Updated Review of the Status of the Upper Willamette River and Middle Columbia River ESUs of Steelhead (*Oncorhynchus mykiss*)

Prepared by the
West Coast Steelhead Biological Review Team*

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 Predecisional ESA Document

"Among these fishermen one occasionally hears more or less protracted discussions as to whether the fish are trout or steelheads. . ." (Snyder, 1925)

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SUMMARY

The National Marine Fisheries Service proposed to list Upper Willamette River and Middle Columbia River steelhead ESUs as threatened under the Endangered Species Act on 10 March 1998. Comments on the listing were received from various agencies and individuals and new genetic data were developed. The Biological Review Team (BRT) reconvened in November 1998 to consider the new information.

The BRT concluded that the distribution of Upper Willamette River ESU should reflect the historical distribution from Willamette Falls to the Calapooia River Basin. They concluded that the ESU occupies rivers on the east side of the Willamette River Basin, but distribution on the west side (e.g., Yamhill River and Rickreall Creek) is unclear. The Upper Willamette River ESU is composed only of the native late-migrating winter steelhead; introduced early-run winter steelhead and summer steelhead are not included. The BRT unanimously agreed that the Upper Willamette River ESU is at risk of endangerment in the foreseeable future.

The Biological Review Team was unable to determine the appropriate composition of the Middle Columbia River ESU due to new genetic data that raised questions about the relationship between these populations and those in neighboring ESUs. Nevertheless, the BRT concluded that the pervasive problems facing steelhead throughout this region place these populations at risk of endangerment in the foreseeable future regardless of how the ESUs are configured.

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INTRODUCTION

The National Marine Fisheries Service (NMFS) published a status review on steelhead (anadromous *Oncorhynchus mykiss*) from Pacific coast U.S. states in 1996 (Busby et al. 1996). In that document, 15 evolutionarily significant units (ESUs) of steelhead were described. NMFS has also considered the status of these ESUs under the U.S. Endangered Species Act (ESA). At present, seven ESUs are listed under the ESA (two as endangered and five as threatened), three are candidate species, and three are not warranted for listing (Table 1). The remaining two ESUs have been proposed for listing, information related to the final listing determination is considered in this document.

On 10 March 1998, NMFS proposed to list the Upper Willamette River (UWR) and Middle Columbia River (MCR) steelhead ESUs as threatened under the ESA (NMFS 1998). This proposal was based on the findings of a Biological Review Team (BRT) of scientists from NMFS and the Biological Resources Division of the U.S. Geological Survey (BRD-USGS) (Schiewe 1997). Following the proposed listing, NMFS received comments and data from several interested parties, including state and tribal agencies. The BRT met again in November 1998 to consider this new information. This document summarizes the new information and the final conclusions of the BRT.

Groupings and Terminology

"what is a steelhead anyway"? (Snyder 1925)

Steelhead is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss* (previously known as *Salmo gairdneri*, see Stearley and Smith 1993). Steelhead occur from southern California north to Alaska and west to Kamchatka, where they are called mikizha. *O. mykiss* express a wide variety of life history characteristics and genetic diversity, which complicates the terminology used in discussion of this species. Terms that are used in this document are introduced and described below.

Anadromous vs. Resident *O. mykiss*

In the Pacific Northwest there are anadromous and nonanadromous forms of *O. mykiss*. The BRT previously concluded that, in general, steelhead ESUs include resident trout in cases where they have the opportunity to interbreed with anadromous fish. Resident trout populations above long-standing natural barriers, and those that have resulted from the introduction of non-native trout, would not be considered part of the ESUs. Resident trout populations that inhabit areas upstream from human-caused migration barriers (e.g., Chief Joseph Dam, Columbia River; the Hells Canyon Dam complex, Snake River; and numerous smaller barriers) may contain genetic resources similar to those of anadromous fish in the ESU, but little information was available on these fish or the role they might play in conserving natural populations of steelhead. The BRT concluded that the status, with respect to steelhead ESUs, of resident fish upstream from human-caused migration barriers must be evaluated on a case-by-case basis as more information becomes available.

Table 1. Current status of steelhead ESUs under the Endangered Species Act.

Status	ESU name	Date of action
Listed as Endangered		
	Southern California	18 August 1997[1]
	Upper Columbia River	18 August 1997[1]
Listed as Threatened		
	Lower Columbia River	19 March 1998[2]
	Central California Coast	18 August 1997[1]
	South-central California Coast	18 August 1997[1]
	Central Valley	19 March 1998[2]
	Snake River Basin	18 August 1997[1]
Proposed as Threatened		
	Upper Willamette River	10 March 1998[3]
	Middle Columbia River	10 March 1998[3]
Candidate Species		
	Oregon Coast	19 March 1998[2]
	Klamath Mountains Province	19 March 1998[2]
	Northern California	19 March 1998[2]
No listing presently warranted		
	Puget Sound	9 August 1996[4]
	Olympic Peninsula	9 August 1996[4]
	Southwest Washington	9 August 1996[4]

[1]Federal Register [Docket 960730210-7193-02, 18 August 1997] 62(159):43937-43954.
[2]Federal Register [Docket 980225046-8060-02, 19 March 1998] 63(53):13347-13371.
[3]Federal Register [Docket 980225046-8046-01, 10 March 1998] 63(46):11798-11809.
[4]Federal Register [Docket 960730210-6210-01, 9 August 1996] 61(155):41541-41561.

Coastal and Inland Forms

Pacific Northwest steelhead include two major genetic groups, *coastal*, and *inland*. Coastal steelhead occur in most coastal river basins from California to Alaska; inland steelhead occur east of the Cascade Mountains in the Fraser and Columbia River Basins (see Busby et al. 1996). Behnke (1992) has proposed that these two groups of *O. mykiss*, including their anadromous and nonanadromous forms, should be considered separate taxonomic subspecies and suggested the names *O. mykiss irideus* and *O. m. gairdneri* for the coastal and inland groups, respectively. The anadromous form is universally called steelhead. However, the nonanadromous forms can be referred to as rainbow trout (coastal subspecies) or redband trout (inland subspecies); additionally, redband trout are often called rainbow trout. In this document the term *steelhead* will refer to the anadromous form, the term *resident trout* will be used to refer to nonanadromous fish, and the scientific name *O. mykiss* will refer to the collective biological species without regard to life history.

Summer and Winter Steelhead

Steelhead spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity. These *runs* are usually named for the season in which the peak migration occurs–e.g. winter and summer steelhead. These names apply to both the coastal and inland subspecies; for example, the Willamette River has winter-run coastal steelhead and the Deschutes River (Oregon) has summer-run inland steelhead.

Biologically, summer and winter steelhead represent two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry and duration of spawning migration (Burgner et al. 1992). The *stream-maturing* type (summer steelhead in the Pacific Northwest) enters fresh water in a sexually immature condition and requires several months to mature and spawn. The *ocean-maturing* type (winter steelhead) enters fresh water with well-developed gonads and spawns shortly thereafter. This document generally uses the terms summer steelhead to refer to the stream-maturing type and winter steelhead to refer to the ocean-maturing type.

Review of Previous Information

In the 1996 status review of west coast steelhead (Busby et al. 1996) the BRT determined that the Upper Willamette River ESU was not, at that time, in significant danger of becoming extinct or endangered, and the BRT was unable to reach a conclusion on the extinction risk for the Middle Columbia River ESU. Additional information since made available prompted the BRT to reconsider the status of these two ESUs in 1997. That reevaluation resulted in NMFS' 1998 proposal to list the two ESUs as threatened. Below, we review the composition of these ESUs and earlier risk assessments.

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Upper Willamette River ESU

This coastal steelhead ESU (*O. m. irideus*, Behnke 1992) occupies the Willamette River and its tributaries upstream of Willamette Falls. The native steelhead of this basin are a late-migrating winter run, entering fresh water primarily in March and April, whereas most winter steelhead in the Columbia River Basin enter fresh water beginning in December. This unusual run timing appears to be an adaptation for ascending Willamette Falls, which functions as an isolating mechanism for upper Willamette River steelhead. Early migrating winter steelhead and summer steelhead have been introduced to the Upper Willamette River Basin; however, these non-native populations are not components of this ESU. Native winter steelhead within this ESU have been declining on average since 1971 and have exhibited large fluctuations in abundance. The main production of native (late-run) winter steelhead is in the North Fork Santiam River, where estimates of the proportion of hatchery fish in natural spawning range from 14% to 54%.

Middle Columbia River ESU

This inland steelhead ESU (*O. m. gairdneri*, Behnke 1992) occupies the Columbia River Basin from above the Wind River in Washington and the Hood River in Oregon upstream to include the Yakima River, Washington. Steelhead of the Snake River Basin are not included. This ESU includes the only populations of winter inland steelhead in the United States. Some uncertainty exists about the exact boundary between the ranges of coastal and inland steelhead, and the western margin of this ESU reflects currently available genetic data. There is good genetic and meristic evidence to separate this ESU from steelhead of the Snake River Basin. The boundary upstream of the Yakima River is based on limited genetic information and environmental differences between this area and areas upstream, including physiographic regions, climate, topography, and vegetation. All BRT members were particularly concerned about the status of this ESU, particularly Yakima River and the limited winter steelhead stocks. Total steelhead abundance in the ESU appears to have been increasing recently, but the majority of natural stocks within this ESU for which we have data have been declining, including those in the John Day River, which is the largest producer of wild, natural steelhead in this ESU. There is widespread production of hatchery steelhead within this ESU, but it is largely based on within-basin stocks. Habitat degradation due to grazing and water diversions has been documented throughout the range of the ESU.

INFORMATION RELATING TO THE SPECIES QUESTION

Following the publication of its proposed rule to list the UWR and MCR ESUs as threatened (NMFS 1998), NMFS received comments from several agencies and individuals. This document will summarize those comments and issues that are of a technical or scientific nature and that address issues pertinent to the BRT's responsibility to determine ESUs in accordance with NMFS' policy (NMFS 1991) and to assess the risk of extinction for these ESUs.

This document will not address comments on the ESU policy, proposed conservation measures, and other policy related comments that are beyond the purview of the BRT.

Upper Willamette River ESU

Substantive comments from the Oregon Department of Fish and Wildlife (ODFW) on the Upper Willamette River ESU (UWR) addressed the boundaries of the ESU and the relationship between the native steelhead of the middle basin and the resident trout of the upper basin (i.e., McKenzie and Middle Fork Willamette Rivers) (Greer 1998). Additionally, NMFS was able to develop new genetic information pertinent to this ESU.

Comments Received

Boundaries of the ESU–ODFW argued that this ESU did not historically extend upstream of the Calapooia River, and cited several historic references including Fulton (1970) who compiled earlier works also referenced by ODFW (see Table 2). According to these references, steelhead were well distributed in eastside basins that drain the Cascade Mountains, and had limited distribution in westside basins. On the east side, steelhead occupied the Molalla, Santiam, and Calapooia River Basins. Westside populations were apparently limited to upper Gales Creek in the Tualatin River Basin–just over the ridge of the Coast Range, at Round Top, from the Nehalem River Basin.

ODFW suggested that the native late-run winter steelhead may have colonized the Yamhill River, based on spawn timing of winter steelhead in that basin in recent years (J. Martin[1]).

Resident trout–The Oregon Department of Fish and Wildlife (ODFW) stated that resident trout in the Willamette River are isolated from the UWR ESU and may have a different ancestry altogether. Therefore, they argued that the steelhead ESU should extend only up to the Calapooia River (Fig. 1) and exclude resident trout from the upper basin. This configuration would be consistent with ODFW's population list (Kostow 1995; Table 2).

ODFW cited several historic references for the upper Willamette River Basin which describe distribution of natural steelhead as extending no further up the Willamette River Basin than the Calapooia River (Table 2). Resident trout in the upper parts of the basin (e.g., McKenzie River) are thought by ODFW to be isolated from the anadromous steelhead. ODFW has postulated that the isolating mechanism may be the pathogen *Ceratomyxa shasta*, which may have prevented downstream colonization by resident fish. ODFW is conducting *C. shasta* challenges on wild trout from the McKenzie River to determine their susceptibility to this pathogen. ODFW has provided NMFS with trout samples from the populations involved in

[1]J. Martin, Director's Office, Oregon Department of Fish and Wildlife, 2501 SW First AV, P.O. Box 59, Portland, OR 97207. Pers. commun., November 1998.

Table 2. Historic and current distribution of winter steelhead stocks in the Upper Willamette River ESU (Fulton 1970, Kostow 1995).

Basin	Historic distribution	Current distribution	Comments
Tualatin River	Upper Gales Creek	Tualatin River	No details on current distribution of Tualitin River population given by Kostow 1995
Molalla River	Main Molalla River Lower NF Molalla River Butte Creek Abiqua Creek Upper Milk Creek	Molalla River	No details on current distribution given by Kostow 1995
Yamhill River	Unknown	Steelhead currently occur in the Yamhill River	Origin of Yamhill River population is uncertain (see "New Genetic Information")
Rickreall Creek	Presumed to occur historically	Steelhead currently occur in Rickreall Creek	Origin of present Rickreall Creek population is uncertain (see "New Genetic Information")
Luckiamute River	Unknown	Steelhead currently occur in the Luckiamute River	Origin of present Luckiamute River population is uncertain (see "New Genetic Information")
Santiam River	North Santiam River South Santiam River Middle Santiam River	Below Detroit Dam Below Foster Dam Above Green Peter Dam	Upper N. Santiam R. and 540 km of tributaries cut off by Detroit and Big Cliff Dams (ca. 1953)
Calapooia River	Upper basin	Calapooia River (see comments)	No details on current distribution given by Kostow 1995
McKenzie River	No	Yes–introduced	Steelhead introduced in 1956.
Middle Fork Willamette River	No	Yes–introduced	Steelhead introduced in 1950s

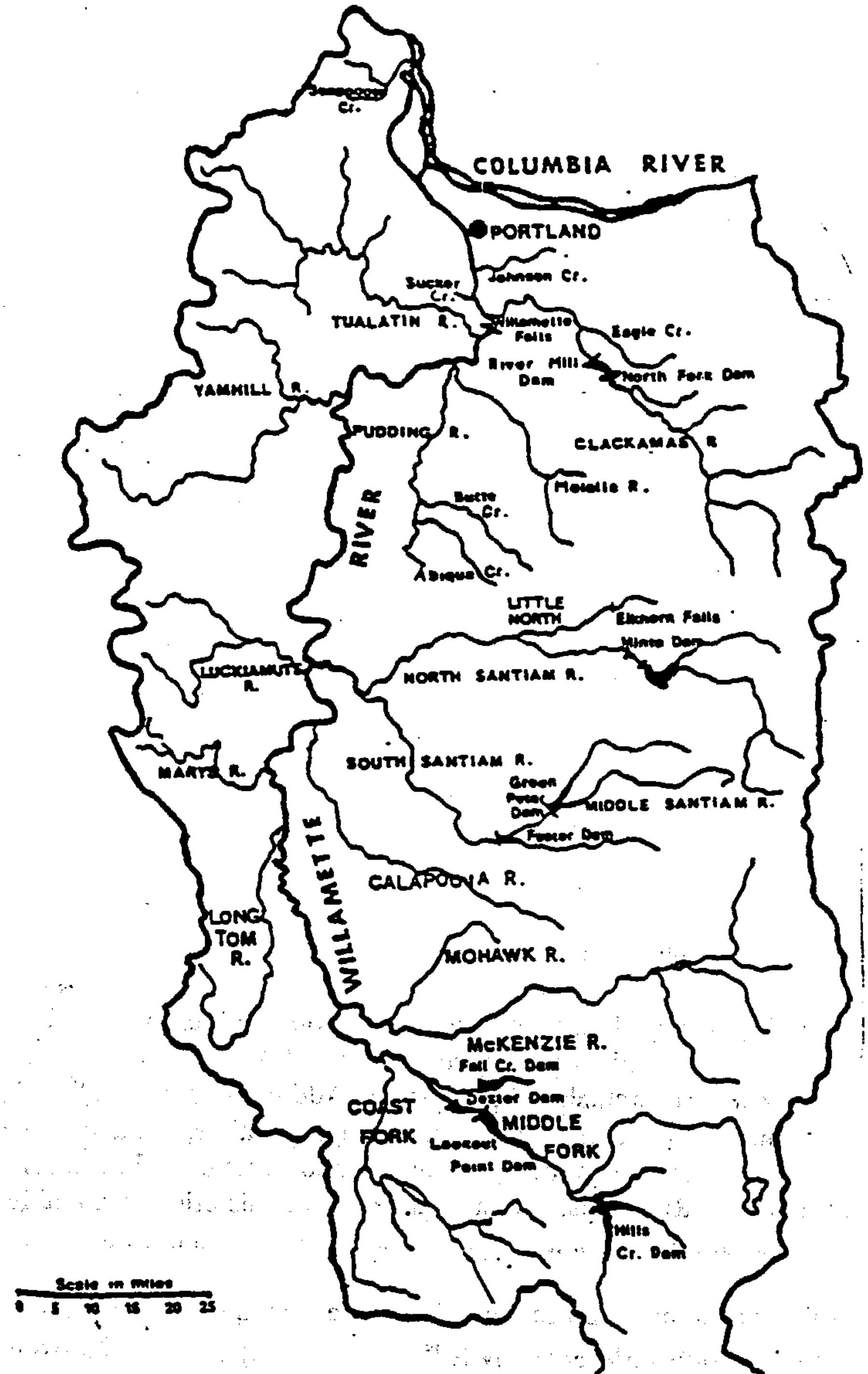

Figure 1. Map of the Willamette River Basin showing locations discussed in the text (from Howell et al. 1985).

the *C. shasta* challenge for genetic analysis and comparison. However, while susceptibility to *C. shasta* may have restricted the downstream distribution of resident fish, it would not have restricted resistant steelhead populations from moving further upstream.

Regarding ancestry of *O. mykiss* in the Willamette River Basin, ODFW provides two theories. Resident trout may represent an early colonization prior to the existence of Willamette Falls and, presumably *C. shasta*. Another theory is that resident trout found their way to the upper Willamette River Basin during a headwater capture event.

New Genetic Information

ODFW provided several new samples of steelhead and resident trout from the upper Willamette River Basin for scientists from the NWFSC to analyze and compare to existing genetic data from other wild and hatchery steelhead from the Columbia River Basin (Table 3). Electrophoretic data for 41 loci were assessed based on Nei's (1978) unbiased genetic distance. The data demonstrate a reasonably distinct clustering of wild and hatchery, putative native, Upper Willamette River steelhead when presented both in a dendrogram constructed using the unweighted pair-group method analysis (UPGMA) with arithmetic averaging and as multidimensional scaling (MDS) plots (Figs. 2 and 3). Fish from westside tributaries do not show a clear relationship with the native, eastside steelhead. Yamhill River and Rickreall Creek steelhead appear to have some affinity with other Columbia River Basin populations, perhaps reflecting stock transfers of Big Creek and Skamania stock steelhead into the Upper Willamette River Basin. The sample from Luckiamute River demonstrates no clear affinity with any of the other populations. The resident trout from the upper McKenzie and Middle Fork Willamette River Basins were quite divergent from any of the steelhead samples.

Discussion and BRT Conclusions

Recently developed resident trout genetic data from the McKenzie and Middle Fork Willamette River Basins showed no genetic continuity with known hatchery trout (Cape Cod stock) or any Willamette River steelhead population. Additionally, ODFW has been unable to achieve success in their attempts to establish steelhead populations in these subbasins. These factors combine to give credence to the theory that, for some unidentified reason, the upper reaches of the Willamette River Basin are not (and were not historically) suitable to support steelhead populations–although resident trout and chinook salmon have been successful there.

The BRT reviewed the steelhead distribution described by Fulton (1970). Little new information was added to that presented by Busby et al. (1996, p. 62). The BRT concluded that the ESU was comprised of the native late-run winter steelhead and that the historic distribution of the ESU did not extend upstream of the Calapooia River. The BRT concluded that there was evidence to suggest that steelhead had some historic distribution in westside tributaries to the Willamette River (e.g., Gales Creek in the Tualatin River Basin) but that current distribution of native fish in westside tributaries is somewhat unclear. Based on genetic analysis, the recent samples from westside tributaries do not appear to reflect populations derived from this ESU.

Table 3. Samples of *Oncorhynchus mykiss* used in Figures 2 and 3 of this report. Analyses were conducted at the genetics laboratory facilities of the Washington Department of Fish and Wildlife (WDFW) in Olympia and the National Marine Fisheries Service (NMFS) in Seattle. Samples were collected by WDFW, NMFS, and the Oregon Department of Fish and Wildlife (ODFW).

Sample code	Sample name	State	Sample size	Year collected	Genetics laboratory
Columbia River Basin below Willamette River					
1	Grays River	WA	111	1994	WDFW
2	Beaver Cr. Hatchery	WA	112	1993	WDFW
3	Clatskanie River	OR	40	1996	NMFS
4	Kalama River	WA	236	1994	WDFW
Willamette River Basin					
5	North Fork Molalla River	OR	50	1996	NMFS
6	Yamhill River	OR	34	1997	NMFS
7	Rickreall Creek	OR	34	1997	NMFS
8	Luckiamute River	OR	31	1997	NMFS
9	Calapooia River	OR	39	1997	NMFS
10	North Santiam River	OR	36	1997	NMFS
11	Marion Forks Hatchery steelhead	OR	40	1998	NMFS
12	South Santiam River	OR	40	1997	NMFS
13	Upper McKenzie River (resident trout)	OR	33	1998	NMFS
14	Middle Fork Willamette River (resident trout)	OR	31	1998	NMFS
Columbia River Basin above Willamette River					
15	Washougal River	WA	132	1993-94	WDFW
16	Skamania Hatchery (summer-run)	WA	141	1993	WDFW
17	Skamania Hatchery (winter-run)	WA	151	1993	WDFW
18	Wind River	WA	132	1993-94	WDFW
19	Wind River (Panther Creek)	WA	55	1994	WDFW

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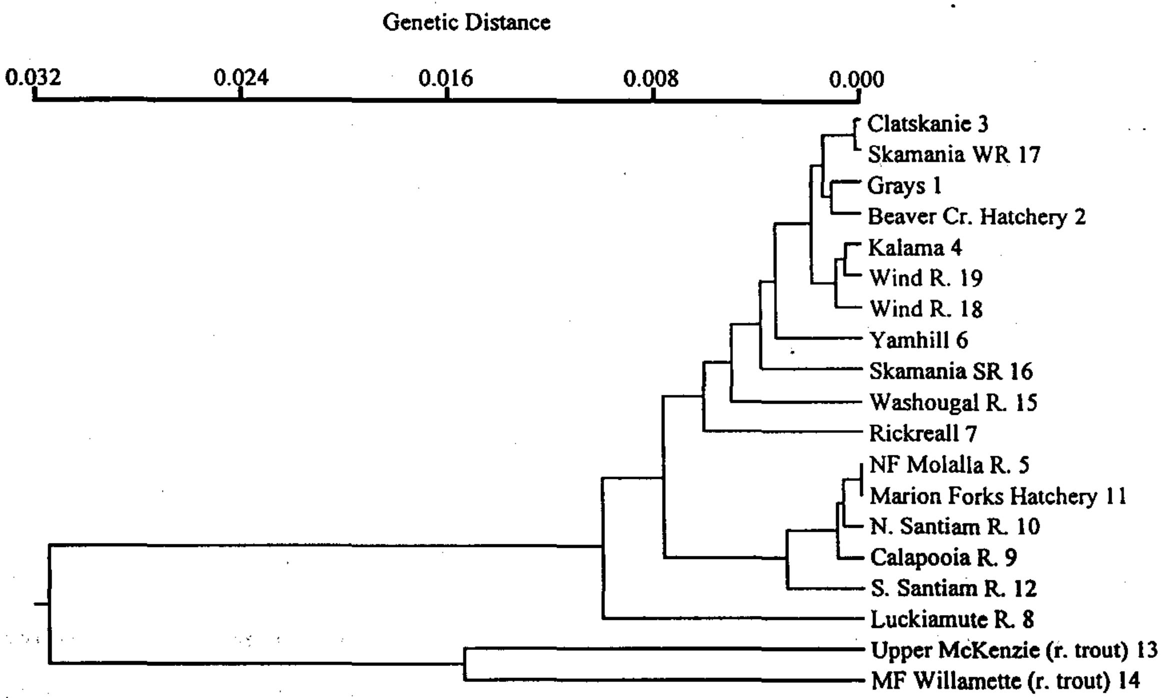


Figure 2. Dendrogram based on unweighted pair-group method analysis (UPGMA) clustering of pairwise genetic distance values (Nei 1978) among 19 hatchery and natural steelhead and resident trout (O. mykiss) populations. Information on samples is presented on Table 3.

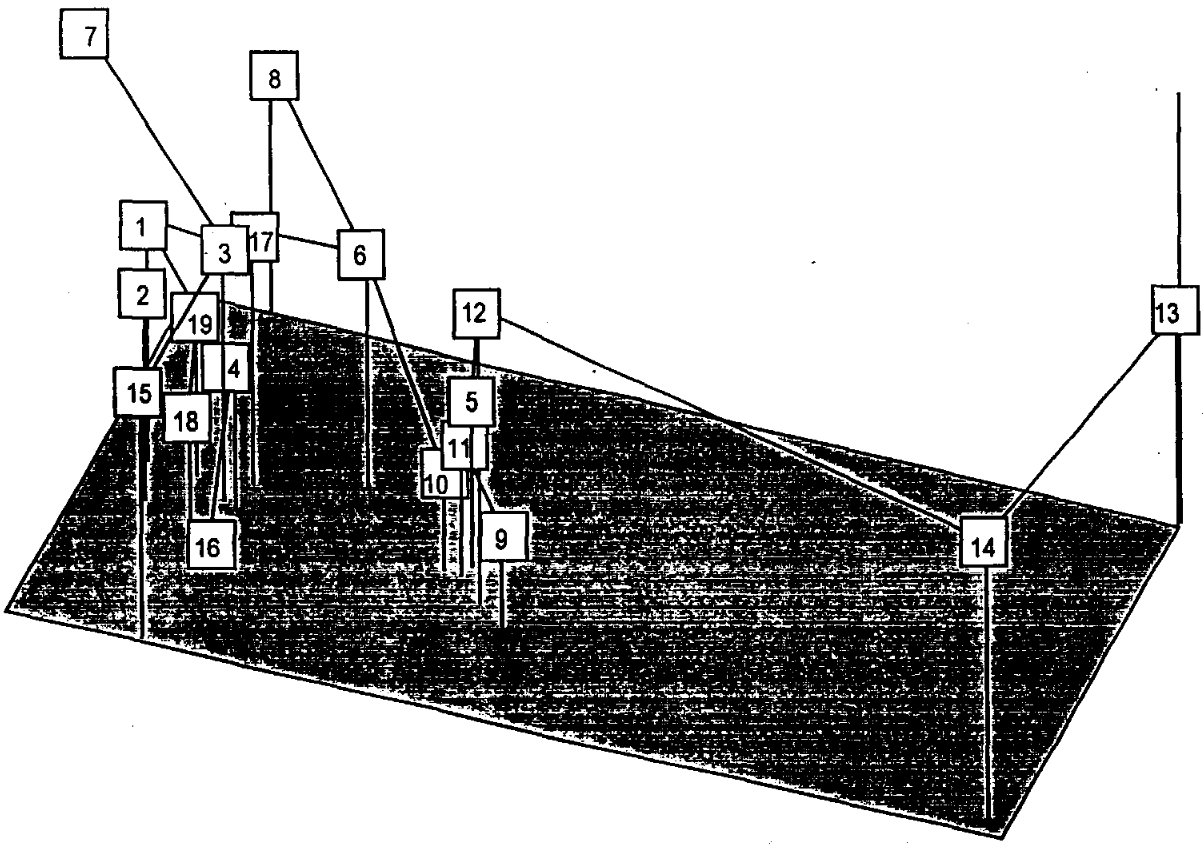


Figure 3. Multidimensional scaling plot (MDS) of genetic distance values used in Figure 2.

Middle Columbia River ESU

The proposed listing of the Middle Columbia River ESU generated substantive comments from ODFW (Greer 1998) and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) (Calica 1998). These included requests to reinstate Candidate Species status to the ESU and to defer a final decision due to substantial scientific disagreement on the relationships between native steelhead, straying steelhead, and resident trout within the Deschutes River Basin.

Comments Received

Resident Trout–The Oregon Department of Fish and Wildlife (ODFW) stated that resident trout were integral to the MCR ESU (particularly in the Deschutes River). Previous comments from the Washington Department of Fish and Wildlife (WDFW 1997) cited studies in the Yakima River Basin (Pearsons et al. 1996) to support inclusion of resident trout within the MCR ESU, not only in terms of the biological makeup of the ESU but in the risk assessment as well.

Winter steelhead in MCR ESU–Inland steelhead (*O. m. gairdneri*) are largely summer-run. However, there are a few populations of winter-run steelhead included in the MCR ESU (Table 4). ODFW has suggested adjusting the boundaries of this ESU so that the winter-run populations would be in the Lower Columbia River ESU.

Ecological differentiation of Deschutes River Steelhead–The CTWSRO commented that NMFS did not consider ecological factors that differentiate Deschutes River steelhead from other populations within the ESU (Calica 1998). Examples of these include: juvenile life history, size and age at maturation, run timing, and fecundity.

New Information

Resident trout studies–Reports on recent studies of steelhead and resident trout in the Deschutes River between Pelton Reregulating Dam and Trout Creek (Fig. 4) indicate a small period of overlap in spawn timing between the two forms (Fig. 5), with steelhead spawning activity peaking in April and concluding in May, while resident trout spawning generally peaked in June and continued into August (Zimmerman and Reeves 1996, 1997, and 1998). Consistent with their larger body size, the steelhead constructed larger redds, in deeper water, and utilized larger substrate than did resident trout (Zimmerman and Reeves 1998).

New genetic information–At the time of the status review, the only populations from the Middle Columbia River ESU represented in the coastwide steelhead genetic data set were from the Yakima and Klickitat River Basins. These samples showed some genetic affinity to each other and, as a group, were distinct from Snake River steelhead. Notably absent from this data set were any recent samples of steelhead from the three major Oregon river basins in the proposed ESU: the Deschutes, John Day, and Umatilla Rivers. As part of this updated status

Table 4. Steelhead stocks in the Middle Columbia River ESU (Kostow 1995, WDF et al. 1993).

Basin	Run
Oregon	
Mosier Creek	winter
Chenowith Creek	winter
Mill Creek	winter
Fifteenmile Creek	winter
Deschutes River	
mainstem below Pelton Dam	summer
John Day River	
Lower John Day River (mouth to South Fork)	summer
North Fork John Day River	summer
Middle Fork John Day River	summer
Upper John Day River (above South Fork)	summer
South Fork John Day River	summer
Umatilla River	summer
Walla Walla River	summer
Washington	
Klickitat River	winter summer
Rock Creek (Klickitat County)	summer
Walla Walla River	summer
White Salmon River	winter summer
Yakima River	summer

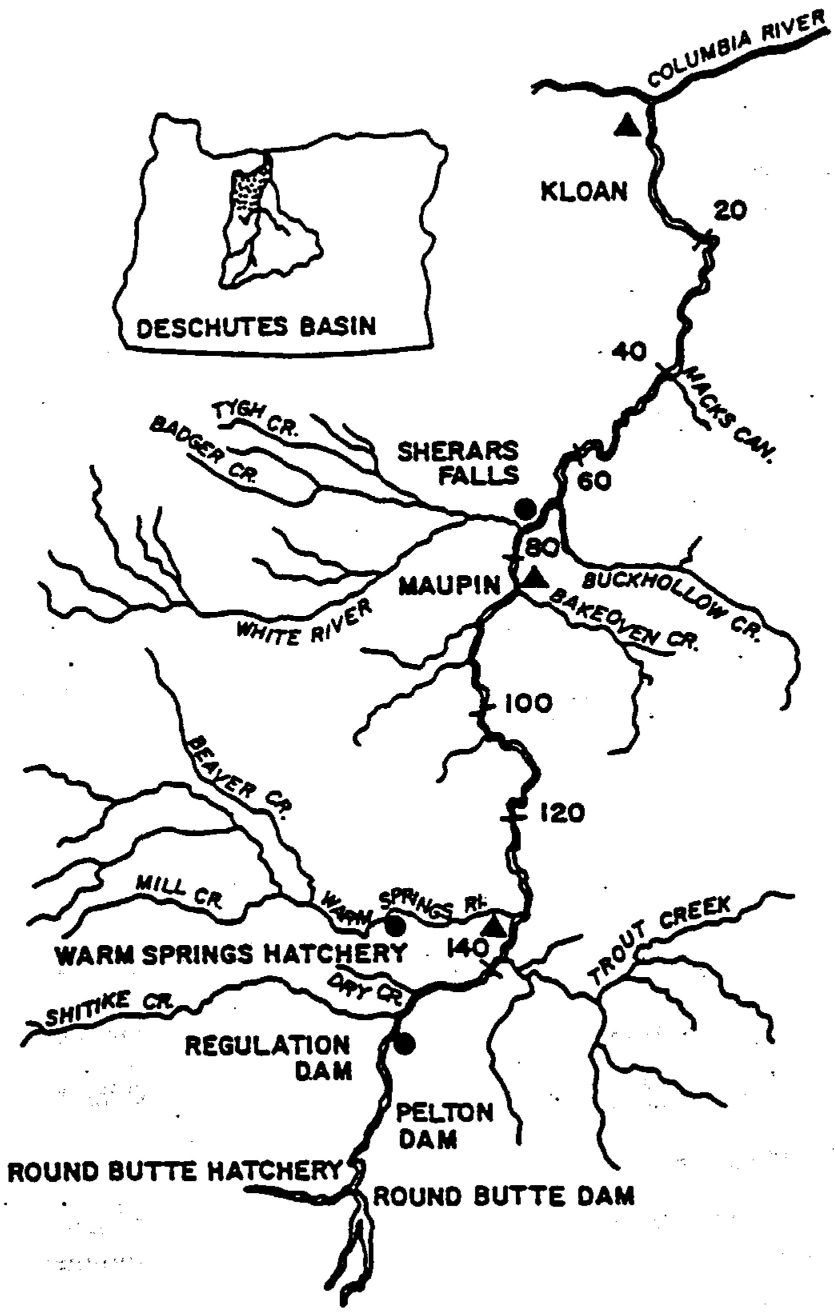
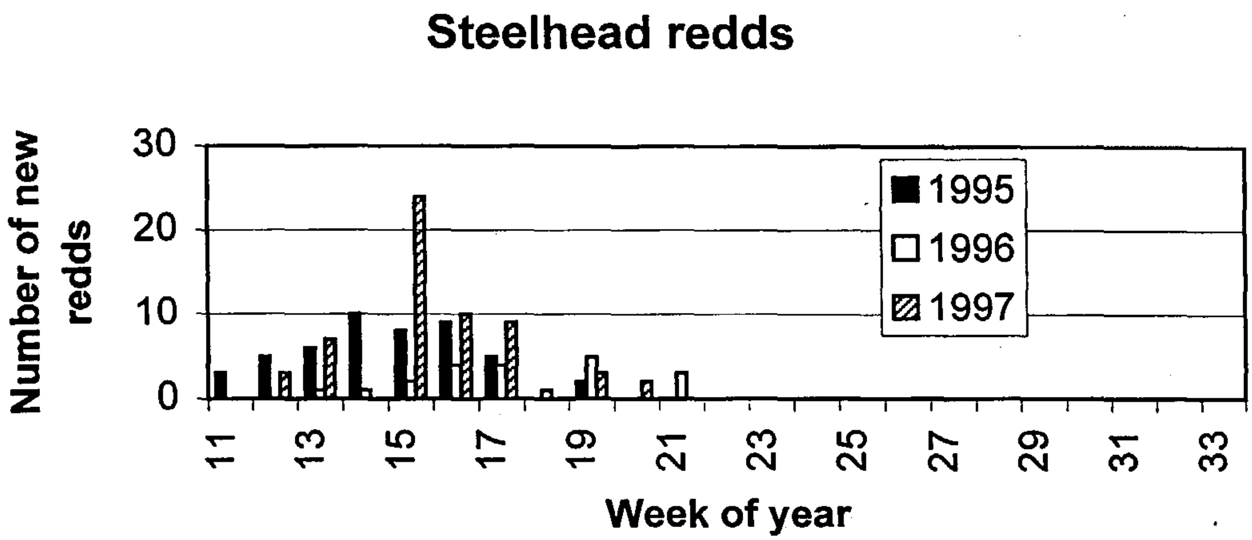


Figure 4. Map of the Deschutes River Basin showing locations mentioned in the text (from Howell et al. 1985).



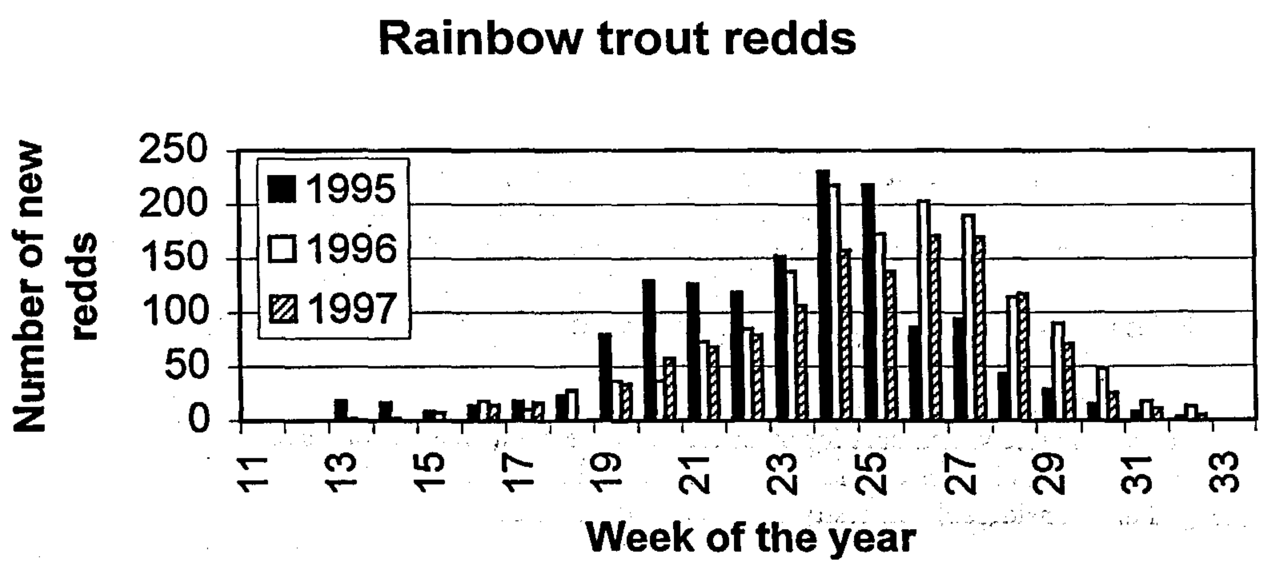


Figure 5. Steelhead and rainbow trout redds observed in the Deschutes River, Oregon, March-August, 1995-1997, suggesting a degree of temporal separation in spawn timing between the two forms of *Oncorhynchus mykiss* in this river basin (Zimmerman and Reeves 1998).

review, NMFS (with the cooperation and assistance of ODFW) obtained new samples from all three locations.

Scientists from the NWFSC compared the new data from Warm Springs (Deschutes), John Day and Umatilla Rivers steelhead to genetic data from other populations from the Columbia and Snake River Basins (Table 5). Electrophoretic data from 41 loci were assessed based on Nei's (1978) unbiased genetic distance. The data demonstrate a strong genetic similarity between the John Day and Umatilla Rivers steelhead, and some affinity between these and lower Snake River steelhead when presented both in a dendrogram constructed using the UPGMA and MDS plot (Figs. 6 and 7). The relationship between the Warm Springs sample and other populations is less clear. Genetically the Warm Springs sample appears to be intermediate between Snake River and Yakima/Klickitat River populations, although it clusters with the latter group in the dendrogram (Fig. 6).

Discussion and BRT Conclusions

Resident trout issue–The steelhead BRT previously concluded that native, resident *O. mykiss* populations that have the opportunity to interbreed with anadromous *O. mykiss* should be included in the steelhead ESUs (Busby et al. 1996). While ODFW and CTWSRO presented anecdotal accounts of spawning interactions between resident trout and steelhead in the Deschutes River, the Zimmerman and Reeves (1996, 1997, and 1998) studies did not provide much evidence of this. The BRT concluded that, given the opportunity for reproductive interaction, co-occurring resident trout are included within this steelhead ESU. Other questions regarding resident trout are addressed below in the Risk Assessment section.

Winter-run populations–Realigning the ESUs to exclude winter steelhead from the Middle Columbia River ESU, as suggested by ODFW, is not supported by any new scientific data. Currently available data indicate that these are inland steelhead populations. An intensive genetic survey of these steelhead populations might provide useful information to further clarify the relationship between coastal and inland steelhead. The BRT concluded that no change in the ESU boundaries was warranted based solely on the presence of a winter-run life history.

Ecological differentiation–Some of the factors identified by CTWSRO were considered in the original status review, and data for other factors were not available for a substantial number of steelhead populations considered in the original status review. NMFS has previously acknowledged that considerable diversity can occur within ESUs.

Conclusion–The new genetic data raise some questions about the proper configuration of the Middle Columbia River ESU and, by extension, the boundaries of other ESUs for inland steelhead (Upper Columbia River and Snake River ESUs). Although some of the BRT members felt that the ESU boundaries should remain as proposed until there is a better understanding of how they might change, the majority felt that the ESU configurations are too uncertain to resolve this issue at the present time. Steps planned to help resolve some of the uncertainties include: 1) review of older genetic data for some of the Oregon populations for evidence of genetic affinities with other inland steelhead; 2) an intensive review of ecological, environmental, and

Table 5. Samples of *Oncorhynchus mykiss* used in Figures 6 and 7 of this report. Analyses were conducted at the genetics laboratory facilities of the Washington Department of Fish and Wildlife (WDFW) in Olympia and the National Marine Fisheries Service (NMFS) in Seattle. Samples were collected by WDFW, NMFS, and the Oregon Department of Fish and Wildlife (ODFW).

Sample code	Sample name	State	Sample size	Year collected	Genetics laboratory
92	White Salmon River (summer-run)	WA	302	1992-93	WDFW
Klickitat River Basin					
93	Upper Klickitat summer-run	WA	484	1991, 1994	WDFW
94	Bowman Creek (Klickitat River tributary)	WA	121	1991	WDFW
95	Little Klickitat River	WA	121	1991	WDFW
96	Lower Klickitat River	WA	121	1994	WDFW
Yakima River Basin					
97	Satus Creek	WA	333	1989-90	WDFW
98	Toppenish Creek	WA	111	1990	WDFW
99	Wapatox Trap	WA	111	1987	WDFW
100	Teanaway River	WA	111	1991	WDFW
101	Roza Trap	WA	111	1989	WDFW
102	Chandler Trap	WA	111	1987	WDFW
Snake River Basin					
103	Lower Tucannon River	WA	143	1989-90	NMFS
104	Upper Tucannon River	WA	184	1989-90	NMFS
105	Dworshak National Fish Hatchery	ID	200	1989, 1991	NMFS
106	Selway River (Gedney Creek)	ID	83	1990	NMFS
107	Lochsa River (Fish Creek)	ID	176	1989-90	NMFS
Grande Ronde River Basin					
108	Chesnimnus Creek	OR	200	1989-90	NMFS
109	Deer Creek	OR	200	1989-90	NMFS

Table 5. Genetic samples used in figures 6 and 7, continued.

Sample code	Sample name	State	Sample size	Year collected	Genetics laboratory
Imnaha River Basin					
110	Lick Creek	OR	192	1989-90	NMFS
111	Camp Creek	OR	99	1990	NMFS
112	Grouse Creek	OR	99	1990	NMFS
113	Little Sheep Creek	OR	200	1989-90	NMFS
New inland steelhead samples					
CL	North Fork Clearwater River	ID	100	1996	NMFS
JD	John Day River	OR	61	1996	NMFS
UM	Umatilla River	OR	56	1996	NMFS
W	Warm Springs River (Deschutes River)	OR	29	1996	NMFS

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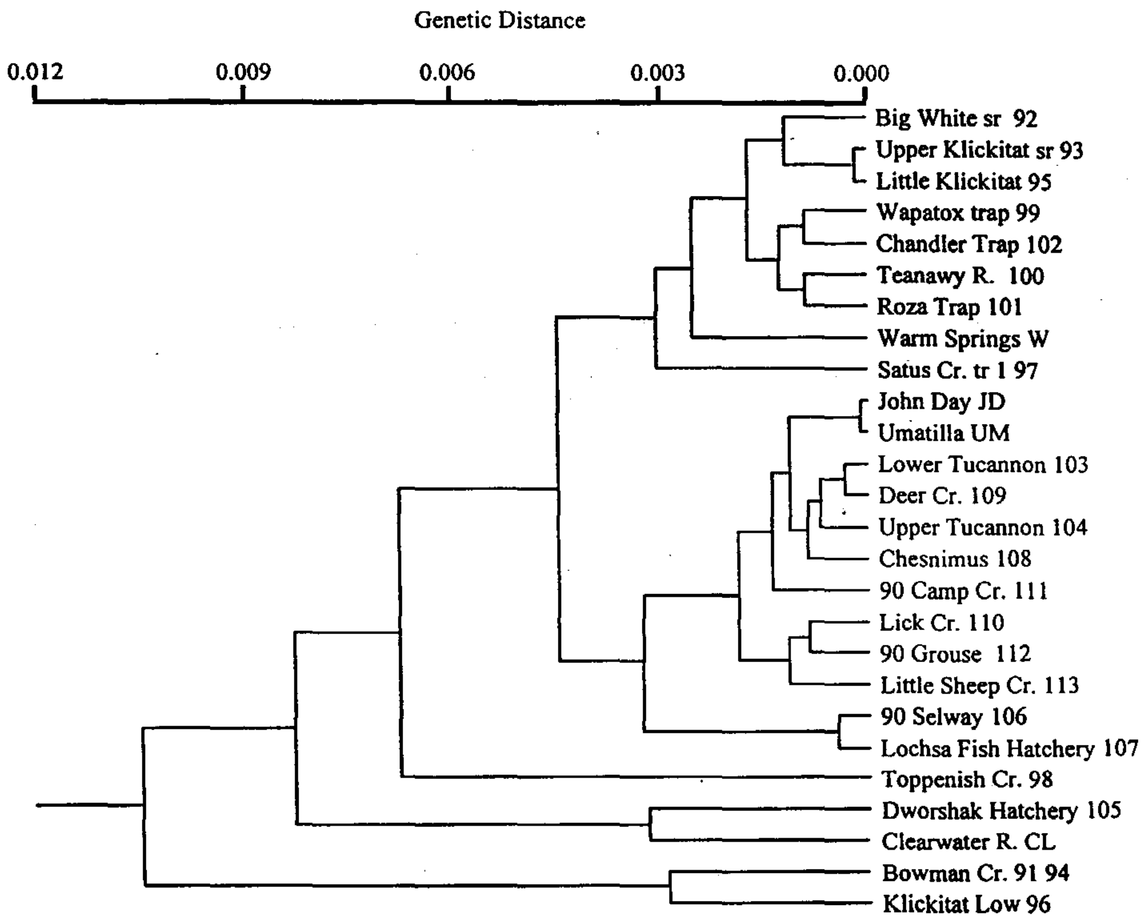

Figure 6. Dendrogram based on unweighted pair-group method analysis (UPGMA) clustering of pairwise genetic distance values (Nei 1978) among 26 hatchery and natural steelhead populations from the Columbia and Snake River Basins. Information on samples is presented on Table 5.

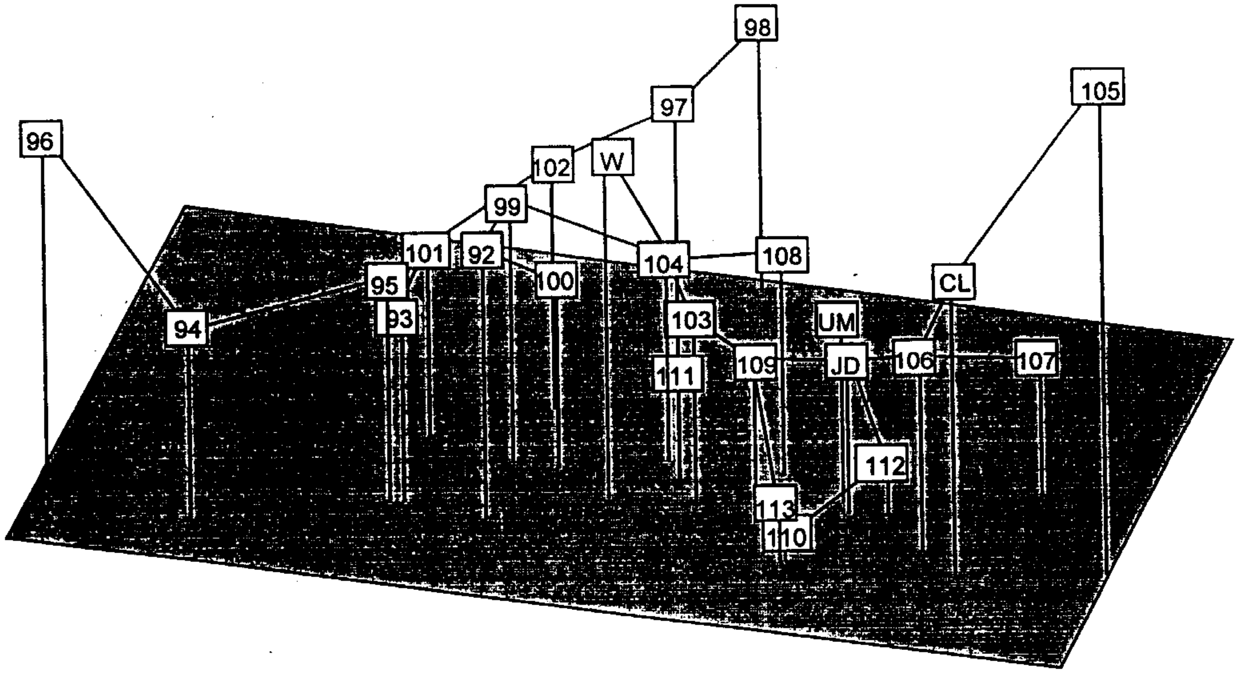

Figure 7. Multidimensional scaling plot (MDS) of genetic distance values used in Figure 6.

life history data for inland steelhead and the basins they inhabit; and 3) collection of additional samples for genetic analysis.

INFORMATION RELATING TO RISK ASSESSMENT

Comments and New Information

Upper Willamette River ESU

Comments received–ODFW (Greer 1998) supported the NMFS proposal to list Upper Willamette River steelhead ESU as threatened under the Endangered Species Act. ODFW argued that, as in all cases, the resident form of *O. mykiss* in the Upper Willamette River ESU should be considered in risk evaluations in areas where the resident and anadromous forms are sympatric. As discussed in the section on ESU boundary determinations, the ESU includes the portions of the Willamette River Basin downstream of the Calapooia River. The BRT agreed that resident and anadromous forms of *O. mykiss* should be considered in risk evaluations where the two forms are sympatric. However, no information on abundance of rainbow trout in the Upper Willamette River ESU was available to the BRT for consideration in its risk evaluations. No other comments pertaining to risk evaluations for the Upper Willamette River ESU were received from comanagers.

Updated risk information–The BRT received revised and some new estimates of winter steelhead abundance in the Upper Willamette River ESU. Updated counts of the native late-run winter steelhead past Willamette Falls had a 5-year geometric mean abundance of just over 3,000 fish through 1997 (Greer 1998). Most of the steelhead monitoring in the Willamette River Basin tributaries consists of redd counts, which are primarily useful for estimating trends in abundance. Nevertheless, ODFW provided expanded estimates of abundance for a few river basins within the Willamette River drainage. An updated estimate (through 1997) of the number of natural and hatchery-origin late run winter steelhead on the Calapooia River results in a 5-year geometric mean abundance of 61 fish (Greer 1998). Counts of the mixed hatchery and naturally-spawning steelhead past Foster Dam on the South Santiam River had a 5-year geometric mean abundance of 240 fish through 1997 (StreamNet 1998). Estimates available at the last status assessment conducted by the BRT indicated that the North and South Santiam River Basins had a mean of 1,800 and 1,200 winter steelhead, respectively, of mixed hatchery and natural origin through 1994. Similarly, as of 1994, the 5-year geometric mean of the estimated total number of late-run winter steelhead in the Molalla River was 840 fish (StreamNet 1997; Table 6). Updated estimates of abundance for the North Santiam or Molalla Rivers were not available to the BRT for this risk evaluation. No estimates of historical abundance of winter steelhead (before 1960s) were available to the BRT, making it more difficult to interpret the risk consequences of current population sizes.

Long-term trends in winter steelhead abundance are universally declining in the tributaries of the Willamette River Basin. The most severe declines in abundance have occurred

Table 6. Summary of steelhead data available to the BRT for Upper Willamette River ESU risk evaluation. Data include information by river/stock.

River Basin	Sub-basin	Run[a]	Production[b]	Data Type[c]	Data Years	Recent abundance Five year geometric mean[d]	Long-term trend[e]	1987-97 Short-term trend[f]	Data references
Willamette R	Basinwide	W	Natural	DC	1955-97	3,146	+1.6	-19.1	PSMFC 1994, Streamnet 1998
		W(early)	Natural	DC	1971-97	2,271	-5.0	-14.0	PSMFC 1994, Streamnet 1998
		W(late)	Natural	DC	1971-97	874	-7.3	-23.2	PSMFC 1994, Streamnet 1998
		S	Natural	DC	1970-97	11,291	+9.7	-7.2	PSMFC 1994, Streamnet 1998
	Molalla R	W	Natural	RM	1979-94	11	-3.1	-8.9	ODFW 1992, 1993, 1994, Kostow 1995
		W(late)	Natural	TL	1980-94	841	-9.2	-18.9	PSMFC 1994
Santiam River	N Santiam R	W(late)	Natural	RM	1980-94	22	-4.0	-6.2	PSMFC 1994
		W	Natural	RM	1985-94	95	-6.3	-1.0	ODFW 1992, 1993, Kostow 1995
		W(late)	Natural	TL	1980-94	1,841	-8.6	-16.6	PSMFC 1994
N Santiam R	Rock Cr	W	Natural	RM	1985-94	16	-8.8		Streamnet 1997
	Mad Cr.	W	Natural	RM	1985-94	56	-6.3	-1.7	Streamnet 1997
	Little Rock Cr	W	Natural	RM	1985-94	16	-8.6		Streamnet 1997
	Elkhorn Cr	W	Natural	RM	1987-94	11	-11.0		Streamnet 1997
	Sinker Cr	W	Natural	RM	1985-95	8	-19.8		Streamnet 1997
M Santiam R		W	Natural	DC	1967-87	22	-16.3		PSMFC 1994
		S	Natural	DC	1970-78	108			PSMFC 1994
S Santiam R		W(late)	Natural	RM	1980-94	17	-2.7	-4.6	PSMFC 1994
		W	Natural	RM	1985-94	42	-1.5	+4.7	ODFW 1992, 1993
		W(late)	Natural	TL	1980-94	1,200	-7.1	-14.4	PSMFC 1994, Streamnet 1997
		W	Mixed	DC	1967-97	240	-6.2	-8.3	Chilcote 1997, Streamnet 1998

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Table 6. Summary of steelhead data available to the BRT for Upper Willamette River ESU risk evaluation, continued.

						Recent abundance		1987-97	
River Basin	**Sub-basin**	**Run[a]**	**Production[b]**	**Data Type[c]**	**Data Years**	**Five year geometric mean[d]**	**Long-term trend[e]**	**Short-term trend[f]**	**Data references**
	Wiley Cr	W	Natural	RM	1985-94	13	-6.6		Streamnet 1997
	Crabtree Cr	W	Natural	RM	1985-95	13	-13.5		Streamnet 1997
	Thomas Cr	W	Natural	RM	1985-94	10	-7.8		Streamnet 1997
	Neal Cr	W	Natural	RM	1985-94	9	-19.0		Streamnet 1997
	Calapooia R	W	Natural	RM	1980-97	4	-6.3	-10.7	Howell et al. 1985, Kostow 1995, Streamnet 1998
		W	Mixed	TL	1980-97	61	-11.3	-17.2	Streamnet 1998

[a] S=summer steelhead; W=winter steelhead.
[b] Production as reported by data reference.
[c] Data Type Codes: DC=dam count; RM=redds per mile; SI=spawner index; TL=total live fish.
[d] Most recent 5 years of data used to calculate spawning escapement geometric mean.
[e] Long-term trend: calculated for all data collected after 1950.
[f] Short-term trend: calculated for the most recent 7-10 years during the period 1988-98.

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in the Calapooia River (-11% per year through 1997; Greer 1998) and in redd counts in tributaries to the North and South Santiam Rivers (-14 to -20% declines per year through 1995; Chilcote 1997; Table 6). Short-term trends in abundance indicate an equally grim status of the winter steelhead in this ESU. Total abundance estimates of late-run hatchery and natural winter steelhead on the Calapooia River are declining by 17% per year, and the late run returning to Willamette Falls has been declining by 14% per year (Greer 1998). The only short-term trend in abundance that is not exhibiting a serious decline is the winter steelhead in the South Santiam River, as indicated by redd counts combined over a number of tributaries through 1994 increasing by almost 5% per year (Greer 1998). More recent information for the combined South Santiam River redd counts was not available to the BRT, so it is difficult to judge the significance of the increasing trends under current conditions.

No new estimates of naturally spawning hatchery fish in the Upper Willamette River ESU have been provided by ODFW since the time of the last risk evaluation conducted by the BRT. As discussed in the Status Review (Busby et al. 1996), both summer steelhead and early-run winter steelhead have been introduced to the Upper Willamette River basin and escape to spawn naturally. As recently as 1995, ODFW (Kostow 1995) estimated that the percentage of hatchery winter steelhead escaping to spawn naturally ranged from 14 to 54% on the North Fork Santiam River. Recent changes in hatchery release practices in the Molalla and North Santiam Rivers led ODFW to estimate that 24 and 17% of naturally spawning steelhead in these rivers currently are hatchery fish, respectively (Greer 1998). Dam counts on the South Santiam River suggest that the percentage of hatchery winter steelhead in natural spawning escapements is between 5-12% (Chilcote 1997, 1998). Finally, ODFW estimated that less than 5% of naturally spawning winter steelhead in the Calapooia River are of hatchery origin, based on predictions about the incidence of strays (Chilcote 1997). In addition to the winter steelhead of hatchery origin in this ESU, there have been extensive hatchery programs propagating non-native summer steelhead throughout the Upper Willamette River basin (Busby et al. 1996). The 5-year geometric mean estimate of summer steelhead abundance over Willamette Falls was 11,000 fish through 1997 (Greer 1998; Table 6). ODFW (Chilcote 1997) conducted its own risk evaluation for this ESU, and found through spawner:recruit analyses that there is a potential for negative impacts on native winter-run steelhead abundance in the Molalla and Santiam rivers, due to the interactions between non-native summer and native wild winter steelhead.

Middle Columbia River ESU

Comments received–ODFW (Greer 1998) argued that steelhead populations in the middle Columbia River tributaries on the Oregon side of the river are highly resilient to periods of low abundance, and therefore they are not presently at risk of endangerment, as proposed by NMFS (NMFS 1998). ODFW submitted an updated risk evaluation of the Middle Columbia River ESU populations in Oregon, including updated abundance data for anadromous and resident forms of *O. mykiss* and new information on the magnitude and origin of steelhead straying into the Deschutes River (Greer 1998). Based on new and updated information they present, ODFW (Greer 1998) concluded that the status of the Middle Columbia River steelhead in Oregon is that of a "Sensitive Species," a classification based on conservation criteria developed by the state of Oregon. This classification is consistent with the previous risk evaluation conducted by Chilcote (1998). ODFW (Greer 1998) stated that continued small population sizes in a number of streams and the increases in naturally spawning stray steelhead in the Deschutes River are significant sources of concern. However, ODFW also felt that the high abundance of resident *O. mykiss* could possibly be an important mitigating factor in preventing extinction of steelhead in several streams. Further details of the comments received from ODFW are presented below.

The Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) also argued that resident forms of *O. mykiss* are potentially important in contributing to the abundance of steelhead populations in the Deschutes River (Calica 1998). Additionally, the CTWSRO provided new information on the extent of straying of steelhead into the Deschutes River Basin (Calica 1998). The CTWSRO stated that ODFW's estimates of the percentage of steelhead straying into the Deschutes River were inflated and that it is not known how many of those stray fish actually spawn naturally in the basin. Nevertheless, the CTWSRO acknowledged that the proportion of stray steelhead into the Warm Springs River was very high (on the order of 60%) (C. Fagan[2]). Further details of the comments received from the CTWSRO are presented below.

WDFW (B. Crawford[3]) agreed with NMFS' assessment that steelhead in several Washington streams within this ESU (Yakima, White Salmon, Klickitat, and Walla Walla Rivers) are very depressed.

Updated risk information–The BRT received new and updated information on abundance of summer steelhead in the Middle Columbia River ESU. Counts of unmarked (natural) summer steelhead at Prosser Dam on the Yakima River indicate a 5-year geometric mean abundance of almost 700 fish through 1997 (WDFW 1998; Table 7). Historically, the run size of steelhead in the Yakima River was estimated to be approximately 100,000 fish (Busby et al. 1996). Dam counts of summer steelhead on the Walla Walla River at Nursery Bridge Dam show a 5-year geometric mean abundance of just over 300 fish (Greer 1998). Summer steelhead on the Umatilla River passing Three Mile Falls Diversion have averaged over 900 in number from 1994 to 1998 (Greer 1998). Estimates of total run sizes in the John Day and Touchet Rivers through 1994 were 10,000 and 300 summer steelhead, respectively (StreamNet 1998; Table 7).

Natural escapement of summer steelhead native to the Deschutes River at Sherars Falls has averaged 1,500 fish from 1994 to 1998, but up to half of these "wild" steelhead may be out-of-basin strays (Greer 1998). Biologists familiar with the steelhead in the Deschutes River have been aware of the increasing numbers of stray hatchery and wild steelhead into the river (CTWSO 1998, Greer 1998), and recently there has been an increase in efforts to get better estimates of the numbers and origin of steelhead spawning in the river basin (see discussion

[2]C. Fagan, Fish Biologist, Confederated Tribes of the Warm Springs Reservation of Oregon, Warm Springs, OR 97761. Pers. commun., November 1998.

[3]B. Crawford, Washington Department of Fish and Wildlife, 600 Capital Way N., Olympia, WA 98501-1091. Pers. commun., November 1998.

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Table 7. Summary of steelhead data available to the BRT for Middle Columbia River risk evaluation. Data include information by river/stock.

River Basin	Sub-basin	Run[a]	Production[b]	Data Type[c]	Data Years	Recent abundance Five year geometric mean[d]	Long-term trend[e]	1987-97 Short-term trend[f]	Data references
Columbia R	Mainstem-McNary	S	Mixed	DC	1955-97	119,111	+1.0	-3.9	Streamnet 1998
	The Dalles	S	Mixed	DC	1958-97	150,806	+1.0	-5.0	Streamnet 1998
	John Day Dam	S	Mixed	DC	1968-97	127,191	+4.5	-4.0	Streamnet 1998
	Yakima R	S	Natural	DC	1985-97	695	-5.2	-8.2	WDFW 1998
		S	Hatchery	DC	1985-97	42	-4.8	+7.8	WDFW 1998
		S	Total	DC	1985-97	75.3	-4.8	-6.9	WDFW 1998
	Umatilla R	S	Natural	DC	1967-96	1,852	+0.5	-3.5	Chilcote 1997
		S	Natural	TL	1980-98	911	-3.9	-7.3	Greer 1998
	Deschutes R	S	Natural	DC	1978-98	1,496	-7.4	-11.6	Greer 1998
		S	Hatchery	DC	1978-98	12,559	+4.4	+6.2	Greer 1998
		S	Total	DC	1978-98	14,148	+1.2	+4.4	Greer 1998
Deschutes R	Warm Springs R	S	Natural	RM	1982-94	1	+1.1		Streamnet 1997
	Shitike Cr	S	Natural	RM	1976-94	2	-6.9	-2.2	PSMFC 1994
Fifteenmile Cr	Mainstem	W	Natural	RM	1964-94	1	-5.4	-11.1	ODFW 1994, PSMFC 1994
	Eightmile Cr	W	Natural	RM	1985-93	3	-39.9		PSMFC 1994
	Ramsey Cr	W	Natural	RM	1985-94	2	+0.9		PSMFC 1994
	Combined	W	Natural	RM	1985-94	2	-28.4	-15.3	PSMFC 1994
Klickitat R & tribs		S	Mixed	TL	1977-85	2,383	-9.2		WDFW 1994
John Day R	Mainstem	S	Natural	TL	1987-94	9,978	-17.4	-14.3	Streamnet 1997

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Table 7. Summary of steelhead data available to the BRT for Middle Columbia River ESU risk evaluation, continued.

River Basin	Sub-basin	Run[a]	Production[b]	Data Type[c]	Data Years	Recent abundance Five year geometric mean[d]	1987-97 Long-term trend[e]	Short-term trend[f]	Data references
	Lower mainstem	S	Natural	SI	1974-98	2	-1.7	-15.9	Greer 1998
	Upper mainstem	S	Natural	SI	1974-98	3	-2.9	-15.2	Greer 1998
	NF John Day R	S	Natural	SI	1974-98	3	-2.5	-1.2	Greer 1998
	MF John Day R	S	Natural	SI	1974-98	3	-3.7	-13.7	Greer 1998
	NF combined	S	Natural	RM	1985-94	5	-20.1	-11.8	PSMFC 1994, WDFW 1995
	MF combined	S	Natural	RM	1968-94	13	+13.7		PSMFC 1994, WDFW 1995
	SF combined	S	Natural	RM	1969-94	9	-5.0	-7.4	PSMFC 1994, WDFW 1995
	John Day River & mainstem	S	Natural	RM	1966-94	37	-0.9	-20.7	PSMFC 1994
Walla Walla R	Mainstem	Unknown	Natural	DC	1993-98	304	-16.8		Greer 1998
	Touchet R	S	Natural	TL	1986-94	287	-1.2	+5.7	WDFW 1994, 1995
		S	Hatchery	TL	1986-94	27	+2.9	+11.5	WDFW 1994, 1994

[a] S=summer steelhead; W=winter steelhead.
[b] Production as reported by data reference.
[c] Data Type Codes: DC=dam count; RM=redds per mile; SI=spawner index; TL=total live fish.
[d] Most recent 5 years of data used to calculate spawning escapement geometric mean.
[e] Long-term trend: calculated for all data collected after 1950.
[f] Short-term trend: calculated for the most recent 7-10 years during the period 1988-98.

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below). The total numbers of wild steelhead in the Deschutes River are severely depressed, regardless of the proportion of the total wild count that is out-of-basin wild strays.

Stray steelhead in the Deschutes River Basin--More information on the extent and nature of straying of steelhead into the Deschutes River has been provided to NMFS by ODFW (Greer 1998) and the CTWSRO (Calica 1998). There are two main issues pertaining to risk from strays in the Deschutes River. First, it is important to know whether strays spawn naturally in the river basin. Potentially deleterious effects on naturally spawning Deschutes River steelhead can occur through competition between strays and steelhead native to the Deschutes River for spawning sites or feeding and rearing sites for juveniles resulting from spawning events. In addition, interbreeding between stray steelhead and Deschutes River native steelhead can result in negative effects from intermixing genetically distinct steelhead populations. Second, the origin of the stray steelhead has important implications for risk to the steelhead native to the Deschutes River Basin. It is not clear what proportion of the total strays into the Deschutes River are hatchery-derived vs. wild steelhead from other streams in the Columbia River Basin. The negative effects of any interbreeding that may occur between stray and native steelhead will be exacerbated if the stray steelhead originated in geographically distant river basins, especially if those river basins are in different ESUs. The populations of steelhead in the Deschutes River Basin include (1) steelhead native to the Deschutes River, (2) hatchery steelhead from the Round Butte Hatchery on the Deschutes River, (3) wild steelhead strays from other rivers in the Columbia River Basin, and (4) hatchery steelhead strays from other Columbia River Basin streams. For 1998, ODFW estimated that the Deschutes River steelhead counted at Sherars Falls were distributed into the following sources: 910 steelhead native to the Deschutes River, 910 wild strays, 2,000 Round Butte Hatchery steelhead from within the Deschutes River Basin, and 20,000 steelhead strays of hatchery-origin from outside the Deschutes River Basin. Although the CTWSRO questioned the ODFW estimates of the numbers of stray steelhead into the Deschutes River basin, they did not dispute the contention that a high percentage of strays continues to return to the Deschutes River.

ODFW (Greer 1998) estimated that the percentage of stray hatchery fish in the Deschutes River has increased to more than 80% of the spawning population in recent years. ODFW further stated that "a majority" of stray steelhead migrating past Sherars Falls spawn in the Deschutes River. The CTWSRO reported preliminary findings from a tagging study conducted by T. Bjornn and M. Jepson (University of Idaho) and NMFS suggesting that a large fraction of the steelhead passing through Columbia River dams (i.e., John Day and Lower Granite dams) have "dipped" into the Deschutes River and then returned to the mainstem Columbia River. In 1996, 223 steelhead tagged at Bonneville Dam entered the Deschutes River, and 142 (64%) of them left the Deschutes, many of them ultimately migrating into the Snake River Basin. A key unresolved question regarding the large numbers of stray steelhead in the Deschutes River Basin is how many stray fish actually remain in the basin and spawn naturally.

Non-migratory *O. mykiss*– If non-migratory *O. mykiss* are sympatric with the anadromous form, they potentially can interact with steelhead, resulting in ecological and genetic effects on steelhead populations that should be considered in risk assessments. Potential negative effects of such interactions include competition between the life history forms for juvenile rearing and adult spawning sites, and genetic and ecological costs to interbreeding. On the other hand, it also is possible that non-migratory forms of *O. mykiss* can buffer anadromous forms from declines, if non-migratory *O. mykiss* parents can give rise to anadromous offspring. ODFW believes that non-migratory, or resident, forms of *O. mykiss* should be included in risk evaluations for this ESU. The evidence supporting suggestions that the two life history forms interbreed and produce offspring of the alternate type is weak. Indeed, ODFW provided information to the BRT indicating that juvenile resident *O. mykiss* released in the Deschutes River Basin in the mid-1970s did not return as steelhead, but very little is known about natural production of anadromous *O. mykiss* from the non-migratory form. Nevertheless, anecdotal and other reports of occasional sympatric spawning of resident and anadromous forms of *O. mykiss* (Zimmerman and Reeves 1996, 1997 and 1998; Calica 1998; Greer 1998) suggested to the BRT that some interbreeding between the two forms probably occurs. Even low levels of interbreeding could have significant demographic or genetic effects on the anadromous *O. mykiss* populations.

ODFW provided the BRT with estimates of the density of the resident form of *O. mykiss* in two index reaches of the mainstem Deschutes River. The densities of resident *O. mykiss* at Nena Creek and North Junction study sections on the Deschutes River ranged from 600 to over 2,500 fish between 1974 and 1997 (Greer 1998). According to biologists familiar with *O. mykiss* in this region, these densities of the resident form are higher than those found in other rivers in the middle Columbia River basin, but they are representative of the high abundance of rainbow trout in the Deschutes River (J. Martin[4]).

Both long- and short-term trends in abundance of naturally spawning fish are universally declining in the Middle Columbia River ESU (Table 7). Especially severe declines occur on the Walla Walla River at Nursery Bridge Dam, where the numbers of summer steelhead have been decreasing by almost 17% per year from 1993 to 1998 (Greer 1998). Short-term trends in summer steelhead abundance on John Day River tributaries range from 1 to 17% declines per year. The most precipitous declines in abundance over the past 10 years have occurred on the South Fork and mainstem of the John Day River (17% and 16% declines per year, respectively) and on the Deschutes River at Sherars Falls (12% decline per year) (Table 7). ODFW pointed out to the BRT that in the two river basins of the Middle Columbia River ESU exhibiting the most severe declines in steelhead abundance (Deschutes and South Fork John Day rivers), the estimated abundance of the resident *O. mykiss* is the greatest (Greer 1998). ODFW concluded that the presence of the resident form in those streams was a mitigating factor to the declines in the anadromous populations.

Trends in populations of winter steelhead in this ESU also have been declining. The BRT did not receive updated abundance information for any of the winter steelhead populations in the Fifteenmile Creek drainage, but data through 1994 showed a greater than 28% decline in abundance per year (StreamNet 1998).

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[4]J. Martin, Director's Office, Oregon Department of Fish and Wildlife, 2501 SW First AV, P.O. Box 59, Portland, OR 97207. Pers. commun., November 1998.

Risks due to negative effects of interactions with hatchery steelhead are very high in the Deschutes River, as discussed above. Hatchery steelhead derived from a native broodstock have contributed an estimated 40 to 60% to natural spawning escapements in the Umatilla River from 1994 to 1998 (Greer 1998). In contrast, information available to the BRT suggests that the influence of hatchery *O. mykiss* is relatively low in other rivers in the region (WDFW 1998).

Approaches to Risk Assessment

Overall Evaluation of Risk and Uncertainty

To tie the various risk considerations into an overall assessment of extinction risk for each ESU, the BRT members scored risks in a number of categories using a matrix form, then drew conclusions regarding overall risk to the ESU after considering the results. The general risk categories evaluated were: abundance, trends in abundance/productivity/variability, genetic integrity, and "other risks." More detailed explanation of these categories and of the nature and use of this matrix approach is provided in Appendix A. The summary of overall risk to an ESU uses categories that correspond to definitions in the Endangered Species Act: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (Note, however, that these votes on overall risk do not correspond to recommendations for a particular listing action. They are based only on past and present biological condition of the populations and do not contain a complete evaluation of conservation measures as required under the ESA for a listing determination.) The risk summary votes do not reflect a simple average of the risk factors for individual categories, but rather a judgement of overall risk based on likely interactions among, and cumulative effects of, the different factors. A single factor with a "high risk" score may be sufficient for an overall conclusion of "in danger of extinction," but such an overall determination could result from a combination of several factors with low or moderate risk scores.

The BRT used two methods to characterize the uncertainty underlying their risk evaluations. One way the BRT captured the levels of uncertainty associated with the overall risk assessments was for each member to attach a certainty score (1=low, 5=high) to their overall risk evaluation for each ESU. For example, a BRT member who felt strongly that an ESU was likely to become endangered in the foreseeable future (or not currently at significant risk) would vote for that category of risk and assign a certainty score of 4 or 5; if that member was less sure about the level of risk, a lower certainty score would be given to the risk vote.

The second method for characterizing uncertainty was fashioned after an approach used by the Forest Ecosystem Management Assessment Team (FEMAT 1993). Each BRT member was given 12 total "likelihood" points to distribute in any way among the three risk categories. For example, complete confidence that an ESU should be in one risk category would be represented by most or all of the 12 points allocated to that category. Alternatively, a BRT member who was undecided about whether the ESU was likely to become endangered but who felt the ESU was at some risk could allocate the same (or nearly the same) number of points into each of the "likely to become endangered" and "not likely to become endangered" categories.

This assessment process follows well-documented peer-reviewed methods for making probabilistic judgements (references in FEMAT 1993, p. IV, 40-45). The BRT interpretation of these scores was similar to FEMAT's, which said "the likelihoods are not probabilities in the classical notion of frequencies. They represented degrees of belief [in risk evaluations], expressed in a probability-like scale that could be mathematically aggregated and compared across [ESUs]" (FEMAT 1993 p. IV-44).

General Risk Conclusions

The two methods used by the BRT to characterize uncertainty in risk assessments generally were consistent in their outcomes. In the first method, most of the certainty scores for both ESUs were moderate to high (in the range of 3 to 5), reflecting a fair amount of certainty regarding the conservation status of steelhead in the ESUs evaluated. Results from the FEMAT method were generally concordant with and support information provided by the first method. That is, when the majority of BRT votes fell in a particular risk category, the majority of likelihood points also fell in the same category. For both the Upper Willamette River and Middle Columbia River ESUs, a small fraction of likelihood votes occurred in the "in danger of extinction" category. This result reflects the limited information available for conducting risk evaluations for steelhead. Although in many cases available information did not provide conclusive evidence of high risk, it also did not clearly demonstrate that the ESUs were not at risk. As a result, at least some BRT members felt that they could not completely exclude the possibility that a particular ESU is presently in danger of extinction. However, when asked to pick only one risk category (the first method), in neither case did BRT members conclude that an ESU is presently in danger of extinction.

Discussion and BRT Conclusions on Risk Assessment

Upper Willamette River ESU

The BRT was unanimous in concluding that the Upper Willamette River ESU is likely to become endangered in the foreseeable future. Most BRT members were relatively certain in their risk evaluations–certainty scores ranged from 3 to 5, and a majority of the BRT gave a certainty score of 4. Similarly, using the FEMAT method, all BRT members allocated the majority of their likelihood points to the "likely to become endangered" risk category. The BRT was concerned about the universally declining trends in abundance in the relatively small-to-moderate sized runs of winter steelhead in this ESU (Table 8). The BRT concurred with ODFW biologists that the inability to identify the underlying causes of continuing declines in abundance in this ESU is reason for concern. Declines in winter steelhead abundance from negative effects of hydropower development and harvest should have been apparent some time ago, but these effects cannot explain the recent and continued declines in abundance within this ESU. Indeed, winter steelhead abundance has not rebounded following reduction in freshwater fisheries that occurred earlier this decade.

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Table 8. Summary of BRT conclusions for extinction risk categories for the steelhead ESUs. Numbers in each cell denote the number of BRT members voting for a particular risk level for each risk category. The five-point scale used is described in Appendix A.

Upper Willamette River ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution			1	10		3.9
Trends/Productivity				9	2	4.2
Genetic Integrity		3	7	1		2.8

Middle Columbia River ESU

	Risk Score					
Risk Category	**1**	**2**	**3**	**4**	**5**	**Mean**
Abundance/Distribution			3	7	1	3.8
Trends/Productivity			2	6	3	4.1
Genetic Integrity			1	10		3.9

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The percentage of hatchery fish in natural spawning escapements is considered relatively low in most rivers in the Upper Willamette River Basin. Declines in winter steelhead runs regardless of degree of hatchery influence suggest that causes other than artificial propagation are primarily responsible for reduced abundances.

The BRT expressed concern about the lack of historical abundance estimates for winter steelhead in the Upper Willamette River ESU. Some members felt that it was possible that population sizes were never large above Willamette Falls, and that the winter steelhead in this ESU are capable of persisting at relatively low abundance. Although not as extreme as is the case for spring chinook salmon, the proportion and total amount of historical steelhead spawning habitat that has been blocked by dams and water diversions is high in the Upper Willamette River ESU. It is possible that several consecutive years of poor ocean conditions and recent harvest pressure in the lower Columbia River have pushed the winter steelhead populations in the Upper Willamette River drainage to the limit of their resiliency. The BRT concluded that ocean and harvest conditions, combined with greatly reduced freshwater spawning and rearing habitat area, likely have resulted in severe impediments to the maintenance of abundant steelhead populations that are well distributed throughout the basin.

Middle Columbia River ESU

Given the uncertainty regarding the boundaries of this ESU (see above), evaluating extinction risk was somewhat problematical. Under the assumption that the ESU was configured as in the proposed listing, a majority of the BRT concluded that the Middle Columbia River ESU is likely to become endangered in the foreseeable future, and a minority felt that it is presently in danger of extinction. Most BRT members had a relatively high degree of certainty in this risk determination (the majority of the scores were 4), but the overall range of certainty scores was very broad (1-5). The FEMAT method produced similar results: a majority of the likelihood points were allocated to the "likely to become endangered" category, and more of the remaining likelihood points were allocated to the "presently in danger" category. Because of the high uncertainty in determining ESU boundaries, the BRT also considered whether any other ESU configurations might result in a lower risk category. Since steelhead face pervasive problems throughout the mid-Columbia River, the BRT could not identify any reasonable ESU configurations that would result in an ESU that was not at risk of endangerment.

The BRT was concerned about the widespread declines in abundance in the steelhead populations in this ESU—declines that have resulted in estimated population sizes well below likely historical levels. Trends in abundance and concerns about genetic integrity were also considered to be high risk factors for this ESU (Table 8). The serious declines in abundance in the John Day River Basin are especially troublesome, because the John Day River has supported the largest populations of native, naturally spawning summer steelhead in the ESU. The BRT could identify no real bright spots for naturally produced steelhead in this ESU. Populations in the Yakima River basin are at a small fraction of historical levels, with the majority of production coming from a single stream (Satus Creek). The number of naturally spawning fish in the Umatilla River has been relatively stable in recent years, but this has been accomplished with substantial supplementation of natural spawning by hatchery-reared fish. Naturally produced steelhead have declined precipitously in the Deschutes River over the past decade. The most optimistic observation that can be made for steelhead in this area is that some populations have shown resiliency to bounce back from even more depressed levels in the past (e.g., the late 1970s).

The continued increases of stray steelhead into the Deschutes River Basin was a major source of concern to the BRT. ODFW and CTWSRO estimate that 60-80% of the naturally spawning population is composed of strays, which greatly outnumber naturally produced fish. Although the level of reproductive success of these stray fish has not been evaluated, the levels are so high that major genetic and ecological effects on natural populations are possible. Recent efforts underway by the CTWSRO and ODFW to determine the origin of strays and the proportion of strays that are spawning naturally in the Deschutes River may prove useful in focusing management efforts to address this serious issue.

ODFW has argued that resident fish in the Deschutes River play a more substantial role in overall population dynamics and abundance of *O. mykiss* than is the case in other streams within this ESU or in most other steelhead ESUs. Further, they argued that the resident populations in the Deschutes River are robust and provide a substantial buffer against extinction. Evaluating the role of resident fish in extinction risk analysis for steelhead ESUs is very complex. Comprehensive abundance information for resident fish is not available, but if the data presented by ODFW for Nena Creek/North Junction are representative, the overall abundance of resident fish in the Deschutes River may be fairly high. Some spawning between resident and anadromous fish has been observed, but there appears to be substantial microhabitat partitioning of reproduction between the forms based on size, timing, and location. Available information is limited but does not provide evidence that resident fish contribute significantly to anadromous returns. A tentative conclusion is that, within the Deschutes River basin, the two forms are closely linked over evolutionary time frames, but the ability of the resident form to substantially affect demographic/genetic processes in steelhead populations in the short term is doubtful. To the extent that the resident form has been producing steelhead offspring in this ESU, the effect of that production has not been sufficient to stave off continued declines in steelhead populations. Furthermore, if there is substantial and continuing gene flow between resident and anadromous forms, that would suggest the high stray rates of non-native hatchery steelhead also pose a genetic risk to resident fish in the Deschutes River. There was not enough information available to the BRT to determine whether the relative abundances of the two life history forms should be viewed positively (e.g., the relatively high abundance of the resident form in those streams can act to buffer the anadromous form from declines) or negatively (e.g., the resident form is outcompeting or interbreeding with the anadromous form) in risk evaluations.

Extensive habitat blockages, water diversions, altered water flow and temperature regimes, and the resulting loss of spawning and rearing habitat for steelhead in the Middle Columbia River ESU have combined to result in a significant threat to its persistence. At least two extinctions of steelhead populations have been documented in this ESU (in the Crooked and Metolius Rivers), and the continuing declines in extant populations both with and without hatchery influence are a source of concern to the BRT.

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Appendix A: Risk Matrix Approach

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Appendix A: Risk Matrix Approach

To tie the various risk considerations into an overall assessment of extinction risk for each ESU, Biological Review Team (BRT) members scored risks in a number of categories using a matrix form (Table A.1). For scoring and reaching an overall conclusion regarding extinction risk for an ESU, the following method was used: 1) After reviewing previous documents and hearing presentations and discussions during the meeting, each BRT member filled in as much of the matrix as possible, scoring the various factors according to the relative degree of risk based on available information. 2) Scores from individual members were tallied on a single sheet, and summarized. 3) The BRT reached an overall conclusion regarding the degree of extinction risk facing each ESU after steps 1 and 2 were completed for all ESUs.

The following is a list of factors considered, along with sub-categories and important questions for each. This is not a complete list, but covers the considerations that have been important in past status reviews. Specific considerations within each of these areas are discussed more fully in the main report.

Abundance

Questions regarding abundance can be put into three sub-categories:

Small population risks: Is the overall ESU (or discrete populations within the ESU) at such low abundance that small-population risks (random genetic effects, Allee effects, random demographic or environmental effects) are likely to be significant?

Distribution: Do present populations adequately represent historical patterns of geographic distribution and ecological/genetic/life-history diversity? Does fragmentation of previously connected populations pose a risk? Is the ESU at risk in a significant portion of its range?

Habitat capacity: Is abundance limited by current habitat capacity? If so, is current habitat capacity adequate to ensure continued population viability? (Here, only habitat capacity is considered. Habitat quality as it affects trends or productivity is considered in the next section.)

Trends, Productivity, and Variability

Again, considerations may be divided into three sub-categories:

Population trends: Is the overall ESU (or populations within it) declining in abundance at a rate that risks extinction in the near future? Is variation in population abundance, in combination with average abundance and trends, sufficiently high to cause risk of extinction?

Productivity: Has population productivity declined or is it declining toward the point where populations may not be sustainable? Is there evidence that natural populations are/can be self sustaining without the infusion of hatchery-reared fish?

Limiting factors: Are there factors (such as poor freshwater or ocean habitat quality, harvest or other human-induced mortality, interactions with other species) that currently limit productivity to the point where populations may not be sustainable? Are such factors expected to continue into the future? Are there natural or anthropogenic factors that have increased variability in reproduction or survival for populations beyond the historic range of environmental variability? Are there factors that have increased the vulnerability of populations to natural levels of environmental variability?

Genetic integrity

Genetic integrity can be affected through either random effects (included under "Small population risks above) or directional effects. The major sources of directional effects that are of concern here are introduced genotypes, interactions with local or non-native hatchery fish, or artificial selection (e.g. through selective harvest or habitat modification). These directional effects pose two major types of risk for natural populations:

Loss of fitness: Has interbreeding or artificial selection reduced fitness of natural populations to the point that this is a significant extinction risk factor?

Loss of diversity: Has there been a substantial loss of diversity within or between populations?

For both types of risk, it may also be important to ask the following question: Even if such interactions are not occurring at present, have past events substantially affected fitness and/or diversity of natural populations within the ESU to the extent that long-term population sustainability is compromised?

Other risks

Are there other factors that indicate risks to the sustainability of the ESU or component populations? such factors may include disease prevalence, predation, and changes in life history characteristics such as spawning age or size.

Recent events

This category was included to recognize events (natural or human-induced) that have predictable effects on risk for the ESU, but which have occurred too recently to be reflected in abundance, trend, genetic, or other data considered by the BRT. Examples might include recent changes in management (such as harvest rates or hatchery practices), human-induced changes in the environment (habitat degradation or enhancement), or natural events (such as floods or volcanic eruptions). Recent changes in management were only considered where they were already fully implemented and had reasonably predictable consequences.

SCORING CATEGORIES

Levels of Risk--Individual Factors

Risk from individual factors were ranked on a scale of 1 (very low risk) to 5 (high risk):

1) Very Low Risk. Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.

2) Low Risk. Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may in combination with other factors.

3) Moderate Risk. This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

4) Increasing Risk. Present risk is Low or Moderate, but is likely to increase to high risk in the foreseeable future if present conditions continue.

5) High Risk. This factor by itself indicates danger of extinction in the near future.

Levels of Risk--Recent Events

The "Recent Events" category does not represent specific risk factors, but rather factors that may alter the overall risk score for an ESU from the conclusion based on data available to date. This category was scored as follows: "++" - expect a strong improvement in status of the ESU, "+" expect some improvement in status, "0" - neutral effect on status, '-' - expect some decline in status, "--" - expect strong decline in status.

Levels of Risk--Overall Summary

The summary score of overall risk uses categories that correspond to definitions in the ESA: in danger of extinction, likely to become endangered in the foreseeable future, or neither. (Note, however, that these scores do not correspond to recommendations for a particular listing action because they are based only on past and present biological condition of the populations and do not contain a complete evaluation of conservation measures as required under the ESA.)

This summary score is not a simple average of the risk factors for individual categories, but rather a judgement of overall risk based on likely interactions among factors. A single factor with a "High Risk" score may be sufficient to result in an overall score of "in danger of extinction," but such an overall score could also result from a combination of several factors with low or moderate risk scores.

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Table A.1. Example of a blank risk matrix for a single ESU. Each Biological Review Team member filled out scores on a separate form for each ESU.

Risk Factor	Comments	Risk
Abundance Small Population Risks Distribution Habitat Capacity		
Trends/Productivity/Variability Population Trends Productivity Risk Agents		
Genetic Integrity Loss of Fitness Loss of Diversity		
Other Risks		
Recent Events		
Summary: Overall Risk level		
Concerns:		