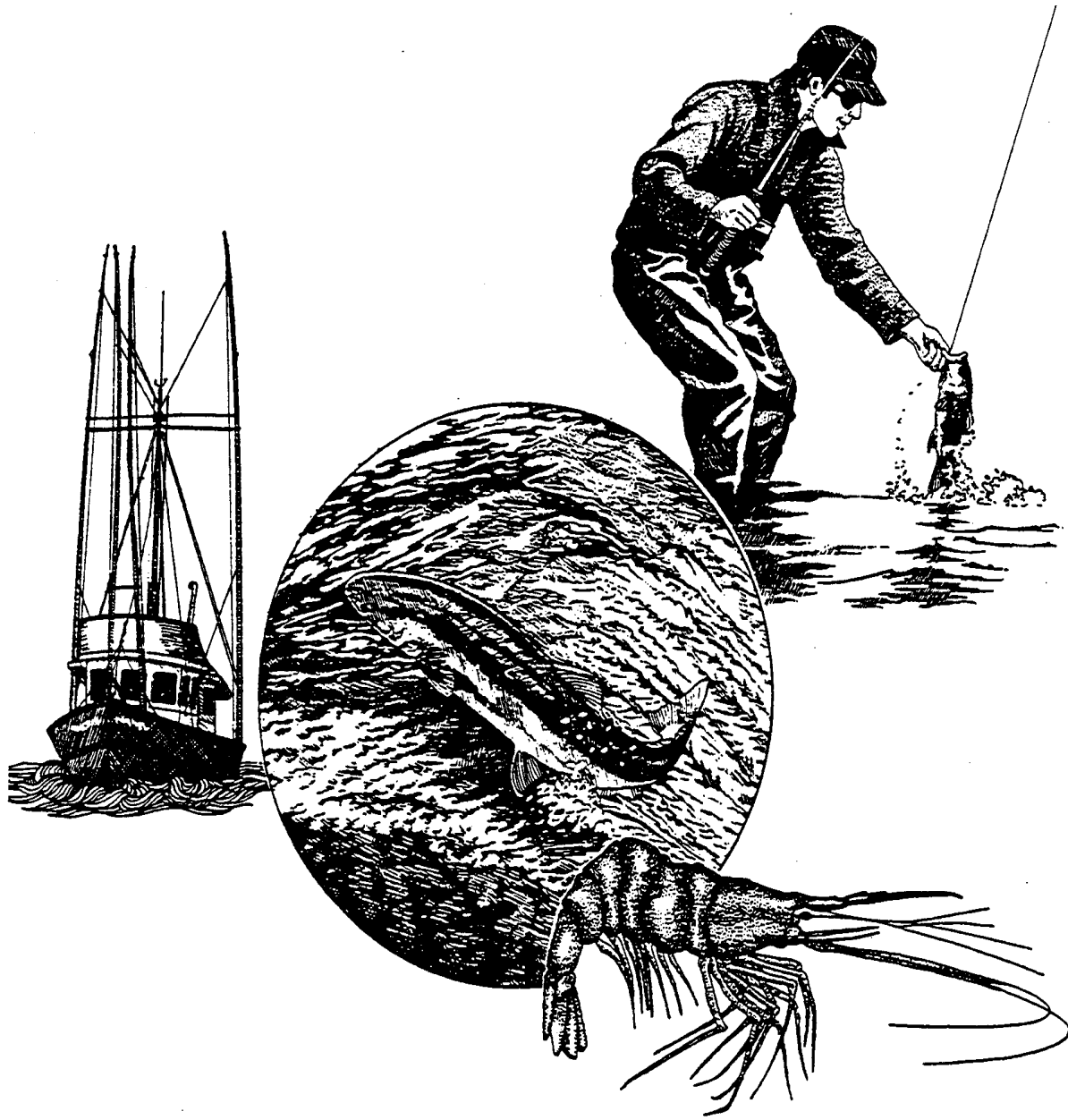


**INFORMATION
REPORTS
NUMBER 98-3**



FISH DIVISION
Oregon Department of Fish and Wildlife
Conservation Status of Steelhead in Oregon

The Oregon Department of Fish and Wildlife prohibits discrimination in all of its programs and services on the basis of race, color, national origin, age, sex, or disability. If you believe that you have been discriminated against as described above in any program, activity, or facility, please contact the ADA Coordinator, P.O. Box 59, Portland, OR 97207, 503-872-5262.

This material will be furnished in alternate format for people with disabilities upon request. To request a copy in alternate format, please call Deb Clinkscales, Oregon Department of Fish and Wildlife, Fish Division, (503)872-5252, extension 5394.

Conservation Status of Steelhead in Oregon

Mark W. Chilcote
Fish Division

Oregon Department of Fish and Wildlife
2501 SW First Avenue
PO Box 59
Portland, Oregon 97207

January 1998

Table of Contents

	<u>PAGE</u>
Executive Summary	iii
Acknowledgments	vi
Introduction	1
Methods, Supporting Information, and Assessment Criteria	1
Assessment Units	1
Adult Population Abundance	2
Fishing Mortality Rates	3
Proportion of Hatchery Fish in Natural Spawning Population	3
Spawner-Recruit Modeling	4
Quasiextinction Assessment Model	7
Reproductive Success of Hatchery Spawners	12
Assessment Criteria	13
Determination of ESU Status	18
Klamath Mountains Province ESU Status Assessment	19
Naturally Spawning Hatchery Fish	19
Population Abundance, Trends, and Recruitment	23
ESU Status Synthesis	28
Oregon Coast ESU Status Assessment	31
Naturally Spawning Hatchery Fish	31
Population Abundance, Trends, and Recruitment	40
ESU Status Synthesis	46
SW Washington ESU Status Assessment	50
General	50
Overview of Populations	50
ESU Status Synthesis	51
Upper Willamette ESU Status Assessment	52
Naturally Spawning Hatchery Fish	52
Population Abundance, Trends, and Recruitment	53
ESU Status Synthesis	61
Lower Columbia ESU Status Assessment	65
General	65
Naturally Spawning Hatchery Fish	65
Population Abundance, Trends, and Recruitment	70
ESU Status Synthesis	77

Table of Contents (continued)

	<u>PAGE</u>
Middle Columbia ESU Status Assessment	80
Naturally Spawning Hatchery Fish	80
Population Abundance, Trends, and Recruitment	84
ESU Status Synthesis	92
Snake ESU Status Assessment	96
Naturally Spawning Hatchery Fish	96
Population Abundance, Trends, and Recruitment	96
ESU Status Synthesis	102
References Cited	105

Executive Summary

This report describes the results of an independent conservation status review of steelhead trout (*Oncorhynchus mykiss*), conducted by the Oregon Department of Fish and Wildlife (ODFW). This review was based on available abundance and life history data, presented and analyzed scientifically to determine if steelhead are at risk of extinction in Oregon.

This is the final revision of the Conservation Status of Steelhead in Oregon report. It incorporates comments and suggestions provided by a wide range of individuals including the following scientific peer reviewers: Oregon Chapter American Fisheries Society, Dr. Jim Berkson (Columbia River Inter-Tribal Fish Commission), Dr. Peter Kareiva (Zoology Department, University of Washington), Dr. John Palmisano (John Palmisano Biological Consultants), Dr. Barry Smith (Ecosystem Modeling, Canadian Wildlife Service), and Dr. Richard Williams (Clear Creek Genetics).

The following three indicators of species health were used to assess the risk of extinction of steelhead in Oregon: 1) the likelihood of long-term population persistence, 2) the capacity of populations to resist and survive short-term periods of extreme environmental stress, and 3) the identification of populations at immediate risk of reproductive failure and extirpation.

For each indicator, related criteria were developed defining the boundaries of four designations: Endangered, Threatened, Sensitive, and Secure. These designations relate only to the issue of species extinction. For example, a designation of Secure does not mean a population is abundant and its habitat is in good condition, it means only that the population is not currently at risk of extinction.

The status assessment results for each steelhead Evolutionarily Significant Unit (ESU) are summarized below.

Klamath Mountains Province ESU = **SECURE**

In terms of resistance to stress and the percentage of populations at immediate risk of extirpation, the assessment for this ESU is secure. However, the long-term persistence indicator results suggest that two of the four populations (mid-Rogue summer run and Applegate winter run) are at some degree of risk. Taken together, these three indicators result in a net classification of secure for this ESU. The only apparent weakness for this ESU is the downward trend of both summer steelhead populations, especially those in the middle portion of the Rogue Basin.

Oregon Coast ESU = **SENSITIVE**

The likelihood of populations in this ESU surviving over the long-term and through periods of environmental stress are generally good and result in a ranking of secure for both of these indicators. However, the seriously depressed state of the Siletz summer steelhead population and the greater than 50% hatchery spawners in several natural populations trigger extirpation warnings for a sufficient percentage of the populations in this ESU to warrant some concern. These findings result in an overall classification of sensitive for this ESU.

SW Washington ESU = **SENSITIVE**

There are no abundance data for populations in Oregon's portion of this ESU. However, the management history and habitat characteristics of steelhead populations in this ESU are most like those belonging to the adjacent Oregon Coast ESU. Therefore, the status of steelhead in the SW Washington ESU is likely the same as those of the Oregon coast. Pending the collection of new information, this perceived similarity is the basis for assigning the sensitive classification to this ESU.

Willamette ESU = **THREATENED**

The long-term of persistence for populations in this ESU appear to be at risk. Modeling results suggest that they have an extremely poor resistance to future episodes of environmental stress. In addition, one of the five populations examined, the Upper South Santiam, is at such low abundance that an extirpation warning is warranted. Given these findings, this ESU meets the criteria for the classification of threatened.

Lower Columbia ESU = **THREATENED**

The indicator results for steelhead in this ESU suggest they are at some risk in terms of long-term persistence, and that their capacity to survive future periods of environment stress is unacceptably low. Of special concern is the recent collapse of winter steelhead in the Clackamas River, and summer steelhead in the Hood River. These two populations, comprising 33% of the populations examined in this ESU, are sending warnings of possible extirpation. In light of these results, the status of this ESU meets the criteria established for a threatened classification.

Middle Columbia ESU = **SENSITIVE**

In terms of resistance to short-term stress and the likelihood of long-term survival, steelhead in this ESU are at some degree of risk, particularly those populations in the John Day Basin. However, the primary trouble spot in this ESU is the Deschutes population. Over the last four years, the wild population has been in almost complete reproductive failure. Stray hatchery fish dominate the spawning population (greater than 75%) and are likely causing severe genetic impact to the innate productivity of the wild population. While not at the same crisis level as the Deschutes population, the South Fork John Day population level has declined 50% over the last 18 years, and is currently at such low abundance that its continued existence may be at some risk. However, these problems averaged across all eight

populations examined in this ESU result in a recommended overall status classification of sensitive.

Snake ESU = **THREATENED**

Of the three populations examined in this ESU, steelhead in Joseph Creek and the Imnaha River appear to be relatively secure in terms of their likelihood of long-term persistence and capacity to survive adverse environmental conditions. However, the third population, the Upper Grande Ronde, meets every test for a population in serious trouble. With only three populations upon which to base this status assessment, finding one of these populations at high risk of extirpation heavily impacts the overall status rating for the ESU. However, if this sampling of populations is in fact representative of the ESU (i.e., 33% of the populations are in serious trouble), then the ESU is not healthy. Therefore, using the status classification criteria devised for this review, the Snake ESU steelhead meet the standard for a threatened designation.

Acknowledgments

This status report of steelhead populations in Oregon would not have been possible without the cooperation of and suggestions from a large number of ODFW employees.

Many individuals were helpful in responding to the numerous requests made in gathering information for this report. I would like to especially acknowledge the efforts of Russ Stauff, Todd Confer, Mike Evenson, Jerry Vogt, Scott Redhead, Tom Satterthwaite, Randy Reeve, Walt Weber, John Haxton, Wayne Hunt, Tom Murtagh, Tim Unterwegner, Mike Gray, Tim Bailey, Jon Germond, Jeff Zakel, Bill Knox, Ken Kenaston, Steve Johnson, Pat Hulett (Washington Department of Fish and Wildlife, WDFW), and Doug Cramer (Portland General Electric, PGE).

Reviewers of earlier drafts of this report provided many excellent and thoughtful suggestions. In particular, I would like to extend thanks to Ken Kenaston, Tom Nickelson, Bruce Schmidt, Tom Murtagh, Steve Pribyl, Pat Hulett (WDFW), Steve Leider (WDFW), John Palmisano (private consultant), and Bill Bakke (Native Fish Society).

I am also indebted to Deb Clinkscales and Evelyn Walton for their identification and correction of the abundant typographical and grammatical errors that plagued earlier versions of this report.

Finally, a special thanks goes to Ken Kenaston, Bob Hooton, and Barry McPherson, for numerous brainstorming sessions and reality checks that were indispensable in developing the ideas and analyses contained in this report.

Introduction

This report describes the results of a conservation status review of steelhead trout (*Oncorhynchus mykiss*), conducted by the Oregon Department of Fish and Wildlife (ODFW). This effort, was undertaken in response to recent actions by the National Marine Fisheries Service (NMFS) to propose the listing of steelhead under the federal Endangered Species Act (ESA) throughout much of Oregon.

The objective of this review is to independently determine if steelhead are at risk of extinction. As such, it is not a review of the state of steelhead fisheries in Oregon, nor is it intended to be a detailed review of the condition of steelhead habitat in Oregon. Rather, the review utilizes existing data sets on the abundance and life history characteristics of steelhead populations to conduct a repeatable, scientific assessment of this species with respect to the likelihood of its continued existence.

This report reflects not only the assistance provided by those recognized in the Acknowledgments section, but also the very useful peer review comments by the following scientists and organizations: Oregon Chapter American Fisheries Society, Dr. Jim Berkson (Columbia River Inter-Tribal Fish Commission), Dr. Peter Kareiva (Zoology Department, University of Washington), Dr. John Palmisano (John Palmisano Biological Consultants), Dr. Barry Smith (Ecosystem Modeling, Canadian Wildlife Service), and Dr. Richard Williams (Clear Creek Genetics).

Methods, Supporting Information, and Assessment Criteria

Assessment Units

ODFW has provisionally described 134 breeding populations of wild steelhead in Oregon, ODFW (1995a) and ODFW (1995b). While most of the analyses contained in this report were done at the level of individual populations, overall status assessments are presented by population clusters NMFS defines as Evolutionarily Significant Units (ESUs).

In the NMFS steelhead status review, Busby et al. (1996) evaluated each steelhead ESU as a separate, listable quantity (population segment) under the ESA. Although NMFS defined 15 ESUs for west coast steelhead, only seven occur in Oregon. Five of these are shared with other states; the Klamath Mountains Province ESU with California; the SW Washington, Lower Columbia, and Middle Columbia ESUs with Washington, and the Snake ESU with Washington and Idaho.

To qualify a cluster of populations as an ESU they must "... 1) be substantially reproductively isolated from other populations, and 2) contribute substantially to the ecological or genetic diversity of the biological species... ." (Busby et al., 1996).

ODFW also uses the idea of distinct population clusters as a means for defining the smallest collection of populations that can be afforded protected species status under Oregon's sensitive and endangered species policy. These population clusters, which ODFW calls Gene Conservation Groups (GCG) differ somewhat from NMFS's ESU concept. Most notably, to qualify as a GCG population clusters need only to have a probable history of reproductive isolation and not additional qualitative assessments of value such as demonstrated evolutionary or ecological diversity.

Regardless, the cluster of steelhead populations in Oregon which constitute individual GCGs have approximately the same boundaries as the Oregon portion of steelhead ESUs described by NMFS.

Because NMFS put considerable effort into reviewing steelhead populations at the ESU level, ODFW used the same units in assessing steelhead populations in Oregon for the purposes of this report. This will make it easier to compare ODFW's steelhead assessment results to those of NMFS.

Adult Population Abundance

Where possible, steelhead abundance was determined from counts of adult fish passing a dam site. For other populations, spawner density estimates for selected stream sections provided an index of relative abundance.

Spawner densities were estimated from the peak count of steelhead redds observed per mile of stream surveyed. Redd densities were converted to spawners per mile using the relationship $S_m = (R_m * F_r) / P_f$; where S_m is the estimate of spawners per mile, R_m is the observed number of redds per mile, F_r is the estimated number females in the spawning population per redd, and P_f is the estimated proportion of females in the spawning population. A value for P_f was based on the best available information for each population. For F_r , a value of 0.81 was used for all populations based on the results presented by Johnson and Cooper (1991) for winter steelhead populations in western Washington.

Unfortunately for many steelhead populations, particularly those on the Oregon coast, there are no adult abundance data. While catch statistics (developed from steelhead catch cards returned to ODFW by anglers) provide an index of steelhead harvest for specific river basins, it is difficult to infer population abundance from these data, particularly for wild fish. This is especially true for catch estimates made after angling regulations were changed to prohibit the taking of wild steelhead. By 1992, most steelhead fisheries in the state were operating under such regulations. For this and other reasons, the analyses presented in this report are based on a subset of steelhead populations with either dam counts or spawner counts directly available.

Fishing Mortality Rates

Fishery catch rates on analyzed steelhead populations were estimated either directly from statistical creel surveys (previously conducted on these populations) or by inference for those populations without such surveys (Kenaston, 1989).

Since the late 1970s an increasing number of steelhead fisheries have required that all wild steelhead caught by anglers be released unharmed (ODFW, 1995a) and (Hooton, 1997). However, evidence suggests that not all wild steelhead survive the handling and stress of being caught and released (Rawding, 1997). For the purposes of the analyses presented in this report, the assumed mortality rate for caught and released wild steelhead was 10%. The overall fishery mortality rate for such wild populations was determined by multiplying estimated catch rates by the catch and release mortality rate of 10%.

Proportion of Hatchery Fish in the Natural Spawning Population

A variable proportion of many naturally spawning steelhead populations in Oregon are hatchery fish. This proportion was estimated either directly from dam counts of fin-clipped steelhead (hatchery fish) and non-fin clipped steelhead (wild fish) or indirectly from hatchery:wild ratios in fisheries based on the reading of scales volunteers collected from caught steelhead. The latter method was largely restricted to the period from 1980 to 1992. Prior to 1980, a widespread volunteer steelhead scale collection program did not exist. After 1992, angling regulations permitted the retention of hatchery fish only in nearly all steelhead fisheries and, therefore, wild fish were not sampled.

Since 1992, temporary upstream migrant traps operated on tributary streams have been used to determine hatchery:wild spawner ratios for several populations. Hatchery:wild ratios for many coastal populations were also based on pre-1992 estimates and the projected impact of management actions implemented between 1994 and 1996 (such as the elimination of hatchery steelhead smolt releases from several basins).

For most populations examined in this report the presence of naturally spawning hatchery fish prior to 1980 was either relatively minor or could be quantified using other methods (direct observations at upstream passage facilities). However, the return timing of the Clackamas winter steelhead population, as counted at North Fork Dam, was used to estimate hatchery:wild ratios in these earlier years. Based on the known return timing of historical wild steelhead populations and the known early return timing of hatchery fish, all fish counted after April 1 at North Fork Dam were assumed to be wild fish. Fish counted at North Fork Dam prior to April 1 were assumed to be hatchery fish.

For winter steelhead in the Sandy Basin, the timing of fish passing a counting location (Marmot Dam) was also used to estimate the proportion of hatchery fish in the spawning escapement. Based on historical run timing information, it appeared that most fish returning prior to March 1 were hatchery fish and those after March 1 were wild fish. However, a video camera used in 1997 automatically filmed fish passing Marmot Dam to determine their origin based on missing fins (all hatchery fish were fin-clipped prior to release). A preliminary review of these data by PGE biologists suggests that hatchery fish comprised only 53% of the run in January and February, and 32% in March and April. Using this information, the number of hatchery fish returning to the Sandy was estimated by adding 53% of the Marmot Dam count prior to March 1 and 32% of the count after March 1. The difference between the total count and the hatchery fish estimate determined the wild fish count.

Using run timing to classify steelhead as either hatchery or wild is a poor substitute for making such determinations from scale analysis or observations of fin-clipped hatchery fish over an entire time series. If hatchery fish are capable of successful reproduction under natural conditions, then it would be expected that some portion of the early return are naturally produced and therefore should be classified as wild fish. However, because they fall into the pre-set window for hatchery fish, they are assigned to the hatchery fish category. As a result, the percentage of hatchery fish is overestimated. Some of this effect may be offset by late-returning hatchery fish classified as wild because they are counted after the preset wild fish starting date.

Spawner-Recruit Modeling

For those populations with sufficient information, spawner-recruit models were developed to place indices of population abundance in the context of habitat capacity. In general, the time series to develop the spawner-recruit relationships covers a period of time from the early 1970s to the spring of 1997. Some notable exceptions are the 50-year time series used for the North Umpqua populations (1947 to 1997) and the 36-year time series used for the Clackamas population (1961-1997).

The underlying expectation for exploring spawner-recruit relationships was that at least some of the variation in observed run sizes could be explained by corresponding fluctuations in the parental spawning population. Further, these relationships should shed light on the approximate production potential of each population. This expectation is based on the assumption that each watershed has a limited maximum number of steelhead it can produce because of habitat quantity and quality limitations, and out-of-basin survival rates in the ocean and migration corridors.

Indices of spawners and recruits were needed to develop recruitment models. Spawners are defined as either a complete count or abundance index of all steelhead that spawn in a basin, regardless of when they spawn or whether they are of hatchery or wild origin.

This definition is problematical where there is evidence that naturally spawning hatchery fish are less efficient at producing offspring than are naturally spawning wild fish such as is the case for Kalama River steelhead populations (Chilcote et al., 1986, Leider et al., 1990, and Hulett WDFW, personal communication). However, for many populations examined in this report, hatchery fish comprise a relatively minor portion of the spawning population. For those populations where hatchery fish were more abundant and genetically different from the wild population, a second recruitment modeling exercise was performed. This second model applied a discount to hatchery spawners corresponding with their expected reproductive performance relative to wild spawners. The details of this second recruitment modeling exercise and associated issues are discussed in the Reproductive Success of Hatchery Spawners section of this report.

The number of recruits produced by each brood year of spawners was estimated in the following fashion. First, the total pre-harvest return of wild fish for each year was determined by dividing annual wild fish spawner escapements by 1 minus the annual fishery mortality rate.

Second, each year's total return estimate was proportionally divided into age categories based on an average age distribution for each population (Table 1). The assumed age structure for each population was based on a variety of both published and unpublished information sources. These include Busby et al. (1996), McGie (1994), Leider et al. (1986), ODFW (1996), and Carmicheal et al. (1995).

Table 1. Estimated proportion of ages at spawning for 26 steelhead populations in Oregon.

Population	Respawners	Age 2	Age 3	Age 4	Age 5	Age 6
Rogue SR	0.10	0.01	0.15	0.54	0.19	0.00
MidRogeSR	0.10	0.01	0.15	0.54	0.19	0.00
Rogue WR	0.20	0.01	0.14	0.48	0.17	0.00
Applegate	0.14	0.00	0.00	0.56	0.26	0.03
NUmp SR	0.10	0.00	0.01	0.25	0.43	0.21
Nump WR	0.14	0.00	0.00	0.59	0.25	0.03
Salmonbry	0.15	0.00	0.09	0.64	0.11	0.00
Molalla	0.10	0.00	0.00	0.83	0.07	0.00
N. Santiam	0.10	0.00	0.00	0.83	0.07	0.00
LoS.Santm	0.10	0.00	0.00	0.83	0.07	0.00
UpS.Santm	0.10	0.00	0.00	0.83	0.07	0.00
Calapooia	0.10	0.00	0.00	0.83	0.07	0.00
Clackamas	0.11	0.00	0.01	0.63	0.23	0.02
Sandy	0.11	0.00	0.01	0.63	0.23	0.02
KalamaSR	0.06	0.00	0.00	0.12	0.64	0.17
KalamaWR	0.11	0.00	0.04	0.51	0.30	0.03
Deschutes	0.05	0.00	0.15	0.41	0.33	0.07
JD below PG	0.05	0.00	0.41	0.43	0.11	0.00
JD abve PG	0.05	0.00	0.41	0.43	0.11	0.00

Table 1. Continued.

<u>Population</u>	<u>Respawners</u>	<u>Age 2</u>	<u>Age 3</u>	<u>Age 4</u>	<u>Age 5</u>	<u>Age 6</u>
NF John D	0.05	0.00	0.41	0.43	0.11	0.00
MF John D	0.05	0.00	0.41	0.43	0.11	0.00
SF John D	0.05	0.00	0.41	0.43	0.11	0.00
Umatilla	0.05	0.00	0.29	0.48	0.18	0.00
Joseph	0.03	0.00	0.02	0.38	0.44	0.13
UpGrRond	0.03	0.00	0.02	0.38	0.44	0.13
Imnaha	0.03	0.00	0.03	0.65	0.28	0.00

Third, the number of recruits produced by each brood year was estimated by adding diagonally across a return-by-age data table. For example, the winter steelhead recruits that spawned in 1980 (brood year) would equal the number of age 2, age 3, age 4, age 5, and age 6 fish estimated to have returned in 1982, 1983, 1984, 1985, and 1986, respectively. It is important to note that while respawners comprise 3% to 15% of the return population, they are excluded from the recruit calculations. To include them would essentially mean counting the respawner portion of the offspring from a given brood year twice, once on its initial return and again on its second return as respawner. For modeling purposes, respawners were counted as spawners but not as recruits.

Once estimates for spawners and recruits were completed for each population, the relationship between spawner abundance and subsequent production of recruits was modeled using the Ricker recruitment function, $R = Se^{(a - BS)}$; where R = recruits, S = spawners, $e = 2.718$, and a and B are parameters that describe the shape of the recruitment curve. For each population, spawner and recruit data were used to estimate parameters a and B through linear regression analysis of the transformed Ricker equation $\ln(R/S) = a - BS$ (Hilborn and Walters, 1992).

For each population, the estimated value for the a parameter was used as an index of innate population productivity or resiliency. The a -value is literally the natural log of the maximum recruits per spawner estimated from a recruitment curve fit to a series of data points for a particular population. The maximum recruits per spawner theoretically occurs at the lowest spawner densities.

An a -value of 1.4 is equal to about four maximum recruits per spawner ($\text{Exp}(1.4) = 4.05$). In contrast, an a -value of only 0.2 translates into a relatively unhealthy maximum recruits per spawner of 1.22. Finally, an a -value less than zero, for example -0.5, equals a maximum recruits per spawner of only 0.6, an extremely unhealthy situation.

When the a -value is zero or less, the population cannot sustain itself at any density, and total reproductive failure is occurring. Such a population is headed for extinction. In contrast, the higher the a -value the more resistant a population is to extinction. Even when reduced to very low abundance levels, if the underlying recruitment

function is robust, as evidenced by relatively high a -values, then the capacity of the population to rebound is great. Populations with strong rebound potential are less vulnerable to extinction.

Both recruitment model parameters, a and B , were used to estimate the population equilibrium abundance, N^* ; where, $N^* = a/B$, as described by Burgman et al. (1993). The population equilibrium abundance level is the average maximum number of spawners a population can sustain, given the available habitat capacity and natural mortality factors. This is the point on the right-hand portion of the recruitment curve where it intersects the replacement line (i.e., recruits per spawner = 1.0).

The confidence in equilibrium abundance estimates for each population was likely related to how well the observed data fit the Ricker recruitment model. To help visualize this presumed relationship, a lower and upper bound for equilibrium abundance estimates were made for each population using the 95% confidence intervals (CI) for the a parameter obtained in the regression analysis. In other words, the upper bound = $(a_{\text{upper 95\% CI}})/B$ and lower bound = $(a_{\text{lower 95\% CI}})/B$.

Quasiextinction Assessment Model

As one component of a repeatable process for assessing the risk of extinction, a population viability analyses based upon techniques described by Burgman et al., 1993 was applied to all steelhead populations for which spawner-recruit relationships could be determined.

These assessments were used to help determine the vulnerability of populations to extinction given their estimated recruitment capacity and an estimate of the annual variation in this recruitment over three different future time periods.

The quasiextinction assessment model was built around the following version of the Ricker equation where:

$$R = [S e^{((a + s.y + V) - BS)}] * [1 - \text{Harvest Rate}].$$

This is the same recruitment equation presented earlier with the addition of a harvest impact term, [1-Harvest Rate] and the additional a parameter terms, $s.y$ and V . For most model runs, future harvest rates were set at either 0.05 or 0.10 (Table 2).

Table 2. Quasiextinction assessment model setup data for 26 populations of steelhead including Ricker recruitment parameters, maximum observed spawner levels (MaxS), assumed future harvest rates (H.R.), and quasiextinction thresholds (QuasiEx).

Population	<i>a</i>	<i>B</i>	<i>s</i>	MaxS ^a	H.R.	QuasiEx ^b	R ²	<i>p</i>
Rogue SR	1.2146	0.0002	0.3719	13000	0.05	300	0.75	< 0.05
MidRogueSR	0.7219	0.0125	0.8969	225.0	0.05	5.0	0.44	< 0.05
Rogue WR	1.3107	0.0002	0.2753	13000	0.05	300	0.85	< 0.05
Applegate	0.7252	0.0008	0.4679	3400	0.05	150	0.71	< 0.05
NUmp SR	0.8595	0.0002	0.3125	9500	0.05	300	0.72	< 0.05
NUmp WR	1.2373	0.0002	0.2569	11500	0.05	300	0.58	< 0.05
Salmonbry	1.0037	0.0319	0.8046	105.0	0.05	5.0	0.44	< 0.05
Molalla	-0.0278	0.0118	0.3999	85.0	0.05	10.0	0.16	0.07
N. Santiam	0.5386	0.0152	0.3512	85.0	0.05	10.0	0.23	< 0.05
LoS.Santrm	0.6078	0.0264	0.3223	49.0	0.05	10.0	0.22	< 0.05
UpS.Santrm	0.2425	0.0011	0.4526	1500	0.05	150	0.42	< 0.05
Calapooia	0.7062	0.0614	0.5891	24.0	0.05	10.0	0.25	< 0.05
Clackamas	1.0498	0.0006	0.6210	4400	0.05	300	0.41	< 0.05
Sandy	0.3383	0.0003	0.6249	4100	0.05	300	0.11	0.23
KalamaSR	-0.2297	0.0002	0.4344	13800	0.05	150	0.76	< 0.05
KalamaWR	0.9874	0.0007	0.4121	2900	0.05	150	0.60	< 0.05
Deschutes	1.0430	0.0001	1.4132	20000	0.10	300	0.20	0.10
JD below PG	1.2362	0.1426	0.9977	22.0	0.10	2.0	0.41	< 0.05
JD above PG	1.1671	0.1283	0.7625	21.0	0.10	2.0	0.40	< 0.05
NF John D	1.3976	0.2723	0.5148	10.0	0.10	2.0	0.67	< 0.05
MF John D	1.4261	0.1655	0.5482	18.0	0.10	2.0	0.67	< 0.05
SF John D	1.0275	0.0974	0.5518	20.0	0.10	2.0	0.43	< 0.05
Umatilla	1.7132	0.0008	0.5591	3300	0.10	150	0.59	< 0.05
Joseph	1.5768	0.2203	0.7144	11.0	0.10	2.0	0.63	< 0.05
UpGrRond	1.5484	0.5469	0.9674	9.0	0.10	2.0	0.65	< 0.05
Imnaha	1.4333	0.1542	0.8354	23.0	0.10	2.0	0.58	< 0.05

^a Numbers with decimal point and following zero identify fish per stream mile spawner abundance data, all other numbers are total spawner counts for basin.

^b QuasiEx = Quasiextinction, the spawner abundance level below which the recruitment function is highly uncertain and therefore an area which should be avoided to minimize the risk of extinction.

Using the terminology of Burgman et al. (1993), the *s* in the expression, *s.y*, represents the standard error of the recruitment regression (Table 1). The *y* represents a randomly selected variable from a normal distribution having a mean of 0, and a variance of 1. These additions to the recruitment model introduce stochasticity to an otherwise deterministic formula. As one consequence, the same number of spawners repeatedly plugged into this equation will yield different numbers of recruits. This variability is intended to address both freshwater and ocean survival uncertainty since its origins are adult to returning adult data - the entire life cycle.

V is a relative survival scalar and was added to perform assessments under a variety of life cycle survival rates. For example, to assess the fate of a population for a future time series in which the average survival rate decreased to 1/2 of that for the base period (for most populations from the early-1970's to 1997) model runs were conducted with $V = \ln(1/2) = -0.69$. Note that the natural logarithmic transformation is necessary to fit with the form of the Ricker equation. In contrast, to assess the fate of a population using the same average survival rates as occurred for the base period (i.e., 1.0), model runs were done with $V = \ln(1.0) = 0.00$.

A conditional limit was set for the maximum number of recruits predicted for each population modeled. This avoids overextending the predictive use of the recruitment regression with respect to actual observations. If the model yielded a recruit estimate greater than two times the maximum spawner abundance ever observed for the population (Table 2), the recruit prediction was set to equal twice maximum wild spawner abundance.

Although the Ricker recruitment model predicts maximum recruits per spawner at very small population sizes, none of the steelhead populations had sufficient data at these low levels to verify this behavior. This was of considerable concern because there is evidence that at such low levels the expected recruitment mechanisms may fail (Glipin and Soule, 1986). Either because of genetic problems or the inability of spawners to find mates in a low density environment, the productive capacity of a population may decrease as the population declines below some critical level of spawners. Using the concepts and terminology of Ginzburg et al. (1982) we define those steelhead populations that cross this critical threshold level as becoming quasiextinct. As used in this report, quasiextinction occurs when a population declines to such low levels of abundance that the recruitment relationship becomes unknown and unpredictable. This high uncertainty poses an unacceptable risk to the continued persistence of the population and, therefore, is a population abundance that from a conservation perspective is undesirable.

Quasiextinction levels were estimated for each steelhead population modeled. In nearly all cases, the threshold selected was a spawner abundance less than ever observed for the population. For populations whose data source were estimates of total spawners (e.g., from dam counts), quasiextinction was set at 150 for small basins and 300 for larger basins (Table 2). For populations where the data source consisted of spawner density indices (e.g., spawners per stream mile), quasiextinction was set at 5.0 fish per mile for coastal populations, 10.0 fish per mile for Willamette Basin streams, and 2.0 fish per mile for the Columbia Basin above the Willamette.

In performing model runs an assumption was made that for spawner abundance less than the population's quasiextinction levels, the recruitment capacity declined sharply from Ricker recruitment model expectations. While this assumption of compensatory behavior may be incorrect, the compensation assumption was made in

order to make the most conservative assessment of the steelhead populations modeled. Models that include this depensation function will yield more pessimistic results concerning the persistence of a population than those which exclude depensation.

To add a low density depensation function to the model runs, recruitment was estimated using the following alternate method to the Ricker model whenever spawner estimates fell below a population's quasiextinction level. If spawner abundance was less than 33% of a population's quasiextinction level, then the recruit estimate was reset to zero. In other words, spawner numbers less than 33% of quasiextinction were judged to yield no recruits because of severe depensatory effects.

For spawner numbers between 33% and 100% of quasiextinction levels, recruits were estimated from the linear relationship, $R_{\text{predicted}} = R_{\text{quasiextinct}} * [(S_{\text{mod}} - 0.33 * S_{\text{quasiextinct}}) / (S_{\text{quasiextinct}} - 0.33 * S_{\text{quasiextinct}})]$. Where $R_{\text{predicted}}$ is the recruit prediction adjusted for depensation, $R_{\text{quasiextinct}}$ is the number of recruits produced when spawners are at quasiextinction abundance, S_{mod} is the number of spawners generated by the model, $S_{\text{quasiextinct}}$ is the quasiextinction level in terms of spawner abundance.

To gauge the level of unacceptable risk to a population, the desired output from each run of the assessment model was the probability of population quasiextinction within a specific time period given key parameters, such as evaluation period duration, starting population size, and assumed population age structure.

For each trial, a quasiextinction result was defined as a consecutive six-year string of spawner abundance less than the quasiextinction level for the population. This definition is based on an inference from observed steelhead life history characteristics that most populations do not have enough seven-year and older individuals to permit recovery in situations where the number of spawners in the previous six years may be zero (due to reproductive failure at low spawner densities).

Quasiextinction probabilities were estimated from the results of 500 independent trials using the same set of population parameters and test conditions. For example, if a quasiextinction event (more than seven years in a row of sub-quasiextinction abundance levels) was predicted in 50 of the 500 trials, then the quasiextinction probability for the model run would be 0.10 or 10%.

Mechanically, each trial consisted of the following steps, repeated as necessary until the desired number of years were modeled. First, based on the total spawning population, the predicted number of recruits produced for each brood year was estimated using the modified recruitment function described previously. Second, each brood year of recruits was divided among individual spawning years based upon the combination of ages at which the recruits are expected to mature, using population specific age data for each population (Table 1). For example, if the recruits belonging to the 1980 brood year numbered 1,000 fish and previous evidence suggested 30% of

the population spawns as 3-year olds, then 300 spawners would be assigned to the pool of adults destined to spawn in 1983.

Third, a portion of the total fish assigned to any one spawning year were assumed to survive to spawn a second time. The number of fish in this category was added to the spawning population in the next year if they were winter steelhead and to the spawning population in two years if they were summer steelhead. The differential treatment of these two groups was based on underlying life history differences. Most winter and summer steelhead that survive to spawn a second time must spend a full summer in the ocean after the first spawning to recover. For winter steelhead this means they can return as spawners in the next year. However, for summer steelhead, their run timing keeps them from returning to freshwater for a full year (the following summer) which then must be followed by a seven-month to ten-month wait in freshwater for the spawning season in the next year's spring. Therefore, responding summer steelhead are on a two-year cycle.

The known exception to this pattern are the summer steelhead in the Rogue Basin. Summer steelhead from this population that survive spawning migrate downstream to the ocean and are able to recover after only a partial summer in the ocean. As a result, these fish return to freshwater in the same year to become spawners once again only one year later.

Upon completion of model runs, the results of each trial were inspected for the occurrence of a quasiextinction sequence (six or more consecutive years with spawner numbers less than the level of quasiextinction). If such a sequence was found, the trial result was recorded as a quasiextinction.

In addition to three different time periods, model runs were also made under various assumptions concerning starting population size and V (future average survival rates relative to the base period). The results from these runs were used to help compare how populations might respond to potential decreases in survival or population abundance.

The structure of the model used to estimate the probability of quasiextinction of individual populations is greatly simplified from what likely occurs in nature. Perhaps the most important omission from the model is that it does not incorporate natural straying and recolonization from nearby populations. The model treats each population as an isolated island that can not be reproductively supported by strays from other populations. As a consequence, the probability of quasiextinction estimates are probably greater than if the model had incorporated natural dispersal rates from other populations. Exploring the consequences of this between population dispersal is complex, but a worthy pursuit of additional model development in the future.

Reproductive Success of Hatchery Spawners

Several populations modeled for recruitment contain both hatchery and wild spawners. As noted earlier, there is evidence that some stocks of hatchery fish have very poor reproductive performance compared to wild fish under natural conditions. At first glance, this fact seems to be reflected in the recruitment parameters estimated for winter steelhead populations in the Molalla and Sandy rivers, and summer steelhead in the Kalama River, with respective values for the Ricker a parameter of -0.0278, 0.3383, and -0.2297.

The unproductive recruitment functions resulting from these low a -values suggests these populations are vulnerable to extinction. However, if hatchery fish are less efficient at producing natural offspring compared to wild fish, these low a -values may be more the result of averaging the poor reproductive performance of hatchery spawners (very low a -values) with the relatively healthy reproductive performance of wild fish (moderate a -values). To explore this possibility, alternate recruitment modeling was done for these three populations (Molalla and Sandy rivers winter steelhead, and Kalama River summer steelhead).

Direct evidence reported by Chilcote et al. (1986), Leider et al. (1990) and Hulett (WDFW personal communication) for steelhead populations in the Kalama Basin suggests the natural reproductive success of hatchery fish ranged from 0.05 to 0.20 relative to wild fish. Assuming a reproductive success for hatchery spawners (RS_h) of 0.15 relative to wild fish, the effective number of spawners for each of these populations was recalculated as:

$$\text{Effective Spawners} = \text{Spawners}_{\text{wild}} + (\text{Spawners}_{\text{hatchery}} \times 0.15)$$

Using these effective spawner calculations, the resulting recruitment model parameter estimates suggest healthier wild populations with a -values all near or greater than 0.50 (Table 3). If these estimates represent the reproductive performance of the wild fish in these basins (which they apparently do at least for the Kalama), are the mechanisms which protect the reproductive capacity of wild spawners secure?

Table 3. A comparison of estimated Ricker recruitment parameters for three populations of steelhead under the scenario hatchery spawners where reproductively equal to wild spawners ($RS_h = 1.00$) versus the scenario where the reproductive success of hatchery spawners is 0.15 relative to wild spawners ($RS_h = 0.15$); a = estimated Ricker parameter and N^* = estimated population equilibrium level.

Population	$RS_h = 1.00$			$RS_h = 0.15$		
	a	N^*	R^2	a	N^*	R^2
Molalla	-0.0278	< 10.0	0.16	0.4736	23.9	0.15
Sandy	0.3383	1,060	0.11	0.6564	1,522	0.07
Kalama _{SR}	-0.2297	< 300	0.76	0.7915	1,339	0.67

Mechanisms that may prevent the accumulation of reproductively maladapted genetic characteristics from hatchery fish into the wild population may include temporal separation in spawn timing, the use of hatchery broodstocks from local wild populations, and natural selection on the wild population removing the introduced genetic material from hatchery fish faster than it is added with each year of additional hatchery spawners. However, it is unknown how effective such influences are in protecting the long-term reproductive potential of wild populations. The collective experience with hatchery steelhead programs in the Pacific Northwest extends back only 50 years, a relatively short time period when trying to make inferences about the health of wild steelhead populations 100+ years into the future.

Therefore, the assessments of steelhead populations presented in this report are based on the conservative assumption that the superior reproductive performance of wild fish compared to hatchery fish cannot be guaranteed over the next 100 years in populations where significant genetic and ecological interactions with hatchery fish are expected to continue. To forecast the future health of steelhead populations under the opposite assumption, that the reproductive differences can be maintained and relied on in the future, would be unacceptably optimistic.

Assessment Criteria

Three indicators of population and ESU health were used to assess the magnitude of extinction risk to steelhead in Oregon: 1) the long-term probability of quasiextinction, 2) the short-term probability of quasiextinction under a “what if” scenario of exceptionally poor environmental conditions, and 3) identification of populations that are at risk of reproductive failure and extirpation from observed trend data, interactions with hatchery fish, or other factors.

For each indicator criteria were developed defining the boundaries of four designations: Endangered, Threatened, Sensitive, and Secure. As implied earlier, these designations relate only to the issue of species extinction. For example, a designation of Secure does not mean a population is abundant and its habitat is in good condition. It means only that the population is not currently at risk of extinction. These criteria and associated rationale are presented as follows.

1. Long-term Probability of Quasiextinction Indicator

Endangered - A > 20% probability of quasiextinction within 60 years.

Threatened - A > 5% probability of quasiextinction within 100 years.

Sensitive - A > 5% probability of quasiextinction within 100 years should relative survivals decrease to 1/2 of the previous 25-year (1972-97) average.

Secure - A ≤ 5% probability of quasiextinction within 100 years should relative survivals decrease to 1/2 of the previous 25-year (1972-97) average.

The criteria for Endangered and Threatened are very similar to those presented by Mace and Lande (1991), with three exceptions. First, Mace and Lande (1991) state these criteria in terms of the probability of extinction (zero individuals left in the population), while the criteria used in this report are stated in terms of the probability of quasiextinction (a number greater than zero). Second, the name “Threatened” was substituted for their “Vulnerable” category, and a more conservative 5% probability of extinction was used compared to the 10% probability proposed by Mace and Lande (1991). The latter change was made to be comparable with other assessments directed specifically at salmon and steelhead (Thompson, 1991 and Allendorf et al., 1996). The quantitative quasiextinction model described earlier was used to calculate the probabilities of quasiextinction for each population.

2. Resistance to Short-term Stress Indicator

Endangered - A > 50% probability of quasiextinction within 12 years should relative survivals be 1/4 of the previous 25-year (1972-97) average.

Threatened - A > 20% probability of quasiextinction within 12 years should relative survivals be 1/4 of the previous 25-year (1972-97) average.

Sensitive - A > 5% probability of quasiextinction within 12 years should relative survivals be 1/4 of the previous 25-year (1972-97) average.

Secure - A ≤ 5% probability of quasiextinction within 12 years should relative survivals be 1/4 of the previous 25 year (1972-97) average.

The short-term stress indicator was designed to address some of the inherent inadequacies of the long-term probability of quasiextinction indicator. Specifically, the long-term indicator is based on model run results that assume the relative survival rates over the next 100 years will average those of the last 25 years ($V = 0$ in equation 1). Given the way variation is introduced into this model it is unlikely that a string of poor survivals or good survivals will be selected. However, important survival factors such as ocean conditions and rainfall patterns are known to often occur in consecutive years. A bad ocean condition in one year often is followed by bad ocean conditions the following year. With such concerns in mind, the short-term indicator was based on the results of model runs where a population has been subjected to the stress of 12 consecutive years of very poor survival conditions (i.e., relative survivals 1/4 of what they have been over the last 25 years). The criteria for each status designation were loosely developed from the categories proposed by Mace and Lande (1991).

3. Observed Extirpation Warnings

Endangered - Greater than 30% of the populations in the ESU are at risk of extirpation based upon observed trends in abundance, hatchery fish interactions or other factors.

Threatened - Greater than 20% of the populations in the ESU are at risk of extirpation based on observed trends in abundance, hatchery fish interactions, or other factors.

Sensitive - Greater than 10% of the populations in the ESU are at risk of extirpation based on observed trends in abundance, hatchery fish interactions, or other factors.

Secure - Less than 10% of the populations in the ESU are at risk of extirpation based on observed trends in abundance, hatchery fish interactions, or other factors.

Extinction of a species (or ESU) is usually forewarned by the extirpation of a subset of the less productive populations. In most cases, a species is not lost in a single and simultaneous collapse of all constituent populations. Therefore, the percentage of populations that have gone extinct in the recent past, or are likely to go extinct in the near future, should have predictive value in terms of the overall health of an ESU.

To date, steelhead populations in Oregon have been strongly resistant to extirpation. The only populations known to have been lost in Oregon are those that were physically blocked by dams from their production areas. In contrast, examples of extirpated populations of coho, chinook, chum, and sockeye salmon are relatively common. Biologically, steelhead are a more robust species and have life history features that better allow them to survive under extreme conditions. Included in these features are the capacity to spawn more than once, the ability to exist under low density conditions, a more generalist approach to habitat utilization, and the option of completing their entire life cycle in freshwater as resident trout should ocean conditions or migration corridors become unduly hostile. Therefore, the extirpation of only a few populations of steelhead is a very strong indicator that the continued existence of the ESU is at risk.

The criteria for this indicator (observed extirpation warnings) were moderately subjective in terms of what qualifies as a clear warning of extirpation and what percentage populations must be at risk of extirpation to qualify an ESU for one of the four classifications (i.e., endangered, threatened, sensitive, and secure).

The quantitative quasiextinction model was used to help with this latter problem, the identification of boundaries between the four ESU classifications. To do this, a sequence of model runs was performed with incrementally fewer spawners in the starting population. To standardize across all populations, the starting population number was stated as some fraction of the natural population equilibrium level, N^* . The model was run at 18 starting population levels ranging from $0.01N^*$ to $1.0N^*$. The results are stated in terms of the percentage of populations predicted to go extinct in 100 years.

The results suggest once 10% of the populations have become extirpated due to stress, increasing this stress only a small amount yields an incrementally greater response in the percentage of extirpated populations (Figure 1). The criteria for this indicator were selected to capture the range in the percentage of extirpated populations between 10% and 30% where the transition of at-risk populations changes most dramatically.

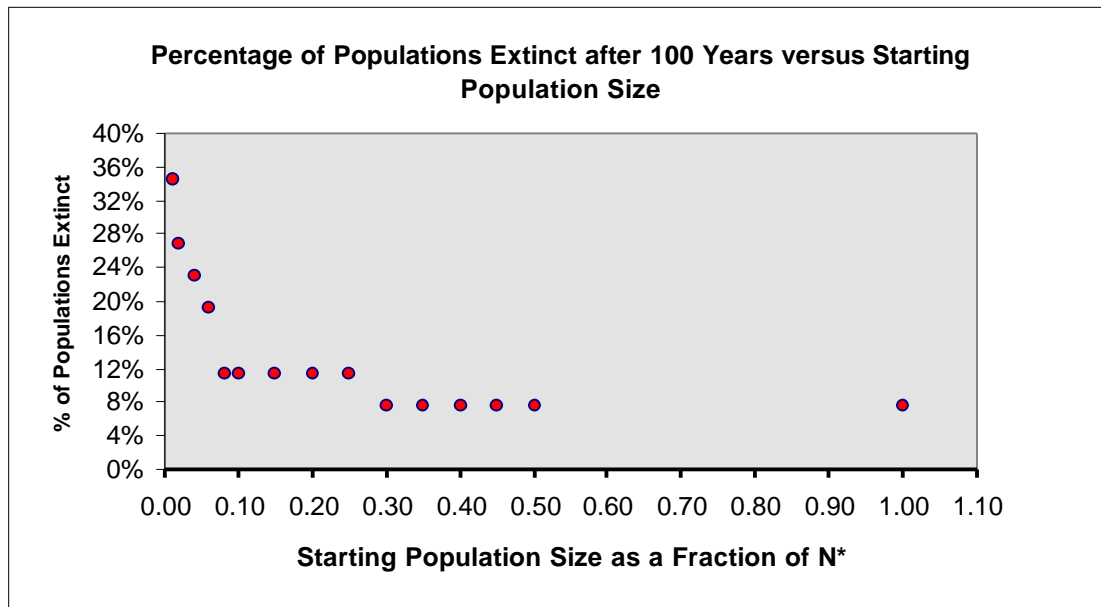


Figure 1. Quasiextinction model run results in terms of percentage of 26 steelhead populations that go extinct after 100 years, starting with various population sizes expressed as a fraction of population equilibrium, N^* .

Three factors were considered as extirpation warnings under this indicator: critically low abundance, sudden downward trends in abundance, and excessive numbers of hatchery fish spawning with the natural population. In extreme circumstances, any one of these factors can cause reproductive failure of the population and, therefore, extirpation.

Critically low abundance and extreme downward trends in abundance were subjectively determined from abundance graphs for each population. Quasiextinction levels for each population and the rate of decline of six-year moving averages of pre-harvest abundance served as the contextual background for making these critical determinations. Trends in abundance were presented in terms of a six-year moving average for wild fish. The moving averages tend to smooth out some of the year-to-year fluctuations in abundance while retaining a degree of sensitivity to the most recent observations.

The critical level at which the presence of naturally spawning hatchery fish posed a risk to the continued existence of a wild population was determined in a more quantifiable fashion. The estimated average percentage of hatchery fish for the 26 populations modeled in this report ranged from 0% to 77%. A regression of Ricker a parameters versus percent hatchery fish revealed that 57% of the variation in the a parameter could be explained by differences in the percentage of hatchery fish in the spawning population. This statistically significant relationship ($p < 0.001$), suggested those populations with a high percentage of naturally spawning hatchery fish had low productivity, demonstrated by low values for recruitment parameter a (Figure 2). While an interesting observation in itself, the existence of this relationship across populations living in such diverse habitats (from the Snake River Basin to the south coast of Oregon) is particularly striking.

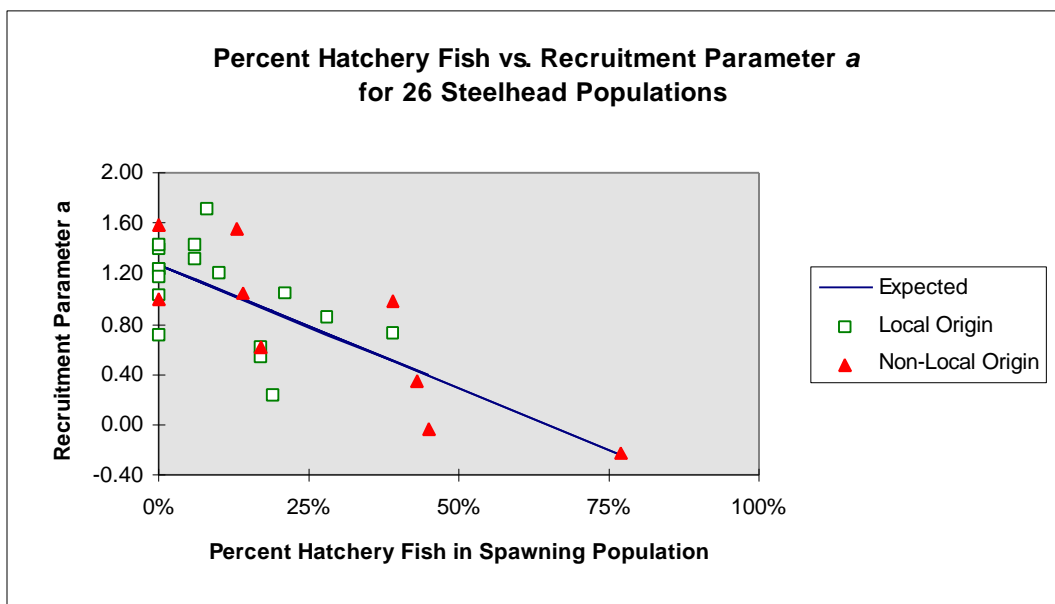


Figure 2. Average percent hatchery fish in 26 natural steelhead populations in Oregon versus corresponding Ricker recruitment model parameter a estimates for the same time period.

Also interesting is the lack of sensitivity this relationship has to the type of hatchery fish. There is no clear evidence that hatchery fish developed from local wild populations are superior to hatchery fish from non-local populations in terms of natural recruitment. This indicates that in terms of possible adverse impacts on the productivity of wild populations, the percentage of hatchery fish in a natural spawning population is more important than the origin of the hatchery stock involved.

Populations of steelhead whose Ricker a -value are less than 0.00 are not replacing themselves at any spawner density and, therefore, are in reproductive failure. Based on the relationship described above (Figure 2), this reproductive failure point occurs when hatchery fish comprise more than 65% of the naturally spawning population.

A conservative interpretation of these findings would indicate that when hatchery fish comprise more than 50% of the natural spawning population there is an unacceptable risk of reproductive failure and, therefore, possible extirpation. This interpretation was used to evaluate the hatchery fish risk for all steelhead populations for which there was sufficient hatchery:wild spawner composition data.

It should be noted that the apparent inverse relationship between percent hatchery fish and recruitment parameter a -values does not necessarily mean that wild fish in populations with a high percentage of hatchery spawners have been genetically damaged. As discussed in the Reproductive Success of Hatchery Fish section, another possibility is that these low a -values are more the result of averaging the poor reproductive performance of hatchery spawners (very low a -values) with the relatively healthy reproductive performance of wild fish (moderate a -values). In such a case, the wild population retains its reproductive potential and, therefore, its resistance to extinction.

However, such an interpretation can only be confidently made for populations in which the reproductive success of hatchery and wild fish have been directly measured (steelhead populations in the Kalama River, for example). In other cases, the interpretation of low values for the recruitment parameter a are ambiguous. Due to this ambiguity, the approach to the criteria for this indicator conservatively assumes that high percentages of hatchery spawners will genetically damage the reproductive resiliency and potential of the wild population.

Determination of ESU Status

Three population status indicators, described previously, were used to quantitatively determine the status of each steelhead ESU (Long-term Probability of Quasiextinction, Resistance to Short-term Stress, and Observed Extirpation Warnings). The third indicator (Observed Extirpation Warnings) stated the results directly at the ESU level. However, for the other two indicators, ESU level scores required the average of individual population scores within each ESU by assigning the values: endangered = 4, threatened = 3, sensitive = 2, secure = 1.

ESU scores for all three indicators were averaged to obtain an overall score for each ESU. The score was rounded to the nearest whole number, and a status assigned accordingly (i.e., 4 = endangered, 3 = threatened, 2 = sensitive, and 1 = secure).

Klamath Mountains Province ESU Status Assessment

Naturally Spawning Hatchery Fish

The estimated percentage of naturally spawning fish that are hatchery fish in this ESU, averaged across all populations is 15% (Table 4). For almost every population, the percentage of hatchery fish was substantially less than presented by Busby et al., (1994). The specific details of these estimates for each population are discussed in the following paragraphs.

Table 4. Estimated percentage of naturally spawning steelhead populations that are hatchery fish in Oregon's portion of the Klamath Mountain Province ESU.

<u>Population</u>	<u>Time Period</u>	<u>Percent Hatchery</u>	<u>n</u>	<u>Source</u>
Elk River - WR	1991-92	4%	82	creel surveys
Euchre Crk - WR	1991-94	11%	na	analysis of strays
Rogue - WR	1975-96	5%	na	dam counts & hatchery returns
	1992-97	5%		
Rogue - SR, upper	1975-96	14%	na	dam counts & hatchery returns
	1992-97	27%		
Rogue - SR, lower	1975-96	< 5.0%	na	analysis of strays
Applegate - WR	1983-97	29%	na	hatchery returns
Applegate - SR	na	na	na	na
Illinois - WR	1975-96	< 5.0%	na	analysis of strays
Hunter Cr - WR	1991-94	11%	na	analysis of strays
Pistol Cr - WR	1991-92	11%	na	analysis of strays
Chetco - WR	1991-94	30%	1049	creel surveys
Winchuck - WR	1991-94	18%	183	creel surveys
ESU Average	most recent data	15%	na	variety

Non-Rogue Populations - For those populations outside of the Rogue Basin, the estimates of percent hatchery fish were based on data from creel surveys conducted in the Chetco, Winchuck, and Elk rivers as presented by Lindsay et al. (1992, 1993, and 1994).

With the exception of the Chetco River, none of these non-Rogue basins are stocked with hatchery fish. Therefore, all hatchery fish observed are strays from other unknown locations. The average percentage of hatchery fish observed in the Elk and Winchuck rivers (11%) was used as a best estimate of hatchery percentage in Pistol River, Euchre Creek, and Hunter Creek.

Rogue Winter Steelhead - Estimates of winter steelhead returning to the upper Rogue Basin have been made from fish counts at Gold Ray Dam since 1943. Beginning with

the hatchery program, these fish have been classified as either wild or hatchery. Since 1975, trap records at Cole Rivers Hatchery indicate that most of the hatchery fish which passed over Gold Ray Dam continued upstream to their release site at the hatchery (Table 5). These data were used to estimate the number of hatchery fish that did not return to Cole Rivers Hatchery and strayed to presumably spawn in the wild. The following logic was used to develop these estimates. It is known that fish entering the upper river are subjected to a fishery which removes a portion of both hatchery and wild fish. An exploitation rate for the upper Rogue of 8%, as suggested by Kenaston (1989), was used to estimate the magnitude of this fishery mortality, except for those years after 1992, when catch and release regulations for wild steelhead were in effect. For these years, it was assumed that the mortality rate on caught and released steelhead was 10% resulting in an overall fishery mortality rate on wild steelhead of $(10\%) \times (8\%) = 0.8\%$.

Table 5. Annual estimates of winter steelhead passing Gold Ray Dam, hatchery winter steelhead trapped at Cole Rivers Hatchery, and the proportion of naturally spawning winter steelhead populations in the upper Rogue River that were hatchery fish.

Year	Wild Count	Hatchery Count	Hatch @ Trap	Wild Escapm	Hatch Escapm	% Hatchery
1975	7438	829	514	6843	249	3.5
1976	5015	187	711	4614	0	0.0
1977	4130	503	357	3800	106	2.7
1978	4904	760	842	4512	0	0.0
1979	9761	2818	1681	8980	912	9.2
1980	8865	2942	1513	8156	1194	12.8
1981	5729	1743	987	5271	617	10.5
1982	4579	1634	1061	4213	442	9.5
1983	7145	1451	1468	6573	0	0.0
1984	5445	3739	4146	5009	0	0.0
1985	8973	1345	1566	8255	0	0.0
1986	1569	1813	1114	10643	554	4.9
1987	12677	3536	2399	11663	854	6.8
1988	10982	2687	2036	10103	436	4.1
1989	9429	4307	2934	8675	1028	10.6
1990	6721	2206	1687	6183	343	5.3
1991	2919	1399	870	2685	417	13.4
1992	2979	865	622	2955	174	5.6
1993	4345	1568	1042	4310	401	8.5
1994	4940	888	643	4900	174	3.4
1995	8628	1956	1138	8559	662	7.2
1996	7338	1417	1855	7279	0	0.0
1997	11001	2633	2025	10913	397	3.5

Hatchery fish trapped at Cole Rivers Hatchery were either removed for broodstock or returned to the river. Although natural spawning of hatchery fish was likely restricted to a very small portion of the river downstream of the hatchery, in some years during the 1980s trapped fish were trucked and released into various streams

in the Rogue Basin. In the last four years, hatchery fish trapped at Cole Rivers Hatchery have been trucked and released into Emigrant Reservoir, which is inaccessible to wild steelhead.

In some years, the count at Gold Ray Dam for hatchery fish was less than the number trapped at Cole Rivers Hatchery (Table 6). For these years, the trap count plus an 8% fishing mortality was used to estimate the number of hatchery fish that migrated above Gold Ray Dam. Estimates of wild and hatchery fish that escaped both the fishery and the trap at Cole Rivers Hatchery were used to determine the percentage of hatchery fish in the natural spawning population. While variable, the average percentage of hatchery fish from 1975 to 1997 was 5.3%. This estimate is consistent with ODFW's observations at an upstream migrant trap located on Elk Creek, a Rogue River tributary five miles downstream from Cole Rivers Hatchery. The percentage of hatchery steelhead at the Elk Creek trap has not exceeded 4.0% in three years of operation. Given the proximity of Elk Creek to the hatchery, these observations support the contention that nearly all of the hatchery fish home back to Cole Rivers Hatchery and away from natural spawning areas.

Table 6. Annual estimates of summer steelhead passing Gold Ray Dam, hatchery summer steelhead trapped at Cole Rivers Hatchery, and the proportion of naturally spawning summer steelhead population in the upper Rogue River that were hatchery fish.

Brood Year	Wild Count	Hatchery Count	Hatch @ Trap	Wild Escapm	Hatch Escapm	% Hatchery
1975	7385	2573	270	6794	2097	23.6%
1976	6746	2438	198	6206	2045	24.8%
1977	2674	946	866	2460	29	1.2%
1978	10371	3184	2389	9541	540	5.4%
1979	3980	1185	1569	3662	53	1.4%
1980	11831	4600	4312	10885	145	1.3%
1981	5592	2605	3068	5145	103	2.0%
1982	7955	4098	7298	7319	246	3.3%
1983	10044	4742	7620	9240	257	2.7%
1984	5038	2845	3046	4635	103	2.2%
1985	5104	2437	3090	4696	104	2.2%
1986	8348	2501	1723	7680	578	7.0%
1987	9786	6186	4783	9003	908	9.2%
1988	12959	13346	10451	11922	1827	13.3%
1989	11273	8869	7745	10371	414	3.8%
1990	5613	8358	5457	5164	2232	30.2%
1991	1633	4555	1960	1502	2231	59.8%
1992	3231	1208	1285	2973	43	1.4%
1993	4043	1953	1093	4011	704	14.9%
1994	4067	7229	4555	4034	2096	34.2%
1995	4229	8706	4940	4195	3070	42.3%
1996	5517	8790	6313	5473	1774	24.5%
1997	2308	9372	6400	2054	1941	48.8%

Rogue Summer Steelhead, Upper River - The methods used to develop new estimates for the percent of hatchery fish spawning in the natural population were essentially the same as those described for Rogue winter steelhead above. However, a slightly different harvest rate of 11% was used, as suggested by Kenaston (1989). As presented in Table 6, the average percentage of hatchery fish in the natural spawning population has ranged from 1% to 59.8%. However, in the last six years it has averaged 27%.

Applegate Winter Steelhead - The methods for estimating the proportion of hatchery steelhead in the Applegate River were similar to those used for the upper Rogue. Like the Rogue, hatchery winter steelhead are trapped and removed from the river at the base of a dam, in this case Applegate Dam. However, unlike the counts of migrating fish for the Rogue populations, no counts were available for the number of fish entering the Applegate. Therefore, alternate methods were used to estimate returning fish.

For hatchery fish, it was assumed that the smolt-to-adult survival of fish released into the Applegate was the same as it was for fish released into the upper Rogue from Cole Rivers Hatchery as measured by returns at Gold Ray Dam. In other words, the proportion of the smolts that survived to enter the Applegate River as adults was assumed to be the same as the proportion of smolts released into the upper Rogue that survived to be counted as adults at Gold Ray Dam. Estimates for the number of hatchery fish returning to the Applegate River each year were made by multiplying annual smolt survival rates for the Rogue by the number of smolts released into the Applegate Basin two years previously (Table 7).

Table 7. Annual estimates of the proportion of naturally spawning winter steelhead population in the Applegate River that were hatchery fish.

Brood Year	Wild Retrtn	Hatch Retrtn	Hatch Trap	Wild Escapm	Hatch Escapm	% Hatch
1983	914	1491	415	740	793	51.7%
1984	396	1689	1117	321	251	43.9%
1985	2150	1906	946	1741	598	25.6%
1985	342	582	436	277	36	11.4%
1986	1246	2122	950	1010	769	43.2%
1987	865	1472	692	700	500	41.7%
1989	2088	3556	2880	1691	0	0.0%
1990	1560	2656	860	1263	2001	61.3%
1991	833	1418	546	674	998	59.7%
1992	508	865	348	498	551	52.5%
1993	733	1249	672	719	861	54.5%
1994	377	641	234	369	285	43.6%
1995	1389	2364	1856	1362	59	4.2%
1996	1041	1773	1436	1021	0	0.0%
1997	1525	2597	1810	1496	294	16.0%

Estimates for each year's return of wild fish to the Applegate River were made from the percentage of hatchery fish observed in fisheries near its mouth (an average of 63%) and the estimated return of hatchery fish to the basin in the same year.

For each year, the number of naturally spawning hatchery and wild fish was estimated by subtracting the number of fish removed by both the trap and the Applegate River sport fishery from the total number estimated to have returned to the basin. The fishing mortality rate used in these calculations was 19%, as suggested by Kenaston (1989).

Hatchery fish comprised a larger percentage of the natural spawners than elsewhere in the Rogue Basin (Table 7). From 1992 to 1997 an average of 29% of the natural spawning population was hatchery fish. It should be noted that in recent years, all fish trapped from the Applegate have been transported and released into Applegate Reservoir, which is inaccessible to the wild population. As a result, the percentage of hatchery fish in the natural spawning population has decreased to an average of less than 7% in the last three years.

Middle Rogue Summer Steelhead and Illinois Winter Steelhead - Direct estimates of naturally spawning hatchery fish for these populations were not available. However, the nearest release sites for hatchery smolts are considerably upstream at Cole Rivers Hatchery and the Applegate River. In view of the low incidence of hatchery strays estimated for the upper Rogue, it was assumed the percentage of hatchery strays in naturally spawning populations of the middle Rogue and Illinois were less than 5%.

Population Abundance, Trends, and Recruitment

Non-Rogue Populations - As stated earlier, ODFW has reservations about using catch information to estimate the abundance and trends of wild populations. While ODFW does not have a better estimate of adult abundance for these populations, the results from recent smolt trapping in the Elk River, Hunter Creek, and the Winchuck River are relevant to the assessment of these populations.

From 1985 to 1996, a juvenile migrant trap was operated in the Elk River at RM 14.5 to estimate the annual number of salmonid emigrants from a portion of the Elk River Basin. As Figure 3 illustrates, steelhead smolt production for this portion of the Elk River Basin has ranged from 2,028 in 1992 to 7,977 in 1994. Assuming an average smolt-to-adult survival of 10%, these smolt numbers suggest that adult returns of 200 to 800 wild steelhead are being produced by this portion of the basin. In addition, the smolt numbers show no obvious trend over the last 11 years, unlike the 8% average rate of decline per year claimed by Busby et al. (1996) for this population.

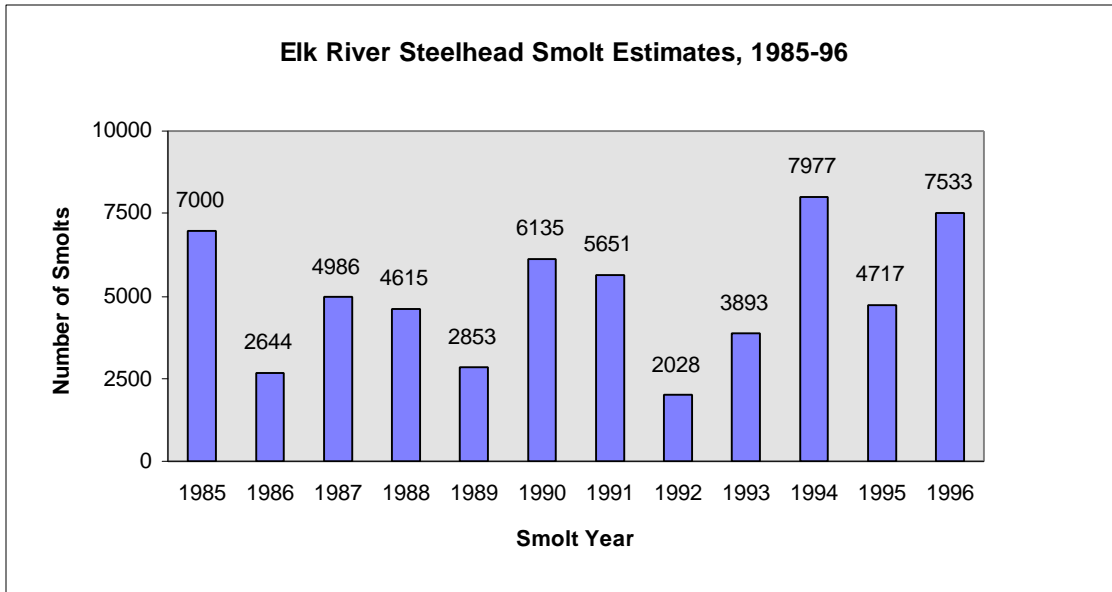


Figure 3. Estimated number of steelhead smolts emigrating from the Elk River, 1985-96.

In 1996 and 1997, juvenile migrant traps were operated in Hunter Creek and the Winchuck River. These traps were located within the Hunter Creek and Winchuck watersheds, and sampled approximately 50% and 61% of the steelhead production area, respectively. The steelhead smolt estimate for Hunter Creek was 3,363 in 1996 and 3,281 in 1997 (Confer, 1996 and Confer, 1997). For the Winchuck, 3,962 steelhead smolts were estimated in 1996 and 5,667 smolts in 1997. Expanded for the entire basin, the two-year average smolt production for Hunter Creek was 6,644 smolts and for the Winchuck River 7,892. Assuming a 10% ocean survival, these smolt migrations would yield roughly 650 to 700 returning adults to each of these two basins.

Rogue Winter Steelhead - Spawning escapement estimates for wild winter steelhead in the Rogue Basin above Gold Ray Dam averaged 6,486 fish from 1992 to 1997 (Table 5). Estimates of wild steelhead abundance indicate that since 1991 the trend for this population has been upward (Figure 4). Of perhaps more significance, the annual return and escapement of wild fish does not depart greatly from the estimated natural equilibrium, N^* , as calculated from spawner-recruit analysis. Therefore, on the average, the habitat will not sustain larger numbers of spawners than what has been observed in recent years. Confidence in such an interpretation is strengthened by the relatively narrow upper and lower bounds obtained for the N^* estimate (Figure 4).

Because hatchery fish are a minor component of the natural spawning population (less than 7%) the observed recruitment of wild fish is almost exclusively the product of wild spawners. In light of this and the number of wild spawners observed in recent years, it appears that this population is maintaining itself at maximum levels for the natural capacity of the existing habitat.

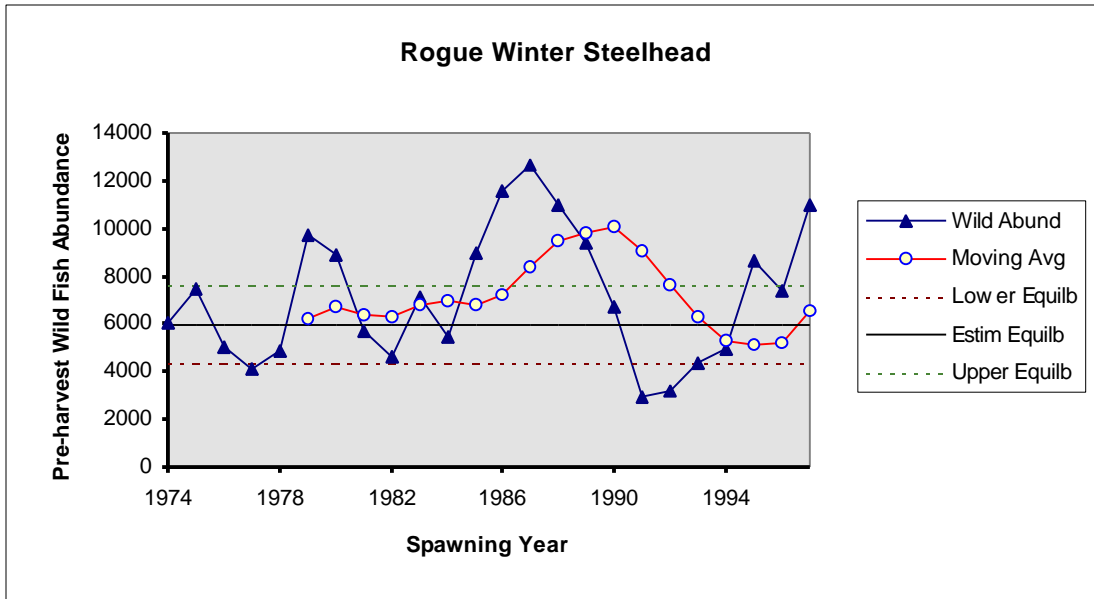


Figure 4. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Rogue River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Rogue Summer Steelhead, Upper Basin - For 1992 to 1997 brood years, the average number of wild summer steelhead spawning above Gold Ray Dam was 3,790 fish (Table 6). As illustrated in Figure 5, the abundance of wild summer steelhead above Gold Ray Dam declined to new low levels in 1991 and has rebounded only modestly since then. This is further evidenced by the smooth decline in the six-year moving average from 1990 to 1995.

Applegate Winter Steelhead - From 1992 to 1997, the average number of wild steelhead spawning in the Applegate River was 911 fish (Table 7). For reference, an equilibrium level of 893 fish was estimated from spawner-recruit analysis performed on this population. However, the upper and lower bounds on this equilibrium estimate encompassed a wide range of possible equilibrium levels (Figure 6). Therefore, the confidence in this equilibrium estimate was not high. Regardless, Applegate River winter steelhead have rebounded from low returns observed in the early 1990s to levels that appear to be on an upward trend.

Rogue Summer Steelhead, Middle Basin - Tributaries to the Rogue River below Gold Ray Dam historically have served as spawning areas for summer steelhead (Everest, 1973). ODFW considers fish that utilize these areas a separate population from the upper basin summer steelhead. While the information available for this population is quite limited, spawners per mile in tributary spawning streams has dropped significantly. The six-year moving average of these data show an almost steady decline for the entire time period (Figure 7).

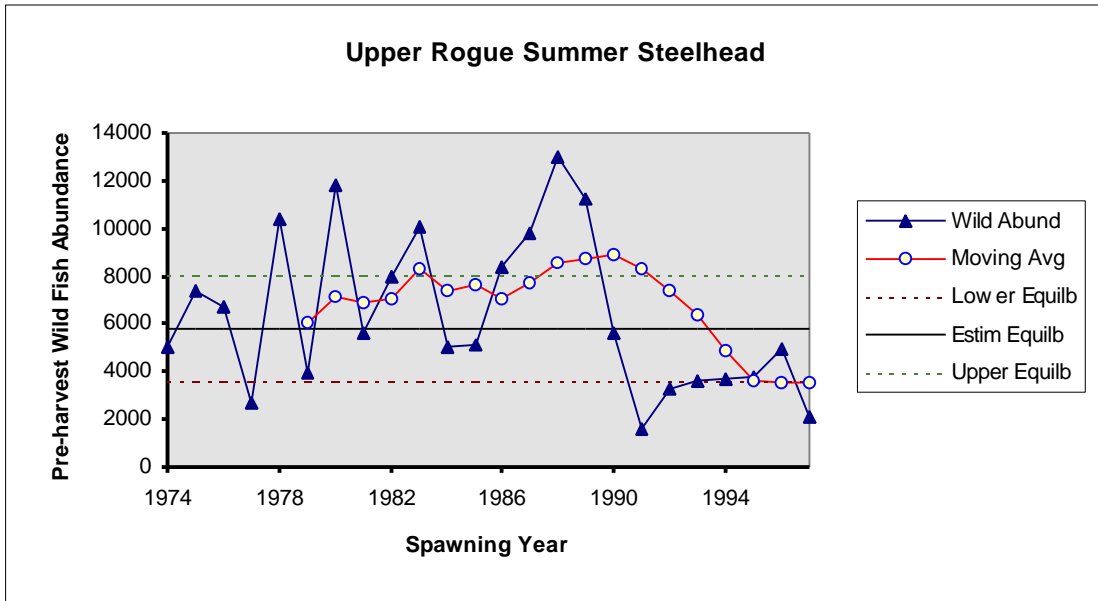


Figure 5. Annual and six-year moving average estimates of the pre-harvest abundance of wild summer steelhead in the upper Rogue River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

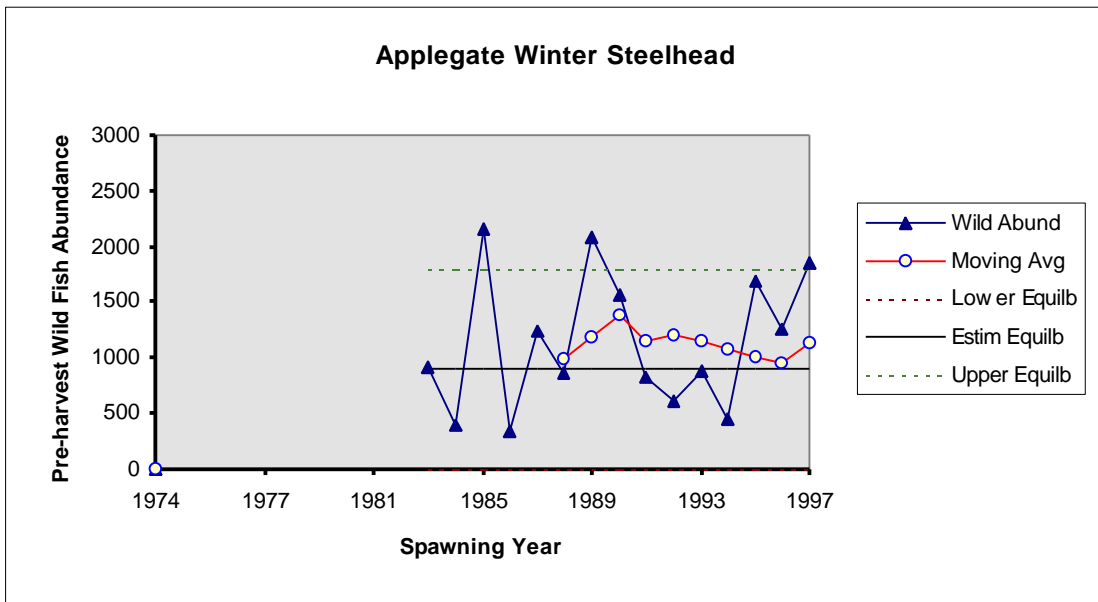


Figure 6. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Applegate River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

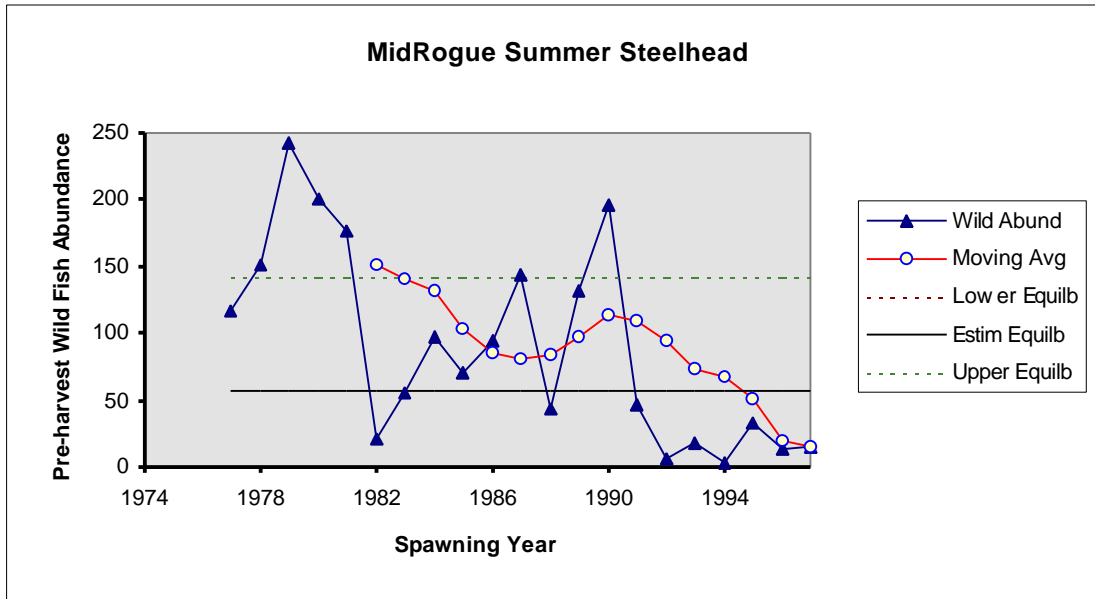


Figure 7. Annual and six-year moving average estimates of the pre-harvest abundance of wild summer steelhead in the middle Rogue River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The life history of this middle basin summer steelhead population differs somewhat from the upper summer-run population. Not only does the mid-river population appear to return later as adults, but also many spawners utilize tributaries that typically dry up by early summer.

Fish produced in such tributaries must hatch and migrate downstream to the Rogue to avoid being stranded in these streams as they go dry (Faudskar, 1980). Given this life cycle characteristic, this population would appear to be very sensitive to drought and human activities that result in removal of water from these tributaries.

In recent years the growth in water demand by the increasing human population in this area of the Rogue Basin has probably played a significant role in the observed decline of these steelhead. The biological impact of these changes was undoubtedly worsened by the extended drought cycle recently experienced in the Rogue Basin. On top of this, a somewhat coinciding period of low ocean survivals has also been in effect. This combination of factors likely explains why this steelhead population appears to be declining. It is unknown if a return to a more normal pattern of precipitation and improvement in ocean survivals will make enough difference for this population to recover. ODFW remains concerned about the fate of the middle Rogue summer steelhead population.

ESU Status Synthesis

Quasiextinction Assessment Results - None of the four populations examined met the assessment model criteria for endangered (greater than 20% probability of quasiextinction in 60 years) or threatened status (greater than 5% probability of quasiextinction in 100 years) (Table 8). However, both the middle Rogue summer steelhead and the Applegate winter steelhead populations qualified for sensitive status under this indicator (greater than 5% probability of quasiextinction in 100 years if life cycle survival drops to 1/2 of what has been over the last 25 years).

Table 8. Probability of quasiextinction estimates for three populations of steelhead in the Klamath mountains province ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
Upper Rogue SR	0.000	0.000	0.000
Middle Rogue SR	0.000	0.000	0.620
Rogue WR	0.000	0.000	0.000
Applegate WR	0.000	0.000	1.000

Hatchery Fish - There is little evidence that hatchery fish are presently interbreeding with wild fish at the level claimed by Busby et al. (1994). Nor is there any evidence that such high rates will occur in the future given management changes that have occurred. Within Oregon’s portion of this ESU, only 15% of the naturally spawning fish, averaged across all populations, are hatchery fish. The highest estimated proportion of hatchery fish in any of the spawning populations was 29% for Applegate winter steelhead (Table 4).

The large discrepancy between estimates of naturally spawning hatchery fish of Busby et al. (1994) and those presented in this report has several possible origins. Busby et al. (1994) essentially made an *a priori* assumption that hatchery fish homed very poorly to smolt release sites and therefore strayed widely upon return. Based on evidence presented earlier in this report, wherein a physical accounting of hatchery fish returning to traps in tributary streams and Cole Rivers Hatchery was examined, it appears that an *a priori* assumption of widespread straying is not correct. In addition, new hatchery:wild ratio information has become available in recent years that is being presented for the first time in this report.

Trends in Abundance - Of the seven major populations examined, two appear to be in decline, both of which are summer steelhead (upper Rogue and middle Rogue populations). This is in contrast to the conclusion reached by Busby et al. (1994) that “...trends in abundance have been downward in most populations for which NMFS has data within the ESU,...” . One likely reason for this difference is that the time series used by Busby et al. (1994) ends in 1991. The abundance estimates presented in this report extend another six years, to 1997. The analysis presented here suggests

that 1991 was the low point for several populations in a decline that started in the late 1980s.

Self-Sustaining - The results of the analyses presented in this report do not support the claim by Busby et al. (1994) that “*We are unable to demonstrate that any steelhead stocks in this region are naturally self-sustaining.*” With the possible exception of the middle Rogue summer steelhead, all populations examined appear to be self-sustaining. While the upper Rogue summer steelhead population has declined in recent years, it does not appear to have lost its ability to be self-sustaining. For the Applegate and upper Rogue winter steelhead populations, recruitment analysis leads to the conclusion that these populations are relatively secure and functioning normally.

It appears Busby et al. (1994) reached nearly the opposite conclusion on the issue of self-sustaining populations for at least two reasons. First, they lacked the benefit of updated information on how many hatchery fish were likely spawning with the wild population. Therefore, they were counting more spawners than actually existed, causing smaller Natural Replacement Ratios (NRR).

Second, Busby et al. (1994) erred in using NRRs without placing them in the context of spawner abundance. To derive a useful interpretation from NRRs, spawner abundance with respect to habitat carrying capacity must be addressed. A population that is larger than its natural equilibrium point, N^* , will generate fewer recruits per spawner and, therefore, a NRR of less than 1.0. Although Busby et al. (1994) used the finding of NRRs less than 1.0 to argue that these populations were not self-sustaining, this is only one possible explanation of such results. Lacking any reference to system capacity or natural equilibrium levels, it is just as logical to argue that these populations are consistently robust and comprised of more spawners than necessary to fully seed the available habitat. In other words, these populations are most definitely sustaining themselves. The assessment of these populations presented by Busby et al. (1994) presents NRRs in such an ambiguous light that a biologically meaningful interpretation is impossible.

ESU Status - As described in the methods section, three indicators were used to assess the status of each steelhead ESU. None of the four populations modeled for long-term quasiextinction probabilities met the threshold for endangered or threatened status. However two of them did qualify for sensitive status. This resulted in a net score for this indicator of 1.5 (Table 9).

Table 9. Summary of status determination scores for the Klamath Mountains Province ESU based on three individual indicators: Long-term PQM (long-term probability of quasiextinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
1.5	1.3	1.0	1.3

For the short-term stress indicator, a scenario where the relative survival collapses to 1/4 of the 25-year average, the quasiextinction model results suggest that one of the populations meet the criteria for a sensitive classification while the remaining three would get a secure classification. The average of the scores for this indicator was 1.3.

Of the 12 populations examined, only the middle Rogue population was judged to be displaying an extirpation warning on the basis of the magnitude and duration of spawner abundance. However, with only 8% of the populations falling into this condition (1/12), the extirpation warning indicator score for this ESU was 1.0, or a classification of secure.

Averaging the scores of all three indicators, the overall status assessment score for this ESU was 1.3 (Table 9). Based on this result, a status classification of **SECURE** was assigned to the KMP ESU.

This quantitative assessment is generally supported by other information available for populations in this ESU. Smolt estimates from Elk River show no downward trends and suggest smolt production is near current habitat capacity. The magnitude of smolt production in the Winchuck River and Hunter Creek also support the conclusion that these populations remain relatively productive. There is little indication that populations in this ESU are failing to sustain themselves, nor is there evidence that large numbers of stray hatchery fish are spawning with wild fish.

Oregon Coast ESU Status Assessment

Naturally Spawning Hatchery Fish

Large changes in steelhead management programs have occurred in populations belonging to this ESU since 1991. For example, in 1994 the Oregon Fish and Wildlife Commission approved a package of Wild Fish Management Policy (WFMP) implementation strategies which were intended to reduce the number of hatchery fish spawning with wild fish. In addition, 1992 was the first year of angling regulations requiring the release of wild fish for nearly all of the steelhead fisheries within this ESU. Therefore, a comprehensive revision of estimates for the percentage of hatchery fish in naturally spawning steelhead populations was made for this ESU. Previous estimates of percent hatchery fish in natural spawning populations of steelhead, such as those presented by Busby et al. (1996), are out-of-date because they are largely based on pre-1992 data and, therefore, do not reflect recent changes.

A summary of percent hatchery fish estimates plus a detailed, population-by-population description for the justification of these revisions is provided in this section. Overall, the revised estimates suggest that across the entire Oregon Coast ESU, the proportion of hatchery fish in naturally spawning populations is 23% in recent years (Table 10). This is a substantial change from the 52% average for these same basins provided by Busby et al. (1996).

Table 10. Estimated percentage of naturally spawning steelhead populations that were hatchery fish in the Oregon Coast ESU.

<u>Population</u>	<u>Pre-1992 Estimate</u>	<u>1997 Revised Estimate</u>	<u>WFMP Hatch Stock Type^a</u>
Necanicum	63%	63%	3
North Nehalem	37%	20%	3
Lower Nehalem	24%	5%	3
Upper Nehalem	26%	5%	3
Miami	48%	10%	3
Kilchis	66%	66%	3
Wilson	51%	30%	2
Trask	55%	15%	3
Tillamook	69%	10%	3
Nestucca	34%	15%	3
Little Nestucca	79%	10%	3
Salmon	70%	10%	3
Siletz, Winter-run	57%	20%	2
Drift Cr (Siletz B.)	58%	10%	3
Siletz, Summer-run	90%	90%	2 (special rehab program)
Yaquina	none given	60%	3
Alsea	71% (average)	20%	3
Drift Cr (Alsea B.)	71% (average)	10%	3
Yachats	10%	5%	3

Table 10. Continued.

<u>Population</u>	<u>Pre-1992 Estimate</u>	<u>1997 Revised Estimate</u>	<u>WFMP Hatch Stock Type^a</u>
Tenmile Cr	27%	5%	3
Big Cr	10%	5%	3
NF Siuslaw	49%	10%	3
Siuslaw	49%	30%	2
Smith	48%	5%	3
N Umpqua, W-r	10%	5%	3
N Umpqua, S-r	62%	25%	2
S Umpqua	62%(average)	38%	2
Tenmile Cr	80%	15%	3
Millicoma (Coos B)	65%	40%	2
Coos	70%	40%	2
Coquille	75%	45%	2
S Coquille	55%	45%	2
Floras	32%	5%	3
Sixes	36%	5%	3
Averages	52%	23%	

^a Wild Fish Management Policy (WFMP) hatchery stock types: Type 3 = out-of-basin origin and/or highly domesticated stock (maximum 10% of natural spawning population can be Type 3 hatchery fish), Type 2 = developed from local wild broodstock, wild fish added each generation to broodstock (maximum 30% of natural spawning population can be Type 2 hatchery fish).

Unless described otherwise, the revised estimates of percent hatchery fish for coastal steelhead populations were based on hatchery changes initiated from 1992 to 1994, with impacts on adult returns beginning in 1996. In general, changes were made either to reduce the number of smolts released or to volitionally draw returning adult hatchery fish to areas where they would not spawn with wild fish. In the latter case, changes in release sites and smolt rearing facilities were the primary mechanisms by which hatchery fish were diverted from wild spawning areas.

In forecasting the proportion of hatchery fish in response to these changes, the following formula was used:

$$Ph_a = (Sh)(1-Rh)(Ph) / [(1-Rh)(Ph) + Pw]$$

where;

- Ph_a = estimated proportion of hatchery fish after strategy implementation,
- Sh = (number of smolts under strategy)/(number of smolt prior to strategy),
- Rh = proportion of hatchery return diverted from natural spawning areas,
- Ph = proportion of hatchery fish prior to implementation of strategy,
- Pw = proportion of wild fish prior to implementing of strategy.

While this estimation formula forecast 0% hatchery fish for populations where hatchery smolt releases had been eliminated, background straying from other ongoing hatchery programs was assumed to contribute hatchery fish to these populations. As a default it was assumed that 5% of the spawners in such populations were hatchery strays. This assumption was supported by evidence

obtained for the Sixes and Elk River populations in 1991-92 from analyses of scale samples collected from fishery caught steelhead (n = 223). These analyses indicate that 4% of the return were hatchery fish, even though hatchery smolts were not released into either of these two rivers.

Necanicum - In 1995-96, ODFW conducted an investigation to determine if the temporal separation in spawn timing between hatchery and wild fish in the Necanicum Basin was great enough for the two groups of fish to be considered as two semi-isolated populations. Preliminary results from this study suggest that while considerable separation occurs, overlap in spawn timing of hatchery and wild fish likely results in some interbreeding. Efforts to complete this assessment are still underway. Until those results are available the 63% hatchery fish estimate for this basin as described by Busby et al. (1996) will be used.

North Nehalem - Beginning in 1995, a trap was operated in a fish ladder in the upper basin to trap all migrating steelhead and pass only wild fish upstream. Overall for this basin it is estimated this action, in conjunction with wild steelhead release regulations implemented in 1992, has resulted in an estimated percentage of hatchery fish in the naturally spawning population of 20%.

Lower and Upper Nehalem - The pre-1991 hatchery spawner percentage for these two populations was likely greater than 30%. However, with the termination of the 50,000 hatchery smolt program to these areas in 1995, the percentage of hatchery fish in both locations is now estimated to be 5% or less.

Miami - The annual release of 10,000 hatchery smolts was terminated in 1995. In addition, acclimation release sites were developed in the nearby Wilson River to reduce the straying of hatchery fish from the Wilson into other Tillamook Bay streams, such as the Miami. In light of these changes, the best estimate for hatchery fish in the Miami Basin is 10%.

Kilchis - The WFMP strategy selected for this basin was the same as for the Necanicum; temporal separation of hatchery and wild spawners. However, no studies have been conducted in the Kilchis, nor have inferences been made from study results in the Necanicum, to determine if this temporal separation approach is successful. Therefore, the estimate of 66% hatchery fish for this population, as described by Busby et al. (1996), was used.

Wilson - In 1996, the transition from a 120,000 hatchery winter steelhead smolt program, based on an out-of-basin broodstock, to one developed from local Wilson wild fish was started. Since 1996, pre-release smolt acclimation ponds have been used to help draw returning hatchery fish away from natural spawning areas. Based on these changes, the estimated proportion of hatchery fish in the naturally spawning population is 30%.

Fifty-thousand summer steelhead smolts from the Siletz broodstock reared at Cedar Creek Hatchery (Nestucca Basin) are also released annually into the Wilson River. Summer steelhead are not native to the Wilson Basin. The impact of these hatchery summer steelhead on the native wild winter steelhead population is not directly known. However, analysis of a similar situation in the Clackamas Basin suggests that offspring of naturally spawning, non-native summer steelhead may cause modest decreases in the winter steelhead population. Because of the reproductively isolating spawn timing differences between hatchery summer and wild winter steelhead, at least in the case of the Clackamas, the observed reduction in productivity is likely due to intraspecific competition for juvenile rearing habitat. For additional information and analysis of this problem, refer to the status discussion for Clackamas winter steelhead presented later in this report.

Trask - No hatchery steelhead smolts are released into the Trask system. However, analysis of scales taken from steelhead returning to this basin from 1985 to 1991 indicate an average of 26% of the run were hatchery fish. With recent changes elsewhere in the Tillamook Basin to reduce strays and implementation of wild steelhead release regulations in 1992 it is estimated that the current percentage of naturally spawning hatchery fish in this basin has declined to 15%.

Tillamook - The 25,000 hatchery smolt program was terminated in 1995. A revised hatchery fish percentage of 10% for this population was made based on this action in conjunction with other changes to reduce strays in nearby basins.

Nestucca - The winter steelhead hatchery stock used in the Nestucca, although raised within the basin at Cedar Creek Hatchery, was not developed from the wild Nestucca population. Since 1991, changes have been made in terms of smolt release location, trapping of hatchery returns, and wild steelhead release angling regulations such that the estimated percentage of hatchery fish spawning in the wild is 15%.

In addition to winter steelhead, hatchery summer steelhead are raised and released into the Nestucca Basin from Cedar Creek Hatchery. The annual releases into the Nestucca Basin of this Siletz-origin hatchery stock has averaged approximately 70,000 smolts in recent years. Summer steelhead are not native to the Nestucca Basin. The impact of these hatchery summer steelhead on the native wild winter steelhead population is not directly known. However, analysis of a similar situation in the Clackamas Basin suggests that offspring of naturally spawning, non-native summer steelhead may cause modest decreases in the winter steelhead population. Because of the reproductively isolating spawn-timing differences between hatchery summer and wild winter steelhead, at least in the case of the Clackamas, it appears the observed reduction in productivity is most likely due to intraspecific competition for juvenile rearing habitat. For additional information and analysis of this problem, refer to the status discussion for Clackamas winter steelhead presented later in this report.

Little Nestucca - The 20,000 hatchery smolt program was terminated in 1995. As a result of this change in combination with efforts to reduce strays from Cedar Creek Hatchery, it is estimated the hatchery percentage for this population is 10%.

Salmon - The 35,000 hatchery smolt program was terminated in 1995. This change reduces the percentage of hatchery fish in the naturally spawning population to 5%.

Siletz, Winter Steelhead - The hatchery smolt program was reduced from 80,000 to 50,000 fish in 1995. This will reduce the proportion of hatchery fish in the naturally spawning population to 20%. In addition, a new hatchery stock was initiated in 1996 and will be the source for all future hatchery winter steelhead smolt releases.

Siletz, Summer Steelhead - An emergency action was implemented in 1995 to rebuild the extremely depressed wild population with the existing hatchery broodstock originally developed from the Siletz Basin steelhead. This action involves using hatchery fish to supplement the few remaining wild fish in order to maintain a minimum spawning population of 300 fish. Because the wild summer steelhead only spawn above the Siletz falls ladder and trap, the mix of spawners for the entire production area can be controlled. It is anticipated this will mean that hatchery fish will make up 90% of the spawning population during the next four years. The intent is to drastically reduce this percentage if the wild population shows signs of rebuilding after five years.

Drift Creek, Siletz Bay - The 20,000 hatchery smolt program was terminated in 1995. It is expected the percentage of hatchery fish will be 10% as a result of this action.

Yaquina - The percentage of hatchery fish spawning in this basin is being revised based on the results of trapping major tributaries for adult fish over the last five years. Until these estimates are available an interim estimate of 60% hatchery fish will be used.

Alsea - The hatchery fish returning to this basin were originally developed from the local population. However, they have been cultured for too long without the infusion of additional wild fish to be considered a local stock. Therefore, their impact on the local wild population is considered the same as an out-of-basin hatchery stock.

Based on data collected from adult traps operated on major tributaries within the Alsea Basin, the majority of hatchery fish straying into natural spawning areas up until 1995 were not released as smolts into the Alsea. Most of these fish were raised at NF Alsea Hatchery, trucked and released into other basins, most notably the Siuslaw. However, significant changes have been made in recent years to prevent this straying of out-basin releases (see Siuslaw below).

From the adult trapping and fishery data, it is apparent that 85 to 95 percent of the adult steelhead released as smolts from NF Alsea Hatchery and that were not caught

in the sport fishery as adults, homed back to the hatchery and away from natural spawning areas. Based on this observation and the expectation that actions to solve straying from out-of-basin releases will succeed, the percentage of hatchery fish in the natural spawning population is estimated to be 20%.

Drift Creek, Alsea Bay - It is anticipated the percentage of hatchery fish will decline to 10% because of recent catch and release regulations for wild fish and efforts in the Siuslaw Basin to reduce straying of fish raised at Alsea Hatchery. From adult trapping and fin clip observations prior to 1996, the source of nearly all stray hatchery fish in Drift Creek appears to have been out-of-basin releases from Alsea Hatchery, most likely the Siuslaw Basin.

Yachats River, Tenmile Creek, and Big Creek - Hatchery steelhead smolts are not released into these basins. Therefore, the adult hatchery fish found in these basins are all strays from other programs, largely the Siuslaw. As described below for the Siuslaw, significant changes have been made in recent years to reduce this straying. These changes are expected to result in only 5% hatchery fish in the natural spawning population in these three basins.

North Siuslaw - The 30,000 hatchery smolt program was eliminated in 1994. Actions have been taken in the mainstem Siuslaw to reduce straying of hatchery returns. In combination, these changes are expected to result in a hatchery percentage of 10% in the North Siuslaw.

Siuslaw - A new hatchery broodstock was developed from wild Siuslaw steelhead. In addition, preliminary findings from a recent steelhead straying study conducted within the basin suggest that 97% of the adult hatchery steelhead home back to the site where they were released as smolts (Lindsay et al., in prep.). This finding has been used to relocate smolt release sites to upstream locations shown by the studies to elicit a strong homing response in returning hatchery adults. In implementing such strategies, hatchery adults will be drawn away from much of the area utilized for spawning by the wild population. However, these hatchery adults are not recaptured and removed from the basin. As an additional precaution, the number of smolts released in the basin was reduced from 170,000 to 100,000 fish.

Finally, in an attempt to further reduce straying both within and outside the basin, ODFW has moved the pre-release rearing of hatchery fish destined for the Siuslaw from Alsea Hatchery to Willamette Hatchery. This is intended to reduce the possibility that smolts destined for release into the Siuslaw will imprint on the Alsea Basin and, therefore, be less likely to stray to the Alsea and other nearby streams as returning adults.

Based on these changes, hatchery fish are expected to comprise 30% of the natural spawning population. Observations of steelhead entering the Siuslaw Basin steelhead spawning tributaries in 1997 confirm this expectation, with 29% identified as hatchery fish (Rapp, 1997).

Smith - The 65,000 hatchery release smolt program was reduced to 20,000 in 1995 and will be eliminated in 1997. This is expected to reduce the percentage of hatchery fish to 5%.

North Umpqua, Winter Steelhead - No hatchery fish are released into this basin. Hatchery strays are estimated to be 5% of the naturally spawning population.

North Umpqua, Summer Steelhead - Beginning in 1991, angling regulations were changed to require the release of wild North Umpqua summer steelhead for much of the basin. This resulted in more wild spawners and potentially fewer hatchery spawners, thereby lowering the percentage of hatchery fish on the spawning grounds.

In addition, a revision was made to the estimate of hatchery summer steelhead that escaped the fishery, but were drawn back to Rock Creek Hatchery and away from most of the natural spawning area within the basin. This revision was made based on data obtained from a statistical creel survey conducted on the North Umpqua in 1990, and is described as follows.

The counts of fish at Winchester Dam were used to estimate pre-harvest abundance of hatchery and wild summer steelhead entering the basin. In 1990, an estimated 2,116 hatchery fish and 339 wild fish were caught in the fishery between Winchester Dam and the mouth of Rock Creek. Subtracting these catches from the counts at Winchester Dam produced an estimate for the number fish surviving the lower river fishery of 5,474 hatchery fish and 2,647 wild fish (67% hatchery fish). However, the percentage of hatchery fish observed in the fishery upstream from the mouth of Rock Creek was only 52%. It was assumed this reduction in hatchery fish was attributed to the likelihood that the hatchery fish had imprinted on their release site at Rock Creek Hatchery and were homing back to this location as returning adults. As a result, those hatchery fish that were homing back to the hatchery would have left the mainstem North Umpqua River and essentially been removed from the fishery upstream of the mouth of Rock Creek. Using the formula: $H = PhW / (1-Ph)$, where H = the number of hatchery fish that continued upstream, Ph = the proportion of hatchery fish observed in upstream fishery (0.52), and W = the number of wild fish continuing upstream (2,647); it was estimated 2,867 hatchery fish did not display the homing response and, as a result, continued upstream.

Therefore, the number of hatchery fish which diverted into Rock Creek was $5,474 - 2,867 = 2,607$ fish. From this result it was estimated that the portion of hatchery fish drawn into Rock Creek was $2,607/5,474 = 0.48$. In other words, 48% of the

hatchery return which escaped the lower river fishery did not continue up the North Umpqua River any further than the mouth of Rock Creek.

From these revisions, the estimate for the percentage of hatchery fish in the naturally spawning population was lower, as evidenced by the average for the last six years of 25% (Table 11).

Table 11. Estimated adult count at Winchester Dam, spawner escapement and percentage of hatchery fish in naturally spawning population for North Umpqua summer steelhead, 1947-97 brood years.

Brood Year	Wild Count	Hatchery Count	Hatch to Rock Cr	Wild Escapm	Hatch Escapm	% Hatchery
1947	3361	0	0	2241	0	0%
1948	5113	0	0	3409	0	0%
1949	2762	0	0	1841	0	0%
1950	1672	0	0	1115	0	0%
1951	2835	0	0	1890	0	0%
1952	3361	0	0	2241	0	0%
1953	4443	0	0	2962	0	0%
1954	2844	0	0	1896	0	0%
1955	3117	0	0	2078	0	0%
1956	3430	0	0	2287	0	0%
1957	2927	0	0	1951	0	0%
1958	2228	0	0	1485	0	0%
1959	2041	0	0	1361	0	0%
1960	1356	693	222	904	240	21%
1961	1782	950	304	1188	329	22%
1962	2437	704	225	1625	244	13%
1963	1318	1186	380	879	411	32%
1964	2907	1920	614	1938	666	26%
1965	2340	560	179	1560	194	11%
1966	3445	1983	635	2297	687	23%
1967	3139	3046	975	2093	1056	34%
1968	2160	2658	851	1440	921	39%
1969	1430	3748	1199	953	1299	58%
1970	4084	10847	3471	2723	3760	58%
1971	2727	12853	4113	1818	4456	71%
1972	2509	13676	4376	1673	4741	74%
1973	3159	10573	3383	2106	3665	64%
1974	2932	6172	1975	1955	2140	52%
1975	3875	4547	1455	2583	1576	38%
1976	4189	4957	1586	2793	1718	38%
1977	2736	3969	1270	1824	1376	43%
1978	5153	4588	1468	3435	1591	32%
1979	3766	5625	1800	2511	1950	44%
1980	5689	5251	1680	3793	1820	32%

Table 11. Continued.

Brood Year	Wild Count	Hatchery Count	Hatch to Rock Cr	Wild Escapm	Hatch Escapm	% Hatchery
1981	5262	5032	1610	3508	1744	33%
1982	4267	2053	657	2845	712	20%
1983	3397	2213	708	2265	767	25%
1984	3301	905	290	2201	314	12%
1985	8333	5817	1861	5555	2017	27%
1986	7499	7658	2451	4999	2655	35%
1987	7743	11999	3840	5162	4160	45%
1988	5388	15337	4908	3592	5317	60%
1989	3800	11524	3688	2533	3995	61%
1990	3602	8906	2850	2401	3087	56%
1991	2986	7590	2429	1991	2631	57%
1992	2534	2339	748	2450	811	25%
1993	1650	2126	680	1595	737	32%
1994	2931	2483	795	2833	861	23%
1995	2599	2111	676	2512	732	23%
1996	3696	2706	866	3573	938	21%
1997	3361	3972	1271	3249	1377	30%
Av1947-97	3443	3829	1225	2394	1327	28%
Av1992-97	2847	2679	857	2752	928	25%

Tenmile Lake Creek - The hatchery program was changed to briefly rear smolts prior to release within the Eel Lake watershed, a minor steelhead production area isolated from the primary steelhead production areas for this population (the inlet tributaries to Tenmile Lake). This change is intended to imprint hatchery steelhead so that as adults they home back to the Eel Lake system, away from major wild steelhead spawning and production areas. It is estimated this change will result in 15% of the naturally spawning steelhead population being hatchery fish.

Millicoma (Coos Basin) - Given new hatchery smolt release strategies and new angling regulations that make the retention of wild fish illegal, it is estimated that the percentage of hatchery fish in the naturally spawning population is 40%.

Coos - For the same reasons as those for the Millicoma, it is estimated the percentage of hatchery fish in the naturally spawning population in the Coos is now 40%.

Coquille - Similar to the Millicoma and Coos in terms of recent actions to reduce the impact of hatchery spawners, the estimated percent hatchery fish in the natural spawning population is 45% based on observations of sport caught fish in the South Coquille.

South Coquille - Smolt release sites are located to draw returning hatchery fish away from natural spawning areas. Evidence based on sampling of steelhead caught in the

1992-93 sport fishery suggests that the percent hatchery fish in this population is 45%.

Floras - No hatchery fish are released into this basin. The estimate of percent hatchery fish in the natural spawning population is 5%.

Sixes - No hatchery fish are released into this basin. The estimate of percent hatchery fish in the natural spawning population is 5%

Population Abundance, Trends, and Recruitment

General - As stated earlier, the use of catch information to estimate the abundance and trends of wild populations has shortcomings and was not used in this analysis. Unfortunately, dam counts and spawner density data, while superior to catch statistics for estimating abundance of wild fish, are available for only a few Oregon Coast ESU populations.

Specifically, these data sets include adult abundance and recruitment estimates for summer and winter steelhead in the North Umpqua (dam counts), and for winter steelhead in the Salmonberry River (Nehalem Basin) based on spawning survey data. In addition, the trend in numbers of wild steelhead smolts produced in two short ocean tributaries located south of the Alsea (Cummins Creek and Tenmile Creek) were examined for signs of recruitment failure.

While there are shortcomings to using such a small sub-set of constituent populations to draw conclusions about overall trends for this ESU, their use allows important analyses that cannot be done with catch statistic information.

It is unclear how representative these populations are with respect to the entire ESU. However, the initial input from ODFW biologists is that the Umpqua, Tenmile, Cummins, and Salmonberry basins are comprised of above-average steelhead habitat. Therefore, caution was used to avoid making overly optimistic inferences with respect to the entire ESU based on the assessment of these populations.

North Umpqua Summer Steelhead - Pre-harvest abundance and spawner escapement estimates were made for both hatchery and wild summer steelhead based on counts of returning fish at Winchester Dam, estimated harvest rates, and estimates for the percentage of hatchery fish that homed back to Rock Creek Hatchery (Table 11).

Since 1947, this population has experienced low points in the early 1960s and again in the early 1990s (Figure 8). An apparent steady increase in numbers from 1963 made an abrupt reverse in 1987, dropping to near record lows within the next eight years. Most recently, returns of wild fish appear to be on the increase.

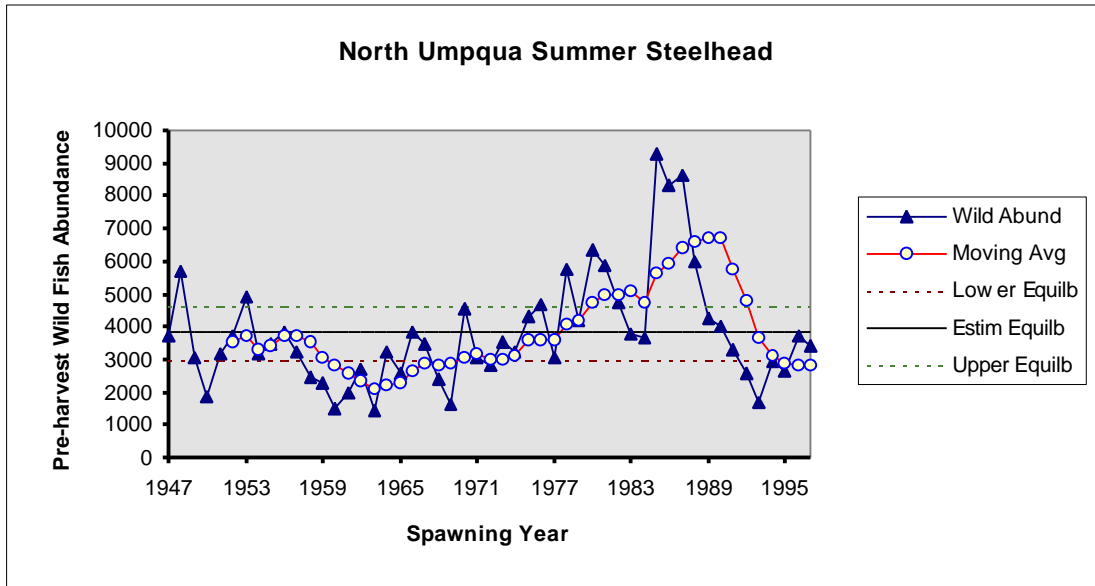


Figure 8. Annual and six-year moving average estimates of the pre-harvest abundance of wild summer steelhead in North Umpqua River, 1947-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

North Umpqua Winter Steelhead - Pre-harvest abundance and spawner escapement estimates were made for wild winter steelhead based on counts of returning fish at Winchester Dam and estimated harvest. As noted earlier the percentage of hatchery fish that stray into this basin is very low, < 5%.

The number of wild winter steelhead returning to the North Umpqua Basin over the last six years has averaged 6,773 fish (Table 12). This abundance level is not much different than the average return for the entire 50-year data set (1946 to present) of 9,246 fish. Fluctuations in abundance appear to roughly follow a 17-year cyclic pattern, with three peaks and three troughs occurring since 1946 (Figure 9). The observed pattern also appears to be nearly balanced around the population equilibrium point for this population, N^* , of 8,887 fish as determined from recruitment modeling. In light of these observations this winter steelhead population is relatively healthy and maintaining itself near levels that are in balance with the maximum capacity of the existing habitat to produce steelhead. The data also suggest that the capacity of the North Umpqua to produce wild winter steelhead has not appreciably changed over the last 50 years.

Table 12. Estimated number of spawners and recruits for wild winter steelhead population in the North Umpqua River, 1946-97 brood years.

<u>Brood Year</u>	<u>Spawners</u>	<u>Pre-Harvest Abundance</u>	<u>Observed Recruits</u>
1946	6038	8204	6876
1947	10322	14025	6600
1948	8924	12125	9770
1949	8487	11531	6786
1950	6447	8760	8598
1951	3853	5235	7032
1952	9775	13281	10557
1953	4686	6368	8804
1954	8394	11405	6905
1955	4375	5944	6812
1956	9394	12764	6439
1957	8209	11154	6465
1958	5842	7938	7818
1959	5862	7965	7074
1960	5647	7673	9030
1961	4777	6490	10412
1962	7115	9668	10381
1963	5370	7296	9721
1964	7108	9658	10268
1965	8714	11840	10176
1966	9140	12419	12502
1967	7902	10736	10515
1968	9074	12329	9009
1969	7472	10153	8918
1970	11183	15194	8110
1971	9504	12913	6584
1972	7605	10333	6377
1973	7680	10435	6333
1974	7456	10130	7519
1975	5616	7630	8456
1976	5531	7515	8097
1977	5006	6801	7068
1978	5968	8109	6100
1979	7186	9764	4590
1980	7199	9781	6405
1981	6140	8343	9794
1982	5893	8006	10680
1983	3545	4816	9337
1984	4221	5735	9775
1985	7732	10505	8116
1986	9688	13163	7721
1987	7501	10191	4707
1988	8993	12219	5403
1989	6612	8984	4712
1990	7854	10671	4986

Table 12. Continued.

<u>Brood Year</u>	<u>Spawners</u>	<u>Pre-Harvest Abundance</u>	<u>Observed Recruits</u>
1991	3614	4910	5964
1992	4847	6585	
1993	4017	5458	
1994	3761	5110	
1995	5261	7149	
1996	4503	6119	
1997	5,313	7,219	
Av1991-97	4,617	6,773	
Av1946-96	6,805	9,246	

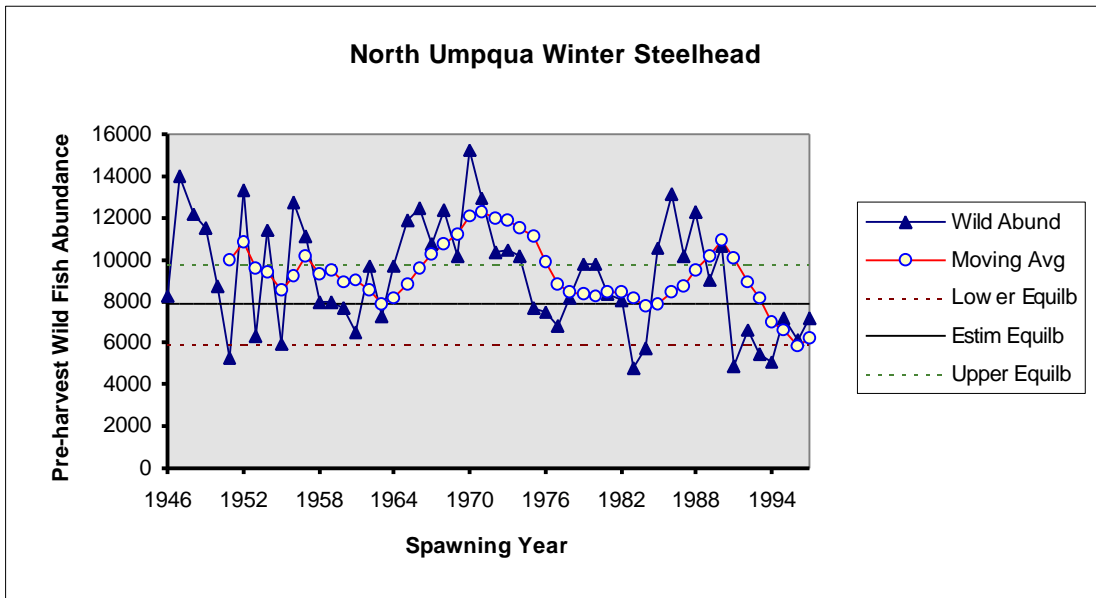


Figure 9. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in North Umpqua River, 1947-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Cummins and Tenmile Creeks - From 1991 to present, the juvenile abundance and smolt production for these small ocean tributaries has been estimated on an annual basis. For comparative purposes, data were standardized to total stream surface area, a rough measure of rearing habitat. The estimate of stream surface areas for these two basins, measured during late summer, was 60,934 m² for Cummins Creek and 211,625 m² for Tenmile Creek. From this information, estimates of fish produced per 100m² of habitat were calculated for evaluation.

As shown in Figure 10, there was no indication of a downward trend in juvenile steelhead density. If the majority of the smolts are two years old at migration, these data span seven brood years of steelhead production, 1991 to 1996. Assuming a two-salt adult life history, the adults belonging to these brood years will return between 1995 and 2000. If ocean survivals do not decline during this time frame, the number of returning adults should reflect the relatively stable pattern of abundance observed for the juveniles.

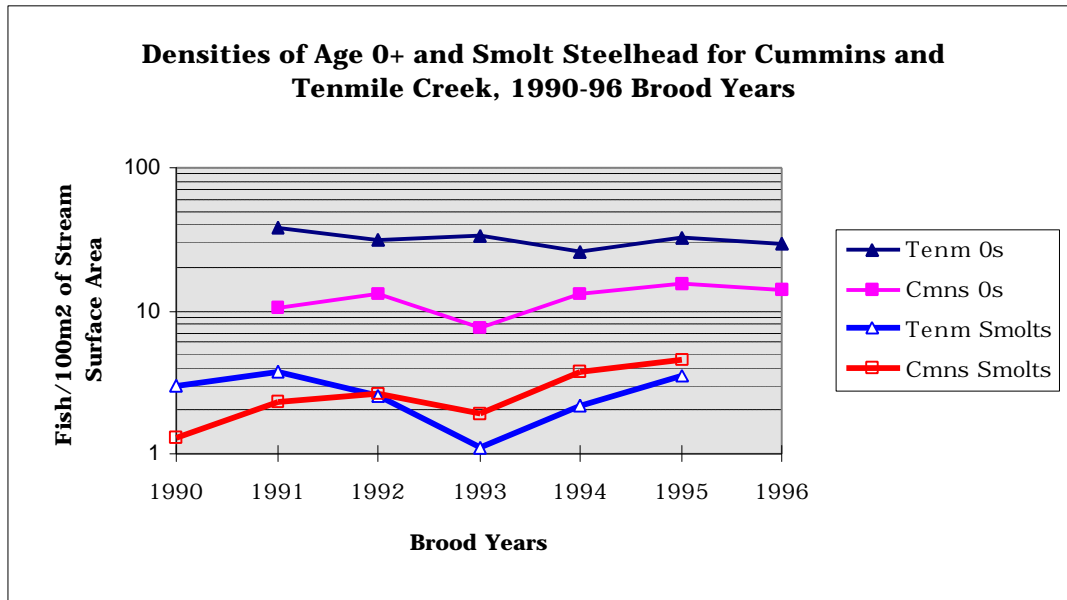


Figure 10. Estimated number of age 0+ and smolt steelhead produced per 100m² of habitat for Cummins and Tenmile Creeks, 1991-1996 brood years.

The average number of smolts produced for these basins since the 1992 trapping season (1990 brood year) was 1,461 fish for Cummins Creek and 5,309 fish for Tenmile Creek. The low percentage of hatchery strays in these or adjacent basins (Table 10), and the apparent stability of the juvenile production suggests that the level of smolt production observed for Cummins and Tenmile creeks is self-sustaining. Assuming a 10% ocean survival, the estimated spawner abundance for this apparent self-sustaining condition in these small basins is only 146 fish for Cummins Creek and 531 fish for Tenmile Creek. We find that such results support the view that an important characteristic of this species is its natural ability to maintain itself at relatively low levels of population abundance.

Siletz Summer Steelhead - As noted earlier, ODFW has recognized that wild summer steelhead in the Siletz Basin are extremely depressed and has taken actions to improve this situation. In recent years, the number of wild fish migrating into the production area above Siletz Falls has been as low as 50 individuals. While it is unlikely this population was historically ever larger than 800 fish, it is thought that the laddering of Siletz Falls in the late 1950s removed a critical isolating mechanism key to the continued existence of summer steelhead in the Siletz Basin. The competition

from winter steelhead and coho salmon, which began using this area for juvenile production, likely had a depressing impact on the native summer steelhead population. Therefore, in the last several years only summer steelhead have been allowed to migrate upstream of Siletz Falls. All other anadromous salmonids have been blocked from entry to this summer steelhead production area. It is expected that this change in management of fish passage at the falls will result in a rebound of the summer steelhead population within the next 10 years.

Salmonberry Winter Steelhead - Since 1973 a three-mile section of the Salmonberry River (tributary to the Nehalem) has been surveyed during April and May for spawning steelhead. Since hatchery fish typically spawn in January and February, it is presumed the counts of spawning steelhead made in April and May represent primarily wild fish. In addition, hatchery steelhead smolts have not been released into Salmonberry, and any hatchery fish entering the basin are strays. The most recent fishery-based estimate of hatchery strays for the Salmonberry return was 9% in 1989.

By visual inspection, a plot of spawner densities for the Salmonberry does not suggest either an upward or downward trend (Figure 10). Although the average return index from 1973 to 1997 has been 39.5 fish per mile, there has been considerable fluctuation in adult abundance from year to year. From recruitment modeling, the estimated equilibrium level, N^* , for the Salmonberry population was 31 fish per mile. As shown in Figure 11, the number of fish per mile has been near or above this equilibrium line for a majority of the years since 1973.

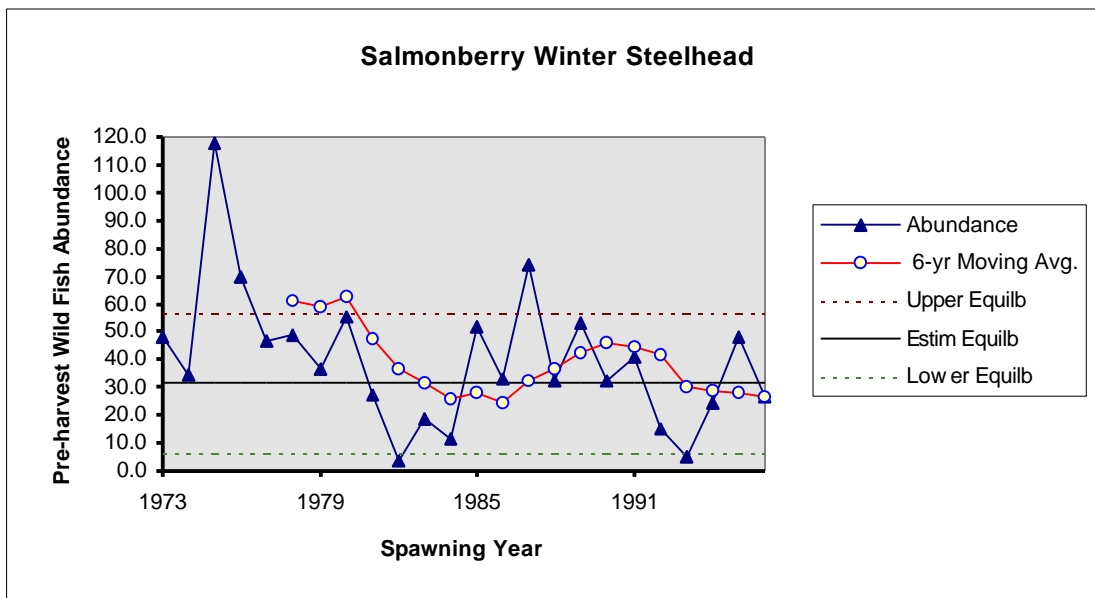


Figure 11. Annual and six-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the Salmonberry River, 1973-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The fact that the average steelhead return index for the Salmonberry over the last six years of 27 fish per mile is nearly the same as the equilibrium estimate ($N^* = 31$ fish per mile), is evidence that this population is maintaining itself at levels consistent with the productive capacity of the existing habitat, and is probably relatively secure. However, such an interpretation should not be overstated considering the rather wide range between the upper and lower bounds for the population equilibrium level estimate.

ESU Status Synthesis

Quasiextinction Assessment Results - None of the three populations examined in the Oregon Coast ESU met the assessment model criteria for endangered or threatened (Table 13). However, the Salmonberry winter steelhead populations qualified for sensitive status under this indicator (greater than 5% probability of quasiextinction in 100 years if life cycle survival drops to 1/2 of what has been over the last 25 years).

Table 13. Probability of quasiextinction estimates for three populations of steelhead in the Oregon Coast ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
N. Umpqua SR	0.000	0.000	0.002
N. Umpqua WR	0.000	0.000	0.000
Salmonberry WR	0.000	0.000	0.550

This finding tends to support the view that these populations are not at immediate risk of extinction. However, it would be unwise to infer the same about the remaining populations in this ESU on the basis of these results alone. As noted earlier, there is some concern that the North Umpqua and Salmonberry populations are not representative of the Oregon coast ESU because they exist in watersheds with superior steelhead habitat.

Hatchery Fish - As recently as five years ago, hatchery fish comprised more than 50% of the natural spawners throughout much of the Oregon Coast ESU. However, with major changes in steelhead management programs, these levels have dropped significantly. Currently it is estimated that 23% of the naturally spawning fish, averaged across all populations, are hatchery fish.

There are still several populations of coastal winter steelhead that exceed Wild Fish Management Policy (WFMP) standards in terms of naturally spawning hatchery fish. These shortcomings are primarily due to the inability to obtain adequate resources to fully implement desired changes (e.g., new smolt release sites, adult collection facilities, monitoring, etc.). At some point, ODFW will be compelled to eliminate additional hatchery programs if funding cannot be obtained to implement these preferred strategies.

Trends in Abundance - Population abundance data presented in this report for five populations belonging to the Oregon coast ESU do not provide strong evidence of downward trends. While there appear to be cyclic patterns for some populations, most notably the winter steelhead in the North Umpqua, the general pattern for these populations appears to be one of equally balanced ups and downs with respect to natural equilibrium levels.

The recruitment modeling results for the Salmonberry and the two North Umpqua populations do not suggest these populations are depressed below what would be expected given the available habitat. Even if it were possible to double the current number of naturally spawning fish for these basins, the analysis suggests that little if any gain in subsequent recruits would occur.

These results contradict the downward trends in abundance described by Busby et al. (1996) for populations belonging to this ESU. It appears the reason for this contradiction is that the findings of Busby et al. (1996) were based on data for an unrepresentative, and now out-of-date, time series (1977-92). In addition, these authors used catch statistics as their primary data to assess population trends. As described earlier, the use of catch records to examine abundance trends for wild steelhead is likely an unreliable strategy.

The Oregon Coast ESU includes several steelhead populations that exist in small watersheds. Conservation biology theory would predict such populations, because they are comprised of relatively few individuals, would be more vulnerable to extinction. However, field observations do not support this expectation. For example, the production of juvenile steelhead in Cummins and Tenmile creeks, as described earlier in this report, appears relatively stable even though the number of spawners for these two populations has been in the 100 to 500 fish range for many years. In addition, there is no record of any steelhead population within this ESU ever going extinct, including those in small basins. On the coast of Oregon, steelhead are found in nearly every location that is accessible to adult steelhead or their juvenile offspring.

While these observations do not prove that vulnerability to extinction is independent of population size, they do suggest that, for steelhead belonging to the Oregon Coast ESU, population sizes have not yet declined to levels where such effects are observable. It is also possible that such vulnerability is being masked by the natural straying of adult steelhead from nearby, larger populations that provide the reproductive cushion against extirpation.

Self-Sustaining - With the exception of the Siletz summer steelhead, the information presented in this report supports the view that populations in this ESU are self-sustaining. In contrast, Busby et al. (1996) arrived at nearly the opposite

conclusion: “... given the substantial presence of hatchery fish in the few stocks that are relatively abundant and stable or increasing, NMFS is concerned that the majority of natural steelhead populations in the ESU may not be self-sustaining.” Their statement does not agree with observation. For example, hatchery steelhead spawners are essentially absent from both the Salmonberry and North Umpqua winter steelhead populations, yet these populations are clearly sustaining themselves and show no signs of reproductive failure. In addition, stable juvenile populations in Cummins and Tenmile creeks suggest that these two populations are also self-sustaining. Very few hatchery fish are found in these two small coastal basins as well.

The attempt by Busby et al. (1996) to determine if populations were self-sustaining yielded different results because their underlying analytical approach to the problem was flawed. Their analysis relied on fishery catch data which primarily reflects the abundance of hatchery fish. Hatchery fish comprise a majority of the reported angler catch in most basins because of their greater abundance relative to wild fish, and the tendency of anglers to focus on the hatchery portion of the run. The abundance (and catch) of hatchery fish is dependent on two factors: the number of hatchery smolts released and ocean survival. Since the annual number of smolts released in these basins has been fairly constant, at least until 1994, the variable Busby et al. (1996) evaluated in their analysis was smolt-to-adult survival, not sustainability of wild populations. They mistook downward trends in ocean survival as evidence that the reproductive capacity of natural populations was failing.

ESU Status - As described in the methods section, three indicators were used to assess the status of each steelhead ESU. For the first indicator (long-term probability of quasiextinction), none of the populations met the thresholds for endangered or threatened status. However, one of them did qualify for sensitive status, the Salmonberry. This resulted in a net score for this indicator of 1.3 (Table 14).

Table 14. Summary of status determination scores for the Oregon Coast ESU based on three individual indicators: Long-term PQM (long-term probability of quasiextinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
1.3	1.3	2.0	1.6

In a scenario where the relative survival collapses to only 1/4 of the most recent 25-year average, the forecasted result of this short-term stress (second indicator) suggests that only the Salmonberry population is vulnerable enough to meet the criteria of sensitive. For the three populations examined, the average rating for this indicator was 1.3.

An extirpation warning (the third indicator) was judged to exist for four of the 34 populations inspected for the Oregon Coast ESU. The extirpation warning the Siletz summer steelhead population was triggered by its extremely low abundance and lack of rebuilding trend. The other three populations were classified with an extirpation warning because more than 50% of their naturally spawning populations are comprised of hatchery fish. The score for this indicator was 2.0 because 12% of the populations examined qualified for extirpation warnings (see methods section for details on criteria).

Averaging the scores for individual indicators, the status assessment score for this ESU was 1.6 (Table 14). Based on this result, a status classification of **SENSITIVE** was assigned to the Oregon Coast ESU.

This quantitative assessment is generally supported by other information presented for populations in this ESU, notably the smolt and juvenile estimates for Cummins and Tenmile creeks.

SW Washington ESU Status Assessment

General

Oregon's portion of this ESU is small and includes only those Oregon tributaries to the Columbia River downstream from the mouth of the Willamette. As there are no abundance data for any of these populations, an in-depth analyses of this ESU was not possible. Because of this a simplified report format was used to describe information relevant to this ESU.

The lack of information about the steelhead populations in Oregon's portion of this ESU makes any conclusions about the status of the populations largely speculative.

Overview of Populations

Clatskanie - ODFW field biologists believe the wild steelhead in this basin may be depressed. In 1990, the winter steelhead hatchery program was reduced from 30,000 to 10,000 smolts. This action should reduce the risk of maladaptive genetic characteristics from hatchery fish being mixed into the wild population and thereby lowering natural reproductive capacity. The hatchery stock used in this basin was not developed from the local population and is considered genetically dissimilar to the wild population.

Gnat Creek - The wild population for this basin is very small because the anadromous zone is restricted to less than two miles in length. Almost all of the fish caught in the Gnat Creek fishery are hatchery origin. This fishery is supported by returns from Gnat Creek Hatchery smolt releases that have averaged 40,000 fish in recent years.

Big Creek - The wild population in Big Creek is probably quite small because natural spawners have been denied access to the basin upstream of Big Creek Hatchery since the 1960s. The remaining anadromous production zone downstream of the hatchery is only about five miles in length. In addition, the wild population is likely influenced by large numbers of returning hatchery fish from smolt releases into Big Creek that have averaged 60,000 fish over the last several years.

However, in 1996, efforts were initiated to re-establish a naturally reproducing population above the artificial anadromous fish barrier at Big Creek Hatchery. This barrier was constructed to prevent anadromous fish from spawning in the upper Big Creek watershed and potentially shedding pathogens into the hatchery water supply. Because this barrier blocked a significant amount of habitat, re-establishing passage should result in the development of a natural population of 200-1,000 steelhead.

North Fork Klaskanine - Due to limited access for anadromous fish, the natural production of steelhead in this basin is probably quite low. Klaskanine Hatchery (located in this basin) releases 60,000 winter steelhead smolts annually to supplement sport fisheries.

South Fork Klaskanine - The abundance of wild steelhead in this basin is unknown. In 1991, smolt releases of hatchery steelhead were eliminated. However, strays from the North Fork Hatchery program probably interbreed with wild fish in the South Fork. Currently, it is estimated that hatchery fish comprise from 15% to 40% of the natural spawning population.

Lewis and Clark - The abundance of wild steelhead is unknown. In 1992, hatchery smolt releases into the Lewis and Clark were eliminated. As a result of this action the percentage of hatchery fish in the basin should drop from 50% to 10%.

ESU Status Synthesis

The lack of abundance data for the populations in Oregon's portion of this ESU makes it difficult to assess their status. Until more definitive information becomes available, it is proposed that a status assessment classification of **SENSITIVE** be assigned to steelhead belonging in the SW Washington ESU in Oregon. In terms of habitat and fishery management history, these populations are quite similar to those in the northern portion of the Oregon Coast ESU. Since the Oregon Coast ESU met the criteria for sensitive classification, it is reasonable to extend this classification to the SW Washington ESU.

Upper Willamette ESU Status Assessment

Naturally Spawning Hatchery Fish

Molalla - Hatchery winter steelhead smolts from the Big Creek stock have been released into the Molalla since the 1960s. This hatchery stock is probably quite different from wild fish of the Molalla Basin as it originated from lower Columbia River wild populations and has been domesticated for many years. This stock is characterized by an earlier spawn and run timing than the wild population. Since the mid-1980s, the number of smolts released into the Molalla has been reduced several times. In 1997, stocking of hatchery winter steelhead in the Molalla was permanently discontinued.

Volunteer-collected scale samples from 1,118 steelhead caught in the Molalla River from 1979 to 1986 suggest that hatchery fish comprised 46% of the return (ODFW, unpublished data). Since 1987, the percentage of hatchery fish has likely decreased because the number of smolts released has been reduced. In addition, the results from trapping several tributaries for adult steelhead in 1992 and 1993 suggest the percentage of naturally spawning steelhead that are hatchery winter runs may be less than 10% (ODFW, 1995a). This information, indicates that from 1992 to present, only 24% of the natural spawning population were hatchery fish. Discontinuing hatchery winter steelhead smolt releases in 1997 will decrease the percentage of hatchery winter steelhead to less than 5% after 1999.

In addition to the winter steelhead hatchery program an average of 60,000 Skamania stock hatchery summer steelhead smolts are released annually into the Molalla Basin. As with all of this ESU, summer steelhead are not native to the Molalla. An analysis of the potential impact of summer steelhead on native wild winter steelhead is presented in the Clackamas winter steelhead section of this report. A summary of this analysis is: 1) natural equilibrium abundance levels for wild winter steelhead decreased by 12% apparently due to interactions with offspring of naturally spawning hatchery summer steelhead; and 2) recruits per spawner at low population densities (an important attribute of population productivity and resilience) declined 27% in the wild winter steelhead population after the introduction of hatchery summer steelhead into the Clackamas Basin.

While it is unclear how these results apply to the Molalla winter steelhead population, it is reasonable to infer that the summer steelhead hatchery program may have caused a reduction in the productivity and resiliency of the wild winter population.

North Santiam - The hatchery winter run stock released into the Santiam Basin was developed from North Santiam wild fish. The return and spawn timing of this hatchery stock is considerably later than Big Creek hatchery stock and is similar to the wild Santiam population. Based on upstream adult migrant trapping at the

Stayton ladder, the latest estimate for hatchery winter steelhead in the North Santiam is 17% (ODFW, 1995b).

As in the Molalla, Skamania-origin summer steelhead hatchery smolts are released into the North Santiam. However, the annual number released (160,000 fish) is much larger than in the smaller Molalla Basin. The impact of these non-native steelhead on wild winter steelhead in the North Santiam can also be inferred from the analysis performed for the Clackamas population described later in this report. Therefore, by inference, wild winter steelhead in the North Santiam may be less productive than they were prior to when the hatchery summer steelhead program began in the late 1960s.

Lower and Upper South Santiam - Hatchery winter steelhead smolts have not been released into the South Santiam except during a seven-year period during the 1980s. These hatchery fish belonged to the North Santiam winter steelhead stock. Based on observations of hatchery and wild fish passing Foster Dam, the estimated average percentage of hatchery fish from 1982 to 1989 was 47%. Before 1982 and after 1990, less than 5% of the winter steelhead passing Foster Dam have been hatchery fish.

Skamania-origin summer steelhead hatchery smolts are also released into the South Santiam. While the average number of smolts released is relatively large (150,000 fish), a substantial portion of the adults generated by this program are either caught by anglers or return to South Santiam Hatchery and do not spawn in the wild. Therefore, the expected potential for adverse impact of the summer steelhead program on wild winter steelhead in the South Santiam is less than in the North Santiam and Molalla.

Calapooia - There is no hatchery steelhead program for the Calapooia, and the incidence of strays from other hatchery programs in the Willamette Basin appear to be rare. While steelhead in the Calapooia have not been directly examined to determine the frequency of stray hatchery fish, it is assumed that their presence within this population is less than 5%.

Population Abundance, Trends, and Recruitment

General - Although the South Santiam is recognized as a single population, a separate assessment was done for steelhead below and above Foster Dam because only redds/mile data are available for areas below Foster Dam, while only total count data are available for areas above Foster Dam.

Except in the upper South Santiam, spawners per mile were used as an index of population abundance for all Willamette ESU populations. Redd counts from 1971 to

1997 for survey sections within each basin were converted to spawners per mile as described in the methods section (Table 15). Redd count data were not available for every year. To fill in these gaps, regressions were developed using available redd count data and the number of late run steelhead passing Willamette Falls. These regressions were then used to estimate redd counts for the missing years based on the number of steelhead passing Willamette Falls. Counts of late run steelhead at Willamette Falls are available in an unbroken time series beginning in 1971.

Table 15. Estimated indices of spawner abundance for five winter steelhead populations in the Willamette Basin above Willamette Falls. Spawner abundance expressed as total fish for the upper South Santiam population and spawners per stream mile for all other populations.

Year	Molalla		N. Santiam		Lo S. Sntm		Up S. Sntm		Calapooia
	Wild	Htch	Wild	Htch	Wild	Htch	Wild	Htch	Wild
1971	44.2	37.6	55.1	11.3	43.8	0.0			23.2
1972	41.2	35.1	52.1	10.7	41.6	0.0			21.6
1973	32.8	28.0	43.7	9.0	35.2	0.0	755	0	16.9
1974	28.9	24.6	39.8	8.1	32.3	0.0	695	0	14.7
1975	19.0	16.2	30.0	6.1	24.9	0.0	354	0	9.1
1976	22.5	19.2	33.5	6.9	27.5	0.0	302	0	11.1
1977	27.5	23.5	38.5	7.9	31.3	0.0	503	0	13.9
1978	27.5	23.5	38.5	7.9	31.3	0.0	488	0	13.9
1979	23.6	20.1	34.6	7.1	28.3	0.0	149	0	11.7
1980	41.1	35.0	51.2	10.5	40.9	0.0	515	0	13.0
1981	33.6	28.6	39.6	8.1	32.2	0.0	317	0	9.0
1982	29.5	25.1	36.2	7.4	17.4	12.2	234	165	21.8
1983	20.2	17.2	41.9	8.6	16.8	8.3	134	66	17.6
1984	28.5	24.3	41.9	8.6	11.5	22.7	504	993	16.1
1985	39.8	33.9	42.4	8.7	17.2	30.4	355	629	25.8
1986	34.9	29.7	69.8	14.3	14.8	22.0	326	485	18.0
1987	27.5	23.4	45.8	9.4	15.5	18.3	214	253	22.3
1988	35.0	29.9	45.3	9.3	19.8	12.8	656	423	20.4
1989	25.8	21.9	24.5	5.0	17.1	4.8	222	62	8.5
1990	29.1	24.8	47.4	9.7	31.3	1.2	272	10	14.8
1991	18.6	15.8	34.5	7.1	33.7	0.0	139	0	14.3
1992	25.1	7.9	24.9	5.1	29.5	0.0	361	0	5.5
1993	7.5	2.4	27.6	5.7	16.0	0.0	256	0	1.8
1994	30.3	9.6	26.2	5.4	28.0	0.0	234	0	7.5
1995	11.9	3.8	17.6	3.6	24.5	0.0	297	0	5.1
1996	18.6	5.9	29.6	6.1	24.6	0.0	131	0	8.9
1997	7.8	2.5	22.2	4.5	9.8	0.0	311	0	11.7

To estimate indices of pre-harvest run size, a harvest rate of 0.21 was assumed for all populations until 1992, when a 0.05 harvest rate was used, reflecting catch and release angling regulations for wild steelhead implemented in 1992.

Molalla - Annual estimates of both hatchery and wild spawners were needed to assess the status of Molalla Basin winter steelhead. Estimates for wild spawners were developed from redd count information as described earlier. These counts were

conducted in early May, the peak spawning for Willamette Basin wild winter steelhead. However, hatchery fish returning to potentially spawn in the Molalla were Big Creek hatchery stock which typically spawns in January and February. Since the average length of time a redd is visible in western Oregon and Washington streams is likely no longer than four weeks, redds constructed by naturally spawning hatchery fish could not be observed during spawning surveys conducted in April and May. Therefore, fish-per-mile estimates of hatchery spawners in the Molalla were obtained by expanding redd counts (for wild fish) by the estimated ratio of hatchery and wild fish in the sport fishery (Table 15).

The index of wild steelhead returning to the Molalla Basin shows a pattern of decline since the mid-1980s (Figure 12). The recruitment parameter a -value estimated for Molalla winter steelhead (-0.0274) was the second lowest of any population modeled (Table 2). The a -value was also negative, indicating that such a population cannot replace itself at any spawner density, clearly an unhealthy sign. The population equilibrium level, N^* , of zero depicted in Figure 12 reinforces this finding.

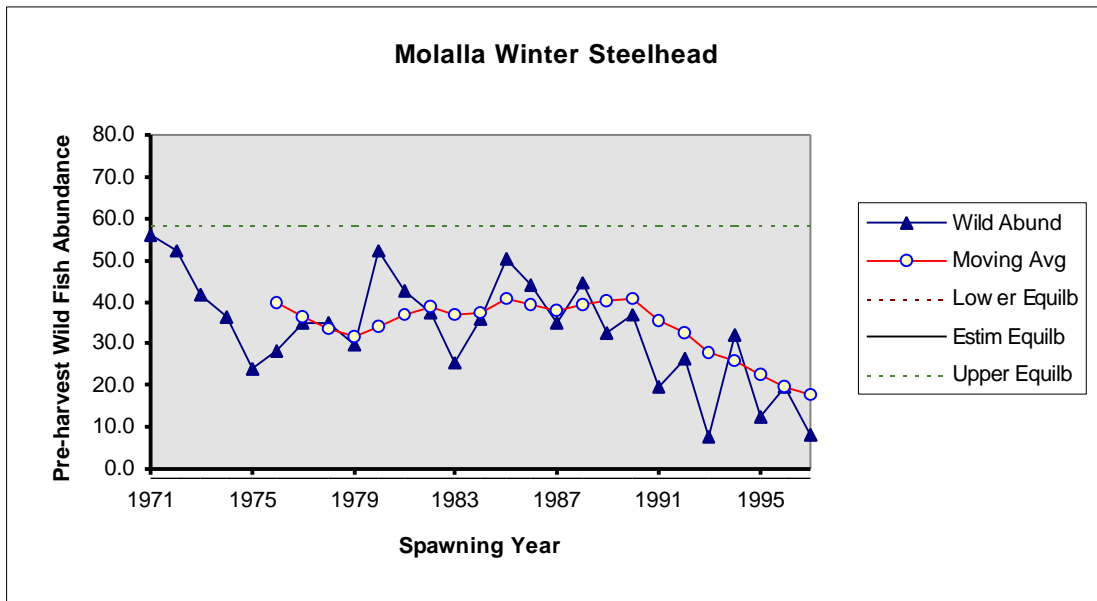


Figure 12. Annual and six-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the Molalla, 1971-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

There are several caveats in drawing inferences about the health of Molalla steelhead based on the a parameter estimated for this population. First, the regression used to estimate Ricker recruitment parameters a and B , poorly fit the data. Only 16% of the variation in the natural log of recruits per spawner could be accounted for by variations in spawner density. In addition, the calculated significance probability for this regression ($p = 0.07$) fails the traditional significance test level of $p = 0.05$ (Table 2). The poor fit is also reflected in the wide range between the lower

equilibrium bound for this population of zero and the upper equilibrium bound of 58 fish per mile (Figure 12).

Second, the fish counted as spawners in modeling this population were likely unequal in terms of their genetic character and reproductive potential. Unpublished information, provided by WDFW, documents that for a SW Washington hatchery steelhead stock the reproductive success was only 0.11 relative to wild fish under the natural spawning conditions of the Kalama River. The stock of hatchery fish from which these results were obtained by WDFW is similar to the one used by ODFW in Molalla in terms of its length of domestication. In the Molalla an estimated 46% of the spawners were hatchery fish. Essentially the low a -value observed for the Molalla population may be due to the averaging of a nearly zero reproductive capability for hatchery fish with a relatively healthy reproductive capability for wild fish.

For recruitment modeling done under the assumption that hatchery spawners had a reproductive success of only 0.11, the Ricker recruitment parameter a was quite different ($a = 0.4736$ versus $a = -0.0274$) as discussed in the Reproductive Success of Hatchery Spawners section earlier in this report. The suggestion is that the wild fish, considered alone, are healthier than they appear when mixed with hatchery spawners.

As mentioned earlier, 1997 was the last year hatchery winter steelhead will be released into the Molalla. How the wild population responds to this change and what conclusions should be reached about the health of the current wild population depends on two alternative possibilities.

The reproductive capacity of hatchery and wild fish in the Molalla could be essentially equal because the level of genetic-based adaptive differences is slight or other factors such as habitat and disease may pose such significant problems for this population that the impact of any genetic-based difference is relatively minor. Under this situation, removal of hatchery fish from the population would make little if any difference in the reproductive capacity of the population. In addition, without the reproductive support of hatchery spawners the population could be expected to decline until extinct.

Alternatively, if the hatchery fish reproductive capacity is near zero, their removal would not cause a decline in current wild fish levels. The recruitment function for the population would also mathematically change, since fish with very low reproductive potential would be removed from the calculations.

Of these two possibilities, the latter is the most likely scenario. As stated earlier, evidence from studies in SW Washington of a similar hatchery stock suggests that their reproductive capacity is nearly zero. These same studies also suggest that wild steelhead in the same basin have retained most of their native reproductive capacity.

Analysis of abundance and recruitment data for Molalla winter steelhead populations reveals some clear warning signs. However, the interpretation of these signs depends on the assumption selected concerning the reproductive capability of naturally spawning fish from the Big Creek hatchery winter steelhead stock. Although a near zero reproductive capacity for hatchery spawners is easier to assume based on available evidence, the real test will occur after 1999, when this hatchery stock will no longer spawn in the Molalla Basin.

Currently, the uncertain reproductive capacity of future wild populations and potential adverse interactions with non-native summer steelhead indicates this population is at some risk.

North Santiam - Unlike the Molalla, the stock of hatchery fish used in the North Santiam was developed from North Santiam wild fish and retains a spawn timing similar to the wild population. Therefore, indices for both hatchery and wild spawners were made directly from redd counts, apportioned by estimated percent hatchery fish in the spawning population.

The pre-harvest abundance and spawner escapement of wild winter steelhead in the North Santiam has been relatively stable, except for a peak during the mid-1980s and a decline since 1990 (Table 15 and Figure 13). Over the last six years, the average of wild abundance index has been 26 fish per mile of spawning habitat.

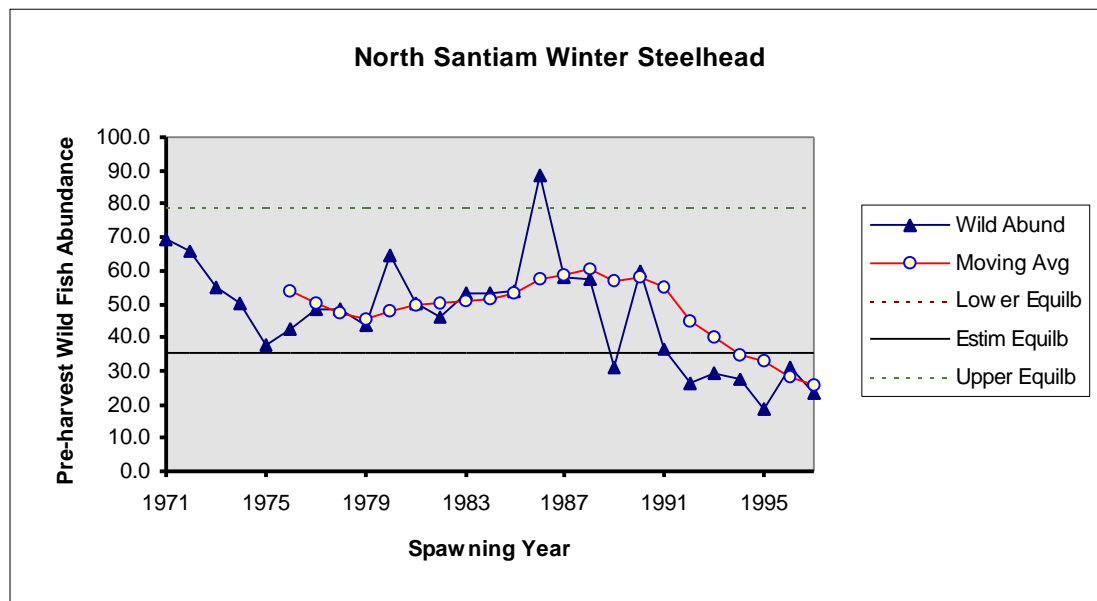


Figure 13. Annual and six-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the North Santiam, 1971-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Except in the last four years, the observed density of spawners for this population appears to have fluctuated equally around the estimated equilibrium level of 35 fish per mile. While this indicates a relatively healthy population, the Ricker model a parameter estimated for this population was only 0.5386 (Table 2), one of the lower values compared to other steelhead populations examined and presented in this report.

Since hatchery fish comprise a relatively small portion of this population (17%), factors other than hatchery fish are causing the low productivity of this stock. There are at least two possible mechanisms by which the innate productivity of this population has been reduced. First, water temperatures in the North Santiam and the mainstem Willamette have been altered due to construction and operation of an extensive network of dams. Such temperature changes may increase disease and mortality for smolts migrating to the Columbia.

Second, large numbers of non-native summer steelhead smolts are released into this basin. If these fish do not get caught, suffer natural pre-spawning mortality or become trapped at the Minto fish collection facility, they spawn in the wild. As demonstrated earlier, naturally rearing summer steelhead juveniles may have a negative impact on the recruitment function for wild winter steelhead. If the estimated 27% decrease in recruits per spawner due to interactions with non-native summer steelhead in the Clackamas River were applied to the North Santiam, removal of naturally spawning hatchery summer steelhead would increase recruits per spawner from 1.9 to 2.4. This gain translates to a Ricker a parameter change from 0.5386 to 0.8086, a substantial difference.

Other than the estimated low value for the Ricker a parameter, wild winter steelhead in the North Santiam are self-sustaining at levels near the estimated equilibrium, N^* . However, in recent years the number of wild fish has declined and remained below N^* . This observation, coupled with concerns about downstream disease infections and competitive impacts of naturally spawning summer steelhead, suggests that this population is at some risk.

Lower South Santiam - The abundance indices for this winter steelhead population suggest a pattern of relatively minor fluctuations around the estimated natural equilibrium of 23 fish per mile (Table 15 and Figure 14). However, the pattern of these fluctuations appears to be somewhat unique. During the mid-1980s when other populations in the Willamette Basin were experiencing peaks in spawner densities, the lower South Santiam population apparently went through an extended period of relatively low escapement. The observation of higher densities for this population in recent years, while most other populations appear to be depressed, seems to validate continuation of the contrary theme for the lower South Santiam population.

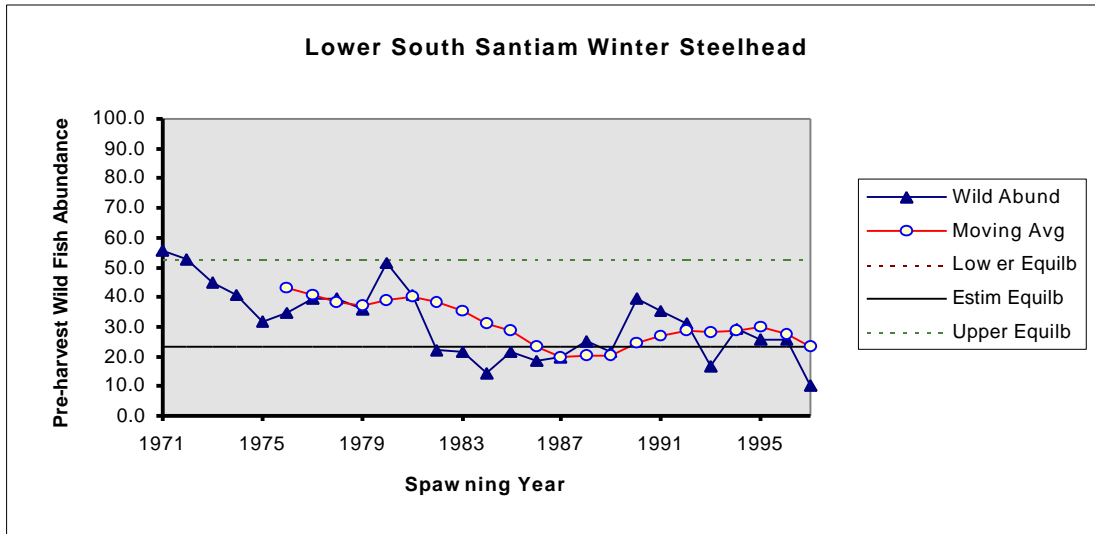


Figure 14. Annual and six-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the lower South Santiam, 1971-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

As with other populations in this ESU, the value for the Ricker parameter a was lower (0.6078) than many other populations examined in Oregon (Table 2). Because most summer steelhead in this basin are either caught or return to South Santiam Hatchery, it is not likely that this lower a -value is due to adverse interactions with naturally produced offspring of non-native summer steelhead. A habitat-related stress seems like a more likely explanation, perhaps mainstem Willamette temperatures that enhance the infection rate of certain pathogens such as *C. shasta*.

The temporal pattern and magnitude of spawner densities for lower South Santiam winter steelhead is consistent with a relatively healthy, self-sustaining population. However, the weaker reproductive performance for this population, as evidenced by lower a -values, is cause for some concern. While relatively healthy, this population has less reproductive resiliency than many other steelhead populations in Oregon.

Upper South Santiam- Counts of winter steelhead from 1973 to 1997 at Foster Dam suggest a population in slow decline, as demonstrated by the downward trend in the six-year moving average of steelhead abundance (Figure 15). In addition, a total spawner escapement in 1996 of only 131 fish (Table 15) indicate that this population is very depressed.

The Ricker a -value of 0.2425 calculated for this population translates into very low recruits per spawner of 1.3. Therefore, it means that, with very little additional stress, steelhead in the upper South Santiam would not be able to sustain themselves and would likely become extinct.

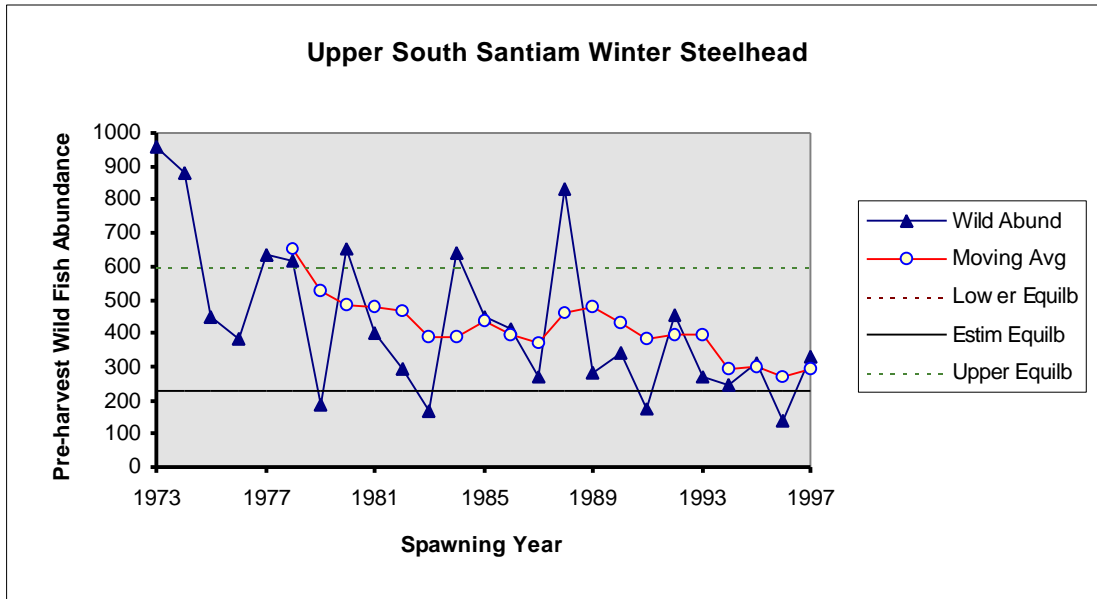


Figure 15. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the upper South Santiam, 1973-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Without winter or summer hatchery steelhead mixing with this population in recent years, the explanation for its tenuous state must be related to other factors. The population below Foster Dam is more healthy than the upper South Santiam population, which suggests a significant source of additional mortality is associated with juvenile passage at Foster Dam, survival through the reservoir, or unidentified habitat inadequacies in the upper South Santiam Basin.

Calapooia - This population is the upstream limit of native winter steelhead distribution in the Willamette Basin. The only hatchery fish that spawn in this system (winter or summer steelhead) are strays and therefore uncommon as noted earlier.

In a pattern similar to the Molalla and North Santiam, the number of winter steelhead in the Calapooia appears to have peaked in the mid-1980s, then declined to record low levels in recent years (Figure 16). Prior to 1989, the density of winter steelhead appears to fluctuate around an abundance level very near the 12 fish per mile equilibrium level estimated for this population. However, since 1992 the density of spawners has dropped below the equilibrium level, with a record low of 1.8 spawners per mile in 1993 (Table 15).

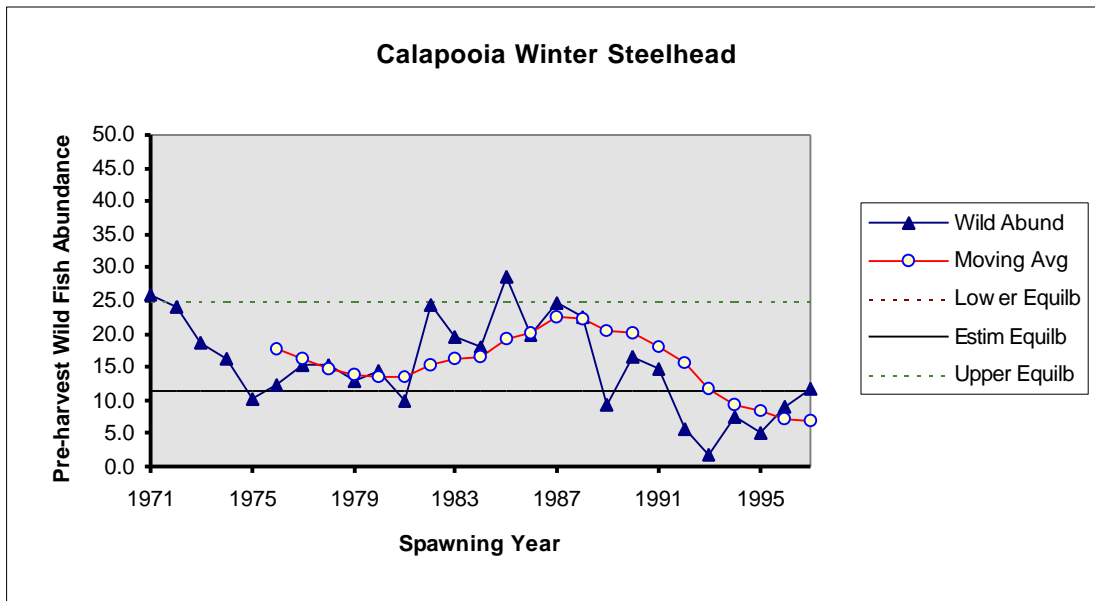


Figure 16. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead (fish per mile) in the Calapooia River, 1971-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The reproductive strength of the Calapooia steelhead population appears less than for most other non-Willamette steelhead as indicated by a below-average Ricker a -value of 0.7062 (Table 2).

ESU Status Synthesis

Quasiextinction Assessment Results - Because of the widespread availability of spawner recruit data for steelhead belonging to the upper Willamette ESU, it was possible to model the probability of quasiextinction for essentially all of the constituent populations.

The assessment model results indicate that three populations, the Molalla, Upper Santiam, and Calapooia, meet the criteria for an endangered classification (greater than 20% probability of quasiextinction in 60 years) (Table 16). The North Santiam and Lower South Santiam populations appear more secure, though they meet the criteria for a sensitive classification (greater than 5% probability of quasiextinction in 100 years with life cycle survival 1/2 of what it has been over the last 25 years).

Table 16. Probability of quasiextinction estimates for five populations of steelhead in the Willamette ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
Molalla	0.998	1.000	1.000
North Santiam	0.000	0.000	1.000
Lower S. Santiam	0.000	0.000	1.000
Upper S. Santiam	0.652	0.806	1.000
Calapooia	1.000	0.958	1.000

Hatchery Fish - Except in the Molalla, the adverse genetic impact of hatchery fish interbreeding with wild fish appears to be a relatively minor issue within this ESU. The cessation of hatchery smolt releases into the Molalla in 1997 will further reduce this potential problem.

The wild Molalla population, in spite of possible interbreeding with the Big Creek hatchery stock, will likely retain most of the genetic characteristics typical of a relatively healthy, productive wild steelhead population. However, this expectation cannot be verified until recruits from a Molalla spawning population comprised mostly of wild fish start returning in 2000.

The other risk associated with hatchery programs in this ESU is the widespread occurrence of non-native summer steelhead and the potential competitive impact of their naturally produced offspring on juvenile winter steelhead. As discussed earlier, an analysis of data from the Clackamas Basin suggests that the introduction of non-native summer steelhead may have caused a 27% reduction in the productivity of the wild winter steelhead population (fewer recruits per spawner). A similar impact may have occurred in several of the populations in the Willamette ESU as well. While relatively healthy winter steelhead populations would sustain such impacts, a 27% reduction in recruits per spawner for populations already under stress from other factors may pose an unacceptable risk.

Because hatchery summer steelhead that return to the Molalla and North Santiam basins have a high probability of spawning naturally if they are not caught, the potential negative impact of hatchery summer steelhead may be greatest in these basins. The weakened reproductive potential (low *a*-values) of wild winter steelhead populations in this ESU may exacerbate the effect of naturally spawning non-native summer steelhead.

In finding solutions to this problem, one critical issue is how to prevent returning summer steelhead from spawning in the wild to any substantial degree. Eliminating the release of hatchery summer steelhead smolts is just one of the strategies by which this can be accomplished. Other alternatives include trapping at passage facilities and releasing smolts so that adults home back to a restricted location where

they can be captured and removed from natural spawning areas. Such strategies are used successfully in other basins, such as the Rogue, to significantly reduce the number of hatchery fish that spawn in the wild.

Trends in Abundance - With the exception of the lower South Santiam, winter steelhead populations in this ESU appear to be in steady slow decline, especially over the last six years. This is particularly alarming given the change to wild fish release angling regulations in 1992. This downward pattern in abundance appears to have occurred without regard to the presence of naturally spawning hatchery steelhead (winter or summer steelhead). Therefore, the explanation appears to lie with some adverse combination of changes in key habitat factors, such as downstream passage conditions for smolts and poor ocean survival.

Self-Sustaining - Recruitment modeling for populations in this ESU suggests that the recruits per spawner at low densities are greater than one for all populations, as evidenced by positive values for the Ricker recruitment function parameter *a* (except the Molalla). This indicates that these populations are self-sustaining. However, the *a*-values obtained for these populations also suggest a consistent, below-average productivity for Willamette steelhead compared to most other populations examined in Oregon. If stress on these populations increases by only a modest amount, several would no longer be self-sustaining and would likely go extinct.

ESU Status - Three indicators were used to assess the status of each steelhead ESU: 1) long-term probability of quasiextinction, 2) short-term resistance to stress, and 3) extirpation warning signs (see methods section). As reported previously, three of the five populations examined met the long-term probability of quasiextinction criteria for endangered, the remaining two populations qualified for a sensitive classification. This resulted in a combined indicator score of 3.2 (Table 17).

Table 17. Summary of scores for status determinations for the Willamette ESU based on three individual indicators: Long-term PQM (long-term probability of quasiextinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
3.2	4.0	3.0	3.4

For the short-term stress resistance indicator, the assessment model results suggest that all five populations have greater than a 50% probability of quasiextinction if life cycle survival collapses to 1/4 its average over the last 25 years. This results in an ESU score of 4.0 for this indicator.

Of the five populations, extirpation warnings were judged to exist for only one, the Upper South Santiam. This population is at very low abundance and appears to be in a long downward trend. Since extirpation warnings were found for 20% of the populations examined, the ESU score for this indicator was 3.0.

Averaging the scores for all individual indicators, the overall status assessment score for this ESU was 3.4 (Table 17). Therefore, a status of **THREATENED** was assigned to the Willamette ESU.

Lower Columbia ESU Status Assessment

General

The analysis of populations in this ESU included two populations from the Kalama River in Washington, in addition to steelhead in the Clackamas, Sandy, and Hood river basins of Oregon. The Kalama River populations were examined because of their close proximity to Oregon's populations and because data were available which permitted recruitment modeling and extinction assessments and therefore added context to similar analyses of the Sandy and Clackamas populations in Oregon.

While summer steelhead are native to the Hood and Kalama rivers, they are not native to the Sandy or Clackamas. In Oregon, there is concern about the ecological impact of these non-native summer steelhead on the health of wild winter steelhead populations. Because of a unique combination of information, it was possible to do a preliminary assessment of this potential problem for the winter steelhead populations in the Clackamas. This analysis is presented under the hatchery fish section for the Clackamas population.

Naturally Spawning Hatchery Fish

Clackamas - Fish counts at North Fork Dam were used to estimate the number of winter steelhead returning to the Clackamas Basin. Although there is natural rearing and spawning habitat below the dam, potential smolt production estimates suggest that a majority of the steelhead production in the Clackamas takes place upstream of the dam (Murtagh et al., 1992). Based on the known return and spawn timing of the Big Creek hatchery stock which has been used in this basin since the 1960s, fish passing North Fork Dam after March 31 were wild fish and those prior to March 31, hatchery fish. While overlap in run timing of these two groups probably exists, the March 31 criterion was acceptable for obtaining an index of wild fish abundance for the Clackamas Basin.

From 1961-96, an average 16% of the naturally spawning population of winter steelhead were hatchery fish. In the last six years this percentage has been higher, 30% (Table 18). In either case, this percentage is much lower than the 70% hatchery fish estimate presented by Busby et al. (1996) for this population. This difference is likely the result of dissimilar methodologies used for estimating the percentage of hatchery fish on the spawning grounds (fishery data versus dam count data). For reasons presented earlier in this report, it is likely the estimate based on dam counts is the more accurate of the two.

Table 18. Estimated number of wild and hatchery winter steelhead passing North Fork Dam, Clackamas River, 1961-96.

Brood Year	Wild Estm (>Mar 31)	Hatch Estm (<Mar 31)	Total Dam Count	Hatchery %
1961	2203	1	2204	0.0%
1962	4359	2	4361	0.0%
1963	2223	14	2237	0.6%
1964	1881	1	1882	0.1%
1965	1544	8	1552	0.5%
1966	1287	3	1290	0.2%
1967	676	6	682	0.9%
1968	767	23	790	2.9%
1969	2245	71	2316	3.1%
1970	2673	136	2809	4.8%
1971	3908	441	4349	10.1%
1972	2466	168	2634	6.4%
1973	1816	81	1897	4.3%
1974	641	30	671	4.5%
1975	1431	95	1526	6.2%
1976	1025	157	1182	13.3%
1977	1156	371	1527	24.3%
1978	1067	920	1987	46.3%
1979	950	561	1511	37.1%
1980	1693	372	2065	18.0%
1981	1798	899	2697	33.3%
1982	1153	293	1446	20.3%
1983	1031	68	1099	6.2%
1984	987	251	1238	20.3%
1985	1027	198	1225	16.2%
1986	1194	238	1432	16.6%
1987	1139	179	1318	13.6%
1988	1773	347	2120	16.4%
1989	963	288	1251	23.0%
1990	953	534	1487	35.9%
1991	482	355	837	42.4%
1992	1430	677	2107	32.1%
1993	1155	197	1352	14.6%
1994	1169	78	1247	6.3%
1995	913	233	1146	20.3%
1996	208	299	507	59.0%
1997	278	252	530	48.0%

Clackamas - Impact of Non-Native Hatchery Summer Steelhead - A summer steelhead run not native to this basin has been created through annual releases of Skamania stock hatchery smolts. These fish, if not caught and removed by anglers, remain in the Clackamas Basin and spawn naturally.

In addition to counts of both adult winter and summer steelhead, the number of downstream migrating steelhead smolts passing North Fork Dam have been estimated since 1960. In 1995, a sample of these naturally produced fish were genetically analyzed for parental origin. It was found that 59% of the wild smolts were offspring of naturally spawning summer steelhead (Cierebiej et al., 1995). Although this finding is somewhat preliminary, as it is based on only one year of data, it was key in the following impact assessment of summer steelhead on winter steelhead.

Assuming most of the smolts sampled in 1995 were two years old, their parents were the winter steelhead that returned and spawned in 1993 and the summer steelhead that returned in 1992 to spawn in 1993. The number of fish from each of these parental groups was estimated from fish counts at North Fork Dam. While there was essentially no harvest of winter steelhead above the dam, a significant number of the summer steelhead that passed upstream of the dam were caught and removed by anglers. The harvest rate on these fish was estimated at 44% on information collected from other summer steelhead fisheries in the Willamette Basin (Kenaston, 1989). Using this harvest rate and observed counts at North Fork Dam, the estimated number of steelhead spawning in 1993 was 1,332 winter steelhead and 3,335 summer steelhead.

Therefore, while summer steelhead comprised 71% of the steelhead spawning in the Clackamas during 1993, only 59% of the smolts resulting from this spawning effort were offspring of summer steelhead. Assuming this difference was the differential reproductive success between summer and winter steelhead spawners, smolt estimates made at North Fork Dam were divided into separate estimates for winter or summer steelhead based on the formula: $S_s = C_h * S_{total}$ and $S_w = S_{total} - S_s$. Where S_s is the estimated number of summer steelhead smolts, S_w the estimated number of winter steelhead smolts, S_{total} is the total number of smolts estimated from counts at North Fork Dam, and C_h is the proportion of the total smolt migration that are summer steelhead as calculated by $C_h = P_h(RS_h) / [P_w + P_h(RS_h)]$. Where P_h is the proportion of the spawning population that were summer steelhead, P_w the proportion of the spawning population that were winter steelhead, and RS_h is the reproductive success of summer steelhead spawners relative to that of winter steelhead estimated from 1995 data as follows: $RS_h = (\text{Proportion Smolts}_h * P_w) / (\text{Proportion Smolts}_w * P_h) = (0.59 * 0.29) / (0.41 * 0.71) = 0.59$.

As presented in Table 19, the additional natural production of summer steelhead smolts which began in the late 1970s did not appear to have a major negative impact on the number of winter steelhead smolts produced in the upper Clackamas Basin. However, it does appear that in the last two years something has caused the number of both winter and summer steelhead smolts to decline dramatically.

Table 19. The estimated number of winter and summer steelhead smolts migrating from the upper Clackamas River.

Smolt Year	Winter Sth. Smolts	Summer Sth. Smolts	Smolt Year	Winter Sth. Smolts	Summer Sth. Smolts
1963	24730	0	1981	23480	20078
1964	30830	0	1982	26804	17740
1965	13892	0	1983	19143	12472
1966	11035	0	1984	20099	20548
1967	31406	0	1985	16119	19033
1968	35758	0	1986	33774	16666
1969	29187	0	1987	12454	35270
1970	31457	0	1988	17144	20834
1971	19111	0	1989	14596	25776
1972	15476	0	1990	20404	15994
1973	21403	0	1991	15237	29601
1974	27306	0	1992	26597	22167
1975	27115	905	1993	14320	23193
1977	28970	4822	1994	19055	6310
1978	48582	29246	1995	9706	13510
1979	31565	9769	1996	7937	4586
1980	31292	16939	1997	2985	1305

To examine the possible interaction between summer and winter steelhead in a more systematic fashion, the number of smolts for each group was converted to adult recruits using a fixed smolt-to-adult survival of 8.7% as reported by Murtagh et al. (1992) for Clackamas steelhead. These recruit estimates were used with the estimates of spawner escapements to compare the recruitment function for winter steelhead in the Clackamas in the pre-summer steelhead time-frame (1963-74) to the post-summer steelhead time-frame (1978-95).

The results of this comparison indicate that the value for the Ricker parameter, a , decreased from 1.20 to 0.87 with the introduction of naturally producing summer steelhead to the Clackamas Basin. Converted to recruits per spawner at low densities, this is a change from 3.3 to 2.4, a 27% decrease in potential productivity. The comparison also suggests that the equilibrium level for winter steelhead in the Clackamas decreased 12% from $N^* = 2,273$ fish to $N^* = 1,980$. These changes suggest the productivity of winter steelhead in the Clackamas has been modestly impacted by the introduction of summer steelhead.

For comparison, the recruitment parameters for summer steelhead were also estimated. A low Ricker a -value of 0.106 and an estimated N^* of only 555 fish suggests that the Skamania summer steelhead stock is genetically poorly adapted to natural conditions in the Clackamas Basin. This is not surprising, as a low reproductive

success for naturally spawning Skamania stock summer steelhead has been previously demonstrated in the nearby Kalama River Basin by Chilcote et al. (1986) and Leider et al. (1990).

Sandy - Big Creek Hatchery stock is the primary source of winter steelhead smolts released into the Sandy Basin. As discussed in the methods section, hatchery fish were estimated at Marmot Dam based on their return timing. From 1978 to 1997, the percentage of hatchery fish in the upper Sandy Basin has averaged 43%. However, since 1989 hatchery winter steelhead smolts have been released only below Marmot Dam. In addition, ODFW is proposing to change release locations for hatchery winter steelhead in 1998 so that the majority of fish that are not caught will be drawn to confined sites in the lower river below Marmot Dam. This management change will likely reduce the percentage of hatchery fish in the upper basin to less than 10%. However, in 1997 it appeared the percentage of hatchery fish passing above Marmot Dam was still quite high, estimated at 39% from video recordings at the passage facility.

Skamania stock summer steelhead are also released into the Sandy Basin. In recent years, the number of hatchery adults returning from these releases has averaged 4,071 fish (ODFW, 1997). Assuming 50% of these fish are caught, the average number of non-native summer steelhead spawning in the Sandy Basin each year has been approximately 2,000 fish. This is about the same escapement as estimated for the wild winter steelhead population. Based on the observations and analysis of a similar situation in the Clackamas, there may be a negative impact of these naturally spawning non-native summer steelhead on the productivity of the Sandy wild winter steelhead population.

Hood River Winter Steelhead - The percentage of hatchery fish in this population has averaged 40.1% since 1992 when the trapping of adults at Powerdale Dam began (Table 20). The adult trapping facility, which has recently been improved, is located about three miles upstream from the confluence of the Hood River with the Columbia. Of important note is the switch of hatchery broodstocks from the Big Creek stock to a local stock developed from Hood River wild fish. Returns of hatchery fish after 1994 are largely members of this new Hood River stock.

Table 20. Number of wild and hatchery winter steelhead counted at Powerdale Dam, Hood River Basin, 1992-97.

Spawning Year	Wild Fish	Hatchery Fish	% Hatchery
1992	699	317	32%
1993	412	237	37%
1994	406	175	30%
1995	206	112	35%
1996	278	280	51%
1997	295	635	68%
Average	383	293	42%

Hood River Summer Steelhead - The Skamania hatchery stock is the source of summer steelhead smolts released into the Hood River. Counts of hatchery and wild summer steelhead passing Powerdale Dam are available for the spawning years 1993 to 1997 (Table 21). A very large portion of the summer steelhead returning to this basin are hatchery fish, an average of 83% of the return from 1993 to 1997.

Table 21. Number of wild and hatchery summer steelhead counted at Powerdale Dam, Hood River Basin, 1993-97 spawning years.

Spawning Year	Wild Fish	Hatchery Fish	% Hatchery
1993	492	1729	79%
1994	244	1112	82%
1995	220	1637	81%
1996	132	553	88%
1997	181	1370	83%
Average	255	1283	83%

Kalama Winter Steelhead - Hatchery winter steelhead smolts released into the Kalama River belong to the Elochoman stock. This stock, in terms of its level of domestication and age, is similar to Oregon's Big Creek hatchery stock. From information provided by WDFW, the percentage of hatchery fish in the population of naturally spawning winter steelhead within the Kalama Basin has averaged 36% from 1977 to 1996.

Kalama Summer Steelhead - Similar to many streams in NW Oregon, the hatchery summer steelhead program in the Kalama River is based upon the Skamania hatchery stock. Information provided by WDFW indicates that from 1977 to 1997 the percentage of hatchery fish in the naturally spawning population has averaged 74%.

Population Abundance, Trends, and Recruitment

Clackamas - From 1961 to present, the average number of wild winter steelhead produced in the upper Clackamas is 2,397 fish. However, in the last six years this wild population has declined to record low levels, with total pre-harvest return of only 217 wild fish in 1996 and 290 wild fish in 1997 (Figure 17). Based on recruitment modeling for this population, the estimated population equilibrium level is 1,810 individuals. From 1979 to 1991, the number of wild winter steelhead produced in this basin appears to have maintained around this equilibrium as depicted by the six-year moving average line in Figure 17. However, there appears to be an overall decline in this population beginning with the earliest data points and becoming suddenly more severe in the last several years.

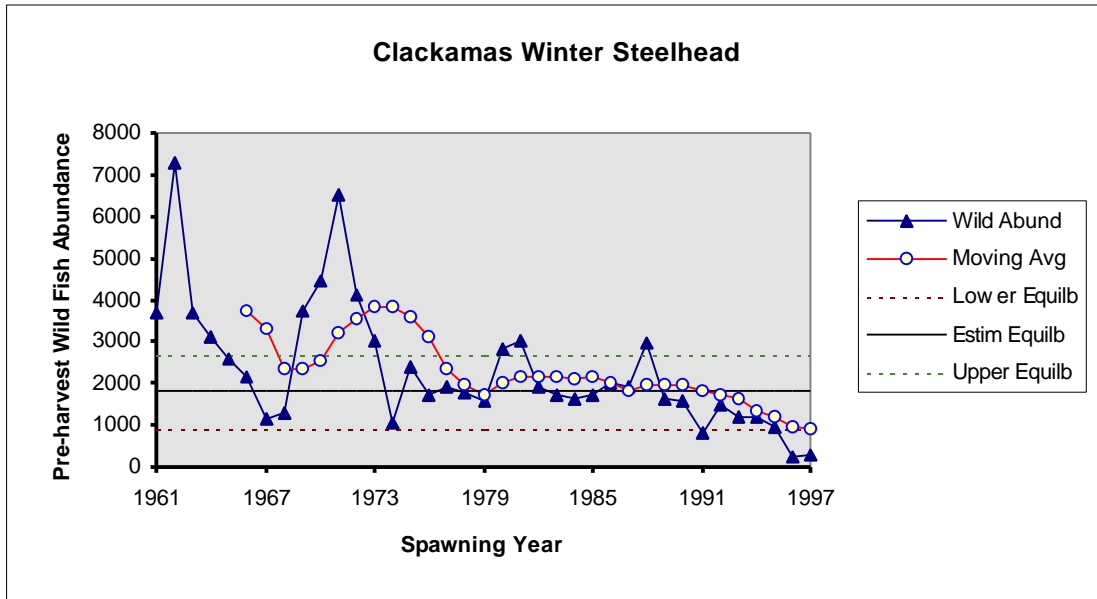


Figure 17. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Clackamas River above North Fork Dam, 1961-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The extremely low wild winter steelhead smolt estimates for 1996 (7,937) and 1997 (2,985), suggest that the decline in adult return will likely continue in 1998 and 1999 (Table 19). The record low adult returns observed in 1996 and 1997 were from smolt emigrations of 19,055 fish in 1994 and 9,706 fish in 1995.

Sandy - From return sizes exceeding 3,000 fish in the mid-1980s, there has been a steady decline in abundance for wild winter steelhead produced in the Sandy Basin upstream from Marmot Dam (Table 22 and Figure 18). Recruitment modeling indicates that the natural equilibrium level for this population is 1,060 fish. While it appears population abundance has been greater than this equilibrium level, there are at least three reasons why this finding should be used cautiously. First, the spawner-recruit data was a poor fit to the Ricker recruitment model as evidenced by a low R^2 of 0.11 and a regression significance probability of 0.23 (Table 2). Therefore, the equilibrium level may in fact be much greater (or smaller) than the estimate presented here suggests.

Table 22. Estimated number of wild and hatchery winter steelhead passing Marmot Dam, Sandy River, 1978-97.

Year	Wild Spawners	Hatchery Spawners	Pre-Harvest Wild Abundance
1978	2195	1876	3659
1979	1222	778	2037
1980	1870	1145	3117
1981	2198	1880	3663
1982	1600	1089	2667
1983	1331	1118	2218
1984	1296	936	2160
1985	1651	1190	2752
1986	1712	1040	2854
1987	2102	1573	3504
1988	1911	1529	3185
1989	1691	1302	2819
1990	1743	1322	2904
1991	1086	909	1131
1992	1572	1346	1638
1993	981	655	1021
1994	905	662	943
1995	927	753	965
1996	298	238	311
1997	851	547	887

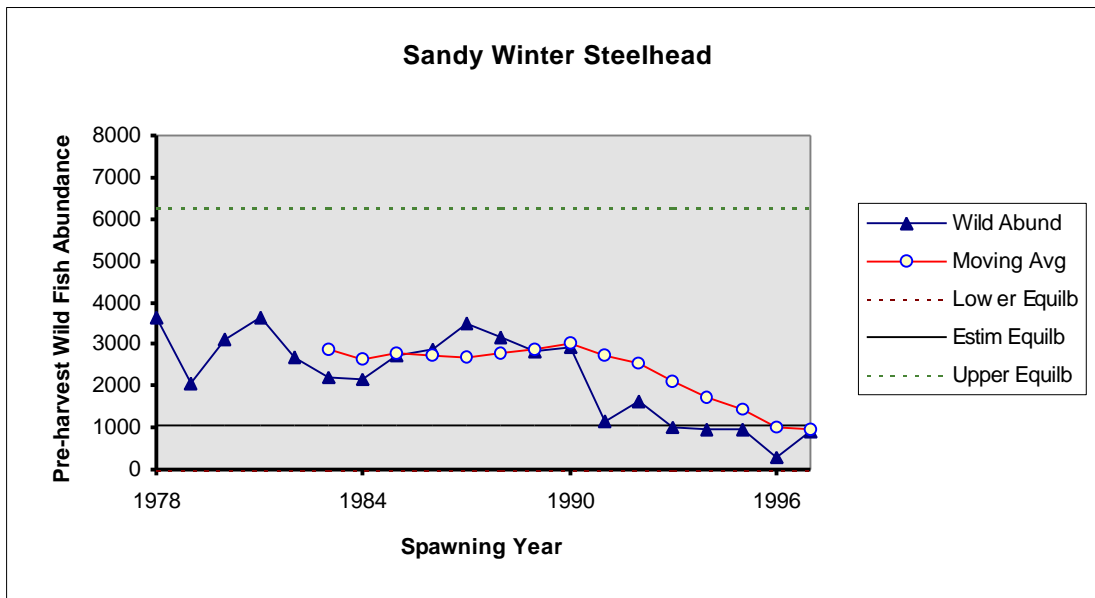


Figure 18. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Sandy River above Marmot Dam, 1978-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Second, almost half of the spawning population are hatchery fish belonging to a stock whose reproductive success under natural conditions may be very poor. As discussed at length under the population assessment for the Molalla population, it is possible the wild population of winter steelhead is much healthier than suggested by the 0.3382 estimate for the Ricker a parameter for the Sandy population.

Finally, as discussed in the methods section of this report, making hatchery-wild classifications in the Sandy is difficult and may be unreliable. A large error in this estimate could strongly affect the numbers of fish that are designated as wild and, thereby, result in quite a different recruitment relationship for this population.

Hood River Winter Steelhead - Although the time series of steelhead counts at Powerdale Dam covers a period of only six years, there is some indication that the wild population may be declining (Table 20). Average wild return during this period was 383 fish. There were insufficient data to estimate recruitment parameters for this population.

Hood River Summer Steelhead - Counts of wild summer steelhead, which are native to the Hood River Basin, have declined since fish counting was initiated at Powerdale Dam five years ago. The return of wild summer steelhead to this basin has averaged only 255 fish in the last five years, with 181 fish observed for 1997 spawning year (Table 21). As with the winter steelhead population, it was not possible to estimate recruitment parameters for this population. However, the Skamania hatchery stock used in this basin is the same as used in the Kalama system. In addition, the Hood River has a high percentage of the natural spawning population comprised of these hatchery fish, as is the case for the Kalama. These shared characteristics suggest that the reproductive capacities of these two populations is similar. As presented later in this report, the Kalama summer steelhead were estimated to have very poor recruitment performance, the worst of any steelhead population examined. By inference, the Hood River summer steelhead population may be in the same category. In light of this possibility, and the preliminary estimate of an extremely low run size in 1998 of 85 wild fish, it appears the summer steelhead in the Hood River may be at serious risk. To address this concern, ODFW stopped passing hatchery summer steelhead trapped at Powerdale Dam in August 1997. This action allows only wild summer steelhead into Hood River summer steelhead spawning and production areas.

Kalama Winter Steelhead - Superficially, the trends in abundance for Kalama River winter steelhead (as illustrated in Figure 19) appear similar to those observed for winter steelhead in the Sandy. It should be noted the large number of fish counted in 1981 for this population (Table 23) is at least partially the result of steelhead from the Toutle River watershed diverted into the Kalama because of the eruption of Mount St. Helens (Leider, 1989).

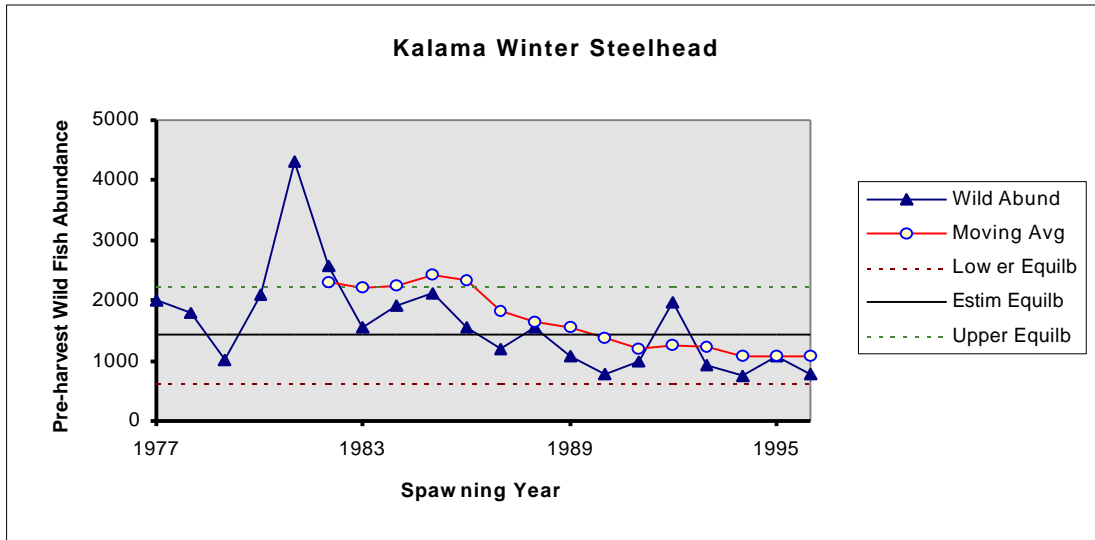


Figure 19. Annual and six-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Kalama River, 1977-96 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Table 23. Estimated number of wild and hatchery winter steelhead, Kalama River, 1977-96.

Year	Wild Spawners	Hatchery Spawners	Pre-Harvest Wild Abundance
1977	774	172	2003
1978	694	921	1808
1979	371	150	1018
1980	1025	322	2092
1981	2150	620	4312
1982	869	239	2588
1983	532	342	1552
1984	943	1064	1902
1985	632	435	2119
1986	919	1613	1562
1987	982	812	1200
1988	1078	1056	1564
1989	494	215	1065
1990	355	399	779
1991	959	329	985
1992	1973	873	1988
1993	842	311	917
1994	725	191	738
1995	1030	285	1083
1996	725	881	773

However, a key difference between these two populations appears to be their relative productivity. The recruitment parameter a estimated for the Kalama population was 0.9873, considerably greater than the 0.3383 estimated for the Sandy (Table 2). It appears the Kalama winter steelhead population retains considerable resilience and ability to rebound quickly with improved ocean conditions or other habitat related factors.

In addition, direct evidence from studies conducted in the Kalama Basin indicate the natural reproductive success of Elochoman origin hatchery spawners is a very low 0.11 (P. Hulett, WDFW personal communication). Therefore, even though 39% of the spawning population are hatchery fish, they have such poor reproductive success that the effective gene flow is only 0.07, as estimated from the equation:

$$m = (P_h * RS_h) / [(P_h * RS_h) + (P_w)];$$

where m = the effective gene flow, P_h is the proportion hatchery fish in the spawning population, RS_h = the reproductive success of naturally spawning hatchery fish, and P_w = the proportion of wild fish in the naturally spawning population.

Kalama Summer Steelhead - In contrast to most other populations within this ESU, the number of wild summer steelhead in Kalama has been relatively stable through the 1990s (Table 24). It should be noted, like the Hood River summer steelhead population, early indications are that the 1997-98 return will be a record low. Other than a peak in abundance during the early 1980s caused by the diversion of out-of-basin steelhead into the Kalama Basin as a result of the eruption of Mount St. Helens, the fluctuations in production of wild summer steelhead have been minimal (Figure 20).

Table 24. Estimated number of wild and hatchery summer steelhead, Kalama River, 1977-97.

Year	Wild Spawners	Hatchery Spawners	Pre-Harvest Wild Abundance
1977	400	1069	1033
1978	1015	3539	2094
1979	484	2120	1316
1980	718	1929	1562
1981	2924	8598	5902
1982	1385	12301	2460
1983	869	4405	2490
1984	247	908	985
1985	461	1106	1315
1986	473	2424	1272
1987	445	4687	593
1988	848	2199	1065
1989	492	2692	582

Table 24. Continued.

Year	Wild Spawners	Hatchery Spawners	Pre-Harvest Wild Abundance
1990	731	924	805
1991	704	1034	720
1992	1075	1588	1080
1993	2283	4905	2487
1994	1041	2797	1113
1995	1302	1741	1311
1996	614	1150	629
1997	650	2100	684

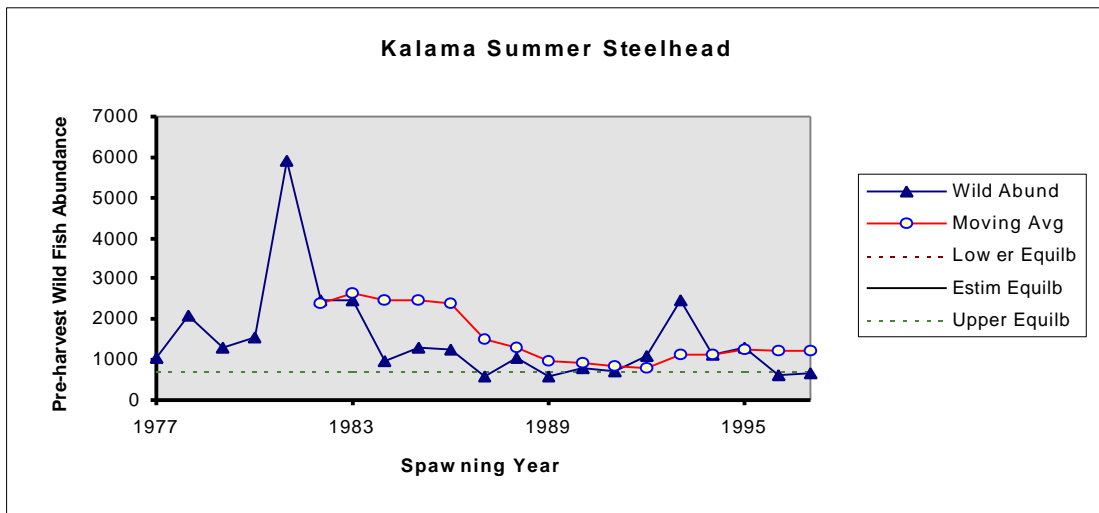


Figure 20. Annual and six-year moving average estimates of the pre-harvest abundance of wild summer steelhead in the Kalama River, 1977-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

While these indicators appear positive, the recruitment parameters estimated for this population suggest just the opposite. The Ricker recruitment parameter a estimated for the Kalama summer steelhead population was -0.2297 , the lowest of any population modeled (Table 2). Translated, this negative value means only 0.83 recruits are produced per spawner at low densities. Essentially, this result suggests the population cannot sustain itself at any level and is destined to go extinct. The population equilibrium level of zero depicted in Figure 20 reinforces this interpretation.

However, the observed flat to upward trend in wild steelhead abundance seems to contradict this conclusion. The resolution to this apparent inconsistency lies in the fact that large numbers of hatchery fish are added to the reproductive pool each

generation. While these hatchery spawners may have poor reproductive success relative to the wild spawners, they do produce enough wild offspring to keep the combined population from going extinct.

Obviously, this is an unnatural situation. However, it is encouraging that in earlier evaluations of steelhead in the Kalama (Chilcote et al., 1986 and Leider et al., 1990), the wild population still retained a substantial reproductive advantage over naturally spawning hatchery fish. This implies that the reproductive capacity of the wild population has not yet been seriously compromised.

Regardless, the situation for this population is not healthy. With an average hatchery fish proportion on the spawning grounds of 0.77 and an associated RS_h of 0.10 (Leider et al., 1990) the estimated gene flow of hatchery genes into the wild population is still dangerously high with $m = 0.25$, as calculated using the formula in the previous presentation for winter steelhead in the Kalama River.

It is unclear how this population would respond to the removal of hatchery spawners. This is an uncertainty common to several of the populations assessed and described in this report (e.g., Molalla winter steelhead). The expectation is that the wild Kalama summer steelhead population still retains a relatively healthy reproductive capacity. However, this expectation can not be proven until the recruitment from spawning populations comprised of mostly wild fish is observed.

ESU Status Synthesis

Quasiextinction Assessment Results - The quasiextinction assessment model results indicate that three of the four populations in this ESU met the criteria for the sensitive classification (Table 25). In addition, one population met the criteria for endangered, Kalama summer steelhead. However, this latter result is open to interpretation. If the known differences in reproductive success between hatchery and wild summer steelhead in the Kalama Basin are considered and the number of hatchery spawners are reduced so that they are stated in terms of wild fish reproductive equivalents, the quasiextinction model results are quite different. Under this alternate scenario, the estimated quasiextinction probability for Kalama summer steelhead fails to meet the criteria for either the threatened or endangered designation. However, for purposes of consistency with the modeling done for other populations, and additional rationale presented in the Reproductive Success of Hatchery Spawners section of this report, this alternate approach to estimating the probability of quasiextinction was not chosen for use in the status assessment of this ESU.

Table 25. Probability of quasiextinction estimates for four populations of steelhead in the Lower Columbia ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
Clackamas	0.000	0.000	0.342
Sandy	0.010	0.030	1.000
Kalama SR	0.634	1.000	1.000
Kalama WR	0.000	0.000	0.020

Hatchery Fish - The relatively high proportion of naturally spawning hatchery fish in the Sandy, Kalama, and Hood rivers put wild populations in these basins at some level of risk.

The ecological impact of non-native summer steelhead being introduced into the Sandy and Clackamas basins has likely cost winter steelhead populations some fraction of their productive capacity. For the Clackamas, a preliminary estimate suggests that the resiliency of the wild winter steelhead population has been reduced by 27% due to these introductions.

Trends in Abundance - All winter steelhead populations examined for this ESU have declined in abundance since the mid-1980s, the most dramatic being winter steelhead in the Clackamas. While the Hood River summer steelhead population has also declined in recent years, wild summer steelhead in the Kalama have not shown the same pattern. However, all indications are that for both of these summer steelhead populations, a record low number of wild fish will spawn in 1998.

Self-Sustaining - With the exception of the summer steelhead in the Kalama and Hood rivers, steelhead populations within this ESU seem self-sustaining. However, their cushion against additional stress does not appear to be great.

ESU Status - Three indicators were used to quantitatively assess the status of each steelhead ESU. As reported at the beginning of this section, the results from the quasiextinction assessment model revealed that three of the four populations modeled in this ESU met the criteria for a sensitive classification and one population qualified for the endangered category. Therefore, the combined score for the first indicator (long-term probability of quasiextinction) was 2.3 (Table 26).

Table 26. Summary of scores for status determinations for the Lower Columbia ESU based on three individual indicators: Long-term PQM (long-term probability of quasiextinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
2.3	1.8	4.0	2.7

For the short-term indicator (resistance to stress) two of the four populations examined met the criteria for secure. However, both the Clackamas and Sandy populations appear to have less resistance to short-term stress. The Clackamas population was classified as sensitive under this indicator, the Sandy population as threatened. Averaged across all four populations examined, the ESU score for this indicator was 1.8 (Table 26).

The magnitude of decline in wild populations of both Hood River summer steelhead and Clackamas River winter steelhead were sufficient to raise concerns about their persistence. As a result they met the criteria for an extirpation warning under the third indicator (extirpation warning). With two out of the six populations in this ESU (33%) at risk of extirpation, the score for this indicator is 4.0, which signifies a very high risk.

Averaging the scores for individual indicators, the status assessment score for this ESU was 2.7 (Table 26). Following the protocol described earlier in the methods section, this translates to a **THREATENED** status classification for the Lower Columbia ESU.

Middle Columbia ESU Status Assessment

Naturally Spawning Hatchery Fish

Deschutes - Evaluating the status of Deschutes summer steelhead is a complex task because four different groups of steelhead occur in this basin. They include hatchery fish produced within the basin at Round Butte Hatchery (RBH), hatchery strays from the Snake and upper Columbia basins, wild strays also from these up-river locations, and wild fish produced within the Deschutes. The Deschutes also contains an abundant population of conspecific resident rainbow/redband trout.

Steelhead escapement estimates for the Deschutes were made using mark-recapture methodologies described in the Deschutes Basin Fish Management plan (ODFW, 1996). The resulting escapement estimates demonstrate a significant increase in out-of-basin strays since the early 1980s (Table 27). The percentage of stray hatchery fish has increased to more than 70% of the spawning population in recent years. During this same time the percentage of wild fish has decreased to less than 15% (Figure 21).

Table 27. Estimated number of Deschutes wild, out-of-basin wild, Round Butte Hatchery, and stray hatchery steelhead escaping to Deschutes Basin above Sherars Falls, 1978-97.

Spawning Year	Wild Deschutes	Wild Strays	Hatchery Round Butte	Hatchery Strays
1978	6423	177	3166	740
1979	2741	59	803	81
1980	4082	118	1785	492
1981	4002	98	2462	406
1982	6664	236	1364	889
1983	6321	246	1383	1267
1984	6715	1513	3843	4697
1985	7136	585	3636	2652
1986	8994	630	3368	3488
1987	5012	1195	5784	7091
1988	2684	2684	7271	6648
1989	2829	717	2088	2076
1990	3630	648	1537	2465
1991	3247	406	1062	1850
1992	3446	1380	2014	6330
1993	452	452	1063	3177
1994	1002	485	770	3125
1995	241	241	804	3196
1996	831	831	1397	9739
1997	1729	1729	2191	17577

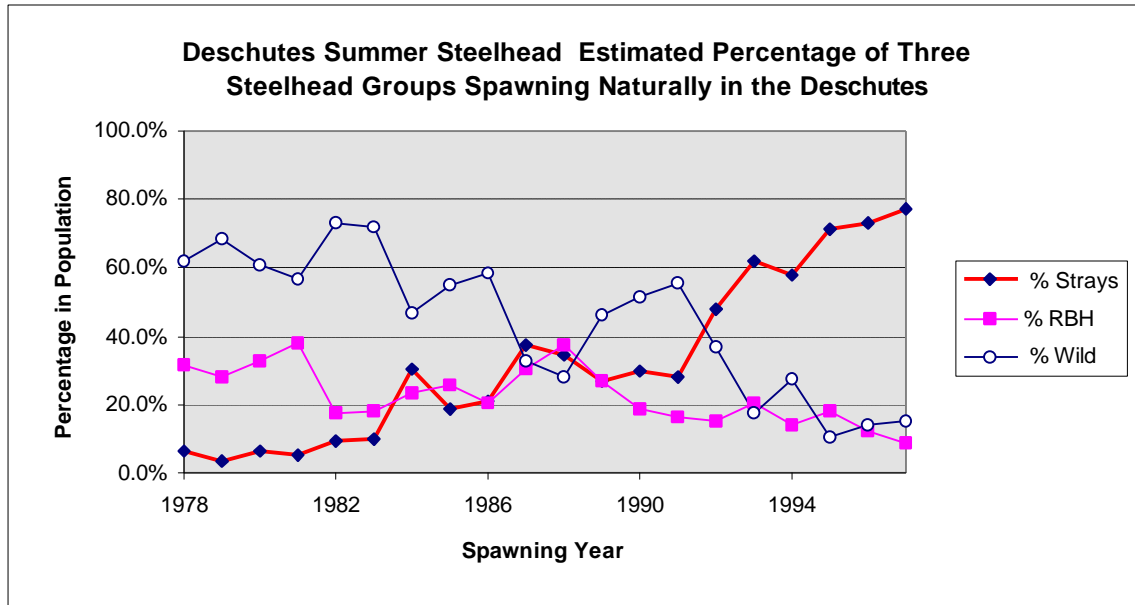


Figure 21. Estimated percentage of stray hatchery fish, Round Butte Hatchery fish, and wild fish in the natural spawning population of the Deschutes, 1978-97 spawning years.

While some of the stray steelhead that enter the Deschutes are known to leave and return to their streams of origin elsewhere in the Columbia Basin prior to spawning, the evidence suggests that the majority of the stray steelhead migrating past Sherars Falls spawn in the Deschutes. In particular, relatively large numbers of stray hatchery fish are observed late in the season at Pelton ladder and Warm Springs National Fish Hatchery (WSNFH), each of which is located over 90 river miles upstream from the Columbia. For example, even though the Pelton ladder is essentially the adult trap for Round Butte Hatchery (RBH), nearly equal numbers of stray out-of-basin and RBH-origin hatchery steelhead have been captured at this location in recent years. It is not likely that these strays, after arriving nearly 100 miles upstream from the Columbia at about the same time as the RBH fish, will spawn anywhere but in the Deschutes. Counts of stray hatchery fish into the Warm Springs River at WSNFH and estimated catches of stray hatchery fish in the Deschutes above Sherars Falls provide additional evidence that a significant portion of these strays remain in the basin to spawn.

Additional evidence that the number of out-of-basin hatchery fish spawning within the Deschutes has increased in recent years is provided by the results of spawning surveys conducted by ODFW field biologists in two Deschutes Basin tributaries, Bakeoven and Buckhollow creeks. In 1990 and 1991, the combined estimate of hatchery spawners, based on visual observation, was 17% (n = 23). However, in 1996 and 1997 the combined estimate of hatchery fish increased substantially to 71% (n = 69). While positive identification of these hatchery fish was not possible, it is likely that a majority of them were out-of-basin strays and not RBH origin. The rationale for this judgment is two-fold.

First, the percentage of out-of-basin strays estimated for the Deschutes, as illustrated in Figure 21, was approximately 30% in 1990-91 (1989-90 run years). However, in the last three years over 70% of the estimated escapement for the Deschutes have been out-of-basin strays. During this same time, the percentage RBH fish remained either the same (20%) or declined. Therefore, the likeliest explanation for the increase in hatchery fish in these two tributaries is the increased abundance of out-of-basin strays.

Second, hatchery steelhead homing behavior observed at other locations in Oregon (Rogue and Alsea rivers) suggests that when smolts are released directly from the hatchery, as is essentially done at RBH, less than 5% of the returning hatchery fish stray into other areas of the basin. Therefore, it is highly unlikely that many of the hatchery fish observed in these two Deschutes tributaries are strays from RBH.

If the artificial transportation of steelhead smolts around mainstem Columbia and Snake dams in recent years is responsible for this growing problem of strays it is likely that wild fish are being similarly effected. The ability to detect out-of-basin wild strays is hampered by inability to identify them. In contrast, hatchery strays are easily identified in the Deschutes Basin due to distinctive fin clips applied to RBH hatchery fish prior to their release.

The following approach was used to obtain an estimate for out-of-basin wild steelhead. First, numbers of wild and hatchery fish caught in the Zone 6 fishery (Bonneville Pool) were subtracted from the numbers of wild and hatchery fish that entered this fishery as measured at Bonneville Dam (WDFW and ODFW, 1996). The resulting numbers represented the steelhead escapement from Bonneville Pool and roughly approximated the number of wild and hatchery fish that passed by the mouth of the Deschutes.

To start the estimation procedure, it was assumed that the population of stray steelhead in the Deschutes Basin was a random sample of steelhead migrating up the Columbia past the mouth of the Deschutes (i.e., hatchery or wild). As such, the percentage of wild fish which escaped Bonneville Pool should be the same as the percentage of wild fish in the population of stray steelhead that entered the Deschutes River. Following this line of reasoning, the population of stray hatchery fish at Sherars Falls could be used to calculate an expected number of wild strays from the relationship:

$$\text{ExptWs} = (\text{Hs} / \text{Ph}) * (\text{Pw})$$

where,

ExptWs = the expected number of wild strays above Sherars Falls;

Hs = the estimated number of hatchery strays above Sherars Falls;

Ph = the proportion of hatchery fish in the steelhead run escaping Bonneville Pool; and

Pw = the proportion of wild fish in the steelhead run escaping Bonneville Pool.

However, when the expected number of wild strays at Sherars Falls was calculated using this equation, there were some years that the expected number of wild strays was greater than the total number of wild fish estimated for the Deschutes using standardized mark-recapture methodologies. Therefore, either wild fish were not straying at the same rate as hatchery fish, or the data necessary to make these estimates were inaccurate.

Unable to separate these two possibilities, the estimates of stray and Deschutes-origin wild fish presented in this report were made by averaging two scenarios. One assumed that all wild fish estimated at Sherars Falls were of Deschutes origin (i.e., not strays). The other scenario assumed that wild and hatchery fish were equally likely to stray into the Deschutes Basin. Under this second scenario, the number of wild Deschutes-origin steelhead were calculated by subtracting ExptWs (see equation on previous page) from the estimate of total wild fish upstream of Sherars Falls. In circumstances where this calculation generated a minus number, it was converted to a value of zero. For the purposes of this status assessment, the number of wild Deschutes-origin steelhead was determined by averaging the results from the two estimation scenarios above. Stray wild fish in the Deschutes were estimated by subtracting the estimated number of wild Deschutes-origin fish from the total number of wild fish calculated to have passed Sherars Falls.

The resulting estimates suggest that the percentage of wild fish in the Deschutes Basin that are strays has increased from 3% in the late 1970s to 50% in recent years. If these estimates for wild fish straying are plausible, this is a relatively recent phenomenon. Past genetic comparisons of steelhead in the Columbia Basin (Schreck et al., 1986) have demonstrated that the Deschutes population is different from those of the Snake Basin. If the Deschutes had historically received a substantial number of stray wild steelhead, any difference between the Deschutes and Snake basins would have likely been lost to genetic homogenization.

John Day Populations - Hatchery fish are not released into any of the five populations examined in the John Day Basin. In addition, this basin has the distinction of being one of the few large basins in Oregon with no history of a steelhead hatchery program. Although stray hatchery steelhead are caught in the lower mainstem, especially in the fishery below Cottonwood Bridge, they have been rare in the upper basin. However, reports from anglers in recent years suggest the incidence of stray hatchery fish is increasing in the upper basin. Until these reports are better verified, it is estimated these fish comprise less than 5% of the naturally spawning population.

Umatilla - Returns of summer steelhead to the Umatilla Basin, as estimated at Threemile Dam, are comprised of wild and hatchery fish. Most of the hatchery fish are of local origin developed from wild Umatilla broodstock. However, in recent years several hatchery fish from the Lyons Ferry Hatchery (Snake Basin) have also been observed at Threemile Dam.

With the initiation of the Umatilla hatchery program in the 1980s the percentage of hatchery fish in the basin increased from essentially 0% to an average of 36% over the last six years (Table 28).

Table 28. Wild and hatchery summer steelhead returning to the Umatilla River as estimated at Threemile Dam, 1980-97 brood years.

Brood Year	Wild Fish	Hatchery Fish	Pre-Harvest Abundance Wild Fish	Percent Hatchery
1980	2380	0	2937	0%
1981	1218	0	1602	0%
1982	608	0	931	0%
1983	1103	0	1522	0%
1984	2262	0	2877	0%
1985	3093	0	4714	0%
1986	2816	0	4280	0%
1987	3296	0	4717	0%
1988	2183	165	3456	7%
1989	1944	372	3164	16%
1990	1315	272	1969	17%
1991	625	388	870	38%
1992	2010	522	2602	21%
1993	1172	616	1546	34%
1994	853	344	1104	29%
1995	789	656	947	45%
1996	1196	785	1382	40%
1997	906	1463	1076	62%

Walla Walla - An adult steelhead trap has been operated for the last five years at Nursery Bridge Dam on the upper Walla Walla in Oregon. While it is unknown what portion of the total steelhead return is represented by fish counted at this upstream location, hatchery fish have comprised less than 2% of the fish observed. Although there is a substantial hatchery steelhead program in Washington, no hatchery fish are released into Oregon's portion of the Walla Walla River.

Population Abundance, Trends, and Recruitment

Deschutes - The annual, pre-harvest abundance of Deschutes-origin wild fish (recruits) was estimated from the number of wild fish caught and killed in the Zone 6 (Bonneville Pool) commercial fishery, the sport fishery in the Deschutes below Sherars Falls, and the dip net fishery at Sherars Falls. The combined fishing mortality on

wild Deschutes steelhead has declined from an estimated 60% in the late 1980s to 20% in 1997.

Since the mid-1980s, the wild Deschutes population has been in steep decline (Figure 22). The average number of wild steelhead produced in the Deschutes in the last three years was only 1,116 fish. The individual returns comprising this three-year average were produced from spawning populations (hatchery plus wild) that averaged greater than 7,000 fish.

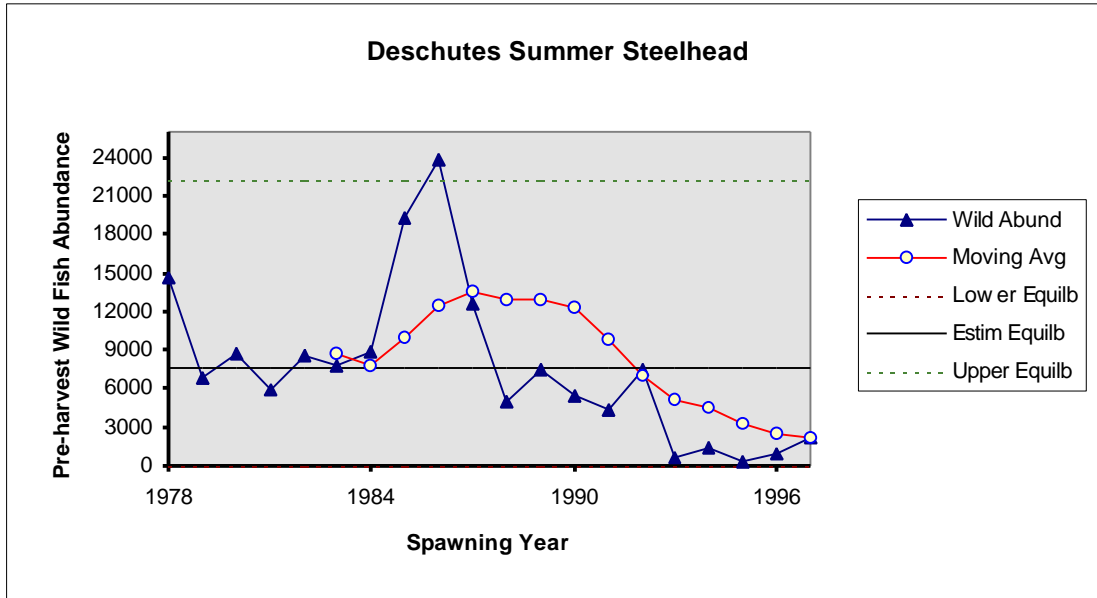


Figure 22. Annual and 6-year moving average estimates of the pre-harvest abundance of wild, Deschutes-origin steelhead in the Deschutes River, 1978-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Recruitment analysis of Deschutes steelhead indicated a poor statistical relationship ($P = 0.09$) between the natural log of recruits per spawner and total spawners. However, the primary cause for this weak relationship was the extremely low number of recruits produced in the last four brood years. The average recruits per spawner for these years was less than 0.20, an indication of almost complete reproductive failure.

The estimated value for the a parameter for the Deschutes population was 1.0430, surprising in light of the near recruitment failure in recent years. However, the recent poor reproductive performance was partially masked by the robust recruitment performance of this population from 1978 to 1984.

It is possible that at least some of the observed decline in wild steelhead in the Deschutes since 1985 is due to corresponding decreases in smolt-to-adult survival. To investigate this possibility, estimates of smolt-to-adult survival for RBH smolts produced and released into the Deschutes Basin were made. The underlying

assumption was that the trends in smolt-to-adult survival for hatchery fish should be similar to those observed for wild fish.

These estimated survival rates were based on data presented by ODFW (1996) including the known number of hatchery steelhead smolts released from RBH each year, the age and number of RBH adults returning to the Pelton ladder in subsequent years, and catch estimates for RBH fish in the Deschutes Basin. Harvest rate data presented by WDFW and ODFW (1996) for steelhead in the Zone 6 commercial fishery were used to estimate the Columbia River catch of RBH fish. Using this information, the approximate number of adults that returned to the mouth of the Columbia River for each release of smolts from RBH was calculated. As shown in Figure 23, there has been a significant decrease in smolt-to-adult survival since 1985. This decrease corresponds with the observed decline in the number of wild, Deschutes origin steelhead.

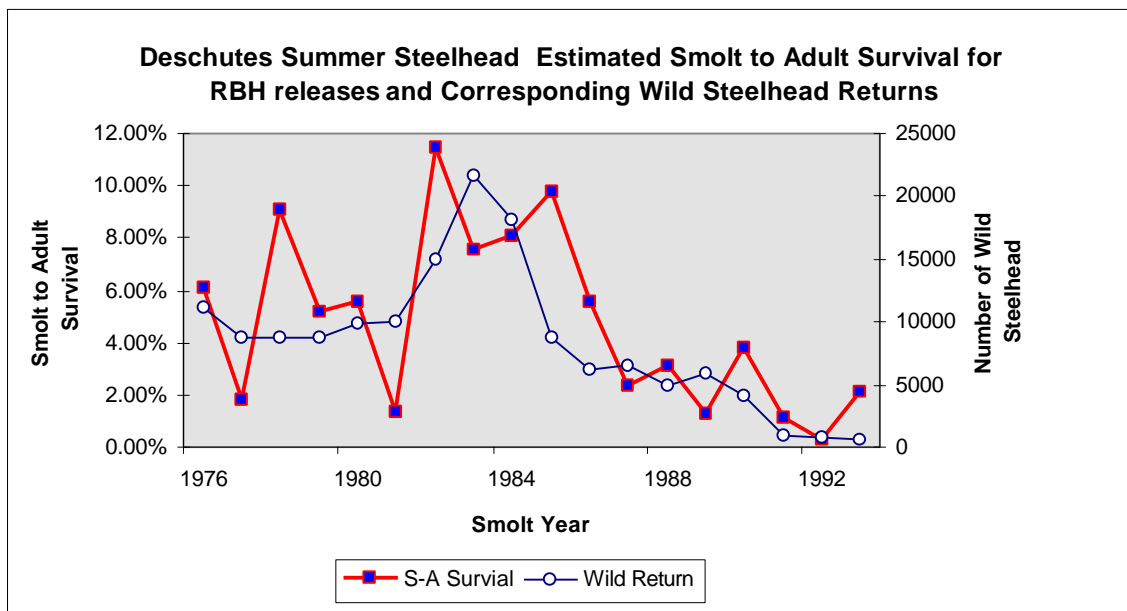


Figure 23. Estimated smolt-to-adult survival for hatchery steelhead released from Round Butte Hatchery and corresponding wild adult steelhead returns to the Deschutes River, 1976-94.

However, it is unlikely all of the reduction in wild steelhead recruitment was due to poor smolt-to-adult survival. Although survival has been on a decline from 1984 to 1994, it is only from 1991 to 1994 that serious recruitment failures have appeared in the wild steelhead population (Figure 23). The apparent discontinuous behavior of recruitment for this population is not consistent with the more gradual and continuous decline observed for smolt-to-adult survival.

A large population of resident *O. mykiss* occurs sympatrically with summer steelhead in the Deschutes Basin. Information presented by ODFW (1996) suggests that the

density of rainbow trout greater than eight inches may average over 1,000 fish per mile of mainstem river. Excluding tributaries, this density of fish expanded for the entire anadromous zone yields a population size of 100,000 fish. If only 1/3 of this population is sexually mature, the potential egg deposition is nearly 23 million eggs, assuming a 50/50 sex ratio and an average fecundity of 1,400. In comparison, the potential egg deposition for a typical Deschutes steelhead spawning population of 8,000 fish is 18 million eggs (assuming 50/50 sex ratio and average fecundity of 4,500). Therefore, the potential for ecological and genetic interactions between resident rainbow/redband trout and naturally spawning steelhead in the Deschutes is significant.

While the interactions between resident trout and steelhead are complex, it is worth noting the density of rainbow/redband in the Deschutes Basin has remained relatively stable during the same period that wild steelhead have been in steep decline (ODFW, 1996). If the abundance of resident trout is a rough index of habitat quality, it suggests that environmental conditions within the Deschutes Basin have remained relatively unchanged over the last ten years. Because of this observation, and the ecological similarity between resident rainbow and steelhead, it is difficult to hypothesize that habitat degradation has been the cause of the wild steelhead decline over the last 10 years. The two most likely explanations are poor out-of-basin survival (in the ocean and migration corridors of the Columbia River) and maladaptive genetic change as a result of the high incidence of naturally spawning stray steelhead.

The evidence provided in this report indicates the wild Deschutes steelhead are at serious risk. The best explanation for the decline in this population may be the loss in reproductive capacity due to genetic mixing with large numbers of out-of-basin, out-of-ESU strays. These stray steelhead, particularly hatchery fish, have dominated the steelhead return in recent years. The decline in smolt-to-adult survival over the last eight years has likely been amplified by the negative genetic effect of these strays on population recruitment. While the recent drought may also have contributed to reduced steelhead production, it appears this has been less important, partly because during the same time period the resident/redband trout population has apparently remained stable.

John Day Populations - Abundance, trend, and recruitment patterns were assessed for all five populations of John Day steelhead: Lower Mainstem (below Picture Gorge), Upper Mainstem (above Picture Gorge), North Fork, Middle Fork, and South Fork. The general pattern in abundance for these populations shows a low point during the late 1970s followed by an increasing trend leading to peak counts during the late 1980s (Table 29). Recently, all populations have declined to lows similar to those observed in the late 1970s.

The Lower Mainstem, Upper Mainstem, and South Fork populations have remained depressed for several years (Figures 24, 25, and 28). During the last four years, these populations have been less than half of estimated equilibrium levels. While equally low or lower spawner densities were estimated in the 1970s, the levels observed in the 1990s cover a longer period of time.

Plots of spawner density indices for the Upper Mainstem (Figure 25), North Fork (Figure 26), and Middle Fork (Figure 27) populations all show a spike in abundance for the 1992 spawning year. A similar pattern was not observed in the Lower Mainstem and is indistinct in the South Fork.

Table 29. Index of steelhead spawners per stream survey mile for five populations of John Day summer steelhead (1974-97).

Year	Lower Mainstem	Upper Mainstem	North Fork	Middle Fork	South Fork
1974	4.2	5.4	5.3	5.8	13.1
1975	12.2	8.1	7.4	8.5	18.8
1976	5.7	7.4	5.8	12.8	10.4
1977	0.7	9.2	3.8	10.3	12.7
1978	7.0	6.1	2.0	8.2	7.3
1979	0.3	0.9	1.9	1.6	3.8
1980	5.3	6.1	2.7	3.1	7.2
1981	5.8	3.8	3.2	6.2	5.7
1982	3.5	4.1	4.3	5.8	9.9
1983	3.9	8.2	5.1	4.1	12.0
1984	4.5	6.5	2.3	4.7	8.1
1985	7.0	10.9	9.3	7.7	15.4
1986	20.7	16.6	8.5	16.5	13.8
1987	21.9	16.3	9.6	9.7	18.4
1988	15.8	20.9	7.8	17.3	19.4
1989	6.5	5.8	1.5	5.8	3.5
1990	5.1	5.8	1.6	2.3	8.4
1991	3.8	3.5	1.8	3.8	4.2
1992	5.0	10.1	5.1	15.9	5.4
1993	1.8	2.3	2.0	3.5	3.2
1994	1.2	4.6	2.3	4.7	5.8
1995	1.8	1.4	1.6	1.6	2.8
1996	3.0	2.4	4.7	2.7	3.1
1997	3.0	2.2	2.6	3.0	1.9

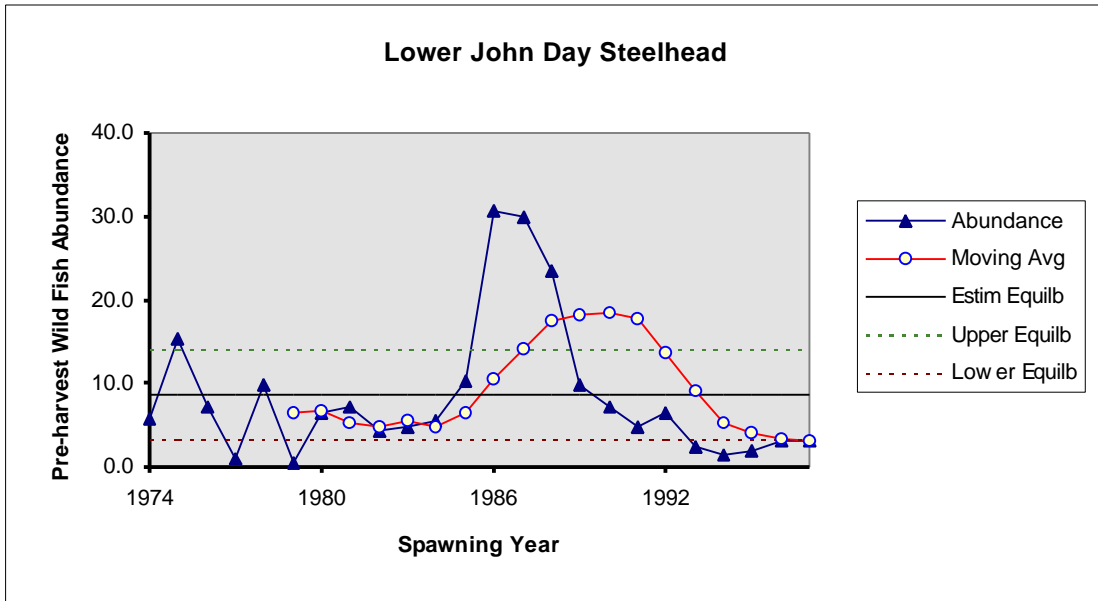


Figure 24. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in lower mainstem tributaries of the John Day River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

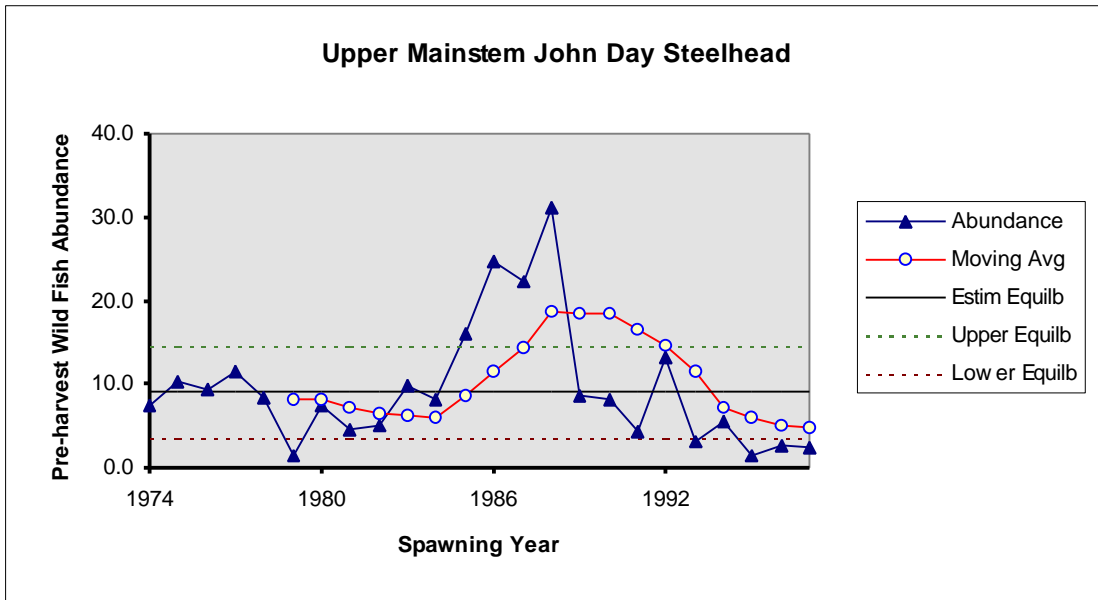


Figure 25. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in upper mainstem tributaries of the John Day River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

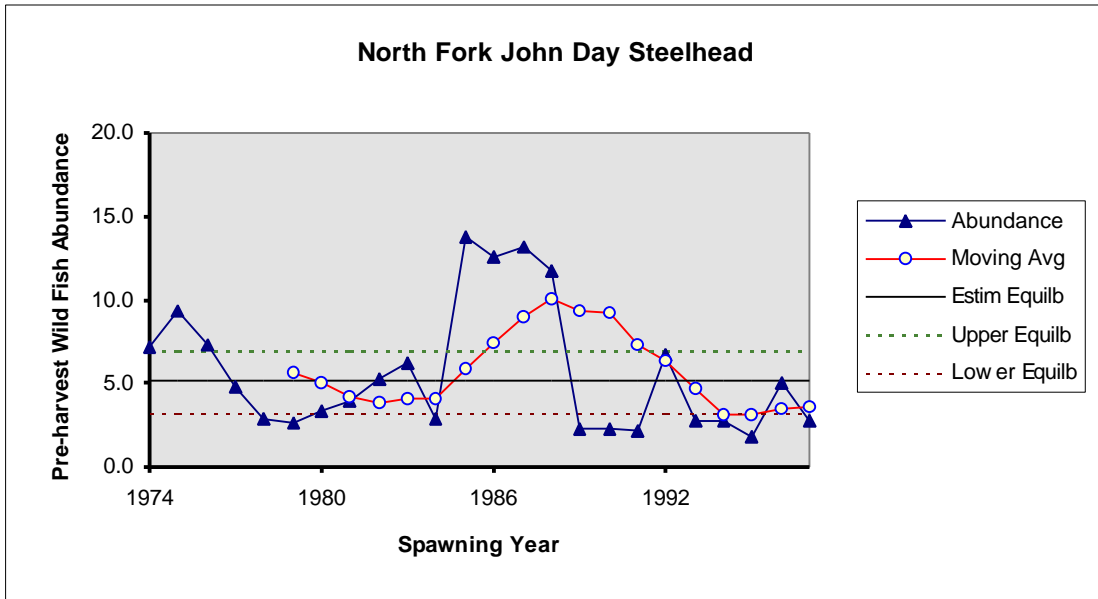


Figure 26. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in the North Fork John Day River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

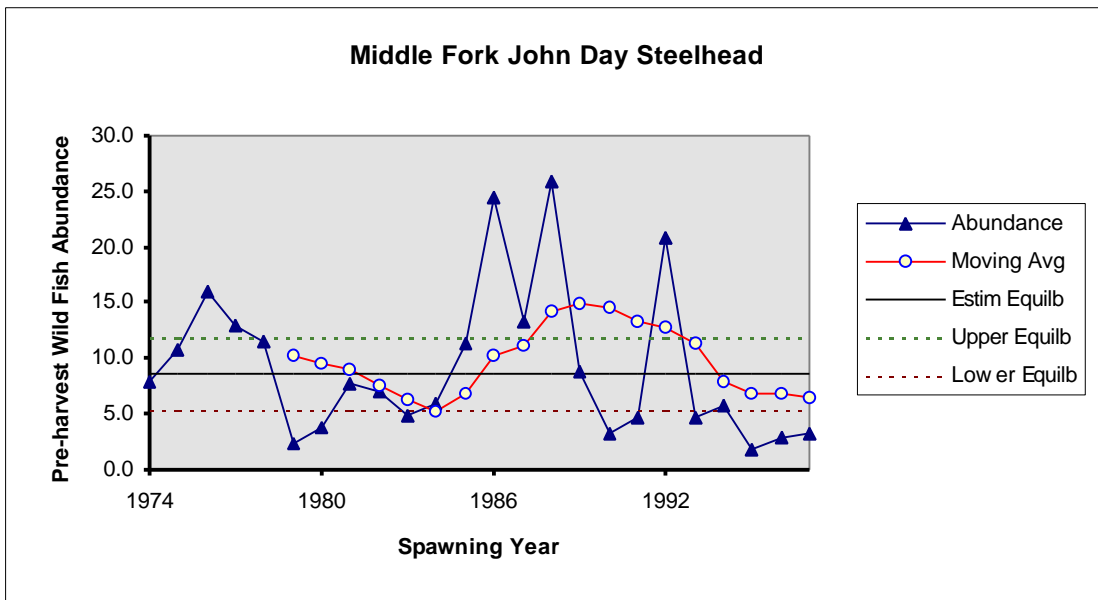


Figure 27. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in the Middle Fork John Day River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

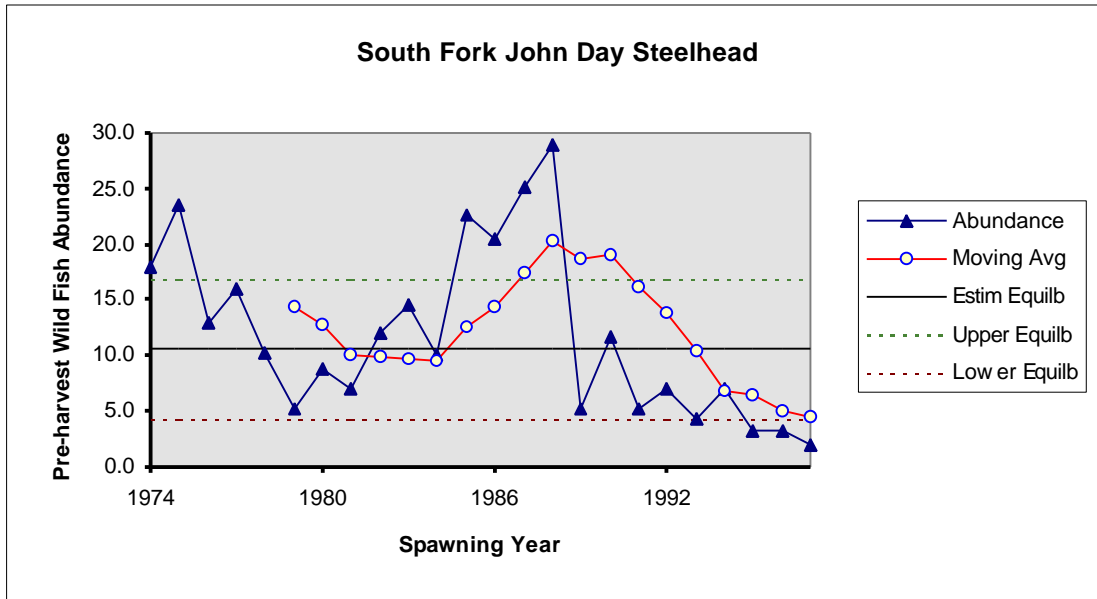


Figure 28. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in the South Fork John Day River, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The spawner abundance analysis suggests the Lower Mainstem and South Fork John Day populations are the least healthy of the five populations within the John Day Basin. The South Fork population in particular shows a decline in spawner densities large enough to warrant concern about its likely persistence.

Although the North Fork population appears to be returning to expected equilibrium abundance levels, all four remaining populations in this basin remain depressed. Recruitment modeling suggests the resiliency of John Day steelhead populations is relatively intact. However, the data do not support a clear conclusion that steelhead densities in this basin have bottomed-out and are returning to equilibrium levels.

Umatilla - The abundance of wild steelhead in the Umatilla Basin since 1980 has followed a pattern similar to other steelhead populations in the Columbia Basin, especially those in the John Day. The Umatilla data show a peak in wild steelhead abundance in the 1980s and a subsequent decline in the 1990s, broken by a spike in abundance in 1992 (Figure 29). This is almost identical to the pattern observed for the North Fork and Upper Mainstem populations of the John Day Basin. However, the plot of the six-year moving average illustrates a downward trend for this population over the last 10 years.

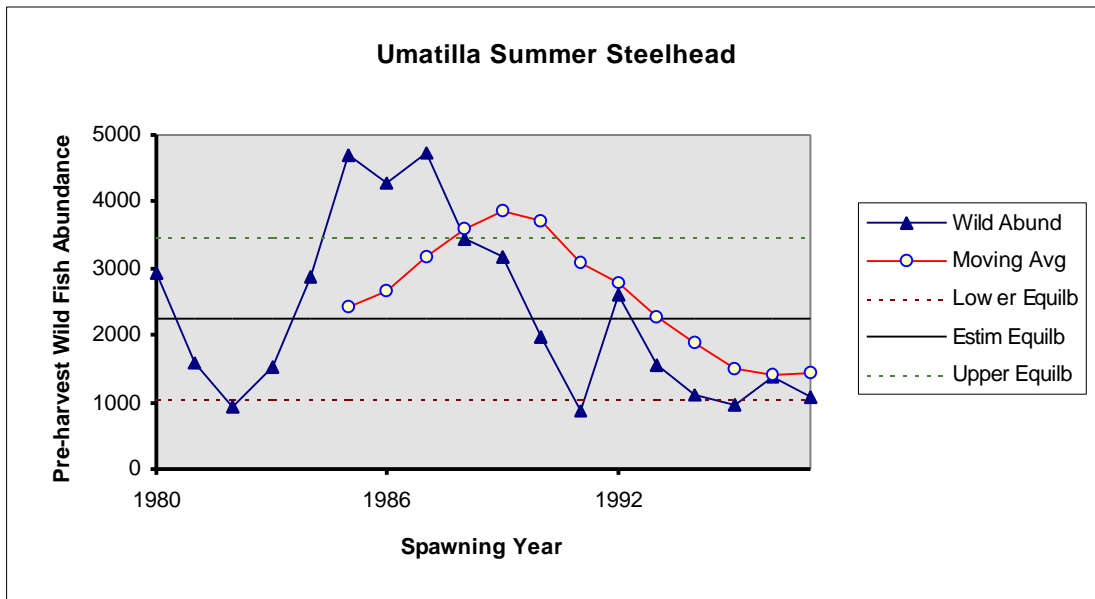


Figure 29. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in the Umatilla River, 1980-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

Walla Walla - Since 1993, when counts of steelhead at Nursery Bridge Dam were initiated, the number of wild fish has steadily declined. In 1993, 722 fish were observed, followed by annual estimates of 423 in 1994, 340 in 1995, 256 in 1996 and 230 fish in 1997. Interpreting these numbers is difficult without steelhead escape-ment estimates in other portions of this basin over a longer time period.

An interesting result of this sampling effort was the discovery that most of the steelhead returning to the Walla Walla at this location (70%), spent two years in the ocean before returning to spawn. This high incidence of two-salt fish is unusual for mid-Columbia populations. This population also contains a relatively large number of fish on their second spawning migration. The percentage of repeat spawners observed in 1993, 1994, and 1995, was 8%, 4%, and 9%, respectively.

ESU Status Synthesis

Quasiextinction Assessment Results - Five of the seven populations in Oregon’s portion of the Middle Columbia ESU met the criteria for a sensitive classification (Table 30). However, none of the populations had quasiextinction probabilities high enough to qualify as threatened or endangered.

Table 30. Probability of quasiextinction estimates for seven populations of steelhead in the Middle Columbia ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
Deschutes	0.000	0.000	0.002
Lower John Day	0.004	0.010	0.538
Upper John Day	0.000	0.000	0.518
North Frk John Day	0.000	0.000	0.958
Middle Frk John Day	0.000	0.000	0.050
South Frk John Day	0.000	0.000	0.692
Umatilla	0.000	0.000	0.000

However, for the Deschutes population, these results may be somewhat misleading. As discussed earlier, the reproductive ability of this population has failed dramatically in the last four brood years, with an average of only one recruit produced for every seven spawners. Prior to this change, the reproductive performance for the Deschutes population appeared quite robust. The quasiextinction model results are based on the underlying recruitment function for each population as estimated from available data. In the Deschutes, the majority of these data were from a healthier period of time. As a result, the estimated probabilities of quasiextinction presented here do not reflect the full effect of observed changes over the last four years. Clearly, the probability of quasiextinction equals 1.000 if reproductive performance remains at the current levels for many more consecutive years.

Hatchery Fish - With the exception of the Deschutes, hatchery fish do not appear to be having a substantial negative impact on the health of Oregon populations within this ESU. The low incidence of hatchery fish (as is the case for populations in the John Day Basin), the fact that hatchery fish in the populations examined are genetically similar to the wild population, and the percentage of hatchery fish in the natural spawning population of less than 30% until recent years, are all contributing factors.

In contrast, the Deschutes population appears to be at great risk because of out-of-basin hatchery strays spawning within the basin. Near complete reproductive failure has occurred in recent years as the number of these out-of-basin strays has increased to more than 70% of the natural spawning population.

Trends in Abundance - All seven populations examined appear to share a pattern of relatively high abundance during the mid-1980s, followed by a decline in the 1990s. This decline coincides with decreases in smolt-to-adult survival as estimated from hatchery fish released from RBH (Figure 23). Because of this observation and the fact the decline in abundance is shared by all populations, the best explanation for the downward trend is common survival factors, most likely mainstem Columbia passage and ocean survival.

Self-Sustaining - Except the South Fork John Day population, there are no obvious signs that steelhead populations in the John Day and Umatilla basins are reproductively failing or at critically low population levels. The underlying recruitment relationships for the Umatilla and John Day populations suggest that their capacity to respond to environmental changes is still intact. Data suggest that much of the decline in recent years has been due to poor smolt-to-adult survival and not population failure within basins. Assuming this pattern is cyclic, the observed declines can be expected to reverse in the next three to five years.

Unlike the Umatilla and John Day, Deschutes wild steelhead have not been self-sustaining, in the last three years. In these three years, spawner escapements of nearly 8,000 fish have yielded an average of less than 1,200 recruits. While declines in smolt-to-adult survival may partially explain the problem, the adverse genetic impact of an overwhelming number of out-of-basin strays is likely the primary important factor.

ESU Status - As reported above (Table 30), the results from the first of the three indicators used to quantitatively assess the status of each steelhead ESU indicated that five of the seven populations qualified for a sensitive classification. From these results, the combined score for the long-term persistence indicator for this ESU was 1.7 (Table 31).

Table 31. Summary of scores for status determinations for the Middle Columbia ESU based on three individual indicators: Long-term PQM (long-term probability of quasi-extinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
1.7	2.0	3.0	2.2

The assessment results for the second indicator (resistance to short-term stress) are that none of the populations within the John Day Basin meet the criteria for secure. All qualify for a sensitive designation under this indicator, with the exception of the North Fork population which appears to have very little resistance to a short (12-year) period of high environmental stress. Averaging across all populations examined in this ESU resulted in an indicator score of 2.0 (Table 31).

Two of the eight populations examined appear to warrant an extirpation warning, the Deschutes and the South Fork John Day. There have been large declines in the six-year moving average abundance of wild steelhead in both of these populations over the last 18 years (- 75% in the Deschutes and - 50% in the South Fork John Day). In addition, there are serious genetic concerns for the Deschutes population as a result of hatchery strays in the natural spawning population which are increasing each

year. For this third indicator, two of the eight populations (25%) rate extirpation warnings, resulting in a score of 3.0 and an indicator designation of threatened.

Averaging the scores for individual indicators, the status assessment score for this ESU was 2.2 (Table 31). Therefore, the overall status classification given to this ESU is **SENSITIVE**.

Snake ESU Status Assessment

Naturally Spawning Hatchery Fish

Joseph Creek (Lower Grande Ronde) - Hatchery smolts are not released into the Joseph Creek system and hatchery adults have never been observed during spawning surveys conducted in this basin since the 1950s. Therefore, less than 5% of the natural spawners in this basin are believed to be hatchery fish.

Upper Grande Ronde - Of the populations examined, the upper Grande Ronde probably contains the largest number of natural spawning, hatchery-origin steelhead. The presence of hatchery fish is a recent feature, beginning in the 1980s with the release of Wallowa stock hatchery smolts. The Wallowa Hatchery stock was developed from wild fish collected at Snake River Dams, and not directly from local populations in the Grande Ronde Basin.

From creel survey data collected between 1987 and 1996 for the upper Grande Ronde, it appears that an average of 56% of the total steelhead return were hatchery fish. Because these data were collected from anglers targeting hatchery fish, it is possible they overestimate the percentage of hatchery fish spawning in the basin. However, the trapping of several tributary streams in 1997 for adult steelhead suggested that 85% of the spawning population were hatchery fish.

Imnaha - The stock of hatchery fish used in the Imnaha Basin was developed from wild Imnaha steelhead. It appears that most of the hatchery adults return to spawn at their smolt release site within the Little Sheep Creek system (an Imnaha tributary). Averaged across the entire Imnaha Basin, the percentage of hatchery fish in the natural spawning population is estimated to be less than 20%.

Population Abundance, Trends, and Recruitment

Joseph Creek (Lower Grande Ronde)- Fish per mile index estimates were calculated for the Joseph Creek system by taking the average of spawners per mile estimated for three Joseph Basin tributaries, Crow, Elk, and Swamp creeks. The pattern of wild spawner abundance indicates that extremely low levels were experienced in the late 1970s, followed by a rebound in the 1980s (Table 32).

Table 32. Index of steelhead spawners per mile, estimated harvest rates, and pre-harvest index of abundance for steelhead returning to Joseph Creek, lower Grande Ronde Basin.

Brood Year	Wild Escapement	Harvest Rates	Pre-Harvest Abundance
1974	2.1	0.19	2.6
1975	0.6	0.12	0.7
1976	0.6	0.11	0.7
1977	1.2	0.11	1.3
1978	1.0	0.20	1.2
1979	0.3	0.20	0.4
1980	3.6	0.10	3.9
1981	2.4	0.10	2.7
1982	2.7	0.08	3.0
1983	1.6	0.07	1.8
1984	2.4	0.10	2.7
1985	10.3	0.24	13.6
1986	10.3	0.25	13.7
1987	8.6	0.19	10.5
1988	10.5	0.25	14.0
1989	10.2	0.26	13.7
1990	9.5	0.20	11.8
1991	1.6	0.18	1.9
1992	2.9	0.15	3.4
1993	7.5	0.17	9.0
1994	2.8	0.15	3.3
1995	2.4	0.09	2.6
1996	2.2	0.07	2.4
1997	3.0	0.07	3.2

Recruitment modeling suggests that the natural equilibrium level of spawners for this population was seven fish per mile (Figure 30). With the exception of the late 1980s this population has been substantially below this equilibrium level.

The estimated value for Ricker parameter a of 1.5768, suggests this population is quite resilient and productive. This is supported by the observed rebound in the 1980s from record low spawner densities of the 1970s. The Joseph Creek population is presently at a depressed level, yet apparently retains its capacity to respond positively when conditions improve.

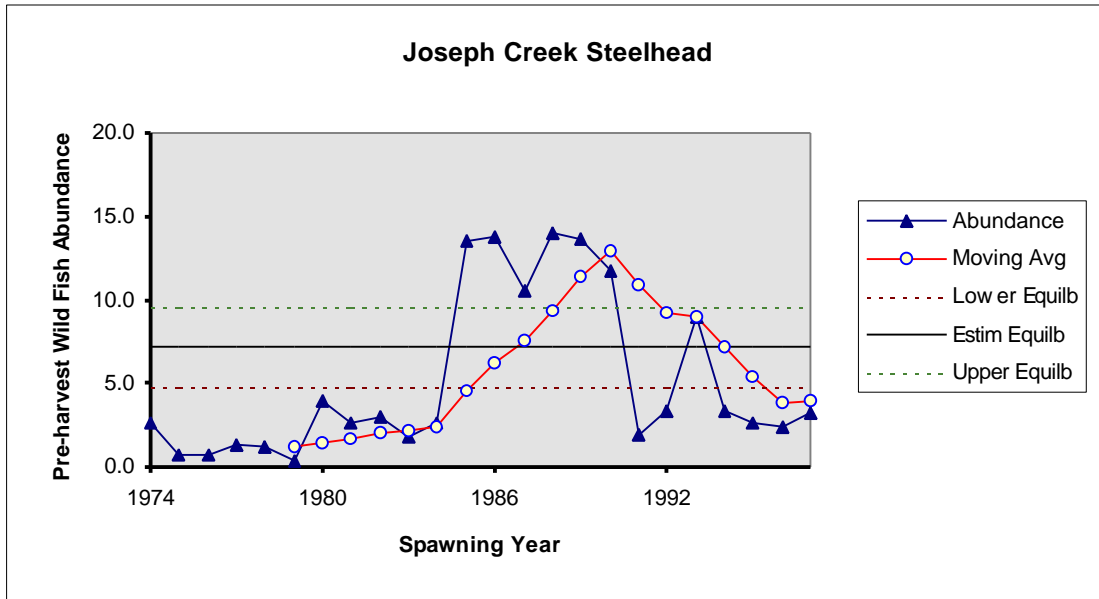


Figure 30. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in Joseph Creek, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

Upper Grande Ronde - The results of spawning survey information collected between 1974 and 1997 for Meadow, Fivepoint, Phillips, McCoy, and Fly creeks were averaged to obtain a steelhead abundance index for this basin. Spawning survey data were unavailable for the years 1984 and 1991. Spawner densities were estimated for these missing years from a regression developed between observations in Joseph Creek (a nearby population in the lower basin) and the upper Grande Ronde spawner index.

Using methods similar to those for other basins, redds per mile were converted to fish per mile based on information that 60% of the population were female and a conversion factor of 0.81 redds per female.

The estimated number of wild spawners per index survey mile has fluctuated between 0.24 in 1979 to 8.2 in 1985 (Table 33). However, in recent years the density of wild steelhead spawning in the upper Grande Ronde Basin index streams has generally been less than 1.0 fish per mile.

Table 33. Index of wild and hatchery steelhead spawners per mile, estimated harvest rates, and pre-harvest index of abundance for steelhead returning to the upper Grande Ronde Basin. Harvest rates from 1974 to 1984 were assumed to be the same as the 1985 to 1989 average harvest rate.

Brood Year	Wild Fish Escapmt	Hatchery Fish Escapmt	Percent Hatchery Fish	Estimated Harvest Rate	Pre-Harv. Wild Fish Abundance
1974	1.28	0.00	0%	0.19	1.58
1975	1.25	0.00	0%	0.12	1.42
1976	0.61	0.00	0%	0.11	0.69
1977	4.42	0.00	0%	0.11	4.99
1978	3.15	0.00	0%	0.20	3.96
1979	0.24	0.00	0%	0.20	0.30
1980	4.26	0.00	0%	0.10	4.72
1981	1.00	0.00	0%	0.10	1.11
1982	1.24	0.00	0%	0.08	1.36
1983	2.32	0.00	0%	0.07	2.51
1984	3.26	0.00	0%	0.10	3.64
1985	8.21	0.00	0%	0.24	10.87
1986	5.77	0.00	0%	0.25	7.69
1987	5.27	1.76	25%	0.19	6.48
1988	3.33	2.73	45%	0.25	4.47
1989	0.96	0.79	45%	0.26	1.30
1990	1.18	1.04	47%	0.20	1.46
1991	0.74	2.62	78%	0.18	0.90
1992	0.50	4.50	90%	0.15	0.58
1993	0.29	1.97	87%	0.17	0.35
1994	0.52	1.48	74%	0.15	0.61
1995	0.56	1.61	74%	0.09	0.62
1996	1.05	1.57	60%	0.07	1.13
1997	0.55	3.11	85%	0.07	0.59

Recruitment modeling estimated a relatively robust a -value of 1.5484 for this population, which translates to five recruits per spawner at low densities. However, production of wild fish since 1991 has been less than 25% of the estimated equilibrium for this population of 2.8 fish per mile (Figure 31). While it may be coincidental, the reproductive performance of this population seems to have declined substantially with the addition of naturally spawning hatchery fish in 1987. It would not be surprising if the addition of the Wallowa Hatchery fish caused some of the observed decline in productivity for this population. Evidence from other populations presented in this report suggests that when hatchery fish exceed more than 50% of the spawning population, reproductive failure of the population is likely.

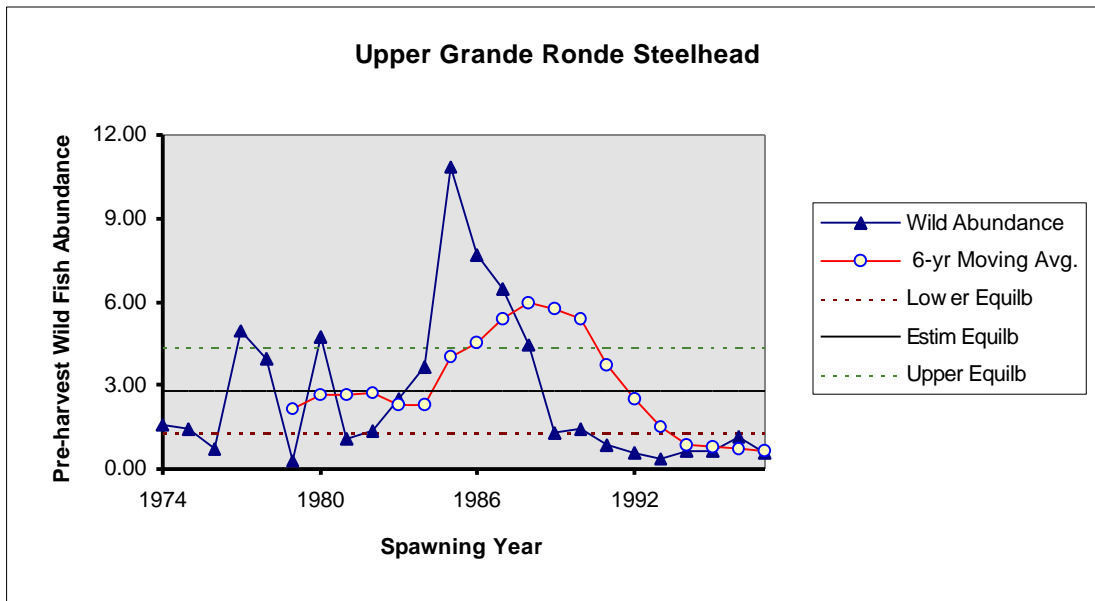


Figure 31. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in upper Grande Ronde, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

The abundance of the upper Grande Ronde steelhead population has declined since 1989 to very low levels and shows little sign of rebounding. This lack of positive response may be partially due to the recent addition of poorly adapted genetic material from large numbers of naturally spawning hatchery fish.

Index estimates of fish per mile for this population were based on steelhead spawning survey data obtained for Camp Creek. Because there is no specific information on the percentage of hatchery fish spawning in Camp Creek, hatchery fish are assumed to have comprised 20% of the spawning population since 1987, when significant numbers of hatchery fish first began returning to the Imnaha Basin.

Imnaha - The temporal pattern of wild spawner abundance for the Imnaha closely resembles that observed for the Joseph population; extremely low levels in the late 1970s, followed by a rebound in the 1980s (Table 34). While the abundance of this population has declined in the 1990s, there have been several spikes in abundance in the last several years that are not present in the upper Grande Ronde population.

Table 34. Index of wild and hatchery steelhead spawners per mile, estimated harvest rates, and pre-harvest index of abundance for steelhead returning to Camp Creek, Imnaha Basin.

Brood Year	Wild Fish Escapemt	Hatchery Fish Escapmt	Percent Hatchery Fish	Estimated Harvest Rate	Pre-Harv. Wild Fish Abundance
1974	3.11	0.00	0%	0.19	3.82
1975	0.95	0.00	0%	0.12	1.07
1976	0.27	0.00	0%	0.11	0.30
1977	1.35	0.00	0%	0.11	1.52
1978	2.43	0.00	0%	0.20	3.05
1979	3.65	0.00	0%	0.20	4.57
1980	7.70	0.00	0%	0.10	8.53
1981	2.03	0.00	0%	0.10	2.24
1982	1.62	0.00	0%	0.08	1.76
1983	3.78	0.00	0%	0.07	4.09
1984	3.11	0.00	0%	0.10	3.47
1985	8.78	0.00	0%	0.24	11.62
1986	9.72	0.00	0%	0.25	12.95
1987	11.56	2.89	20%	0.19	14.21
1988	18.14	4.54	20%	0.25	24.31
1989	8.86	2.21	20%	0.26	11.96
1990	14.04	3.51	20%	0.20	17.46
1991	4.10	1.03	20%	0.18	4.98
1992	1.94	0.49	20%	0.15	2.27
1993	7.34	1.84	20%	0.17	8.84
1994	7.13	1.78	20%	0.15	8.40
1995	2.38	0.59	20%	0.09	2.60
1996	3.02	0.76	20%	0.07	3.26
1997	3.67	0.92	20%	0.07	3.94

The wild steelhead average abundance for the Imnaha over the last three years has been about half of the estimated equilibrium of nine fish per mile (Figure 32). While depressed, this level is considerably higher than record low densities observed in the 1970s. A relative high Ricker model a -value of 1.433 was estimated for the recruitment function of this population (Table 2). In combination, these indicate that the Imnaha steelhead population has both the demonstrated and theoretical capacity to rebuild from depressed densities.

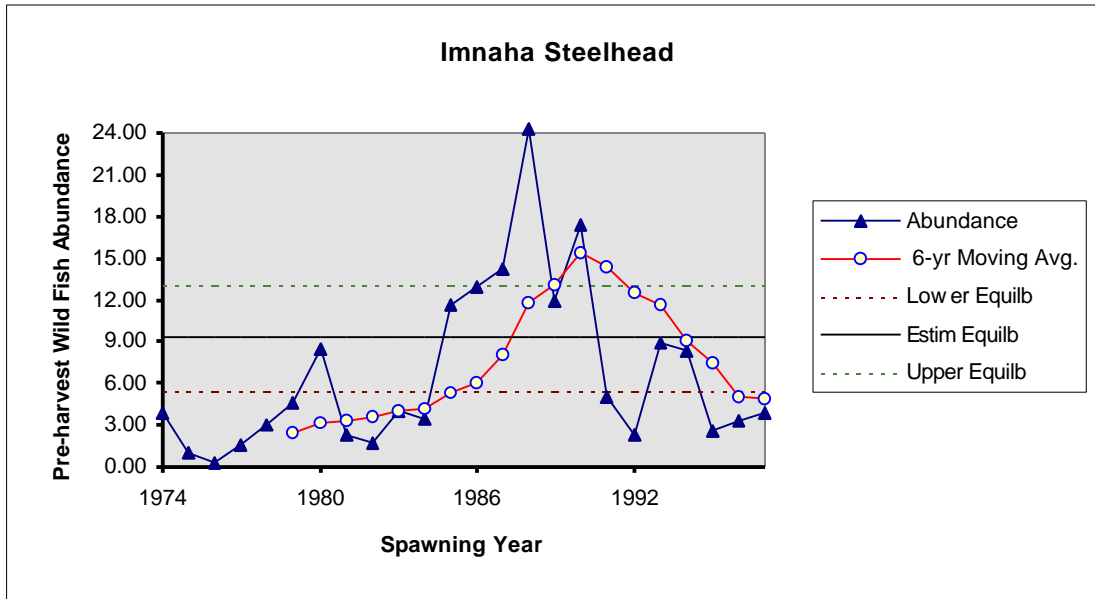


Figure 32. Annual and six-year moving average estimates of the pre-harvest abundance of wild steelhead in Camp Creek, Imnaha Basin, 1974-97 relative to predicted population equilibrium (N^*) and associated upper and lower confidence bounds derived from recruitment modeling.

ESU Status Synthesis

Quasiextinction Assessment Results - The results of the quasiextinction assessment model indicate that the upper Grande Ronde population meets the criteria for endangered status (Table 35). The other two populations, Joseph Creek and the Imnaha qualify only for the sensitive risk category.

Table 35. Probability of quasiextinction estimates for three populations of steelhead belonging to the Snake ESU at three levels of risk.

Population	Endangered (60 Yrs)	Threatened (100 Yrs)	Sensitive (100 Yrs - 1/2 Survival)
Joseph Creek	0.000	0.002	0.130
Upper Grande Ronde	0.658	0.874	1.000
Imnaha	0.000	0.002	0.128

Hatchery Fish - Hatchery fish are either absent or at relatively low proportions for the Imnaha and Joseph populations. However, hatchery fish comprise a majority of the natural spawners in the Upper Grande Ronde. Evidence indicates the reproductive capacity of the Upper Grande Ronde population has declined coincidentally with the addition of these hatchery fish to the naturally spawning population. ODFW is currently developing and evaluating strategies to reduce the presence of these hatchery fish in the natural spawning population.

Trends in Abundance - The extent and longevity of depressed spawner densities in the 1990s has been varied among the three populations examined in this ESU. The Upper Grande Ronde shows the least evidence of rebounding from abundance levels nearly as low as those recorded in the mid-1970s. By contrast, the decline in abundance for both the Joseph and Imnaha populations has not been as severe as occurred in the 1970s for these two populations. There is also evidence that in the most recent years, some upward movement in spawner densities has occurred, most notably in 1993.

Self-Sustaining - The Joseph Creek and Imnaha populations appear to be self-sustaining. The Upper Grande Ronde population appears dangerously depressed and more vulnerable to random events which could cause the population to collapse. This condition has developed largely since the addition of large numbers of hatchery spawners in 1989. Prior to 1989, the pattern of fluctuation in abundance for Upper Grande Ronde steelhead is suggestive of a healthier population with periods of low spawner densities being relatively short-lived. In contrast, for the eight years starting in 1989, this population has been in a constant state of very low abundance and its continued existence appears in jeopardy.

ESU Status - As reported previously (Table 35), the results from the first of the three indicators used to quantitatively assess the status of each steelhead ESU indicated that two populations qualified for a sensitive classification, and one for endangered. From these results, the combined score for the long-term persistence indicator for this ESU was 2.7 (Table 36).

Table 36. Summary of scores for status determinations for the Snake ESU based on three individual indicators: Long-term PQM (long-term probability of quasiextinction model results), Short-Term Stress (resistance to short-term stress), Extirpation Warning (observed extirpation warning).

Long-term PQM	Short-term Stress	Extirpation Warning	OVERALL
2.7	2.0	4.0	2.9

The assessment results for the second indicator (resistance to short-term stress) were that only the Upper Grande Ronde population appears to be at risk of extirpation under a 12-year scenario of survival rates declining to 1/4 of what they have been in recent years. Both of the other two populations examined meet the criteria under this indicator for secure. Averaged across the populations examined, the resulting score for this indicator was 2.0 (Table 36).

Of the three populations examined, the Upper Grande Ronde appeared to warrant an extirpation warning based on the extremely depressed condition of the wild population and the presence of more than 50% hatchery fish in the natural spawning population. The spawner densities of wild fish in the Upper Grande Ronde have been

at near record low levels for eight consecutive years. Therefore, for this third indicator 33% of the populations examined (one out of three) rate extirpation warnings, resulting in a score of 4.0 and an indicator designation of endangered.

Averaging the scores for individual indicators, the status assessment score for this ESU was 2.9 (Table 36). Therefore, the overall status classification given to this ESU is **THREATENED**.

References Cited

- Allendorf, F.W., D. Bayles, D.L. Bottom, K.P. Currens, C.A. Frissel, D. Hankin, J.A. Lichatowich, W. Nehlsen, P.C. Trotter, and T.H. Williams. 1997. Prioritizing Pacific Salmon Stocks for Conservation. *Conservation Biology* 11:140-152.
- Burgman, M.A., S. Ferson, H.R. Akcakaya. 1993. Risk assessment in conservation biology, 314p. Chapman and Hall, London.
- Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261p.
- Busby, P.J., T.C. Wainwright, R.S. Waples. 1994. Status Review for Klamath Mountains Province Steelhead. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-10, 130p.
- Carmichael, R.W., T.A. Whitesel, B.C. Jonasson. 1995. Evaluation of the success of supplementing Imnaha River steelhead with hatchery reared smolts, phase one. Oregon Department of Fish Wildlife Fish Research Project. Completion Report to the Bonneville Power Administration, Contract DE-BI79-92BP01016, 160p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208).
- Cierebiej D.A., S.R. Phelps, S. Cierebiej. 1995. Mixed-stock analysis of steelhead, *Oncorhynchus mykiss*, from the Clackamas River, Oregon. Washington Department of Fish and Wildlife, Genetics Unit Publication, 14p. Washington Department of Fish and Wildlife, Olympia, Washington.
- Chilcote, M.W., S.A. Leider, J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. *Transactions of the American Fisheries Society* 115:726-735.
- Confer, T. 1996. Steelhead Smolt Trapping - Hunter Creek and Winchuck River. Oregon Department of Fish and Wildlife Memo, SW Region, Roseburg, 16p.
- Confer, T. 1997. Steelhead Smolt Trapping - Lobster Creek, Hunter Creek and Winchuck River. Oregon Department of Fish and Wildlife Memorandum to Steve Denny, SW Region, Roseburg, 30p.
- Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Comm., Fishery Research Report 7, Corvallis, 48p.

- Faudskar, J.D. 1980. Ecology of Underyearling Summer Steelhead Trout in Intermittent Streams Tributary to the Rogue River, Oregon. MS Thesis, Oregon State University, Corvallis.
- Ginzberg, L.R., Slobodkin, L.B., Johnson, K., and Bindman, A.G. 1982. Quasiextinction probabilities as a measure of impact on population growth. *Risk Analysis* 21:171-81.
- Glipin, M.E. and M.E. Soule. 1986. Minimum viable populations: processes of species extinction, in *Conservation Biology: the Science of Scarcity and Diversity* (ed M.E. Soule), Sinauer, Sunderland, Massachusetts, pp.19-34.
- Hilborn, R. and C. J. Walters. 1992. Quantitative Fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, London.
- Hooton, B. 1997. Memorandum on steelhead conservation strategies to Barry McPherson, dated 18 April 1997, 19p. (Available from Oregon Department of Fish and Wildlife, Portland, Oregon).
- Kenaston, K.R. 1989. Estimated run size of winter steelhead in Oregon coastal streams, 1980-85. Information Report 89-1. Oregon Department of Fish and Wildlife, Portland, 18p.
- Leider, S.A. 1989. Increased straying by adult steelhead trout, *Salmo gairdneri*, following the 1980 eruption of Mount St. Helens. *Environmental Biology of Fishes* 24:219-229.
- Leider, S.A., M.W. Chilcote, J.J. Loch. 1986. Comparative life history characteristics of hatchery wild steelhead trout (*Salmo gairdneri*) of summer and winter races in the Kalama River, Washington. *Can. J. Fish. Aquat. Sci.* 43: 1398-1409.
- Leider, S.A., P.L. Hulett, J.J. Loch, M.W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. *Aquaculture* 88:239-252.
- Lindsay, R.B., K.R. Kenaston, and R.K. Schroeder. 1992. Steelhead production factors. Oregon Department of Fish and Wildlife, Annual Progress Report. Portland.
- Lindsay, R.B., K.R. Kenaston, and R.K. Schroeder. 1993. Steelhead production factors. Oregon Department of Fish and Wildlife, Annual Progress Report. Portland.

- Lindsay, R.B., K.R. Kenaston, and R.K. Schroeder. 1994. Steelhead production factors. Oregon Department of Fish and Wildlife, Annual Progress Report. Portland.
- Lindsay, R.B., K.R. Kenaston, and R.K. Schroeder. In Preparation. Steelhead production factors. Oregon Department of Fish and Wildlife, Annual Progress Report. Portland.
- Johnson, T.H. and R. Cooper. 1991. Snow Creek anadromous fish research. Washington Department of Wildlife, Annual Performance Report 92-5, 37p. Olympia, WA.
- Mace, G.M. and Lande, R. 1991. Assessing extinction threats: towards a re-evaluation of IUCN threatened species categories. Conservation Biology, 5:148-57.
- McGie, A.M. 1994. Stock-Recruitment in Summer-Run Steelhead of the North Umpqua River, Oregon. Oregon Department of Fish and Wildlife, Information Report 94-5, 36p. Portland.
- Murtagh, T., R. Rohrer, M. Gray, E. Olsen, T. Rien, and J. Massey. 1992. Clackamas subbasin fish management plan. Oregon Department of Fish and Wildlife, 173p. Portland, Oregon.
- Oregon Department of Fish and Wildlife. 1995a. Comprehensive plan for production and management of Oregon's anadromous salmon and trout: Part III, Steelhead Plan. Oregon Department of Fish and Wildlife, Portland, OR. 58p.
- Oregon Department of Fish and Wildlife. 1995b. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland, OR. 217p.
- Oregon Department of Fish and Wildlife. 1996. Draft lower Deschutes River subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland, OR.
- Oregon Department of Fish and Wildlife. 1997. Draft Sandy River subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland, OR.
- Rapp, S.M. 1997. Summary Report - the 1997 Siuslaw winter steelhead broodstock project. Oregon Department of Fish and Wildlife, Northwest Region, Corvallis, OR.

- Rawding, D. 1997. Memorandum to Bruce Sanford on the mortality of wild winter steelhead in wild steelhead release sport fisheries in Washington's lower Columbia River tributaries, dated 25 March 1997, 6p. (Available from Washington Department of Fish and Wildlife, Olympia, Washington).
- Schreck, C.B., H.W. Li, R.C. Hjort, and C.S. Sharpe. 1986. Stock identification of Columbia River chinook salmon and steelhead trout. Final Report to Bonneville Power Administration, Contract DE-A179-83BP13499, Project 83-451, 184p. (Available from Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208).
- Thompson, G.G. 1991. Determining minimum viable populations under the Endangered Species Act. NOAA technical memorandum NMFS F/NWC-198. National Marine Fisheries Service, Seattle.
- Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW). 1996. Columbia River fish runs and fisheries, 1938-95, status report. WDFW, Olympia, WA and ODFW, Portland, OR.