# Chapter 4
# Information Specific to Steelhead

## SUMMARY OF REVISIONS TO STEELHEAD STATUS REPORT

The final version of the steelhead status report "*Conservation Status of Steelhead in Oregon, Information Report 98-3*" does not differ substantially from the December 17, 1997, draft contained in the Steelhead Supplement of the Oregon Plan. In addition to the correction of numerous typographical errors, several sentences were rewritten to correct grammatical problems and improve readability. The most glaring error uncovered was in Table 9 on page 4-36 where the overall status assessment score should have been 1.3, rather than the 0.47 value reported.

The final version of this report may be obtained by contacting Deb Clinkscales by phone at the ODFW office (1-503-872-5252 Ext. 5394 or E-Mail, Deb.Clinkscales@state.or.us).

## INTRODUCTION

The Oregon Plan is based on watershed restoration and ecosystem management, and employs a whole systems approach to the conservation of native species and their habitat. Many different individuals, organizations and agencies are working together to plan and implement habitat restoration measures that will benefit the native species of Oregon's ecosystems. Within this broader context, the task of the Steelhead Supplement is to provide necessary detail for the restoration and protection of steelhead. This chapter presents information specific to steelhead, including information on risk agents, habitat and life history requirements, and restoration needs, organizing it into the following sections:

- Life History
- Habitat Requirements
- Distribution
- Stock Status
- Risk Agents
- Priorities for Restoration Activities
- Oregon Department of Fish and Wildlife's Steelhead Monitoring Proposal
- Research Needs
- Appendix: *Conservation Status of Steelhead in Oregon* (Chilcote 1997)

### Life History, Habitat Requirements and Distribution

This chapter begins with a brief overview of the life history, habitat requirements and distribution of steelhead in Oregon. It covers the taxonomic complexity and variability of the species, including differences between winter and summer steelhead, and highlights the differences between steelhead and coho salmon. Significant differences between the two species include the eastern extent of steelhead habitat, steelhead's greater tendency to disperse in freshwater, and their preference for steeper gradients and upstream areas.

### Stock Status

An executive summary of Mark Chilcote's report, *Conservation Status of Steelhead in Oregon* (1997) provides an update of the extinction risk for steelhead by Evolutionarily Significant Unit (ESU), dividing them into "endangered," "threatened," "sensitive" and "secure." This review of their status was based upon available abundance and life history data, and the accompanying analysis incorporates the comments and suggestions of a wide range of reviewers. The full report is appended at the end of the chapter.

### Risk Agents

After defining risk agents as natural processes or human activities that place sustainability of salmon at risk, the next section begins with a discussion of the major risk agents facing steelhead. It covers risks from harvest, including selective fishing and over-fishing, risks from artificial propagation, including threats to the genetic integrity and diversity of wild fish, and risks from habitat alteration, including accompanying changes in water quality and quantity. In a separate discussion it covers risks from large storage dams and hydroelectric projects, which have become a much larger concern with the extension of the Oregon Plan into eastern Oregon. Additional risks arise from ocean conditions and predation by birds and marine mammals; both are discussed, along with a detailed look at pinniped predation. The section concludes with a discussion of possible synergistic interaction among risk agents.

### Priorities for Restoration Activities

The next section provides priority areas by ESU for restoration activities, based on the following five criteria:

1. Areas utilized by steelhead populations at risk of extinction
2. Areas of suspected high steelhead production
3. Areas having high potential for restoration
4. Areas with high potential for monitoring
5. Areas providing the necessary connectivity between selected areas

The discussion emphasizes that these criteria and the high priority areas they delineate are provisional and subject to change as future information improves.

### Oregon Department of Fish and Wildlife's Steelhead Monitoring Proposal

The section on monitoring begins with a discussion of the monitoring plan for coho salmon, detailing measures such as stratified random survey techniques, stream habitat condition surveys, and population monitoring at coastal index sites that are also applicable to steelhead. Special monitoring needed for steelhead includes: establishing useful indicators of population trend, distribution and causal factors; developing and validating alternative methodologies for assessing adult and juvenile abundance; expanding coastal surveys to cover the geographic range of steelhead habitat; and estimating hatchery-wild composition. Additional monitoring proposals for steelhead include instituting a stratified random survey design, increasing and expanding juvenile and spawner surveys, and establishing survival monitoring for wild steelhead.

The monitoring section concludes with a listing of specific tasks ODFW has developed for steelhead under the Oregon Plan's Comprehensive Monitoring Program, including harvest monitoring, genetic and life history monitoring, and, at the sub-basin scale, life cycle and survival monitoring. In addition to these measures by ODFW, other agencies have expanded the geographic scope of their monitoring, including water quality monitoring, measuring water quantity and the timing of flows, and monitoring the effects of land management activities.

### Research Needs

In addition to monitoring, further research is needed to restore and sustain Oregon's steelhead populations. In general, more information is needed on steelhead genetic, life history, production and critical habitat needs. Future research should also evaluate habitat restoration techniques, models for setting escapement goals, and strategies for developing local broodstocks. Future research on hatchery production should evaluate the effects of supplementing natural production with artificial propagation, and the benefits of using natural-type rearing environments for the production of hatchery steelhead. Regarding fisheries, research should look at possible ways of lowering hooking mortality in catch and release steelhead fisheries, and should attempt to determine smolt release and adult recapture strategies that will provide for hatchery fisheries without detrimental inbreeding and competition with wild steelhead.

Although this chapter represents a considerable effort towards collating information specific to steelhead and their restoration needs, the Oregon Plan's adaptive monitoring strategy calls for continual revision and improvement. Understanding of steelhead and their needs will improve as the monitoring program and future research provide new information, and the plan will be revised on an iterative basis.

## LIFE HISTORY

Steelhead are the sea-run form of rainbow trout, which belong to the species *Oncorhynchus mykiss*. In some waters, such as the Deschutes River, resident and migratory forms exist together. Steelhead are characterized by a spring migration of juveniles to the sea and a physiological transformation called "smolting" which adapts them to salt water.

The species *Oncorhynchus mykiss* is one of the most taxonomically complicated groups of salmonids in Oregon. The species probably consists of multiple subspecies, none of which have been formally recognized. The most recently published treatise on the species is in Behnke (1992), where three subspecies with ranges extending into Oregon are proposed: *O.m. irideus*, or coastal rainbow and steelhead trout; *O.m. gairdneri*, or inland Columbia Basin redband and steelhead trout; and *O.m. newberrii*, or Oregon Basin redband trout. This supplement to the Oregon Plan follows Behnke's (1992) subspecies and range designations since it is the most recently published treatment of *O. mykiss* subspecies taxonomy. Readers should expect, however, that subspecies boundaries and names may be modified in the future.

Winter and summer steelhead are differentiated by the time of year at which adults migrate into fresh water to spawn. Winter steelhead return to streams beginning in November, with the majority returning from January through March. Sexual maturation is completed during migration, and spawning occurs shortly thereafter from January to May.

In contrast, summer steelhead enter fresh water from spring through early fall (May through October) and do not mature and spawn until January through May of the following year. The summer-run populations in the Columbia Basin east of the Cascade Mountains are further divided into two groups, "A-run" and "B-run", depending largely on their run timing past Bonneville Dam. The "B-run" steelhead tend to be larger, older and later running and migrate specifically to certain Snake River subbasins in Idaho. All of Oregon's populations are "A-run" steelhead that generally spend only one year in the ocean and return over Bonneville Dam before the end of August.

Most steelhead spend from one to three years in salt water before returning as adults to fresh water to spawn. However, steelhead life history is highly variable. Wild fish may rear in fresh water from one to four years and in the ocean from a few months to four years. As a result, there are sixteen possible combinations of freshwater and saltwater ages in first-spawning adults.

The most striking difference between steelhead and salmon is that steelhead do not always die after spawning. However, the percentage of fish that has spawned in previous years is small, ranging from 3-20% of runs in Oregon coastal streams and in lower Columbia tributaries, to near zero in mid- and upper-Columbia tributaries. Usually only females survive to spawn more than once.

Females dig redds and deposit eggs in the gravel. Eggs hatch after 35-50 days depending upon water temperature. Alevins remain in the gravel two to three weeks until their yolk sac is absorbed and then emerge as fry and begin to actively feed. Most juveniles rear two to three years in the stream before migrating to the ocean in spring as 6-8 inch smolts.

Smolts grow rapidly in the ocean, reaching 16-20 inches by fall. A small proportion of winter steelhead, mostly males, reach sexual maturity in their first winter and return to spawn as jacks. Immature "half-pounders" enter the Rogue River at a size of 11-16 inches after only three to four months in the ocean. After spending about eight months in fresh water without spawning, half-pounders return to the ocean to complete rearing and maturation. Similar half-pounder runs exist only in the Klamath and Eel rivers of northern California.

Information on migration patterns and distribution of steelhead in the Pacific Ocean is limited, although it is possible to piece together a general picture of ocean distribution. Based on ocean sampling, juvenile steelhead tend to migrate directly offshore during their first, rather than migrating along the coastal belt as do salmon. During fall and winter, juveniles move southward and eastward. Steelhead have a widespread distribution throughout the Gulf of Alaska and the Aleutian Island area. They are distributed in the north central Pacific off the tip of the Aleutian chain as far west as longitude 168E and as far south as latitude 41S. No steelhead have been found in the Bering Sea. Distributions of steelhead from British Columbia, Washington, Oregon, and Idaho tend to overlap in the ocean.

## HABITAT REQUIREMENTS

During the course of their freshwater life history, steelhead tend to disperse widely, naturally existing at relatively low abundance over a large percentage of available habitat within any given basin. This is in contrast to most salmon, which tend to be less dispersed and naturally exist at relatively higher densities over a smaller portion of available habitat.

Spawning and initial rearing of juvenile steelhead generally takes place in reaches of small tributary streams with steeper gradients (generally 3-5%) than those generally used by salmon. In some basins, steelhead spawn in sections of main streams if factors such as tributary flow are inadequate and the main streams have appropriate gradient and gravel quality. Steelhead require clean pea to orange size gravel for spawning and cool water temperatures (45-58F) for rearing. Fry emerge in late spring and occupy the stream margins.

The first summer of steelhead rearing takes place primarily in the more rapid sections of pools, although year's young are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, often in the form of boulders and woody material in stream channels. As juveniles get older and larger, some tend to move downstream to rear in larger tributaries and mainstem rivers. Summer steelhead in the Rogue River move into the mainstem soon after emergence, as the streams they spawn in go dry by early summer. After one to four years rearing in freshwater, juvenile steelhead smolt and migrate to the sea, generally spending little time in estuaries. Habitat complexity in estuaries, although not well understood, is thought to be important in protecting them from predation.

Most biologists believe that the most limiting, or bottleneck, period for steelhead is the last year of freshwater rearing prior to emigration as smolts. In the Columbia River and many of its tributaries, however, dams may be the major bottleneck. The alterations they cause in the physical and biological characteristics of rivers create a high mortality rate among migrants. Generally, steelhead populations are not limited by spawning habitat or rearing habitat for sub-yearling juveniles.

Summer steelhead share additional habitat requirements with spring chinook salmon, in contrast to requirements for winter steelhead and fall-migrating salmon. Essential habitat requirements for summer steelhead include adequate stream flow during spring and summer for the migration of adult-size fish, and the presence of adequate numbers of cool, deep pools where adults can rest and mature during summer and fall. Summer steelhead usually spawn higher in basins than winter steelhead, as summer water temperatures are generally higher in the lower reaches of basins.

## DISTRIBUTION

Coastal steelhead (*Oncorhynchus mykiss irideus*) occupy North American coastal river basins from the Kuskokwim River in Alaska to the Otay River in California. They also exist in Asia along the Kamchatka Peninsula, although this group may represent one or more different subspecies. In Oregon, coastal steelhead occupy most basins in the Columbia Basin west of Hood River, including the Willamette River, and most basins along the coast. However, coastal summer steelhead populations are only indigenous to the Hood, Siletz, North Umpqua, and Rogue basins. Hatchery runs of coastal summer steelhead have been introduced to the Sandy, Willamette, and Wilson basins.

Inland Columbia Basin steelhead (*Oncorhynchus mykiss gairdneri*) are present in the Columbia Basin east of the Cascade Mountains starting at Fifteenmile Creek in Oregon. The same subspecies is present in the inland Fraser River in British Columbia, according to Behnke (1992). Most inland steelhead are summer-run fish. Oregon has only four populations of winter-run *O.m. gairdneri*, all located on the western boundary of the subspecies, in Fifteenmile Creek and adjacent creeks.

A list of summer and winter steelhead populations in Oregon is published in the Biennial Report on the Status of Wild Fish in Oregon (ODFW 1995). The report is available from ODFW's Portland office and accessible through the Internet at ODFW's Home Page (http://www.dfw.state.or.us).

Maps of winter and summer steelhead distribution are also available from ODFW for basins throughout Oregon. Figure 1 is an example showing the spawning and rearing distribution of winter steelhead in the Alsea River, a mid-coast basin of Oregon. Maps can be obtained from ODFW's Portland office and can also be accessed through the Internet at ODFW's home page, using the following steps:

1. Log on to ODFW Home Page at http://www.dfw.state.or.us
2. Click on "Agency" or "Agency Organization"
3. Click on the "GIS Information Systems (GIS)" subheading under the "Habitat Conservation Division" heading
4. Click on "Data & Maps"
5. Click on "Our Local FTP site"
6. Click on "PS-maps". Read the display that shows which Hydrologic Unit Code number (HUC number) matches the basin map you want.
7. Click on "StS" or "StW" depending on whether you want summer or winter steelhead maps
8. Click on the HUC number of the map you want and copy the file to your computer

At present, the steelhead map files posted on the ODFW Home Page are "postscript" files that have been zipped to compress them (".zip" files). After copying a steelhead map file to your computer, it must be unzipped or uncompressed (using programs such as WinZip and Unzip) before it can be viewed using a program that can open postscript files (such as several Adobe software products, Corell Draw, and others).

## STOCK STATUS

This is an executive summary of Mark Chilcote's report, *Conservation Status of Steelhead in Oregon* (December 1997). The full text of this report is attached at the end of this chapter.

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 upon available abundance and life history data, presented and analyzed in a scientific manner to determine if steelhead are at risk of extinction in Oregon.

This is the third and final revision of the steelhead conservation status 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).

Three indicators of species health were used to assess the magnitude of extinction risk to steelhead in Oregon: 1) the likelihood of long-term population persistence, 2) the capacity of populations to resist and survive short-term periods extreme environmental stress, and 3) the identification of populations that are at immediate risk of reproductive failure and extirpation from observed trend data, interactions with hatchery fish, or other factors are at immediate risk of reproductive failure and extirpation.

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

The status assessment results for each steelhead evolutionarily significant unit (ESU) are summarized as follows.

Klamath Mountains Province ESU = **SECURE**
In terms of resistance to stress and the percentage of populations at immediate risk of extirpation, the picture for this ESU is secure. The long-term persistence indicator results suggested that two of the four populations assessed would qualify for a sensitive species designation. However, taken together these three indicators gave a net classification of secure for this ESU. The only apparent weak spot 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 serious depressed state of the summer steelhead population in the Siletz and the greater than 50% hatchery spawners in several natural populations triggers extirpation warnings for a sufficient percentage of the populations in this ESU to warrant some concern. The net result of these findings was this ESU was assigned an overall classification of sensitive.

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

Willamette ESU = **THREATENED**
The long-term persistence for populations in this ESU appears to be at risk. Modeling results suggest that they have an extremely poor resistance to future episodes 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 suggests 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. However, of special concern is the recent collapse of winter steelhead in the Clackamas River and summer steelhead in the Hood River. Comprising 33% of the populations examined in this ESU, they are sending clear warnings of possible extirpation. In light of these results, it was concluded that that the status of this ESU meets the criteria established for threatened.

Middle Columbia ESU = **SENSITIVE**
The assessment results for this ESU in terms of resistance to short term-stress and the likelihood long-term survival suggest that 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. Over the last 4 years the wild population has been in almost complete reproductive failure. Stray hatchery fish dominate the spawning population (greater than 75%) and likely are causing severe genetic impact to the innate productivity of the wild population. The South Fork John Day population, although not at the same level of crisis as the Deschutes, 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 resulted 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 to base this status assessment upon, the finding of one of these populations at high risk of extirpation weighs heavily on 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 statewide review, the steelhead in the Snake ESU meet the standard for a threatened designation.

## RISK AGENTS

### Introduction

Populations of anadromous salmonids have generally declined compared to their historic abundance. Society recognizes the immediate crisis, namely, too few fish. This crisis is actually a symptom of many factors that have combined to reduce the productivity and innate resilience of salmon populations. A partial list of these factors would include the following:

- Fishing
- Urbanization
- Farming, grazing, and other related agricultural activities
- Logging
- Road building
- Hatchery operations
- Splash-damming in coastal streams
- Mining gravel from streambeds
- Withdrawing water from streams
- Damming streams
- Historic efforts to remove wood from streams
- Natural cyclic variation in weather and ocean productivity

### Risk Agents

Risk agents consist of natural processes or human activities that place sustainability of salmon at risk. Examples of natural risk agents include short- and long-term variation in freshwater, estuarine, and oceanic environments that may adversely affect steelhead productivity. Volcanic eruptions, earthquakes, landslides, fire, ice ages, and the like, are also natural risk agents that have and will affect the sustainability of human populations.

Risk agents related to the activities of people have often been categorized as related to fishing (harvest), artificial propagation (hatcheries), and landscape alteration (habitat). Dams and hydropower structure may be considered a subset of habitat alteration. Although the Oregon Plan primarily addresses the effects of human activities, it also adjusts its restoration and management activities to compensate for natural conditions.

The harvest risk agent category includes all activities related to fishing, including direct and indirect effects on any life stage in freshwater or the ocean. Salmon are a commodity that has been exploited by various fishing methods in the Pacific Northwest for well over a century. Some stocks of salmon and steelhead, during specific time periods, have been exploited by high seas driftnet fishing that fails to recognize international agreements protecting those species. The problems of over-fishing less productive stocks and species in mixed-stock fisheries and of selectively fishing populations and species have been widely recognized but poorly resolved by society. Mortality associated directly and indirectly with fishing can eliminate populations, reduce numbers within populations, alter or eliminate life history patterns, reduce fitness, and mask population trends. All of these effects may adversely affect the sustainability of wild salmon populations and should be evaluated in an assessment of extinction risk.

The hatchery risk agent category includes all genetic and ecological interactions related to the use of artificial propagation. Many parameters may be useful in evaluating whether hatcheries are adversely affecting sustainability of wild populations, including numbers and sizes of fish stocked, species stocked, release locations, evidence of residualism, genetic characteristics, disease history, homing fidelity to a recapture facility, occurrence of hatchery fish in natural spawning populations.

The habitat risk agent category includes all activities that alter the nature of freshwater and estuarine landscapes in a way that affects sustainability of wild salmon. This is the most complex risk-factor category, because salmon use watersheds from the headwaters to the coast at some time throughout their life cycle. As steelhead habitat extends into eastern Oregon, some of the most significant human activities altering their habitat are the building of large storage dams and hydroelectric projects. The risk to steelhead from this particular type of activity will be discussed at the end of this section.

For restoration to be effective, it is important to identify the effect of risk agents on the populations. These effects, which cause population declines or impede recovery, will be referred to as *factors for decline* and are discussed in Chapter 14. The purpose of this section is to provide a brief discussion of the major risk agent categories that have been identified for steelhead.

### *General Impacts of Harvest*

Harvest rates can, both directly and indirectly, influence extinction risk. Harvest mortality can directly affect spawner numbers and trends. Harvest in mixed stock fisheries managed for optimal production of more abundant stocks will overexploit the less productive stocks contributing to the fishery. This can diminish both the range and the genetic diversity of the species as a whole. Harvest can also produce strong selective pressure for smaller size at maturity which can compromise the species' adaptive ability by reducing numbers of eggs and by influencing spawning habitat selection. In responding to changes in abundance, trends in harvest rates can also mask trends in stock productivity. By masking trends in productivity, harvest can affect the perception of risk resulting from other factors, and thus delay response to other threats to the survival of the species.

### *Impact of Harvest on Oregon Steelhead*

Because of concerns over declining abundance in some steelhead populations, and the desire to increase the proportion of wild fish in spawning populations, regulations to reduce harvest impacts on wild fish have been instituted over the past decade. Both domestic regulations and international agreements are designed to minimize ocean fishery mortality of steelhead. Further inland, by 1992 anglers were required to release wild steelhead caught in most Oregon rivers and starting in 1997, their take has been further reduced. In the few rivers left open to retention of wild steelhead, they are allowed to retain only 1 wild steelhead per week and 5 per year for all rivers combined.

Natural mortality from the smolt to the adult stage in the ocean and natural mortality in freshwater, particularly during juvenile rearing stages, appear to be larger factors for decline of steelhead than harvest impacts in most cases. During the early part of this century, commercial fisheries for steelhead existed in some Oregon bays and rivers associated with commercial salmon fisheries, but the only commercial fisheries remaining today are tribal fisheries in the Columbia River.

Illegal driftnet fishing for steelhead in high seas areas is a more difficult topic to address. Since 1986, the National Marine Fisheries Service has investigated high seas salmon and steelhead fisheries that place those fish on the world market. As a result of several covert investigations, NMFS has documented evidence of illegal high seas fishing efforts. Resolution by the United Nations outlawed high seas driftnet fishing in the North Pacific after December 31, 1992. At present, illegal high seas fisheries that might intercept steelhead are not thought to be a major factor influencing the current status of this species.

Steelhead are far less susceptible than salmon to sport fisheries in estuaries where some of the most popular salmon fisheries occur, but are more susceptible than salmon (and often over a longer period of time) to sport fisheries in rivers and streams. Juvenile steelhead are more susceptible to harvest in streams than juvenile salmon because they generally spend 1-3 years longer in freshwater, look more like trout, and reach larger sizes before smolting, thereby becoming more desirable to anglers.

Historically, excessive harvest is not thought to have been a significant factor in the decline of many populations of Oregon steelhead.

### *General Impacts of Artificial Propagation*

Artificial propagation may affect wild salmonid populations in a number of ways. For example, occurrence of hatchery fish in spawning populations of wild fish may mask declines in natural populations, making it difficult to detect changes in abundance and to determine whether the wild fish are self-sustaining. Also, artificial propagation presents the potential for genetic and ecological risks to natural populations that may affect their productivity. Stock transfers that result in interbreeding of hatchery and natural fish (or hatchery programs that lead to high levels of straying) can cause loss of fitness in local populations and loss of diversity among populations. Genetic changes that occur in hatchery populations due to domestication may cause adverse impacts if interbreeding occurs with wild fish.

### Impacts of Recent Hatchery Programs on Steelhead

The significance of genetic alteration of wild steelhead populations from hatchery fish is debatable in most Oregon streams, due partly to a lack of information on changes in the productive capacity of wild populations over time. It has been shown in several instances that hatchery fish can alter fitness of wild steelhead, but no studies have been completed to show the rate of recovery of fitness in a wild steelhead population when hatchery fish no longer spawn with the wild population.

There are Oregon streams where stocking of hatchery steelhead occurred for a period of years and was then discontinued earlier in this century. In addition, some Oregon basins have received little (or zero) historical stocking, yet populations have declined along with basins receiving numerous hatchery fish. This suggests that in many Oregon basins, hatchery fish are not the primary cause of the decline in wild steelhead. However, evidence from other basins (e.g., Deschutes) suggests that stray hatchery fish have introduced foreign genetic material into the wild population. Steps are being taken to further reduce the potential of genetic impact to wild steelhead populations statewide.

### Physical Habitat

Steelhead evolved in freshwater ecosystems that were historically characterized by flood plains, braided channels, and off-channel areas-all of which contained considerable structural complexity, such as large wood debris and debris jams. Human activities have simplified and degraded freshwater habitats utilized by anadromous salmonids in Oregon and throughout the Pacific Northwest.

Habitat reduction and degradation probably have reduced the resiliency of steelhead to withstand natural variability in biological and physical factors, such as low spawner abundance, severe hydrologic events (high or low flows), and variability in ocean productivity. Habitats that have been altered by human activities are more likely to suffer degradation from disturbance events such as severe winter storms. For example, the frequency and magnitude of debris torrents increases with activities such as logging and road building. While debris torrents are recognized as potential sources of woody debris that may ultimately be beneficial to salmon production, such events may have a disastrous effect on salmon production in the short term.

Although some habitat functions can be readily restored through habitat improvement projects, other functions (e.g., production and recruitment of large woody debris into streams or transportation of fine sediments out of spawning gravels) may require decades or centuries to recover. Also, instream habitat restoration work can only be conducted in a relatively small proportion of watersheds. A considerable lag time may be expected between initiation of some corrective actions and restoration of significantly improved habitat function.

### *Impact of Contemporary Habitat Conditions on Oregon Steelhead*

Alteration of steelhead habitat from historic conditions is thought to be extensive. Contemporary habitats in the state's river basins are usually characterized by a combination of the following features:

- Summer flows are lower in some areas because less water is retained in upriver areas and water is withdrawn from streams.
- Water temperatures are higher in some areas because riparian vegetation has been reduced.
- Stream channels generally lack complexity.
- Insufficient large wood is present in stream channels.
- Off-channel, wetland and slough habitat is uncommon.

Overall, steelhead appear to be less sensitive than coho salmon to changes in their physical habitat, including changes in in-stream conditions. For example, the productivity of coho is closely related to the presence of large woody debris. As large woody debris decreases, the productivity of steelhead will decrease less than the productivity of coho.

While there is considerable overlap in the habitat of these two species, there are also considerable differences. The range of steelhead currently extends much further east than that of coho salmon, which are primarily found downstream of the Bonneville Dam. Steelhead will also overwinter in harsher streamflow conditions. Steelhead distribution, including juvenile rearing and adult spawning, is generally more diffuse within watersheds than that of coho. Steelhead will also reside in streams with a steeper gradient, and therefore tend to be found further upstream. As the headwaters of many watersheds are often found on federal lands, this means that the upper reaches of steelhead habitat will generally be more protected than habitat found on private and state lands.

Regardless of these differences, measures addressing water quality, peak flows, or passage, for example, will improve watershed function to the benefit of both species.

### *Large Storage Dams and Hydroelectric Projects*

Within the risk agent category of habitat alteration, dam building can be one of the most damaging activities to anadromous fish and their habitats. Hydroelectric projects and large storage dams were not explicitly addressed in the coho restoration plan because there are few such facilities in coastal basins. With the expansion of the Oregon Plan into steelhead habitat in the Columbia and Snake River Basins, this particular activity has increased in importance.

In addition to directly causing fish injuries and mortality, in passage through reservoirs, turbines, juvenile fish bypass systems, adult fishways or sluiceways, large dams and hydroelectric power facilities also increase indirect risks. They can affect water quality parameters important to steelhead survival, particularly temperature, dissolved oxygen, total dissolved gases, pH, turbidity, and intergravel dissolved oxygen. They change not only the flow of water but also the flow of sediment, gravel, and woody debris, altering river beds, channels, riparian vegetation and other habitat important to steelhead. By altering streamflows, dams may increase juvenile salmonid mortality by delaying migration, blocking habitat, decreasing habitat, stranding fish, and entraining juveniles into poorly screened or unscreened diversions. They may also reduce adult steelhead survival by adversely impacting spawning and rearing habitat.

### *Impact of Large Storage Dams and Hydroelectric Projects on Steelhead*

Management actions prescribed by the Oregon Plan for tributaries to the Columbia River will generally benefit Columbia Basin steelhead. However, the Oregon Plan also recognizes that these benefits will be realized only if certain survival targets are met for fish migrating in the mainstem Snake and Columbia rivers, as major risks to steelhead still exist in the migratory corridor to the sea. Large storage dams and hydroelectric projects are one of the primary sources of risk to steelhead in these mainstems. Although the Oregon Plan does not directly address large storage dams and hydroelectric projects on the mainstem Columbia, a number of forums are available for federal partners to the plan to address the effects of these structures on steelhead and other species of concern.

The National Marine Fisheries Service (NMFS) develops and implements actions to improve survival of listed juvenile and adult salmon and steelhead through the Federal Columbia River Power System (FCRPS) under an Endangered Species Act Section 7 Biological Opinion. It develops and issues this opinion on FCRPS operations as part of its consultations with the Corps of Engineers and the Bureau of Reclamation. Regional scientists are currently working to evaluate the likelihood that listed steelhead will recover under various mainstem management strategies and various resulting watershed “health” scenarios.

The state of Oregon has the opportunity to provide input into this Biological Opinion, which schedules key decisions affecting the long-term configuration and operation of the FCRPS in 1999. The state is currently discussing with NMFS what the decision criteria should be, what information is pertinent to the decisions, and which evaluations are necessary for accurate risk assessment of each alternative. Policy and legal arguments made by the state in comments on the Biological Opinion and in the *IDFG v NMFS* and *American Rivers* court cases reflect Oregon’s position on the standard of recovery that any action alternative should meet and what the process should be for making key decisions.

Additionally, many of the federal partners to the Oregon Plan have measures stating that they will exercise their authority under the Federal Energy Regulatory Commission (FERC) relicensing process to ensure consideration of steelhead needs. This opportunity arises as the federal and state licenses of hydroelectric projects expire, as many will during the next ten years. The federal relicensing and state reauthorization processes offer significant opportunities to 1) assess project-specific impacts; 2) evaluate existing and proposed mitigation, protection and enhancement measures, and 3) propose alternatives to current project operations, and 4) implement a package of operation and physical project changes and mitigation measures as part of a new license. For a brief description of the (FERC) relicensing process for hydroelectric projects, see Large Storage Dam and Hydroelectric Projects (Chapter 14A, Section 5).

## Other Risk Agents

Natural risk agents that are also thought to contribute to the decline of steelhead include ocean conditions and predation by birds and marine mammals.

### *Ocean Conditions*

Cyclic variation in the ocean environment is thought to be a major determinant of stock size and productivity of Oregon steelhead. Climate conditions are known to have changed recently in the Pacific Northwest, and Pacific salmonid stocks have been affected by changes in ocean production that occurred during the 1970s. Climate factors affecting ocean conditions are large-scale processes that also affect terrestrial and freshwater environments. Logically, climate factors that affect the productivity of the ocean environment may have simultaneous effects on the productivity of the freshwater and estuarine environment. These climate conditions are thought to be cyclic in nature, but it is not possible to accurately predict whether conditions will return to more favorable conditions in the near future. Changes in ocean productivity since 1976 are thought to be a major determinant of the recent decline in steelhead return ratios.

NOAA's Coastal Ocean Program is providing funding and program oversight for the Pacific Northwest Coastal Ecosystem Regional Study (PNCERS), a program to study the linkages between coastal and offshore waters around Coos Bay, Oregon and Willapa Bay and Grays Harbor, Washington. PNCERS is a joint effort of the NMFS Northwest Fisheries Science Center, the Oregon Coastal Management Program, and the Oregon and Washington Sea Grant Programs. Among the questions that PNCERS is seeking to answer is how salmonid stocks in the Pacific Northwest are affected by oceanic and atmospheric variability.

A separate study has been funded to address issues of large scale oceanic and atmospheric processes that affect productivity of salmonids in the ocean (GLOBEC).

### *Predation by Birds and Marine Mammals*

Birds and marine mammals eat salmon. The magnitude of this predation on regional steelhead production remains a matter of intense debate. Scientific studies and recent reviews of Pacific Northwest salmonids by the National Research Council in the Botkin Report have tended to assert that predation by coastal bird and marine mammal populations, except in unusual, isolated locations, is not a major, underlying cause of the decline in regional salmonid populations. Many people, however, believe that seals and sea lions, and to a lesser degree, cormorants, are primarily responsible for the decline in Oregon's salmonid populations.

The U.S. Fish and Wildlife Service (USFWS)will be working with the Oregon Department of Fish and Wildlife (ODFW) to develop policy on management of avian salmonid predators. Bonneville Power Administration, the Corps of Engineers, and ODFW have sponsored research on impacts of avian predation on salmon restoration and effects of predator management such as hazing. The USFWS will support and oversee the necessary research, and upon completion will consider recommendations for avian predator management consistent with applicable treaties, statutes and regulations.

## The Issue of Seals and Seal Lions as Predators

Seals and sea lions (pinnipeds) are predatory animals that depend almost exclusively on fish for their diet. As such, pinnipeds have long been viewed as competitors of humans for marine fish resources. For most of the first part of this century, seals and sea lions were hunted and killed as part of bounty programs in an attempt to keep these animals out of coastal bays and rivers, and to reduce their numbers overall. Although bounty programs were based on the idea that reducing pinniped numbers would result in increased fish populations, no scientific data proved this assumption.

In 1972, the federal government passed the Marine Mammal Protection Act (MMPA), which removed all management authority for pinnipeds from the states and vested it with the National Marine Fisheries Service (NMFS). Increases in pinniped numbers in the Pacific Northwest over the past 20 years have raised new concerns about the potential impacts of seal and sea lion predation on depleted fish resources. The concern for pinniped predation is more significant when fish populations are depressed and/or when estuary habitat has been simplified. If a localized situation exists where fish numbers are abnormally low, barriers to fish migration exist, and local predator numbers are high, then predation by seals and sea lions may have a significant adverse effect on individual salmonid populations.

NMFS will work with Oregon and other states to address the issue of growing pinniped populations and their potential effects on depressed salmonid stocks in the Pacific Northwest. Currently, Oregon is working with California and Washington, as well as NMFS, to identify areas with potentially significant impacts of pinniped predation on salmonids. NMFS has expressed a concern about potential effects of growing pinniped populations on depressed salmon populations in the Pacific Northwest. In specific areas, pinniped predation could be hindering the rebuilding of salmon populations. Additional research is necessary to determine the extent of actual impacts on salmonid populations. Where predation is determined to be a significant problem, management actions consistent with the ESA and MMPA can be taken to reduce salmon mortality. NMFS will seek funding to assess pinniped interactions with salmon populations at critical sites and initiate appropriate management actions to minimize predation where assessments indicate such action is needed.

## Interactions Among Risk Agents

Many human activities and natural processes, individually, can cause a decease in salmonid populations, in the productive capacity of populations, and in the productive capacity of their supporting habitats. Interactions of risk agents can compound these effects. For example, overharvesting a wild population can make it more vulnerable to the detrimental effects of interbreeding with hatchery fish, by simultaneously reducing the genetic variability present in the wild population and reducing the proportion of wild spawners in the overall population.

## Literature Cited

Cooper, R. and T.H. Johnson. 1992. Trends in steelhead (*Oncorhynchus mykiss*) abundance in

Washington and along the Pacific coast of North America. Washington Department of Wildlife, Fisheries Management Division, Report number 92-20. 90p.

# PRIORITIES FOR RESTORATION ACTIVITIES

## Purpose for Identification of Priority Areas

NOTE: The March 1997 Oregon Plan contained draft core area maps for coho, steelhead, chum, and chinook salmon (Chapter 15). These maps were intended to provide landowners and resource managers information regarding local stream reaches thought to be particularly important spawning and rearing areas for coho and steelhead, or spawning areas for chum and chinook. The draft maps of coho core areas are being used to guide efforts by agencies and landowners to focus conservation and restoration efforts.

Steelhead and coho exhibit differences in the life histories , habitat requirements, and behaviors that confound efforts to map sub-basins that are analogous to the core areas that have been described for coho. For example, coho core areas represent sub-basins where coho are likely to complete spawning, summer rearing, and winter rearing and are present in relatively high densities for any given basin. Steelhead, in contrast to coho, do not usually concentrate in spawning areas, and may migrate extensively between summer and winter rearing areas.

Consequently, the draft steelhead core areas that were mapped in March 1997 are hereby replaced with steelhead priority areas that are listed in a table in this section. This list of steelhead priority areas is intended to assist landowners and resource management agencies focus limited resources on conservation and restoration efforts.

Recognizing that the coho core areas and steelhead priority areas are intended to provide interim guidance, the Oregon Department of Fish and Wildlife will take the lead role in reviewing these designations (see measure ODFW IVA9).

In developing an effective conservation strategy to protect and restore steelhead populations in Oregon it is desirable to have an approach for how to prioritize a wide range of proposed and ongoing conservation activities. This is necessary only because the resources to address steelhead restoration are limited and the scope of the problems facing this species are not evenly distributed across its range.

One tool for assisting in this prioritization process is the use of species range maps that highlight those areas of special importance to the species. Once identified, these high priority areas can be used to help make decisions on where specific conservation and restoration strategies should be distributed, given that resources are insufficient for implementation across the entire range.

The danger in such an approach is that it may lead to the interpretation that steelhead populations and habitats outside of the high priority areas have no conservation value. This interpretation is incorrect. All steelhead populations and their habitats have conservation value; the prioritization process is only designed to ensure that limited available resources will be used to conserve the species in the most efficient manner.

Assignment of high priority to individual areas is not necessarily permanent. For example, as restoration activities make sustainable improvements, areas that were initially assigned high priority may be downgraded and a higher priority may be assigned to new areas. The priority area approach to species restoration is based on the assumption that strategies to conserve and restore steelhead habitat will eventually be applied to many potential production areas. This approach is intended to provide a systematic way of phasing in actions that cannot realistically be accomplished in one step.

## Methodology for Selection of Priority Areas

The following set of criteria were used to select priority areas for steelhead conservation and restoration activities. The criteria should be considered provisional because of the many uncertainties associated with quantifying the productive capacity of habitat for steelhead. With future analyses, a better understanding of the habitat requirements of this complex species will develop and will likely result in the need to change the criteria described below. Therefore, it is also likely that the list of high priority areas will also change when the results from these new analyses become available. However, it is not expected that the changes will be large. Therefore, the high priority areas identified in this section should be useful in the selection and implementation of conservation strategies for steelhead.

The five criteria used to select high priority areas for steelhead are described as follows.

### *1. Areas utilized by steelhead populations at risk of extinction.*

The list of at risk populations was obtained from a steelhead status report recently completed by the ODFW (Chilcote 1997), that has been appended at the end of Chapter 4. These populations were: mid-Rogue summer steelhead, Siletz summer steelhead, Clackamas and Upper South Santiam winter steelhead, and summer steelhead in the Hood, Deschutes, South Fork John Day, and Upper Grande Ronde.

### *2. Areas of suspected high steelhead production.*

Identification of high production areas for steelhead is a difficult task. Steelhead are a highly dispersed, adaptive species, naturally existing at low densities over a large percentage of the available habitat in any given basin. Adding to this complexity is the fact that juvenile steelhead typically spend 1 to 4 years in freshwater, during which time their habitat preferences are known to change. As a consequence juvenile steelhead are not found in concentrated areas as are some other species, such as coho salmon, with much narrower habitat requirements. Therefore, any scheme to identify high quality steelhead habitat must be based on a grosser level of detail and include larger portions of a basin to include the full range of habitat types that steelhead utilize.

The primary factors used under this criteria were stream gradient (steep gradient streams are generally good steelhead habitat), historical or current observations of dense populations of adults or juveniles, acceptably cool water temperatures in the summer, and federal or state land ownership (generally associated with better protection of aquatic environment and therefore assumed to represent more productive areas for all fish species, including steelhead).

### 3. Areas having high potential for restoration.

Areas where habitat restoration activities could yield important gains in steelhead production were identified based on general knowledge of steelhead habitat in Oregon. Examples include improving late spring water flows in small tributaries of the middle Rogue River utilized by summer steelhead for spawning and early rearing, or fencing riparian areas to exclude cattle in many basins in order to improve stream habitat and lower summer water temperatures.

### 4. Areas with high potential for monitoring.

Monitoring activities for steelhead (such as counting steelhead at dams, determining spawner densities from field observations, estimating numbers of smolts, and conducting juvenile density surveys) are ongoing in many locations and provide an opportunity to evaluate the success of restoration actions. The distribution of this current monitoring effort was used as an overlay in the selection of high priority areas for restoration and protection. Steelhead production areas with ongoing monitoring programs were given selection preference over those without such monitoring programs. Areas with high ratings for attributes other than monitoring, but with low levels of current monitoring, will be considered for adjustment as ODFW and the Monitoring Group establish priorities for new monitoring efforts.

### 5. Overall distribution of areas within ESU.

In order to avoid unconnected “islands” of high steelhead production within an ESU, high priority areas were selected such that they were distributed throughout each ESU as evenly as possible. In some cases, this meant selecting a high priority area primarily to bridge the geography between other high priority areas within the ESU. In adding this dimension to the selection process it was assumed that a healthy ESU must contain populations that are linked together for the benefit of genetic diversity and reproductive cushion. Another assumption was that selecting high priority areas for restoration and protection in an evenly distributed fashion across each ESU will help ensure these linkages.

## Priority Areas by ESU

Klamath Mountains Province ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Elk River | No | High | Moderate | High |
| Upper Illinois (basin upstream and including Deer Creek) | No | High | High | Moderate |
| Upper Rogue (basin upstream and including Evans Creek, but excluding Bear Creek) | Yes | High | High | High |
| Upper Chetco (basin upstream | | | | |

| | | | | |
|---|---|---|---|---|
| and including South Fork Chetco) | No | High | Low | Moderate |

Oregon Coast ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Necanicum | No | High | Moderate | Moderate |
| Lower Nehalem (watershed from Cook Creek to Cronin Creek, inclusive) | No | High | Low | High |
| Rock Creek (Nehalem Basin) | No | High | Moderate | Moderate |
| Wilson | No | High | Moderate | Moderate |
| North Fork Trask | No | High | Moderate | Low |
| South Fork Trask | No | High | Moderate | Low |
| Upper Nestucca (basin upstream and including Limestone Creek) | No | High | Moderate | Moderate |
| Salmon | No | Moderate | Moderate | Moderate |
| Drift Creek (Siletz Bay tributary) | No | High | Moderate | Low |
| Upper Siletz (basin above falls) | Yes | High | Moderate | High |
| Big Elk Creek (Yaquina Basin) | No | High | Moderate | High |
| Drift Creek (Alsea Basin) | No | High | Low | High |
| South Fork Alsea | No | Moderate | High | Moderate |
| North Fork Alsea | No | High | Moderate | High |
| Yachats | No | High | Moderate | Moderate |
| Cummins Creek | No | High | Low | High |
| Tenmile Creek | No | High | Moderate | High |
| Indian Creek | No | High | Moderate | Moderate |
| Upper Siuslaw (basin upstream and including Whittaker Creek) | No | Moderate | Moderate | High |
| Upper North Umpqua (basin accessible to anadromous fish above Rock Creek) | No | High | Moderate | High |
| Upper South Umpqua (basin upstream and including Elk Creek) | No | High | Moderate | Moderate |
| West Fork Millicoma | No | High | Low | High |
| East Fork Millicoma | No | Moderate | Moderate | Moderate |

| | | | | |
|---|---|---|---|---|
| South Fork Coquille | No | High | Moderate | High |
| Sixes | No | High | Moderate | Moderate |

Upper Willamette ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Molalla | No | High | Moderate | High |
| Upper North Santiam (basin upstream and including Little NF Santiam accessible to anadromous fish) | No | High | Low | High |
| Upper South Santiam (basin upstream of Foster Dam) | Yes | High | Moderate | High |

Lower Columbia ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Upper Clackamas (basin upstream and including North Fork Clackamas accessible to anadromous fish) | Yes | High | Moderate | High |
| Salmon River (Sandy Basin) | No | High | Low | High |
| Hood | Yes | High | Moderate | High |

Middle Columbia ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Deschutes (basin accessible to anadromous fish) | Yes | High | High | High |
| Upper North Fork John Day (basin upstream and including Middle Fork John Day) | No | High | Moderate | High |
| South Fork John Day | Yes | High | High | High |
| Upper Umatilla (basin upstream and including Birch Creek) | No | High | High | High |

Snake ESU - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Joseph Creek (Grande Ronde Basin) | No | High | High | High |
| Wenaha (Grande Ronde Basin) | No | High | Low | Moderate |
| Upper Grande Ronde (basin upstream and including Five Points Creek) | Yes | Moderate | High | High |
| Imnaha | No | High | Moderate | High |

SW Washington (Oregon Side) - Priority Areas

| Priority Area | Special Risk | Production Potential | Habitat Restoration Potential | Monitoring |
|---|---|---|---|---|
| Lewis and Clark | No | Moderate | Moderate | High |
| Big Creek | No | High | High | High |

## OREGON DEPARTMENT OF FISH AND WILDLIFE'S STEELHEAD MONITORING PROPOSAL

### Program Structure and Design

The Oregon Plan describes the structure of a comprehensive monitoring program, and Chapter 15 B of the Steelhead Supplement contains the implementation progress reports. The report states that existing monitoring efforts to enumerate steelhead abundance were strong only in those areas with fixed counting facilities (dams and fish ladders). The ability to monitor overall steelhead abundance and distribution, and to monitor trends over time required improvement. This section on the monitoring proposal for steelhead describes the first of what are expected to be a series of such improvements specifically geared at measuring steelhead abundance.

The Oregon Department of Fish and Wildlife's (ODFW) monitoring tasks for steelhead are linked to actions, components, and indicators that were originally described in the Oregon Plan's Comprehensive Monitoring Program (Chapter 16). For each steelhead related component and indicator relevant monitoring tasks from the Oregon Plan are listed.

The tasks in the Oregon Plan are primarily focused on two of the four monitoring components: natural-cultural trends as indicated by salmon populations and habitats (Tasks 3, 4, 5, 6, 9, and 11) and adaptive management as supported by indicators of hatchery and harvest risks to wild salmonid populations (Tasks 5, 7, and 8). The general design and rationale of these two components in the base monitoring program (e.g., in the original plan) and modifications proposed in this Steelhead Supplement are briefly summarized below. This is followed by a more detailed evaluation of each of the ODFW monitoring tasks.

## Population and Habitat Trends

### *Base Monitoring Program*

The monitoring program for coho salmon in the Oregon Plan incorporates a statistical survey design for measuring abundance trends in adult and juvenile salmon. The adult estimates are based on spawning ground counts using random surveys stratified at the level of Gene Conservation Groups. In 1997, more than 500 stream reaches will be surveyed throughout the Oregon coast. Surveys to estimate juvenile salmon trends will also employ a stratified random design at 30 sites within each Gene Conservation Group, where summer snorkeling surveys will be conducted. Although the precision of the estimates will vary with the number of samples within a strata, results of both the adult and juvenile surveys can be “nested” to provide information on population trends at a variety of spatial scales, including individual river basins, Gene Conservation Groups, and coastwide.

Results of the coastal population surveys will be supported by ongoing surveys of stream habitat conditions. ODFW habitat surveys, which encompass more than 7,300 stream miles since 1990 and 80% or more of the core area streams, provide a snapshot of habitat conditions needed to evaluate population trends and the effectiveness of habitat restoration activities. To date these surveys are funded by a variety of sources, which dictate the sampling locations.

In addition to the broad-based surveys above, a series of twelve to eighteen index sites spread geographically along the Oregon coast were identified and targeted for more intensive population monitoring. At these locations, adult weirs and juvenile traps will be placed to directly measure abundance and to monitor trends in freshwater and marine survival of wild salmon. The importance of these sites is increased by the lack of any direct estimates of freshwater and marine survival of wild salmon in Oregon. Survival trends for populations from a diversity of coastal ecoregions will help to interpret effects of changing climate and habitat conditions on salmon recovery. Moreover, by providing independent and quantitative measures of adult abundance at selected sites, the index streams will allow us to validate results of the random spawner surveys described above. Cooperative efforts to enumerate smolt abundance and production are planned or ongoing in an additional thirty to fifty sites. (See Figure 1.)

## Additional Monitoring Proposed for Steelhead Populations and Habitats

The Oregon Department of Fish and Wildlife and the Oregon Plan’s monitoring team propose to expand monitoring activities originally described in the plan to improve evaluation of steelhead populations and habitat. Among the monitoring activities proposed if additional funding becomes available are the following:

- Double the current number of spawner surveys in the coastal Evolutionarily Significant Unit (ESU) for steelhead.

- Expand the summer juvenile surveys in coastal basins to monitor changes in steelhead distribution and abundance.

- Continue existing smolt trapping sites for steelhead on the South Coast and establish survival monitoring (adult/smolt counting and sub-basin monitoring) at one site each in the Lower Columbia and Southwest Washington ESUs.

- Institute a stratified random survey design for stream habitat surveys in each of the coastal and interior steelhead ESUs.

- Expand surveys of abundance and distribution of juvenile and spawning adult steelhead in conjunction with habitat surveys in each coastal steelhead ESU, Lower Columbia ESU, Willamette ESU, and interior basins.

- Monitor proportions of hatchery steelhead on spawning grounds in the Grande Ronde and John Day River basins.

- Restore creel surveys to estimate hatchery:wild composition in recreational fisheries in the Grande Ronde, Wallowa, Imnaha, and John Day River basins.

- Construct an adult trap and establish a survival monitoring site on Fifteenmile Creek in the Mid Columbia ESU.

### *Special Needs for Steelhead*

New survey methodologies are needed to provide an adequate assessment of abundance trends in Oregon steelhead populations.  In the past, angler punch card data and dam counts at a few locations provided the primary data sources for tracking steelhead abundance.  Angler data no longer provide a useful assessment of these trends because fisheries have been widely restricted for conservation purposes.  However, direct estimates of steelhead abundance and survival from spawner and juvenile surveys in Oregon rivers are problematic compared with coho salmon: the small adult and juvenile steelhead are more difficult to visually locate and count underwater; adults spawn repeatedly so that numbers on the spawning grounds represent only a fraction of a particular brood; steelhead are widely distributed in upper tributaries as well as larger rivers and in interior as well as coastal basins; and significant numbers of adults and juveniles may occur in mainstem habitats that cannot be sampled with adult and juvenile traps.

To establish more useful indicators of coastal steelhead trends and distribution and their causal factors the Steelhead Supplement proposes to:

- Develop and validate alternative methodologies for assessing adult and juvenile abundance over large areas of steelhead distribution.
- Expand the coastwide salmon spawning surveys to increase the geographic coverage of steelhead habitats using the methodologies developed above.
- Estimate abundance of juvenile steelhead and cutthroat trout at an expanded number of randomly selected sites for summer snorkel surveys.
- Independently validate the results of snorkel surveys using more precise techniques at selected sites.
- Monitor adult and juvenile steelhead abundance in the twelve to eighteen coastal index streams to evaluate effects of freshwater and ocean conditions on juvenile production and life histories.
- Develop a statistical random survey design for evaluating habitat trends for salmon and steelhead.
- Evaluate changes in salmon and steelhead distribution as part of the habitat surveys of the Aquatic Inventory Project.

In 1997-98, thirty two months of seasonal time has been allocated to develop better methods for estimating adult steelhead abundance. A study is being designed to compare alternate methods of indexing steelhead abundance (spawning surveys, creel surveys) with known numbers of spawners in several coastal basins that have trap counts or dam counts. Preliminary work will begin in spring 1998 identifying survey site locations in the North Nehalem, Mill Creek (Siletz), North Umpqua, and Upper Rogue basins, with the complete study design to be implemented in December 1998.

Juvenile counts may ultimately yield the most useful index of steelhead abundance by providing a direct measure of relative production and seeding of available freshwater habitat. The random summer juvenile surveys for coho salmon described above will also be expanded to develop an index of abundance and distribution of juvenile steelhead along the coast. Again, because steelhead numbers are more difficult to visually estimate from snorkeling surveys, the counts of different surveyors will need to be calibrated. Independent pass removal estimates of juvenile steelhead and cutthroat will be made in a subsample of the summer snorkeling sites. This calibration will be made as part of the biotic and water quality monitoring of the Environmental Protection Agency's EMAP program. If the EMAP program is not continued, ODFW will take responsibility for the validation.

The more intensive sampling proposed at the twelve to eighteen coastal index sites will provide information about the relative production of steelhead parr from available adults and production of different age classes of juvenile migrants from the available parr. Because significant numbers of steelhead rear in larger streams that cannot be effectively trapped, and because multiple age classes of steelhead juveniles will likely occur within a basin, the index sites cannot quantify steelhead survival as they can for coho salmon. Nonetheless, the index streams will provide useful information about the effects of ocean and freshwater habitat conditions on the relative numbers of adults returning, the numbers of parr produced, and the different age classes of migrant juvenile steelhead within selected basins along the Oregon coast. At each index stream a modified Hankin and Reeves (1988) survey methodology will be used to estimate summer abundance of juvenile steelhead and cutthroat trout. Additional information on basin habitat conditions will become available through cooperative efforts with landowners, the Oregon Department of Forestry, Water Resources Department, and Department of Environmental Quality. Variations in the abundance of downstream migrating steelhead and cutthroat trout will be determined from the smolt traps in each index stream.

To better assess habitat trends for steelhead, expansion of the current geographic coverage of underrepresented stream habitats and establishment of a randomized survey design for monitoring long-term trends in habitat conditions statewide is proposed. This will require more stable and flexible sources of funding than are currently available. The January 30, 1998, decision by the Legislative Emergency Board to fund additional monitoring measures for steelhead includes support for this program. Additional support for both randomized stream habitat surveys and to focus on areas currently underrepresented in the stream habitat database has been provided by the Bureau of Land Management. As part of the Aquatic Inventory Project, broad patterns of fish distribution will be monitored based on presence and absence information. In interior basins the habitat survey crews of the Aquatic Inventory Project will also provide information on the distribution of adult and juvenile steelhead.

## Hatchery and Wild Interactions

All hatchery salmon and steelhead are now marked so that hatchery and wild fish can be more readily distinguished on spawning grounds and in fisheries. However, in coastal basins the ability to estimate hatchery: wild ratios in steelhead populations has been reduced by recent harvest restrictions. Although hatchery marks will be identified where possible during spawning ground surveys, identification of marks on steelhead is very difficult because few carcasses are handled. If it turns out that redd counts are a better indicator of adult steelhead abundance, then surveys of live fish may be suspended. The best source of information on hatchery: wild ratios for coastal steelhead will come from established trapping sites for adults. Monitoring of hatchery: wild ratios for steelhead will be continued at the twelve to eighteen adult index sites on the coast, at Gold Ray and Winchester dams, and at broodstock collection sites in the Siuslaw Basin.

In the Columbia Basin, ongoing evaluations of hatchery: wild ratios in adult steelhead will be increased. The current proposal is to expand creel survey programs in the John Day, Grande Ronde, Wallowa, and Imnaha River basins and to conduct to conduct detailed field studies of hatchery: wild ratios for summer steelhead in the Grande Ronde basin. Although funding for this proposal was not included in the request to the Legislative Emergency Board, support for these activities has been requested from Federal sources.

## New ODFW Monitoring Specifically for Steelhead

These actions follow the organization by Monitoring Task as originally developed for the Comprehensive Monitoring Program in the March 10, 1997 Oregon Plan. Funding for key components of these tasks has been submitted for approval to the Legislative Oversight Committee and the Legislative Emergency Board. Additional funding is needed to fully implement the programs, particularly for the Mid-Columbia and Snake River ESU's.

### *Task 3: Juvenile Salmon Abundance Sampling*

An expansion of the summer juvenile rearing surveys for coho is proposed to increase the area of coverage and to support additional summer sampling for steelhead in the Coastal and Klamath Mountain Province (KMP) ESUs (measure ODFW I.B.1S). This work is needed not only to develop an indicator of change in relative steelhead abundance but also to assess changes in the geographic distribution and spatial use of habitats at basin and coastwide scales (see Task 4 below). Quantitative estimates of juvenile steelhead abundance are more difficult to obtain than for coho salmon using the snorkeling methodology. The proposal is to calibrate the snorkel counts for steelhead and cutthroat trout using pass removal or mark-recapture methods to improve abundance estimation. Presence-absence data collected over large areas will also provide a useful indicator of change in the distribution of juvenile coho and steelhead relative to habitat conditions (see Task 4). This additional work will require new funds to support five two-person survey crews for two months each at a total annual cost of $54,000.

Additional juvenile rearing surveys are also proposed for each of the Columbia Basin ESUs. These will be conducted in conjunction with the habitat surveys of the Aquatic Inventory Project (see Task 4 below).

### *Task 4. Stream Channel and Habitat Assessments*

An expansion of the coastal aquatic habitat surveys is proposed to provide broader geographic coverage and to support a more systematic survey design for salmon and steelhead habitat (measure ODFW I.B.2.S). This would add six additional, two-person crews for three months each to survey coastal habitats (annual cost of $102,300). Another proposal is to add several additional summer crews to evaluate steelhead distribution and relative juvenile abundance (measure I.B.1S; see Task 3). From these combined habitat and population results, the relationship between observed changes in habitat quality and spatial organization and the abundance, distribution, and life histories of juvenile steelhead can be evaluated

Habitat and population surveys for steelhead will similarly require additional manpower in each of the Columbia River ESUs to support a statistically valid, random-survey design. In the Columbia Basin, the same survey crews will be employed to collect data on stream habitat, juvenile steelhead distribution and relative abundance (Task 3), and adult spawner abundance (Task.5). This work would require four crews for eight months in the Lower Columbia, Upper Willamette, and Southwest Washington ESUs (annual cost of $190,600) Funding for this task was included in the request to the Legislative Emergency Board. Additionally, ODFW recommends three crews and a crew leader for six months in the Snake River ESU (annual cost of $125,600) and three crews and a crew leader for eight months in the Mid Columbia ESU (annual cost $192,000). Although funding for this proposal was not included in the request to the Legislative Emergency Board, support for these activities has been requested from Federal sources.

### *Task 5: Spawner Abundance Surveys*

This task of the Oregon Plan originally included support for spawning surveys for some steelhead populations as well as coho. With this supplement the effort for steelhead monitoring will be doubled to more adequately survey the Coastal and KMP ESU's by adding eight additional surveyors for four months at a total annual cost of $91,000 (measure ODFW I.B.1S). Depending on availability of funds, four additional two-person crews are proposed to survey spawning grounds in the Lower Columbia, Upper Willamette, and Southwest Washington ESUs. Three additional crews each will be needed for the Snake River ESU and the Mid-Columbia ESU. Although funding for this proposal was not included in the request to the Legislative Emergency Board, support for these activities has been requested from Federal sources.

### *Task 6: Genetic and Life History Monitoring*

The combined information obtained by monitoring steelhead abundance and distribution in the Coastal, KMP, and Lower Columbia ESUs will be analyzed to increase knowledge of life history variability within these regions. We will have improved information on migration timing, size and condition characteristics of steelhead juveniles, adults and smolts. Ongoing monitoring of presence or absence based on systematic sampling of distribution and habitat characteristics will also improve understanding of life history variability. Little information is available on life history, production, and critical habitat needs of summer steelhead in the John Day, Umatilla, Grande Ronde, and Imnaha River basins of northeast Oregon. In addition, it is unclear how anadromous and resident forms of the species are related in these rivers, where spawning and rearing overlap significantly in time and space. This information is needed to better define steelhead stock management units and to develop recovery strategies. Funding is currently being sought to develop a cooperative study with Oregon State University on life histories and habitat associations of steelhead in northeast Oregon.

### *Task 7. Fish Propagation Monitoring*

There is widespread concern about potential genetic and productivity effects of stray hatchery fish interbreeding with wild summer steelhead. ODFW will continue to provide regular reports on the number of steelhead released, location of releases, and on the timing and composition of hatchery returns. This information, combined with the assessment of hatchery: wild ratio from dam counts, adult trapping sites, and other counts, will help assess the level of impact on wild populations.

Little quantitative information is available to verify whether hatcheries can be used effectively to reintroduce or rebuild depressed wild steelhead populations. Monitoring will be required wherever plans are developed to augment declining wild production through artificial means. Federal funding is currently supporting evaluations in the Imnaha, Umatilla, and Hood rivers. Outside funding is being sought for a broad-scale survey in the Grande Ronde Basin to evaluate benefits and risks of using hatchery supplementation for recovering federally listed stocks of summer steelhead. Annual costs for this work are estimated to be $300,000.

### *Task 8. Harvest Monitoring*

There is a need to improve monitoring of the proportions of hatchery and wild fish in recreational fisheries. One level of monitoring wild and hatchery steelhead harvest will be continued in all areas open to steelhead angling, even if restricted to catch-and-release fishing, by continuing the requirement that steelhead anglers carry a salmon-steelhead tag and record the fish they keep and the fish they release. Recording steelhead that are released is not legally required, but a special area on the tag is provided for this purpose and anglers are requested to provide such records. Data from these records must be interpreted with appropriate assumptions regarding response bias.

A second level of monitoring is provided by OSP personnel as they check anglers for compliance with angling regulations and by ODFW employees conducting non-random interviews with anglers. A third level of monitoring is provided by statistical creel surveys conducted by ODFW to sample anglers and estimate actual catch in specific river areas during specific time periods. These studies provide more accurate information on fish harvest, numbers of fish released, hatchery/wild ratios and distribution of harvest over season and area. Statistical creel surveys are not always conducted in the same location or in consecutive years, and are often related to levels of funding available and relative need for information they can provide. Such surveys have been conducted, for example, in the Necanicum, Siletz, Siuslaw, North Umpqua, Rogue, Grande Ronde, Wallowa, Imnaha, Deschutes, and John Day basins. A list basins where statistical creel surveys will be conducted in the next two years is not currently available, but will be developed by ODFW as part of the comprehensive monitoring program.

### *Task 9: "Core Area" and "Index Area" Monitoring of Habitat and Populations*

Smolt trapping sites identified for coho salmon will also provide information on coastal steelhead abundance (measure ODFW I.B.1S). However, additional support will be needed to continue ongoing monitoring programs for steelhead in several South Coast streams. The U.S. Forest Service has agreed to continue support for smolt trapping sites on the Winchuck River Lobster Creek, Upper Elk River, and to a trop on the Chetco River. However, another $20,000 per year is needed to maintain trapping facilities for steelhead on the Lower Elk River and for Hunter Creek. The current plan is to establish adult and juvenile trapping sites for monitoring steelhead survival in the Lower Columbia (Scappoose Creek) and Southwest Washington ESU (Lewis and Clark River). This will require purchase of two smolt traps and support for six additional months for each of four biologists (total first year coast of $92,200). Support for these activities was included in the funding proposal to the Legislative Emergency Board.

We will establish a smolt and adult monitoring site in the Fifteenmile Creek sub-basin, which is the easternmost distribution of wild winter steelhead in the Columbia River system and the site of an ongoing Bonneville Power Administration habitat improvement effort. This BPA funded project will cost an estimated $47,800 annually plus an initial expense of $112,000 to construct adult and juvenile traps.

## RESEARCH NEEDS

Managing steelhead and their habitats for sustainable populations capable of supporting fisheries and other beneficial uses requires a solid scientific basis. Part of the required scientific basis is provided by monitoring the fish, their habitat, the fisheries, and other factors, while another part is provided by research of more basic questions. Although there is sometimes a fine line between monitoring and more basic research, the Steelhead Supplement recognizes the following as important research needs for restoring and sustaining Oregon steelhead populations and fisheries.

### Assess Applicability of Washington Department of Fish and Wildlife's Existing Production Potential Model

There is an absence of scientifically based spawning escapement goals for steelhead in many Oregon streams, and an inadequate long-term database on fish abundance from which escapement goals could be established. Another way of setting escapement goals is to utilize coarse-scale habitat information to set habitat-based goals in basins lacking adequate adult or juvenile data. This would involve using existing data on habitat parameters and a habitat-based production potential model similar to the one developed by Washington Department of Fish and Wildlife. Research on Oregon streams is needed to determine if WDFW's model is applicable or needs to be adjusted for the variety of steelhead habitat types in Oregon.

### Evaluation of Habitat Restoration Techniques for Steelhead

Much more information exists on the benefits of various habitat restoration techniques for coho salmon than for steelhead. Although steelhead share some habitat requirements with coho salmon and benefit from some habitat restoration projects aimed at coho, the two species have different habitat requirements during parts of their life history. More research on the benefits of various techniques is needed, as considerable habitat restoration work for steelhead is already being planned and implemented. Habitat restoration techniques should be evaluated for the diversity of habitats in both western and eastern Oregon.

### Genetic, Life History, Production, and Critical Habitat Needs of Steelhead and Rainbow Trout in Northeast Oregon

Genetic and environmental factors acted in a complex manner to produce diverse life history strategies in *O. mykiss*. Information on life history, production, and critical habitat needs of summer steelhead in northeast Oregon is very limited compared with information for coastal steelhead. In addition, it is unclear how anadromous and resident forms of *O.m. gairdneri* are related in northeast Oregon where significant temporal and spatial spawning and rearing overlap occurs. Understanding the life history, production, and critical habitat needs, and the relationship of anadromous and resident forms is essential to defining stock management units, developing enhancement strategies, and establishing recovery goals. This information is needed for the John Day, Umatilla, Grande Ronde, and Imnaha river basin populations. The research should be done in cooperation with Oregon State University or another institution with comparable fishery research capabilities.

### Assessment of the Success of Supplementing Natural Production with Artificial Propagation of Steelhead

There is inadequate quantitative information available to fully assess the benefits and risks of using artificial propagation to enhance natural production of steelhead. It is likely that hatchery programs will be utilized in restoration efforts, especially for summer steelhead in northeast Oregon. A broad-scale study needs should assess the benefits and risks of utilizing artificial propagation, including various smolt release strategies, in recovery of steelhead listed under the federal Endangered Species Act (ESA).

### Assessment of Strategies for Developing Local Broodstocks in the Grande Ronde Basin

Managers have identified a potential need to modify the current steelhead hatchery program to ensure consistency with the federal ESA and Oregon's Wild Fish Management Policy. One option under consideration is replacing the Wallowa Hatchery stock with one developed from local populations. Future research should attempt to define the most appropriate conceptual and logistical approach to local broodstock development.

### Determination of Smolt Release and Adult Recapture Strategies to Provide for Hatchery Steelhead Fisheries without Detrimental Interbreeding and Competition with Wild Steelhead

Current information suggests the possibility of operating selective recreational fisheries on 100% fin-marked hatchery steelhead while keeping incidental mortality to wild steelhead to less than 5% in some populations. However, information is sometimes inadequate to control surviving hatchery juveniles and resultant competition with wild steelhead juveniles, or to control straying of excessive numbers of hatchery adults to wild steelhead spawning areas with resultant risk to the genetic fitness of wild populations. Past research on acclimation of juvenile hatchery smolts to terminal adult recapture areas, volitional smolt release practices, timing and size of smolt releases, and various adult recapture methods is not adequate to accurately predict results in many new situations and locations. A broader scale study with a systematic design to provide more extensive application of results is needed to restore both fish and fisheries.

### Determination of Hooking Mortality in Catch and Release Steelhead Fisheries

Although past research on the rate of hooking mortality in catch and release fishing may be adequate for winter steelhead fisheries, more information is needed for summer steelhead fisheries and would also be beneficial to managing winter steelhead fisheries. Mortality is likely to be higher in situations where water temperatures are warmer for at least part of the angling season. This information gap is greater for summer steelhead than for winter steelhead.

### Evaluation of the Benefits of Using Natural-Type Rearing Environments for the Production of Hatchery Steelhead

Recent small-scale experiments conducted by NMFS indicate that modifying hatchery environments to be more like natural environments may increase the rate of hatchery fish survival in the wild. Future research should evaluate whether natural-type rearing is applicable to summer steelhead on a hatchery production scale.

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# Conservation Status of Steelhead in Oregon

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# Table of Contents

## **Table of Contents** (continued)

## 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 upon available abundance and life history data, presented and analyzed in a scientific manner to determine if steelhead are at risk of extinction in Oregon.

This is the third and final revision of the steelhead conservation status 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).

Three indicators of species health were used to assess the magnitude of extinction risk to steelhead in Oregon: 1) the likelihood of long-term population persistence, 2) the capacity of populations to resist and survive short-term periods extreme environmental stress, and 3) the identification of populations that are at immediate risk of reproductive failure and extirpation from observed trend data, interactions with hatchery fish, or other factors are at immediate risk of reproductive failure and extirpation.

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

The status assessment results for each steelhead evolutionarily significant unit (ESU) are summarized as follows.

Klamath Mountains Province ESU = **SECURE**
In terms of resistance to stress and the percentage of populations at immediate risk of extirpation, the picture for this ESU is secure. The long-term persistence indicator results suggested that two of the four populations assessed would qualify for a sensitive species designation. However, taken together these three indicators gave a net classification of secure for this ESU. The only apparent weak spot 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 serious depressed state of the summer steelhead population in the Siletz and the greater than 50% hatchery spawners in several natural populations triggers extirpation warnings for a sufficient percentage of the populations in this ESU to warrant some concern. The net result of these findings was

this ESU was assigned an overall classification of sensitive.

SW Washington ESU = **SENSITIVE**
There are no abundance data for populations in Oregon's portion of this ESU. However, in terms of management history and habitat characteristics it was assumed that steelhead populations in this ESU are most like those belonging to the adjacent Oregon Coast ESU. Therefore, it was assumed the status of steelhead in the SW Washington ESU was likely the same as those of the Oregon coast. Pending the collection of new information, this perceived similarity was 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 environmental stress. In addition, 1 of the 5 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 suggests 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. However, of special concern is the recent collapse of winter steelhead in the Clackamas River and summer steelhead in the Hood River. Comprising 33% of the populations examined in this ESU, they are sending clear warnings of possible extirpation. In light of these results, it was concluded that that the status of this ESU meets the criteria established for threatened.

Middle Columbia ESU = **SENSITIVE**
The assessment results for this ESU in terms of resistance to short term-stress and the likelihood long-term survival suggest that 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. Over the last 4 years the wild population has been in almost complete reproductive failure. Stray hatchery fish dominate the spawning population (greater than 75%) and likely are causing severe genetic impact to the innate productivity of the wild population. The South Fork John Day population, although not at the same level of crisis as the Deschutes, 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 resulted 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 to base this status assessment upon, the finding of one of these populations at high risk of extirpation weighs heavily on 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 statewide review, the steelhead in the Snake ESU meet the standard

for a threatened designation.

# Acknowledgments

This status report of steelhead populations in Oregon would not have been possible without the cooperation and suggestions from a large number of ODFW biologists, as well as comments from reviewers of the first report draft completed in June, 1997.

Many individuals were helpful in responding to the numerous requests I 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 (WDFW), and Doug Cramer (PGE).

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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 throughout much of Oregon.

The objective of ODFW's review was to independently determine if steelhead are at risk of extinction. As such it was not a review of the state of steelhead fisheries in Oregon, nor was it intended to be a detailed review of the condition of steelhead habitat in Oregon. Rather, the review utilized 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.

The third and final draft of this report, it 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 (i.e., "population segment") under the endangered species act (ESA). Although NMFS defined 15 ESUs for west coast steelhead, only 7 occur in Oregon. Five of these ESUs 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 evolutionarily 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 has put considerable effort into reviewing steelhead populations at the ESU level, ODFW decided to use the same units in assessing steelhead populations in Oregon for the purposes of this report. It assumed this will make it easier to compare the results of ODFW’s steelhead assessment 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 were used as 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 for each redd completed, and $P_f$ is the estimated proportion of females in the spawning population. A value for $P_f$ was based upon the best available information for each population. For $F_r$, a value of 0.81 was used for all populations based upon 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 provides an index of steelhead harvest for specific river basins, it is difficult to infer population abundance from these data, especially for wild fish. This is especially the case for catch estimates made after angling regulations were changed to prohibit the kill of wild steelhead. By 1992 most steelhead fisheries in the state were operating under such regulations. Therefore, for this and other reasons, the analyses presented in this report are based upon a subset of steelhead populations for which either dam counts or spawner counts were directly available.

## Fishing Mortality Rates

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

Since the late 1970's an increasing number of steelhead fisheries have operated under the requirement 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). It was assumed, for the purposes of the analyses presented in this report, that the mortality rate for caught and released wild steelhead was 10%.

## Proportion of Hatchery Fish in the Natural Spawning Population

A variable proportion of many natural 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 upon the reading of scales volunteers collected from caught steelhead. The latter method was largely restricted to the time period from 1980 to 1992. Prior to 1980, a widespread volunteer steelhead scale collection program was not in existence. After 1992, angling regulations permitted the retention of only hatchery fish 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. In addition, hatchery:wild ratios were made for many coastal populations based upon pre-1992 estimates and the projected impact of new 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, in the case of the Clackamas population, the return timing of winter steelhead, as counted at North Fork Dam, was used to estimate hatchery:wild ratios in these earlier years. Based upon the known return timing of historical wild steelhead populations to and the known early run-timing of hatchery fish, it was assumed that all fish counted after April 1 at North Fork Dam in the were wild fish. Fish counted at North Fork Dam prior to these dates were classified as 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 upon historical run timing information, it appeared that most fish that returned prior to March 1 were likely hatchery fish and those afterwards wild fish. However, in 1997 a video camera was used to automatically take pictures of fish passing Marmot Dam to determine their hatchery or wild classification on the basis of missing fins (all hatchery fish were fin clipped prior to release as smolts). A preliminary review of these data by PGE biologists suggests that hatchery fish comprised only 53% of the run in January and February, while in March and April they comprised 32% of the return. 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 made after March 1. Wild fish were estimated from the difference between the total count and the hatchery fish estimate.

It is acknowledged that 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 that are classified as wild fish because they are counted after the preset starting date for wild fish.

## Spawner-Recruit Modeling

For those populations with sufficient information, spawner-recruit models were developed to help place indices of population abundance in the context of habitat capacity. In general, the time series used to develop the spawner-recruit relationships covered a period of time from the early 1970's to the spring of 1997. Some notable exceptions being 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, that these relationships should shed light on the approximate production potential of each population. This expectation is based upon the assumption that each watershed has a limit on the maximum number of steelhead it can produce because of limitations of habitat quantity, quality, and out-of-basin survival at rates in the ocean and migration corridors.

Indices of spawners and recruits were needed to develop recruitment models. Spawners were 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 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 also believed to genetically differ from the wild population, a second recruitment modeling exercise was performed with a discount applied 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 report section “Reproductive Success of Hatchery Spawners”.

The number of recruits produced by each brood year of spawners was estimated in the following fashion. First, the pre-harvest, total 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 upon an average age distribution for each population (Table 1). The assumed age structure for each population was based upon 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 |
| 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 recruits for winter steelhead that spawned in 1980 (brood year) would equal the number of age 2, age 3, age 4, age 5, and age 6 fish that were estimated to have returned in 1982, 1983, 1984, 1985, and 1986, respectively. It is important to note that while respawners comprise from 3% to 15% of the return population, they are excluded from the recruit calculations. To do so 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 the parameters *a* and *B* through linear regression analysis of the transformed Ricker equation, $\mathrm{Ln}(R/S) = a - BS$, as described by Burgman et al (1993) and 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. In theory, the maximum recruits per spawner occurs at the lowest spawner densities.

An *a*-value of 1.4 is equal to about 4 maximum recruits per spawner, Exp(1.4) = 4.05. In contrast an *a*-value of only 0.2 translates into a relatively unhealthy maximum recruits per spawner of only 1.22. Finally, an *a*-value less than zero, for example -0.1, equals a maximum recruits per spawner of only 0.9, 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 on a path to extinction. In contrast, the higher the *a*-value the more resistant a population is to extinction. Even if the population is reduced to very low levels of abundance, 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 maximum number of spawners a population can sustain, on the average, 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).

It was assumed the confidence in equilibrium abundance estimates for each population was 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 = $(a_{\text{lower 95\% CI}})/B$.

## Quantitative Quasiextinction Assessment Model

As one component of a repeatable process for assessing the risk of extinction, a quantitative approach, using commonly accepted analyses as 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 build around the following version of the Ricker equation where:

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

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).

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) and *y* 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 stocasticity 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 cover both freshwater and ocean uncertainty since its origins are adult to returning adult data - the entire life cycle. It is also the heart of the quasiextinction assessment model.

*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 what it was for the base period (for most populations from the early-1970’s to 1997) model runs were conducted with $V = \text{Ln}(1/2) = -0.69$. 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 $V = \text{Ln}(1.0) = 0.00$.

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

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 depensation thresholds (Dep).

| Population | a | B | s | MaxS | H.R. | QuasiEx[b] | $R^2$ | p |
|---|---|---|---|---|---|---|---|---|
| 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.Santm | 0.6078 | 0.0264 | 0.3223 | 49.0 | 0.05 | 10.0 | 0.22 | < 0.05 |
| UpS.Santm | 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.

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 an area of 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 where the source of data 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 source data consisted of indices of spawner density (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 below these quasiextinction levels, the recruitment capacity declined sharply from Ricker recruitment model expectations. However, this assumption of a depensatory function may be incorrect. It is equally possible that recruitment at very low abundance levels follows Ricker model expectations and a depensation mechanism does not exist. The issue is that below quasiextinction levels it is not clear which behavior predominates. We have assumed that depensation exists because we wished to make the most conservative assessment of the steelhead populations modeled. Model runs which 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, a conditional step was set such that recruitment would be 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 that fell between 33% and 100% of quasiextinction levels, recruits were estimated from the linear relationship, $R_{predicted} = R_{quasiextinct} * [(S_{mod} - 0.33*S_{quasiextinct})/(S_{quasiextinct} - 0.33*S_{quasiextinct})]$. Where $R_{predicted}$ is the recruit prediction adjusted for depensation, $R_{quasiextinct}$ is the number of recruits produced when spawners are at quasiextinction abundance, $S_{mod}$ is the number of spawners generated by the model, $S_{quasiextinct}$ 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 6-year string spawner abundance less than the quasiextinction level for the population. This definition is based upon an inference from observed steelhead life history characteristics that most populations do not have enough 7-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 6 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 upon the total spawning population the predicted number of recruits (offspring) 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 two years out 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 7 to 10 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 recover after only partial summer in the ocean. As a result, these fish then return to freshwater in the same year and end up being spawners once again only one year later.

Upon completion, the results of each trial were inspected for the occurrence of an quasiextinction sequence (6 or more consecutive years with of 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 “what if” decreases in survival or population abundance.

The structure of the model used to estimate the probability of quasiextinction of individual populations is much simplified from what likely occurs in nature. Perhaps one of the most important omissions from the model is that does not incorporate natural straying and recolonization from nearby populations. The model treats each population as an isolated island such that it 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 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 suggested 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:

$$\text{Effective Spawners} = \text{Spawners}_{\text{wild}} + (\text{Spawners}_{\text{hatchery}} \times 0.15) \qquad (2)$$

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.

|  | $RS_h$ = 1.00 | $RS_h$ = 0.15 |
|---|---|---|

| Population | *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 |
| $\text{Kalma}_{SR}$ | -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, restricting the number of hatchery fish that spawn in the wild, 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 aggressive these actions need to be in order to protect the reproductive potential of wild populations. Not only are the genetic consequences of actions (such as use of local wild fish for hatchery broodstock) largely unexplored, it is unclear if these actions will be effective over the long term. 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 future 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 manage wild and hatchery steelhead programs under the opposite assumption, that the reproductive differences can be maintained and relied on in the future, may result in the extinction of wild populations.

## 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 from observed trend data, interactions with hatchery fish, or other factors are at risk of reproductive failure and extirpation.

For each of these indicators and related criteria were developed to define the boundaries of four designations: Endangered, Threatened, Sensitive, and Secure. As implied earlier, these designation relate only to issue of species extinction. For example, a designation of 'Secure' does not mean a population is abundant and its habitat in good condition, it only means that it is not 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 under the scenario where relative survivals decrease to 1/2 of the previous 25 year (1972-97) average.
**Secure** - A ≤ 5% probability of quasiextinction within 100 years under the scenario where 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 <u>extinction</u> (zero individuals left in the population), the criteria used in this report are stated in terms of the probability of <u>quasiextinction</u> (a number greater than zero). Second, the name "Threatened" was substituted for their "Vulnerable" category, and a more conservative 5% probability of extinction than the 10% they proposed was used. 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. <u>Resistance to Short-term Stress Indicator</u>

**Endangered** - A > 50% probability of quasiextinction within 12 years under the scenario where relative survivals are 1/4 of the previous 25 year (1972-97) average.
**Threatened** - A > 20% probability of quasiextinction within 12 years under the scenario where relative survivals are 1/4 of the previous 25 year (1972-97) average.
**Sensitive** - A > 5% probability of quasiextinction within 12 years under the scenario where relative survivals are 1/4 of the previous 25 year (1972-97) average.
**Secure** - A ≤ 5% probability of quasiextinction within 12 years under the scenario where relative survivals are 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 upon model run results that assumes the relative survival rate over the next 100 years will average what they have been for the last 25 years ($V = 0$ in equation 1). In addition, 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 known to often occur in strings. A bad ocean condition in one year often is followed by bad ocean conditions the following year. With these concerns in the mind the short-term indicator was based upon 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. <u>Observed Extirpation Warnings</u>

**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 upon 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 upon 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 upon 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. It is assumed that 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.

Up to the present 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 having access to former 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 this suite of features is 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 signal the continued existence of the ESU is at risk.

The criteria for this indicator (observed extirpation warnings) were somewhat subjective in their origins, both in terms of what qualifies as a clear warning of extirpation and in terms of the percent of the populations that 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 were 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 on the population, increasing this stress only a small amount yields an increasingly dramatically increase the percentage of extirpated populations (Figure 1). The criteria for this indicator were selected to capture the transition range between 10% and 30% extirpation.

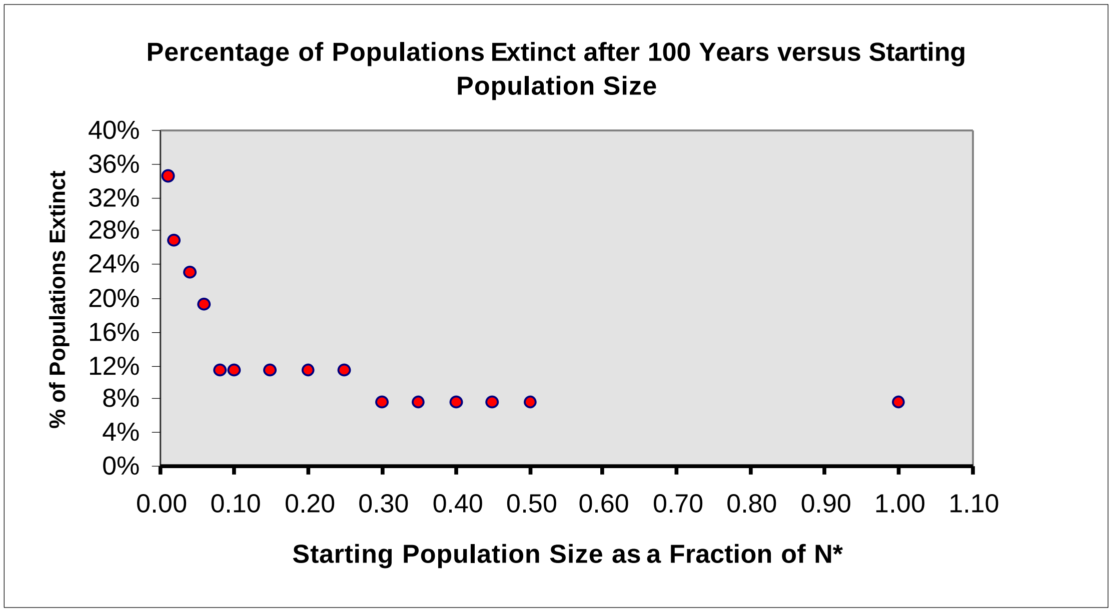

Figure 1. Quasiextinction model run results in terms of percentage of 26 steelhead populations that go extinct after 100 years starting with various population sizes expressed as a fraction of population equilibrium, N*.

Three factors were considered as extirpation warnings under this indicator: critically low abundance, sudden downward trends in abundance, and excessive numbers of genetically incompatible hatchery fish spawning with the natural population. Under extreme circumstances each 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 visual inspection of abundance graphs for each population. Quasiextinction levels for each population and the rate of decline of six year moving averages of pre-harvest abundance were used 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 observations made in the most recent years.

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, as evidenced 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 (the Snake Basin to the south coast of Oregon) is particularly striking.

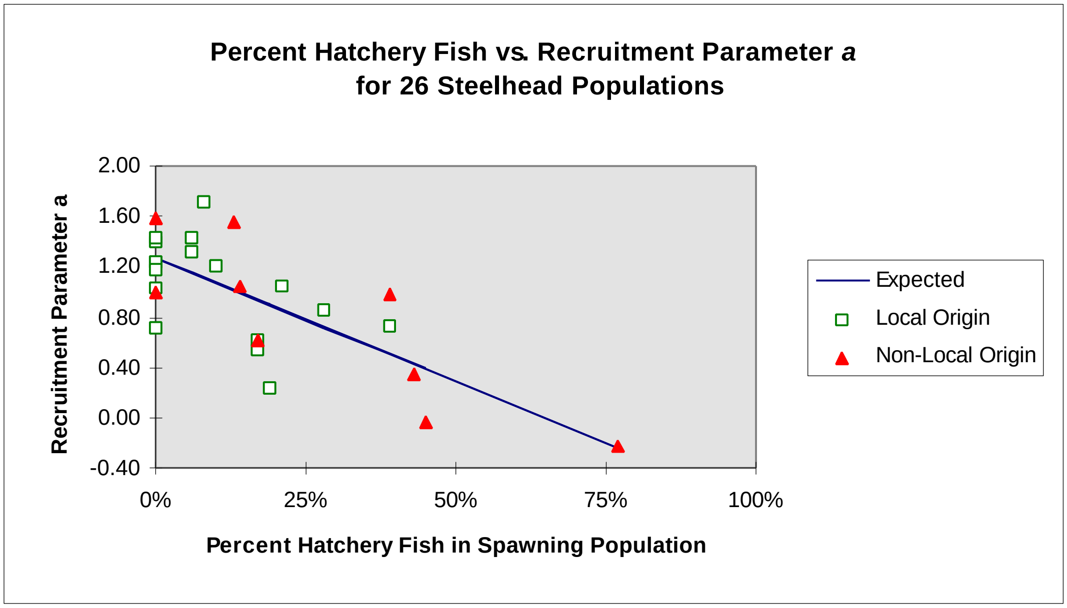

Figure 2. Average percent hatchery fish in 26 natural steelhead populations in Oregon versus corresponding Ricker recruitment model parameter *a* estimates for the same time period.

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 which originated from non-local populations in terms of natural recruitment. The implications are 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 stock origin and history of the hatchery fish 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 upon the relationship described above (Figure 2), this reproductive failure point occurs when hatchery fish comprise more than 65% of the spawning population. Based upon a conservative interpretation of these findings, it was assumed 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 assumption was used to evaluate the hatchery fish risk for all steelhead populations for which there was sufficient hatchery : wild spawner composition data.

However, it should be stated that the apparent inverse relationship between percent hatchery fish and recruitment parameter *a*-values does not necessarily mean that wild fish in populations with high percentage of hatchery spawners have been genetically damaged. As discussed earlier in the "Reproductive Success of Hatchery Fish" section, another possibility is that 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). In such a case, the wild population retains its reproductive potential and, therefore, its resistance to extinction.

However, such an interpretation can only be made with confidence 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. In light of this ambiguity, the approach to the criteria for both this indicator conservatively assume the worst: that high percentages of hatchery spawners will eventually 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. The third indicator (observed extirpation warnings) stated the results directly at the at the ESU level. However, for the other two indicators, ESU level scores required the averaging of individual population scores within each ESU. This was done 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.

## 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.

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 the Pistol River, Euchre Creek and Hunter Creek.

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

| Population | Time Period | Percent Hatchery | n | Source |
|---|---|---|---|---|
| Elk River - WR | 1991-92 | 4% | 82 | creel surveys |
| Euchre Crk - WR | 1991-94 | 11% | na | analysis of strays |
| Rogue - WR | 1975-96<br>1992-97 | 5%<br>5% | na | dam counts & hatchery returns |
| Rogue - SR, upper | 1975-96<br>1992-97 | 14%<br>27% | na | dam counts & hatchery returns |
| 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** |

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. The exception being 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%) x (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 population 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 4 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 as an estimate of 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 estimate 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%.

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% |

This estimate is consistent with ODFW’s observations at an upstream migrant trap located on Elk Creek, a Rogue River tributary 5 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.

<u>Rogue Summer Steelhead, Upper River</u> - 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 6 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 after they had migrated up to the reservoir outlet. However, unlike the Gold Ray Dam counts 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 which 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 2 years previously (Table 7).

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 it's 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 0.19, 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 were hatchery fish.

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

| Brood Year | Wild Retrn | Hatch Retrn | 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% |

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 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.

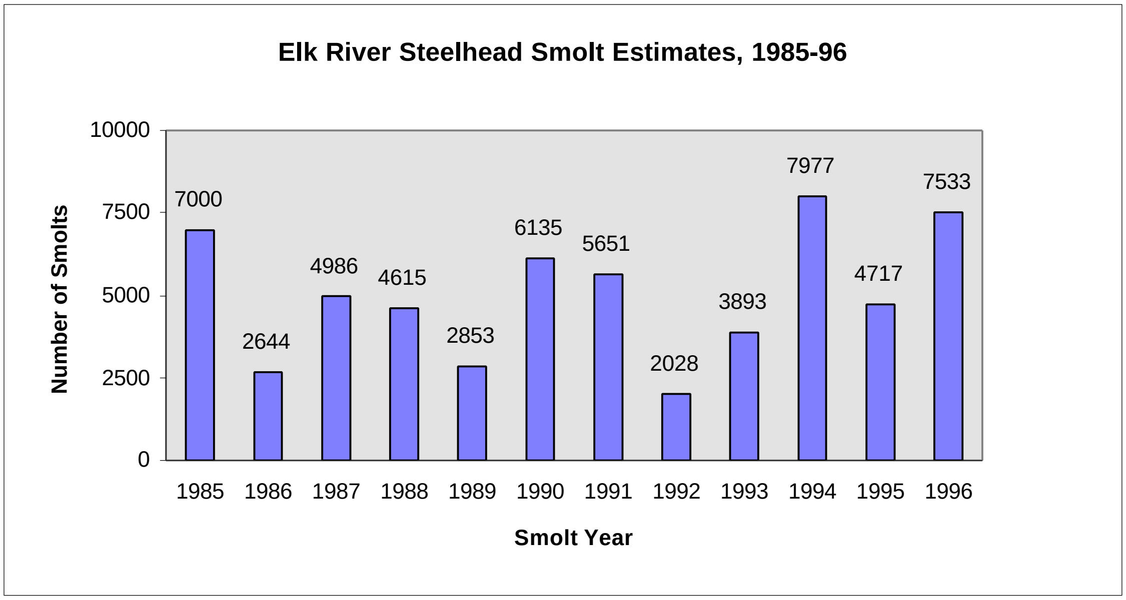

Figure 3. Estimated number of steelhead smolts emigrating from the Elk River, 1985-96.

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, such that they 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 2-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.

<u>Rogue Winter Steelhead</u> - 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. For example, in the last two years the observed population levels are nearly identical to N*. Therefore, on the average, the habitat will not sustain larger numbers of spawners than what has been observed during these two years. Confidence in such an interpretation is strengthened by the relatively narrow upper and lower bounds obtained for the N* estimate (Figure 4).

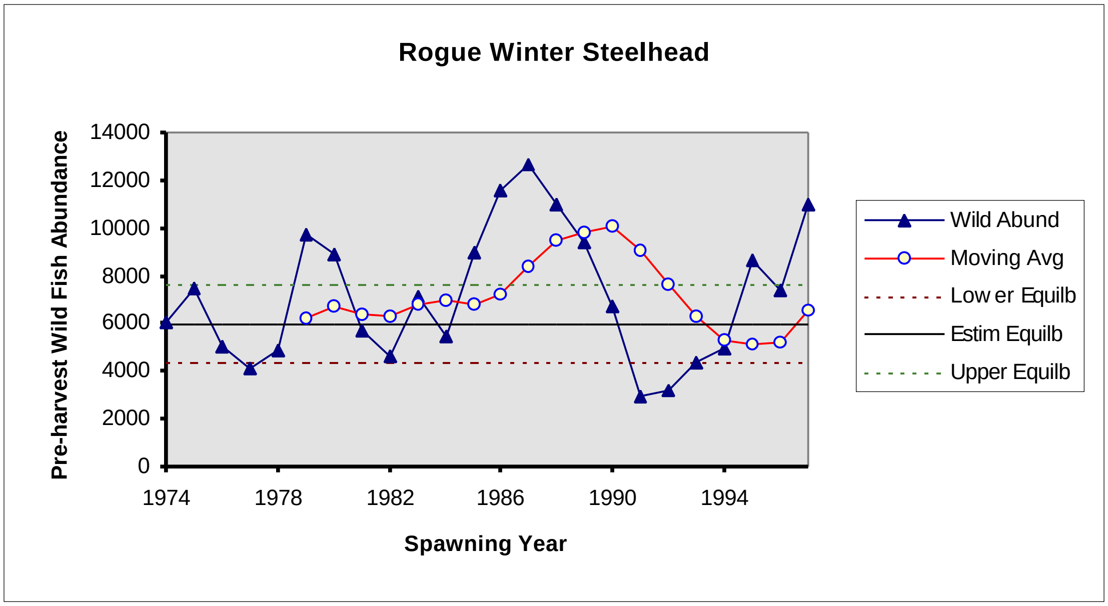

Figure 4. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Rogue River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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. On the average, larger escapements than those of the last couple years would exceed the system's sustainable capacity.

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 6-year moving average from 1990 to 1995. Although this downward trend appears to be reversing itself, it is premature to make this conclusion.

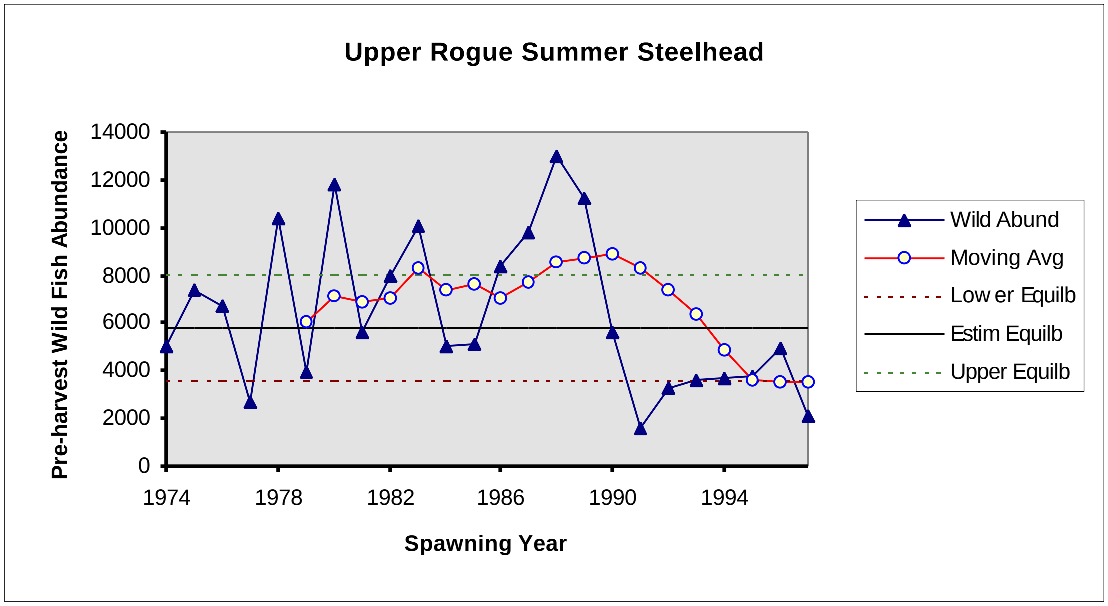

Figure 5. Annual and 6-year moving average estimates of the pre-harvest abundance of wild summer steelhead in the upper Rogue River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

Applegate Winter Steelhead - From 1992 to 1997 the average number of wild steelhead spawning in the Applegate 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 winter steelhead have rebounded from low returns observed in the early 1990's to levels that are appear to be on an upward trend.

Rogue Summer Steelhead, Middle Basin - Tributaries to the Rogue 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 6-year moving average of these data show an almost steady decline for the entire time period (Figure 7).

The life history of the 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, many spawners utilize tributaries that typically dry up by early summer.

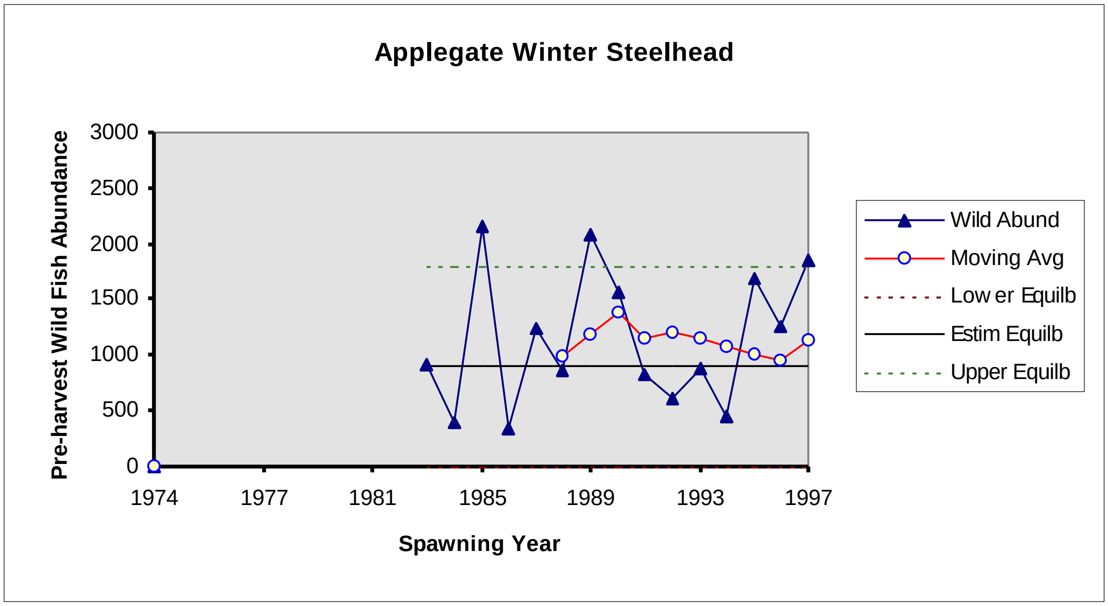

Figure 6. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Applegate River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

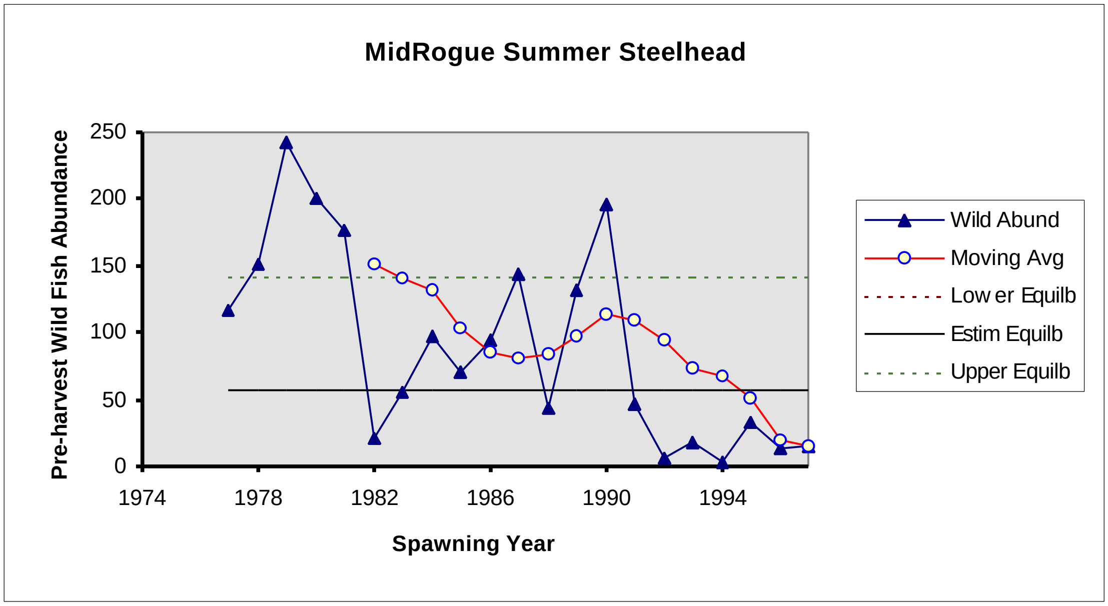

Figure 7. Annual and 6-year moving average estimates of the pre-harvest abundance of wild summer steelhead in the middle Rogue River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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.

## Quasiextinction Assessments and 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 upon 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 (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 in opinion is that the time series used by Busby et al. (1994) ends in 1991. The abundance estimates presented in this report extend another 6 years, to 1997. The analysis presented in this report suggests that 1991 was the low point for several populations in a decline that started in the late 1980's.

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 that were 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 NRR's (natural replacement ratios).

Second, Busby et al. (1994) erred in using NRR's without placing them in the context of spawner abundance. To derive a useful interpretation from NRR's, 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 very much sustaining themselves. The assessment of these populations presented by Busby et al. (1994) presents NRR's in such an ambiguous light that a biologically meaningful interpretation is impossible.

ESU Status Synthesis - As described in the methods section, three indicators were used to assess the status of each steelhead ESU. The results were as follows. None of the four populations modeled for 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 3 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 3 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 a extirpation warning on the basis of the magnitude and duration of spawner abundance. 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 for individual indicators, the status assessment score for this ESU was 1.3 (Table 9). On this basis, and following the protocol described in the methods section, 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 probably 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 the steelhead management programs have occurred in populations belonging to this ESU since 1991. For example, the Oregon Fish and Wildlife Commission approved in 1994 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 inaccurate and 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 average for these same basins provided by Busby et al. (1996) of 52%.

Unless described otherwise, the revised estimates of percent hatchery fish for coastal steelhead populations were based upon hatchery changes that were 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 voluntionally 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:

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

where;

Pha = 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

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

| Population | Pre-1992 Estimate | 1997 Revised Estimate | WFMP Hatch Stock Type[a] |
|---|---|---|---|
| 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 |
| 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).

populations were hatchery strays. This assumption was supported by evidence ODFW obtained for the Sixes and Elk River populations in 1991-92 from analyses of scale samples collected from fishery caught steelhead (n = 223). This analyses indicated 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, the percentage of hatchery fish in the naturally spawning population is 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 estimated to now 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, which should reduce the straying of hatchery fish from the Wilson to 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 will be 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, it appears 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, indicated 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 upon 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 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 the additional information and analysis of this problem the reader should 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 will be 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 which was originally developed from the Siletz Basin. 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 4 years. The intent is to drastically reduce this percentage if the wild population shows signs of rebuilding after 5 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 upon the results of trapping major tributaries for adult fish over the last 5 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 upon data collected from adult traps operated on major tributaries within the Alsea Basin, the majority of hatchery fish straying into natural spawning areas were not released as smolts into the Alsea. Most of these fish were raised at NF Alsea hatchery, but trucked and released into other basins, most notably the Siuslaw. In recent years, significant changes have been made 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 which were 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 the straying problem from out-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 no kill 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 the stray hatchery fish in Drift Creek appear 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 which have been found in these basins are all strays from other programs; largely the Siuslaw. As described below for the Siuslaw, significant changes have been made to reduce this straying in recent years. These changes are expected to result in only 5% of the natural spawning population in these three basins being hatchery fish.

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

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 change 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 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 tend to confirm this expectation, with 29% being 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. It is expected this will reduce the percentage of hatchery fish to 5%.

North Umpqua, Winter Steelhead - No major changes; no hatchery fish released into basin. The estimate of hatchery strays is 5%.

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 which 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 upon 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 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 6 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% |

Table 11. Continued.

| Brood Year | Wild Count | Hatchery Count | Hatch to Rock Cr | Wild Escapm | Hatch Escapm | % Hatchery |
|---|---|---|---|---|---|---|
| 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% |
| 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 - Hatchery program changed to rear smolts for a short period of time prior to release such they imprint on the Eel Lake outlet, a minor steelhead production area and isolated from the primary steelhead production area for this population, inlet tributaries to Tenmile Lake.

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 keeping of wild fish illegal, it is estimated the percentage of hatchery fish in the naturally spawning population is 40%.

Coos - For the same reasons as given 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. Estimated percent hatchery fish in the natural spawning population is 45% based upon observations of sport caught fish in the South Coquille.

South Coquille - Smolt release sites located to draw returning hatchery fish away from natural spawning areas. Evidence based upon sampling of steelhead caught in the 1992-93 sport fishery suggests that the percent hatchery fish in this population is 45%.

Floras - No major changes; no hatchery fish released into basin. The estimate of hatchery strays is 5%.

Sixes - No major changes; no hatchery fish released into basin. The estimate of hatchery strays 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 the catch statistic information.

It is unclear how representative these populations are with respect to the entire ESU. However, the initial feeling 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 1960's and again in the early 1990's (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.

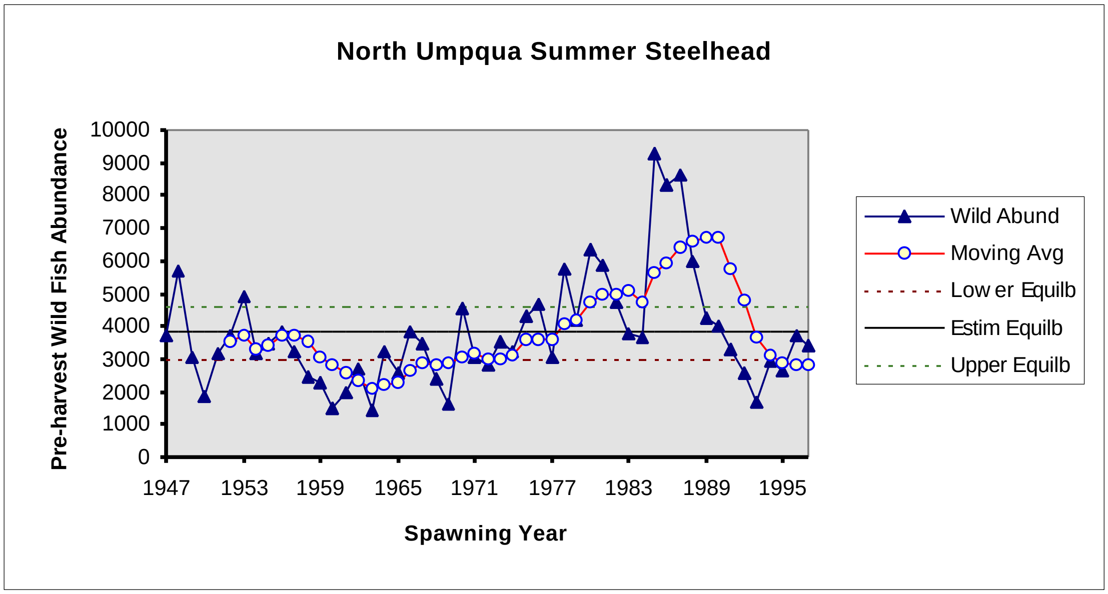

Figure 8. Annual and 6-year moving average estimates of the pre-harvest abundance of wild summer steelhead in North Umpqua River, 1947-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

North Umpqua Winter Steelhead - Pre-harvest abundance and spawner escapement estimates were made for wild winter steelhead based upon 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 6 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 3 peaks and 3 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 it is concluded that 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 for 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.

| | | Pre-Harvest Abundance | |
|---|---|---|---|
| **Brood Year** | **Spawners** | | **Observed Recruits** |
| 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 |

|  |  |  |  |
|---|---|---|---|
| 1991 | 3614 | 4910 | 5964 |

Table 12.  Continued.

| Brood Year | Spawners | Pre-Harvest Abundance | Observed Recruits |
|---|---|---|---|
| 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** | |

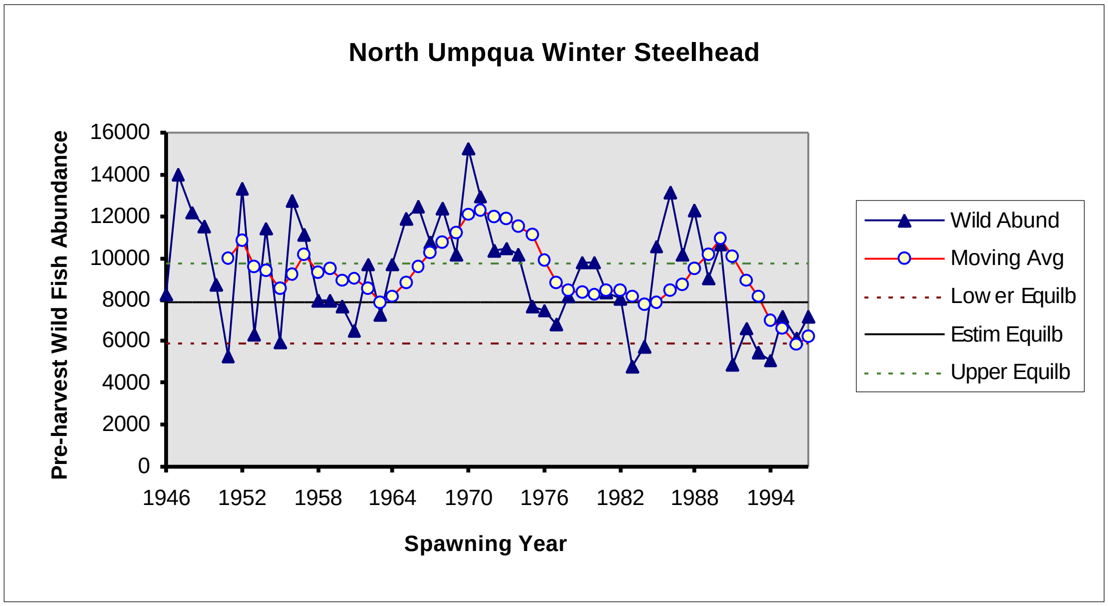

Figure 9.  Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in North Umpqua River, 1947-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

<u>Cummins and Tenmile Creeks</u> - 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 $m^2$ for Cummins Creek and 211,625 $m^2$ for Tenmile Creek.  From this information, estimates of fish produced per $100m^2$ 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 2 years old at migration, these data span 7 brood years of steelhead production, 1991 to 1996.   Assuming a 2-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.

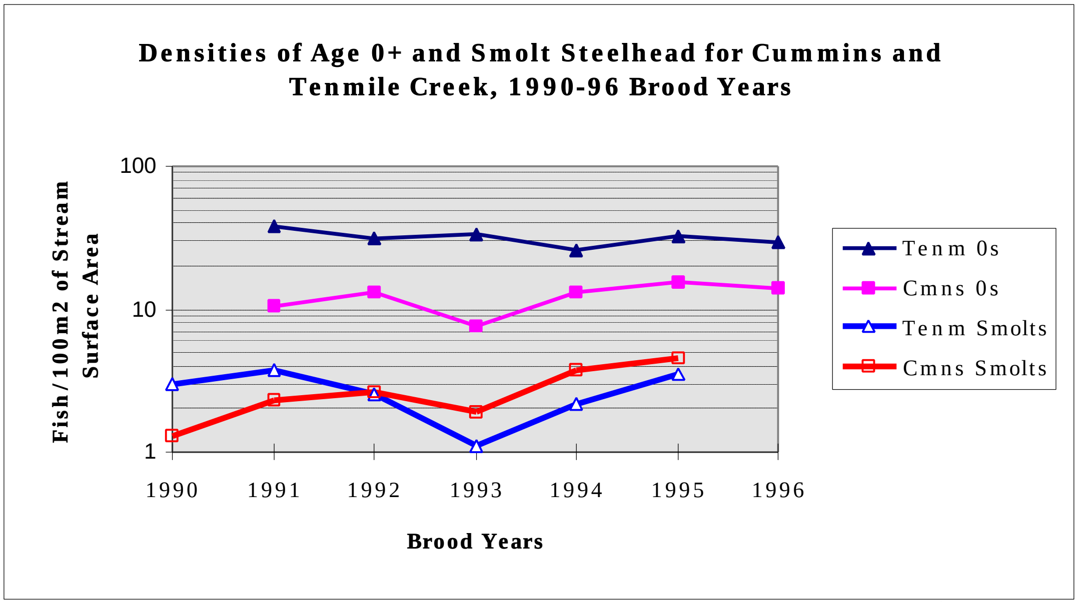

Figure 10. Estimated number of age 0+ and smolt steelhead produced per 100m$^2$ of habitat for Cummins and Tenmile Creeks, 1991-1996 brood years.

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 Creek 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 help 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 the laddering of Siletz Falls in the late 1950's removed a critical isolating mechanism which was key to the continued existence of summer steelhead in the Siletz Basin. It was felt 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 3-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 were wild fish. In addition, hatchery steelhead smolts have not been released into Salmonberry and so any hatchery fish that enter 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.

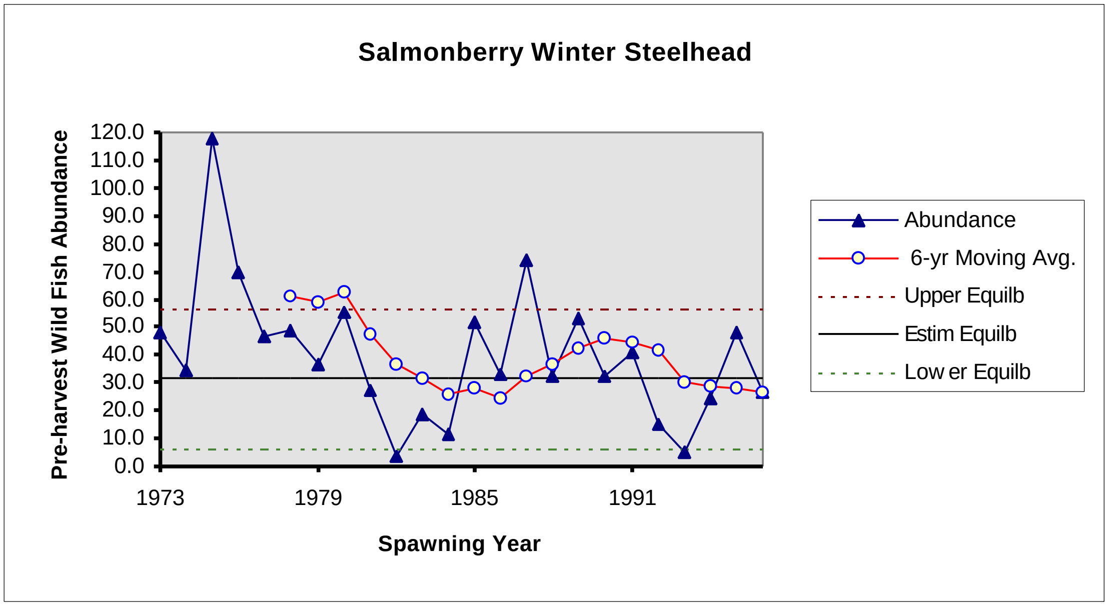

Figure 11. Annual and 6-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the Salmonberry River, 1973-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

The fact that the average steelhead return index for the Salmonberry over the last 6 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 probably relatively secure. However, such an interpretation should not be overstated considering rather wide range between the upper and lower bounds for the population equilibrium level estimate.

## Quasiextinction Assessments and ESU Status Synthesis

Quasiextinction Assessment Results - None of the three populations examined 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 not at immediate risk of extinction. However, it is probably unwise to infer the same about the remaining populations which belong to this ESU on the basis of these results alone. As noted earlier, there is some concern that the N. 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 5 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 an inability to obtain adequate resources to fully implement the 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 can not be obtained to implement these preferred strategies.

Trends in Abundance - Population abundance data presented in this report for 5 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 2 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 upon 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 populations 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 probably 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, it appears 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 which 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 upon 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 for anglers to focus their attention 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 Synthesis - 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 3 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 those populations examined the average rating for this indicator was 1.3.

An extirpation warning (the third indicator) was judged to exist for 4 of the 34 populations inspected for the Oregon Coast ESU. The warning for one of these populations, the summer steelhead in the Siletz, was triggered by its extremely low abundance and lack of rebuilding trend. The other 3 populations were classified with an extirpation warning on the basis of having more than 50% of their naturally spawning populations being comprised of hatchery fish. The score for this indicator was 2.0, because greater than 10% of the populations examined (12%) had 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). From this result and following the protocol described earlier in the methods section, 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 were no abundance data for any of these populations, an in-depth analyses of this ESU was not possible. Because of this fact, the report format used to describe information relevant to this ESU was simplified.

It should also be recognized that the lack of information about the 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 feel 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 2 miles in length. Almost all of the fish caught in the Gnat Creek fishery are hatchery origin. This fishery is supported by the 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 1960’s. The remaining anadromous production zone downstream of the hatchery is only about 5 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, it is anticipated re-establishing passage will 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 released 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 the number of hatchery smolts released into the Lewis and Clark was reduced from 40,000 to 0. It is estimated that 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 the SW Washington ESU in Oregon. The logic being that in terms of habitat and the history of fishery management, 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 seems reasonable to extent 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 1960's. This hatchery stock is probably quite different from wild fish of the Molalla Basin as it originated from wild populations from the lower Columbia 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-1980's, the number of smolts released into the Molalla has been reduced several times. In 1997, ODFW decided to permanently discontinue stocking hatchery winter steelhead in the Molalla.

Scale samples collected by volunteers 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 it is suspected the percentage of hatchery fish has 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). In light of this information, a judgment was made that, from 1992 to present, only 24% of the natural spawning population were hatchery fish. With the discontinuation of hatchery winter steelhead smolt releases in 1997, the percentage of hatchery winter steelhead fish will be less than 5% from 1999 on.

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 other locations within 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% as a result of 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) apparently 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 seems reasonable to infer that the summer steelhead hatchery program may have caused a reduction in the productivity and resiliency of this wild population.

North Santiam - The hatchery winter run stock released into the Santiam Basin was developed from wild fish from the North Santiam. The return and spawn timing of this hatchery stock is considerably later than the Big Creek hatchery stock and is more similar to the wild population in the Santiam. Based upon upstream adult migrant trapping at the Stayton ladder, the latest estimate for hatchery winter steelhead in the North Santiam is 17% (ODFW, 1995b).

Similar to the Molalla, Skamania origin summer steelhead hatchery smolts are also released into the North Santiam. However, the annual number released, 160,000 fish, is much larger than in the Molalla, a smaller basin. As described above for the Molalla, the impact of these non-native steelhead on wild winter steelhead can be inferred from the analysis performed for the Clackamas population described later in this report. Based on this analysis, it is suspected that wild winter steelhead in the North Santiam are less productive than they were prior to the existence of the hatchery summer steelhead program which began in the late 1960's.

Lower and Upper South Santiam - Hatchery winter steelhead smolts have not been released into the South Santiam except during a 7-year period during the 1980's. These hatchery fish belonged to the North Santiam winter steelhead stock. Based upon observations of hatchery and wild fish passing Foster Dam it was estimated the average percentage of hatchery fish from 1982 to 1989 was 47%. Prior to 1982 and after 1990, less than 5% of the winter steelhead passing Foster Dam have been hatchery fish.

As with the Molalla and North Santiam, 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 large portion of the adults generated by this program are either caught or return to South Santiam Hatchery and do not spawn in the wild. Therefore, it is expected the 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 it is believed the incidence of strays from other hatchery programs in the Willamette Basin are rare. Therefore, it was assumed the percentage of hatchery fish in this basin 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. This was done because only redds/mile data are available for areas below Foster Dam, while only total count data are available for the South Santiam above Foster Dam.

With the exception of the upper South Santiam, spawners per mile were used as an index of population abundance for all populations within the Willamette ESU. Redd counts from 1971 to 1997 for survey sections within each basin were converted to spawners per mile using the approach described in the methods section. 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 upon the number of steelhead passing Willamette Falls (Table 15). 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.

| | Molalla | | N. Santiam | | Lo S. Sntm | | Up S. Sntm | | Calapooia |
|---|---|---|---|---|---|---|---|---|---|
| Year | 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 |

For the purposes of estimating indices of pre-harvest run-size, a harvest rate of 0.21 was assumed for all populations until 1992, at which point a 0.05 harvest rate was used, reflecting no kill angling regulations for wild steelhead implemented in 1992.

Molalla - Annual estimates of both hatchery and wild spawners were needed to assess the status of winter steelhead in the Molalla Basin. Estimates for wild spawners were developed from redd count information as described earlier. These counts were conducted in early May, the peak spawning for wild winter steelhead in the Willamette Basin. However, hatchery fish returning to potentially spawn in the Molalla belonged to the Big Creek hatchery stock which typically spawns in January and February. Since the average length of time a redd is visible in streams of western Oregon and Washington is unlikely longer than 4 weeks, redds constructed by naturally spawning hatchery fish would not be observed during spawning surveys conducted in April and May. Therefore, fish per mile estimates for 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-1980's (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 which means that such a population can not replace itself at any spawner density, clearly an unhealthy sign. The population equilibrium level, N*, of zero depicted in Figure 12 reinforces this finding.

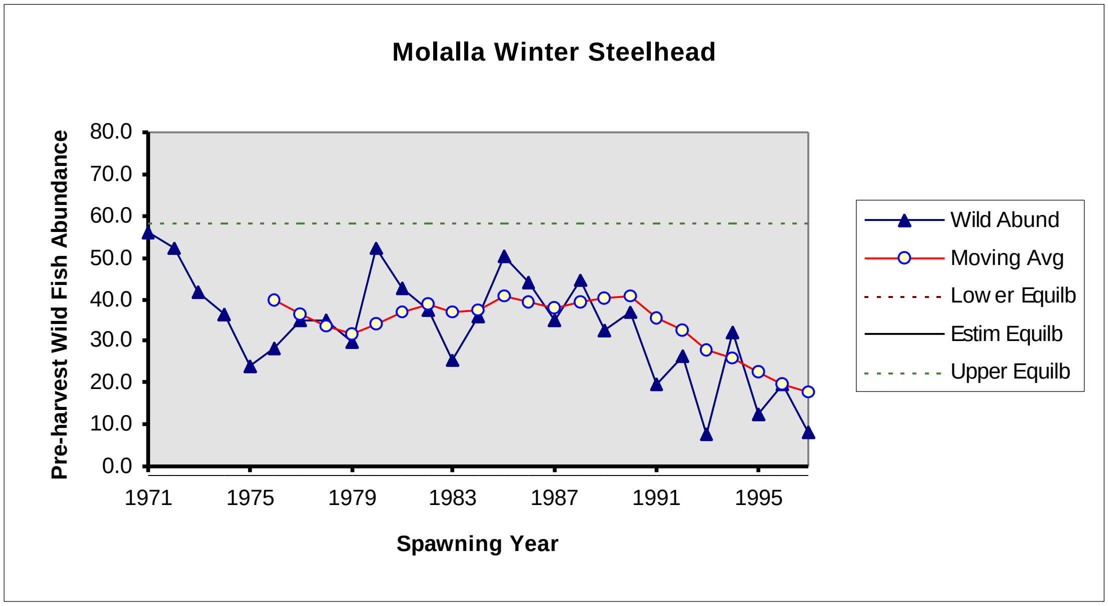

Figure 12. Annual and 6-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the Molalla, 1971-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

There are at least several caveats that should be noted in drawing inferences about the health of Molalla steelhead on the basis of the *a* parameter estimated for this population. First, the regression used to estimate Ricker recruitment parameters *a* and *B*, was a relatively poor fit to 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 (Table 2) fails the traditional significance test level of p = 0.05. 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 unlikely equal 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.

It is worth noting that 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 being that the wild fish, considered by themselves are healthier than they appear when mixed together 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 upon 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 to extinction.

Alternatively, if the reproductive capacity of the hatchery fish is near zero, their removal would not cause a decline in the current levels of wild fish. In addition, the recruitment function for the population would mathematically change because fish with very low reproductive potential (the hatchery fish) now would be removed from the calculations.

Of these two possibilities, it appears the most likely scenario is the latter. As mentioned earlier, evidence obtained 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 if not all of their native reproductive capacity.

In summary, analysis of abundance and recruitment data for Molalla winter steelhead population reveals some clear warning signs. However, the interpretation of these signals hinges on which assumption is selected concerning the reproductive capability of naturally spawning fish belonging to the Big Creek hatchery stock of winter steelhead. Although it appears the assumption of near zero reproductive capacity for hatchery spawners is easier to make based on available evidence, the real test will occur after 1999 when this hatchery stock will no longer spawn in the basin.

At this point, the uncertain reproductive capacity of the wild population in future generations and the 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 wild fish from the North Santiam 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 with the exception of a peak during the mid-1980's and a decline since 1990 (Table 15 and Figure 13). Over the last 6 years the average of wild abundance index has been 26 fish per mile of spawning habitat.

With the exception of the last 4 years, the observed density of spawners appears to have been fluctuating equally around the estimated equilibrium level for this population of 35 fish per mile. While this is a sign of a relatively healthy population, other complicating factors aside, 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.

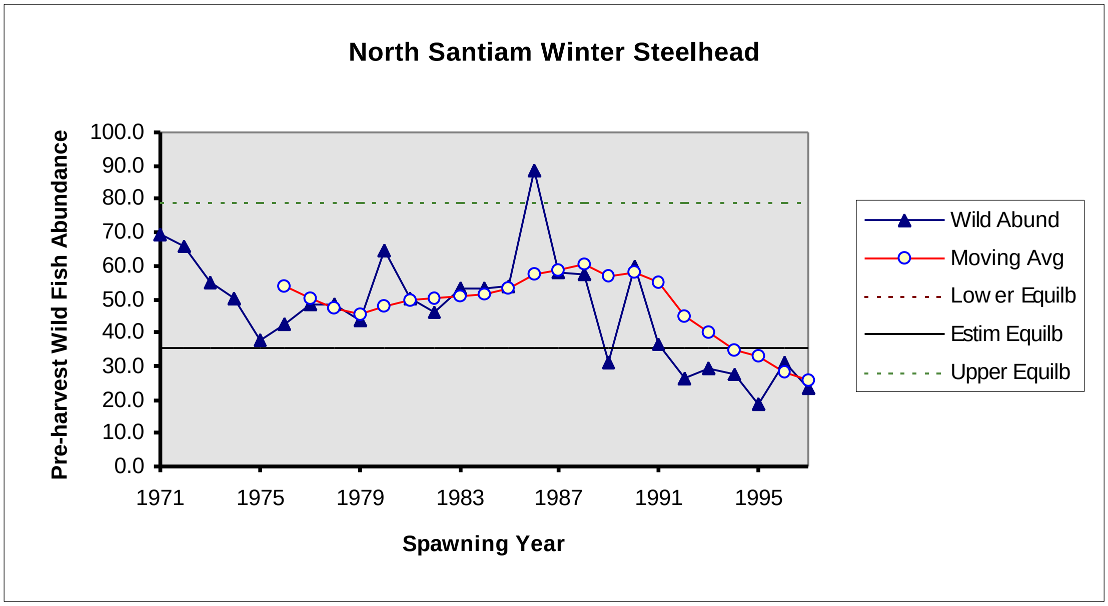

Figure 13. Annual and 6-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the North Santiam, 1971-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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

Second, large numbers of non-native summer steelhead are released as smolts 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 referenced earlier, it appears that naturally rearing summer steelhead juveniles may have a negative effect 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 situation, 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, it appears the wild winter steelhead in the North Santiam are self-sustaining at levels near the estimated equilibrium, N*. However, in the last four years the number of wild fish has uncharacteristically dropped and remained below N*. In light of this observation and concerns about downstream disease infections and competitive impacts of naturally spawning summer steelhead, it appears that this population is at some risk.

<u>Lower South Santiam</u> - The abundance indices for this population of winter steelhead suggest a pattern of relatively minor fluctuations about the estimated natural equilibrium estimated for this population of 23 fish per mile (Table 15 and Figure 14). However, the pattern of these fluctuations appears to be somewhat unique. During the mid-1980’s 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 escapements. The observation of higher densities for this population in recent years while most other populations appeared to be depressed, seems to be a continuation of the contrary theme for the lower South Santiam population.

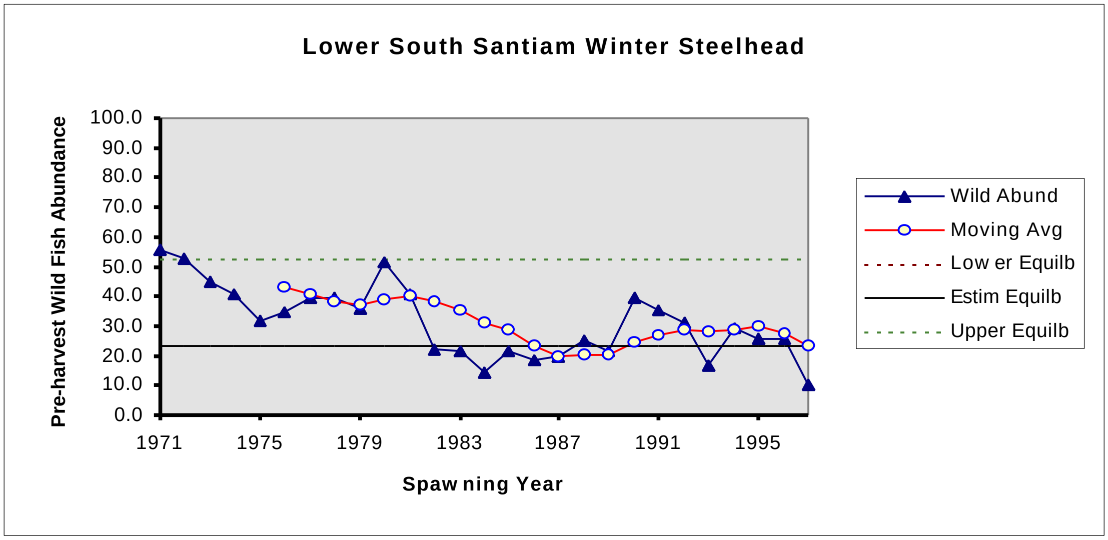

Figure 14. Annual and 6-year moving average estimates of the pre-harvest abundance (spawners per mile) of wild winter steelhead in the lower South Santiam, 1971-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from

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 does not seem likely this lower *a*-value is due to adverse interactions with naturally produced offspring of non-native summer steelhead. A habitat related stress, perhaps mainstem Willamette temperature regimes that enhance the infection rate of certain pathogens such as *C. shasta*, seems like a more likely explanation.

The temporal pattern and magnitude of spawner densities for lower South Santiam winter steelhead appears consistent with a relatively healthy, self-sustaining population. However, the weaker reproductive performance for this population, as evidenced by lower *a*-values is an issue of some concern. While relatively healthy, this population apparently 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 evidenced by the downward trend in the 6-year moving average of steelhead abundance (Figure 15). In addition, this population appears very depressed as evidenced by a total spawner escapement in 1996 of only 131 fish (Table 15).

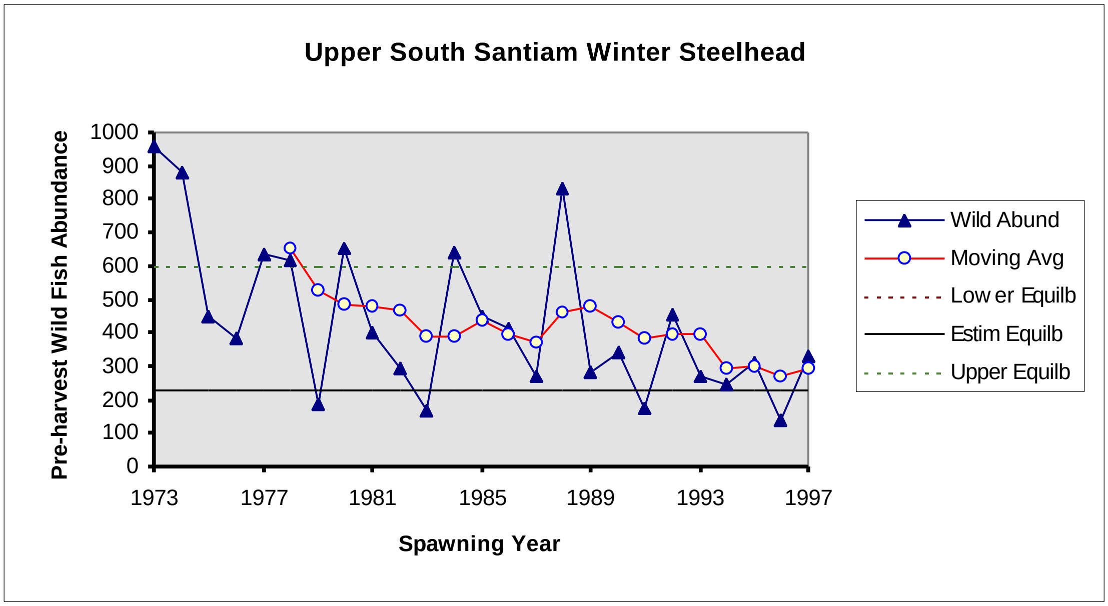

Figure 15. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the upper South Santiam, 1973-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

The Ricker *a*-value of 0.2425 calculated for this population translates into very low recruits per spawner of 1.3. Not only is this result the reason why a low equilibrium value was calculated for this population, it also means that with very little additional stress, steelhead in the upper South

Santiam would not be able to sustain themselves and likely go extinct.

Without hatchery fish (winter or summer steelhead) mixing with this population in recent years, the explanation for its tenuous state must be related to other factors. That the population below Foster Dam is more healthy than the upper South Santiam population, suggests a significant source of additional mortality is associated with either juvenile passage at Foster Dam, survival through the reservoir, or unknown habitat problems 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-1980's, followed by a decline to record low levels in recent years (Figure 16). Prior to 1989 the density of winter steelhead appears to be fluctuating around an abundance level very close to the 12 fish per mile equilibrium level estimated from the recruitment modeling for this population. However, since 1992 the density of spawners has dropped below the equilibrium level, with a record low of only 1.8 spawners per mile occurring in 1993 (Table 15).

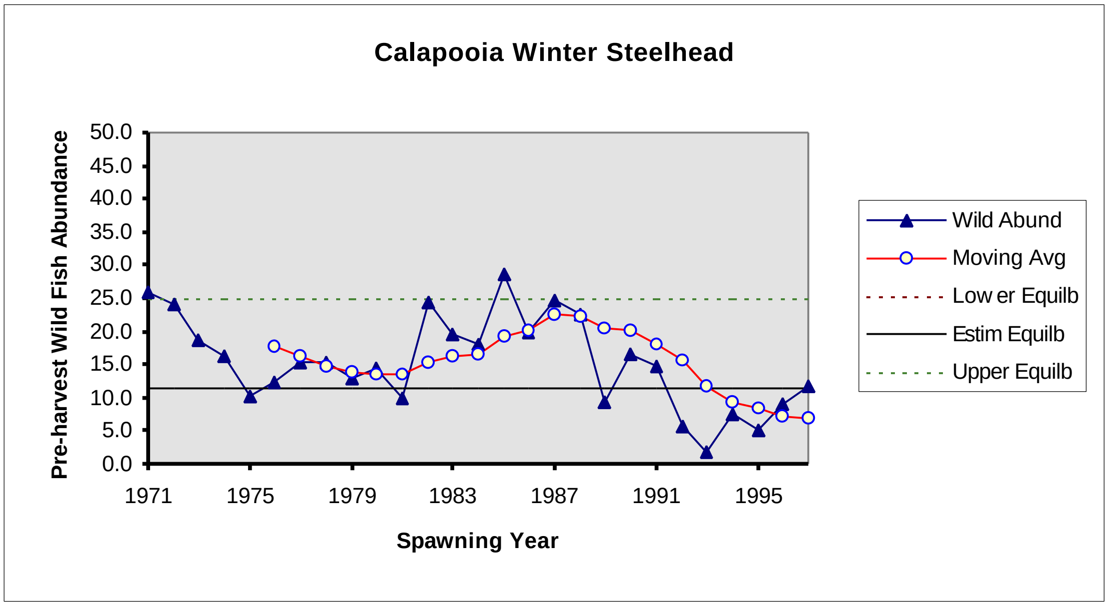

Figure 16. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead (fish per mile) in the Calapooia River, 1971-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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

## Quasiextinction Assessments and 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 indicated that 3 populations, the Molalla, Upper Santiam, and Calapooia, met 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, however even these populations met 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 - With the exception of the Molalla, the adverse genetic impacts of hatchery fish interbreeding with wild fish appears to be a relatively minor issue within this ESU. With the cessation of hatchery smolt releases into the Molalla in 1997, this potential problem will be corrected.

It is anticipated the wild Molalla population, in spite of a history of possible interbreeding with the Big Creek hatchery stock, will retain most of the genetic characteristics typical of a relatively healthy, productive wild steelhead population. However, this expectation will not be proven 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 their naturally produced offspring may have 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). There is a possibility that a similar impact may have occurred in several of the populations in the Willamette ESU as well. While relatively healthy winter populations probably have a productive cushion that allows them to sustain such impacts, a 27% reduction in recruits per spawner for winter steelhead populations that are 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 summer steelhead may be greatest in these basins. The fact that wild winter steelhead populations in this ESU appear somewhat weakened in terms of the reproductive potential (low *a*-values) may exacerbate the effect of naturally spawning non-native summer steelhead.

In finding solutions to this potential problem, the critical issue is how to prevent returning summer steelhead that are not caught in sport fisheries 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 also exist, such as trapping at passage facilities and release of smolts in such a manner 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 the last 6 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 existence of naturally spawning hatchery steelhead (winter or summer steelhead). Therefore, its 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 recruits per spawner at low densities is greater than one for all populations as evidenced by positive values for the Ricker recruitment function parameter *a*, except the Molalla. This is an indication that these populations are theoretically 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 likely would go extinct.

ESU Status Synthesis - Three indicators were used to assess the status of each steelhead ESU, long-term probability of quasiextinction, short-term resistance to stress, and extirpation warning signs (see methods section). As reported previously, 3 of the 5 populations examined met the long-term probability of quasiextinction criteria for endangered, the remaining 2 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 3 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 suggested that all five populations have greater than a 50% probability of quasiextinction under a scenario where life cycle survival collapses to 1/4 of what it has averaged over the last 25 years. This results in 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 T**HREATENED** 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 for the Kalama populations which permitted recruitment modeling and extinction assessments and therefore added context to similar analyses carried out for 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 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 in this report 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 potential estimates suggest that a majority of the steelhead production in the Clackamas takes place upstream of the dam (Murtagh et al 1992). Based upon the known return and spawn timing of the Big Creek hatchery stock which has been used in this basin since the 1960's it was assumed that 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, it was felt the March 31 criterion, was acceptable for obtaining an index of wild fish abundance for the Clackamas Basin.

From 1961-96, an average of 16% of the naturally spawning population of winter steelhead were hatchery fish. In the last 6 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 believed the estimate based upon 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% |

<u>Clackamas - Impact of Non-native Hatchery Summer Steelhead</u> - As mentioned earlier, 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 the 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. It was assumed that the harvest rate on these fish was 44% based upon 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 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: $RS_h = (PS_h * P_w)/(PS_w * P_h) = (0.59*0.29) / (0.41*0.71) = 0.59$.

As presented in Table 19, the additional natural production of summer steelhead smolts which began in the late 1970's 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 2 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 were 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 suggested 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 impacted, to a modest extent, 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 a surprising finding, 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 **-** The Big Creek Hatchery stock is the primary source of winter steelhead smolts that are released into the Sandy Basin. As discussed earlier in the methods section, hatchery fish were estimated at Marmot Dam based upon 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 such that the majority of fish that are not caught will be drawn to confined sites in the lower river below Marmot Dam. It is anticipated that this management change will 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 from video recordings at the passage facility at 39%.

In addition to hatchery winter steelhead, 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 upon 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 3 miles upstream from 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 from 1995 on 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 probably 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 in the natural spawning population has averaged 74%.

## Population Abundance, Trends, and Recruitment

Clackamas - From 1961 to present the average number of wild winter steelhead produced in upper Clackamas was 2,397 fish. However, in the last 6 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 upon recruitment modeling done for this population, the estimated population equilibrium level is 1810 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 6-year moving average line in Figure 17. However, there appears to be an overall decline in this population being with the earliest data points and becoming suddenly more severe in the last several years.

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 years were from smolt emigrations of 19,055 fish and 1994 and 9,706 fish in 1995.

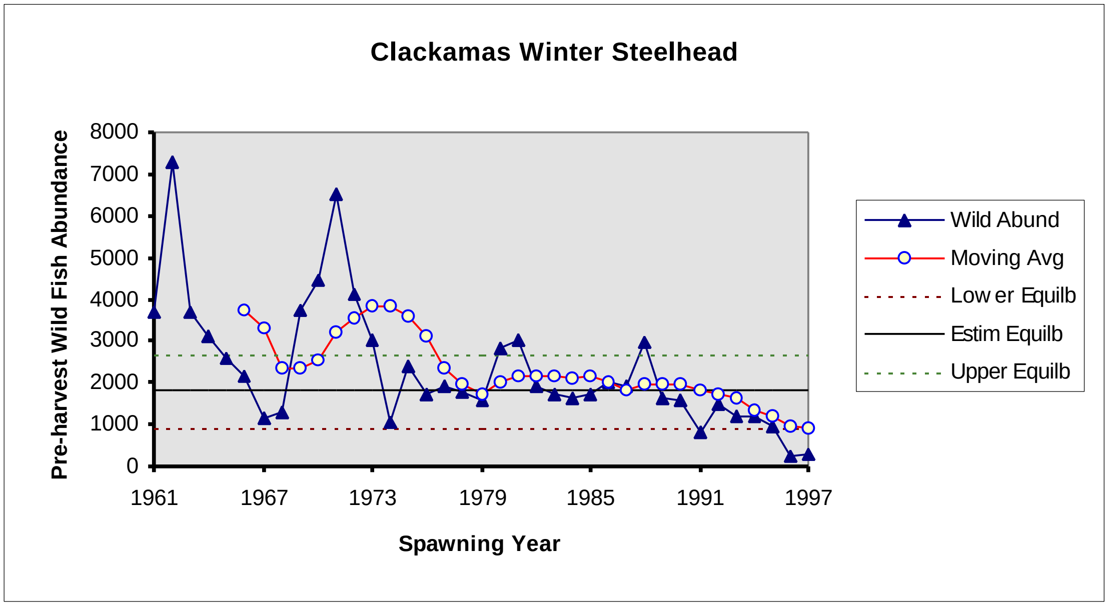

Figure 17. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Clackamas River above North Fork Dam, 1961-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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 be in fact much greater (or smaller) than the estimate presented here suggests.

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 earlier in this report under the population assessment for the Molalla population, it is possible the wild population of winter steelhead is much healthier than the 0.3382 estimated for the Ricker *a* parameter for the Sandy population suggests.

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.

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 |

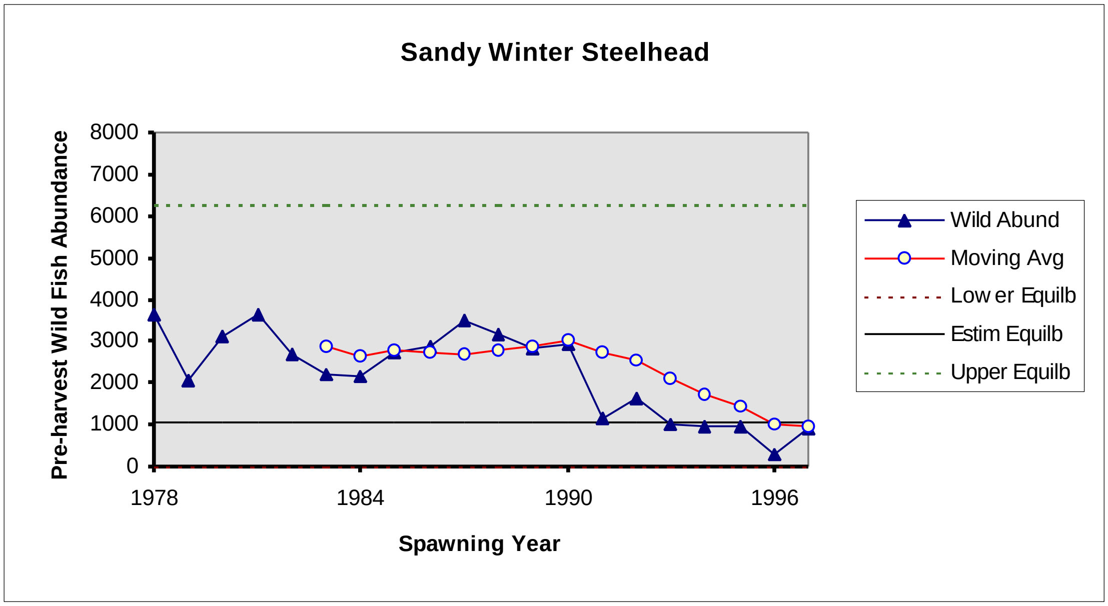

Figure 18. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Sandy River above Marmot Dam, 1978-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

Hood River Winter Steelhead - Although the time series of steelhead counts at Powerdale Dam covers a period of only 6 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 5 years ago. The return of wild summer steelhead to this basin has averaged only 255 fish in the last 5 years, with 181 fish observed in 1997 (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 two populations may be 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 for this report. 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, perhaps less than 70 wild fish, it appears the summer steelhead in the Hood River may be at serious risk. To address this concern, in August, 1997 ODFW stopped passing hatchery summer steelhead trapped at Powerdale Dam. Essentially, this action allows only wild summer steelhead into the 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 Mt. St. Helens (Leider, 1989).

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 retains considerable resilience and ability to rebound quickly with improved ocean conditions or other habitat related factors.

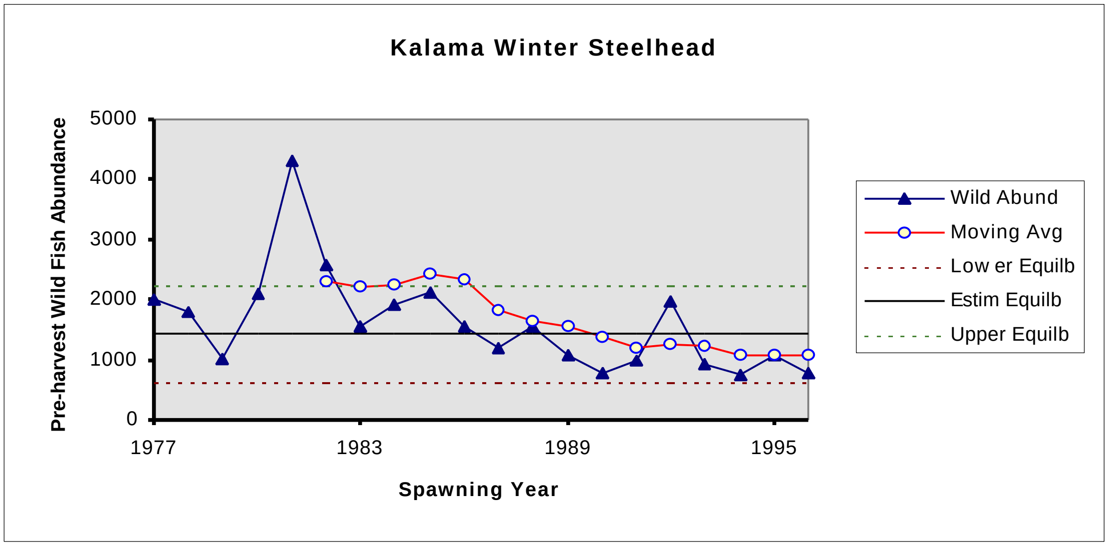

Figure 19. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Kalama River, 1977-96 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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.

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 |

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 1990's (Table 24). Although it should be noted, that like the Hood 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 1980's caused by the diversion of out-of-basin steelhead into the Kalama Basin as a result of the eruption of Mt. St. Helens, the fluctuations in production of wild summer steelhead have not been dramatic (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 |
| 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 |

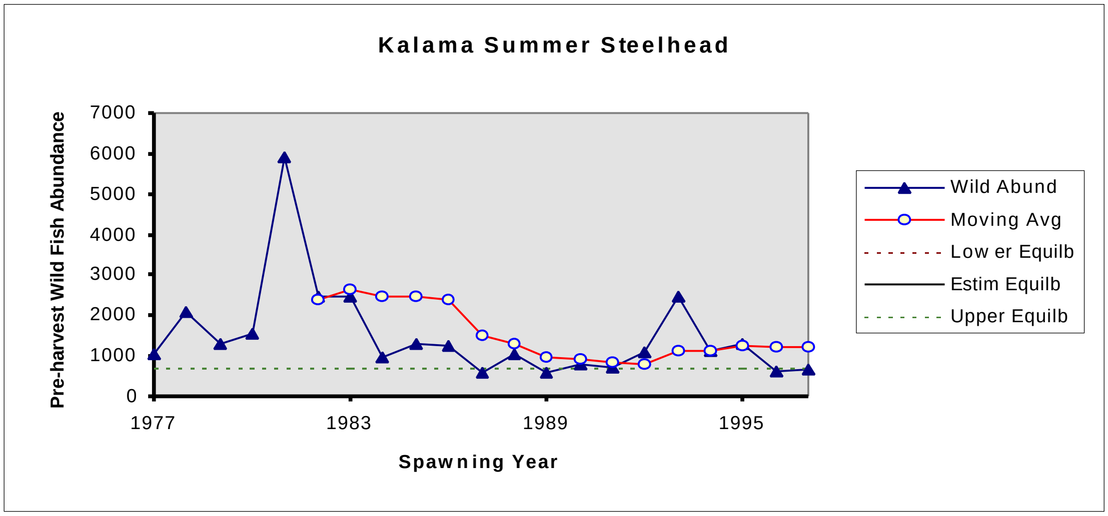

Figure 20. Annual and 6-year moving average estimates of the pre-harvest abundance of wild winter steelhead in the Kalama River, 1977-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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, representing 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 can not sustain itself at any level and is destined to go extinct. The population equilibrium level of zero depicted in Figure 20 reinforces this finding.

However, the observed flat to upward trend in wild steelhead abundance seems to contradict this prediction. The resolution to this apparent inconsistency lies in the fact that large numbers of hatchery fish, created at a hatchery, 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. The implication being the reproductive capacity of the wild population had not yet been seriously damaged.

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, as reported by 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 presented in the previous presentation for winter steelhead in the Kalama River.

It is unclear how this population would respond to the removal hatchery spawners. The expectation is, as it has been elsewhere in this report for other populations in similar situations (e.g., Molalla winter steelhead), that the wild 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.

## Quasiextinction Assessments and ESU Status Synthesis

Quasiextinction Assessment Results - The quasiextinction assessment model results indicated that 3 of the 4 populations in this ESU met the criteria for the sensitive classification (Table 25). In addition, 1 population met the criteria for endangered, Kalama summer steelhead. However, this latter result is open to interpretation. If the known differences if reproductive success between hatchery and wild summer steelhead in the Kalama Basin are taken into account 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 is 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 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-1980's, the most dramatic of which have been winter steelhead in the Clackamas. While the Hood River summer steelhead population has also been in decline 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 appear self-sustaining. However, it appears their cushion against additional stress is not great.

ESU Status Synthesis - 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 3 of the 4 populations modeled in this ESU met the criteria a sensitive classification and 1 population qualifying 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

For the short-term indicator (resistance to stress) 2 of the 4 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 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 judged to be 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 2 out of the 6 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. In addition, 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 fish management plan (ODFW, 1996). The resulting escapement estimates demonstrate a significant increase in out-of-basin strays since the early 1980's (Table 27). The percentage of stray hatchery fish in the natural spawning population has increased to more than 70% recently. 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 |

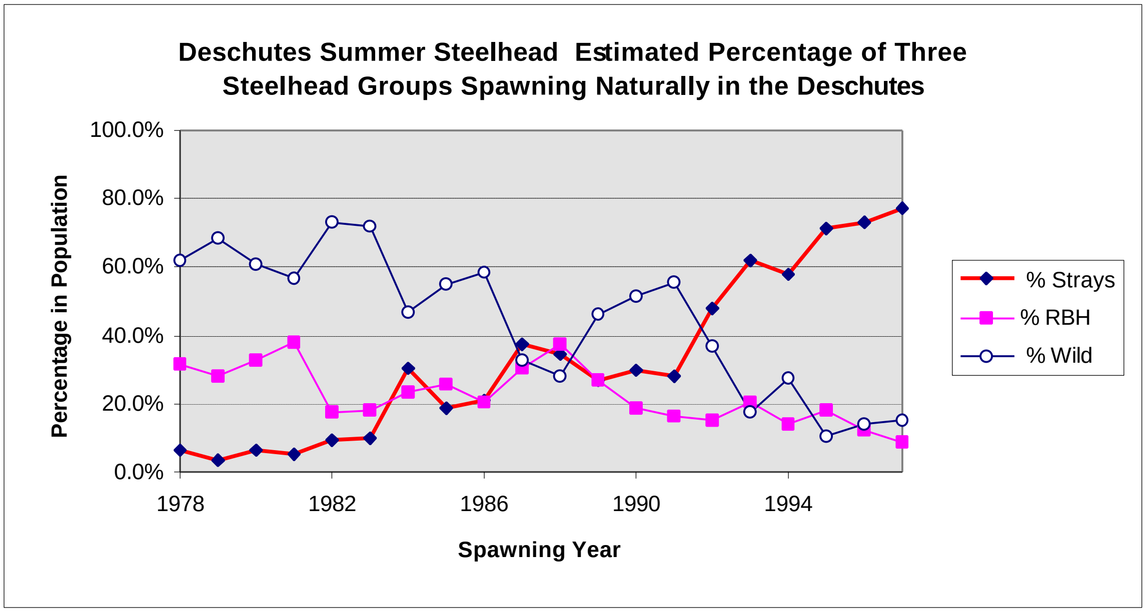

Figure 21. Estimated percentage of stray hatchery fish, Round Butte Hatchery fish, and wild fish in the natural spawning population of the Deschutes, 1978-97 spawning years.

While some of the stray steelhead that enter the Deschutes are known 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, the relatively large numbers of stray hatchery fish observed late in the season at Pelton ladder and Warm Spring 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 does not seem likely that many of 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 suggesting 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 upon 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. It therefore seems the explanation for the increase in hatchery fish in these two tributaries was the increase in the 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 unlikely that very 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 as is suspected, it is likely that wild fish are being effected in a similar manner. The ability to detect out-of-basin wild strays is hampered by having no easy way to identify them. In contrast, hatchery strays are easily identified in the Deschutes Basin because of the distinctive fin clips applied to RBH hatchery fish prior to their release as smolts.

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). It was assumed that 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 passing by the mouth of the Columbia regardless of their origin (i.e., hatchery or wild). Under this assumption 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:

$$ExptWs = (Hs / Ph) * (Pw)$$

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, it was found that 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 ODFW had estimated for the Deschutes standardized mark-recapture methodologies. Therefore, it appeared either wild fish were not straying at the same rate as hatchery fish or that the data necessary to make these estimates was itself inaccurate.

Unable to separate these two possibilities, the estimates of stray and Deschutes origin wild fish presented in this report were made by the averaging of 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 number of wild Deschutes origin fish from the total number of wild fish that were 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 1970’s to 50% in the most recent years. If these estimates for wild fish straying are plausible, it appears this is a relatively recent phenomenon. Past genetic comparisons of steelhead in Columbia Basin (Schreck et al., 1986) have demonstrated the Deschutes population is different from populations of the Snake Basin. If the Deschutes had historically been a recipient of a substantial number of stray wild steelhead any difference between the Deschutes and Snake basins would have likely been lost to genetic homogenization.

<u>John Day Populations</u> - 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, until recently they have been rare in the upper basin. However, reports from anglers in recent years suggest the incidence of stray hatchery fish is increasing. Until these reports are better verified, it is assumed these fish comprise less than 5% of the naturally spawning population.

<u>Umatilla</u> - 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 hatchery program for the Umatilla in the 1980’s the percentage of hatchery fish in the basin increased from essentially 0% to an average of 36% over the last 6 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 the last 5 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.

## 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-1980's to 20% in 1997.

Since the mid-1980's, the wild Deschutes population has been in steep decline (Figure 22). The average number of wild steelhead produced in the Deschutes in the last 3 years was only 1,116 fish. The individual returns which comprise this 3-year average were produced from spawning populations (hatchery plus wild) that averaged greater than 7,000 fish.

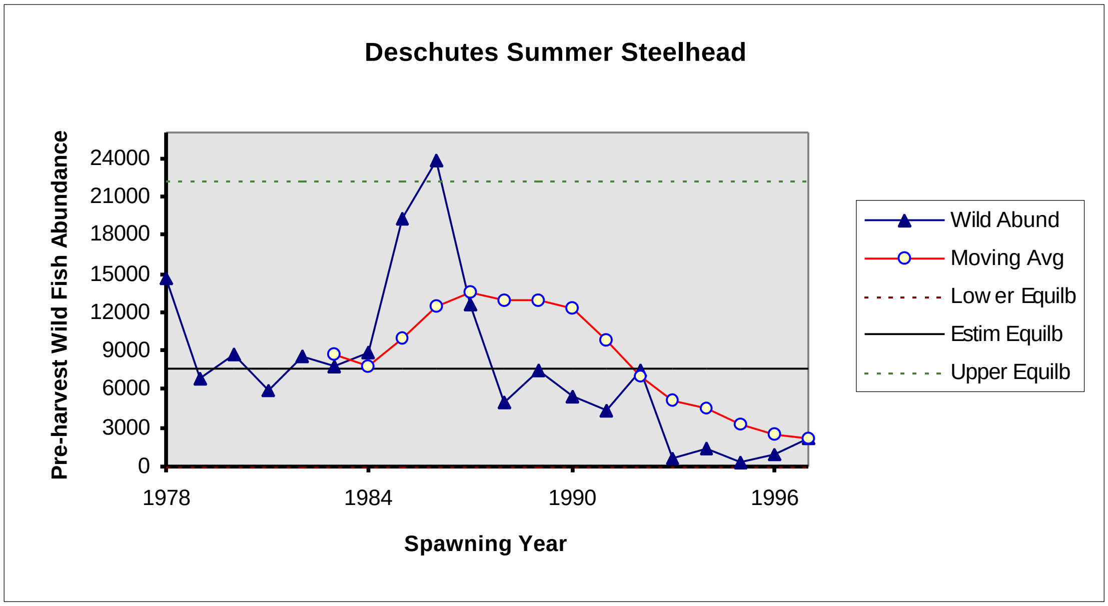

Figure 22. Annual and 6-year moving average estimates of the pre-harvest abundance of wild, Deschutes origin steelhead in the Deschutes River, 1978-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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 by the last 4 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 a 1.0430, a surprising finding in light of the near recruitment failure in recent years. However, these data points were countered by the robust recruitment performance of this population from 1978 to 1984. Demonstrating once again, that a dramatic and sudden change has occurred in the productivity of this stock. It also suggests that up until 1984, this population was one of the most productive steelhead populations in Oregon.

It is possible that at least some of the observed decline in wild steelhead in the Deschutes since 1985 was due to corresponding decreases in smolt to adult survival. To investigate this possibility estimates of smolt to adult survival for RBH hatchery 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 upon 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 hatchery fish. Using this information, the approximate number of adults that returned to the mouth of the Columbia 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 appears to correspond with the observed decline in the number of wild, Deschutes origin steelhead.

However, it is unlikely all of the reduction in wild steelhead recruitment was due to poor smolt to adult survival. Although survival has apparently 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 does not seem to be consistent with the more gradual and continuous decline observed for smolt to adult survival.

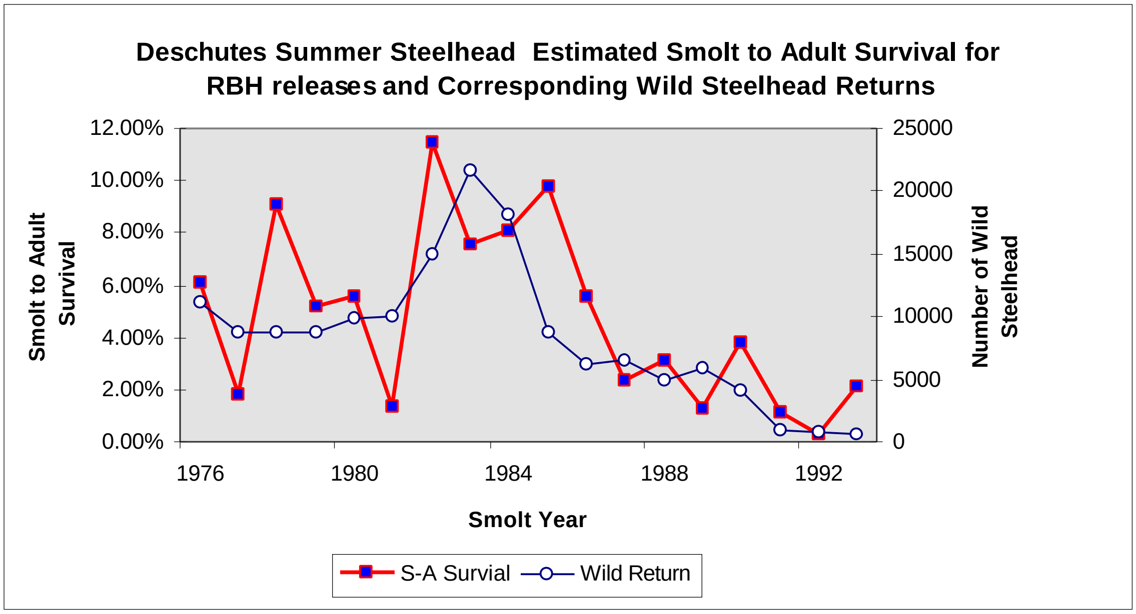

Figure 23. Estimated smolt to adult survival for hatchery steelhead released from Round Butte Hatchery and corresponding wild adult steelhead returns to the Deschutes River, 1976-94.

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 8” 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 and 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 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 10 years. Because of this observation and the ecological similarity between resident rainbow and steelhead, it is difficult to hypothesize habitat loss and degradation has been the cause of the wild steelhead decline over the last 10 years. The two most likely explanations appear to be out-of-basin survival (ocean and migration corridors in the Columbia) 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. It appears that the best explanation for the decline in this population, may be the loss in reproductive capacity due to the 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. It is likely the decline in smolt to adult survival over the last eight years has been amplified by the negative genetic effect of these strays with respect to population recruitment. While the recent drought may also have played a role in reducing steelhead production, it appears this has been of less importance, partially because during the same time period the resident/redband trout population has apparently remained stable.

<u>John Day Populations</u> - 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 is a low point during the late 1970's followed an increasing trend leading to peak counts during the late 1980's (Table 29). In recent years all populations have declined to lows that are similar to counts observed in the late 1970's.

The Lower Mainstem, Upper Mainstem, South Fork populations have remained in a depressed state for several years (Figures 24, 25, and 28). During the last four years, both populations have been less than 1/2 of the equilibrium level estimated for these populations. While equally low (or lower) spawner densities were estimated in the 1970's, the low levels observed for these populations in the 1990's extends over 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 for the Lower Mainstem and is indistinct for the South Fork.

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 is showing such a large decline in spawner densities that concern about it likely persistence is warranted.

Although the North Fork population appears to be returning to expected equilibrium abundance levels, all of the other populations in this basin remain depressed. While recruitment modeling suggests the resiliency of John Day populations is relatively intact, a clear signal that steelhead densities in this basin have bottomed-out and are returning to expected levels is not suggested by the data.

Table 29. Index of steelhead spawners per stream survey mile for 5 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 |

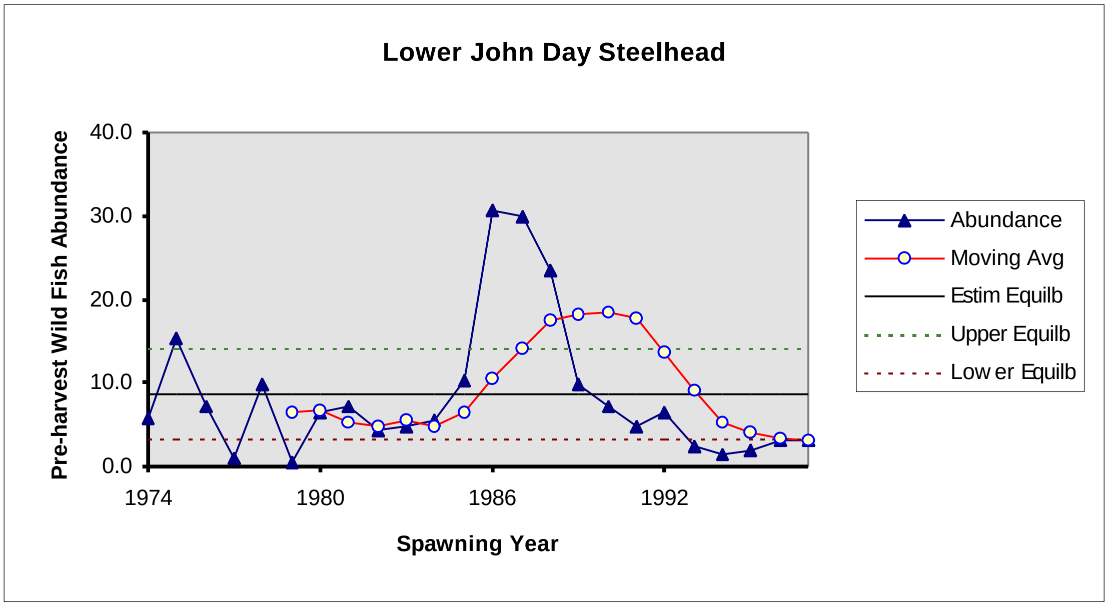

Figure 24. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in lower mainstem tributaries of the John Day River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

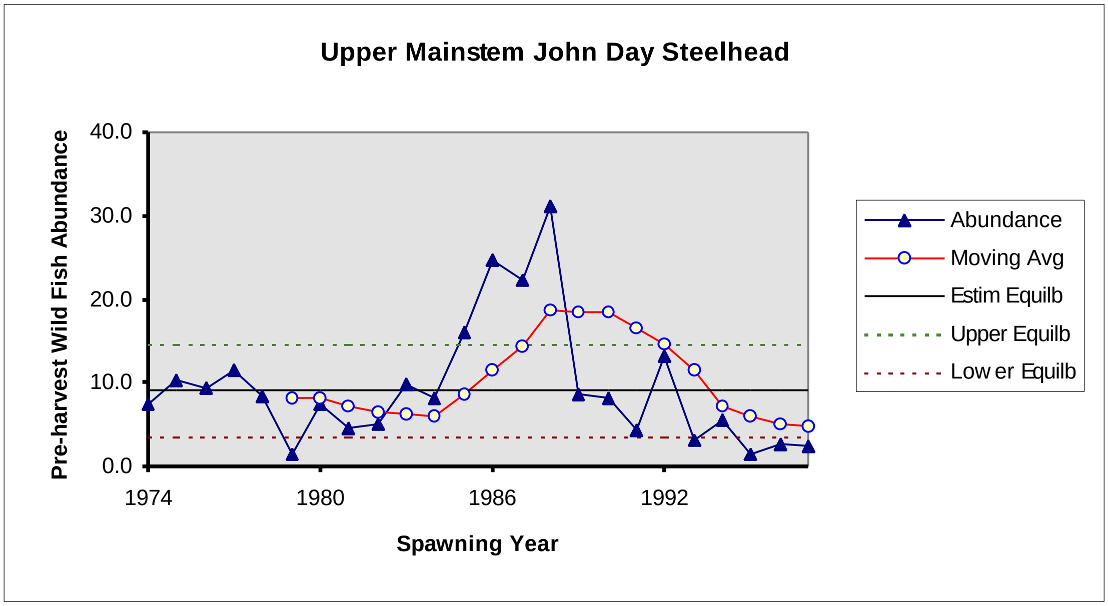

Figure 25. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in upper mainstem tributaries of the John Day River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

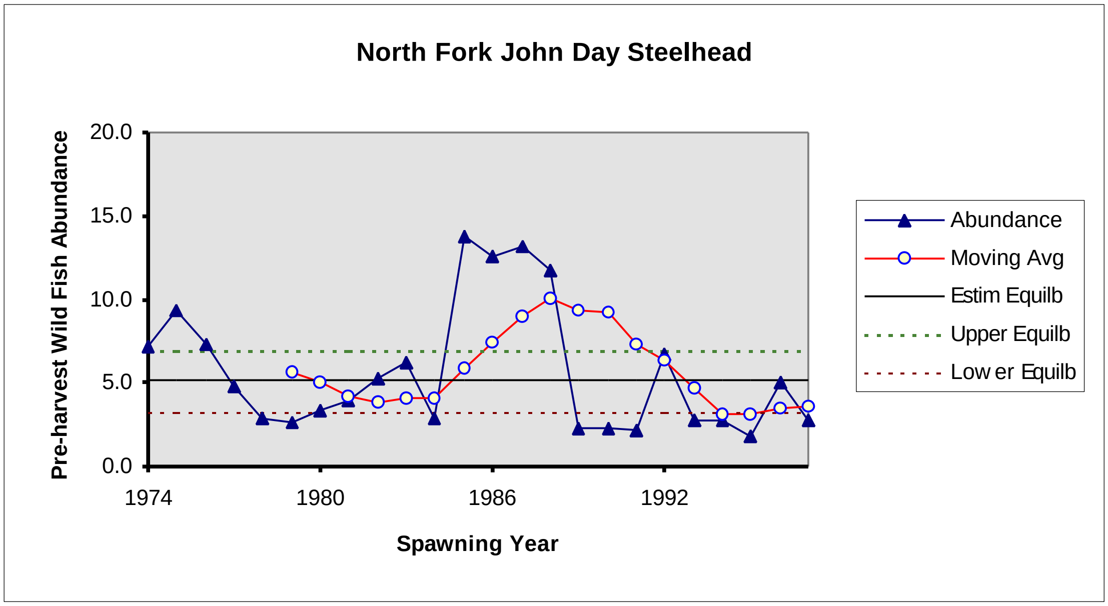

Figure 26. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in the North Fork John Day River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

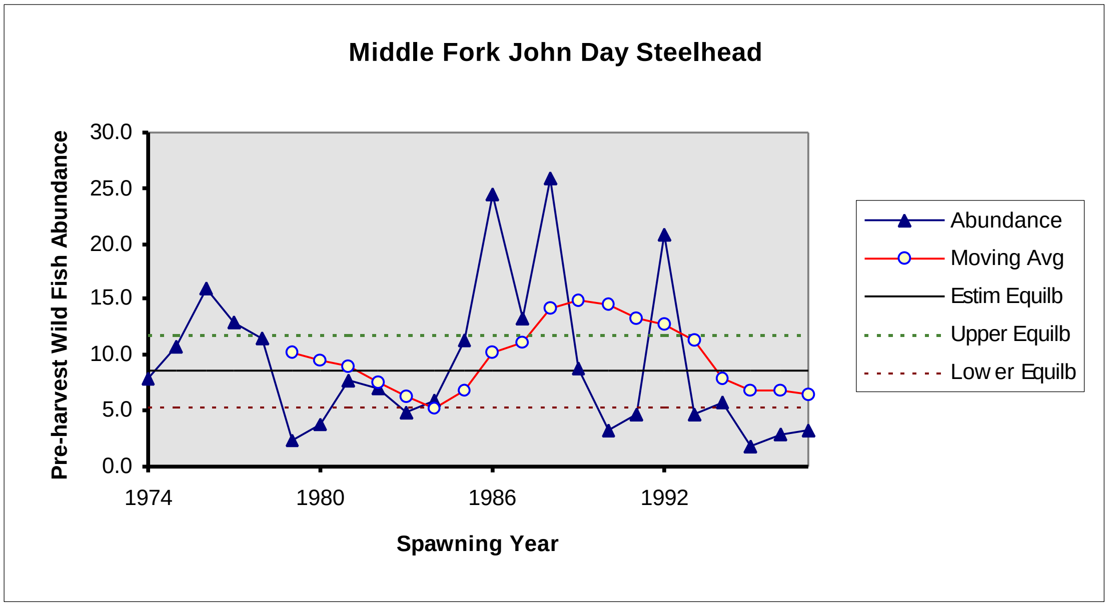

Figure 27. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in the Middle Fork John Day River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

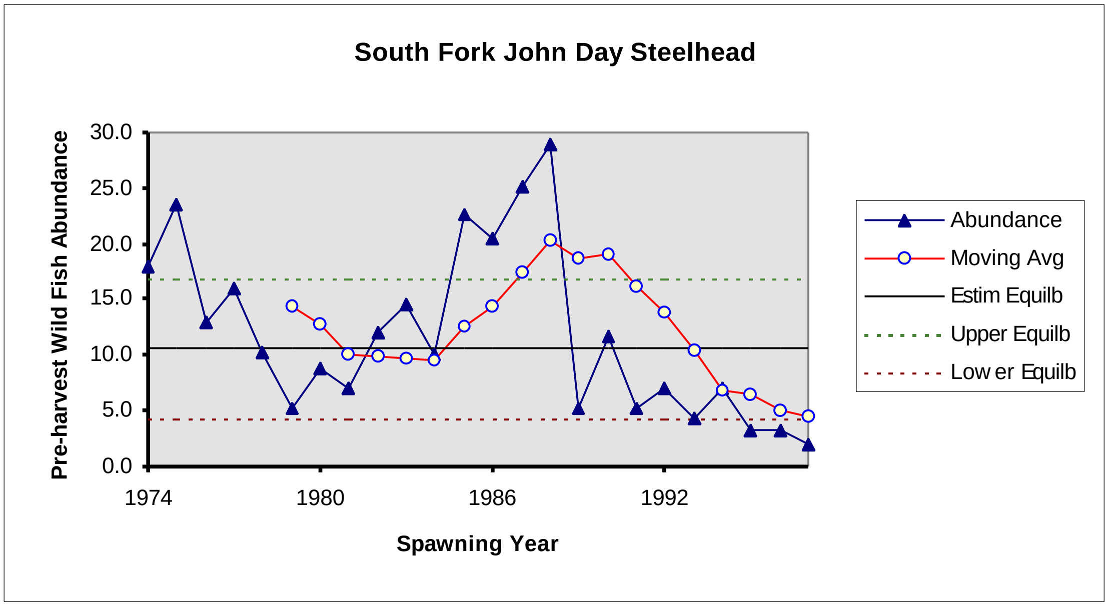

Figure 28. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in the South Fork John Day River, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

Umatilla - The abundance of wild steelhead in the Umatilla since 1980 has followed a pattern that is similar to other steelhead populations in the Columbia Basin, especially those in the John Day. For the Umatilla the peak in abundance in the 1980's, the subsequent decline in the 1990's broken by a spike in abundance in 1992 (Figure 29), is almost identical to the pattern observed for the North Fork and Upper Mainstem populations of the John Day. However, as the plot of the 6-year moving average illustrates the trend for this population over the last 10 years has been down.

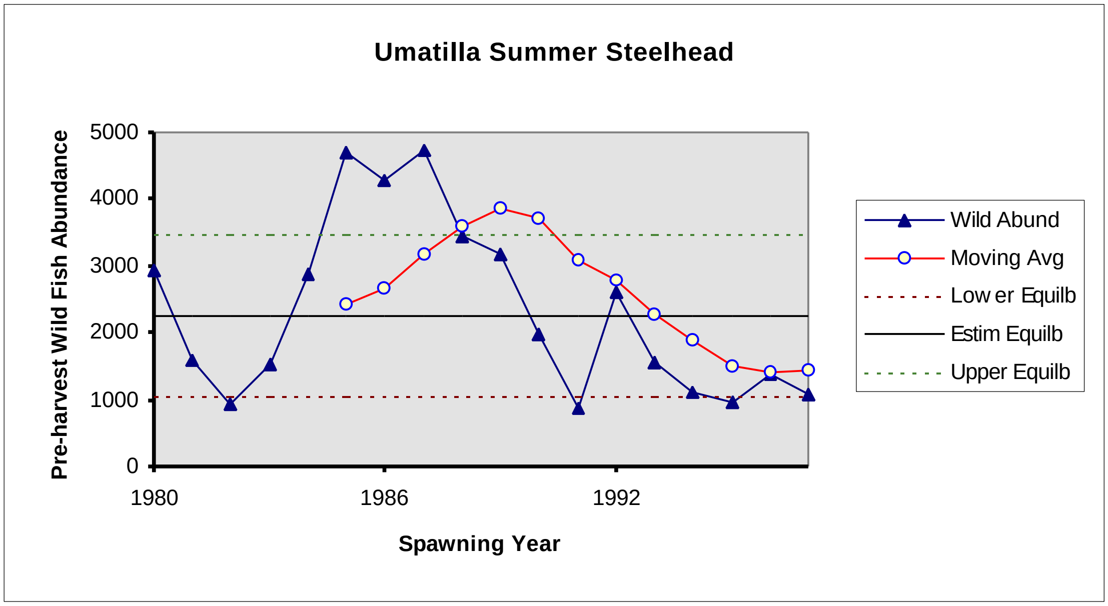

Figure 29. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in the Umatilla River, 1980-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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. The interpretation of these numbers is difficult without the context of steelhead escapement estimates in other portions of this basin and a longer time series.

One interesting sidelight of this sampling effort was the finding that most (70%) of the steelhead returning to the Walla Walla at this location, spent 2 years in the ocean before returning to spawn. This high incidence of 2-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.

## Quasiextinction Assessments and ESU Status Synthesis

Quasiextinction Assessment Results - Five of the 7 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 for the threatened or endangered designation.

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, 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 1 recruit produced for every 7 spawners. Prior to this change, the reproductive performance for the Deschutes population appeared quite robust. The quasiextinction model results are based upon the underlying recruitment function for each population as estimated from available data. In the case of 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 the observed changes of the last 4 years. Clearly, the probability of quasiextinction equals 1.000 if reproductive performance remains at the current levels for very many years in a row.

Hatchery Fish - With the exception of the Deschutes, hatchery fish do not appear to be having a substantial negative effect on the health of Oregon populations within this ESU. This is because the incidence of hatchery fish is very low, as is the case for populations in the John Day Basin, or it is because the hatchery fish are genetically similar to the wild population and their percentage in the natural spawning population has generally been less than 30% until recent years, as is the case for the Umatilla population.

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-1980's followed by a decline in the 1990's. This decline coincides with decreases in smolt to adult survival as determined from hatchery fish released from RBH (Figure 23). Because of this observation and the fact the decline in abundance is shared by all populations, it appears that the best explanation for the downward trend are common survival factors, most likely mainstem Columbia passage and ocean survival.

Self-Sustaining - There are no obvious signs that steelhead populations in the John Day and Umatilla 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, it can be expected the observed declines will reverse themselves in the next 3 to 5 years as smolt passage and ocean conditions improve. However, if this reversal does not take place several populations within this ESU could reach abundance levels that put them at risk in 10 years.

Unlike the Umatilla and John Day, Deschutes wild steelhead are not self-sustaining, at least in the last 3 years. In these 3 years, spawner escapements of nearly 8,000 fish have yielded, on the average, less than 1200 recruits. While declines in smolt to adult survival may explain a portion of the problem, the adverse genetic impact of an overwhelming number of out-of-basin strays is likely the primary important factor.

ESU Status Synthesis - 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 5 of the 7 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 3 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 |
|---|---|---|---|
| 1.7 | 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 being 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 appeared to warrant an extirpation warning, the Deschutes and the South Fork John Day. There have been large declines in the 6-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 which are increasing in the natural spawning population each year. For the this third indicator, 2 of the 8 populations (25%) rate extirpation warnings which results 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 1950's. It is assumed that less than 5% of the natural spawners in this basin are hatchery fish.

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

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

Imnaha - The stock of hatchery fish used in the Imnaha Basin was developed from wild Imnaha steelhead. This is a relatively new hatchery steelhead program, however evidence suggests that most of the hatchery fish return to the smolt release site within the Little Sheep Creek system (an Imnaha tributary) to spawn. It is estimated that, averaged across the entire Imnaha Basin, the percentage of hatchery fish in the natural spawning population is less than 20%. Because there is no specific information on percentage of hatchery fish for the spawning survey stream, Camp Creek, it was assumed that hatchery fish have comprised 20% of the spawning population since 1987 when significant numbers of hatchery fish first began returning to the Imnaha Basin.

## 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 1970's, followed by a rebound in the 1980's (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 for this population suggests that the natural equilibrium level of spawners for this population was seven fish per mile (Figure 30). With the exception of the late-1980's this population has been substantially below this level since 1974.

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

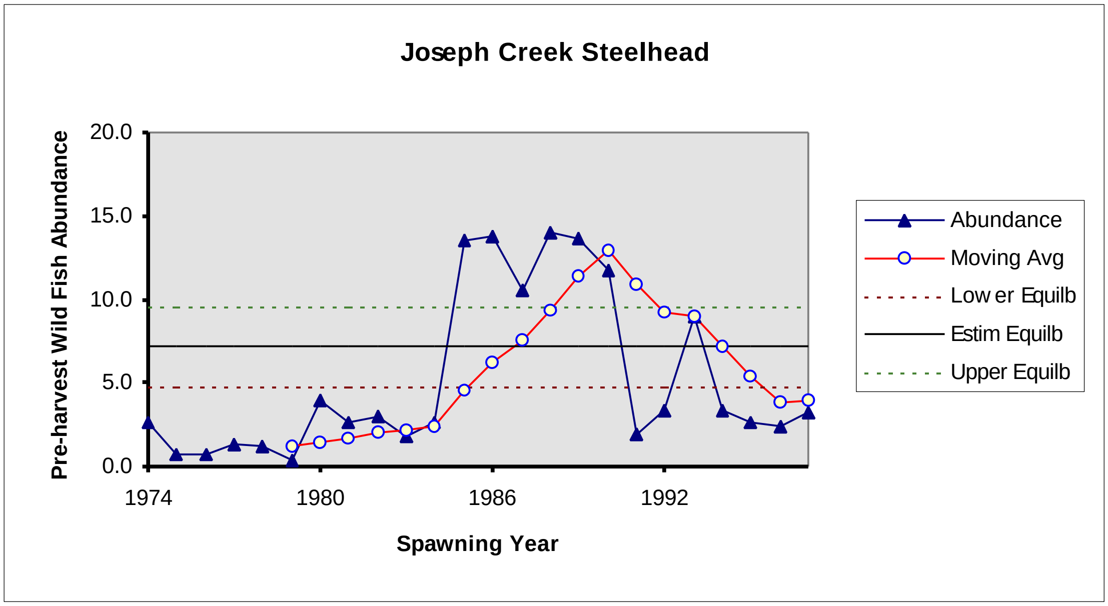

Figure 30. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in Joseph Creek, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

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 an steelhead abundance index for this basin. Spawning survey data were unavailable for two 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 upon information that 60% of the population was female and a conversion factor 0.81 redds per female.

The estimated number of wild spawners per index survey mile has fluctuated between 0.3 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 Escapement | 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 |

While recruitment modeling estimated a relatively robust *a*-value of 1.5484 for this population (translates to 5 recruits per spawner at low densities), 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 had 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 30% of the spawning population, overall reproductive performance for the population declines.

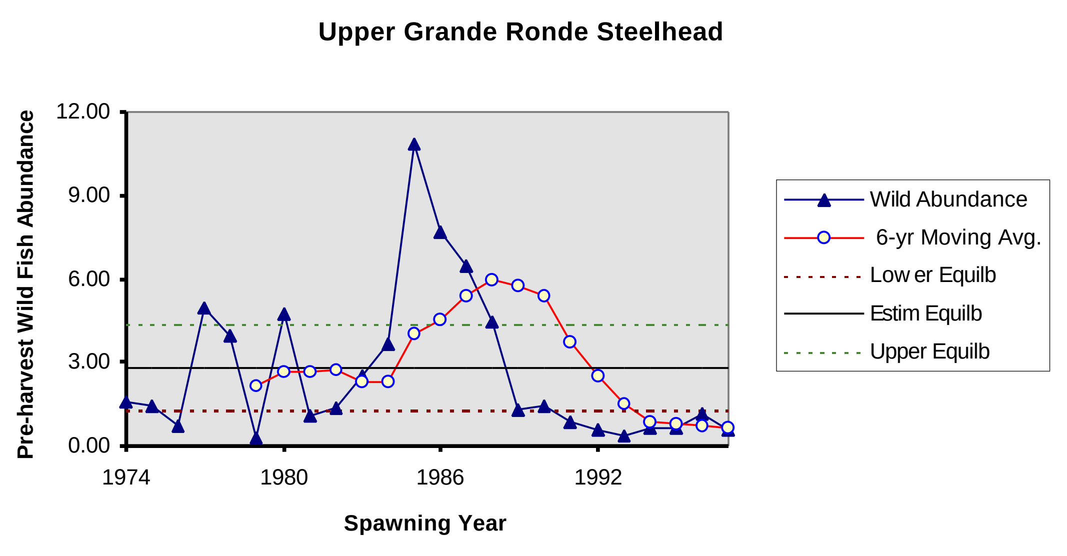

Figure 31. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in upper Grande Ronde, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

The abundance of upper Grande Ronde 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.

Imnaha - The temporal pattern of wild spawner abundance for the Imnaha closely resembles what was observed for the Joseph population; extremely low levels in the late 1970's, followed by a rebound in the 1980's (Table 34). While the abundance of this population has declined in the 1990's, there have been several spikes in abundance in the last several years that are missing from the upper Grande Ronde population.

The wild steelhead average abundance for Imnaha over the last 3 years has been about 1/2 of the estimated equilibrium of 9 fish per mile (Figure 32). While depressed, this level is considerably higher than record low densities observed in the 1970's. A relative high Ricker model *a*-value of 1.433 was estimated for the recruitment function of this population (Table 2). In combination, these findings support the view that the Imnaha steelhead population has both the demonstrated and theoretical capacity to rebuild from depressed densities.

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.

| | Hatchery | Percent | Estimated | Pre-Harv. |
|---|---|---|---|---|

| Brood Year | Wild Fish Escapemt | Fish Escapmt | Hatchery Fish | Harvest Rate | 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 |

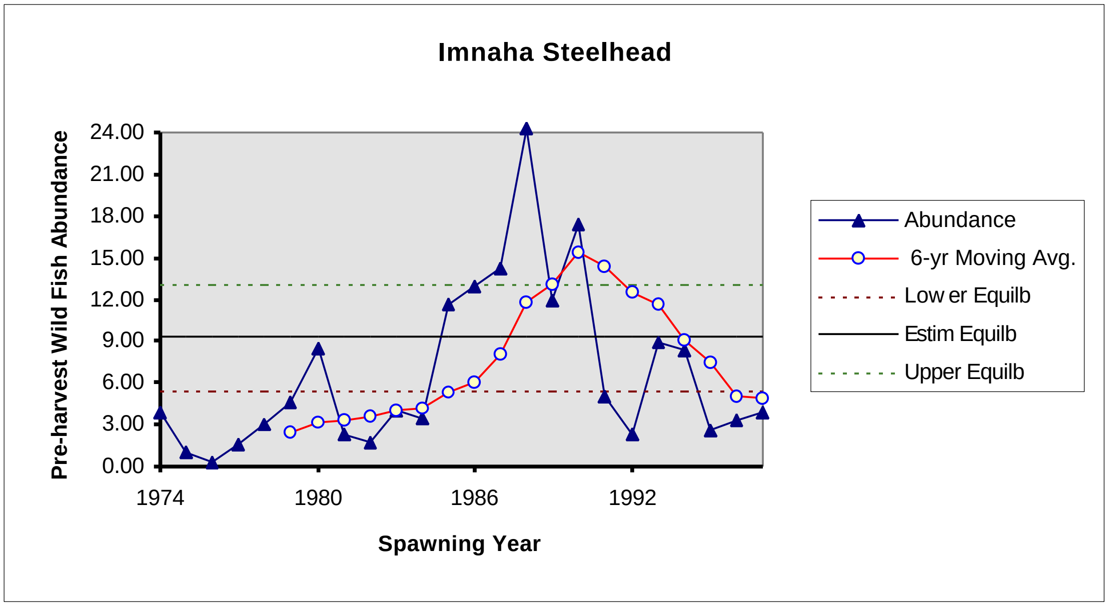

Figure 32. Annual and 6-year moving average estimates of the pre-harvest abundance of wild steelhead in Camp Creek, Imnaha Basin, 1974-97 relative to predicted population equilibrium (N*) and associated upper and lower confidence bounds derived from recruitment modeling.

## Quasiextinction Assessments and ESU Status Synthesis

Quasiextinction Assessment Results - The results of the quasiextinction assessment model result 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. In recent years there is some evidence the reproductive capacity of the Upper Grande Ronde population has declined in response to the addition of these hatchery fish, which are presumed to be genetically dissimilar to the wild population. Efforts are currently underway to obtain better estimates for the proportion of the naturally spawning population in the upper Grande Ronde Basin that are hatchery fish. Depending on these findings, strategies to reduce the magnitude or improve the genetic quality of these hatchery spawners will be developed by ODFW.

Trends in Abundance - The extent and longevity of depressed spawner densities in the 1990's has been variable among the three populations examined in this ESU. The Upper Grande Ronde shows the least evidence of rebounding from abundance levels that are nearly as low as those recorded in the mid-1970's. By contrast, the decline in abundance for both the Joseph and Imnaha populations has not been as severe as apparently occurred in the 1970's 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, while mathematically self-sustaining, seems dangerously low and more vulnerable to random events which could cause the population to collapse. This later possibility seems to have developed since 1989, coinciding with the addition of large numbers of hatchery spawners. Prior, to 1989 the pattern of fluctuation in abundance for Upper Grande Ronde steelhead is suggestive of a more healthy population with periods of low spawner densities being relatively short-lived. In contrast, for the 8-year time period starting in 1989, this population has been in a constant state of very low abundance and its continued existence appears in jeopardy.

ESU Status Synthesis - 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 Snake ESU based on 3 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 on the basis 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 8 years in a row. Therefore, for this third indicator 33% of the populations examined (1 out of 3) rate extirpation warnings which results 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**.

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