freshwater rearing habitat for juvenile NP CHF changed significantly within areas downstream of the two USACE dams constructed in the Rogue River Basin. Fish enhancement is a primary authorized project purpose (United States Congress 1962) and the USACE releases reservoir storage from Lost Creek Lake during summer for multiple fish purposes; one of which is to increase the amount of habitat for juvenile salmonids rearing in downstream areas. This operational strategy has been successful by increasing the amount of habitat for juvenile NP CHF in the Rogue River (ODFW 1992); as evidenced by the increase in flow during the critical period of summer rearing (Figure 28).

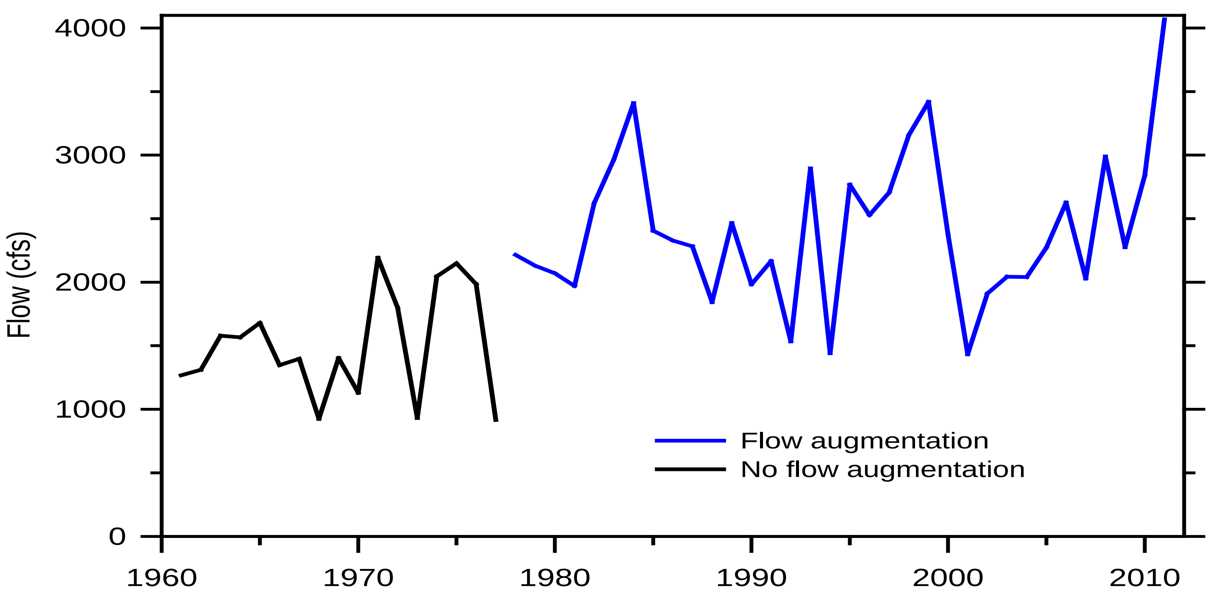

Figure 28. Mean flow of the Rogue River at Agness (RM 30) in July-August, 1961-2011.

Operation of Applegate Dam also increases the amount of juvenile NP CHF rearing habitat. Applegate Dam first filled in 1980 and the reservoir has been operated to augment flow during June-July (Figure 29) in order to increase the rearing capacity for juvenile NP CHF in the Applegate River. Juvenile NP CHF rear in the Applegate during spring and most migrate into the Rogue River during May-July; where they rear to smolt size before ocean entry (Fustish et al.

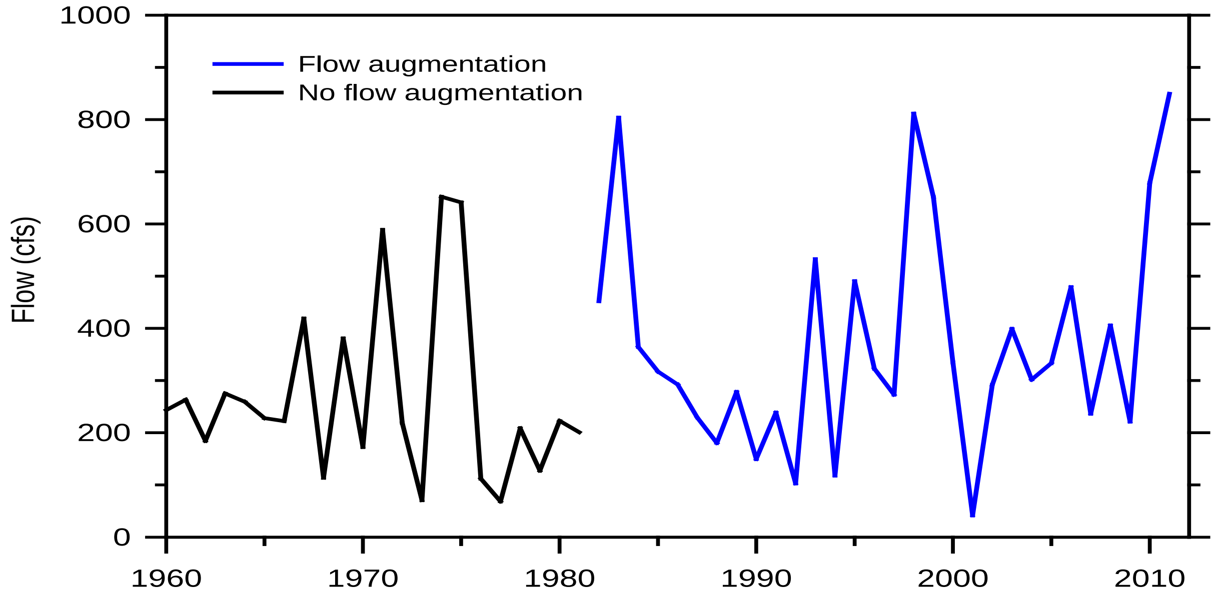

Figure 29. Mean flow of the Applegate River at Applegate (RM 27) in June-July, 1960-2011.

1988; ODFW 1992). In addition, the increased upstream distribution of spawning resulted in a significant increase in the number of juvenile NP CHF produced in the upper portion of the Applegate River (Fustish et al. 1988).

Flow augmentation from USACE dams, coupled with the ladder installed at Illinois River falls, indicates that the volume of freshwater habitat for juvenile NP CHF has increased significantly as a result of development. Channel alterations resulting from gravel extraction and the construction of riprap levies (dikes) are primarily limited to the lower half of the Applegate River. These developments negatively impacted the volume of NP CHF rearing habitat, but the scope of negative impact is relatively minor compared with (1) the positive impacts of flow augmentation which added about 60 miles of NP CHF habitat in the Applegate River and (2) installation of the fish ladder at Illinois River Falls which added about 100 miles of NP CHF habitat in the Illinois River Basin.

Estuary Rearing Habitat: Similar to the other coastal drainages in the SMU, the estuary of the Rogue River is relatively small given the volume of freshwater that enters the water body. The shape of the estuary closely follows the shape of the river channel and the upstream terminus of the estuary commonly extends up to river mile 4.5. During 1975 and 1976, water depths at low tide ranged between 5 and 23 feet in the estuary (Ratti 1979). In contrast to estuaries farther north along the Oregon coast, the Rogue estuary lacks a large bay and broad intertidal areas, and also lacks significant areas of reduced currents (Ratti 1979).

Ratti (1979) defined two areas within the estuary, with the definitions based on gradients and modifications to the estuary. The lower portion (335 acres) was classified as a marine subsystem with high salinity. Lee and Brown (2009) estimated that the Rogue River estuary encompassed a total area of 685 acres; with 326 acres being estuarine habitat and 356 acres being tidal riverine habitat. Good (2000) estimated a total estuary size of 880 acres in 1970 and that 30 acres (3%) had been lost due to diking or filling since 1870. Given that juveniles primarily rear in the mainstem of the Rogue River (ODFW 1992), the small area of the estuary is probably not a primary limiting factor for NP CHF populations in the Rogue River Basin.

Habitat Quality

Aspects of habitat quality that have the potential to affect the abundance and life history of NP CHF are diverse. Habitat features that affect adult NP CHF include channel morphology, water quality, and flow. Habitat features that affect juvenile NP CHF include channel morphology, water quality (estuary and freshwater), flow, changes in flow, sedimentation, gravel composition, riparian areas, and water diversions.

Freshwater Habitat: Water quality elements that can affect juvenile NP CHF include temperature, dissolved oxygen, nutrients, sedimentation, and toxic pollutants. Based on water quality index ratings reported by Mrazik (2008), none of these factors, except water temperature, are likely to affect the growth and survival of juvenile NP CHF rearing in population areas of the Rogue River Basin. Concerns about water quality are greatest in the smaller tributary streams, as evidenced by low levels of dissolved oxygen during summer (Mazik 2008). However, most juvenile NP CHF have migrated downstream and entered the Rogue River before summer (Fustish 1988, ODFW 1992).

Water temperature is likely the water quality parameter that most greatly impacts juvenile NP CHF in the Rogue River Basin. During freshwater residence, juvenile NP CHF are commonly exposed to water temperatures that can exceed 24^{o}C (75^{o}F), likely resulting in decreased survival rates from either indirect or direct thermal effects (Baker et al. 1995; Connor et al. 2003; Marine and Cech 2004; Bartholow and Henriksen 2006; Geist et al. 2010) and an earlier date of smoltification (Sykes and Shrimpton 2010). The greatest impact of high water temperatures in the Rogue River Basin likely relates to a decreased growth rate of juvenile NP CHF.

Banks et al. (1971) determined that juvenile CH grew faster at 15^{o}C (59^{o}F) as compared with 18^{o}C (64^{o}F). Brett et al. (1982) found that the optimum temperature for growth of juvenile CH was about 15^{o}C (59^{o}F) and that no growth would be realized at temperatures greater than about 21^{o}C (70^{o}F). However, juveniles used in these experiments originated from northern populations that may be naturally more sensitive to warmer water temperatures. In contrast, Marine and Cech (2004) found that juvenile CH of Sacramento River origin, grew somewhat at water temperatures of 21-24^{o}C (70-75^{o}F) and grew well at water temperatures of 17-20^{o}C (63-68^{o}F). Foott et al. (2012) reared juvenile CH of Klamath Basin origin for 21 days under two fluctuating temperature profiles that averaged 18ºC (64^{o}F) and 23ºC (73^{o}F). They found that juvenile CH grew at the higher temperature, although more slowly as compared those counterparts reared at the lower temperature.

As water temperatures during summer commonly exceed 21^{o}C (70^{o}F) in those areas primarily used as juvenile rearing habitat, lower rates of food conversion likely affect the size of juvenile NP CHF at the time of estuary entrance and possibly even at the time of ocean entrance. Size at ocean entrance is a primary factor that affects the potential for ocean survival (*see* **Juvenile Size at Time of Migration**, page 83).

Water temperature modeling indicated that vegetation removal from riparian zones has resulted in increased water temperatures in the Rogue River and in tributary streams during summer (ODEQ 2008). Resultant increases in water temperature in the Rogue River have been masked by the decreases in water temperature resulting from flow augmentation from William Jess Dam (ODEQ 2008). Water temperature is also affected by water withdrawals and return flows from irrigated lands and municipal discharges (ODEQ 2008). Water withdrawals can also affect the survival of juvenile salmonids if the diversions are unscreened, or are poorly maintained. The volume of water diverted from the Rogue River will increase in the future as additional storage from Lost Creek Lake is purchased for irrigation use or municipal and industrial use.

Flows, and changes in flows, have also been documented as factors that affect juvenile NP CHF in the Rogue River Basin. Peak flows were negatively related to fry production, almost certainly as the result of scouring when eggs and alevins incubate in the gravel (ODFW 1992). Fast decreases in flow can strand and kill fry, and also can cause fry to be trapped in side channels (ODFW 2000). Low flows also can result in dewatered redds and can cause mortality among eggs and alevins resident in the gravel (Fustish et al. 1988). Operation of USACE dams in the Rogue River Basin decrease the intensity of peak flow events (Fustish et al. 1988; ODFW 2000) and mitigate, to an unknown degree, the increase in the intensity of peak flow events that have resulted from the increase in the proportion of the basin that is now covered by impervious surfaces resulting from development (Booth et al. 2002).

Flows, especially peak flows, also affect channel morphology, sedimentation rates, and gravel quality. Higher flows can increase the width of unconstrained channels and the size of pools in low gradient streams; low gradient pools are the riverine habitat type preferred by juvenile Chinook salmon in large streams of southern Oregon (ODFW 1992; Roper et al. 1994; Scarnecchia and Roper 2000). In addition, wide, unconstrained, channels in low gradient streams tend to be characterized by larger areas of more diverse spawning habitat (Montgomery et al. 1999). Peak flows are also associated with storm events that increase the amount of sediment introduced into streams.

Sediment can arise from numerous sources, and sediment deposition on redds has been associated with decreased survival rates of eggs and alevins. Sediment deposition can also affect gravel quality in spawning areas. Fines can fill spaces within gravel, reducing space for incubating alevins and reducing water exchange around eggs and alevins (Chapman 1988). Of possibly greater concern, however, is the recent lack of recruitment of gravel from areas upstream of Applegate Dam. With the lack of gravel recruitment, the average size of gravel within proximal spawning areas downstream of Applegate Dam will likely increase because small gravel is more likely to be displaced during scour events as compared with larger gravel (Williams and Wolman 1984). Farther downstream, a preliminary assessment suggested that gravel inputs exceed the river’s transport capacity (Jones et al. 2011).

The amount of sediment that enters streams depends on a variety of factors including mass failures, landslides, surface erosion, and stream bank erosion. Rates of bank erosion along streams are influenced by a number of factors including flow, integrity of the riparian zone, and substrate composition of the stream bank. The riparian zone also produces large wood pieces that provide cover for fish, helps to stabilize stream channels, produces terrestrial sources of food for fish. In addition, vegetation in riparian zones shade streams and shade is known to be a significant factor that affects water temperature of the Rogue River and modeling indicated that a fully restored mature riparian zone would decrease water temperatures by about 2^{o}C (3.5^{o}F) within the lower 100 miles of the Rogue River during summer thermal peaks in air temperature (ODEQ 2008).

Adult NP CHF are potentially affected by a smaller set of habitat quality features as compared to juveniles. Prior to spawning, adult NP CHF can temporarily cease upstream migration by holding within microhabitats. Habitat features associated with specific holding sites in the Rogue River

Basin are mostly unknown, but such locations likely include such features as deep pools, undercut stream banks, and large structures used for cover (bedrock outcrops, large boulders, downed trees or logs). These types of morphological features can be impacted by bank erosion, removal of riparian vegetation, and placement of rock (rip-rap) along channel margins.

Water quality elements that can affect adult NP CHF include temperature, dissolved oxygen, nutrients, and pollutants. Based on water quality index ratings reported by ODEQ (2008), none of these factors, except water temperature, are likely to affect the survival of adult NP CHF in the Rogue River Basin because adults reside in the mainstem of the Rogue River during summer and enter the tributary streams during autumn. In contrast, water temperature is a primary factor that has affected the survival rates of migrating adults. Pre-spawning mortality rates can exceed 50% (Table 19) during years of relatively high water temperatures (ODFW 1992). Almost all of the pre-spawning mortality occurred downstream of Grants Pass (RM 103) during August-September, and the estimated rates of pre-spawning mortality are highly correlated with water temperature (correlation coefficient (r) = 0.93, $P < 0.001$ at the 95% confidence level, ODFW 1992). Simulation modeling indicated that NP CHF recruitment was most sensitive to increases in water temperature during the upstream migration of parents (ODFW 1992).

Table 19. Estimated mortality rates (and number) of adult fall Chinook salmon that died in the Rogue River before spawning, 1978-86. Water temperatures, during succeeding years, averaged less than 19^{o}C (66^{o}F). No estimates of statistical confidence could be generated for the mortality rates (ODFW 1992).

Year	Mortality rate	Water temperature[a]	Number dead
1978	12%	19.6^{o}C (67.3^{o}F)	23,200
1979	81%	20.8^{o}C (69.4^{o}F)	140,900
1980	57%	20.3^{o}C (68.5^{o}F)	47,000
1981	12%	20.2^{o}C (68.4^{o}F)	11,800
1982	4%	19.6^{o}C (67.3^{o}F)	5,400
1983	<1%	19.1^{o}C (66.4^{o}F)	100
1984	<1%	18.8^{o}C (65.8^{o}F)	200
1985	<1%	18.9^{o}C (66.0^{o}F)	500
1986	<1%	19.4^{o}C (66.9^{o}F)	1,400

[a] *Mean daily maximum (^{o}F) during August-September at Agness (RM 30).*

River flow is a major factor that affects water temperature in areas downstream of Grants Pass during late spring and summer. Higher flows result in lower water temperature during that period of time (USACE 1991; ODEQ 2008). Aerial thermal infrared remote sensing surveys in late July of 2003 indicated that the Rogue River warmed gradually between William Jess Dam and the Pacific Ocean (Watershed Sciences 2004). This survey determined that, upstream of Grants Pass, all of the tributary streams contributed flows that were warmer than the Rogue River. In contrast, 10 of 17 tributary streams in the area downstream of Grants Pass contributed flows that were cooler than the Rogue River. Among the lower 17 tributaries, only the Applegate River, which was warmer than the Rogue River, had sufficient flow to significantly impact the water temperature of the Rogue River (Watershed Sciences 2004). Smaller tributaries, such as Mule Creek and Stair Creek in the Wild and Scenic Section of the Rogue River, can provide thermal refuges for adult Chinook salmon provided they are colder than the mainstem of the Rogue River (Satterthwaite 2002).

Within Jackson County, the need for municipal and industrial water supplies is predicted to increase from 36,000 acre-feet in 2000 to 71,000 acre-feet in 2050 (Ryan and Dittmer 2001). Increased demands can also be assumed for other counties in the Rogue River Basin. About 45,000 acre-feet of water in Lost Creek Lake is allocated for irrigation and municipal and industrial use, of which about 34,000 acre-feet has yet to be contracted. This 34,000 acre-feet is currently used for fish enhancement purposes (including protection of NP CHF) but will become less available for fish enhancement purposes in future years as more storage is purchased for consumptive uses. While increased amounts of released reservoir storage may be diverted for consumptive use, no further reductions in natural flows are expected in the Rogue River Basin (Table 20).

Table 20. Summary of water availability in the Rogue River during summer. Flow (cfs) estimates are relevant to the mouth of the Rogue River. Natural flows represent the estimated 50% exceedance level. Instream flows represent water rights held by the state of Oregon. Use represents an estimate of current use and water rights held in reserve. All streams in the Rogue River Basin are closed to the appropriation of natural flows, July-September.

June			July			August			September		
Natural	Instream	Use	Natural	Instream	Use	Natural	Instream	Use	Natural	Instream	Use
4,890	3,000	656	2,690	2,000	716	1,980	2,400	653	1,930	2,400	558

The impact of the reduction in the volume of storage available for fish enhancement purposes was assessed by comparing predictions of pre-spawning mortality rates of naturally produced Chinook salmon runs under two scenarios: (1) a year of low water yield and (2) a year of average water yield. Projections indicated that there is a good possibility that there will be sufficient reservoir storage to protect most CHS, provided that greater rates of pre-spawning mortality among NP CHF are acceptable (Table 21). These projections indicate that the protection and enhancement of Chinook salmon populations, especially CHF, will become more difficult with decreases in the volume of reservoir storage available for fish enhancement purposes in downstream areas.

Within the foreseeable future, it is expected that rates of prespawning mortality among adult NP CHF will increase. Mortality rates will increase because proportionally more reservoir storage, available for fish enhancement purposes, will be used to minimize disease outbreaks among adult CHS (ODFW 2007). Protection of adult CHS has a greater priority than protection of adult CHF because production of NP CHS decreased significantly after construction and operation of Lost Creek Dam (ODFW 2000) whereas production of NP CHF increased significantly after the construction and operation of Lost Creek and Applegate dams.

Table 21. Projected impacts of a 30,000 acre-feet reduction in the availability of reservoir storage from Lost Creek Lake. Projections were generated for 2001 (a drought year) and for 2002 (a year of average water yield). Projections assume (1) zero return flows from the 30,000 acre-feet removal of water from the Rogue River, (2) no reductions in reservoir releases for fish enhancement purposes from Applegate Lake, and (3) average air temperatures during the period of potential disease outbreaks. Mortality rates of adult Chinook salmon were predicted using relationships between water temperature and fish mortality (ODFW 1992; ODFW 2000).

	2001		2002	
Fish variety	Predicted[a]	Predicted[b]	Predicted[a]	Predicted[b]
Spring Chinook salmon	21%	24%	3%	4%
Fall Chinook salmon	40%	61%	8%	17%

[a] *Pre-season prediction that assumed average air temperatures, May-September.*
[b] *Pre-season prediction that assumed average air temperatures, May-September, with 30,000 acre-feet of reservoir storage removed from fish allocation.*

Estuary Habitat: The quality of habitat in the estuary of the Rogue River does not appear to be a primary factor that could limit the production of NP CHF in the Rogue River Basin. The small size of the estuary, relative to flow of the Rogue River, generally limits the potential to accumulate nutrients or pollutants, especially in the riverine portion of the estuary (Ratti 1979). However, localized areas near the substrate historically exhibited poor water quality. During 1975, dissolved oxygen concentrations ranged between 1.0 and 5.0 mg/liter (11-57% saturation) near the substrate at a location in the upper portion of the estuary (Lichatowich and Martin 1977). Water quality in the estuary may have improved as a result of flow augmentation during summer. Sampling during 2005 failed to reveal any dissolved oxygen concentrations lower than 5.2 mg/liter (Cindy Ricks-Meyers, South Coast Watershed Council, personal communication dated February 26, 2010). Juvenile NP CHF do not appear to rear extensively in the Rogue River estuary. Instead, they primarily rear in the mainstem of the Rogue River until attainment of smolt sizes and only inhabit the estuary for a short period of time before ocean entry (ODFW 1992). Thus, juvenile NP CHF that rear in the estuary for an extended period of time mostly originated from the Lower Rogue population area.

Conclusions Related to Habitat Quality: Manageable aspects of habitat quality that have the largest impact on NP CHF production appear to be (1) water temperature of the Rogue River in summer during juvenile rearing and adult migration, and (2) the intensity of peak flows during egg and alevin incubation in the gravel.

Biological Factors

Numerous biological factors have the potential to affect the abundance and life history of NP CHF in the Rogue SMU. The list of generalized factors includes competitors, predators, disease, spawner abundance, and hatchery fish. A discussion of specific aspects follows.

Competitors: Redside shiners (*Richardsonius balteatus*) are likely the primary species that compete with juvenile NP CHF, as both species are found in similar types of habitat. Redside shiners were first documented after an undocumented introduction in the Rogue River Basin during the 1950s, and by 1962 had become widely spread between Agness and Gold Ray Dam (Rivers 1964). This species dominated the number of fish caught with beach seines at some sites downstream of Grants Pass in the 1970s and 1980s, but was much less abundant at sites sampled upstream of Gold Ray Dam. Redside shiners prefer warmer water temperatures than salmonids. Decreased water temperatures, resulting from reservoir releases during summer, have likely decreased the competitive ability of redside shiners in the primary rearing area of juvenile NP CHF (Reeves et al. 1987).

Juvenile Umpqua pikeminnow (*Ptychocheilus umpquaei*) may also compete with juvenile NP CHF, but to a lesser degree as compared with redside shiners. Umpqua pikeminnow were introduced in the Rogue River Basin during 1979. By the middle of the 1990s, the species was very abundant in the Rogue River between Grants Pass and Gold Beach. Anecdotal evidence suggests that Umpqua pikeminnow densities decrease markedly in the area between Grants Pass and Gold Ray Dam. Large numbers of Umpqua pikeminnow have also been seen by ODFW staff during snorkel surveys conducted in the Applegate and Illinois rivers; and also in the lower portions of larger tributary streams including Grave Creek, Jumpoff Joe Creek, and Sucker Creek. Similar to redside shiners, this species tends to prefer warmer water temperatures than salmonids. Decreased water temperatures, resulting from reservoir releases during summer, have likely limited the upstream distribution of Umpqua pikeminnows in the Rogue River.

There is likely minimal competition between juvenile NP CHF and hatchery fish in freshwater. Spring Chinook salmon, coho salmon, and steelhead are reared to full-sized smolts before release from hatcheries in the Rogue River Basin. Some juvenile steelhead fail to migrate downstream from the release sites (Evenson et al. 1982) but most migrate downstream within one week (ODFW 1991; ODFW 1994; ODFW 2000).

While there are large numbers of competitors resident in the Rogue River Basin, there is evidence that the impact on competition may not be significant, at least in relation to freshwater growth rates of juvenile NP CHF. ODFW (1992) determined that NP CHF smolts entered the ocean earlier after operation of Lost Creek Dam. Before reservoir operation, the mean date of ocean entry was 15 September (95% CI = ± 7 days). After reservoir operation, the mean date of ocean entry was 23 August (95% CI = ± 12 days). The 23 day difference in mean date of ocean entry was significant at $P = 0.002$ and the earlier time of ocean entry was related to an increase in freshwater growth rates (ODFW 1992). Smolting of juvenile CH of Rogue River Basin origin appears to be triggered by attainment of a minimum size threshold of about 10 cm (Ewing et al. 1979; ODFW 1992). Faster growth rates resulting from flow augmentation at William Jess Dam, resulted in a faster attainment of body size associated with the downstream migration of NP CHF smolts (ODFW 1992).

In summary, it appears that competition is not a primary factor that limits the production of NP CHF in the Rogue River Basin. Manageable aspects of competition that have the largest impact on NP CHF abundance most likely relate to the ability to affect water temperatures during summer through reservoir management practices. Flow augmentation from William Jess Dam reduces water temperatures throughout the Rogue River during summer (USACE 1991, ODEQ 2008).

Predators: While competitors may be relatively few, there are a myriad of animals that prey upon NP CHF produced in the SMU. Known predators are listed in Table 22, along with the designation of each species as administered by the state of Oregon, and by the federal government. Among predators that inhabit freshwater, only two species (both fish) are not protected under either state or federal law (Table 22).

Table 22. A list of animals that prey, or likely prey, on juvenile or adult fall Chinook salmon of Rogue River origin. Salmonids of hatchery origin and largemouth bass and are protected by the state of Oregon only under the provisions of harvest regulations for game fish.

	Protected species?	
Species or animal type	**Federal**	**State**
FISH		
Umpqua pikeminnow	no	no
Prickly sculpin	no	no
Largemouth bass	no	yes
Coho salmon (hatchery)	no	yes
Steelhead (hatchery)	no	yes
Coho salmon (wild)	yes	yes
Steelhead (wild)	no	yes
Cutthroat trout	no	yes
Marine species	some	some
BIRDS		
Cormorant (double-crested)	yes	yes
Cormorant (pelagic)	yes	yes
Cormorant (Brandt’s)	yes	yes
American merganser	yes	yes
Hooded merganser	yes	yes
Herons (multiple species)	yes	yes
Belted kingfisher	yes	yes
Gulls (multiple species)	yes	yes
Tern	yes	yes
Bald eagle	yes	yes
Osprey	yes	yes
Marine species	yes	yes
MAMMALS		
River otter	no	yes
Mink	no	yes
Harbor seal	yes	yes
California sea lion	yes	yes
Northern sea lion	yes	yes

The issue of predation on anadromous salmonids has received significant attention in the Pacific Northwest, and numerous research projects have attempted to estimate salmonid losses as related to predation. The majority of these assessments have been conducted in the Columbia River Basin. Inferences that can be derived from predation assessments conducted in areas are limited in scope because predation impacts are dependent on at least four primary factors: predator numbers, potential prey species, potential prey abundance, and potential prey life history. For example, there is a good chance that birds preyed on fewer juvenile NP CHF after redside shiners became abundant in the Rogue River during the 1950s.

Within the Rogue River Basin, directed predation assessments are limited to two predatory groups of animals: pinnipeds and Umpqua pikeminnows. One study conducted in 1977-78 estimated that pinnipeds preyed on less than 1% of the returning CHS and summer steelhead but did not attempt to estimate impacts on CHF (Roffe and Mate 1984). These estimates are dated because pinniped abundance in the Rogue River and estuary increased markedly since the late 1970s. Another study, conducted in 1997-99, estimated that pinnipeds consumed an average of 625 juvenile and adult salmonids during the period of September-November (Riemer et al. 2001).

These latter estimates could be used to estimate pinniped impact rates under a worst-case scenario assumption. One could assume that all of the 625 salmonids eaten in 1997-99 were adult NP CHF (no summer steelhead, half-pounders, or coho salmon). During those years, the number of NP CHF that passed Huntley Park during September-October averaged 20,100 fish. Under a worst-case scenario, the pinniped impact on adult NP CHF would then be about 3% (625/20,100). In comparison, a predation study completed in the Klamath River and estuary estimated that pinnipeds consumed an average of 4% of the returning NP CHF annually during 1997-1999 (Hillemeier 1999; Williamson and Hillemeier 2001a; Williamson and Hillemeier 2001b).

Among Umpqua pikeminnows collected during summer in the Middle Rogue population area, 4% (1993) and 7% (1994) contained salmonids (Satterthwaite 1995). Other sampling in the spring of 1994 determined that 30% of the pikeminnows contained salmonids within their digestive tracts. Within all sampling periods, most of the consumed salmonids were juvenile Chinook salmon. The best estimate of losses resulting from pikeminnow predation comes from the Columbia River, where it has been estimated that pikeminnows consume 8% of the juvenile salmonids that migrated as smolts (Beamesderfer et al. 1996; Zimmerman and Ward 1999). However, pikeminnow predation rates in the Rogue River must be lower because the mainstem dams in the Columbia River exacerbate predation opportunities (Beamesderfer et al. 1996; Zimmerman and Ward 1999).

In summary, the impacts of predators on NP CHF production in the Rogue River Basin are relatively unknown and could range markedly depending on predator abundance and predator preferences of prey. The most likely predator that could have significant impact on NP CHF was judged to be non-native Umpqua pikeminnows because they are very abundant and have been documented as consumers of juvenile NP CHF.

Disease: Disease is known to be a primary factor that affects the abundance of NP CHF in the Rogue River Basin. Extensive pre-spawning mortalities of adults were mentioned in 13 of 30 years of monthly reports written by fish biologists during the 1940s through the 1960s. Incidences of prespawning mortality were associated with years of low flows during the period of upstream migration (ODFW 1992). Mean flows at the USGS Raygold gage (RM 125) during July and August averaged 1,247 cfs during years of documented mortality and 1,526 cfs during years with no mention of mortality in the monthly reports. The difference in mean flows was significant at $P = 0.007$. Extensive pre-spawning mortalities of adult CHF were also documented during 1978-1981. ODFW estimated that the rates of prespawning mortality ranged between 12% and 81% during those years and found a positive relationship ($P < 0.001$) between mortality rates and water temperature during the period of 1978-1986 (ODFW 1992).

A bacterial pathogen, *Flexibacter columnaris* (*Columnaris*), was the disease organism most often isolated from dead and dying CHF sampled in the Rogue River during the late 1970s and early 1980s (Amandi et al. 1982). Virulence of this bacterium varies among strains and epizootics may occur intermittently in salmonid populations (Becker and Fujihara 1978). Mortality rates of juvenile Chinook salmon infected with *Columnaris* increase as water temperatures increase from

12°C (54°F) to 21°C (70°F) (Holt et al. 1975; Becker and Fujihara 1978). In the Rogue River Basin, juvenile and adult NP CHF are annually exposed to water temperatures close to the upper end of this range during summer. Simulation modeling indicated that water temperature in late summer can be a primary limiting factor when mean water temperature exceeds 19.8°C (68°F) during August-September (ODFW 1992).

Columnaris was detected in resident fish in Lost Creek Lake and in juvenile Chinook salmon held in the reservoir, but was not detected in reservoir water or reservoir outflow (Amandi et al. 1982). Among the various water bodies sampled, pathogen concentrations were greatest in the outflow from Cole M. Rivers Hatchery. CHS held in the hatchery were also found to be infected with the disease. It could not be determined whether adult salmon carried the disease into the hatchery or contracted the disease after entry. *Columnaris* was also found in several species of fish sampled throughout the Rogue River Basin, including the Applegate River (Amandi et al. 1982). Other disease organisms detected in CHS include Infectious Hematopoeitic Necrosis (IHN), Bacterial Kidney Disease (BKD), *Furunculosis*, and *Ceratomyxa shasta*. At the present time, *Columnaris* is believed to pose the greatest risk to NP CHF in the Rogue SMU.

To minimize losses of adult NP CHF to disease, ODFW identified targets for maximum water temperature at the USGS gage near Agness (RM 30) and since 1986, has requested releases of reservoir storage in order to meet water temperature targets in downstream areas. River flow must be augmented to meet water temperature targets because the effect of outflow temperature at Lost Creek Lake diminishes rapidly with distance downstream (USACE 1991). This approach has proved to be effective in decreasing losses related to disease. For example, the mortality rate of adult NP CHF in 2001 was estimated to be 11%, even though the yield of water in the Rogue River Basin was one of the lowest of record (Satterthwaite 2002). With the exception of 2001, there have been few anecdotal reports of dead adult NP CHF in the Rogue River prior to the spawning period.

Similar methods of flow augmentation are employed to reduce the risk of *Columnaris* outbreaks among adult CHS (ODFW 2007). This approach means that currently, during an average year of water yield, the available amount of reservoir storage is sufficient to prevent significant disease-related losses of adult NP CHF. Reservoir storage is limited because ODFW also requests the release of storage to minimize the chance of disease outbreaks among NP CHF and also to increase the survival rates of juvenile salmonids that rear and migrate in the Rogue River during the middle of summer (ODFW 2000). As more reservoir storage is purchased for irrigation, and municipal and industrial supply, the amount of storage available for fish enhancement purposes will decrease.

Spawner Abundance: A critical factor that obviously affects salmon populations is the number of spawning adults. Knowledge of the relationship between spawner abundance and the production of progeny is of primary importance in order to effectively manage salmon populations. Identification of the effects of spawner abundance on recruitment was evaluated with population models. A brief description of the analytical approach follows and a more complete description can be found in **APPENDIX F**. The population models were expanded to include environmental covariates thought, based on research findings, to directly affect recruitment of Chinook salmon produced in the Rogue SMU. Environmental covariates were retained in the spawner-recruit models only if the resulting increase in explanatory power exceeded the statistical penalty for model complexity as assessed with a Deviance Information Criterion (DIC) that was less than or equal to a value of two.

Environmental covariates incorporated into the analyses for the Rogue populations of NP CHF were specific to the Rogue River Basin. These covariates included (1) peak flow of the Rogue River at Grants Pass when NP CHF eggs and alevins incubated in the gravel, (2) mean flow of the Rogue River at Agness during July-August when pre-smolts were rearing in freshwater, (3) mean flow of the Applegate River in October-November during adult CHF migration and spawning, and (4) survival rate estimates of CWT marked spring Chinook salmon smolts released during September-October at Cole M. Rivers Hatchery. The rationale associated with the inclusion of these four covariates is: (1) the intensity of peak flow has been shown to be negatively related to the production of NP Chinook salmon in the Rogue River Basin (Fustish et al. 1988; ODFW 1992; ODFW 2000), (2) water temperature of the Rogue River commonly exceeds 24^{o}C (75^{o}F) during juvenile NP CHF rearing (flow was used as a proxy for water temperature because of incomplete temperature data), (3) flow during autumn has been shown to be positively related to CHF spawner distribution in the Applegate River; a primary producer of NP CHF in the Rogue River Basin (Fustish et al. 1988), and (4) incorporation of hatchery smolt-adult survival theoretically allows introduction of a primarily marine survival effect that is independent of adult stock size. Smolt-adult survival rates of wild and hatchery Chinook salmon have been shown to highly correlated (Buchanan et al. 2010) and addition of a survival rate covariate for hatchery fish improved a stock-recruitment relationship developed for CHF in the nearby Klamath River Basin (STT 2005).

Of the five independent populations of NP CHF in the Rogue River Basin, appropriate recruit and spawner data was available for only the Upper Rogue and Lower Rogue populations. However, there is appropriate data that can be used to develop spawner-recruit relationships for the aggregated populations of NP CHF in the Rogue River Basin. Stock recruitment models were not produced for the Upper Rogue population because this population can no longer be monitored with the loss of the fish counting station resulting from the removal of Gold Ray Dam. Model results are shown graphically in the following sections. More complete descriptions of the population models can be found in **APPENDIX F**.

Rogue Aggregate Populations: Of the seven stock-recruitment models built for Rogue aggregate populations, three were distinguished by lower (≤2) DIC scores as compared to the other four models (Appendix Table F-1). The three best models could not be differentiated based on their DIC scores (Table 23). Model results suggest that brood harvest rates should average about 0.54 for MSY and that about 35,000 spawners are needed for MSY (Table 23).

Parameter coefficients in the models suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The models indicated that NP CHF recruitment was positively related to two factors: (1) survival rates of young hatchery fish in the ocean and (2) flow of the Rogue River during the period of peak water temperatures when juvenile NP CHF are resident in freshwater; and was negatively related to the intensity of peak flow when eggs and alevins of NP CHF are incubating in the gravel. These environmental effects can be marked, as conveyed in the

Table 23. Best 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. Additional information about these models is included in **APPENDIX F**.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY	Harvest rate for MSY
Rogue1	Ricker	1[a]	45.0	35,475	0.55
Rogue2	Ricker	2[b]	46.4	35,021	0.54
Rogue3	Ricker	2[c]	45.6	34,992	0.54

[a] Survival rate of hatchery smolts.
[b] Hatchery smolt survival rate and peak flow during egg and alevin incubation.
[c] Hatchery smolt survival rate and summer flow during juvenile rearing.

example shown in Figure 30. This particular model was chosen for the graphic because these two environmental factors are significant covariates in at least one best model for all of the NP CHF populations in the Rogue SMU (Appendix Table F-1).

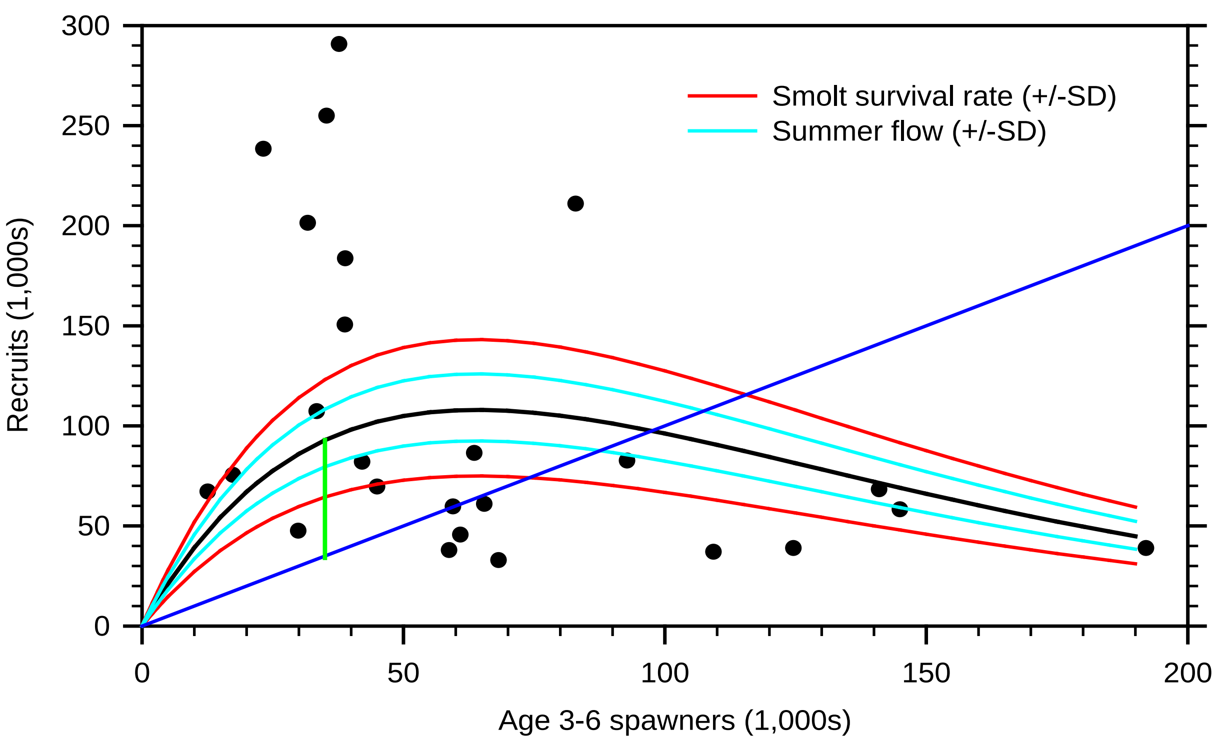

Figure 30. One of the Ricker stock-recruitment models (Rogue3) that best fit spawner and recruit estimates for the Rogue aggregate populations of naturally produced fall Chinook salmon, 1980-2004 brood years. The solid black line represents the estimated relationship between recruits and spawners under average environmental conditions. The colored curved lines represent the estimated spawner-recruit relationship with each mean covariate value varied by +/- one standard deviation. The dark blue line represents replacement (recruits = spawners) and the green line represents the model estimate of maximum sustained yield.

Lower Rogue Population: No satisfactory stock-recruitment model could be developed for this population. Consequently, the quantitative characterization of the Lower Rogue population remains uncertain and this uncertainty needs to be addressed as additional data becomes available (*see* **Monitoring Needs**, page 139). However, criteria (desired status and conservation status) are needed to manage the population, and the effects of spawning escapement, so NP CHF production was assessed with the development of a modified parent-progeny plot. As in the stock-recruitment analyses, parents were defined as the number of age 3-6 spawners. However, progeny abundance was characterized as an index of wild smolt production.

Annual estimates of smolt-age 2 survival rates are available for CWT-marked CHS released from Cole Rivers Hatchery. These survival rate estimates were used as proxy that reflects variable survival rates of young CH during the nine months after ocean entry. Models competed for all of the other NP CHF populations in the SMU indicated that these survival rate estimates are an important covariate that helps improve the fit of the stock-recruitment relationships (*see* preceding section and **Spawner Abundance:**, page 60).

Estimates of the number of age 2 fish are available from the cohort reconstruction. Annual indexes of smolt production in the Lower Rogue population area, were generated by dividing the number of fish alive at age 2 by the survival rates of the CWT-marked hatchery cohorts. The resultant parent-progeny relationship is shown in Figure 31. This relationship was used to evaluate options for a desired status criterion relevant to spawning escapement.

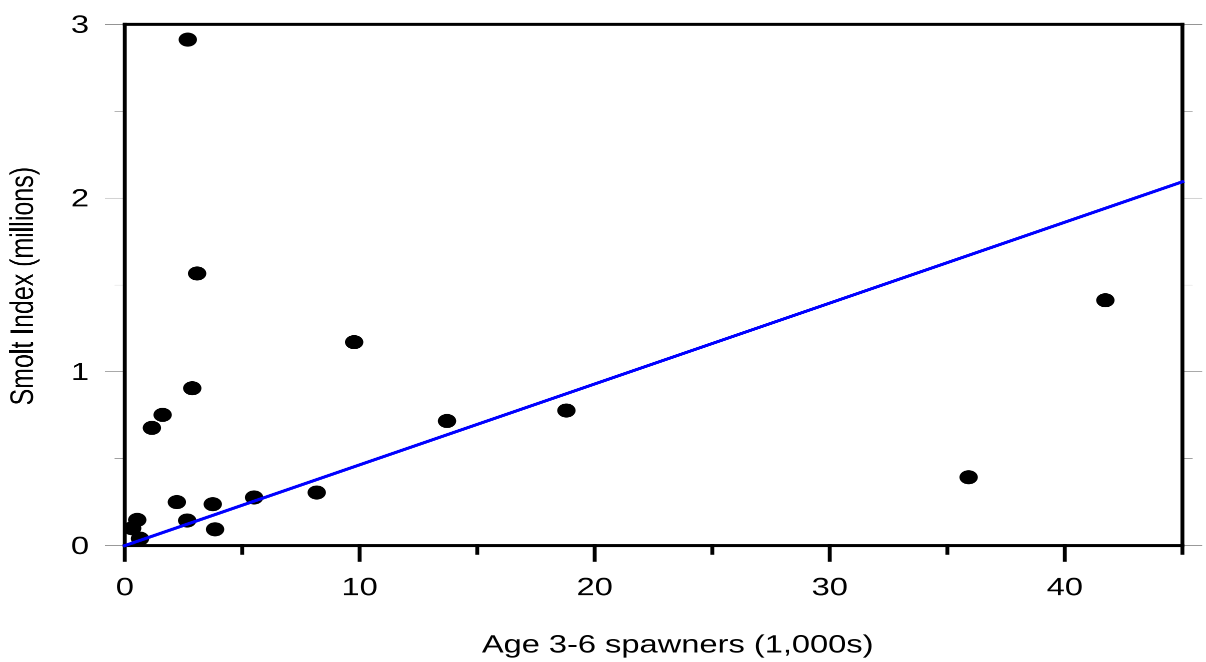

Figure 31. Annual abundance indexes of naturally produced fall Chinook salmon smolts plotted on the number of age 3-6 parents that spawned in the Lower Rogue population area, 1986-2004 brood years. The dark blue line represents replacement (recruits = spawners).

The replacement line in Figure 31 was generated by (1) taking a hypothetical number (value does not matter) of recruits, (2) applying a conventional 0.5 overwinter survival rate for age 2-3 CHF in the ocean, (3) applying the mean maturation rate of age 2 jacks, and (4) applying the mean smolt - age 2 survival rates for CWT-marked CHS released from Cole Rivers Hatchery. These four steps result in replacement estimates for the smolt indexes at any given level of spawning escapement.

To summarize this section, the population assessments indicate that low spawner abundance is a primary factor that periodically limits the production of NP CHF in the Rogue Stratum.

Hatchery Fish: During the last 20 years, there has been increased concern that hatchery fish may be partially responsible for documented declines in the abundance of some naturally produced salmon populations (ISAB 2002). Potential impacts may be due to genetic factors or to ecological interactions. Genetic impacts can develop when populations of naturally produced and hatchery fish have different genetic characteristics. Differences in genotypes or gene frequencies can result from domestication of a hatchery population, use of a non-local broodstock to establish a hatchery population, or inbreeding resulting from small hatchery broodstock size (ISAB 2002). Ecological impacts can result from (1) competition between naturally produced and hatchery fish, (2) direct predation by hatchery fish on naturally produced fish, (3) increased losses if hatchery fish attract additional predators, (4) disease transmission from hatchery fish to naturally produced fish, and (5) changes in water quality directly attributable to hatchery operations (HSRG 2005). There are also indications that natural spawning hatchery fish, even from locally adapted broodstocks, produce fewer progeny as compared to wild fish (Schroder et al. 2008; Berejikian et al. 2009) and that hatchery fry survive at lower rates in streams as compared to wild fry (Tatara et al. 2009).

The risk of potential negative impacts to NP CHF, which result from the release of CHF from Indian Creek Hatchery, is difficult to thoroughly evaluate. However, the following information can be used, to some degree, to assess the potential for risk to NP CHF:

1. Very few hatchery fish spawn in CHF population areas in the Rogue River Basin, with the exception of the Lower Rogue population. In the Lower Rogue population area, hatchery fish composed an average of 4% of the natural spawners. In the other four population areas, hatchery fish composed less than 1% of the natural spawners.
2. The amount of domestication of the hatchery population is unknown. Indian Creek Hatchery has been operational since 1984. The estimated proportion of NP CHF among the broodstock averaged 55% (95% CI = 46-64% as estimated from arcsine transformed data) during 1992-2011 and ranged between 12% and 81%.
3. A minimum of 76 adults (usually more than 100) composed the broodstocks spawned annually during the last 13 years.
4. Since 1998, CHF smolts reared at Indian Creek Hatchery have been released no earlier than early July. This date of release ensures that the preponderance of the juvenile hatchery fish do not rear in the Rogue River, or in the Rogue River estuary, for an appreciable period of time (ODFW 1992).
5. Hatchery smolts are now released only Indian Creek Hatchery and returning adults spawn in small creeks proximal to the release site rather than in the primary spawning areas of Lobster and Quosatana creeks. This type of spatial distribution may help maintain the genetic integrity of the NP CHF population in the basin (Heggenes et al 2011).

The production program for CHF at Indian Creek Hatchery is comparable to an "integrated hatchery program" as defined by Hatchery Scientific Review Group (HSRG 2009). This term describes a management scenario where the hatchery broodstock is managed as a genetically integrated component of an existing population. Recommendations (HSRG 2009) for broodstock composition for an integrated hatchery program are dependent on the classification of management concern in relation to stock productivity and abundance. Based on a persistence probability of >99% over 100 years (*see* **VIABILITY OF THE SPECIES MANAGEMENT UNIT**, page 111), and good population productivity (*see* **Spawner Abundance:**, page 60),

NP CHF in the Lower Rogue population area seems to be most appropriately classified as a "Stabilizing" population (definition of HSRG 2009). HSRG (2009) did not propose broodstock composition recommendations for stabilizing populations because employed operating criteria were judged to be adequate in relation to conservation goals.

Alternatively, if NP CHF in the Lower Rogue population area were to be classified as a "Contributing" population (definition of HSRG 2009), then the following HSRG (2009) recommendation would apply: the proportion of hatchery fish among natural spawners should be less than 0.30 (30%) and (2) the proportion of naturally produced fish within the hatchery broodstock should exceed proportion of hatchery fish among natural spawners. Under this scenario, both criteria were met during 1992-2011 operations at Indian Creek Hatchery. Other recommendations related to principles of hatchery programs (HSRG 2009) are also mostly attained by the production program for CHF at Indian Creek Hatchery (ODFW 2006b) and revisions to the HSRG recommendations can be expected as more refined research results become available on this issue. Thus, the HSRG recommendations should not be considered as sole guidance in relation to the management of hatchery fish.

The hatchery and genetic management plan, implemented for Indian Creek Hatchery, complies with ODFW's Fish Hatchery Management Policy (ODFW 2003). This policy describes best management practices that are intended to help ensure the conservation of both naturally produced native fish and hatchery produced fish. Policy goals include:
1. Foster and sustain opportunities for sport, commercial and tribal fishers consistent with the conservation of naturally produced native fish.
2. Contribute toward the sustainability of naturally produced fish populations through the responsible use of hatcheries and hatchery-produced fish.
3. Maintain genetic resources of native fish populations spawned or reared in captivity.
4. Minimize adverse ecological impacts to watersheds caused by hatchery facilities and operations.

The Fish Hatchery Management Policy requires that ODFW hatchery programs be distinguished as harvest or conservation hatchery programs. Currently, ODFW manages the Rogue CHF program at Indian Creek Hatchery as a Harvest Augmentation Program. As described in the Fish Hatchery Management Policy, harvest augmentation programs operate to enhance fisheries without impairing naturally reproducing populations.

To summarize this section, the history of broodstock collection practices and smolt release practices at Indian Creek Hatchery, coupled with a low rate of hatchery fish among natural spawners, have likely resulted in minimal impacts to naturally produced fish in the Lower Rogue population as compared with most other hatchery programs for salmon in the Pacific Northwest. Given that few hatchery fish spawn naturally in the other four population areas in the Rogue River Basin, the current program for hatchery fish is not likely a primary factor that could possibly limit attainment or maintenance of desired status.

Fisheries

A primary impact exerted on salmon populations is mortality that results from fishing activities. Wading and boating may have some impact on production (Roberts and White 1992; Horton 1994), but the greatest impact almost certainly originates from the directed fishing on salmon by recreational and commercial fisheries. Mortality rates associated with fishing can vary widely for Pacific salmon, especially for Chinook salmon that mature at multiple ages.

Harvest rates, unless otherwise stated, are defined as that percentage of recruits which were taken by fishers, for the brood years in question. Methods devised to estimate recruits, ocean harvest, and freshwater harvest are described in **APPENDIX C**.

Rogue Aggregate Populations: Estimates of brood harvest rates for NP CHF produced in the Rogue River Basin ranged from 13% to 88% for the 1972-2006 brood years. Brood harvest rates were greatest for fish produced in the 1970s, generally declined for fish produced during the mid 1980s through the mid 1990s, increased for fish produced in the late 1990s, and then declined again for fish produced during the 2000s (Figure 32). The sharp decline in brood harvest rates for fish produced in 1980 and 1981 was partially linked to the extremely strong El Niño event of 1982-83 (ODFW 1992).

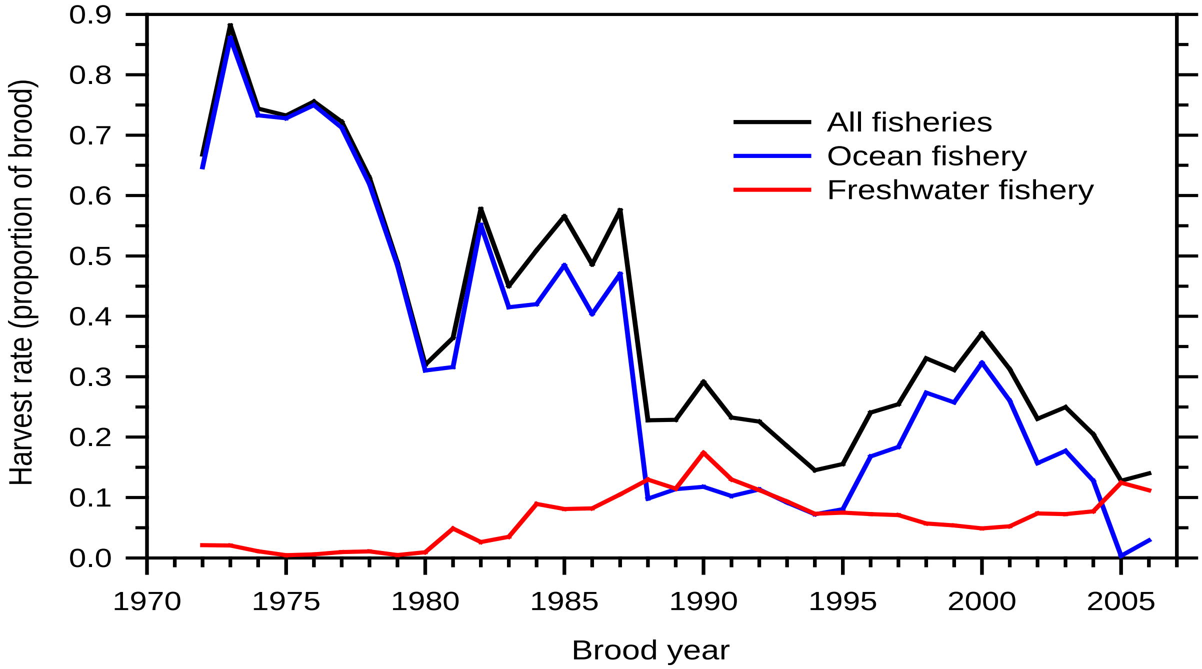

Figure 32. Estimated brood harvest rates of naturally produced fall Chinook salmon of Rogue River Basin origin, 1972-2006 brood years. Confidence bounds could not be generated for these estimates.

Brood harvest rates averaged 71% (95% CI = 61-80%) for broods produced in the 1970s, 43% (95% CI = 33-53%) for broods produced in the 1980s, 24% (95% CI = 19-28%) for broods produced in the 1990s, and 23% (95% CI = 15-32%) for broods produced in the 2000s; with all of the confidence intervals estimated from arcsine transformed data. The stock-recruitment models built for the Rogue aggregate populations (*see* **Rogue Aggregate Populations:**, page 25), indicated that an brood harvest rates of about 54% would result in MSY. These results suggest that mortality related to fishing likely had a substantially adverse effect on NP CHF recruitment prior to the mid-1980s, but generally did not during later years.

Ocean harvest rates of NP CHF produced in the Rogue River Basin have decreased since the 1970s (Figure 32). Harvest rates specific to the ocean fisheries averaged 70% (95% CI = 60-79%) for broods produced in the 1970s, 35% (95% CI = 23-47%) for broods produced in the 1980s, 14% (95% CI = 9-19%) for broods produced in the 1990s, and 12% (95% CI = 4-29%) for broods produced in the 2000s; with all of the confidence intervals estimated from arcsine transformed data. The decline in ocean harvest rates coincided with decreases in ocean harvest for CHF in the

Klamath River Basin of northern California, beginning in 1988 (PFMC 1988). Resultant harvest restrictions to the ocean fisheries caused NP CHF of Rogue River Basin origin to be harvested at lower rates because both groups of fish tend to be caught in the same general area of the ocean (Appendix Table C-3). For the purposes of this conservation plan, the brood harvest rates of NP CHF, of Rogue River Basin origin, in the ocean fisheries can be assumed to average about 20% for the foreseeable future.

In contrast to ocean harvest rates, brood harvest rates in the river fishery (includes estuary) increased during the 1980s (Figure 32). Harvest rates in the river fisheries averaged 1% (95% CI = 1-2%) for broods produced in the 1970s, 7% (95% CI = 4-10%) for broods produced in the 1980s, 8% (95% CI = 6-10%) for broods produced in the 1990s, and 8% (95% CI = 5-10%) for broods produced in the 2000s; with all of the confidence intervals estimated from arcsine transformed data.

The freshwater fishery (includes estuary) harvested 3-26% of the age 3-6 CHF that returned to freshwater during 1986-2009. Annual exploitation rates in the freshwater fishery were negatively related to CHF abundance (Figure 33). Anglers harvested a greater proportion of the run during years of low abundance. In contrast, anglers harvested a smaller proportion of the run during years of high abundance. During years when less than 30,000 CHF returned to the Rogue River, the freshwater fishery harvested 11-26% of the freshwater returns (Figure 33).

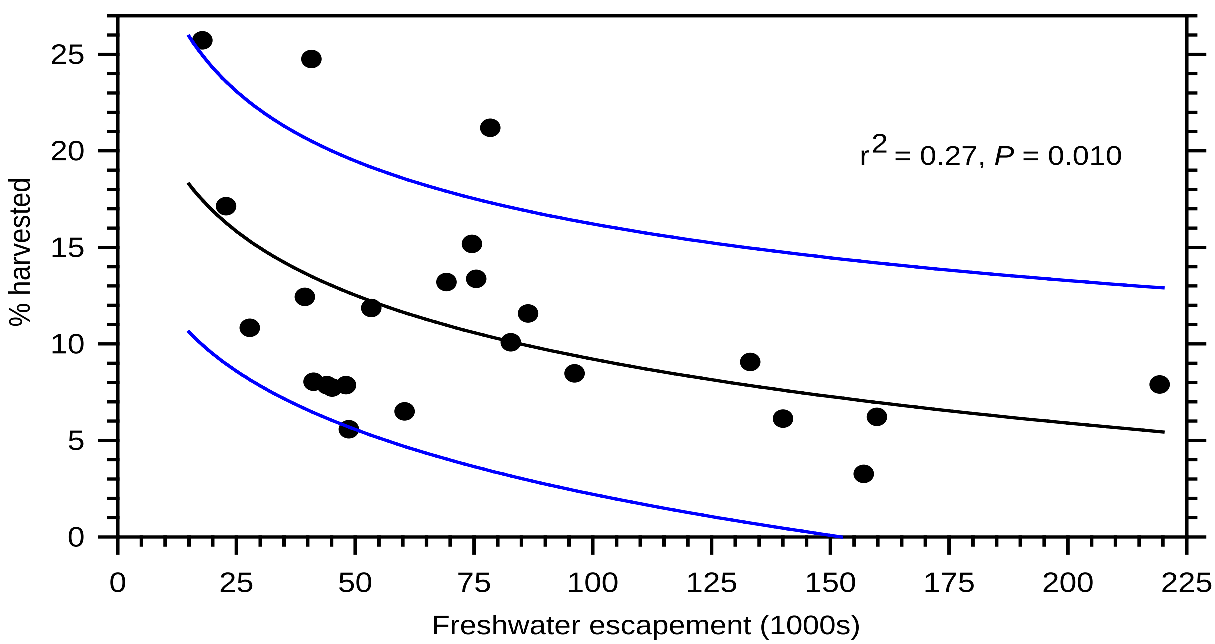

Figure 33. Relationship between annual exploitation rates in the freshwater fishery and the annual returns of age 3-6 fall Chinook salmon to the Rogue River, 1986-2009. The black line is the regression equation and the blue lines represent the 90% confidence bounds. Data prior to 1986 were not included in the analysis because angler interest in this fishery increased markedly during the early 1980s (ODFW 1992).

Lower Rogue Population: Estimates of brood harvest rates for NP CHF produced in the Lower Rogue population area ranged between 9% and 59% for the 1984-2005 brood years. Harvest rates were greatest for fish produced in the mid-1980s and then decreased in later years (Figure 34). The decrease in harvest rates corresponded to increased restrictions within the ocean fisheries (*see* previous section). Harvest rates for the 1984-1987 brood years averaged 49% (95% CI = 40-59% as estimated from arcsine transformed data). In contrast, harvest rates for the 1988-2006 brood years averaged 20% (95% CI = 16-23% as estimated from arcsine transformed data), somewhat greater than those estimated for the Rogue aggregate populations (15%).

To summarize this section, harvest can limit the abundance of NP CHF populations in the Rogue stratum when population abundances are lower than S_{MSY} (spawners needed for maximum sustained yield).

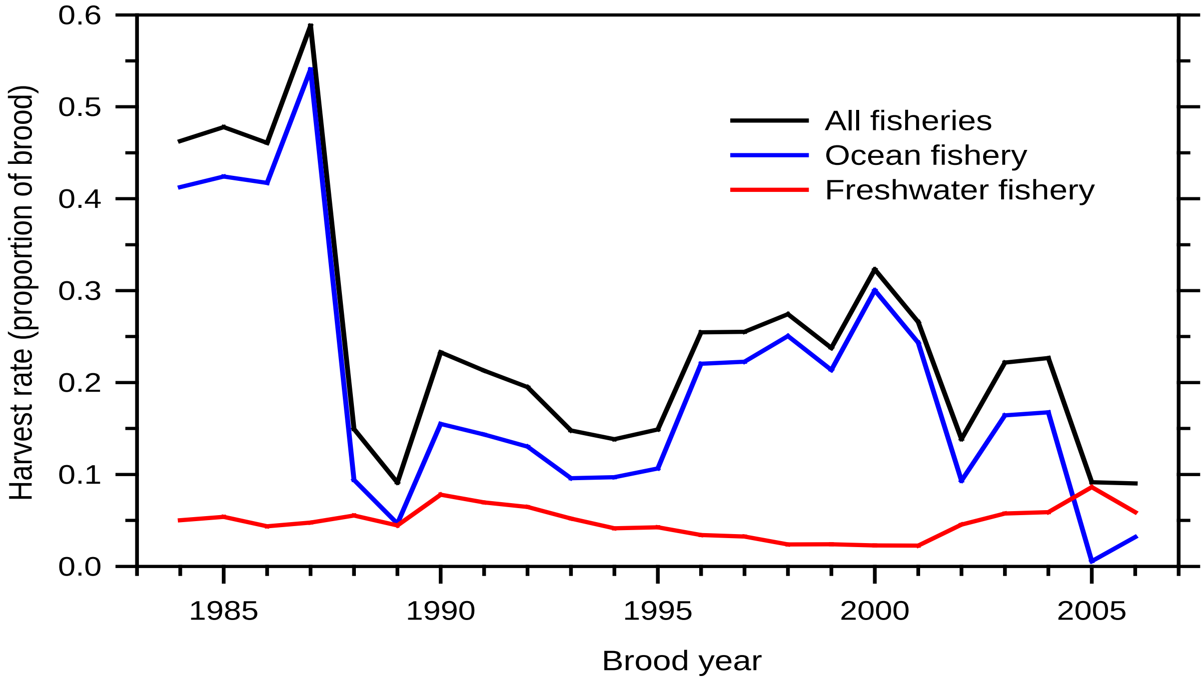

Figure 34. Estimated harvest rates of fall Chinook salmon naturally produced in the Lower Rogue population area, 1984-2006 brood years. Confidence bounds could not be generated for these estimates.

Simulation Model for Rogue Aggregate Populations: ODFW (1992) developed a simulation model for NP CHF produced in the Rogue River Basin. The model was designed for three primary purposes: (1) development of recommendations for the management of USACE reservoirs in the Rogue River Basin, (2) identification of the primary factors that affect the production and harvest of NP CHF, and (3) identification of additional information needed to improve understanding of population dynamics of NP CHF.

The model structure reflects the basic life history of NP CHF during periods of freshwater and ocean residence. The model simulates population and harvest parameters for one brood year based on selected values of input variables, because it was not possible to quantitatively simulate the primary factors that could account for the wide variations in ocean survival rates. Regression equations composed the primary components of the model. It was assumed that the regressions were independent of each other for the purposes of simulation analyses. In actuality, regressions were not independent of each other because many were developed with the same sets of independent variables that included the same sources of measurement errors.

A simulation run with mean values for input variables indicated that the model has a relatively high degree of precision. Coefficients of variation associated with most of the key output parameters were less than 20% (ODFW 1992). The predicted outputs from simulation runs with mean input values exhibited a high degree of precision because the simulations were run under the assumption of constant rates of survival in the ocean. Consequently, the precision of the outputs were primarily affected by environmental conditions in freshwater. As one primary purpose of the modeling effort was to develop optimal strategies for reservoir releases, model precision appeared to be sufficient for that particular purpose.

Sensitivity analyses suggested that the production and harvest of NP CHF was most sensitive to increased water temperature of the Rogue River when adult fish were migrating in the river during summer (Table 24). Sensitivity to an increase in water temperature was four times greater than sensitivity to any other change among input parameters (Table 24). Except for increased water temperature, sensitivities exceeded 0.1 only for decreased exploitation rate in the ocean fisheries and decreased peak flow when eggs and alevins incubate in the gravel (Table 24). Results of the sensitivity analyses lend support to previous conclusions that water temperature during the upstream migration of adult NP CHF, and the intensity of peak flow during the gravel incubation of NP CHF embryos, are primary factors that limit NP CHF production in the Rogue River Basin.

Table 24. Estimated recruitment of age 3 naturally produced fall Chinook salmon in response to variations of simulation model input parameters (ODFW 1992). Average input values predicted a recruitment of 685,222 age 3 fish. These estimates are relative to the historical Huntley Index (Appendix Table C-2) and do not reflect the current estimates of the abundance of fall Chinook salmon presented in this conservation plan.

	Input	Predicted recruitment		Sensitivity	
Parameter	value	Input-10%	Input+10%	Input-10%	Input+10%
Juvenile abundance[a]	119	689,384	683,163	<0.01	<0.01
Age 2 freshwater return	12,102	706,257	718,191	0.03	0.05
Age 3 freshwater return	12,784	662,015	737,080	0.03	0.08
Age 4 freshwater return	16,202	686,708	704,556	<0.01	0.03
Age 5 freshwater return	2,639	705,275	705,025	0.03	0.03
Ocean harvest rate	0.59	781,351	641,886	0.14	0.06
Water temperature[b]	19.6	730,316	255,256	0.07	0.63
Migration flow[c]	347	673,962	727,171	0.02	0.06
Peak flow[d]	24,312	759,499	675,687	0.11	0.01

[a] *Index of annual juvenile NP CHF abundance during early summer.*
[b] *Mean maximum water temperature (^{o}C) at Agness during August-September.*
[c] *Mean flow (cfs) at Applegate during October-November.*
[d] *Flow (cfs) at Grants Pass during November-February.*

Comparisons to Other Populations: Cyclical patterns in survival rates of regional groups of Pacific salmon are related to changes in current patterns that typify various regions of the ocean (Beamish et al. 2004). Abundance trends among geographically proximal populations track with each other, unless limiting factors differentially affect one or more of the populations (Pyper et al. 2005; Malick et al. 2009).

The Klamath River Basin is located immediately south of the Rogue River Basin and NP CHF are endemic in both river basins. Populations within both basins are mostly grouped in the same Evolutionarily Significant Unit based on genetic assessments (Myers et al. 1998). There is likely some commonality among factors that affect the natural production of CHF because both basins adjoin each other, share similar geology, and exhibit similar patterns of flow volume and timing of water yield. In addition, the ocean distribution NP CHF produced in both basins is likely very similar, based on the landing distributions CWT-marked CHF released from hatcheries in both basins (Appendix Table C-3).

The number of natural spawning CHF has been estimated in the Klamath River Basin since 1985 (KRTT 2012). Annual estimates of natural spawners in the Klamath River Basin are positively related to annual passage estimates of NP CHF at Huntley Park, although the correlation is marginal (Figure 35).

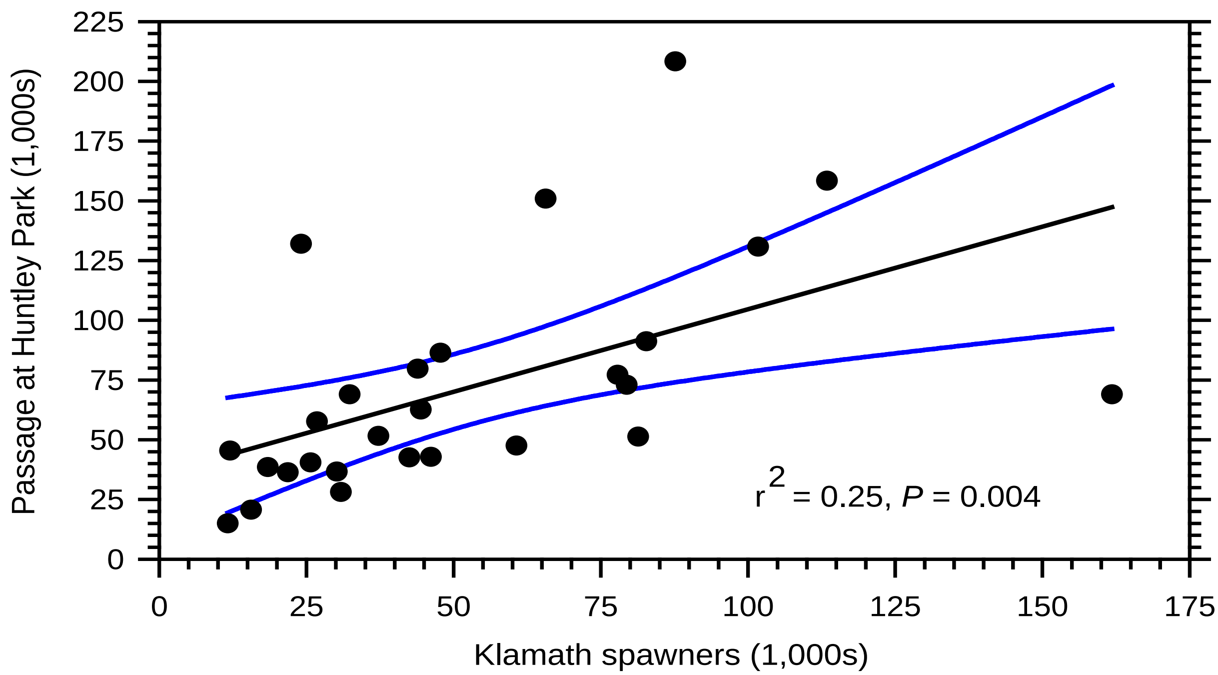

Figure 35. Estimated number of age 3-5 naturally produced fall Chinook salmon that passed Huntley Park in relation to the estimated number of age 3-5 fall Chinook salmon that spawned naturally in the Klamath River Basin, 1985-2011. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Spawner estimates in the Klamath River Basin include an unknown number of hatchery fish.

Comparisons of the number of age 3 NP CHF alive in the ocean during spring, prior to the onset of fishing, may be a more sensitive method by which to assess co-variation in NP CHF abundance for the Rogue populations and CHF of Klamath River Basin origin. This approach would theoretically not be affected by stock-specific differences in fishing mortality and maturation schedules. However, the lack of ocean stock size estimates specific for naturally produced Klamath CHF seemingly biases such an analysis. Regardless, estimates of the number of age 3 NP CHF of Rogue River Basin origin were positively related to estimates of the number of age 3 CHF of Klamath River Basin origin (Figure 36).

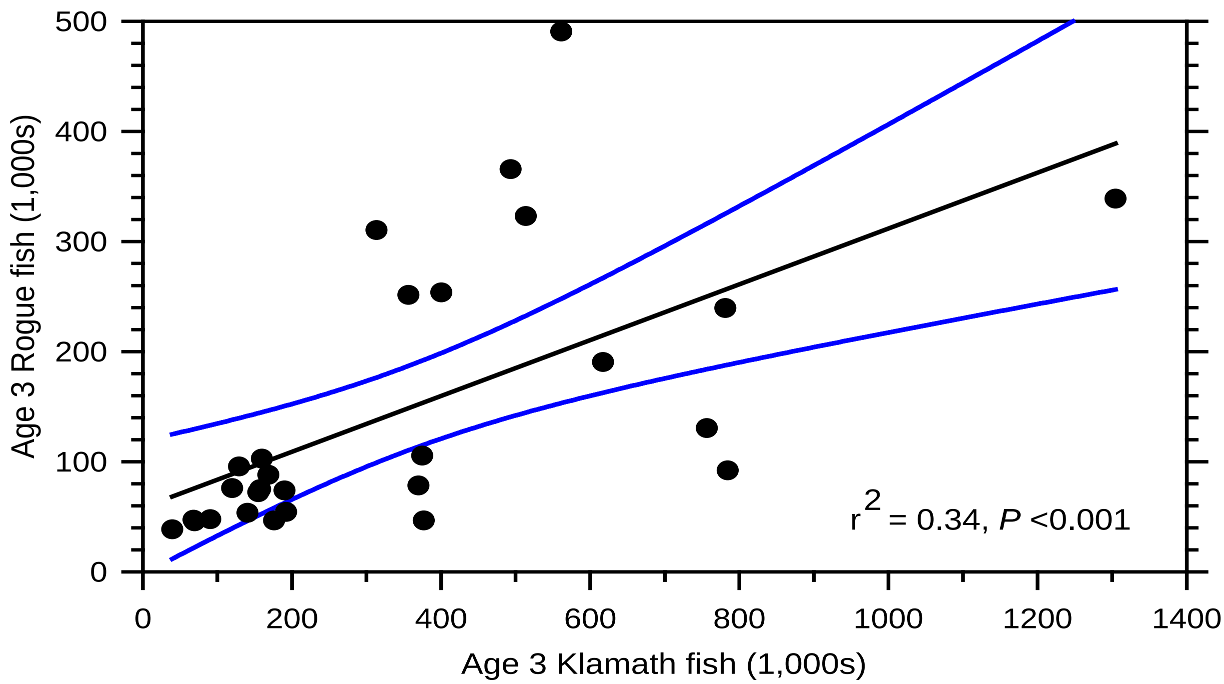

Figure 36. Relationship between numerical estimates of naturally produced age 3 fall chinook salmon produced in the Rogue River Basin and in the Klamath River Basin, brood years 1984-2006. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Estimates reflect the number of fish alive in the ocean during spring prior to the onset of fishing.

This finding indicates there is co-variation in the freshwater abundance of NP CHF in both river basins; suggesting co-variation of ocean survival rates for immature NP CHF produced in both river basins. Co-variation in ocean survival rates has been documented for hatchery CH released in the Rogue and Klamath river basins (Hankin and Logan 2010). Hankin and Logan (2010) also found that (1) maturation probabilities and (2) lengths at a given age co-varied among hatchery CH released in both river basins. Taken collectively, these results indicate that regional ocean conditions, just after smolts enter the ocean, are (1) primary factors that affect recruitment for populations of NP CHF produced in the Rogue River Basin and (2) lend support to the use of survival rates of CWT-marked hatchery smolts as a proxy for annual variations in the early ocean survival rates of naturally produced fish.

Summary of Limiting Factors Assessment - Rogue Stratum: Based on the limiting factors assessment outlined within the preceding sections, the primary factors that appear to limit the abundance and expression of life history strategies of NP CHF populations in the Rogue stratum include: (1) water temperature of the Rogue River in summer during adult migration, (2) water temperature of the Rogue River in summer during juvenile rearing, (3) the intensity of peak flows during egg and alevin incubation in the gravel, (4) brood harvest rates during periods of low fish abundance, and (5) low spawning escapement. All of these factors can be managed to some degree by natural resource agencies.

Coastal Stratum

Habitat Volume

Spawning Habitat: ODFW estimates there are about 143 miles of habitat accessible to adult NP CHF in the five population areas that constitute the coastal stratum of the SMU. Estimates of the total amount of CHF spawning habitat in each population area ranged between 8.7 and 60.5 miles (Table 25). However, only a portion of this habitat is usually available to spawning adults because of stream gradient and variable flows during upstream migration. To better estimate the mileage of spawning habitat that is of annual importance, ODFW attempted to identify areas of minor NP CHF spawning. Minor spawning areas were defined as those areas where NP CHF would not be expected to spawn in at least 50% of the years and at minimum densities of at least two fish per mile. Criteria generated to filter out areas of inconsistent spawning were:

1. Gradient exceeds 4% in reaches immediately downstream of the perceived upstream terminus of NP CHF spawning, or
2. Gradient averages greater than 3.5% in areas immediately downstream of the upstream terminus of perceived NP CHF spawning, or
3. Adult NP CHF do not pass upstream of any point where gradient exceeds 6% within a reach that is at least 100 meters in length.

Table 25. Classification of spawning habitat for fall Chinook salmon in the coastal population areas within the Species Management Unit. Estimates are rounded to the nearest 0.1 miles. No estimates of statistical confidence could be generated from the classification approach.

	Spawning habitat (miles)		
Population Area	**Primary**	**Minor**	**Total**
Euchre	**8.6**	**0.1**	**8.7**
Hunter	**9.1**	**0.8**	**9.9**
Pistol	**24.2**	**2.5**	**26.7**
Chetco	**53.8**	**6.7**	**60.5**
Winchuck	**34.4**	**2.5**	**36.9**

Steep slopes, high drainage densities, and high gravel transport rates characterize the stream basins within the Klamath Mountains physiographic province (Wallick et al. 2009). Estimates of gravel resources available to NP CHF are not available for any of the coastal population areas because systematic habitat surveys have yet to be conducted in any of the stream basins. However, estimates of bed load transport rates are available for the Pistol River and for the Chetco River. These estimates give some insight as to the amount of gravel migrating downstream in the lower end of each river. Based on a landslide volume analysis, Russell (1994) estimated an annual average bed load production rate of 80-100 m^3/km^2 in the Pistol River Basin (22,000 - 27,000 m^3). For the Chetco River Basin, Wallick et al. (2009) estimated bed load production to average 40,000-100,000 m^3 annually. The estimates for both the Pistol and Chetco population areas suggest high rates of gravel recruitment, which probably indicate that spawning gravel abundance is likely not a primary limiting factor for the coastal NP CHF populations. This conclusion is also based on the large numbers of small juvenile NP CHF that migrate into the estuaries (*see* **Juvenile Size at Time of Migration,** page 83).

The volume of spawning habitat is also affected by stream flow just before, and during, NP CHF spawning. The upstream migration of adult NP CHF in smaller tributary streams can be limited during years of low flow in autumn and early winter. Entry into relatively small spawning tributaries is dependent on increases in flow, which usually occurs commonly over the course of the spawning period. Stream flow during autumn and early winter is solely a function of precipitation as there are no significant water diversions on small tributaries in the coastal population areas.

Migration Barriers: Virtually all historical spawning habitat remains accessible to migrating adult NP CHF in the coastal stratum of the SMU. Problem culverts on Deep Creek (Pistol River Basin), Cat Creek (Winchuck River Basin), and Little South Fork Hunter Creek have been recently replaced. A culvert located on Joe Hall Creek (Chetco River Basin), which blocks passage at low flows, is scheduled for replacement in 2012. Other known artificial barriers that likely impede adult NP CHF passage include a culvert at the mouth of Ferry Creek (Chetco River Basin) and a culvert located on an unnamed tributary of Pistol River at river mile 1.5. Thus, artificial migration barriers do not appear to be a primary factor that limits NP CHF production in any of the coastal population areas.

Natural barriers to the upstream passage of adult NP CHF are present in all of the population areas. In most instances, increased stream gradient and natural low flow limits the amount of spawning habitat available to adult NP CHF. However, there are some cases where falls or cascades function as barriers, regardless of stream flow. These types of known natural barriers include a cascade at RM 2 on the South Fork of the Chetco River (partial or periodic barrier) and a cascade at RM 6 on the North Fork Chetco (complete barrier). Thus, natural migration barriers somewhat limits NP CHF production in all of the coastal population areas, but not in the context of natural historical conditions.

Freshwater Rearing Habitat: The volume of freshwater habitat for juvenile NP CHF appears to have decreased to only a minor degree as a result of development. Within localized areas in the lower portions of the larger streams, minor channel alterations have occurred, but the area of alterations (i.e. riprap) appears to be very low (Maguire 2001a; Maguire 2001b; Maguire 2001c; Maguire 2001d; Maguire 2001e). In addition, stream flows are relatively unaltered during the critical period of summer residence by juvenile NP CHF, with the exception of the Chetco River (Table 26). Water withdrawals (permitted and reserved) in late summer account for less than 5% of the natural flows in the Euchre, Hunter, and Pistol population areas; and less than 15% in the Winchuck population area (Table 26). In contrast, water withdrawal accounts for about 40% of the flow of the Chetco River (Table 26). The impact of water withdrawals on the volume of freshwater habitat during summer is offset to a major degree by the location of the diversions, which are primarily near the downstream terminus of the largest stream in each population area. The largest appropriation is 37.5 cfs from the Chetco River for municipal use; of which about 13 cfs is currently utilized. The city of Brookings and the Harbor Water Peoples Utility District diversion sites are located at about RM 5.5 and RM 4.5, respectively.

Low flows during summer naturally limit the habitat volume for rearing juvenile NP CHF in each of the population areas. Average flows during August decrease to 40 cfs or lower, with the exception of the Chetco River (Table 26). Summer flows in the Chetco River are substantially greater as compared with the other coastal streams and thus the volume of rearing habitat for rearing juvenile NP CHF in the Chetco River must be substantially greater as well.

Table 26. Summary of water availability in the coastal population areas during summer. Flow (cfs) estimates are relevant to the mouth of each stream, unless otherwise noted. Natural flows represent the estimated 50% exceedance level. Instream flows represent water rights held by the state of Oregon, which are junior to some senior water rights. Use represents an estimate of current use and water rights held in reserve. All streams are closed to the appropriation of additional surface water, except for the Chetco River (open for appropriation in June) and the Winchuck River (open for appropriation in July).

	June			July			August			September		
Population	Natural	Instream	Use	Natural	Instream	Use	Natural	Instream	Use	Natural	Instream	Use
Euchre	71.7	71.4	0.8	46.2	45.8	1.1	29.3	28.9	0.9	19.9	19.6	0.4
Hunter	46.3	70.0	0.2	27.1	27.0	0.3	17.2	17.1	0.2	14.2	14.1	0.2
Pistol	122	122	0.4	65.8	65.8	0.6	40.4	40.4	0.5	32.8	32.8	0.3
Chetco	420	350	44	214	213	45	130	129	44	102	101	43
Winchuck[a]	68.3	80.0	2.1	38.1	20.0	2.7	22.3	20.0	2.4	13.0	20.0	1.6

[a] As estimated upstream of the South Fork of the Winchuck River.

Flow volume affects the production of Chinook salmon smolts in streams (Connor et al. 2003). Streams with minimal flow have less rearing area for juveniles as compared with streams with large flows during the summer months. For the five coastal population areas, the number of naturally produced recruits was positively related to the estimated mean natural flow during July-August (r^2 = 0.93, P = 0.005). However, the value of this finding is confounded because stream flow in summer is also related to the miles of CHF spawning habitat (r^2 = 0.72, P = 0.069). Instead, a comparison of flow and recruit production rates (recruits produced per mile of spawning habitat) is a more appropriate analytical approach.

A comparison of NP CHF production rates and stream flow during the critical summer months failed to reveal any significant relationship between the two variables (Figure 37). Given the flow during summer, production rates appear to be very high in the Hunter population and very low in the Euchre population area (Figure 37). There is about a 10-fold difference in the estimated production rates between the Euchre and Hunter population areas. Stream flow during summer fails to account for this difference. Flow during the freshwater residence of juveniles is only one factor that can influence production rates. However, the data set (five) is too small to analyze with multiple regression analyses that would help estimate the singular affect of flow on the production rates of NP CHF in the coastal population areas.

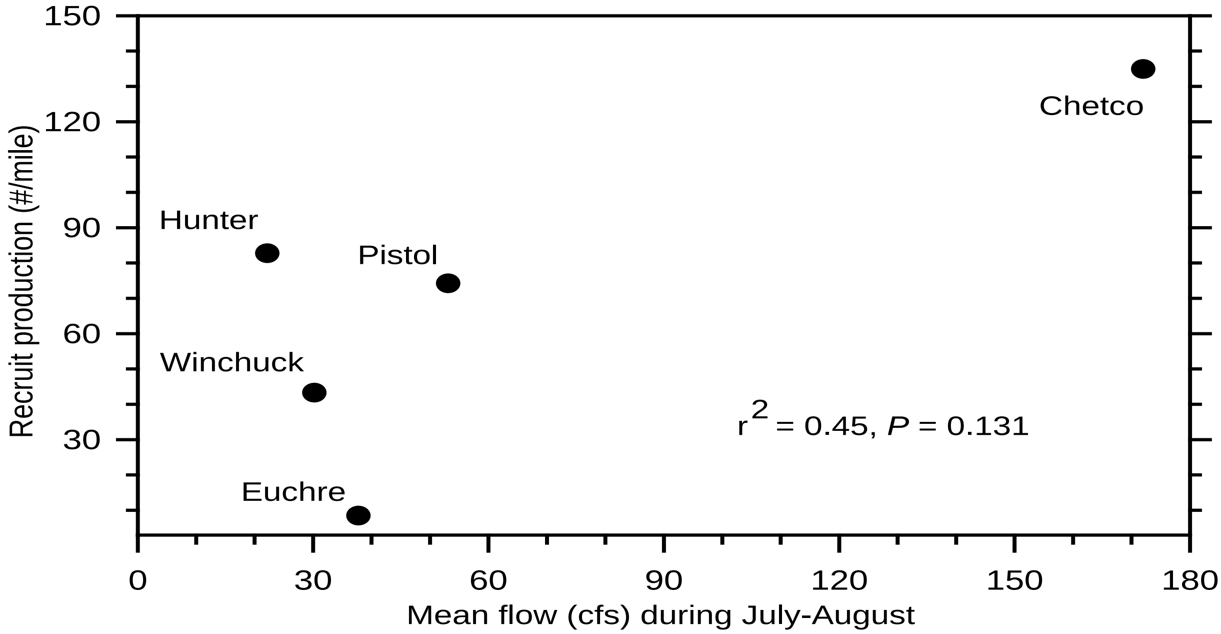

Figure 37. Relationship between mean production rates (recruits produced per mile of spawning habitat) of naturally produced fall Chinook salmon plotted and estimated natural flow of the largest streams within the coastal population stratum, brood years 1986-2006.

Estuary Rearing Habitat: The amount of rearing habitat for juvenile salmonids in an estuary can be estimated using a variety of methods. Size estimates of estuaries in the SMU are available from two primary sources: ODFW and the Environmental Protection Agency (Lee and Brown 2009). In 2010, ODFW estimated the size of the estuaries from aerial photographs taken during the summer (June 29 through August 15) of 2005. ODFW generated estimates of the wetted area of each estuary based on the perimeter of watered areas. ODFW also generated estimates of the total area of each estuary based on the perimeter of what appeared to be the ordinary high water mark. Lee and Brown (2009) used geospatial data obtained from the National Wetland Inventory (United States Fish and Wildlife Service) and on-site digitization of paper maps to fill in data gaps not available in digital format, to estimate four indexes of estuary size. A summary of both of these efforts is presented in Table 27.

Table 27. Area estimates of estuaries inhabited by coastal populations of fall Chinook salmon.

Population area	Habitat type (EPA)			Habitat type (ODFW)		
	Estuarine	Riverine	Total	Wetted	Dry	Total
			Square Kilometers			
Euchre	0.11	<0.01	0.12	0.02	0.07	0.10
Hunter	0.07	0.02	0.10	0.04	0.03	0.08
Pistol	0.44	0.11	0.55	0.17	0.26	0.43
Chetco	0.40	0.32	0.72	0.60	0.13	0.69
Winchuck	0.09	0.03	0.12	0.06	0.04	0.10
			Acres			
Euchre	27.2	<2.5	29.7	6	18	24
Hunter	17.3	4.9	24.7	11	8	19
Pistol	108.7	27.2	135.9	43	64	107
Chetco	98.8	79.1	177.9	149	31	170
Winchuck	22.2	7.4	29.7	15	9	24

Multiple indices of estuary size could be used to make comparisons with indexes of NP CHF production. Lee and Brown (2009) estimates of estuary size were compared with ODFW estimates of wetted estuary size (Figure 38). The comparisons indicated that Lee and Brown (2009) estimates of riverine habitat within the estuaries were positively related to ODFW estimates of wetted area (Figure 38). ODFW estimates of wetted area during summer, when juvenile CHF rear in the estuaries, is probably the best metric to use in population assessments.

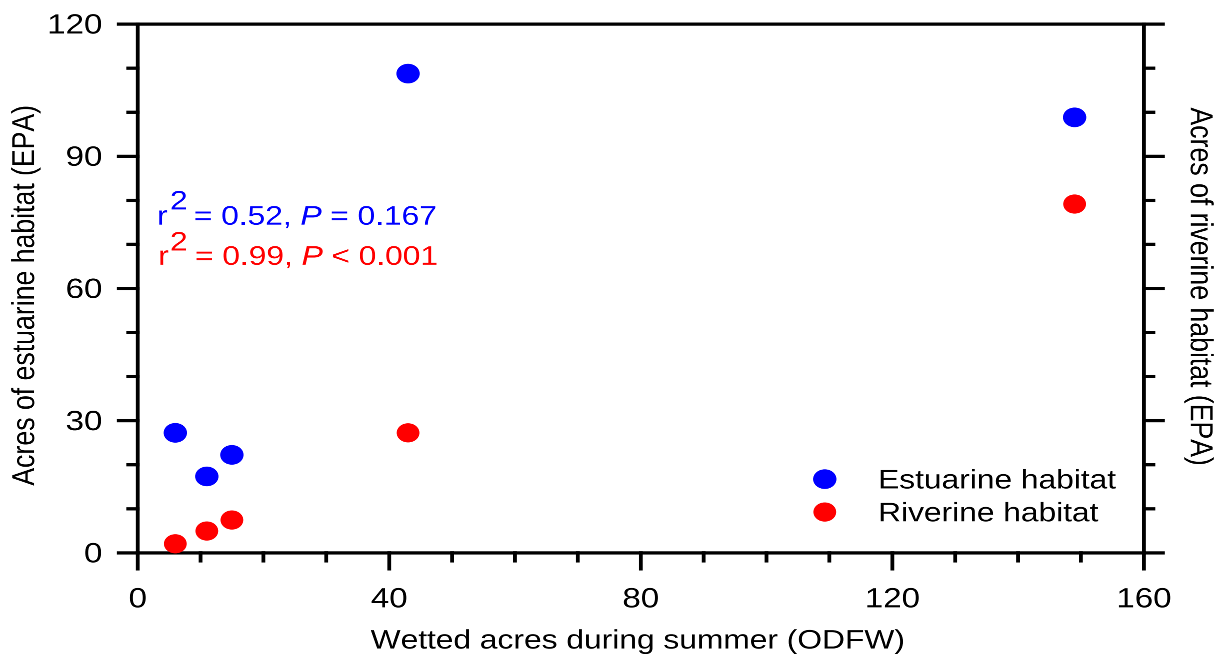

Figure 38. Oregon Department of Fish and Wildlife estimates of the wetted estuary area during summer as compared with two metrics of estuary size generated by the Environmental Protection Agency.

Estuary size can affect the production of Chinook salmon smolts. Small estuaries have less rearing area for juveniles as compared with large estuaries. For the five coastal population areas, the number of naturally produced recruits was positively related ($r^2 = 0.97$, $P = 0.001$) to the estimated wetted area of estuaries during summer. However, the value of this finding is confounded because stream flow in summer is also related to the wetted area of estuaries during summer ($r^2 = 0.75$, $P = 0.059$). Instead, a comparison of estuary size and recruit production rates (recruits produced per mile of spawning habitat) is a more appropriate analytical approach.

A comparison of NP CHF production rates (recruits produced per mile of habitat) and estuary size during summer suggested there is a significant relationship between the two variables (Figure 39). However, given the similar size of the estuaries, smolt production rates appear to be very high in the Hunter population and very low in the Euchre population area (Figure 39). There is about a 10-fold difference in the estimated production rates between the Euchre and Hunter population areas. Estuary size fails to account for this difference and is only one factor that can influence smolt production rates. However, the data set (five) is too small to analyze with multiple regression analyses that would help estimate the singular affect of flow on the production rates of NP CHF in the coastal population areas.

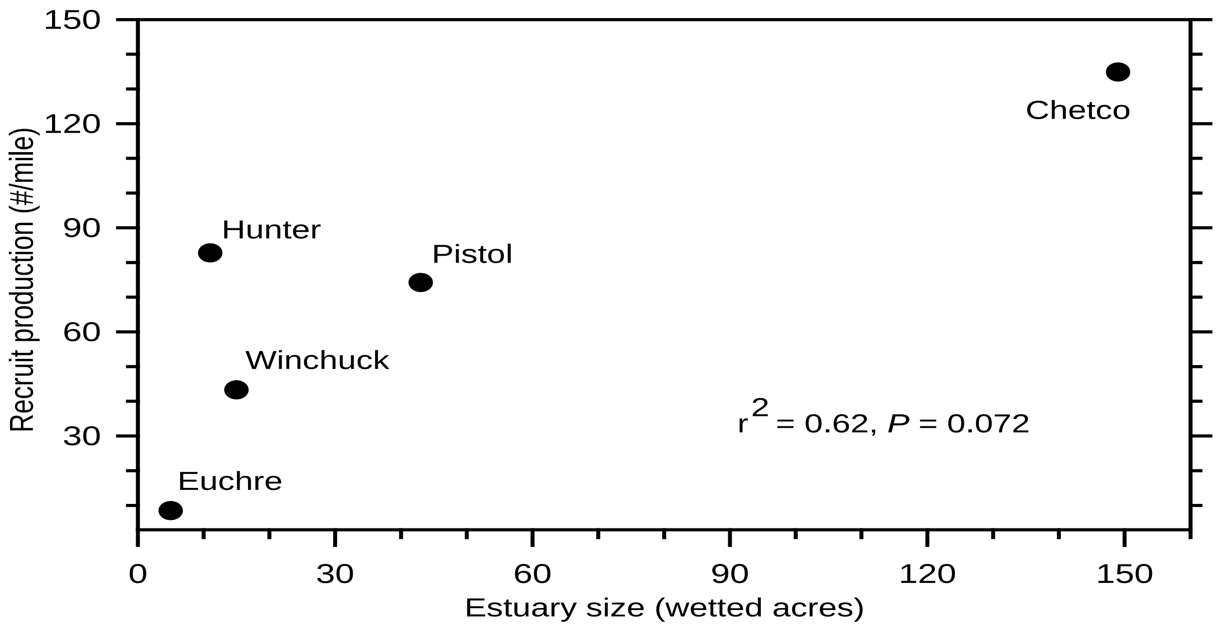

Figure 39. Relationship between mean production rates (recruits produced per mile of spawning habitat) of naturally produced fall Chinook salmon and the wetted area of estuaries within the coastal population stratum, brood years 1986-2006.

Some estuarine habitat has been lost in the coastal population areas, but the amount of loss is relatively unknown. For the Chetco River estuary, Good (2000) estimated a total estuary size of 171 acres in 1970 and that 5 acres (3%) had been lost to dike construction or filling since 1870. The amount of habitat lost in the other four estuaries inhabited by the coastal NP CHF populations is currently unknown. Lost estuary habitat was likely to be important rearing areas for juvenile NP CHF because many juveniles enter the estuaries before reaching a size that allows for a good chance of survival after ocean entry (*see* **Juvenile Size at Time of Migration**, page 83).

Habitat Quality

Aspects of habitat quality that have the potential to affect the abundance and life history of NP CHF are diverse. Habitat features that affect adult NP CHF include channel morphology, water quality, and flow. Habitat features that affect juvenile NP CHF include channel morphology, water quality (estuary and freshwater), flow, changes in flow, sedimentation, gravel composition, riparian areas, and hiding cover in the estuaries.

Freshwater Habitat: Water quality elements that can affect juvenile NP CHF include temperature, dissolved oxygen, nutrients, and toxic pollutants. Based on water quality index ratings reported by Mrazik (2008), none of these factors, except water temperature, are likely to affect the growth and survival of juvenile NP CHF in streams of the coastal population areas. However, this inference is based on sampling at only one site in each of the Winchuck, Chetco, and Pistol CHF population areas (Mrazik 2008). No sites were reported for the Hunter or Euchre population areas. Based on a score termed the Oregon Water Quality Index (OWQI), water quality at sampling locations is rated from 10 (worst) to 100 (ideal). Mean minimum seasonal average OWQI scores were 95 and 90 (excellent ratings) at the Winchuck River and Chetco River sampling sites, and was 70 (poor rating) at the Pistol River sampling site (Mrazik 2008). The score for the Pistol River was likely affected by estuarine water of lower quality that sometimes reaches the sampling site. Analyses of scores for the years 1998-2007 failed to detect any significant increases in water quality scores, except for the Pistol River samples; which indicated that OWQI scores were increasing through time (Mrazik 2008).

Watershed assessments completed by the South Coast Watershed Council (Maguire 2001a; Maguire 2001b; Maguire 2001c; Maguire 2001d; Maguire 2001e) raised concerns about various water quality parameters indicative of general stream health. Five of these parameters could be directly reflective of possible limiting factors for NP CHF production within streams of the coastal population areas: dissolved oxygen, nitrate levels, phosphate levels, pH and water temperature. With the exception of water temperature (discussed later), it appears unlikely that water quality is a primary factor that limits NP CHF production within streams inhabited by the coastal populations (Table 28).

Table 28. Summary of four parameters judged to reflect water quality for naturally produced fall Chinook salmon in streams of the coastal population stratum. Data were retrieved from LASAR records maintained by the Oregon Department of Environmental Quality. Fish protection standards shown for each value were taken from Bell (1991). No data was available for the Euchre population area.

Population	Sample sites	Dissolved oxygen[a] (*N*)	Total nitrate[b] (*N*)	Total phosphorous[b] (*N*)	pH[b] (*N*)
Hunter	RM 2	6.5 (789)	0.11 (17)	0.01 (27)	7.7 (513)
Pistol	RM 1,2	6.1 (703)	0.02 (32)	0.02 (157)	7.5 (457)
Chetco	RM 4,11	7.5 (137)	0.04 (24)	0.01 (62)	7.7 (149)
Winchuck	RM 2	7.5 (741)	0.09 (40)	0.02 (154)	7.0 (755)
Fish standards		>7.0	<1.00	<0.15	6.7-8.3
Oregon standards[c]		>8.0	none	none	6.5-8.5

[a] *Minimum value of samples (mg/l).*
[b] *Median value of samples (mg/l).*
[c] *For aquatic life.*

As compared with other water quality parameters, water temperature is more likely to be a factor that limits NP CHF production in the coastal population areas. Water temperatures encountered by adult NP CHF are unlikely to be a limiting factor because freshwater entry does not occur until the middle of October. In contrast, juvenile NP CHF rearing in streams within the coastal stratum can be exposed to warm water temperatures during summer. During freshwater residence, juvenile NP CHF are commonly exposed to water temperatures that can exceed 24ºC (75ºF), likely resulting in decreased survival rates from either indirect or direct thermal effects (Baker et al. 1995; Connor et al. 2003; Marine and Cech 2004; Bartholow and Henriksen 2006; Geist et al. 2010) and an earlier date of smoltification (Sykes and Shrimpton 2010). The greatest impact of high water temperatures in the coastal population areas likely relates to a decreased growth rate of juvenile NP CHF.

Banks et al. (1971) determined that juvenile CH grew faster at 15ºC (59ºF) as compared with 18ºC (64ºF). Brett et al. (1982) found that the optimum temperature for growth of juvenile CH was about 15ºC (59ºF) and that no growth would be realized at temperatures greater than about 21ºC (70ºF). However, juveniles used in these experiments originated from northern populations that may be naturally more sensitive to warmer water temperatures. In contrast, Marine and Cech (2004) found that juvenile CHF of Sacramento River origin, grew somewhat at water temperatures of 21-24ºC (70-75ºF) and grew well at water temperatures of 17-20ºC (63-68ºF). Foott et al. (2012) reared juvenile CHF of Klamath Basin origin for 21 days under two fluctuating temperature profiles that averaged 18ºC (64ºF) and 23ºC (73ºF). They found that juvenile CH grew at the higher temperature, although more slowly as compared those counterparts reared at the lower temperature.

As water temperatures during summer can exceed 21ºC (70ºF) in those areas primarily used as juvenile rearing habitat in the coastal population areas (Table 29), lower rates of food conversion likely affect the size of juvenile NP CHF at the time of estuary entrance and possibly even at the time of ocean entrance. Size at ocean entrance is a primary factor that affects the potential for ocean survival (*see* **Juvenile Size at Time of Migration**, page 83).

Changes in stream temperatures can be estimated with water temperature models. As a result of development, riparian zones in all of the larger streams within the coastal areas have been modified to some unknown degree, probably resulting in some increase in water temperatures during summer. Water temperature models have yet to be completed for any streams in the coastal populations, but should be within the next few years as ODEQ develops the analytical tools needed to address issues in the coastal streams identified as having impaired water quality (as per the federal Clean Water Act).

Flows, especially peak flows, also affect channel morphology, sedimentation rates, and gravel quality. Higher flows increase the width of unconstrained channels and the size of pools in low gradient streams, and pools are the riverine habitat type preferred by juvenile Chinook salmon in large streams of southern Oregon (ODFW 1992; Roper et al. 1994). In addition, wide, unconstrained, channels in low gradient streams tend to be characterized by larger areas of more diverse spawning habitat (Montgomery et al. 1999). However, peak flows are also associated with storm events that increase the amount of sediment introduced into streams (Booth et al. 2002).

Sediment can arise from numerous sources, and sediment deposition on redds has been

Table 29. Mean daily maximum water temperature during the warmest seven consecutive days of continuous gage sampling in the coastal population areas. Data were reported by (Maguire 2001a; Maguire 2001b; Maguire 2001c; Maguire 2001d; Maguire 2001e) and are listed only for those gages judged to be most relevant in relation to development of the conservation plan.

	Water Temperature (°F)						Water Temperature (°C)					
Gage location	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
EUCHRE POPULATION AREA												
Euchre Creek[a]	68.8	--	--	70.2	67.4	--	20.4	--	--	21.2	19.6	--
Euchre Creek[b]	65.8	--	--	66.3	64.2	65.5	18.8	--	--	19.0	17.9	18.6
Cedar Creek[c]	70.3	--	--	70.9	67.7	68.7	21.3	--	--	21.6	19.8	20.4
HUNTER POPULATION AREA												
Hunter Creek[d]	71.2	70.4	--	71.5	69.6	70.9	21.8	21.4	--	22.0	20.9	21.6
North Fork[c]	65.6	65.3	68.6	68.0	65.6	68.0	18.6	18.5	20.4	20.0	18.6	20.0
PISTOL POPULATION AREA												
Pistol River[e]	75.0	73.4	--	--	--	--	23.9	23.0	--	--	--	--
Pistol River[f]	70.5	68.5	71.9	72.1	69.7	--	21.4	20.3	22.2	22.3	21.0	--
South Fork[c]	--	--	--	72.8	72.7	72.7	--	--	--	22.6	22.6	22.6
Deep Creek[c]	--	64.4	--	65.3	--	65.0	--	18.0	--	18.5	--	18.4
CHETCO POPULATION AREA												
Chetco River[g]	76.0	73.1	--	--	--	--	24.4	22.8	--	--	--	--
Chetco River[h]	--	74.5	--	--	74.6	75.3	--	23.6	--	--	23.6	24.0
Chetco River[i]	--	73.3	--	73.9	70.9	72.9	--	23.0	--	23.3	21.6	22.7
Chetco River[j]	--	73.2	72.5	--	--	--	--	22.9	22.5	--	--	--
South Fork[c]	68.5	--	69.3	68.4	68.1	68.6	20.3	--	20.7	20.2	20.0	20.4
Emily Creek[c]	67.2	--	68.1	67.0	60.5	65.9	19.6	--	68.1	19.4	15.8	18.8
WINCHUCK POPULATION AREA												
Winchuck River[k]	--	68.6	70.0	69.3	67.6	--	--	20.4	21.1	20.7	19.8	--
Winchuck River[l]	--	--	68.1	67.0	66.5	66.3	--	--	20.0	19.4	19.2	19.0
East Fork[c]	--	--	66.0	65.7	64.4	64.5	--	--	18.9	18.7	18.0	18.0
Wheeler Creek[c]	--	--	65.0	64.3	63.6	63.7	--	--	18.4	17.9	17.6	17.6

[a] *RM 0.9.*
[b] *RM 2.1.*
[c] *At or near mouth.*
[d] *RM 7.2.*
[e] *RM 2.5.*
[f] *RM 9.9.*
[g] *RM 8.2.*
[h] *RM 18.6.*
[i] *RM 31.0.*
[j] *RM 46.0.*
[k] *RM 2.4.*
[l] *RM 10.0.*

associated with decreased survival rates of eggs and alevins. Sediment deposition can also affect gravel quality in spawning areas. Fines can fill spaces within gravel, reducing space for incubating alevins and reducing water exchange around eggs and alevins (Chapman 1988). The amount of sediment that enters streams is dependent on a variety of factors including mass failures, landslides, surface erosion, and stream bank erosion. Increased rates of sedimentation, resulting from various types of development, have been documented within all of the NP CHF population areas in the coastal stratum of the SMU (Maguire 2001a; Maguire 2001b; Maguire 2001c; Maguire 2001d; Maguire 2001e). Rates of bank erosion along streams are influenced by the integrity of the riparian zone. The riparian zone also produces large wood pieces that provide cover for fish, helps to stabilize stream channels, produces terrestrial sources of food for fish, and also helps shade streams.

As compared to juveniles, adult NP CHF are potentially affected by a relatively restricted array of features related to habitat quality because of the relatively short period of freshwater residence. Prior to spawning, adult CHF can temporarily cease upstream migration by holding within microhabitats. Habitat features associated with specific holding sites in streams within the coastal population areas are mostly unknown, but such locations likely include such features as deep pools, undercut stream banks, and large structures for cover (bedrock outcrops, large boulders, downed trees or logs). The complexity of channel morphology can be negatively impacted by accelerated bank erosion, removal of riparian vegetation, and placement of rock (rip-rap) along channel margins.

Estuary Habitat: Relatively little is known about the quality of habitat in estuaries of the coastal population areas because there is no systematic monitoring of water quality by any governmental agency. Information is limited to special projects completed by the South Coast Watershed Council and by ODFW. In addition there is almost no data related to indexes of habitat complexity within the estuaries. Habitat complexity is likely significantly more important in the estuaries, as compared with streams, because of the virtual absence of large woody material in estuaries.

The Oregon Fish Commission sampled some water quality parameters in the Pistol River and Winchuck River estuaries during 1967 and 1968 (McGie 1968; McGie 1969). Water temperatures during summer ranged between 56 and 71°F (13.4-21.7°C) in the Pistol River estuary and ranged between 61 and 66°F (16.1-18.9°C) in the Winchuck River estuary. Dissolved oxygen concentrations during summer, measured only during 1967, were at least 7.0 mg/liter in both estuaries. Based on these limited data, there was no indication that water quality limited the rearing distribution of juvenile NP CHF in either of these two estuaries. However, snorkel surveys conducted during 1967 indicated that juvenile Chinook salmon in both estuaries were observed only in those areas where shade and cover were present (McGie 1968). In addition, subsequent sampling by ODFW documented maximum water temperatures greater than 80°F (26.7°C) in the Winchuck River estuary during several weeks in 1974 and 1975 (Lichatowich and Nicholas 1985). There is evidence that juvenile CHF growth rates decrease in southern Oregon estuaries when water temperatures 15°C (59°F) during summer (Neilson et al. 1985).

The Oregon Fish Commission documented two large-scale fish mortalities (including juvenile Chinook salmon) in the Chetco River estuary during late July and early August of 1969, and concluded that low levels of dissolved oxygen were likely responsible for the mortalities (McGie 1970). The low levels of dissolved oxygen resulted from three factors (1) unusually large numbers of anchovies and smelt, (2) warm water temperatures, and (3) organic waste water draining into the estuary. During the initial mortality, dissolved oxygen levels in the estuary dropped as low as 0.2 mg/l. In contrast, the dissolved oxygen level in the river was 9.6 mg/l (McGie 1970).

During 2002-2006, the South Coast Watershed Council sampled one - three estuaries annually each summer in relation to the following water quality parameters: temperature, dissolved oxygen, pH, and salinity (personal communication dated February 26, 2010, Cindy Ricks-Meyers, South Coast Watershed Council, Brookings). Sampling consisted of three 24 hour events annually during June-September. A summary of their findings follows.

Oregon standards (ODEQ) for water temperature, dissolved oxygen and pH were violated for at least part of the summer in every estuary. Seven day mean maximum water temperatures exceeded 81^{o}F at one sampling site in the Winchuck River estuary. Dissolved oxygen levels of 1.2 mg/l (lethal for juvenile CHF) were documented at one sampling site in the Pistol River estuary. These data indicate that, during some a portion of the summer, poor water quality can limit the effective rearing area for juvenile NP CHF in portions of the estuaries. Poor water quality conditions are more likely to arise in the smaller estuaries of the CHF population areas because:

1. Freshwater inflows are low and warmer during summer.
2. Bars (sills) can develop and the lack of tidal influence allows for development of algae masses.
3. Extensive algal respiration and decomposition of algae can produce low levels of dissolved oxygen.
4. The magnitude and duration of dissolved oxygen depletion (respiration and decay) progresses seasonally with the growth and decomposition of algal mats and other aquatic plants.
5. Even if estuary mouths remain open during summer, water quality problems may develop. While marine inflows through open estuaries are cooler, marine inflows are typified by a greater biochemical oxygen demand and a greater nitrate concentration as compared with freshwater that enters the estuaries (personal communication dated February 26, 2010, Cindy Ricks-Meyers, South Coast Watershed Council, Brookings).

These findings, coupled with those of Neilson et al. (1985) and Magnusson and Hilborn (2003), suggest that portions of the estuaries in southern Oregon are, at times, unfavorable rearing habitat for juvenile NP CHF. Because the amount of unfavorable habitat in any single estuary can change over the course of a day depending on weather patterns, sill formation, and tidal conditions, it is impossible to develop any quantitative estimate of the impacts of poor water quality on juvenile NP CHF that rear in the estuaries. However, it is apparent that large numbers of NP CHF fry enter the estuaries at a relatively small size and that these fish must grow to smolt size before having a good chance to survive after ocean entry (*see* **Juvenile Size at Time of Migration**, page 83). Consequently, there is a reasonable chance that water quality in estuaries is a primary factor that could limit attainment, or maintenance, of desired status for coastal populations of NP CHF.

Conclusions Related to Habitat Quality

Manageable aspects of habitat quality that have the largest impact on NP CHF production in the coastal population areas appear to be (1) water temperature in freshwater and in the estuaries during summer and (2) nutrient inputs into estuaries during summer. A lack of habitat complexity in the estuaries, with the associated lack of hiding cover for juvenile NP CHF (Quiñones and Mulligan 2005), is also likely to be a significant limiting factor.

Biological Factors

Numerous biological factors have the potential to affect the abundance and life history of NP CHF in the coastal population areas of the SMU. The list of generalized factors includes juvenile size at ocean entry, competitors, predators, disease, spawner abundance, and hatchery fish. A discussion of specific aspects follows.

Juvenile Size at Time of Migration

Juvenile NP CHF first emerge from the gravel and begin to live as free swimming fry during spring. After emergence from the gravel, it appears that most fry remain in streams for a period of time, although some newly emergent fry migrate into estuaries relatively soon after emergence. It is also highly probable that early-migrating fry reside in the freshwater portion of the estuary until physiologically ready to begin to reside in the saltwater portion of the estuaries (Kreeger 1995). Virtually all of the juveniles enter the ocean during their first year of life as subyearling migrants. This conclusion is based on interpretations of scales taken from spawned adults in the Chetco population area and the virtual absence of large yearlings among juvenile NP CHF caught in migrant traps operated near the mouths of the Pistol and Winchuck rivers during spring.

Juvenile size at time of ocean entry is a primary factor that affects NP CHF survival in the ocean. Multiple research projects documented that juvenile NP CHF produced in coastal streams of southern Oregon need to be at least 9 cm in length in order to have a good chance of surviving in the ocean (Nicholas and Hankin 1988; ODFW 1992). While there are no empirical estimates of juvenile size at ocean entry, many juvenile NP CHF produced in the coastal populations enter the estuaries at lengths smaller than 9 cm (Figure 40 and Figure 41). During the period just after ocean entry, larger juvenile Chinook salmon survive at greater rates as compared to smaller counterparts (Duffy and Beauchamp 2011).

Juvenile NP CHF in the coastal population areas appear to migrate downstream and enter estuaries primarily during June through August (Figure 40 and Figure 41). This conclusion is based on a combination of migration timing estimates generated for juvenile NP CHF in the lower portions of Pistol (RM 2.5), Winchuck (RM 2.0), and Elk (RM 2.3) rivers. Migrant traps in the Pistol and Winchuck rivers operated consistently only during a portion (June-August) of the downstream migration period. In contrast, ODFW operated a downstream migrant trap in nearby Elk River throughout the downstream migration period for eight years during the 1980s and 1990s. All three traps were operated to generate weekly estimates of the number of juvenile NP CHF that passed the trap, with the mark-recapture method described by Thedinga et al. (1994).

For the Elk River trap, downstream migration timing was estimated as the proportion of the annual total numbers of migrants divided by the number that migrated during a given week. Application of the mean weekly migration timing estimates from the Elk River trap suggested that the Pistol River trap annually operated during periods when an average of 71% (95% CI = 66-76% as estimated from arcsine transformed data) juvenile NP CHF migrated downstream and that the Winchuck River trap annually operated during periods when an average of 75% (95% CI = 73-78%) as estimated from arcsine transformed data) juvenile NP CHF migrated downstream. These results indicated there was a good chance that the Pistol River and Winchuck River traps operated during periods when most juvenile NP CHF migrated downstream and that, for non-sampled periods, it could be assumed that the proportions of outmigrating juvenile NP CHF in the Pistol and Winchuck rivers were the same as for the for counterparts in Elk River.

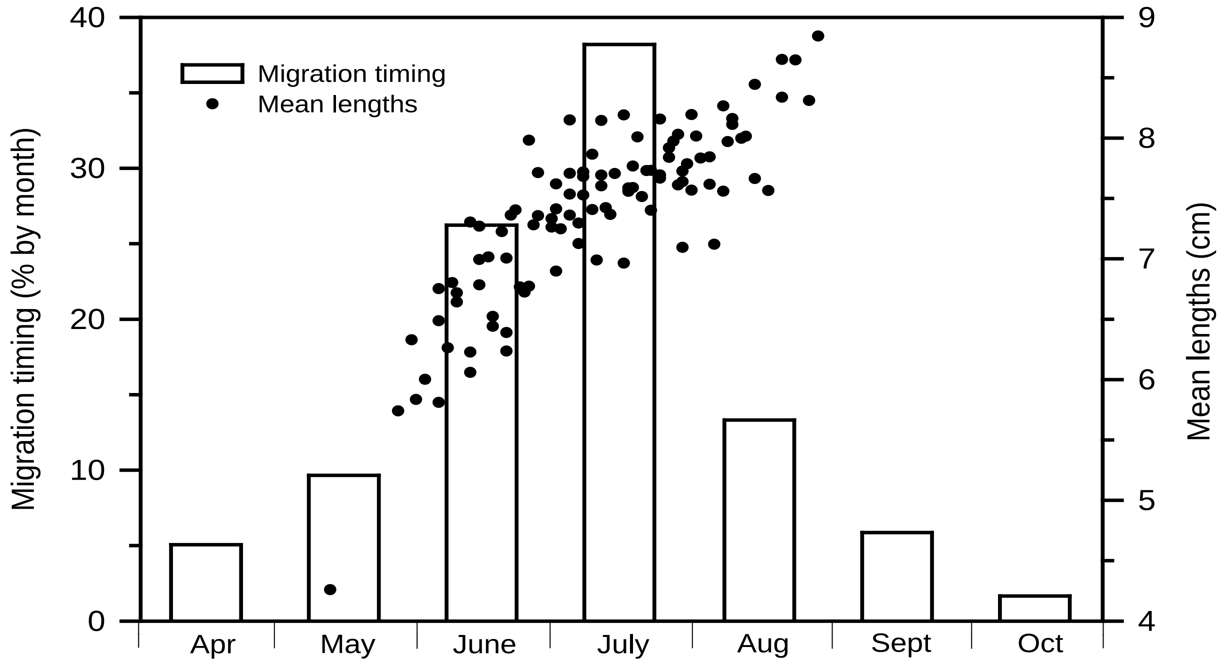

Figure 40. Estimated mean downstream migration timing and mean lengths of subyearling fall Chinook salmon in the Pistol River, 1993-2002. Migration timing estimates for April-May and September-October are mostly assumed (*see* text for explanation).

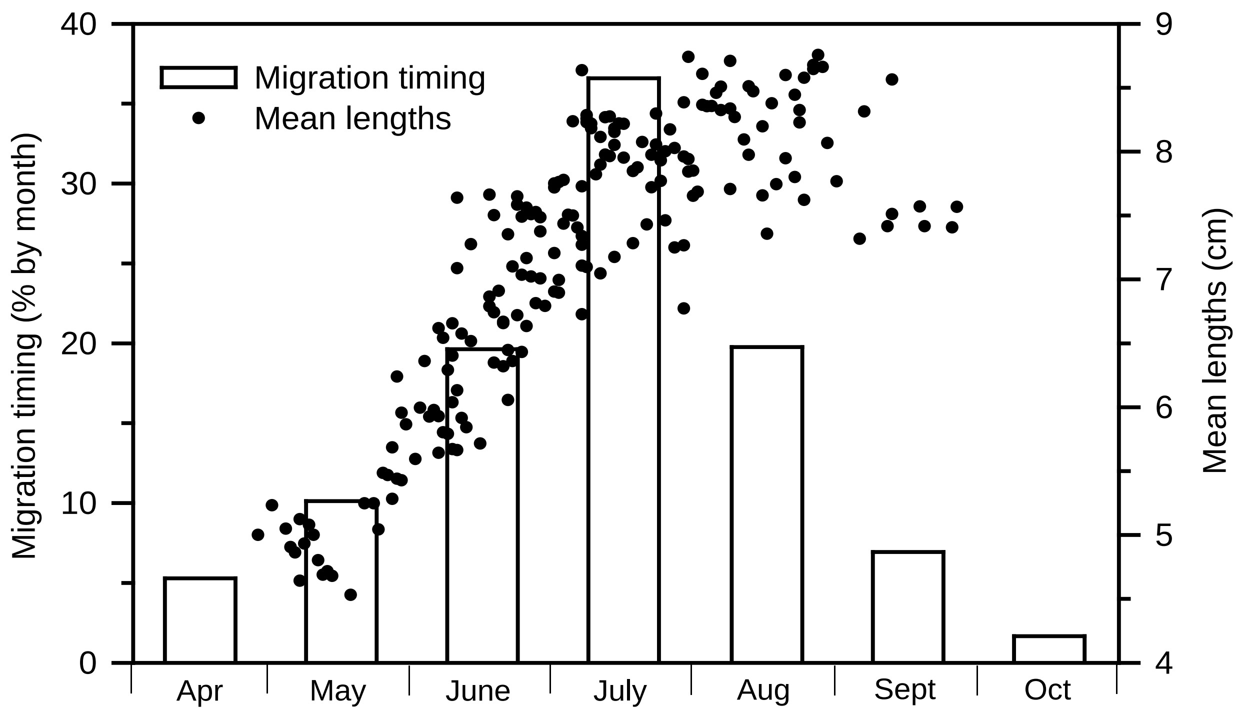

Figure 41. Estimated mean downstream migration timing and mean lengths of subyearling fall Chinook salmon in the Winchuck River, 1991-2011. Migration timing estimates for April-May and September-October are mostly assumed (*see* text for explanation).

The size of juvenile NP CHF increased steadily during June through August in the Pistol River trap (Figure 40) and during May through the middle of August in the Winchuck River trap (Figure 41). However, from the middle of August through September, there were times when relatively small juveniles entered the Winchuck estuary (Figure 41). The sporadic presence of relatively small juveniles during the later portion of the period of downstream migration suggested that freshwater growth rates may have been low during some years.

Juvenile abundance appears to have a significant influence on the time of downstream migration. During years when juveniles were relatively abundant, greater proportions tended to migrate during late spring and early summer. In contrast, during years when fewer juveniles were produced, proportionally fewer migrated during late spring and early summer. A positive relationship between juvenile abundance and early migration was readily apparent from the Pistol River data (Figure 42), but was less apparent from the Winchuck River data (Figure 43).

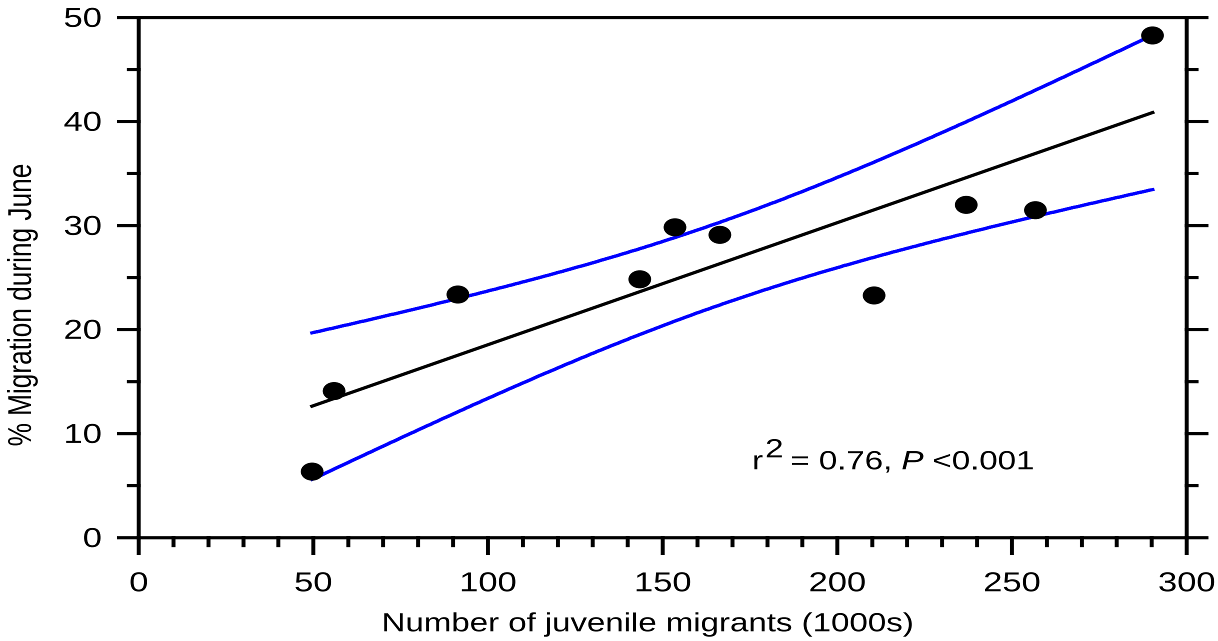

Figure 42. Relationship between the percent downstream migration during June and the number of naturally produced juvenile fall Chinook salmon that migrated downstream in the Pistol River, 1993-2002. The black line is the regression equation and the blue lines represent the 95% confidence bounds.

The preceding data and analyses indicate that many juvenile NP CHF migrate into southern Oregon estuaries at sizes not conducive to survival in the ocean. This conclusion was similar to that of Volk et al. (2010) who estimated that 77% of the juvenile CHF caught, at the mouth of a central Oregon estuary, migrated into the estuary during June-August and two-thirds of these fish resided in the estuary for more than 30 days. In addition, both relationships between higher juvenile densities and earlier downstream migrations indicate density dependent food or habitat limitations. There is other evidence that juvenile Chinook salmon can grow slowly in estuaries (MacFarlane 2010).

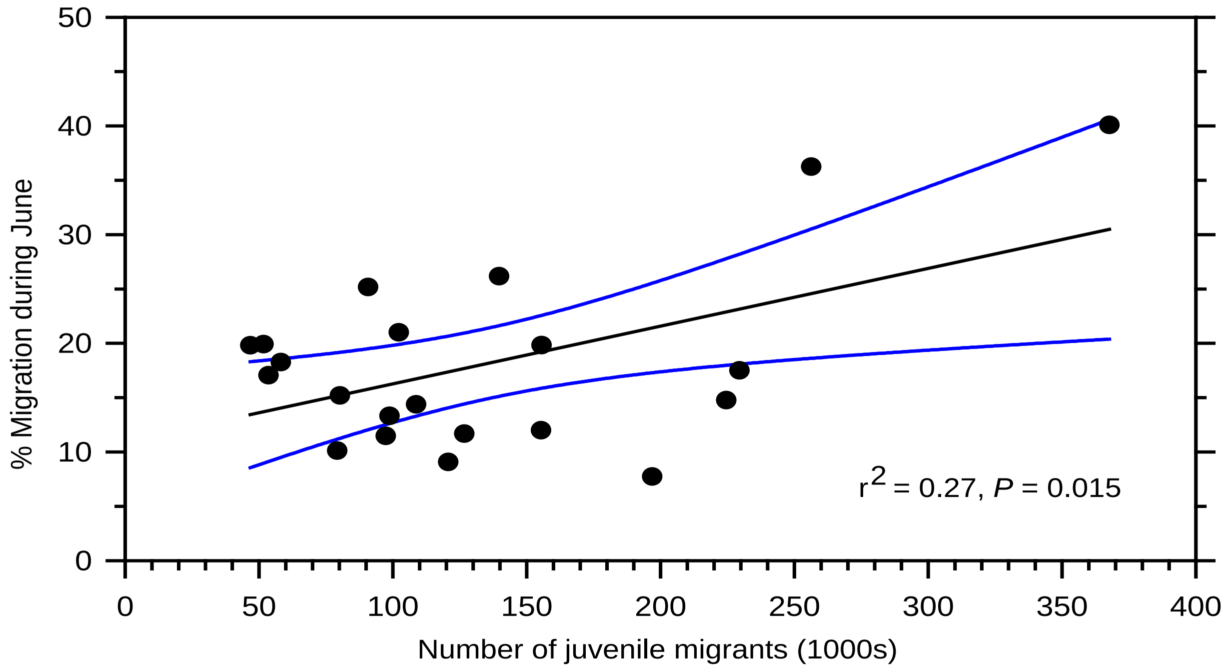

Figure 43. Relationship between the percent downstream migration during June and the number of naturally produced juvenile fall Chinook salmon that migrated downstream in the Winchuck River, 1991-2011. The black line is the regression equation and the blue lines represent the 95% confidence bounds.

Density dependent food and habitat limitations for juvenile NP CHF in small southern Oregon estuaries is evident based on findings of Neilson et al. (1985). They found that juvenile CHF grew slowly during June-September in the Sixes River estuary each year during 1979-1981. The summer reduction in growth rates coincided with water temperatures above 15^{o}C (59^{o}F), a decline in the abundance of a primary prey item, and increased juvenile NP CHF densities as additional fish migrated from the river into the estuary.

Based on trapping results in the lower portions of the Pistol River and the Winchuck River, it appears that at least one-half of the juvenile NP CHF entered the estuaries must have reared for a protracted period of time before attainment of a size conducive to survival after ocean entry. With the evidence of density dependent food and habitat limitations for juvenile NP CHF in small southern Oregon estuaries, it appears that the volume and quality of rearing habitat in the estuaries is likely a primary factor that limits NP CHF production in the coastal population areas. This conclusion should be tested with research designed to directly estimate growth rates of juvenile NP CHF within each of the population areas in the SMU (*see* **Research Needs**, page 142).

Competitors

Threespine sticklebacks (*Gasterosteus aculeatus)* are likely the primary species that compete with juvenile NP CHF, as both species are found in similar types of habitat. However, the distribution of threespine sticklebacks is primarily limited to the estuaries. During stream residence, juvenile NP CHF in the coastal population areas likely have few competitors, with the exception of redside shiners (*Richardsonius balteatus*) in Hunter Creek. Redside shiners are not native to Hunter Creek and the year of introduction is uncertain although their presence was first documented in 1973 (Martin 1973). Observations made by ODFW staff indicate that redside shiners are very abundant within the lower 3 miles of Hunter Creek and their abundance decreases with distance upstream between RM 3 and RM 7. Redside shiners are not typically observed upstream of RM 7 in Hunter Creek.

There appears to be minimal competition between juvenile NP CHF and hatchery fish in freshwater. Significant numbers of CHF fry are no longer released in any of the population areas. CHF smolts and steelhead smolts are released only in the lower portion of the Chetco population area and likely enter the ocean soon after release.

At this time, it appears that competition is not a primary factor that limits the production of NP CHF in the coastal population areas. Manageable aspects of competition that could subsequently have the largest impact on NP CHF abundance most likely relate to the possibility that non-native species could become established as a result of surreptitious introductions.

Predators

While competitors may be relatively few, there are a myriad of animals that prey upon NP CHF produced in the coastal population areas of the SMU. Known predators are listed in Table 30, along with the designation of each species as administered by the state of Oregon, and by the federal government. Among predators that inhabit freshwater, only two species (both sculpins) are not protected under either state or federal law (Table 30).

The issue of predation on anadromous salmonids has received significant attention in the Pacific Northwest, and numerous research projects have attempted to estimate salmonid losses as related to predation. The majority of these assessments have been conducted in the Columbia River Basin. Inferences that can be derived from predation assessments conducted in areas are limited in scope because predation impacts are dependent on at least four primary factors: predator numbers, potential prey species, potential prey abundance, and potential prey life history. For example, there is a good chance that birds preyed on fewer juvenile NP CHF after redside shiners became abundant in the Rogue River during the 1950s.

Within the coastal population areas, directed predation assessments on juvenile NP CHF are very limited. Martin (1975) reported that all (11) sampled wild cutthroat trout had consumed juvenile NP CHF. Martin (1973) sampled the stomach contents of “several” mergansers, but was unable to identify prey remains except “that the boney remains of sticklebacks were obvious in all of the samples”. No other relevant information related to NP CHF predators could be found. Potential NP CHF predators in the coastal population areas are listed in Table 30.

In summary, at this time it is not known whether predation is a primary factor that limits the production of NP CHF in the coastal population areas. Manageable aspects of predation that could subsequently have the largest impact on NP CHF abundance most likely relate to the possibility that non-native predatory species could become established as a result of surreptitious introductions; especially since most of the potential predators are protected under state or federal law.

Table 30. A list of animals that prey, or likely prey, on juvenile or adult Fall Chinook salmon present in the coastal population areas. Salmonids of hatchery origin and largemouth bass are protected by the state of Oregon only under the provisions of harvest regulations for game fish.

	Protected species?	
Species or animal type	Federal	State
FISH		
Prickly sculpin	no	no
Coastrange sculpin	no	no
Brown bullhead*	no	yes
Steelhead (hatchery)	no	yes
Coho salmon (wild)	yes	yes
Steelhead (wild)	no	yes
Cutthroat trout	no	yes
Marine species	some	some
BIRDS		
Cormorant (double-crested)	yes	yes
Cormorant (pelagic)	yes	yes
Cormorant (Brandt's)	yes	yes
American merganser	yes	yes
Hooded merganser	yes	yes
Herons (multiple species)	yes	yes
Belted kingfisher	yes	yes
Gulls (multiple species)	yes	yes
Tern	yes	yes
Bald eagle	yes	yes
Osprey	yes	yes
Marine species	yes	yes
MAMMALS		
River otter	no	yes
Mink	no	yes
Harbor seal	yes	yes
California sea lion	yes	yes
Northern sea lion	yes	yes

* Documented only in the Winchuck River.

Disease

Similar to predation and competition, disease does not appear to be a primary factor that limits the abundance of NP CHF. There is no historical evidence of extensive pre-spawning mortalities of adults in any of the population areas. It is possible that juvenile NP CHF are negatively impacted by fish diseases during periods of warm water temperatures; but empirical evidence is lacking. Manageable aspects of potential disease outbreaks that could subsequently have the largest impact on NP CHF abundance most likely relate to high water temperatures during summer.

Spawner Abundance: A critical factor that obviously affects salmon populations is the number of spawning adults. Knowledge of the relationship between spawner abundance and the production of progeny is of primary importance in order to effectively manage salmon populations.

Identification of the effects of spawner abundance on recruitment was evaluated with population models. A brief description of the analytical approach follows and a more complete description can be found in **APPENDIX F**. The population models were expanded to include environmental covariates thought, based on research findings, to directly affect recruitment of Chinook salmon produced in the Rogue SMU. Environmental covariates were retained in the spawner-recruit models only if the resulting increase in explanatory power exceeded the statistical penalty for model complexity as assessed with a Deviance Information Criterion (DIC) that was less than or equal to a value of two.

Environmental covariates incorporated into the analyses were specific to the coastal basins of the Rogue SMU to the greatest extent possible. However, data representative of freshwater conditions were limited solely to the Chetco River because of the absence of appropriate data for the other population areas. These covariates included (1) peak flow of the Chetco River when NP CHF eggs and alevins incubated in the gravel, (2) mean flow of the Chetco during May-June when fry were rearing in freshwater, (3) mean flow of the Chetco during July-August when pre-smolts were rearing in freshwater, (4) mean flow of the Chetco River in November-December during adult CHF migration and spawning, and (5) survival rate estimates of CWT marked spring Chinook salmon smolts released during September-October at Cole M. Rivers Hatchery. The rationale associated with the inclusion of these five covariates is: (1) the intensity of peak flow has been shown to be negatively related to the production of NP Chinook salmon in other NP CH populations of the Rogue SMU (Fustish et al. 1988; ODFW 1992; ODFW 2000), (2) flow during late spring may affect fry migration timing into small estuaries with limited capabilities to rear juvenile NP CHF, (3) water temperature of the Chetco River commonly exceeds 70^{o}F during juvenile NP CHF rearing (flow was used as a proxy for water temperature because of the absence of water temperature data), (4) flow during autumn has been shown to be positively related to CHF spawner distribution in the Applegate River; a primary producer of NP CHF in the Rogue River Basin (Fustish et al. 1988), and (5) incorporation of hatchery smolt-adult survival theoretically allows introduction of a primarily marine survival effect on recruitment that is independent of adult stock size. Smolt-adult survival rates of wild and hatchery Chinook salmon have been shown to highly correlated (Buchanan et al. 2010) and addition of a survival rate covariate for hatchery fish improved a stock-recruitment relationship developed for CHF in the nearby Klamath River Basin (STT 2005).

Chetco Population: Of the eight stock-recruitment models built for the Chetco population, two were distinguished by lower (≤2) DIC scores as compared to the other six models (Appendix Table F-1). The two best models could not be differentiated based on their DIC scores (Table 31). Model results suggest that brood harvest rates should average about 0.51 for MSY and that about 2,750 spawners are needed for MSY (Table 31).

Table 31. Best stock-recruitment models built for naturally produced fall Chinook salmon in the Chetco population area, 1986-2004 brood years. Data included in the models are listed in Appendix Tables E-10, E-12, and E-14. Additional information about these models is included in **APPENDIX F**.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY	Harvest rate for MSY
Chetco1	Ricker	1[a]	31.0	2,750	0.51
Chetco2	Ricker	2[b]	32.5	2,730	0.51

[a] Survival rate of hatchery smolts.
[b] Hatchery smolt survival rate and summer flow during juvenile rearing.

Parameter coefficients in the models suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The models indicated that NP CHF recruitment was positively related to two factors: (1) survival rates of young hatchery fish in the ocean and (2) flow of the Chetco River during the period of peak water temperatures when juvenile NP CHF are resident in freshwater. These environmental effects can be marked, as conveyed in the example shown in Figure 44. This particular model was chosen for the graphic because these two environmental factors are significant covariates in at least one best model for all of the NP CHF populations in the Rogue SMU (Appendix Table F-1).

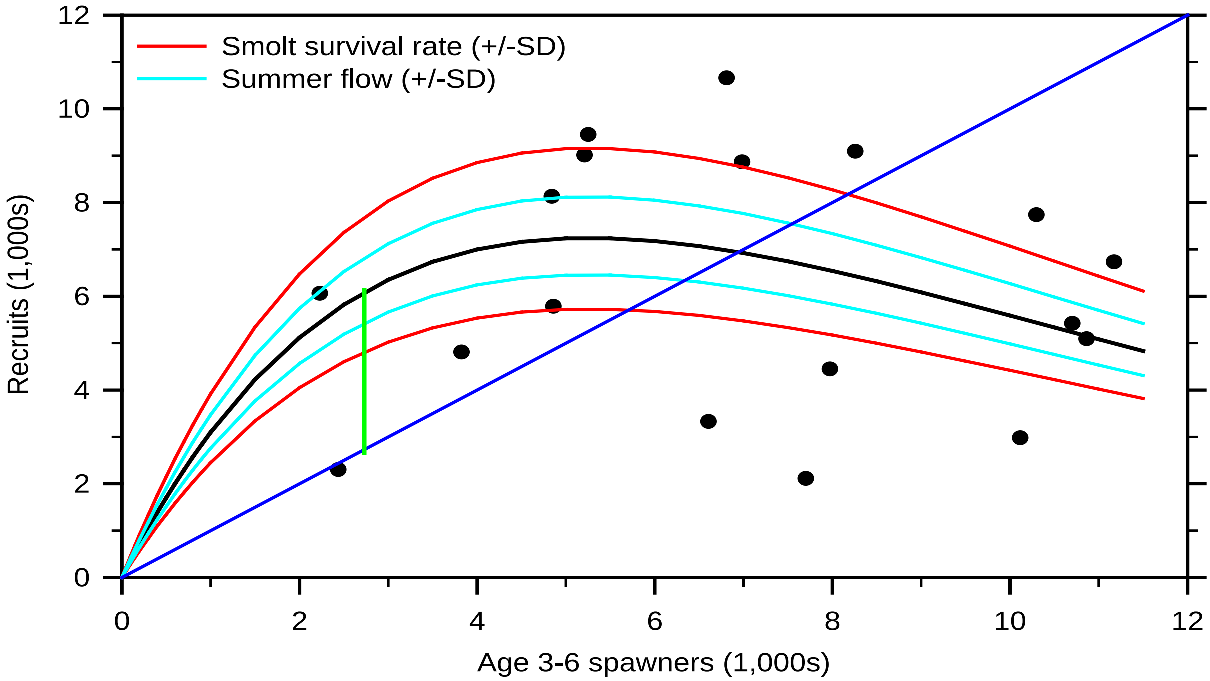

Figure 44. One of the Ricker stock-recruitment models (Chetco2) that best fit spawner and recruit estimates for the Chetco population of naturally produced fall Chinook salmon, 1986-2004 brood years. The solid black line represents the estimated relationship between recruits and spawners under average environmental conditions. The colored curved lines represent the estimated spawner-recruit relationship with each mean covariate value varied by +/- one standard deviation. The dark blue line represents replacement (recruits = spawners) and the green line represents the model estimate of maximum sustained yield.

Winchuck Population: Of the eight stock-recruitment models built for the Winchuck population, six were distinguished by lower (≤2) DIC scores as compared to the other two models (Appendix Table F-1). The six best models could not be differentiated based on their DIC scores (Table 32). Model results suggest that brood harvest rates should average about 0.56 for MSY and that about 560 spawners are needed for MSY (Table 32).

Table 32. Best stock-recruitment models built for naturally produced fall Chinook salmon in the Winchuck population area, 1986-2004 brood years. Data included in the models are listed in Appendix Tables E-11, E-12, and E-14. Additional information about these models is included in **APPENDIX F**.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY	Harvest rate for MSY
Winchuck1	Ricker	0	31.5	562	0.58
Winchuck2	Ricker	1[a]	32.7	571	0.57
Winchuck3	Ricker	1[b]	31.3	559	0.57
Winchuck4	Ricker	1[c]	31.2	559	0.55
Winchuck5	Ricker	2[d]	30.7	566	0.56
Winchuck6	Ricker	2[e]	31.6	562	0.55

[a] Survival rate of hatchery smolts.
[b] Summer flow during juvenile rearing.
[c] Spring flow during juvenile rearing.
[d] Hatchery smolt survival rate and summer flow during juvenile rearing.
[e] Hatchery smolt survival rate and spring flow during juvenile rearing.

Parameter coefficients in the models suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The models indicated that NP CHF recruitment was positively related to three factors: (1) survival rates of young hatchery fish in the ocean, (2) flow of the Chetco River during the period of peak water temperatures when juvenile NP CHF are resident in freshwater, and (2) flow of the Chetco River during late spring when densities of juvenile NP CHF are greatest in freshwater. These environmental effects can be marked, as conveyed in the example shown in Figure 45. This particular model was chosen for the graphic because these two environmental factors are significant covariates in at least one best model for all of the NP CHF populations in the Rogue SMU (Appendix Table F-1).

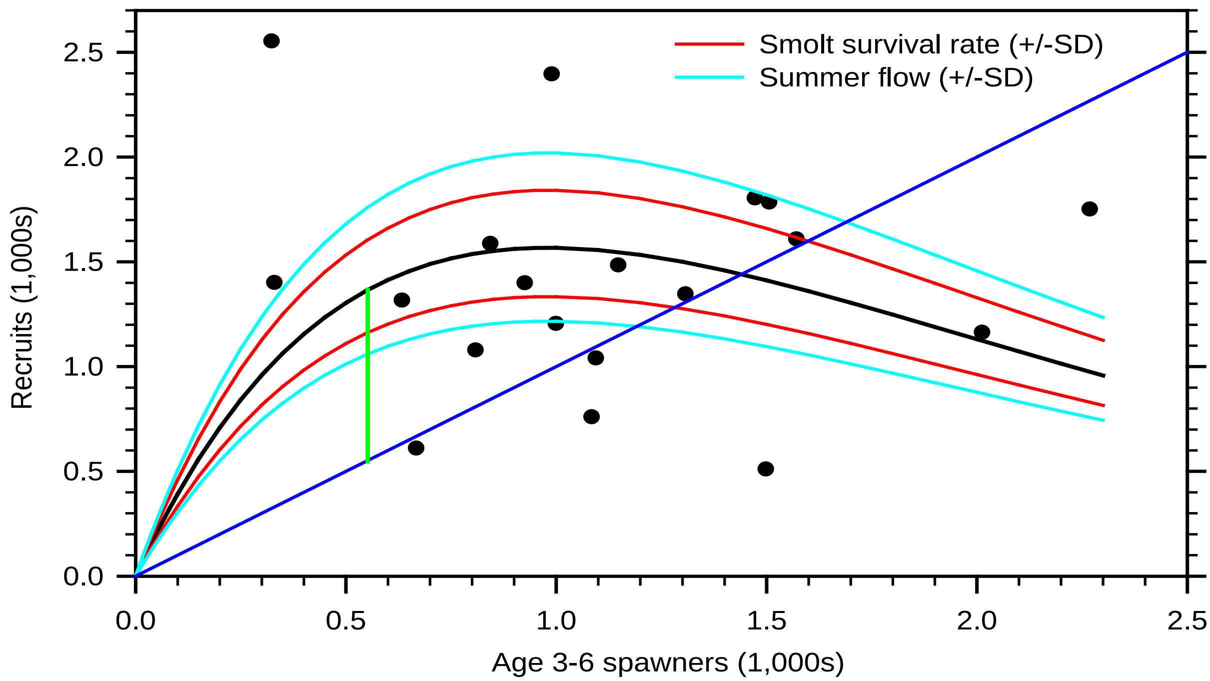

Figure 45. One of the Ricker stock-recruitment models (Winchuck5) that best fit spawner and recruit estimates for the Winchuck population of naturally produced fall Chinook salmon, 1986-2004 brood years. The solid black line represents the estimated relationship between recruits and spawners under average environmental conditions. The colored curved lines represent the estimated spawner-recruit relationship with the mean covariate value varied by +/- one standard deviation. The dark blue line represents replacement (recruits = spawners) and the green line represents the model estimate of maximum sustained yield.

The effects of variable spawner escapements on NP CHF production in the Winchuck population area was also evaluated based on annual estimates of spawner escapement and annual estimates of the number of NP CHF juveniles that migrated downstream past a trap operated at river mile 2.0 (see **Winchuck River Population**, page 41 and **Juvenile Size at Time of Migration**, page 83 for more information related to data generated by trap operation).

Of the four juvenile recruitment models built for the Winchuck population, one (Winjuv4) was distinguished by a lower (≤2) DIC score as compared to the other three models (Table 33). This model suggested that 660 spawners are needed for MSY (Table 33). In comparison, the stock-recruitment models based on brood reconstructions indicated that about 560 spawners are needed for MSY (Table 32). The 15% difference in estimates of spawners needed for MSY is not surprising because many of the juvenile NP CHF that pass the trap are not smolt-sized and must grow in the estuary in order to have a good chance to survive after ocean entry (*see* **Juvenile Size at Time of Migration**, page 83). Thus, the 15% difference may be another indicator that the quantity and quality of estuary habitat is likely a primary factor that limits NP CHF production in population areas within the coastal stratum of the Rogue SMU.

Table 33. Juvenile recruitment models built for naturally produced fall Chinook salmon in the Winchuck population area, 1990-2010 brood years.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY
Winjuv1	Ricker	0	42.3	667
Winjuv2	Ricker	1[a]	44.4	667
Winjuv3	Ricker	1[b]	44.2	671
Winjuv4	Ricker	1[c]	39.6	662

[a] Peak flow (cfs) of the Chetco River during egg and alevin incubation.
[b] Mean November flow (cfs) of the Chetco River during adult CHF migration.
[c] Mean December flow (cfs) of the Chetco River during adult CHF migration and spawning.

Parameter coefficients in the best model suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The model indicated that juvenile NP CHF production was positively related to flow of the Chetco River during December, a peak period of adult CHF migration and spawning. This environmental effect may be marked, as conveyed in Figure 46.

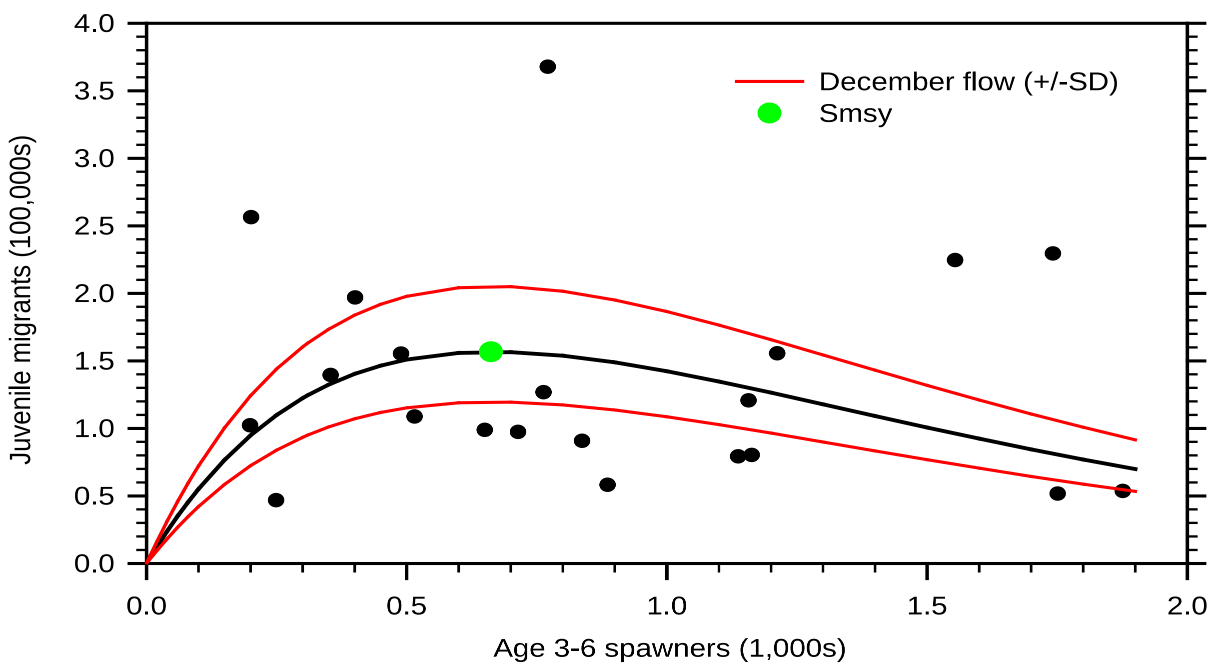

Figure 46. Ricker recruitment model (Winjuv4) that best fit spawner and juvenile migrant estimates for the Winchuck population of naturally produced fall Chinook salmon, 1990-2010 brood years. The solid black line represents the estimated relationship between juvenile migrants and spawners under average environmental conditions. The colored curved lines represent the estimated migrant-recruit relationship with the mean covariate value varied by +/- one standard deviation. The green symbol represents the estimated number of spawners needed for maximum juvenile production (S_{MSY}).

Pistol Population: Of the eight stock-recruitment models built for the Pistol population, four were distinguished by lower (≤2) DIC scores as compared to the other four models (Appendix Table F-1). The four best models could not be differentiated based on their DIC scores (Table 34).

Model results suggest that brood harvest rates should average about 0.54 for MSY and that about 950 spawners are needed for MSY (Table 34).

Table 34. Best stock-recruitment models built for naturally produced fall Chinook salmon in the Pistol population area, 1987-2004 brood years. Data included in the models are listed in Appendix Tables E-9, E-12, and E-14. Additional information about these models is included in **APPENDIX F**.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY	Harvest rate for MSY
Pistol1	Ricker	0	38.4	914	0.56
Pistol2	Ricker	1[a]	36.9	991	0.51
Pistol3	Ricker	2[b]	38.2	940	0.52
Pistol4	Ricker	2[c]	38.2	958	0.51

[a] Survival rate of hatchery smolts.
[b] Hatchery smolt survival rate and summer flow during juvenile rearing.
[c] Hatchery smolt survival rate and spring flow during juvenile rearing.

Parameter coefficients in the models suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The models indicated that NP CHF recruitment was positively related to three factors: (1) survival rates of young hatchery fish in the ocean, (2) flow of the Chetco River during the period of peak water temperatures when juvenile NP CHF are resident in freshwater, and (2) flow of the Chetco River during late spring when densities of juvenile NP CHF are greatest in freshwater. These environmental effects can be marked, as conveyed in the example shown in Figure 47. This particular model was chosen for the graphic because these two environmental factors are significant covariates in at least one best model for all of the NP CHF populations in the Rogue SMU (Appendix Table F-1).

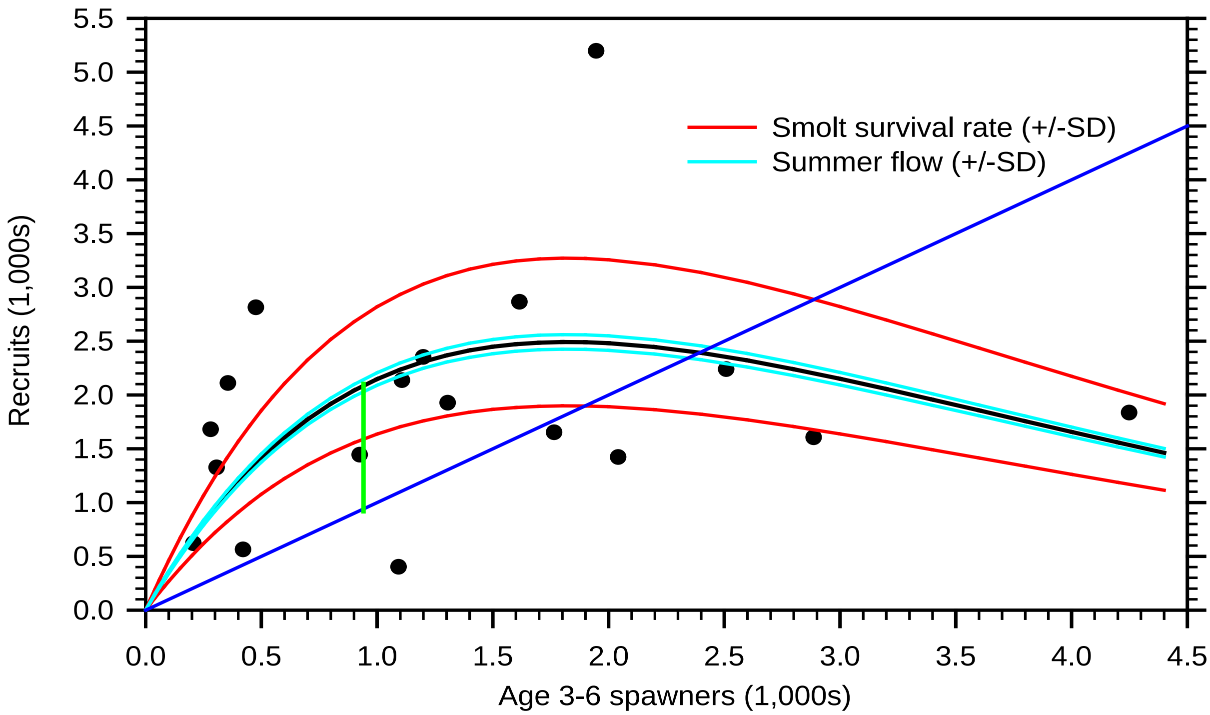

Figure 47. One of the Ricker stock-recruitment models (Pistol3) that best fit spawner and recruit estimates for the Pistol population of naturally produced fall Chinook salmon, 1987-2004 brood years. The solid black line represents the estimated relationship between recruits and spawners under average environmental conditions. The colored curved lines represent the estimated spawner-recruit relationship with the mean covariate value varied by +/- one standard deviation. The dark blue line represents replacement (recruits = spawners) and the green line represents the model estimate of maximum sustained yield.

Hunter Population: Of the eight stock-recruitment models built for the Hunter population, three were distinguished by lower (≤2) DIC scores as compared to the other five models (Appendix Table F-1). The three best models could not be differentiated based on their DIC scores (Table 35). Model results suggest that brood harvest rates should average about 0.58 for MSY and that about 390 spawners are needed for MSY (Table 35).

Table 35. Best stock-recruitment models built for naturally produced fall Chinook salmon in the Hunter population area, 1989-2004 brood years. Data included in the models are listed in Appendix Tables E-8, E-12, and E-14. Additional information about these models is included in **APPENDIX F**.

Model	Model form	Environmental covariates (#)	DIC	Spawners for MSY	Harvest rate for MSY
Hunter1	**Ricker**	**2**[a]	**26.0**	**399**	**0.57**
Hunter2	**Ricker**	**2**[b]	**25.7**	**380**	**0.59**

a Hatchery smolt survival rate and summer flow during juvenile rearing.
b Hatchery smolt survival rate and spring flow during juvenile rearing.

Parameter coefficients in the models suggested that the number of recruits produced per spawner changed in response to changes in environmental conditions and that these changes can be substantial. The models indicated that NP CHF recruitment was positively related to three factors: (1) survival rates of young hatchery fish in the ocean, (2) flow of the Chetco River during the period of peak water temperatures when juvenile NP CHF are resident in freshwater, and (2) flow of the Chetco River during late spring when densities of juvenile NP CHF are greatest in freshwater. These environmental effects can be marked, as conveyed in the example shown in Figure 48. This particular model was chosen for the graphic because these two environmental factors are significant covariates in at least one best model for all of the NP CHF populations in the Rogue SMU (Appendix Table F-1).

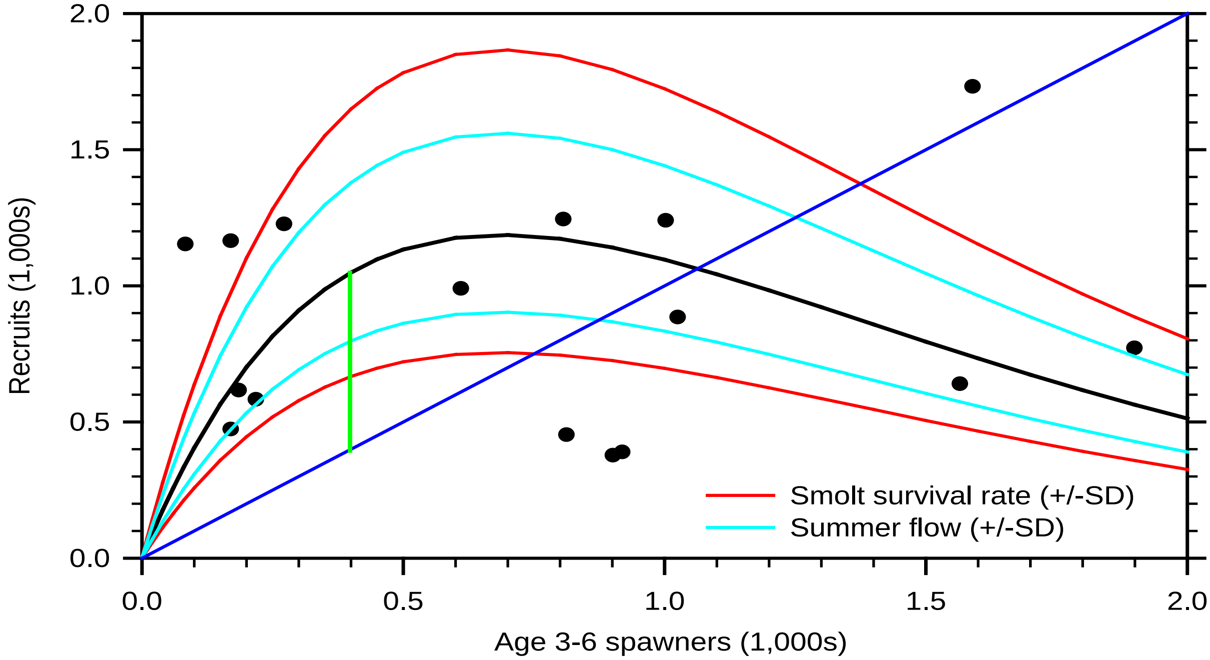

Figure 48. One of the Ricker stock-recruitment models (Hunter1) that best fit spawner and recruit estimates for the Hunter population of naturally produced fall Chinook salmon, 1989-2004 brood years. The solid black line represents the estimated relationship between recruits and spawners under average environmental conditions. The colored curved lines represent the estimated spawner-recruit relationship with the mean covariate value varied by +/- one standard deviation. The dark blue line represents replacement (recruits = spawners) and the green line represents the model estimate of maximum sustained yield.

To summarize this section, all of the population models indicate that low spawner abundance is a primary factor that periodically limits the production of NP CHF in the Rogue Stratum.

Hatchery Fish

During the last 20 years, there has been increased concern that hatchery fish may be partially responsible for documented declines in the abundance of some naturally produced salmon populations (ISAB 2002). Potential impacts can be classified as either genetic in basis, or as ecological interactions. Genetic impacts can develop when populations of naturally produced and hatchery fish have different genetic complements. Differences in genotypes can result from domestication of a hatchery population, or use of a non-local broodstock to establish a hatchery population, or inbreeding caused by small numbers of hatchery fish in the broodstock (ISAB 2002). Ecological impacts can result from (1) competition of naturally produced and hatchery fish, (2) direct predation on naturally produced fish by hatchery fish, (3) increased losses if hatchery fish attract additional predators, (4) disease transmission from hatchery fish to naturally produced fish, and (5) changes in water quality directly attributable to hatchery operations (HSRG 2005). There are also indications that natural spawning hatchery fish, even from locally adapted broodstocks, produce fewer progeny as compared to wild fish (Schroder et al. 2008; Berejikian et al. 2009) and that hatchery fry survive at lower rates in streams as compared to wild fry (Tatara et al. 2009).

The risk of potential negative impacts to the coastal populations of NP CHF, which result from releases of juvenile hatchery CHF produced at Indian Creek (Rogue River Basin) and Elk River (Elk River Basin) hatcheries, is difficult to thoroughly evaluate. However, the following information can be used, to some degree, to assess the potential for risk to independent populations of NP CHF in the coastal stratum of the SMU:

1. There is minimal chance that the CHF production program at Indian Creek Hatchery poses risk to NP CHF in any of the coastal population areas. Adult CHF of Indian Creek Hatchery origin enter the Rogue River before flows of the coastal streams increase to a volume that permits freshwater entry. In the coastal population areas, CWT marked fish released from Indian Creek Hatchery have only been recovered in the proximal Hunter population area and none have been found since 1997, with the exception of one fish found in 2001.
2. Juvenile CHF of hatchery origin released in the Hunter, Pistol, and Winchuck population areas during 1985-1996 originated solely from broodstocks collected within natal population areas, except for (1) unfed fry of Chetco origin released in the Pistol population area during 1989 and (2) unfed fry and smolts of Chetco origin released in the Winchuck population area during 1987-1989.
3. Survival rates of unfed fry were probably very low (Thériault et al. 2010).
4. All juvenile CHF of hatchery origin released in the Chetco population area originated solely from broodstocks collected within the natal population area.
5. The proportion of hatchery fish among spawners is generally low within the coastal population areas. During the last ten years, hatchery fish accounted for (1) less than 5% of the CHF that spawned in the Hunter and Pistol population areas, (2) less than 6% of the CHF that spawned in the Winchuck population area, and (3) less than 15% of the CHF that spawned in the Chetco population area.
6. There is minimal chance that the CHF production program for the Chetco River Basin poses risk to NP CHF in any of the other coastal populations. No CWTs of Chetco origin have been found in any of the other coastal population areas, with the exception of the Winchuck.
7. The amount of domestication in the Chetco production groups is unknown. During the 1980s through the mid-1990s, hatchery fish likely composed more than 50% of the annual broodstocks.
8. Hatchery fish are annually released near the mouth of the Chetco River during autumn after almost all juvenile NP CHF have entered the ocean. Thus, there is minimal chance that hatchery fish prey or compete with juvenile NP CHF. In addition, there is minimal chance that predation losses of juvenile NP CHF increase as a result of hatchery fish releases or that hatchery fish may transmit diseases to juvenile NP CHF.
9. As compared to an earlier release, the autumn release of juvenile hatchery fish decreases the chance of disease transmission might occur as a result of rearing the fish at Elk River Hatchery.

The production program for hatchery CHF in the Chetco population area is comparable to an “integrated hatchery program” as defined by Hatchery Scientific Review Group (HSRG 2009). This term describes a management scenario where the hatchery broodstock is managed as a genetically integrated component of an existing population. Recommendations (HSRG 2009) for broodstock composition for an integrated hatchery program are dependent on the classification of management concern in relation to stock productivity and abundance. Based on a persistence probability of > 0.99 over 100 years (*see* **VIABILITY OF THE SPECIES MANAGEMENT UNIT**, page 111), and good population productivity (*see* **Chetco Population:**, page 89), NP CHF in the Chetco population area seem to be most appropriately classified as a “Stabilizing” population (definition of HSRG 2009). HSRG (2009) did not propose broodstock composition recommendations for stabilizing populations because employed operating criteria were judged to be adequate in relation to conservation goals.

Alternatively, if NP CHF in the Chetco population area was to be classified as a "Contributing" population (definition of HSRG 2009), then the following HSRG (2009) recommendation would apply: the proportion of hatchery fish among natural spawners should be less than 0.30 (30%) and (2) the proportion of naturally produced fish within the hatchery broodstock should exceed proportion of hatchery fish among natural spawners. Under this scenario, during 2005-2011, the Chetco hatchery program met the first criterion every year and met the second criterion in six of seven years. During 2005-2011, NP CHF composed an average of 69% (range = 41-94%) of the adult CHF collected for broodstock. Other recommendations related to principles of hatchery programs (HSRG 2009) are also mostly attained by the production program for CHF in the Chetco population area (ODFW 2006c) and revisions to the HSRG recommendations can be expected as more refined research results become available on this issue. Thus, the HSRG recommendations should not be considered as sole guidance in relation to the management of hatchery fish.

The hatchery and genetic management plans (ODFW 2006b; ODFW 2006c; ODFW 2006d), implemented for Indian Creek and Elk River hatcheries, comply with ODFW's Fish Hatchery Management Policy (ODFW 2003). This policy describes best management practices that are intended to help ensure the conservation of both naturally produced native fish and hatchery produced fish. Policy goals include:

1. Foster and sustain opportunities for sport, commercial and tribal fishers consistent with the conservation of naturally produced native fish.
2. Contribute toward the sustainability of naturally produced fish populations through the responsible use of hatcheries and hatchery-produced fish.
3. Maintain genetic resources of native fish populations spawned or reared in captivity.
4. Minimize adverse ecological impacts to watersheds caused by hatchery facilities and operations.

The Fish Hatchery Management Policy requires that ODFW hatchery programs be distinguished as harvest or conservation hatchery programs. Currently, ODFW manages the Chetco CHF hatchery program as a Harvest Augmentation Program. As described in the Fish Hatchery Management Policy, harvest augmentation programs operate to enhance fisheries without impairing naturally reproducing populations.

To summarize this section, the history of broodstock collection practices and smolt release practices within the Lower Rogue population area (Indian Creek Hatchery) and within the Chetco population area (juveniles are reared at Elk River Hatchery) have likely resulted in lesser impacts to NP CHF in the coastal stratum of the SMU as compared with most other hatchery programs for salmon in the Pacific Northwest. Given that few hatchery fish spawn naturally within any of independent NP CHF populations (Chetco population excepted), the current programs for hatchery fish are not likely a primary factor that could possibly limit attainment or maintenance of desired status for independent NP CHF populations in the coastal stratum of the SMU.

Fisheries

A primary impact exerted on salmon populations is mortality that results from fishing activities. Wading and boating may have some impact on production (Roberts and White 1992; Horton 1994), but the greatest impact almost certainly originates from the directed fishing on salmon by recreational and commercial fisheries. Mortality rates associated with fishing can vary widely for Pacific salmon, especially for Chinook salmon that mature at multiple ages.

Harvest rates, unless otherwise stated, are defined as that percentage of recruits which were taken by fishers, for the brood years in question. Methods devised to estimate recruits, ocean harvest, and freshwater harvest are described in **APPENDIX D**.

All Populations: Estimates of brood harvest rates for NP CHF produced in the coastal population areas ranged between 3% and 82% for the 1983-2006 brood years. Harvest rates were greatest for fish produced in the mid 1980s, were generally low for fish produced during the late 1980s through the mid 1990s, and secondarily peaked for fish produced around the turn of the century (Figure 49). The decline in ocean exploitation rates coincided with decreases in ocean harvest for CHF in the Klamath River Basin of northern California, beginning in 1988 (PFMC 1988). Resultant harvest restrictions to the ocean fisheries caused the coastal populations of NP CHF to be harvested at lower rates because CH originating from the coastal populations tend to be caught in the same general area of the ocean as Klamath River Chinook (Appendix Table D-15).

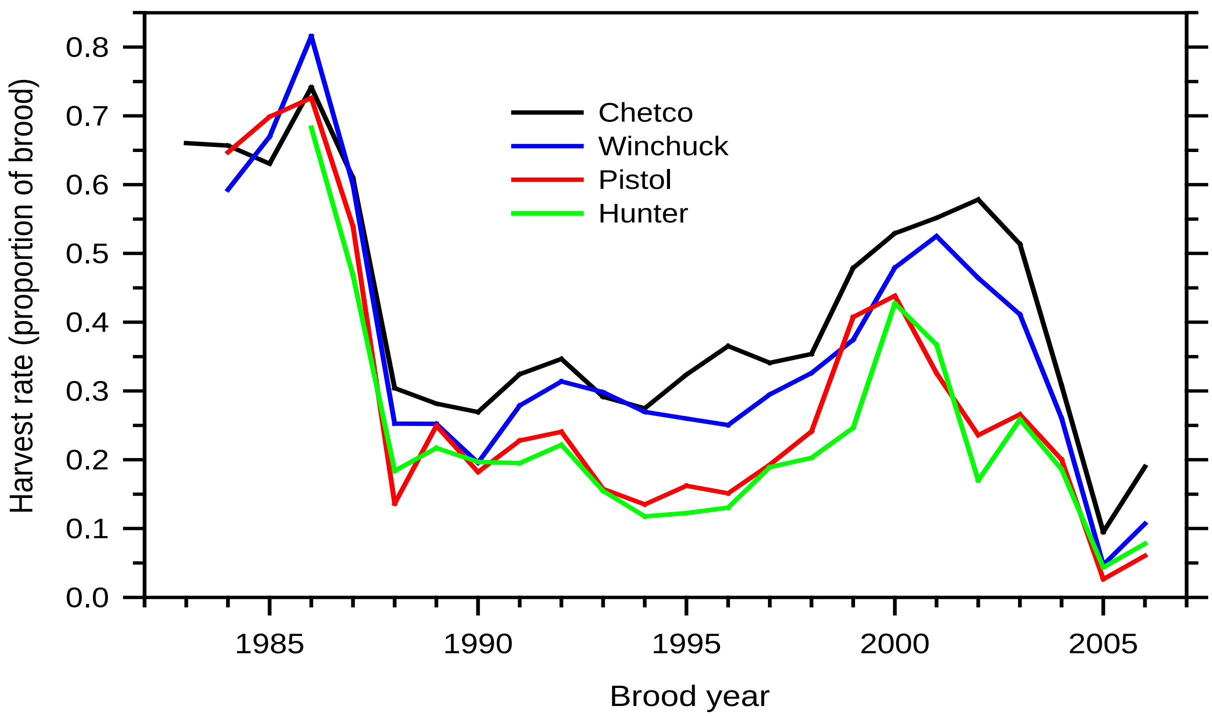

Figure 49. Estimated brood harvest rates of fall Chinook salmon naturally produced by independent populations in the coastal population stratum, 1983-2006 brood years. Confidence bounds could not be generated for these estimates.

Chetco Population: Commercial and recreational fisheries in the ocean were likely the primary harvesters of NP CHF produced in the Chetco population area through the mid-1980s. With greater constraints on CH harvest during the general ocean season in the late 1980s, a late-season near-shore fishery was opened in areas proximal to the mouth of the Chetco River. This terminal fishery harvested 0-20% of the NP CHF broods produced during the period of record (Figure 50).

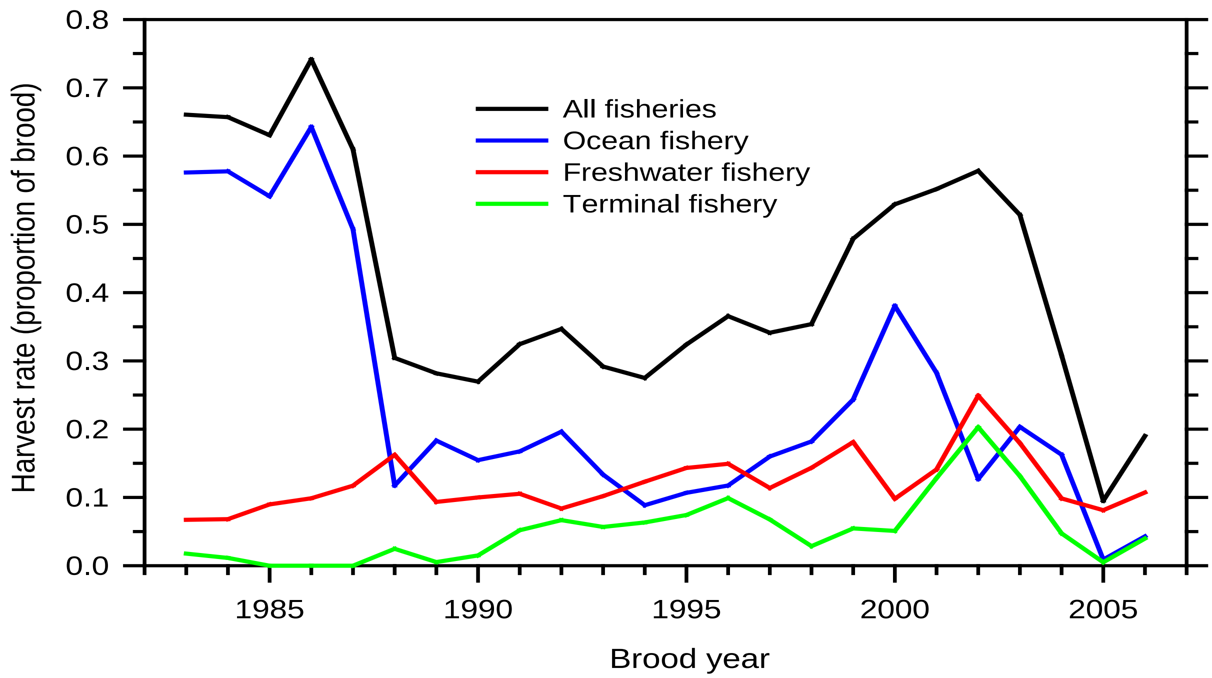

Figure 50. Estimated brood harvest rates of fall Chinook salmon naturally produced in the Chetco population area, 1983-2006 brood years. The terminal fishery operates in the ocean near the mouth of the Chetco and Winchuck rivers after the closure of the general ocean season. Confidence bounds could not be generated for these estimates.

The stock-recruitment models for the Chetco population (*see* **Chetco Population:**, page 89), indicated a brood harvest rate of 51% would result in MSY. Brood harvest rates (all fisheries combined) exceeded 51% for NP CHF produced in the late 1980s and early 2000s (Figure 50). Since the initiation of increased restraints on the ocean fisheries in 1988 (PFMC 1988), brood harvest rates of NP CHF have averaged 35% (95% CI = 29-41% as estimated from arcsine transformed data); which is probably a good indication of an average brood harvest rate that can be expected in future years.

The freshwater fishery (includes estuary) harvested 5-42% of the CHF that returned to freshwater during 1986-2009 (Figure 51). Annual exploitation rates in the freshwater fishery are negatively related to CHF abundance (Figure 51). Anglers harvested a greater proportion of the run during years of low abundance. In contrast, anglers harvested a smaller proportion of the run during years of high abundance. During years when less than 4,000 CHF returned to the Chetco River, the freshwater fishery harvested 19-42% of the freshwater returns (Figure 51).

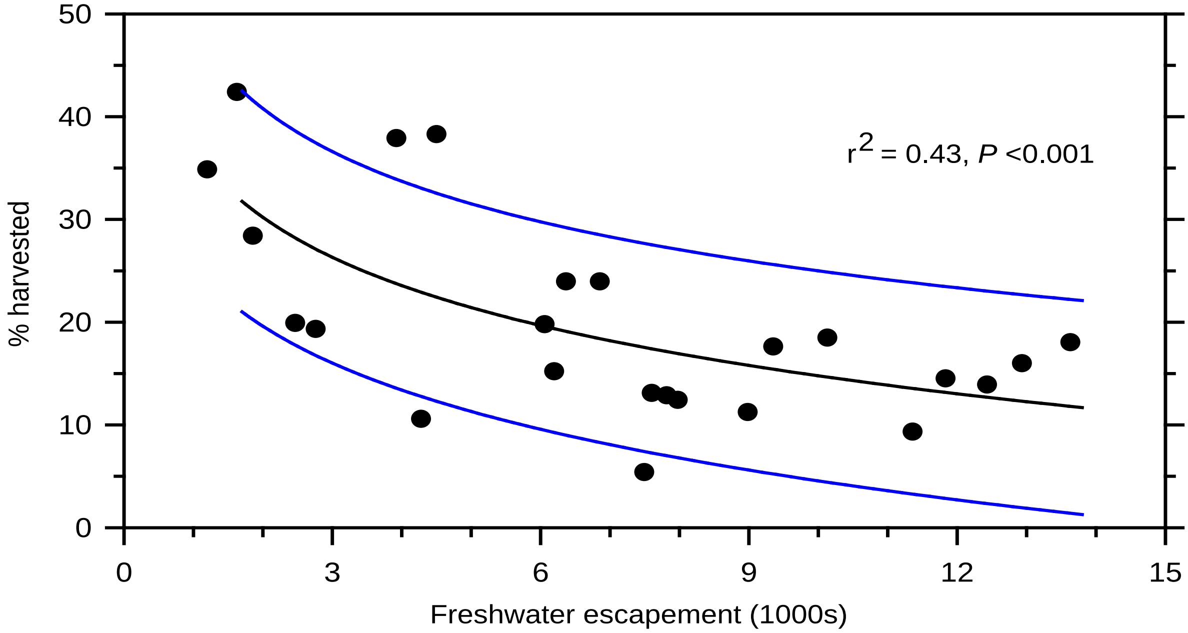

Figure 51. Relationship between annual exploitation rates in the freshwater fishery and the annual returns of age 3-6 fall Chinook salmon to the Chetco River, 1986-2009. The black line is the regression equation and the blue lines represent the 90% confidence bounds.

Winchuck Population: Commercial and recreational fisheries in the ocean were likely the primary harvesters of NP CHF produced in the Winchuck population area through the mid-1980s. With greater constraints on CH harvest during the general ocean season in the late 1980s, a late-season near-shore fishery was opened in areas proximal to the mouth of the Chetco River. This special fishery harvested 0-18% of the NP CHF broods produced in the Winchuck population area during the period of record (Figure 52).

The stock-recruitment models for the Winchuck population (*see* **Winchuck Population:**, page 91), indicated brood harvest rates of 55-58% would result in MSY. Brood harvest rates (all fisheries combined) exceeded 55% only for NP CHF produced in the late 1980s (Figure 52). Since the initiation of increased restraints on the ocean fisheries in 1988 (PFMC 1988), brood harvest rates of NP CHF have averaged 30% (95% CI = 23-35% as estimated from arcsine transformed data); which is probably a good indication of an average brood harvest rate that can be expected in future years.

The freshwater fishery (includes estuary) harvested 2-24% of the CHF that returned to freshwater during 1986-2009 (Figure 53). Annual exploitation rates in the freshwater fishery are negatively related to CHF abundance (Figure 53). Anglers harvested a greater proportion of the run during years of low abundance. In contrast, anglers harvested a smaller proportion of the run during years of high abundance. During years when less than 500 CHF returned to the Winchuck River, the freshwater fishery harvested 17-24% of the freshwater returns (Figure 53).

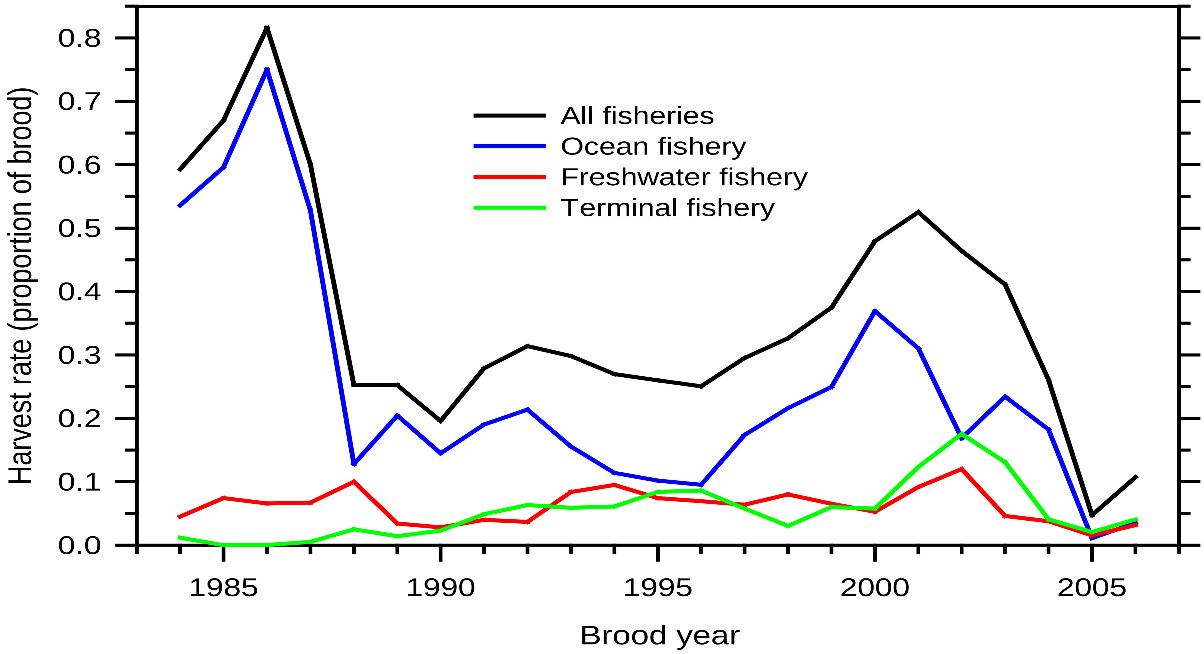

Figure 52. Estimated brood harvest rates of fall Chinook salmon naturally produced in the Winchuck population area, 1984-2006 brood years. The terminal fishery operates in the ocean near the mouth of the Chetco and Winchuck rivers after the closure of the general ocean season. Confidence bounds could not be generated for these estimates.

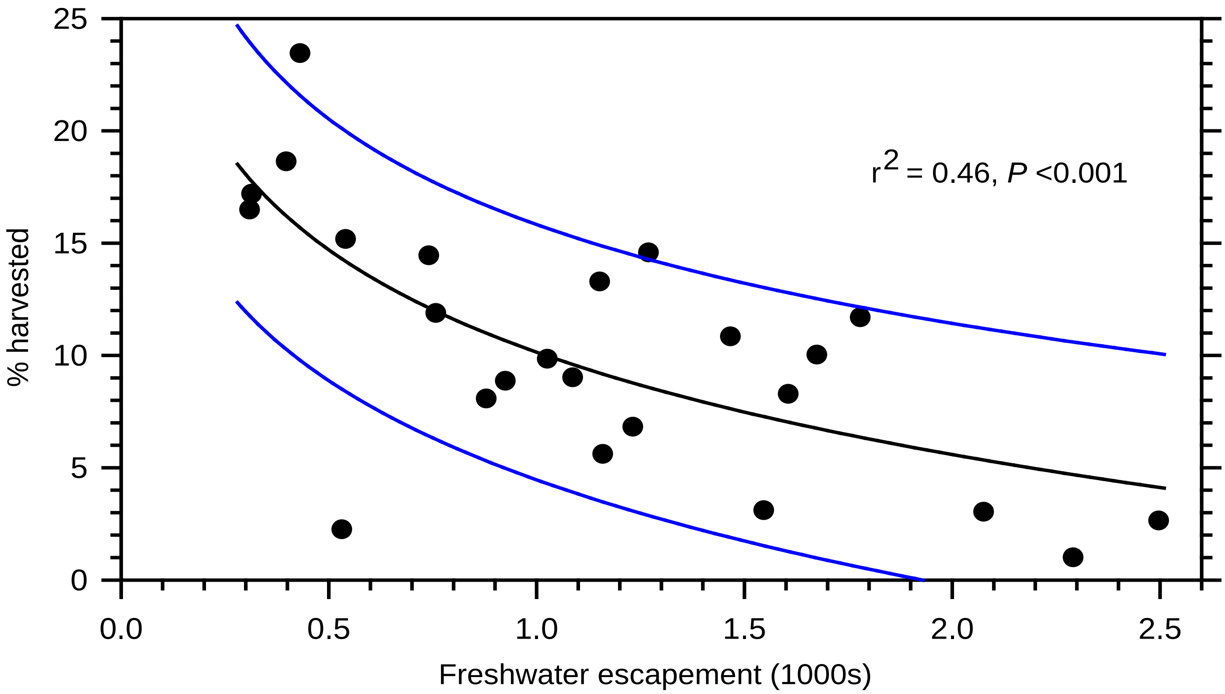

Figure 53. Relationship between annual exploitation rates in the freshwater fishery and the annual returns of age 3-6 fall Chinook salmon to the Winchuck River, 1986-2009. The black line is the regression equation and the blue lines represent the 90% confidence bounds.

Pistol Population: Commercial and recreational fisheries in the ocean were likely the primary harvesters of NP CHF produced in the Pistol population area through the mid-1980s. With greater constraints on CH harvest during the general ocean season in the late 1980s, a late-season near-shore fishery was opened in areas proximal to the mouth of the Chetco River. This special fishery harvested 0-5% of the NP CHF broods produced in the Pistol population area during the period of record (Figure 54). The river fishery operated for a greater number of years and this fishery harvested 0-2% of the NP CHF broods produced during the period of record (Figure 54).

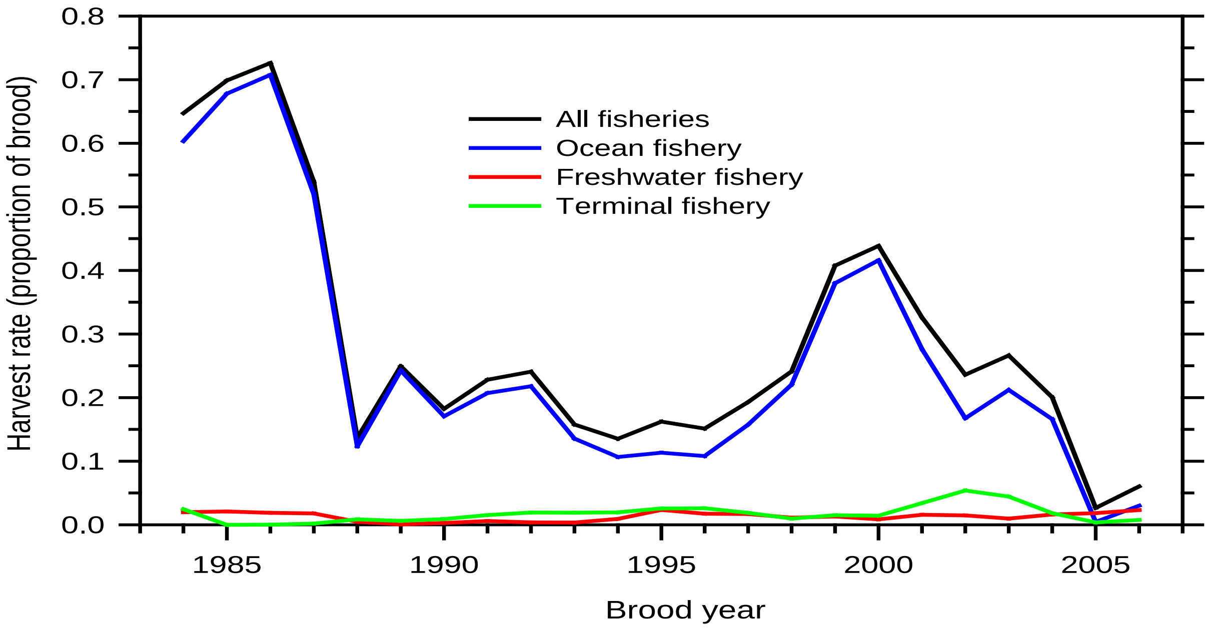

Figure 54. Estimated brood harvest rates of fall Chinook salmon naturally produced in the Pistol population area, 1984-2006 brood years. The terminal fishery operates in the ocean near the mouth of the Chetco and Winchuck rivers after the closure of the general ocean season. Confidence bounds could not be generated for these estimates.

The stock-recruitment model for the Pistol population (*see* **Pistol Population:**, page 93), indicated brood harvest rates of 51-56% would result in MSY. Brood harvest rates (all fisheries combined) exceeded 51% only for NP CHF produced in the late 1980s (Figure 54). Since the initiation of increased restraints on the ocean fisheries in 1988 (PFMC 1988), brood harvest rates of NP CHF have averaged 21% (95% CI = 15-26% as estimated from arcsine transformed data); which is probably a good indication of an average brood harvest rate that can be expected in future years.

Hunter Population: Commercial and recreational fisheries in the ocean were likely the primary harvesters of NP CHF produced in the Hunter population area through the mid-1980s. With greater constraints on CH harvest during the general ocean season in the late 1980s, a late-season near-shore fishery was opened in areas proximal to the mouth of the Chetco River. This special fishery harvested 0-2% of the NP CHF broods produced in the Hunter population area during the period of record (Figure 55). The river fishery operated for a greater number of years and this fishery harvested 0-3% of the NP CHF broods produced during the period of record (Figure 55).

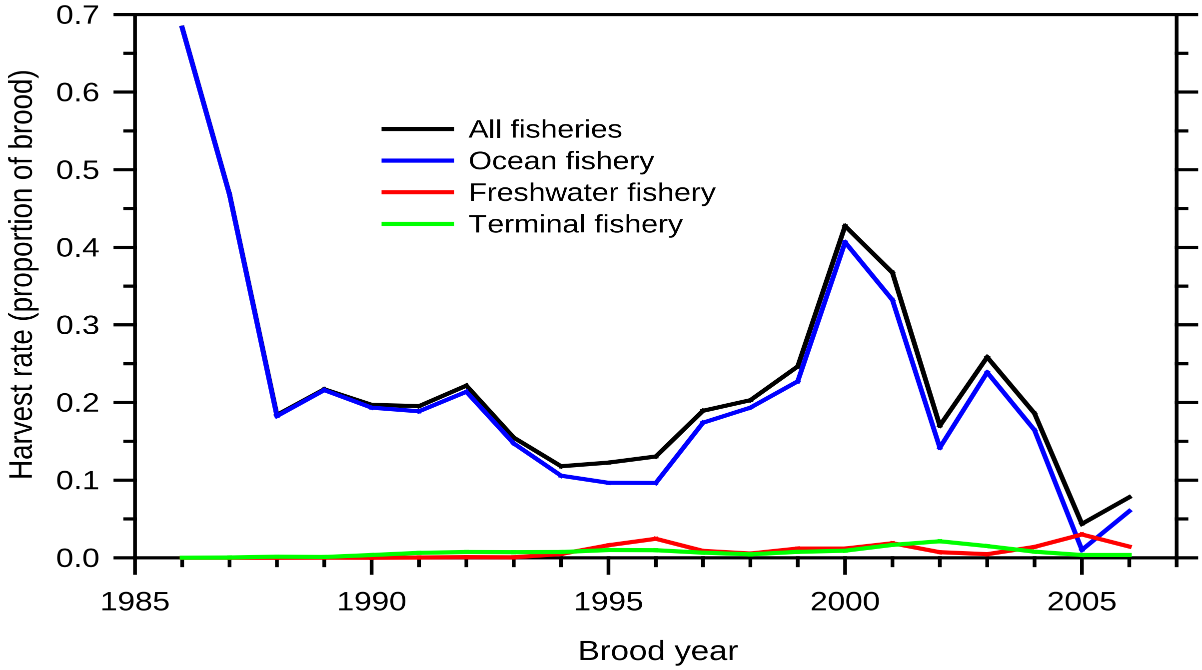

Figure 55. Estimated brood harvest rates of fall Chinook salmon naturally produced in the Hunter population area, 1986-2006 brood years. The terminal fishery operates in the ocean near the mouth of the Chetco and Winchuck rivers after the closure of the general ocean season. Confidence bounds could not be generated for these estimates.

The stock-recruitment model for the Hunter population (*see* **Hunter Population:**, page 95), indicated brood harvest rates of 57-59% would result in MSY. Brood harvest rates (all fisheries combined) exceeded 57% only for NP CHF produced in the late 1980s (Figure 55). Since the initiation of increased restraints on the ocean fisheries in 1988 (PFMC 1988), brood harvest rates of NP CHF have averaged 20% (95% CI = 15-23% as estimated from arcsine transformed data); which is probably a good indication of an average brood harvest rate that can be expected in future years.

To summarize this section, harvest can limit the abundance of NP CHF populations in the Coastal Stratum when population abundances are lower than S_{MSY}.

Comparisons to Other Populations: Cyclical patterns in survival rates of regional groups of Pacific salmon are related to changes in current patterns that typify various regions of the ocean (Beamish et al. 2004). Abundance trends among geographically proximal populations track with each other, unless limiting factors differentially affect one or more of the populations (Pyper et al. 2005; Malick et al. 2009).

The Klamath River Basin is located immediately south of the coastal populations of NP CHF in the Rogue SMU. Populations within both of these areas are mostly grouped in the same Evolutionarily Significant Unit; based on genetic assessments (Myers et al. 1998). There is likely some commonality among factors that affect the natural production of CHF because the Klamath and coastal basins share similar geology, and exhibit similar patterns of flow volume and timing of water yield. In addition, the ocean distribution NP CHF produced in both areas is similar, based on the landing distributions CWT-marked CHF released in both areas (Appendix Table D-15).

The number of natural spawning CHF has been estimated in the Klamath River Basin since 1985 (KRTT 2012). Annual estimates of natural spawners in the Klamath River Basin were not significantly related to annual estimates of NP CHF spawners in any of the coastal population areas Hunter population (*P* = 0.164 for the Chetco population, *P* = 0.860 for the Winchuck population, *P* = 0.914 for the Pistol population, and *P* = 0.066 for the Hunter population). These results could be expected as the coastal populations of NP CHF in the Rogue SMU mature at older ages as compared to Klamath CHF.

Comparisons of the number of age 3 NP CHF alive in the ocean during spring, prior to the onset of fishing, is a more sensitive method by which to assess co-variation in NP CHF abundance for the coastal populations of the Rogue SMU and CHF of Klamath River Basin origin. This approach would theoretically not be affected by stock-specific differences in fishing mortality and maturation schedules. However, the lack of ocean stock size estimates solely for naturally produced CHF seemingly biases such an analysis. Regardless, estimates of the number of age 3 NP CHF of Chetco Basin origin were positively related to estimates of the number of age 3 CHF of Klamath River Basin origin (Figure 56). Analogous analyses for the other coastal populations also revealed a positive relationship for the Hunter population (*P* = 0.016), but no significant relationships for the Winchuck (*P* = 0.342) and Pistol (*P* = 0.368) populations. Thus, there is some evidence that NP CHF production in the coastal population area of the Rogue SMU co-varies in relation with CHF production in the Klamath River Basin. Taken collectively, these results indicate that regional ocean conditions, just after smolts enter the ocean, are (1) primary factors that affect recruitment for populations of NP CHF produced in the coastal population areas and (2) lend support to the use of survival rates of CWT-marked hatchery smolts as a proxy for annual variations in the early ocean survival rates of naturally produced fish.

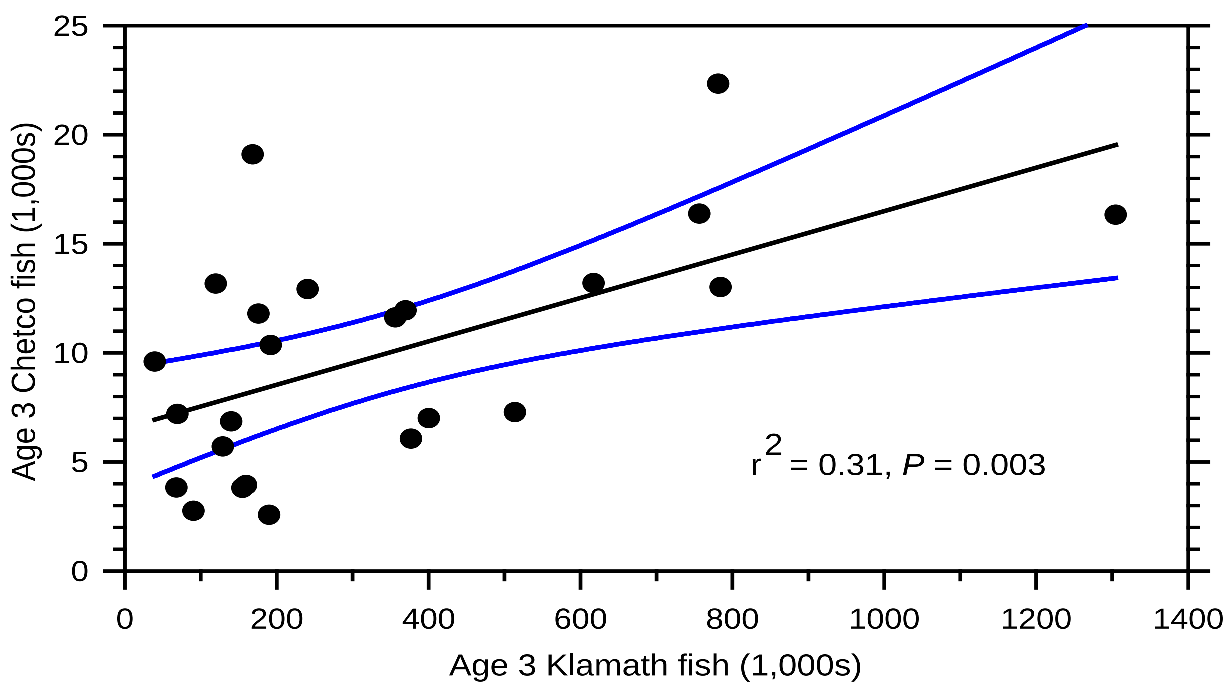

Figure 56. Relationship between numerical estimates of naturally produced age 3 fall chinook salmon produced in the Chetco population area and in the Klamath River Basin, brood years 1983-2006. The black line is the regression equation and the blue lines represent the 95% confidence bounds. Estimates reflect the number of fish alive in the ocean during spring prior to the onset of fishing.

Summary of Limiting Factors Assessment - Coastal Stratum: Based on the limiting factors assessment outlined within the preceding sections, the primary factors that appear to limit the abundance and expression of life history strategies of NP CHF populations in the coastal stratum include: (1) volume of juvenile rearing habitat in streams and estuaries, (2) water temperature in streams and in the estuaries during summer, (3) habitat quality in the estuaries during summer, (4) brood harvest rates during periods of low fish abundance, and (5) low spawning escapement. All of these factors can be managed to some degree by natural resource agencies.

DESIRED BIOLOGICAL STATUS

As outlined in the Native Fish Conservation Policy, conservation plans should describe a desired status for the SMU that reflects the ecological, economic and cultural benefits desired from naturally produced fish. These benefits will accrue with the attainment (or maintenance of) the desired status criteria outlined in this section because the criteria were developed with the associated benefits as an underlying primary goal for each independent NP CHF population in the SMU. Each independent population is important for overall SMU health and the populations should be managed on an individual basis in addition to management on a collective basis.

The Native Fish Conservation Policy also conveys that the desired biological status must be based on measurable criteria that are directly relevant to biological attributes of populations within the SMU. Consequently, measurable criteria must reflect population parameters that can be measured through the sampling of NP CHF populations. The need for criteria to be measurable directly limited the scope of metrics that could possibly be included in a desired status statement.

Criteria for Individual Populations

Sampling of NP CHF populations, and their habitat, in the SMU is presently less comprehensive than for many other populations of anadromous salmonids in coastal Oregon. In the Rogue stratum, ODFW annually samples (1) adult CHF (aggregate populations) migrating through the lower portion of the Rogue River, and (2) adult CHF that spawn in the Lower Rogue population area. For migrating adults, metrics judged to be important enough, based on the Native Fish Conservation Policy, for incorporation within a desired status statement included (1) adult abundance, (2) adult age composition, (3) run timing, and (4) hatchery fraction of the run. A discussion of the relevance of these attributes follows. While it is most desirable to establish status metrics for individual populations, the lack of monitoring makes this impossible. The high degree of co-variation in adult abundance among NP CHF populations in the Rogue stratum (*see* **Rogue Aggregate Populations**, page 25) provides evidence that criteria for aggregated populations will likely appropriately cover the constituent individual populations, until such time when additional monitoring funds become available (*see* **Monitoring Needs**, page 139).

Abundance of adult NP CHF was judged to be an important metric because an appropriate number of spawners are needed to maintain subsequent production and maintain the viability of populations through the retention of genetic diversity. Age composition of adult NP CHF was judged to be an important status metric because of the need to maintain population viability and genetic structure under the current management of the ocean salmon fisheries that harvest CHF in an age-selective manner. For example, there is evidence that an older age composition among spawning salmon results in greater recruitment (Forbes and Peterman 1994; Williamson 2010) and Chinook salmon age at maturity is influenced by parental ages (Hankin et al. 1993). Run timing was judged to be an important status metric because individual NP CHF populations are not currently sampled within the Rogue stratum and run timing provides some indication of the relative abundance of NP CHF abundance within individual population areas (*see* **Rogue Aggregate Populations**, page 25). The percentage of hatchery fish within the run was judged to be an important status metric because of the chance that hatchery fish could reduce the productivity of wild NP CHF populations (Chilcote et al. 2011).

In the coastal stratum, ODFW annually surveys CHF spawners in at least one stream reach within each population area and aids volunteers with sampling downstream migrant juveniles in the Winchuck River. Sampling to estimate the age composition of spawners consistently occurred only in the Chetco River Basin. Population metrics judged to be important enough for incorporation into status statements included (1) spawner abundance, (2) spawner age composition (Chetco population only), (3) hatchery fraction of the spawners, and (4) juvenile abundance in the Winchuck River. Juvenile abundance in the Winchuck River was judged to be an important status metric because juvenile production is a direct measure of NP CHF production in freshwater and there is a good chance that this metric can serve as a long-term index of juvenile NP CHF production in a coastal population area that is relatively un-impacted by development. Rationale associated with the other metric choices was outlined in the preceding paragraph.

Development of a desired status statement followed a decision tree approach based on assessments of the production and life history of NP CHF populations in the SMU. Potential numerical values for desired status criteria were considered at length by the public advisory committee and by ODFW. Relevant information considered during this process included (1) findings reported in the scientific literature, (2) plots of spawners and recruits (*see* **Spawner Abundance:**, page 60 and **Spawner Abundance:**, page 88), (3) implications of the stock-recruitment models (*see* **Spawner Abundance:**, page 60 and **Spawner Abundance:**, page 88), and (4) period of record metrics. Consideration was also given to the length of time that provided an effective period by which to judge the status of attributes. A period of ten years was chosen, which represents an interval that basically covers two complete generations of NP CHF for all populations in the SMU. The following desired status criteria, for NP CHF populations in the Rogue stratum (Table 36), represent a product that is supported by all nine members of the public advisory committee and by ODFW.

Table 36. Biological criteria indicative of desired status for individual populations of naturally produced fall Chinook salmon in the Rogue stratum of the Species Management Unit. All criteria apply as annual estimates averaged over a running period of ten years, except for the persistence element.

Aggregate Populations

1. **Abundance:** At least 54,400[a] naturally produced age 3-6 fall Chinook salmon should pass Huntley Park.

2. **Age Structure:** Age 5+6 fish should compose at least 10% of the naturally produced fall Chinook salmon that pass Huntley Park.

3. **Run Timing:** At least 8% of the naturally produced fall Chinook salmon should pass Huntley Park during October.

4. **Run Composition:** Hatchery fish should compose no more than 5% of the fall Chinook salmon that pass Huntley Park.

5. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

Lower Rogue Population

1. **Abundance:** Spawning escapement should be at least 3,500 naturally produced fall Chinook salmon.

2. **Spawner Composition:** Hatchery fish should compose no more than 10% of the naturally spawning fall Chinook salmon.

3. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

[a] *Equates to 49,000 spawners (average loss of 10% between Huntley Park and spawning).*

The following desired status criteria for NP CHF populations in the coastal stratum (Table 37), represents a product that was preferred by all nine members of the public advisory committee and by ODFW.

Table 37. Criteria indicative of desired status for individual populations of naturally produced fall Chinook salmon in the Coastal stratum of the Species Management Unit. All criteria apply as annual estimates averaged over a running period of ten years, except for the persistence element.

Hunter Creek Population

1. **Abundance:** Spawner escapement should be at least 560 naturally produced fall Chinook salmon.

2. **Spawner Composition:** Hatchery fish should compose no more than 5% of the naturally spawning fall Chinook salmon.

3. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

Pistol River Population

1. **Abundance:** Spawner escapement should be at least 1,300 naturally produced fall Chinook salmon.

2. **Spawner Composition:** Hatchery fish should compose no more than 5% of the naturally spawning fall Chinook salmon.

3. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

Chetco River Population

1. **Abundance:** Spawner escapement should be at least 3,800 naturally produced fall Chinook salmon.

2. **Age Structure:** Age 5+6 fish should compose at least 16% of the spawners among naturally produced fall Chinook salmon.

3. **Spawner Composition:** Hatchery fish should compose no more than 18% of the naturally spawning fall Chinook salmon.

4. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

Winchuck River Population

1. **Adult Abundance:** Spawner escapement should be at least 1,000 naturally produced fall Chinook salmon.

2. **Juvenile Abundance:** At least 125,000 naturally produced juvenile fall Chinook salmon should migrate downstream past a trap sited just upstream of the South Fork.

3. **Spawner Composition:** Hatchery fish should compose no more than 10% of the naturally spawning fall Chinook salmon.

4. **Persistence:** There is at least a 99% chance of persistence over a period of 100 years.

Criteria for the Species Management Unit

Formulation of desired status criteria for the entire SMU has significant benefits. Such criteria provide an overview of the entire SMU and should clearly state that the conservation plan is designed to ensure attainment of specific desired status criteria for all of the independent NP CHF populations in the SMU. In addition, as there are two population strata (Rogue and Coastal) in the SMU, there should also be desired status criteria that encompass the entirety of each stratum. The following collective desired status criteria represent a product that is supported by all nine members of the public advisory committee and by ODFW (Table 38). Attainment of the collective desired status criteria for all independent NP CHF populations at the strata level and the SMU level will help ensure genetic diversity and spatial diversity throughout the entire SMU.

Table 38. Desired status criteria collective groups of fall Chinook salmon populations in the Species Management Unit.

Species Management Unit
Both strata of naturally produced fall Chinook salmon should meet or exceed the desired status criteria established for each stratum in order to ensure maintenance of populations at levels that provide ecological, societal, and fishery benefits.
Rogue Stratum
All independent populations of naturally produced fall Chinook salmon should meet or exceed the desired status criteria established for each population or the population aggregate.
Coastal Stratum
All independent populations of naturally produced fall Chinook salmon should meet or exceed the desired status criteria established for each population.

The Native Fish Conservation Policy calls for the crafting of measurable criteria related to abundance, diversity, spatial structure, and productivity. Criteria listed in Table 36 and Table 37 directly meet this need for abundance and diversity; and criteria listed in Table 38 directly meet the need for spatial structure and the stratum and SMU levels. However, there remains a need to develop productivity criteria; as discussed in the following section.

Population Productivity

As outlined in the Native Fish Conservation Policy, conservation plans should include, if possible, measurable criteria for a “standardized rate of population growth”. This attribute is often referred to by another term: "population productivity". Total life-cycle population productivity can be expressed as the ratio of progeny (recruits) to their parents (spawners), and is subject to environmental and biological processes that affect survival at different life-stages. Alternatively, intrinsic productivity is defined as the productivity of a population in the absence of compensation (i.e. no density dependent effects) as spawner abundance approaches zero.

Intrinsic productivity represents a population’s ability to rebuild under conditions of low abundance, and is a fundamental characteristic of a population’s risk of extinction. However, it is difficult to estimate this characteristic because of (1) confounding affects of environmental conditions, (2) measurement errors resulting from imperfect sampling (numbers of spawners and recruits must be estimated), and (3) data are often lacking for extremely low levels of spawning escapement. Ocean and freshwater conditions theoretically have independent effects on survival rates of potential recruits, but these distinct effects usually cannot be separated using typical data sets for spawners and recruits. As a result of these factors, there is a high degree of uncertainty associated with the estimation of population productivity; which depends on conditions for survival in ocean and freshwater environments.

The alpha (α) parameter of stock-recruitment models has been used to characterize the intrinsic productivity of populations. Estimates of the alpha parameter have been reported for multiple populations of Chinook salmon (i.e. Parken et al. 2006; Chilcote et al. 2011), but direct comparisons of those alpha parameters with those estimated for NP CHF populations in the Rogue SMU are confounded by the differing methods employed during development of the stock-recruitment models. Such differences are exemplified by the inclusion, or lack of inclusion, of environmental covariates in the stock-recruitment models (Table 39). Such differential results make it difficult to identify a metric of desired status that relates directly to population productivity. Resolution of this problem is needed not only for NP CHF in the Rogue SMU, but is also needed for other SMUs in Oregon. ODFW should encourage and support such efforts (*see* **Research Needs**, page 142). Should ODFW resolve this issue, then this conservation plan should be amended to include criteria for population productivity.

Table 39. Comparisons of the estimated alpha parameters for two variations of the Ricker stock-recruitment models developed for naturally produced fall Chinook salmon in the Rogue Species Management Unit. Alpha values shown for models with covariates included survival rates of CWT-marked hatchery spring Chinook salmon and mean summer flow when juveniles reared in freshwater (**APPENDIX F**).

	No covariates		Covariates included	
Population(s)	alpha	95% CI	alpha	95% CI
Hunter	5.39	2.56-8.62	4.35	2.54-6.50
Pistol	4.17	2.22-6.53	3.67	1.92-5.76
Chetco	4.00	1.61-6.80	3.73	1.60-6.23
Winchuck	4.56	2.09-7.36	4.32	2.11-6.95
Rogue aggregate	6.62	4.23-9.68	3.93	2.03-6.01
SMU (mean)	4.94	3.60-6.28	4.00	3.60-4.40

VIABILITY OF THE SPECIES MANAGEMENT UNIT

As outlined in the Native Fish Conservation Policy, conservation plans should forecast the likelihood of SMU persistence in the near and long terms. To meet this need, relationships between recruits and spawners were used to assess persistence potential (viability) of NP CHF populations in the Rogue SMU. A population viability modeling exercise was undertaken to evaluate the viability of NP CHF populations. An abbreviated description of this approach follows, with a more detailed description presented in **APPENDIX F**.

Salmon populations exhibit unique demographics because of differences in production potential of their habitat and differences in life history parameters such as age at maturity. It is therefore necessary to assess viability separately for each population. For NP CHF populations in the Rogue SMU, several spawner-recruit functions were considered, each with unique assumptions about the nature of density-dependence and relevant environmental covariates. The parameter values of the spawner-recruit function that best fit empirical observations (**APPENDIX F**) were used to drive a population viability analysis (PVA) for each independent NP CHF population. The PVA model was used to estimate the probability of extinction over 100 years; once spawner abundance reached a critical low level. Critical low abundance was assumed to be any spawner abundance less than 50% (upper 75th percentile estimate) of S_{MSY}; as described in **APPENDIX F.**

With the ability to define a wide range of possible future conditions PVAs can be used to assess either (1) the likelihood of population extinction should conditions remain unchanged, and/or (2) the likelihood of population extinction should these conditions change in response to implementation of successful conservation strategies. All viability models attempt to mimic the stochastic nature of population recruitment for some period of time (e.g., the next 100 years).

Simulations of this natural process are the basis for estimating probabilities of extinction, or in this case abundance less than a quasi-extinction threshold (QET).

The chosen quasi-extinction thresholds exceed 0 because theory suggests that demographic (mate finding, predator avoidance) and genetic (drift, unequal sex ratio) problems compound at low abundance and create an extinction vortex from which populations will not recover. These processes are difficult to observe and are therefore even more difficult to explicitly model. Quasi-extinction threshold (QET) values selected for inclusion in the PVAs followed the population size criteria for Chinook salmon employed by ODFW (2010), except the QET for the Rogue aggregate was set at 950 fish; which is the sum of the QET values for the five independent populations of NP CHF in the Rogue River Basin (Table 40).

Table 40. Quasi-extinction thresholds (QETs) chosen for independent populations of naturally produced fall Chinook salmon in the Rogue Species Management Unit and allied metrics used as guidance for choices.

Population(s)	CHF spawning habitat	Size Category[a]	QET chosen[a]
Euchre	20.1 km	Small	50
Hunter	14.6 km	Small	50
Pistol	38.9 km	Small	50
Chetco	86.6 km	Medium	150
Winchuck	55.2 km	Medium	150
Upper Rogue	121 km	Medium	150
Middle Rogue	195 km	Large	250
Lower Rogue	114 km	Medium	150
Applegate	129 km	Medium	150
Illinois	164 km	Large	250
Rogue Aggregate	822 km	n/a	950[b]

[a] *Classification scheme follows ODFW (2010).*

[b] *Sum of all five NP CHF populations in the Rogue River Basin.*

Female NP CHF in the Rogue SMU populations mature primarily at ages 3-5. As a result, most females from a single brood year contribute to spawning escapement primarily over the course of three consecutive years. Consequently, QET values should cover a three year period of time. Simulation analyses started with an assumed brood harvest rate of 0.1, with the harvest rate gradually increased until spawner abundance fell below the generic conservation criterion (50% of the upper 75th percentile of S_{MSY}). At that point, harvest rate was set as described in the next paragraph and the population response was simulated over a period of 100 years. This process was replicated 5000 times, and the proportion of replicates that fell below the quasi-extinction threshold for 3 consecutive years is the estimate of the probability of population extinction.

Different levels of brood harvest rates were incorporated into the PVAs after the simulated populations fell below the generic conservation criterion. For each coastal population, simulations were completed at specific brood 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 contrast, simulations of the Rogue populations incorporated brood harvest rates that were dependent on population abundance. This approach more appropriately accounted for ocean fishery management strategies employed since the late 1980s and is described in **APPENDIX F**.

Results from the PVA simulations indicated the risk of extinction is less than 1% for all independent populations of NP CHF in the Rogue SMU and that there is a greater than 99% chance that these populations will persist during the next 100 years, except the risk of extinction for the Chetco and Winchuck populations increases to about 1% if brood harvest rates are constant at about 0.40 (Tables 41 and 42). However, these conclusions are valid only under the assumption that the quality and quantity of freshwater habitat will not decrease over time and that fishery exploitation rates will not increase significantly over time. Brood harvest rates on these two populations can be expected to average about 35% (Chetco) and 30% (Winchuck) for the foreseeable future.

Table 41. Estimated extinction probabilities for NP CHF populations in the coastal stratum of the Rogue Species Management under two scenarios of brood harvest rates. Estimates pertain to a simulated 100 year period with initial spawner escapements of less than $0.5*S_{MSY}$. All of the PVAs, employed to estimate extinction probabilities, incorporated the population-specific Ricker model with smolt survival rates as the only covariate (*see* **APPENDIX F** for more details).

		Extinction probability	
Population	**QET chosen[a]**	**Harvest rate=0.25**	**Harvest rate=0.40**
Euchre[b]	**50**	**0.821**	**0.896**
Hunter	**50**	**<0.001**	**<0.001**
Pistol	**50**	**<0.001**	**0.001**
Chetco	**150**	**0.003**	**0.014**
Winchuck	**150**	**0.004**	**0.012**

[a] *Number of spawners at Quasi-extinction threshold.*

[b] *Classified in plan as a dependent population.*

In contrast, the NP CHF population in Euchre Creek is likely to become functionally extinct (Table 41), and there is a good possibility that this population was never a viable NP CHF population (*see* **Euchre Creek Population**, page 29). As the Euchre population is classified as a dependent population, persistence of this population is less important for maintenance of SMU viability; as compared to the persistence of the independent populations.

Table 42. Estimated extinction probabilities for NP CHF populations in the Rogue stratum of the Rogue Species Management exposed to brood harvest rates that vary in relation to population abundance. Estimates pertain to a simulated 100 year period with initial spawner escapements of less than $0.5*S_{MSY}$. The PVA, employed to estimate extinction probability for the Rogue aggregate population, incorporated the Ricker model with smolt survival rates as the only covariate (*see* **APPENDIX F** for more details).

Population(s)	QET chosen[a]	Extinction probability
Lower Rogue	150	b
Rogue Aggregate[c]	950	<0.001

[a] *Number of spawners at Quasi-extinction threshold.*

[b] *No satisfactory model could be fit to this population.*

[c] *Sum of all the NP CHF populations in the Rogue River Basin.*

While the independent NP CHF populations in the SMU currently exhibit very high persistence probabilities, there is no guarantee that there will not be changes in fishing mortality rates or habitat capacity during future years. Fishing mortality rates of Rogue SMU populations in the ocean could increase if the allowable ocean harvest of CHF of Klamath River Basin origin increases after the planned removal of dams located on the upper portion of the Klamath River. In contrast, there is no indication that fishing mortality rates in freshwater will increase through time; with the possible exception of the fishery in the Chetco River (*see* **Fisheries**, page 100).

Changes in habitat capacity will almost certainly occur. Flow of the Rogue River during summer will decrease as additional reservoir storage is purchased for municipal, industrial, and irrigation purposes. The decrease in summer flow will lead to a decrease in the production of NP CHF in the Rogue River Basin. The intensity of peak flow events will increase as additional development will increase the amount of imperious surfaces; with the effect most pronounced in the Rogue River Basin. Greater peak flows will lead to a decrease in the production of NP CHF. Peak flow events during egg and alevin incubation, and stream flow during summer, are primary factors that limit NP CHF populations in the SMU (*see* **Summary of Limiting Factors Assessment - Rogue Stratum:**, page 71 and **Summary of Limiting Factors Assessment - Coastal Stratum:**, page 106).

It also appears there is a good chance the climate will change in southwest Oregon. Doppelt et al. (2008) adapted three models in order to project future conditions of the local climate of the Rogue River Basin. A summary of their conclusions follows in relation to the primary factors that limit NP CHF populations in the SMU:

1. Summer air temperatures may increase by 7 to 15° F (3.8 to 8.3° C) above baseline by 2080.
2. Rising temperatures will cause snow to turn to rain in lower elevations and decrease average January snow pack significantly, with a corresponding decline in runoff and stream flows. According to one model, snow pack will be reduced 75% from the baseline by 2040, and another 75% from 2040 to an insignificant amount by 2080.
3. The basin is likely to experience more severe storm events, variable weather, higher and flashier winter and spring runoff events, and increased flooding.

4. Both wet and dry cycles are likely to last longer and be more extreme, leading to periods of deeper drought and periods of more extensive flooding.

If these projections are even roughly accurate, then it is almost certain that NP CHF populations in the SMU will decrease over time. While the viability analyses indicate that the populations exhibit very high probabilities of persistence, these conclusions are dependent on the assumption that environmental conditions during the last 25 years (data embedded in the PVAs) will remain unchanged in future years.

Finally, there is also uncertainty related to the propriety of the QET values chosen for the viability assessments outlined in this section. Continued refinement of the methods designed to better assess persistence and viability will likely accrue during the next few years as a result of attempts to recover salmonids listed under the Endangered Species Act. Consequently, persistence estimates for independent NP CHF populations in the SMU should be updated during the development of comprehensive assessments; which are scheduled for every 15 years (*see* **Reporting**, page 145).

DISPARITY BETWEEN DESIRED AND CURRENT STATUS

Some differences, or gaps, may exist between elements of current and desired status. Desired status elements, except for population persistence, are formatted as running ten year averages. To be directly comparable to desired status metrics, metrics of current status were calculated as running averages over a period of ten years.

Annual comparisons of current and desired status will be conveyed in annual reports (*see* **Reporting,** page 145). These comparisons provide a concise summary of population status in comparison to desired status. Management strategies and actions will not be changed in the event that current status does not meet or exceed desired status. Changes in management strategies will only occur when population metrics encompass conservation criteria or are forecasted to encompass conservation criteria (*see* **CRITERIA INDICATING DETERIORATION IN STATUS,** page 133). In contrast, changes in management actions may be implemented as additional information becomes available (*see* **Adaptive Management**, page 144).

Rogue Stratum

Estimates of current status met desired status criteria for all of the population metrics (Table 43).

Table 43. Current status for independent populations of naturally produced fall Chinook salmon in the Rogue stratum of the Species Management Unit, 2002-2011. Metrics (except persistence) cover the most recent 10 year period so as to interface directly with desired status criteria. Confidence intervals for percentages were estimated from arcsine transformed data. Confidence intervals are not shown for metrics that required pooled data from multiple years.

			Current status
Population area	Criterion	Desired status	Mean (95% CI)
Rogue aggregate	Adult abundance[a]	≥54,400	82,819 (±42,785)
Lower Rogue	Adult abundance[b]	≥3,500	14,289 (±9,725)
Rogue aggregate	Age composition[c]	≥10%	14% (8-20%)
Rogue aggregate	Run timing[d]	≥8%	8% (4-11%)
Rogue aggregate	Run composition[e]	≤5%	4% (3-6%)
Lower Rogue	Spawner composition[f]	≤10%	3% (--)
Rogue aggregate	Persistence[g]	≥99%	>99% (n/a)
Lower Rogue	Persistence[g]	≥99%	>99% (n/a)

[a] *Estimated number that passed Huntley Park.*
[b] *Estimated number of spawners.*
[c] *Estimated percentage of adult migrants that were age 5 and age 6.*
[d] *Estimated percentage of adults that migrated during October.*
[e] *Estimated percentage of adult migrants that were of hatchery origin.*
[f] *Estimated percentage of spawners that were of hatchery origin.*
[g] *Estimated chance that population(s) will persist over a 100 year period.*

Coastal Stratum

Estimates of current status meet desired status criteria for all population metrics, with the exception of three of four NP CHF spawner escapements (Table 44). The shortfalls in spawner escapements ranged between 5% (Pistol population) and 11% (Hunter population).

Table 44. Current status for independent populations of naturally produced fall Chinook salmon in the coastal stratum of the Species Management Unit, 2001-2011. Metrics (except persistence) cover the most recent 10 year period so as to interface directly with desired status criteria. Confidence intervals for percentages were estimated from arcsine transformed data. Confidence intervals are not shown for metrics that required pooled data from multiple years. Metrics that do not currently meet desired status criteria are marked with an asterisk.

			Current status
Population area	Criteria	Desired status	Mean (95% CI)
Hunter	Adult abundance[a]	≥560	507* (±183)
Pistol	Adult abundance[a]	≥1,300	1,239* (±369)
Chetco	Adult abundance[a]	≥3,800	3,434* (±1,783)
Winchuck	Adult abundance[a]	≥1,000	1,007 (±545)
Winchuck	Juvenile abundance[b]	≥125,000	145,300 (±46,100)
Chetco	Age composition[c]	≥16%	16% (10-24%)
Hunter	Spawner composition[d]	≤5%	3% (--)
Pistol	Spawner composition[d]	≤5%	3% (--)
Chetco	Spawner composition[d]	≤18%	13% (--)
Winchuck	Spawner composition[d]	≤10%	4% (--)
Hunter	Persistence[e]	≥99%	>99% (n/a)
Pistol	Persistence[e]	≥99%	>99% (n/a)
Chetco	Persistence[e]	≥99%	>99% (n/a)
Winchuck	Persistence[e]	≥99%	>99% (n/a)

[a] *Estimated number of age 3-6 spawners.*
[b] *Estimated number that migrated downstream at a location upstream of the South Fork.*
[c] *Estimated percentage of adult spawners that were age 5 and age 6.*
[d] *Estimated percentage of spawners that were of hatchery origin.*
[e] *Estimated chance that population will persist over a 100 year period.*

ALTERNATIVE SUITES OF MANAGEMENT STRATEGIES

The Native Fish Conservation Policy requires that conservation plans shall illustrate a range of options for recovery strategies, fisheries, and the responsible use of hatchery produced fish. Accordingly, a primary goal of the planning process was to develop alternatives that (1) if implemented, would have a reasonable chance for attainment of desired status for NP CHF in the Rogue SMU (*see* **DESIRED BIOLOGICAL STATUS**, page 106) and (2) would encompass a broad range of potential management strategies. A formidable number of potential management actions were considered during the planning process. Each potential management action was categorically linked to those factors that limit, or could limit, attainment for each element of desired status (**APPENDIX G** and **APPENDIX H**). Potential limiting factors and potential management actions were also assigned alphanumeric codes in order to aid in cross-referencing singular management strategies embedded within the various alternatives.

The lists of action items included in this section are relevant solely to this conservation plan for naturally produced fall Chinook salmon in the Rogue Species Management Unit. There are numerous other management actions that can (and are) undertaken to promote the use and enjoyment of fish resources in the SMU. Some examples include angler education, the construction of boat ramps and access for bank anglers, and the hazing project designed to reduce pinniped interference with the sport fishery in the Rogue River estuary.

Rogue Stratum

Based on the limiting factors assessment, the primary factors that appear to limit, or may limit in the future, attainment of desired status for NP CHF populations in the Rogue stratum include: (1) water temperature of the Rogue River in summer during adult migration, (2) water temperature of the Rogue River in summer during juvenile rearing, (3) the intensity of peak flows during egg and alevin incubation in the gravel, (4) brood harvest rates when population abundances are lower than S_{MSY}, and (5) low spawning escapement (*see* **Summary of Limiting Factors Assessment - Rogue Stratum:**, page 71). All of these factors can be managed to some degree by natural resource agencies. Initial attempts to develop management alternatives focused on options related to addressing the primary limiting factors.

This approach resulted in the development of five alternative suites of management strategies for the Rogue population stratum (Table 45). Probability of attainment, or maintenance, of desired status varies considerably among the various alternatives, yet no objective means of ranking suite efficacy could be developed. Alternatives are presented in sequential order, but without implied ranking with respect to expected outcome. All of the alternatives were considered by the public advisory committee. Two of the five alternatives received support from some members of the public advisory committee. Alternatives supported by members of the advisory committee are discussed below in greater detail.

Table 45. Summary of the primary features that differ among the five alternative suites of management strategies developed for the Rogue population stratum. Complete lists of specific management actions associated with each alternative can be found in **APPENDIX G**.

Rogue 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

Rogue 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%

Rogue 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

Rogue 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

Rogue 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

Rogue Alternative 4: This alternative was preferred by two members of the public advisory committee and by ODFW. The alternative incorporates various elements of input received from the entire advisory committee during the course of plan development. Primary features of the alternative, which are common to most of the other alternatives, include (1) support for habitat restoration, maintenance and habitat enhancement programs, (2) development and support of programs designed to decrease introductions of non-native species, (3) decrease rates of predation by introduced species, (4) management of recreational and commercial fisheries to sustain population productivity, and (5) management of hatchery fish to minimize the risk of genetic changes among naturally produced fish. In general terms, alternative 4 differs from the other alternatives by (1) less emphasis on the use of hatchery fish, (2) more emphasis on NP CHS recovery as compared to NP CHF enhancement, (3) less emphasis on the control of native predators, and (5) more emphasis on simplified regulations for anglers. Unless otherwise stated, all actions outlined in the following section are directed to ODFW.

It is very likely that adoption of this alternative will result in the maintenance of desired status for NP CHF in the Rogue stratum. The current status of the Rogue stratum of the SMU mostly exceeds desired status, primarily for three reasons: (1) increased NP CHF production that results from flow augmentation from the two USACE reservoirs that operate in the Rogue River Basin, (2) fishery impact rates are lower than those estimated for MSY, and (3) hatchery fish compose a very low proportion of the natural spawners.

Specific management actions are listed for each alternative suite of management strategies. Some brief explanatory information is provided where it may not be clear how the action item directly links with the management strategy. Further information on proposed actions can be found in **APPENDIX G**.

Specific actions are listed within each management strategy. Some brief explanatory information is provided where it may be not clear how the action item directly links with the management strategy. Further information on proposed actions can be found in **APPENDIX G**.

<u>Management Strategy 4.1.</u> Support habitat restoration, maintenance, and enhancement programs to ensure that aquatic and terrestrial habitat is managed to maintain productive populations of naturally produced fall Chinook salmon.

This management strategy addresses the quantity and quality of NP CHF habitat. Habitat features that appear to be primary factors limiting the production of NP CHF in the Rogue River Basin include (1) water temperature in the Rogue River during summer, (2) intensity of peak flow events during the period of egg and alevin incubation in the gravel, and (3) low flows in tributary streams during the upstream migration of adults (*see* **Habitat Volume**, page 46 and **Habitat Quality,** page 52). As the operation of both USACE dams in the Rogue River Basin affect the first two limiting factors and Applegate Dam affects the third limiting factor, many of the actions embedded in this management strategy relate to development of ODFW recommendations for reservoir management strategies. Only some actions are directed at operation of both USACE dams because NP CHS, rather than NP CHF, spawn in downstream areas proximal to William Jess Dam.

Assumptions and Rationale

1. As outlined by the Congress of the United States of America, enhancement of fish resources in downstream areas is a primary authorized purpose by which Lost Creek and Applegate lakes should be managed by the USACE.

2. As outlined by the Congress of the United States of America, fish enhancement, irrigation supply, and municipal and industrial supply are primary authorized purposes of equal priority, and are of lower priority only during those operations designed to prevent flooding in downstream areas.
3. Findings that resulted from long-term fish research projects, funded by the USACE, provide reliable predictions of the impacts of reservoir operations on NP CHF produced in areas downstream of Lost Creek and Applegate lakes.
4. Reservoir management strategies will continue to be refined as additional information becomes available.
5. Gravel quality and quantity will decrease in areas downstream of Applegate Lake as a result of gravel being trapped at the upstream end of the reservoir.
6. Quality of riparian zones along the Rogue River will continue to decline as human population numbers increase in the general area.
7. Intensity of peak flow events during winter will continue to increase as continued land development adds impervious surfaces.

Implementation Actions

Action 1.1. 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 (Item A1(a) in **APPENDIX G)**. The purpose of this action is to increase egg-fry survival rates in downstream areas and to minimize rates of spawning gravel loss below the dams.

Action 1.2. ODFW annually recommends that the USACE release the coldest water possible from Applegate Lake during November through February (Item A2(a) in **APPENDIX G)**. The purpose of this action is to minimize the early emergence of fry from the gravel in order to increase fry survival rates.

Action 1.3. 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 (Item A2(b) in **APPENDIX G)**. The purpose of this action is to determine optimal use of the limited supply of cold hypolimnetic storage during years of varied water yield.

Action 1.4. ODFW annually recommends that the USACE manage reservoir releases at Applegate Lake to optimize CHF spawning distribution in the Applegate River (Item A3(b) in **APPENDIX G)**.

Action 1.5. ODFW annually recommends that the USACE manage reservoir releases at Applegate Lake in order to minimize the number of CHF redds that would be dewatered during the season of reservoir filling (Item A4(a) in **APPENDIX G)**.

Action 1.6. 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 (Item A5(a) in **APPENDIX G)**. The purpose of this action is to increase the survival rates of NP CHF fry.

Action 1.7. ODFW annually recommends that the USACE manage reservoir releases from Lost Creek Lake to decrease disease-related losses of adult CHF, with CHF being a secondary priority as compared to CHS (Item A6(b) in **APPENDIX G)**. The purpose of this action is to protect CHF from disease losses, while recognizing that restoration of NP CHS is of higher priority.

Action 1.8. During those years when disease-related losses of adult CHF are forecasted to reach or exceed 40%, ODFW recommends the additional release of reservoir storage from Lost Creek Lake (Item A6(d) in **APPENDIX G)**. This additional water would be used to decrease CHF mortality rates. The purpose of this action is to minimize CHF disease losses during years of low water yield.

Action 1.9. 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 CHF (Item A7(a) in **APPENDIX G)**. The purpose of this action is to increase the survival rates of juvenile NP CHF rearing in the Rogue River.

Action 1.10. 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 (Item A9(a) in **APPENDIX G)**. The purpose of this action is to mitigate for the loss of spawning gravel resulting from construction of Applegate Dam.

Action 1.11. ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat (Item A7(c) in **APPENDIX G)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.12. ODFW initiates or supports efforts designed to restore mature riparian habitat (Item A7(d) in **APPENDIX G)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.13. ODFW initiates or supports efforts designed to promote the natural development of mature riparian habitat in natural bar or floodplain areas (Item A7(e) in **APPENDIX G)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.14. 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 (Item A9(b), among others, in **APPENDIX G)**. The purpose of this action is to minimize deleterious effects of development on aquatic habitat and riparian zones.

Action 1.15. ODFW supports local government's participation in Oregon's Phase II Municipal Stormwater Program; which is administered through ODEQ (Item A10(b) in **APPENDIX G)**. The purpose of this action is to help reduce (1) the intensity of peak flow events and (2) the amount of stormwater pollutants discharged into streams.

Action 1.16. 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 (Item A8(a) in **APPENDIX G)**. The purpose of this action is to increase the amount of spawning habitat accessible to adult NP CHF.

Action 1.17. ODFW continues to support improvements at diversion sites in order to increase the survival rates of juvenile salmonids (Item A11(a) in **APPENDIX G)**. The purpose of this action is to increase the survival rates of juvenile NP CHF.

Management Strategy 4.2. Develop and support programs designed to decrease introductions of non-native species into areas inhabited by naturally produced fall Chinook salmon.

This management strategy addresses the chance that non-native species could become established in the Rogue River Basin. Introduced species commonly have deleterious effects on native species and can possibly result in becoming a primary limiting factor for NP CHF.

Implementation Actions

Action 2.1. ODFW initiates or supports efforts designed to decrease the chance that non-native species could be introduced into streams and estuaries (Item A12(g) in **APPENDIX G)**.

Management Strategy 4.3. Decrease rates of predation by introduced species on naturally produced fall Chinook salmon.

This management strategy addresses Umpqua pikeminnow predation on juvenile NP CHF. Umpqua pikeminnow were introduced in the Rogue River Basin during the late 1970s and have been documented as a major predator of juvenile NP CHF.

Implementation Actions

Action 3.1. ODFW encourages fishing-related mortality for non-native fish (Umpqua pikeminnows) (Item A12(a) in **APPENDIX G)**.

Action 3.2. ODFW annually recommends that the USACE manage releases from Lost Creek Lake to increase survival of juvenile NP CHF by releasing, during the middle of summer, reservoir storage that is not needed to decrease disease-related losses of adult CHS and adult CHF (Item A12(b) in **APPENDIX G)**. The purpose of this action is to decrease water temperatures in areas inhabited by Umpqua pikeminnows and juvenile NP CHF. Lower water temperatures in downstream areas result in fewer predation losses because of decreases in pikeminnow metabolic rates and growth rates.

Management Strategy 4.4. Manage recreational and commercial fisheries to sustain productivity for all populations of naturally produced fall Chinook salmon, and to provide harvest opportunities for recreational and commercial fishers.

This management strategy addresses fishery impact rates on NP CHF produced in the Rogue River Basin. Fishery impacts on NP CHF are not a primary limiting factor, except during years of low returns to freshwater.

Assumptions and Rationale

1. Age-specific ocean harvest rates during the federally managed seasons do not differ between CHF of Klamath River Basin origin and CHF populations in the Rogue stratum.
2. Spawner abundance goals, harvest rate goals, and harvest allocations established for CHF in the Klamath River Basin will remain unchanged over the lifetime of this plan.
3. Future rates of ocean harvest will be 15-30% for completed broods of NP CHF.
4. It is in the public interest to minimize the complexity of regulations for freshwater fisheries.

Implementation Actions

Action 4.1. ODFW employs regional (zone) freshwater fishery regulations during those years when NP CHF spawning escapement is forecasted to meet or exceed spawner escapement goals related to conservation criteria for single or aggregate populations (Item A14(b) in **APPENDIX G)**. The purpose of this action is to minimize the complexity of freshwater fishery regulations.

Action 4.2. During years when freshwater returns are forecasted to trigger conservation criteria, ODFW proposes freshwater fishery regulations to ensure, if possible, NP CHF spawning escapement exceeds conservation criteria (Item A14(c) in **APPENDIX G)**. The purpose of this action is to ensure sustained NP CHF production through time.

Action 4.3. 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 (Item A13(a) in **APPENDIX G)**. Fisheries operating (3-200 miles offshore) in this area are managed by NOAA Fisheries, with input from the Pacific Fisheries Management Council. The purpose of this action is to ensure sustained NP CHF production through time.

Action 4.4 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 (Item A13(b) in **APPENDIX G)**. The purpose of this action is to ensure sustained NP CHF production through time.

Management Strategy 4.5. Manage fall Chinook salmon of hatchery origin to minimize the risk of genetic changes among naturally produced fish.

This management strategy addresses the potential risk of hatchery fish to NP CHF produced in the Rogue River Basin. The impact of hatchery fish is not a primary factor that currently limits NP CHF production.

Assumptions and Rationale

1. Reductions in the proportion of hatchery fish among natural spawners decrease the risk of genetic impacts on NP CHF.

2. Hatchery fish account for less than 1% of the CHF that spawn in all population areas, except for the Lower Rogue.
3. Changes in broodstock age composition at Indian Creek Hatchery are warranted to produce CHF that mature at more natural ages.
4. Hatchery production will be consistent with the Fish Hatchery Management Policy of ODFW.

Implementation Actions

Action 5.1 Manage CHF in the Upper Rogue, Middle Rogue, Applegate, and Illinois population areas for NP CHF (Item D1(a) in **APPENDIX G)**. The purpose of this action is to negate potential impacts of hatchery fish within populations that are harvested at rates significantly less than those needed for MSY.

Action 5.2 If desired status is not attained for run or spawner composition, ODFW decreases the number of juvenile CHF released from Indian Creek Hatchery until attainment of desired status (Item E1(a) in **APPENDIX G)**. The purpose of this action is to negate potential impacts of hatchery fish within the Lower Rogue population area.

Action 5.3 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 (Item E1(b) in **APPENDIX G)**. The purpose of this action is to produce hatchery fish that mature at more natural ages.

Action 5.4 ODFW continues to implement the Hatchery and Genetic Management Plan completed for Indian Creek Hatchery in 2006 (Item E1(c) in **APPENDIX G)**. The purpose of this action is to maintain the genetic integrity of hatchery fish; some of which spawn naturally in the Lower Rogue population area.

Rogue Alternative 5: This alternative was preferred by seven members of the public advisory committee. The alternative incorporates various elements of input received from the entire advisory committee during the course of plan development. Primary features of the alternative include (1) support for habitat restoration, maintenance and habitat enhancement programs, (2) development and support of programs designed to decrease introductions of non-native species, (3) decreased rates of predation by native and introduced species, (4) management of recreational and commercial fisheries to sustain population productivity, and (5) management of hatchery fish to minimize the risk of genetic changes among naturally produced fish. Unless otherwise stated, all actions outlined in the following section are directed to ODFW.

It is very likely that adoption of this alternative will result in the maintenance of desired status. The current status of the Rogue stratum of the SMU mostly exceeds desired status, primarily because of three factors: (1) increased NP CHF production that results from flow augmentation from the two USACE reservoirs that operate in the Rogue River Basin, (2) fishery impact rates are lower than those estimated for MSY, and (3) hatchery fish compose a very low proportion of the natural spawners.

This alternative is very similar to Alternative 4. The two alternatives differ only in relation to one management strategy and two allied actions that relate to native predators of juvenile and adult NP CHF. Some brief explanatory information is provided where it may be not clear how the action item directly links with the management strategy. Further information on proposed actions can be found in **APPENDIX G**.

Management Strategy 5.1. **Support habitat restoration, maintenance and enhancement programs to ensure that aquatic and terrestrial habitat is managed to maintain productive populations of naturally produced fall Chinook salmon.** This strategy, and allied actions, is the same as **Management Strategy 4.1**.

Management Strategy 5.2. **Develop and support programs designed to decrease introductions of non-native species into areas inhabited by naturally produced fall Chinook salmon.** This strategy, and allied actions, is the same as **Management Strategy 4.2**.

Management Strategy 5.3. **Decrease rates of predation on naturally produced fall Chinook salmon.**

This management strategy addresses predation on juvenile and adult NP CHF. Reductions in predation rates on juvenile NP CHF will result in greater benefits as compared to reductions in predation losses of adult NP CHF because spawner escapements usually exceed those projected to result in MSY.

Implementation Actions

Action 3.1. ODFW encourages fishing-related mortality for non-native fish (Umpqua pikeminnows). This action is the same as **Action 3.1.** in **Management Strategy 4.3.**

Action 3.2. ODFW annually recommends that the USACE manage releases from Lost Creek Lake to increase survival of juvenile NP CHF by releasing, during the middle of summer, reservoir storage that is not needed to decrease disease-related losses of adult CHS and adult CHF. This action is the same as **Action 3.2.** in **Management Strategy 4.3.**

Action 3.3. ODFW initiates a program to decrease cormorant densities in the Rogue River estuary (Item A12(d) in **APPENDIX G)**. The purpose of this action is to decrease predation mortality on juvenile NP CHF through reductions in the numbers of cormorants that forage in the estuary.

Action 3.4. ODFW supports a program designed to harass pinnipeds in the Rogue River estuary (Item A12(e) in **APPENDIX G)**. The purpose of this action is to decrease predation mortality on juvenile and adult NP CHF through reductions in the numbers of pinnipeds that forage in the estuary.

Management Strategy 5.4. **Manage recreational and commercial fisheries to sustain productivity for all populations of naturally produced fall Chinook salmon.** This strategy, and allied actions, is the same as **Management Strategy 4.4**.

Management Strategy 5.5. **Manage fall Chinook salmon of hatchery origin to minimize the risk of genetic changes among naturally produced fish.** This strategy, and allied actions, is the same as **Management Strategy 4.5**.

Coastal Stratum

Based on the limiting factors assessment, the primary factors that appear to limit, or may limit in the future, attainment of desired status for NP CHF populations in the coastal stratum include: (1) volume of juvenile rearing habitat in streams and estuaries, (2) water temperature in streams and in the estuaries during summer, (3) habitat quality in the estuaries during summer, (4) brood harvest rates when population abundances are lower than S_{MSY}, and (5) low spawning escapement (*see* **Summary of Limiting Factors Assessment - Coastal Stratum:**, page 106). All of these factors can be managed to some degree by natural resource agencies. Initial attempts to develop management alternatives focused on options related to addressing the primary limiting factors.

This approach resulted in the development of six alternative suites of management strategies for the coastal population stratum (Table 46). Probability of attainment, or maintenance, of desired status varies considerably among the various alternatives, yet no objective means of ranking suite efficacy could be developed. As a result, the alternatives are presented in sequential order, without any implications in relation to a ranking of expected outcome. All of the alternatives

Table 46. Summary of the primary features that compose the five alternative suites of management strategies developed for the Rogue population stratum. Individual management actions associated with each alternative can be found in **APPENDIX H**.

Coastal 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

Coastal 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

Coastal 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

Coastal 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

Coastal 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

Coastal 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

were considered by the public advisory committee. Two of the six alternatives received support from some members of the public advisory committee. Supported alternatives are discussed below in greater detail.

Coastal Alternative 5: This alternative was preferred by seven members of the public advisory committee and by ODFW. The alternative incorporates various elements of input received from the entire advisory committee during the course of plan development. Primary features of the alternative include (1) support for habitat restoration, maintenance, and habitat enhancement programs, (2) development and support of programs designed to decrease introductions of non-native species, (3) management of recreational and commercial fisheries to sustain population productivity, and (4) management of hatchery fish to minimize the risk of genetic changes among naturally produced fish. Unless otherwise stated, all actions outlined in the following section are directed to ODFW.

It is very likely that adoption of this alternative will result in the maintenance of desired status in the coastal stratum. The current status of the coastal stratum of the SMU comes close to meeting desired status; primarily because of three factors: (1) low rates of water withdrawals from streams, (2) fishery impact rates are lower than those estimated for attainment of MSY for most of the populations, and (3) hatchery fish compose a very low proportion of the natural spawners in most population areas.

Specific actions are listed within each management strategy. Some brief explanatory information is provided where it may not be clear how the action item directly links with the management strategy. Further information on proposed actions can be found in **APPENDIX H**.

Management Strategy 5.1. Support habitat restoration, maintenance, and enhancement programs to ensure that aquatic and terrestrial habitat is managed to maintain productive populations of naturally produced fall Chinook salmon.

This management strategy addresses the quantity and quality of NP CHF habitat. Habitat features that appear to be primary factors that limit the production of NP CHF within the coastal stratum include (1) water temperature in steams during summer, (2) estuary volumes during summer, and (3) water quality in estuaries during summer (*see* **Habitat Volume**, page 72 and **Habitat Quality,** page 77).

Assumptions and Rationale

1. Quality of riparian zones along streams will continue to decline as human population numbers increase in the general area.
2. The volume of large wood material in streams and estuaries decreased significantly as a result of development, with an associated loss of fish hiding cover and substrates for macroinvertebrate production.
3. Below optimum water quality in estuaries during summer limits the volume of habitat for juveniles and causes juveniles to grow at slower rates.

Implementation Actions

Action 1.1. 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 (Item A1(a) in **APPENDIX H)**. The purpose of this action is to increase the amount of rearing habitat for juvenile NP CHF.

Action 1.2. 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 (Item A1(g), among others, in **APPENDIX H)**. The purpose of this action is to minimize deleterious effects of development on aquatic habitat and riparian zones.

Action 1.3. ODFW develops an outreach effort designed to encourage maintenance of mature riparian habitat (Item A3(a), among others, in **APPENDIX H)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.4. ODFW initiates or supports efforts designed to restore mature riparian habitat (Items A3(b)+A7(d) in **APPENDIX H)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.5. ODFW initiates or supports efforts designed to promote the natural development of mature riparian habitat in natural bar or floodplain areas (Items A3(c)+A7(e) in **APPENDIX H)**. The purpose of this action is to improve juvenile NP CHF habitat by restoring the benefits associated with mature riparian zones (shading to reduce water temperature, streambank stability, creation of undercut banks, and the eventual production of instream large wood).

Action 1.6. ODFW files for increased instream flow rights for those population areas with significant amounts of unappropriated stream flow during summer (Item A1(f) in **APPENDIX H)**. The purpose of this action is to increase the amount of rearing habitat for juvenile NP CHF.

Action 1.7. ODFW initiates or supports efforts to increase summer flow through the purchase, lease, transfer, or cancellation of water rights (Item A1(h) in **APPENDIX H)**. The purpose of this action is to increase the amount of rearing habitat for juvenile NP CHF.

Action 1.8. ODFW initiates or supports efforts to limit further appropriation of surface water from areas where instream water rights are not met (Item A1(i) in **APPENDIX H)**. The purpose of this action is to maintain the amount of rearing habitat for juvenile NP CHF.

Action 1.9. ODFW initiates or supports the restoration of filled, diked, or otherwise impacted areas in estuaries in order to increase the area and depth of accessible wetted areas (Item A2(a) in **APPENDIX H)**. The purpose of this action is to increase the amount of rearing habitat for juvenile NP CHF.

Action 1.10. 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 (Item A6(d) in **APPENDIX H)**. The purpose of this action is to decrease predation losses of NP CHF.

Action 1.11. ODFW initiates or supports efforts designed to enhance the volume of macroinvertebrate habitat through the installation of large woody debris in streams and estuaries

(Item A5(d) in **APPENDIX H)**. The purpose of this action is to increase the size of juvenile NP CHF during stream residence.

Action 1.12. ODFW initiates or supports efforts designed to restore the amount of hiding cover for juvenile CHF resident in estuaries through the seasonal installation of artificial structures (Item A6(e) in **APPENDIX H)**. The purpose of this action is to decrease predation losses of NP CHF.

Action 1.13. ODFW initiates or supports efforts designed to enhance the volume of macroinvertebrate habitat through the installation of artificial structures in estuaries (Item A5(e) in **APPENDIX H)**. The purpose of this action is to increase the size of juvenile NP CHF during estuary residence.

Action 1.14. ODFW develops a program designed to enhance primary and secondary production in streams that meet Oregon Water Quality standards related to nutrient levels (Item A5(b) in **APPENDIX H)**. The purpose of this action is to increase the size of juvenile NP CHF during stream residence.

Action 1.15. ODFW initiates or supports efforts designed to decrease the amount of phosphorus and nitrogen that eventually enter estuaries (Item A4(a) in **APPENDIX H)**. The purpose of this action is to increase the amount of juvenile NP CHF rearing habitat through improvements to estuary water quality.

Action 1.16. ODFW initiates or supports efforts designed to increase levels of dissolved oxygen in estuaries found to be oxygen deficient (Item A4(d) in **APPENDIX H)**. The purpose of this action is to increase the amount of juvenile NP CHF rearing habitat through improvements to estuary water quality.

Action 1.17. ODFW initiates or supports efforts designed to control European beach grass in areas proximal to estuary mouths (Item A1(c) in **APPENDIX H)**. The purpose of this action is to increase the amount of juvenile NP CHF rearing habitat through improvements to estuary water quality as a result of increased tidal exchange.

Management Strategy 5.2. Develop and support programs designed to decrease introductions of non-native species into areas inhabited by naturally produced fall Chinook salmon.

This management strategy addresses the chance that non-native species could become established in the coastal population stratum. Introduced species commonly have deleterious effects on native species and can possibly result in becoming a primary limiting factor for NP CHF.

Implementation Actions

Action 2.1. ODFW initiates or supports efforts designed to decrease the chance that non-native species could be introduced into streams and estuaries (Items A5(c)+A6(a) in **APPENDIX H)**.

Management Strategy 5.3. Manage recreational and commercial fisheries to sustain productivity for all populations of naturally produced fall Chinook salmon, and to provide harvest opportunities for recreational and commercial fishers.

This management strategy addresses fishery impact rates on NP CHF produced in the coastal population stratum. Fishery impacts on NP CHF are not a primary limiting factor, except during years of low returns to freshwater.

Assumptions and Rationale

1. Age-specific ocean harvest rates during the federally managed seasons do not differ between CHF of Klamath River Basin origin and CHF populations in the coastal stratum.
2. Spawner abundance goals, harvest rate goals, and harvest allocations established for CHF in the Klamath River Basin will remain unchanged over the lifetime of this plan.
3. Future rates of ocean harvest during the federally managed seasons will be about 15-30% for completed broods of NP CHF.
4. It is in the public interest to minimize the complexity of regulations for freshwater fisheries.

Implementation Actions

Action 3.1. ODFW employs regional (zone) freshwater fishery 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, Chetco excepted (Item A8(b) in **APPENDIX H)**. Freshwater fishery regulations for the Chetco could differ based on the outcome of Action 3.8 and water quality concerns during October. The purpose of this action is to minimize the complexity of freshwater fishery regulations.

Action 3.2. During years when freshwater returns are forecasted to trigger conservation criteria for any single NP CHF population, ODFW proposes freshwater fishery regulations to ensure, if possible, NP CHF spawning escapement exceeds conservation criteria (Item A8(c) in **APPENDIX H)**. The purpose of this action is to ensure sustained NP CHF production through time.

Action 3.3. 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. The purpose of this action is to ensure sustained NP CHF production through time (Item A7(a) in **APPENDIX H)**.

Action 3.4. During years when freshwater returns are forecasted to trigger conservation criteria within the Chetco population area, ODFW proposes additional harvest restrictions inside the three mile coastal zone during the period of harvest covered by regulations adopted by NOAA. The purpose of this action is to ensure sustained NP CHF production through time (Item A7(b) in **APPENDIX H)**.

Action 3.5. 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 S_{MSY}s for proximal populations of NP CHF and (2) provide additional harvest opportunities when forecasted spawner escapements exceed estimates of those needed for MSY. The purpose of this action is to take advantage of harvest opportunities during periods of high abundance (Item A7(c) in **APPENDIX H)**.

Action 3.6. 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 (Item A7(d) in **APPENDIX H)**. The purpose of this action is to ensure sustained NP CHF production through time.

Action 3.7. During years when freshwater returns are forecasted to trigger conservation criteria for any single NP CHF population, ODFW requests increased enforcement of fishery regulations (Item A8(d) in **APPENDIX H)**.

Action 3.8. 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 (Items A7(e)+A8(e) in **APPENDIX H)**. The purpose of this action is to develop management guidance by which to allocate allowable harvest.

Management Strategy 5.4. Manage fall Chinook salmon of hatchery origin to minimize the risk of genetic changes among naturally produced fish.

This management strategy addresses the potential risk of hatchery fish to NP CHF produced in the coastal population stratum. The impact of hatchery fish is not a primary factor that currently limits NP CHF production.

Assumptions and Rationale

1. Reductions in the proportion of hatchery fish among natural spawners decrease the risk of genetic impacts on NP CHF.
2. Hatchery fish account for less than 5% of the CHF that spawn in all population areas, except for the Chetco.
3. Changes in broodstock composition for the Chetco CHF program are warranted to produce CHF that mature at more natural ages.

Implementation Actions

Action 4.1. Manage for naturally produced CHF in the Hunter, Pistol, and Winchuck population areas (Items D1(b)+E1(a) in **APPENDIX H)**. Releases of hatchery fish in these population areas would occur only in relation to (1) educational purposes or (2) a short-term recovery action in the case of a catastrophic NP CHF mortality event. The purpose of this action is to ensure that small populations remain unaffected by naturally spawning hatchery fish.

Action 4.2. If desired status is not attained in either the Chetco or Winchuck population areas, ODFW decreases the number of juvenile CHF released in the Chetco River until attainment of desired status (Items C1(a)+D1(a) in **APPENDIX H)**.

Action 4.3. ODFW shall establish an acclimation and collection facility designed to capture returning adult CHF of hatchery origin in the Chetco River Basin (Item C1(b) in **APPENDIX H)**. The purpose of this action is to decrease the proportion of hatchery fish among natural spawners.

Action 4.4. Release hatchery CHF smolts after September. The purpose of this action is to (1) decrease competition with juvenile NP CHF and (2) avoid attraction of animals that prey on juvenile NP CHF (Item A6(c) in **APPENDIX H)**.

Action 4.5. 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. The purpose of this action is to produce hatchery fish that mature at more natural ages (Item C1(c) in **APPENDIX H)**.

Action 4.6. ODFW continues to implement the Hatchery and Genetic Management Plan completed in 2006 for the CHF Chetco program (Item E1(c) in **APPENDIX H)**. The purpose of this action is to maintain the genetic integrity of hatchery fish, some of which spawn naturally in the Chetco population area.

Alternative 6

This alternative was preferred by two members of the public advisory committee. The alternative incorporates various elements of input received from the entire advisory committee during the course of plan development. Primary features of the alternative include (1) support for habitat restoration, maintenance, and habitat enhancement programs, (2) development and support of programs designed to decrease introductions of non-native species, (3) management of recreational and commercial fisheries to sustain population productivity, and (4) management of hatchery fish to minimize the risk of genetic changes among naturally produced fish. Unless otherwise stated, all actions outlined in the following section are directed to ODFW.

There is a high degree of certainty that adoption of this alternative will result in the maintenance of desired status. The current status of the coastal stratum of the SMU is close to meeting desired status; primarily because of three factors: (1) low rates of water withdrawals from streams, (2) fishery impact rates are lower than those estimated for MSY in most population areas, and (3) hatchery fish compose a very low proportion of the natural spawners in most population areas.

This alternative is very similar to Alternative 5. Alternative 6 includes all of the management strategies described in Alternative 5 along with one additional management strategy; which follows below.

Management Strategy 6.1. Support habitat restoration, maintenance and enhancement programs to ensure that aquatic and terrestrial habitat is managed to maintain productive populations of naturally produced fall Chinook salmon. This strategy, and allied actions, is the same as **Management Strategy 5.1.**

Management Strategy 6.2. Develop and support programs designed to decrease introductions of non-native species into areas inhabited by naturally produced fall Chinook salmon. This strategy, and allied actions, is the same as **Management Strategy 5.2.**

Management Strategy 6.3. Manage recreational and commercial fisheries to sustain productivity for all populations of naturally produced fall Chinook salmon. This strategy, and allied actions, is the same as **Management Strategy 5.3.**

Management Strategy 6.4. Manage fall Chinook salmon of hatchery origin to minimize the risk of genetic changes among naturally produced fish. This strategy, and allied actions, is the same as **Management Strategy 5.4.**, except that Action 4.2 is directed at only the Chetco population area (Winchuck population area was deleted from the action).

Action 4.2. If desired status is not attained in the Chetco population area, ODFW decreases the number of juvenile CHF released in the Chetco River until attainment of desired status (Item D1(a) in **APPENDIX H)**.

Management Strategy 6.5. Ensure complete access of fall Chinook salmon to stream habitat capable of producing full sized smolts.

This management strategy addresses partial migration barriers that sporadically or periodically block the upstream migration of adult NP CHF into areas capable of producing full sized NP CHF smolts. ODFW staff is currently aware of only one instance, in the coastal stratum, where a natural stream feature appears to periodically block access to a significant amount of spawning and rearing habitat.

Assumptions and Rationale

1. A cascade located at about river mile 2 on the South Fork of the Chetco River appears to periodically block about 7 miles of NP CHF habitat in upstream areas.
2. Flows during late spring and summer are sufficient to support the production of full sized NP CHF smolts.
3. Landowner permission can be obtained to modify the cascade to allow for unrestricted upstream passage of adult CHF.
4. Modifications of natural barriers are advisable to compensate for negative impacts of development on NP CHF habitat (anthropogenic factors).
5. Natural barriers can be modified to allow passage of native migratory fish if deemed advisable by the Oregon Fish and Wildlife Commission (ORS 509.630).

Action 5.1. ODFW initiates or supports the modification of natural barriers that periodically limit the upstream migration of adult CHF (Item A1(c) in **APPENDIX H)**. The purpose of this action is to increase the amount of rearing habitat for older juvenile NP CHF.

CRITERIA INDICATING DETERIORATION IN STATUS

As outlined in the Native Fish Conservation Policy, measurable criteria are needed as indicators of a significant deterioration in SMU status and are hereafter termed “conservation criteria”. Each criterion must be based on some measured (monitored) attribute of population status.

A number of potential criteria were considered as candidate indicators of status deterioration of NP CHF populations in the Rogue SMU. Of primary importance was the identification of conservation criteria that would ensure maintenance of genetic diversity, population productivity, and historical life history attributes. Development of criteria that directly interface with elements included in the desired status statement (*see* **DESIRED BIOLOGICAL STATUS**, page 106) is advantageous because these attributes were already identified as those primary indicators of population status that can be effectively monitored through time. In addition, consideration was given to the length of time that provided an effective period by which to judge whether significant deterioration may have occurred. A three year period of coverage was considered to be most appropriate for conservation criteria related to NP CHF life history and spawner composition. A one year period of coverage was considered to be most appropriate for juvenile NP CHF abundance in the Winchuck River because this metric directly measures the production of potential NP CHF recruits. Selections of these two aforementioned periods of conservation coverage were based on best judgment, as scientific guidance related to this matter is lacking. In contrast, there is some information that helped guide the selection of conservation criteria related to NP CHF spawning escapement.

Subpart D of the federal Magnuson-Stevens Act includes National Standard 1 (§ 600.310). This standard describes conservation and management measures designed to prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery managed by the federal government. Status determination criteria to determine overfished stocks are to be based on minimum stock size thresholds and must be expressed in terms of spawning biomass or other measure of reproductive potential, and should equal whichever of the following is greater: one-half (50%) of the spawning stock needed to maintain MSY, or the minimum stock size at which rebuilding to attain MSY would be expected to occur within 10 years.

In 2011, the Pacific Fisheries Management Council (PFMC) adopted Amendment 16 to the Pacific Coast Salmon Plan. Included in Amendment 16 are status determination criteria related to minimum stock size thresholds (MSST) and these criteria options functionally serve the same purpose as conservation criteria to be included in the CHF conservation plan for the Rogue SMU (Ad Hoc Salmon Amendment Committee 2011). ODFW agrees with the Ad Hoc Salmon Amendment Committee (2011) conclusion that definition of MSST as 0.5* S_{MSY} is appropriate because salmon populations are relatively productive compared to other managed fish species. Consequently, this guidance was used to identify appropriate conservation criteria for NP CHF spawning escapements in the Rogue SMU.

Population models developed for the independent populations, and the Rogue aggregate populations, generated estimates of S_{MSY} (*see* **Spawner Abundance**, page 60 and **Spawner Abundance**, page 88). To account for model uncertainty associated with modeled estimates of MSY, modeled estimates of S_{MSY} were bootstrapped by re-sampling the spawner and recruit data 1000 times and refitting the best recruitment model. The upper 75th percentiles of these bootstrapped estimates were chosen as the most appropriate metrics for the numerical component of conservation criteria for NP CHF spawner escapements (Table 47). This approach is more completely described in **APPENDIX F**.

Table 47. Model point estimates, and bootstrap estimates of the 75th percentile, for the number of spawners estimated for maximum sustained yield within independent populations of naturally produced fall Chinook salmon in the Species Management Unit. The table also conveys a rounded value considered for conservation criteria (50% of the spawners estimated for maximum sustained yield). Values included in the table reflect estimates generated from population models that included smolt survival rates and summer flow as environmental covariates. No reliable model could be developed for the Lower Rogue population.

	S_{MSY} estimates		Value considered
Population	Point estimate	75th percentile	for criterion
Rogue Aggregate	34,992	36,880	18,400
Hunter	399	421	210
Pistol	940	1,067	540
Chetco	2,730	2,879	1,440
Winchuck	566	598	300

Conservation criteria for spawner escapements should take into account factors other than solely metrics associated with stock-recruitment relationships. Small numbers of spawners can lead to a reduction in genetic diversity among hatchery programs (Brannon et al. 2004). ODFW guidelines have called for at least 300 fish to be spawned annually within hatchery programs so as to reduce the risk of random loss of genetic variation (Chilcote et al. 1992). Loss of genetic diversity is also a possibility within wild salmon populations when few fish successfully spawn. Based on this concern, it was judged prudent, by the public advisory committee and by ODFW, to select a numerical conservation value for spawner escapement in the Hunter population of no less than 300 age 3-6 NP CHF; as compared to the population model guidance of 210 spawners (Table 47).

In addition, no satisfactory stock-recruitment model could be developed for the Lower Rogue population. Consequently, the quantitative characterization of this population remains uncertain and this uncertainty needs to be addressed as additional data becomes available (*see* **Monitoring Needs**, page 139). As a conservation status criterion is needed for spawner escapement, the advisory committee and ODFW examined a truncated parent-progeny plot for the Lower Rogue population. This plot appears to show substantial smolt production at escapements between 1,000 and 2,000 spawners, with a notable drop in productivity at escapements below 1,000 spawners (Figure 57). As a result, the advisory committee and ODFW concluded that the conservation status criterion should be at least 1,500 age 3-6 spawners.

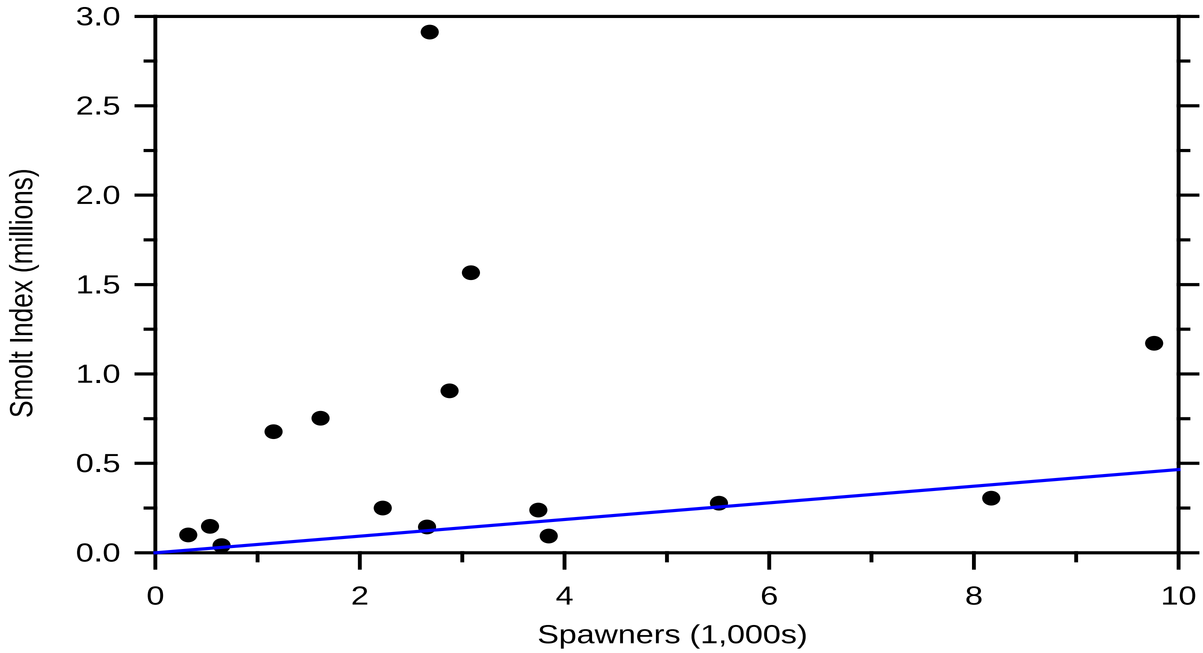

Figure 57. Annual abundance indexes of naturally produced fall Chinook salmon smolts plotted on the number of age 3-6 parents that spawned in the Lower Rogue population area, for those years when less than 10,000 parents spawned. The dark blue line represents replacement (recruits = spawners).

A temporal component is also needed within any conservation criteria promulgated for the management of fish populations. Temporal coverage for conservation criteria employed by fish management agencies range between one and three years for Pacific salmon populations. Choice of temporal coverage choices are influenced by the life history of the target salmon stock. As females within the NP CHF populations of the Rogue SMU mature primarily at three ages (age 3-5), temporal periods of 1-3 years were considered, along with estimates of the efficacy of pre-season forecasting. Pre-season forecasts provide fish management agencies with the means to possibly avoid population(s) falling below conservation criteria, as appropriate harvest strategies can be crafted before the onset of annual fishing mortality. The efficacy of a forecasting method is of primary importance because over-predicted stock sizes can result in spawning escapements that fall below conservation criteria. Conversely, under-predicted stock sizes can lead to forgone fishery opportunities.

Methods for pre-season forecasts of NP CHF had to be developed to take into account the estimates of NP CHF abundance developed for this conservation plan (**APPENDIX K)**. The efficacy of developed methods was judged to be of marginal value for a conservation coverage period of one year because of a relatively high rate of forecasting error (**APPENDIX K)**. In contrast, conservation coverage periods of two or three years were more effective and the relative efficacies of pre-season forecasts were dependent on the NP CHF population in question (**APPENDIX K)**. In general, populations sampled more intensively by ODFW, and with freshwater exploitation rates exceeding 5%, were effectively covered by two year conservation criteria. Populations sampled at lower intensities, and with freshwater exploitation rates lower than 5%, were more effectively covered by three year conservation criteria (**APPENDIX K)**. As the choice of a two year, versus a three year, coverage period for conservation criteria remained uncertain, the advisory committee and ODFW, eventually concluded populations subjected to freshwater exploitation rates greater than 5% should be covered by a two year conservation criterion and populations subjected to lower freshwater exploitation rates should be covered by a three year conservation criterion.

The following statement of conservation status criteria for NP CHF populations in the Rogue stratum (Table 48) represents a coordinated product supported by all nine members of the public advisory committee and by ODFW. Similarly, the following statement of conservation status criteria for NP CCHF populations in the coastal stratum (Table 49) represents a coordinated product that was supported by nine advisory committee members (for all conservation status criteria except Chetco River spawner composition) and by ODFW. Two advisory committee members objected to the Chetco River spawner composition conservation criteria of 20% and advocated for a lower proportion.

Table 48. Conservation criteria indicative of a significant deterioration in status for the Rogue stratum of the Species Management Unit.

Aggregate Populations

1. **Abundance:** Passage of naturally produced fall Chinook salmon at Huntley Park averages less than 20,400[a] age 3-6 fish during any two consecutive years.

2. **Age Structure:** Age 5 and age 6 fish compose less than 3% of the naturally produced fall Chinook salmon that pass Huntley Park. This criterion represents a running average over a period of three years.

3. **Run Timing:** Less than 5% of the naturally produced fall Chinook salmon pass Huntley Park during October. This criterion represents a running average over a period of three years.

4. **Run Composition:** Hatchery fish compose more than 10% of the fall Chinook salmon that pass Huntley Park. This criterion represents a running average over a period of three years.

Lower Rogue Population

1. **Abundance:** Spawning escapement of naturally produced fall Chinook salmon averages less than 1,500 age 3-6 fish during any three consecutive years.

2. **Spawner Composition:** Hatchery fish compose more than 15% of the fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

[a] *Equates to 18,400 spawners (average loss of 10% between Huntley Park and spawning).*

Table 49. Conservation criteria indicative of a significant deterioration in status for the coastal stratum of the Species Management Unit.

Hunter Creek Population

1. **Abundance:** Spawning escapement of naturally produced fall Chinook salmon averages less than 300 age 3-6 fish during any three consecutive years.

2. **Spawner Composition:** Hatchery fish compose more than 10% of the fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

Pistol River Population

1. **Abundance:** Spawning escapement of naturally produced fall Chinook salmon averages less than 540 age 3-6 fish during any three consecutive years.

2. **Spawner Composition:** Hatchery fish compose more than 10% of the fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

Chetco River Population

1. **Abundance:** Spawning escapement of naturally produced fall Chinook salmon averages less than 1,440 age 3-6 fish during any two consecutive years.

2. **Age Structure:** Age 5 and age 6 fish compose less than 5% of the naturally produced fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

3. **Spawner Composition:** Hatchery fish compose more than 20% of the fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

Winchuck River Population

1. **Abundance:** Spawning escapement of naturally produced fall Chinook salmon averages less than 300 age 3-6 fish during any two consecutive years.

2. **Juvenile Abundance:** Less than 50,000 naturally produced juvenile fall Chinook salmon migrate downstream past a trap sited just upstream of the South Fork.

3. **Spawner Composition:** Hatchery fish compose more than 15% of the fall Chinook salmon that spawn naturally. This criterion represents a running average over a period of three years.

As described in the Native Fish Conservation Policy, the conservation criteria identified above are intended to trigger modifications to management strategies before the viability of any independent NP CHF population in the Rogue SMU may be in jeopardy. This conservative approach makes it very likely that not only will the entire SMU remain viable through time, but also makes it very likely that all independent populations in the Rogue and coastal population strata will remain viable through time. The conservation criteria were developed with the knowledge that there is a level of uncertainty with some of the analyses that were used to develop the management strategies described in this plan.

As described in the Native Fish Conservation Policy, realization of criteria outlined in Table 48 or Table 49, could trigger a temporary modification of management strategies, or actions, implemented as part of this conservation plan for CHF in the Rogue SMU (*see* **ALTERNATIVE SUITES OF MANAGEMENT STRATEGIES**, page 117). Any temporary modification of strategies, or actions, should depend on which conservation criteria were realized, the current status of the populations, and the projected status of the populations during subsequent years. In addition, temporary modifications to management strategies may be employed when preseason or in-season forecasts indicate there is a good chance that population metrics are projected to fall below conservation criteria. Finally, adaptive management will be employed by ODFW as a means to identify and implement revisions to management actions outlined in this conservation plan (*see* **Adaptive Management**, page 144).

MONITORING, EVALUATION, AND RESEARCH NEEDS

Effectiveness of resource management plans can be determined only if objective measures are developed by which to track and evaluate progress towards attainment of plan goals. Tracking of progress can be accomplished through the development of methods to monitor those SMU attributes relevant to critical components of the plan. As new information becomes available, updated evaluations can better identify (or quantify) the relationships between limiting factors and management strategies employed by the plan. For those management strategies that are critical to plan execution, and that have substantial uncertainty, research projects will be needed to test the assumptions associated with adoption and implementation of specific management strategies. To complete all of the efforts detailed within this section, ODFW will need additional staff, or will need to restructure the priorities of current staff, or will need to arrange for help from other entities. Prioritization of evaluation and research needs will be completed by ODFW after adoption of the final version of this conservation plan, as priorities are dependent upon the adopted suite of management strategies. As the adaptive management process begins with this plan, it is likely that additional monitoring, evaluation and research needs will be identified in future years. The needs listed below are based on knowledge at the time this plan was developed.

Monitoring Needs

In addition to the need to monitor CHF populations in the SMU, there is a diverse array of monitoring needs for physical and chemical parameters of streams and estuaries within the SMU. Generalized monitoring needs for streams throughout the state of Oregon were described by the Oregon Watershed Enhancement Board (2003). The following section outlines those ODFW monitoring efforts needed to (1) track NP CHF population status and SMU status, and (2) track those physical parameters that appear to be primary limiting factors. Additional monitoring efforts may be added during future years if: (1) additional monitoring funds become available and/or (2) criteria for desired or conservation status are modified by the Oregon Fish and Wildlife Commission and/or (3) results from completed research or evaluation projects indicate there is a need or additional monitoring.

Annual Monitoring

Specific monitoring must be conducted annually by ODFW in order to determine population and SMU status in relation to the desired and conservation status statements embedded in this plan. Estimates relevant to annual monitoring needs for independent NP CHF populations in the Rogue stratum include:

1. Number of adult NP CHF that pass Huntley Park.
2. Migration timing of adult NP CHF that pass Huntley Park.
3. Age composition of adult NP CHF that pass Huntley Park.
4. Percent hatchery fish among adult CHF that pass Huntley Park.
5. Number of NP CHF that spawn in the Lower Rogue population area.

6. Percent hatchery fish among CHF that spawn the Lower Rogue population area.

Should additional monitoring funds become available, then the primary need is implementation of monitoring designed to estimate, or index, the number of NP CHF that spawn in each population area of the Rogue Stratum, with the Illinois population being of greatest priority.

Estimates relevant to annual monitoring needs for independent NP CHF populations in the coastal stratum include:

1. Number of NP CHF that spawn in each population area.
2. Age composition of NP CHF that spawn in the Chetco population area.
3. Percent hatchery fish among CHF that spawn in each population area.
4. Number of juvenile NP CHF that migrate downstream in the Winchuck River at RM 2.0.

Weekly Monitoring

Monitoring of river physical parameters and reservoir volume should be conducted multiple times each week by ODFW in order to ensure that releases from Lost Creek and Applegate lakes directly interface with fish management objectives in downstream areas. During rapidly changing conditions (includes forecasted), monitoring should be conducted daily. Specific monitoring to be conducted each week includes:

1. Rate of reduction (ramping rates) in outflows from USACE reservoirs.
2. Outflows from USACE reservoirs.
3. Volume and rate of volume change in USACE reservoirs.
4. Inflow and rate of inflow change for USACE reservoirs.
5. Flow and water temperature of the Rogue River near Agness (USGS gage) during summer.
6. Water temperature at release from Applegate Lake (USGS Copper gage).

Periodic Monitoring

Periodic monitoring is defined as surveys that should be conducted to monitor resources that may change over a span of a number of years or generations of NP CHF. Specific periodic monitoring to be conducted includes:

1. During years when the prespawning mortality rate among adult NP CHF is forecasted to exceed 20% in the Rogue River, ODFW should count adult CHF carcasses in the Rogue River canyon on a bi-weekly basis in order estimate the actual rate of prespawning mortality. Surveys and estimation procedures should follow those described by ODFW (1992).

2. During years when fewer than 10,000 age 3-6 CHF spawn in the Lower Rogue population area, ODFW should monitor the recruitment from those brood years to assess the efficacy of the conservation criterion of at least 1,500 age 3-6 spawners. This effort is advisable because no satisfactory stock-recruitment model could be developed for this population.

3. Assessments of the amount of shade provided by the riparian zone along the Rogue River should be conducted approximately every ten years because water temperature during summer is a primary limiting factor for NP CHF populations in the Rogue River Basin. Possible approaches to this type of monitoring are outlined by the Oregon Watershed Enhancement Board (2004); and a

state of Oregon agency, or a watershed council, should be identified as the entity to be responsible for this effort.

4. Assessments of the amount, distribution, and composition of gravel in spawning areas located between Applegate Dam and the Little Applegate River. This effort should be the responsibility of the USACE, and should be conducted approximately every ten years. Resultant data should be in such a form that it is possible to estimate the habitat capacity for spawning Chinook salmon in this area. Habitat capacity for spawners can be estimated with methods similar to those employed by Beechie et al. (2006).

Evaluation Needs

In contrast to monitoring needs, evaluation needs vary greatly in relation to immediacy of need, frequency of need, and duration of need. However, as with the proposed monitoring, the following evaluations should be conducted to help assess the efficacy of the management strategies adopted as part of this conservation plan. Evaluation needs are outlined below, and are ranked in an approximate order of priority:

Rogue Stratum

1. Evaluate the efficacy of ODFW recommendations for the release of reservoir storage from Lost Creek Lake during years of low water yield. Surveys of CHF prespawning mortalities should be conducted during years of low flow to identify optimal use of the limited volume of reservoir storage allocated for fish enhancement purposes. Availability of reservoir storage utilized for fish enhancement purposes in downstream areas will decrease through time; as additional reservoir storage is purchased for consumptive uses.

2. Evaluate the efficacy of ODFW recommendations for ramping rates (rates of flow decreases) at Applegate Lake. During periods when reservoir outflow decreases by more than 20% over a 24 hour period, surveys of dewatered areas should be conducted in order to identify optimal recommendations that will minimize stranding rates of juvenile NP CHF.

3. Complete comprehensive surveys of NP CHF habitat following standard ODFW survey methods for wadeable streams and methods developed by EPA for non-wadeable streams (Peck et al. 2012). Results from these surveys can be used to quantify the amount of stream rearing habitat available for juvenile NP CHF (Mossup and Bradford 2006; Holecek et al. 2009).

4. Evaluate the impacts of cormorants on juvenile NP CHF during late spring and summer. The number of birds should be estimated in areas proximal to the estuary and prey composition should be estimated based on diagnosis of bones and other hard body parts recovered from feces.

5. Evaluate the age composition estimates for adult NP CHF that passed Huntley Park during 1989-2006. Scale samples were collected during most of these years and should be interpreted before any significant effort to update the stock-recruitment relationships for the Rogue aggregate populations.

6. A fluvial geomorphogical assessement should be completed for the Applegate River. An evaluation of the effects of long-term operation of Applegate Dam on NP CHF habitat in downstream areas should be included as part of this assessment.

Coastal Stratum

1. Intensively evaluate water quality in the estuaries during summer. This evaluation needs to be thorough with numerous sampling locations spatially distributed within an estuary. Critical water quality parameters to be evaluated include water temperature and dissolved oxygen. Results from these evaluations should be used for guidance in relation to the construction and placement of hiding cover for juvenile NP CHF.

2. Evaluate the efficacy of adding natural and artificial hiding cover for juvenile NP CHF in estuaries. Deployment of pop-nets in locations with and without hiding cover can be used for this purpose, but results should be carefully considered because of the myriad of factors that affect habitat choices of juvenile Chinook salmon in estuaries (Seals-Price and Schreck 2003; Webster et al. 2007; Semmens 2008).

3. Complete comprehensive surveys of NP CHF habitat following standard ODFW survey methods for wadeable streams and methods developed by EPA for non-wadeable streams (Peck et al. 2012). Results from these surveys can be used to quantify the amount of stream rearing habitat available for juvenile NP CHF (Mossup and Bradford 2006; Holecek et al. 2009).

Research Needs

Research needs were identified as discrete projects designed to generate products needed to test the propriety of estimation methods developed, during formulation of this conservation plan, from limited or highly uncertain data. It is imperative that estimates of uncertainty be developed as part of each proposed project. Estimation of uncertainty will significantly increase the amount of effort needed to complete each of the proposed research projects. As a result, research projects should be conducted if the appropriate amount of funding can be obtained. Proposed needs follow and are listed in order of priority within each section. The ranking of priorities is based primarily on two factors (1) implications for populations if the estimation methods are markedly erroneous (greatest to least) and (2) the level of uncertainty associated with the estimation method (greatest to least).

Species Management Unit

1. All NP CHF populations should be tested for genetic differences. The purpose of this proposed research project is to determine whether unique management strategies are warranted for the various populations. This assessment should include NP CHF in the Euchre Creek population, which is currently judged to be a dependent population. The rationale associated with this research need was previously discussed (*see* **SPECIES MANAGEMENT UNIT AND CONSTITUENT POPULATIONS**, page 7).

2. Methods should be developed to allow for the inclusion of some population model-based estimate of productivity as a desired status criterion for NP CHF populations. Subsequently, allied desired status criteria should be developed for independent NP CHF populations in the Rogue SMU. The rationale associated with this research need was previously discussed (*see* **Population Productivity**, page 110).

Rogue Stratum

1. Determine if the population origin of NP CHF sampled at Huntley Park can be determined by genetic sampling of fish captured at Huntley Park. If individual NP CHF from independent NP CHF populations can be identified with a high degree of accuracy, then it would be possible to estimate freshwater escapement for individual populations in the Rogue Stratum. The rationale associated with this research need was previously discussed (*see* **Rogue Aggregate Populations**, page 25).

2. The Illinois population of NP CHF should be tested to determine whether spawner abundance covaries significantly with freshwater returns for all Rogue NP CHF. The purpose of this proposed research project is to verify that it is appropriate to include the Illinois population as an integrated component in the collective management strategies for all NP CHF in the Rogue River Basin. The rationale associated with this research need was previously discussed (*see* **Illinois River Population**, page 24).

Coastal Stratum

1. Results from the proposed genetic assessments for all of the NP CHF populations in the SMU should be utilized to classify the population origin of NP CHF landed in the terminal fishery off of the mouth of the Chetco River. The purpose of this proposed research project is to verify the estimated relative contribution rates of each population to the fishery. The rationale associated with this research need is discussed in **APPENDIX D** (*see* **Estimation of Harvest in the Chetco Terminal Fishery**, page 197).

2. If an effective collection facility can be established for hatchery CHF that return to the Chetco River, then estimates of ocean exploitation rates should be generated through the release of CWT-marked juvenile CHF; provided that mature CHF home to the facility at a rate exceeding 80%. The purpose of this proposed research project is to test the assumption that age-specific exploitation rates do not differ significantly between hatchery CHF of Chetco and Klamath origin. The rationale associated with this research need is discussed in **APPENDIX D** (*see* **Estimation of Ocean Fishery Impacts**, page 196).

3. The age composition of NP CHF spawners in all the coastal populations should be tested for differences. Comparisons of length frequency distributions of spawners are viable options as compared to the greater effort of collecting and interpreting scale samples. The rationale associated with this research need is discussed in **APPENDIX D** (*see* **Estimation of Spawner Ages:**, page 194).

4. Growth rates of juvenile NP CHF in streams and estuaries should be tested during late spring and summer with physiological indicators of instantaneous growth (i.e. Beckman et al. 2004; MacLean et al. 2008) and should be compared to paired samples collected from juvenile NP CHF that rear in the Rogue River. The purpose of this proposed research project is to (1) verify that juveniles grow slowly during summer within water bodies of the coastal stratum and (2) provide guidance in relation to priorities for habitat improvement projects. The rationale associated with this research need was previously discussed (*see* **Juvenile Size at Time of Migration**, page 83).

5. The propriety of methods employed to estimate spawner escapement should be tested with the application of more conventional methods, such as a mark-recapture experiment, to estimate salmon abundance. Other methods, such as a mean count of spawners (Holt and Cox 2008), may prove to be more accurate. The rationale associated with this research need is discussed in **APPENDIX D** (*see* **Analyses of Peak Densities for Adult Spawners:**, page 177).

PROCESS TO MODIFY CORRECTIVE STRATEGIES

Findings that result from monitoring, evaluation, and research efforts described in the previous section will provide insight as to the efficacy of management strategies and actions outlined in this conservation plan for NP CHF in the Rogue SMU. Management strategies adopted as components of this plan are mostly general in nature, while management actions are fairly specific. Specificity can be advantageous, yet can also be disadvantageous unless there is flexibility to revise management actions as new information becomes available. In addition, changes in local, state, or federal laws may require modifications to management strategies or actions outlined in this plan. Should ODFW conclude a modification(s) is warranted for a management strategy, ODFW will solicit input from the public before formulation of a recommendation for action by the Oregon Fish and Wildlife Commission. Temporary deviations from adopted management strategies are permitted under adaptive management (*see* next section) when NP CHF populations reach, or are forecasted to reach, conservation criteria embedded in this plan.

Adaptive Management

Given the inherent uncertainty associated with quantitative estimates of cause-and-effect relationships, ODFW will employ adaptive management as a means to identify and implement revisions to management actions embedded as plan components. Annual reviews of population status will begin upon implementation of this plan (*see* next section). This information will be used to help assess the efficacy of implemented actions and allow for adjustments to those actions, if deemed warranted. ODFW fish managers will consider current population status, forecasted run size, and the predicted rate of disease loss (Rogue NP CHF only) prior to deciding whether or not to increase harvest opportunities for NP CHF in freshwater or in the near-shore Chetco terminal fishery.

ODFW may also revise actions to improve efficacy, or actions may be terminated and be replaced by other actions that are determined to be more effective. Rationale associated with any such changes in the management actions embedded in this plan will be detailed in ODFW annual reports (*see* next section), and where applicable, will be linked to findings from monitoring, evaluation, and research efforts.

Findings from research projects not directly applicable to NP CHF in the Rogue SMU should be evaluated thoroughly prior to revision of any management actions outlined in this plan. Should specific research projects proposed for NP CHF not be completed, it is probable that at least two generations (10 years) of NP CHF will need to return to freshwater before the efficacy of employed strategies and actions can be evaluated.

In the event that pre-season forecasts indicate that conservation criteria will likely be realized (*see* **CRITERIA INDICATING DETERIORATION IN STATUS**, page 133), ODFW will craft options to address the need to temporarily modify the management strategies embedded in this plan. These options will be presented in the annual report, and ODFW will solicit public input. ODFW will evaluate input received from the public prior to making decisions related to conservation actions needed for individual, or multiple, NP CHF populations in the SMU.

Reporting

Status reports will be produced on an annual basis for NP CHF in the Rogue SMU. At a minimum, annual reports will present population status in relation to desired status criteria and conservation status criteria embedded in this plan and documentation of whether work was completed on any of the action items.

Other primary components of annual reports should include (1) presentation of the implications of research or evaluation projects completed during the reporting year, (2) presentation of any updated assessments of population attributes completed during the reporting year, and (3) presentation of the rationale associated with any changes in management actions made during the reporting year. Annual status reports should be completed within the succeeding year of the reporting period to be covered. These reports will be available to the public from the district offices in the Rogue Watershed District and the ODFW website; and should address all SMUs within the Rogue Watershed District that have completed conservation plans.

In addition, status reviews will be completed by ODFW every five years, beginning in 2016. These reviews should be designed to brief the public and the ODFW commission on the progress made towards attainment of desired status for all SMUs within the Rogue Watershed District. Status reviews will form the basis for the periodic assessment of the efficacy of management strategies and actions employed under this conservation plan. Attainment of desired status, progress towards attainment of desired status, or the lack of progress towards attainment of desired status will be used to judge the success of the management strategies and actions. Findings from monitoring, evaluation, and research efforts will also be presented and discussed in detail.

Finally, a comprehensive assessment of the efficacy of this conservation plan will be undertaken during intervals not to exceed every 15 years, which is approximately three generations of NP CHF in the Rogue SMU. The purpose of a comprehensive assessment is to determine whether the adopted management strategies are making progress towards the attainment of, or maintenance of, desired status criteria. The results of the comprehensive assessment will be presented in a summary report, and two public meetings will be held in order to obtain input. These meetings will be held at locations near the ODFW district offices in the Rogue Watershed District. Should the assessment indicate that there is a need to modify management strategies or other key elements of the plan, ODFW will craft options for those changes, will include them in the assessment report, and will seek input on the options at the public meetings. ODFW will evaluate input received during the public meetings prior to making revisions to the conservation plan. If revisions to the strategies or desired status are needed, the revised plan, including public comments, will be submitted to the ODFW commission for approval.

POTENTIAL IMPACTS TO OTHER NATIVE SPECIES

Implementation of the management strategies and allied actions described in this conservation plan are likely to result in minimal, if any, negative impacts to other species of native fish in the Rogue SMU. Should Alternative 6 be incorporated into the adopted conservation plan, modification of the partial barrier in the lower portion of the South Fork of the Chetco River will likely lead to increased upstream passage of adult NP CHF and an associated increase in the production of juvenile NP CHF. This portion of the South Fork is a primary producer of steelhead. Cutthroat trout, and probably some coho salmon, also reside in the area. Increased numbers of CHF may not have significant impacts because (1) CHF spawn earlier than the other species, (2) juvenile NP CHF mostly spend less than one year in freshwater, (3) juvenile coho salmon appear to dominate (out-compete) juvenile Chinook salmon (Taylor 1991), and (4) juvenile steelhead appear to dominate (out-compete) juvenile Chinook salmon (Kelsey et al. 2002).

Instead, it is more probable that implementation of this conservation plan is likely to result in positive impacts to other species of native fish. Benefits to other species of native fish can be expected because management strategies are designed to (1) support habitat maintenance and habitat enhancement programs, (2) development and support programs designed to decrease introductions of non-native species, (3) decreased rates of predation by introduced species, and (4) manage hatchery fish within localized areas to support specific fish management goals.

ECONOMIC IMPACTS

Economic impacts of plan implementation will likely be minimal. Regardless of which management alternatives are adopted, no reporting requirements are proposed for any business or the public. Consequently, there are no compliance costs associated with the implementation of this plan, except for some minor reporting costs accrued by ODFW.

Implementation of any of the primary alternatives outlined presented in this plan are expected to have the following economic impacts:

1. Commercial fishers, fishing guides, commercial fish distributors, tackle shops, lodging providers, restaurants, and other support services will be positively impacted as a result of the improved structure for the management of CHF fisheries within Oregon waters. Decreased opportunities for harvest during years with low NP CHF escapements will be offset by greater production during succeeding years because recruits produced per spawner exceed 3.0 at low spawner densities.

2. The state of Oregon (ODFW) will accrue additional expense as a result of the proposed monitoring, evaluation, and research tasks that result from plan implementation. In addition, ODFW will accrue some additional expense related to supporting, or executing, the actions that result from plan implementation.

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