The Status of Wild Steelhead and Their Management in Western Washington:

Strategies for Conservation and Recreation

Wild Steelhead Coalition

May 10, 2006

Wild Steelhead Coalition, 218 Main St., Box #264, Kirkland, WA 98033

Copies of this report are available for download via the internet off our web-page at: http://www.wildsteelheadcoalition.com

Contributors

Richard T. Burge, B.S., Retired Fisheries Biologist, Washington Department of Fish and Wildlife.

Nathan J. Mantua, Ph.D., Research Scientist, Joint Institute for the Study of the Oceans and Atmosphere, University of Washington, Seattle, WA.

Jack W. Berryman, Ph.D., Professor, University of Washington School of Medicine, Seattle, WA and Journalist, with membership in the Outdoor Writers Association of America and the Society for Environmental Journalists.

Larry B. Doyle, B.S., Retired Engineer, Lockheed.

Acknowledgments

The authors would like to thank the following individuals for contributing information for the content of this report: WSC Members, Carl Ostberg and Rich and Ingrid Simms; Washington Department of Fish and Wildlife Staff, Bob Leland, Bill Gill, Terry Manning, Peter Hahn, and Randy Cooper. We also thank Bob Hooton, Bill McMillan, John McMillan, Kaitlin Lovell, Bill Redman, Clint Munns, Curt Kraemer, and Ramon VandenBrulle for their critical and constructive comments and suggestions for revising an earlier draft of this report.

Cover design by Jeff Bright and Rich Simms

Table of Contents

1. Executive Summary

Wild steelhead populations are in the midst of a long-term crisis across most of Washington's waters. Except for a handful of stocks on the Olympic Peninsula and in Southwest Washington rivers, wild steelhead in Washington have been in a prolonged period of serious decline. Today, the majority of Washington's wild steelhead stocks are either listed under the federal Endangered Species Act (ESA), chronically failing to meet habitat-related escapement goals, or are in a period of declining abundance. Wild steelhead declines in Washington are just one part of a much broader pattern of decline. In the past century, the entire Pacific Northwest has witnessed catastrophic declines in wild salmonid populations and productivity due to a combination of degraded freshwater and estuarine habitat, poor hatchery practices, hydropower dams, natural cycles in riverine and ocean carrying capacity, and management and harvest policies.

In the mid 1950s, over 125 Washington rivers were producing wild steelhead harvests. Recently there have been only 11 Washington rivers open to wild fish harvest due to ESA listings and low spawner escapements. In the mid-1950s, 120,000 to 160,000 wild steelhead were annually harvested by Washington sport fishers (WDG, 1956 and 1957). In the Skagit Basin alone, annual harvests in the 1950s ranged from 11,000 to 22,000 mostly wild steelhead (WDW, 1994). During the 2002/2003 fishing season, Washington sport fishers harvested only 3,554 wild steelhead from all Washington rivers combined, with the vast majority of that harvest coming from a few river systems on the Olympic Peninsula.

History shows that *Maximum Sustained Harvest* (MSH) concepts, the ruling management philosophy for Washington's wild steelhead, when applied as harvest policies, are a prescription for periodic and long-term escapement failures and fishery closures. The high harvest rates promoted by MSH management aim to keep spawner numbers low. MSH harvest rates are based on an attempt to maximize annual harvests and not on protecting the long-term resilience of the target fish populations. For Washington's wild steelhead, the combination of harvest-driven low escapements with unrecognized and/or unpredictable natural changes in river and ocean productivity results in run-sizes that often fail to meet escapement goals. As a consequence of chronically depleted run-sizes, the health and resilience of the steelhead populations are jeopardized.

MSH policies meet the management objectives of providing substantial harvest opportunities without compromising stock productivity only during periods of high productivity. It is clear that productivity varies in space and time due to both human and climate-related changes in river, estuary, and ocean conditions. Likewise, it is also apparent that healthy steelhead populations exhibit a great deal of diversity in life history types, and that this diversity is critical for maintaining population resilience in a variable environment. In contrast, the MSH concept is focused only on numbers of fish, not diversity, and it fails to account for time-space changes in productivity. The flaws in the MSH concept are unfortunately demonstrated in streams like those on Hood Canal and South Puget Sound where wild steelhead populations plummeted one to two decades ago and still remain at low abundance levels in spite of prolonged harvest closures.

An additional serious problem with MSH concepts as they are applied to Washington's steelhead is that the data used to develop escapement goals is based on the run-sizes and productivity starting in 1976. Significant here is that severe declines for many stocks were already well underway. As an example, the annual harvest on the Skagit River in the 1950s (when spawner escapement was not counted or included as part of the run) was often higher than the total runs (harvest plus wild escapement) in the years after 1976. Contrary to the scientific underpinnings of the MSH concept of compensation, many of Washington's rivers with very low wild steelhead spawner populations have failed to rebound and refill the now underutilized river habitat. The end result is an unnatural and undesirable poverty for both the people and the ecosystems in these steelhead-poor watersheds.

The Wild Steelhead Coalition (WSC) believes that continuing to manage with the present MSH policies places the remaining few healthy stocks at an undue, unnecessary, and unacceptable risk of over fishing and fishing closures. MSH policies consequently put the wild steelhead populations on the Olympic Peninsula rivers at risk of collapse and place Olympic Peninsula steelhead fisheries at risk of closure if (and likely when) productivity declines from the high levels experienced in the recent past. With this probable occurrence, all wild stock fisheries in Washington may be closed to fishing.

The four pillars supporting the health of wild anadromous fish populations are *abundance, life history and genetic diversity*, *productivity*, and *spatial distribution*. Each of these pillars supports the inherent *resilience* of a steelhead population. Resilience, in this context, is the capacity for a steelhead population to bounce back from short periods of low abundance. The MSH concept runs counter to three of these pillars – abundance, diversity, and distribution – and by doing so also undermines the fourth key pillar, productivity.

Washington's existing habitat-related stress on our salmonid populations is periodically amplified by natural downturns in productivity related to changes in ocean conditions, regional drought, extreme flooding, and landslide episodes. Layering MSH harvest policies upon the highly degraded habitat and the largely unpredictable changes in ocean and river flow conditions amounts to a management philosophy that errs strongly on the side of providing maximum numbers of wild steelhead for harvest at the risk of seriously depleting spawner abundances and diversity. The high harvest rates that come with MSH fisheries remove the least productive and most heavily fished components of the stock as a whole, thereby reducing the abundance and life history diversity of the stock complex. The reduced abundance and reduced life history diversity lead to a reduced spatial distribution of spawners. This combination results in a "quadruple threat" to the long-term health of wild steelhead stocks.

The Wild Steelhead Coalition believes that the time is past due for the co-managers to adopt management approaches that err on the side of protecting wild steelhead resilience in order to protect and restore the wealth that wild steelhead bring to our watersheds. To that end, the WSC believes that optimizing the balance between providing quality steelhead fishing opportunities and protecting wild steelhead ecosystems begs for a shift away from the MSH policies of the past towards a greater use of Wild Fish Release (WFR) and selective gear regulations. Increasing the use of WFR while reducing harvest will yield immediate economic benefits in the form of maximizing recreational seasons and quality fishing opportunities. At the same time, a shift towards a greater emphasis on WFR policies will yield immediate ecological benefits by vastly reducing fishing impacts on the abundance, life history and genetic diversity, productivity, and spatial distribution of adult spawner populations. Additional benefits will also come from a greater use of selective gear regulations, which will increase the protection for resident rainbow trout, rearing parr, migrating smolts, and resident fish of other species that are integral parts of steelhead ecosystems. Shifting away from MSH policies towards an increased emphasis on WFR and selective gear regulations will also offer significantly better trade-offs in the constant management challenge to optimize the balance between fishing impacts on wild stocks and providing quality fishing opportunities.

The Wild Steelhead Coalition has developed a management plan for wild steelhead based on the science, principles, and angler support detailed in this report (see Section 7 for the complete plan). This plan provides for improved conservation of healthy stocks and recovery of those that are now depleted, with goals to rebuild all stocks to a higher abundance and greater diversity. It also allows for high stock productivity periods to help maintain viable populations and quality fisheries through the low productive periods. We also suggest limited harvest fisheries on wild fish when their abundance is 50% above the minimal escapements prescribed by MSH models. Reformed hatchery production should continue to provide the "lion's share" of the steelhead harvest so that wild fish runs can sustain, remain healthy, and provide for quality WFR full-season fisheries. The plan also provides management tools for maintaining the important life history diversity and the recovery of depleted seasonal runs and resident spawners with suggestions to protect steelhead parr and smolts, and other species of resident fish. The plan further contains sections on hatchery reform and river specific harvest tags to help the WDFW maintain compliance with catch regulations.

A shift away from a focus on maximizing the harvest of wild steelhead to a focus on maximizing the wealth that wild steelhead bring to their watersheds is a long term philosophy that promises to benefit the overall health of Washington's wild steelhead. This benefit has already attracted the widespread support of the citizens of Washington State.

The reader is referred to Appendix 1, which contains definitions for some of the technical terms used in this report, and to Appendix 2, which explains how and why we applied the sport harvest data from the 1950s.

2. Introduction

Steelhead fishing has been a long and noble tradition in Washington and in 1969; the Legislature adopted the steelhead trout as a state symbol. Numerous books, magazines, lectures, museum exhibits, equipment, merchandise, and businesses have been devoted to steelheading over the years and steelheaders are some of the most devoted anglers in the region. In fact, Jeff Koenings, Director of the Washington Department of Fish and Wildlife (WDFW), noted that the steelhead is "one of the icons of the Pacific Northwest. It's like the orca. It's almost like a religion. There's a real interest in keeping steelheading going" (Mayor, 2003).

The management of Washington's wild steelhead populations is one of the many activities carried out by the WDFW, but since the 1970s as hatchery production increased and numbers of wild steelhead decreased, the Department has come under fire for its wild stock management practices. Management of both hatchery and wild stocks for maximum harvest, coupled with lost and degraded habitat and the unpredictable natural cycles in river and ocean productivity, have sent steelhead stocks plummeting.

This should come as no surprise. The historical record of salmon documented by University of Washington professor David Montgomery in his book, *King of Fish: The Thousand-Year Run of Salmon* (2003), clearly shows that the once large runs of Atlantic salmon in Europe and eastern United States have nearly disappeared. Concerned individuals decried this gradual loss as it was happening, but nothing of any significance was ever done to save the fish. Now, most wild Atlantic salmon are gone. (Montgomery, 2003)

Here in the northwest, similar alarm was beginning during the early years of the twentieth century and, by the 1930s, keen observers began to warn of the declining salmon and steelhead runs. For example, in Roderick Haig-Brown's early classic report, *The Western Angler: An Account of Pacific Salmon & Western Trout in British Columbia* (1939), he noted that:

> "At no time in the history of the continent has a check been applied soon enough to the destruction of a natural resource… The continent was nothing more than a series of natural resources – land, timber, fur, fish and game. Each resource was capable of a certain maximum yield until the resource itself was no longer large enough to provide a useful natural increase" (Haig-Brown, 1939).

Others have voiced the same message since then, but none more forcefully than Bruce Brown in *Mountain in the Clouds: A Search for the Wild Salmon* (1982). Twenty-four years ago, Brown wrote about "an environment in crisis" and referred to the plight of the wild Pacific salmon as "the abuse of our natural heritage." For Brown, as well as many more recent advocates for wild fish, the decline and even disappearance of specific traditionally large runs of salmon and steelhead marked a significant turning point in the ever-increasing intervention of man into the life cycle of these magnificent fish that are at the very center of Pacific Northwest culture, history, ecology, economics, and lore (Brown, 1982).

More recently, in 1999, fisheries biologist Jim Lichatowich also cited specific reasons for the decline of Pacific Northwest stocks of salmon and steelhead in his highly acclaimed book, *Salmon Without Rivers: A History of the Pacific Salmon Crisis*. He focused on habitat destruction, commercial fishing, and a dependence on hatcheries in his analysis and noted "unless we recognize the real roots of the salmon's problem and deal with it at that fundamental level, the fish will continue their slide toward extinction." (Lichatowich, 1999)

Continued declines in wild steelhead populations during the past few years served to rally some of the more conservation minded angling groups. They called for mandatory release of all wild steelhead statewide with no exceptions in 2000 and 2001 and appealed to Washington's Fish and Wildlife Commission for sport fishing rule changes. In 2002, the Commission voted unanimously to limit the wild steelhead kill to one per day and five per year in those rivers still open to the harvest of wild fish. Then, in 2004, the Commission voted to impose a two-year moratorium on killing wild steelhead, despite the fact that WDFW Director Koenings argued that the Department's position " is where you have healthy runs, you should have the opportunity to catch and keep a wild steelhead." The moratorium was appealed and the Commissioners held a public hearing on the issue in late August 2004. WDFW staff biologists recommended re-implementing the previous regulation, which permitted anglers to kill one wild steelhead per day and five per year on about a dozen rivers on the Olympic Peninsula. Public testimony was about three to one in favor of continuing the moratorium, and more than half of those in favor of wild steelhead release suggested that it should be a permanent rule. A WDFW

Commission vote was taken on September 2, 2004 and they voted six to three to limit the killing of wild steelhead to one fish per year per angler on twelve of the state's rivers. The new regulation went into effect on October 3, 2004 (Berryman, 2004; Mayor, 2003; Berryman, 2005).

The Wild Steelhead Coalition has studied the historic decline of wild steelhead and believes it is time for sportsmen to stop killing the few remaining wild stocks until the WDFW develops a more conservative management plan that provides improved protections for wild steelhead and their ecosystems. Specifically, we advocate a shift away from a focus on maximizing harvests through large hatchery programs and MSH-defined escapement goals for wild steelhead to a new philosophy that focuses on protecting and restoring wild steelhead resilience through reduced harvest rates on wild fish, an increased protection for resident stream fish via a greater application of selective gear regulations, and hatchery reform.

There is still time to change and to learn from history. We are reminded of the sage advice and warning provided by noted fisheries biologist W.F. Thompson almost forty years ago. As the former Director of the International Pacific Salmon Fisheries Commission and later Director of the School of Fisheries at the University of Washington, Thompson noted:

> "We regulate our fisheries…. but we concentrate them on the best races, and one by one these shrink or vanish, and we don't even follow their fate…. knowing only that our total catches diminish, as one by one small populations disappear unnoticed from the greater mixtures that we fish….so we greatly underestimate what is needed or when it is needed and feel self-righteous about our conservation" (from Lichatowich, 1999).

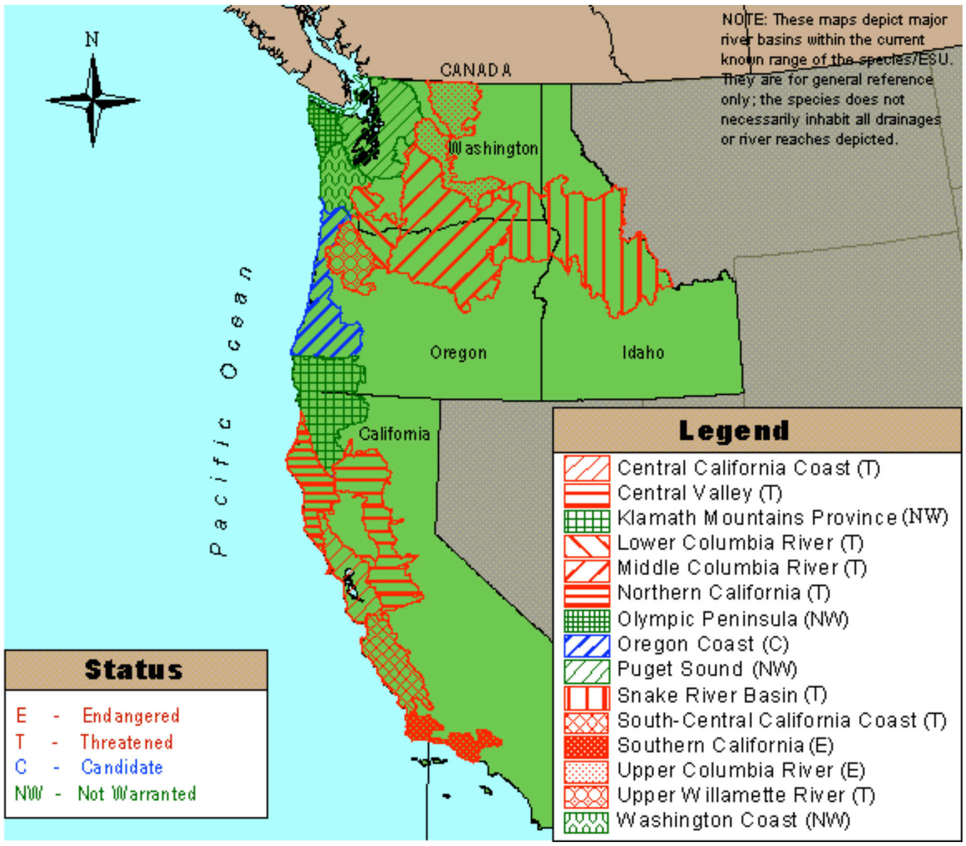
The remainder of this report contains an up-to-date review on the status of Western Washington's wild steelhead stocks, the many problems of managing at MSH levels, and recommendations for a new management plan. Section 3 is a status review of federal ESA listings for west coast wild steelhead. Section 4 presents a river-by-river status review of WDFW's historical run size, harvest, and escapement data for Western Washington's wild steelhead. Harvest impacts on Olympic Peninsula rivers are discussed in Section 5, the issues and problems of MSH management are reviewed in Section 6, and the Wild Steelhead Coalition's recommendations for wild steelhead harvest policies and a new management plan are presented in Section 7.

3. Status of Wild Steelhead on the West Coast

In 1991, the American Fisheries Society identified 214 salmon and steelhead stocks in California, Oregon, Idaho, and Washington that were depleted (Nehlson, et al., 1991). Forty-four of those were wild steelhead stocks in Washington, including 23 winter stocks and 21 summer stocks.

In 1996, NOAA fisheries separated west coast wild steelhead populations in California, Oregon, Washington, and Idaho into 15 Evolutionary Significant Units (ESUs), or regional population groups with similar genetic, evolutionary, and reproductive traits. These separate distinctions allowed evaluation and listing, as necessary, of each ESU under the Endangered Species Act (ESA). As of August 2005, the NOAA internet site: http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm, shows 12 of the 15 ESUs were either listed or were candidates under review (see Figure 1). Two of the 15 units were listed as ***endangered*** (in danger of extinction), 8 of the ESU's were listed as ***threatened*** (at risk of becoming endangered), and the coastal Oregon ESU and the Puget Sound ESU remained under further review.

Figure 1. Steelhead ESU listings map showing NOAA Fisheries status designations under the Endangered Species Act. (Accessed July 13, 2004 from: http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm)



In British Columbia, the general trend over the length of the province's coast since the late 1990s has been a dramatic decline in steelhead abundance in southern regions, a less dramatic decline in the central coast region, and relative stability among stocks further north. Compelling evidence that persistent low marine survival is the limiting factor in the southern region comes from a thirty-year research program on the Keogh River on northern Vancouver Island. Winter steelhead returns in 2004 appeared to be at or near all time lows in several of the index streams within the Georgia Basin and the west coast of Vancouver Island area (Hooton, 2004).

Today, the majority of Washington's wild steelhead populations are either listed under the Endangered Species Act, chronically under-escaped, or in periods of population decline. Of Washington's 7 steelhead ESUs, 3 are now listed as threatened, (Lower

Columbia River ESU, Middle Columbia River ESU, and Snake River Basin ESU), 1 is listed as endangered (Upper Columbia River ESU), and the 3 other ESU's (Washington Coast, Olympic Peninsula, and Puget Sound) are classified as "ESA listing not warranted." However, in 2004, a petition was filed and later accepted for review with the US Department of Commerce, NOAA Fisheries, to list Puget Sound steelhead as an endangered or threatened species under the Endangered Species Act (Wright, 2004a). The above listed ESU's contain many Washington rivers once famous for their wild steelhead fishing and include the Snake and Salmon Rivers as well as their tributaries, the Clearwater, Grand Ronde, Wenatchee, Methow, Yakima, Klickitat, Cowlitz, Kalama, Lewis, Washougal, Wind and Columbia Rivers, to mention a few.

Publications from the turn of the 20th century indicate the commercial landings of steelhead averaged 8 to 15 pounds, depending on the locality taken, and were chiefly caught during January through March (Rathbun, 1899). Wilcox (1896) reported the yield from shore fisheries in 1895 to be 4,971,385 pounds, or about 430,000 steelhead. In the mid-1950s, over 125 Washington rivers were producing wild steelhead harvests. Recently there have been only 11 to 17 Washington rivers open to wild fish harvest due to ESA listings and low spawner escapements in the unlisted ESU's. In the mid-1950s, 120,000 to 160,000 wild steelhead were annually harvested by Washington sport fishers (WDG, 1956, 1957). In the Skagit River Basin alone, 11,000 to 22,000 mostly wild steelhead (WDW, 1994) were harvested in the 1950s[1]. In contrast, Washington sport fishers harvested only 3,554 wild steelhead during the 2002/2003 fishing season. Today, wild steelhead harvest is not allowed in the majority of Washington's rivers because of chronically low wild spawner escapements. In 2003, WDFW staff proposed closing 5 of the remaining 17 open rivers on the Olympic Peninsula to harvest because there was no information available to determine their condition. Nine of the 11 rivers remaining open comprise the 4 major river systems on the peninsula and 2 are very small rivers.

The statewide catch of wild steelhead declined from nearly 100% of the total catch (wild and hatchery fish) during the years before 1960, to about 20% of the catch during the1980s, and recently to only 2.3% during the 2002/2003 season (Table 1). This decline

---

[1] Please see Appendix 2 for a review of historical steelhead catch and run-size data discussed in this report.

in the wild fish percentage of the catch is due to the statewide depletion of wild steelhead and the increased production of hatchery fish. In Western Washington, where there are some harvest fisheries for wild steelhead, hatchery fish comprised 90.4% of the steelhead catch in 2002/2003.

Table 1. Statewide Hatchery and Wild Steelhead Sport Catch (Data collected from WDFW)

	1996/1997		1999/2000		2001/2002		2002/2003	
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
Total	80,029	9,276	71,184	6,802	184,220	6,786	153,293	3,554
Percent	89.6%	10.40%	91.3%	8.70%	96.4%	3.60%	97.7%	2.30%

Puget Sound and Coastal Catch Areas		
Wild % of Puget Sound and Coastal Steelhead Catch	9.1%	9.6%
Coastal Area Only		
Wild % of Coastal Steelhead Catch	15.0%	18.9%

In spite of the “not warranted” ESA determinations, wild steelhead have been chronically under-escaped in recent years in the majority of the Puget Sound and Southwest Washington ESU’s rivers. Only the Olympic Peninsula ESU consistently had wild steelhead returns that usually met or exceeded escapement goals in the past 15 to 20 years (the period when wild steelhead run-size and harvest data have been collected separate from hatchery harvest). Today, increasing harvest pressure poses a new and high risk to the long-term health of the steelhead populations on the major Olympic Peninsula rivers and most runs are showing recent declines.

4. Status of Wild Steelhead in Western Washington

Wild steelhead harvest and spawner escapement data was obtained from WDFW for Western Washington's rivers and are graphically presented and discussed in some detail in this section. Note that systematic data collections for wild steelhead harvests and spawner escapements did not begin until the mid-to-late 1970s. Between 1962 and the mid-1970s, harvest of wild and hatchery fish was combined on catch record card reporting and is not separable. While only a limited number of Washington rivers are represented in our graphs, we believe that the river systems selected for review offer a valuable and informative picture of the status of western Washington's wild winter run steelhead populations.

A. Puget Sound ESU

In the 2004 WDFW and Western Washington Treaty Tribes Salmonid Stock Inventory (SaSI), 5 stocks in this ESU were rated healthy, 19 were rated depressed, 1 stock was rated critical, and 20 stocks were rated unknown (Wilson, 2004).

The Puget Sound ESU (Figure 2), which includes a large number of rivers tributary to 5 geographical regions of Puget Sound including Hood Canal, the Eastern section of the Strait of Juan de Fuca, Bellingham Bay, South Puget Sound, and Central Puget Sound, had no rivers/stocks with adult returns making escapement goals in return years 2000, 2001, and 2002. In 2003, only the Skagit River made its required escapement (Figure 3). Generally speaking, wild winter steelhead run-sizes and escapements for Puget Sound stocks have been in decline since the late-1980s. Some stocks, such as those of the Skagit, the Stillaguamish (Figure 4), the Snohomish (Figure 5), and the Green River (Figure 6), had run sizes that recently fell below their respective escapement goals (1999 or 2000). Others, such as the Puyallup (Figure 7), the Nisqually (Figure 8), and the Cedar Rivers (Figure 9) declined below escapement around 1995 and have continued to decline to depressed levels with no sign of recovery.

The WDFW run reconstruction data shows very high harvest rates for many Puget Sound Rivers in the 1970s and early 1980s (Figures 3 through 9). For example, harvest rates of ~50% are indicated for the Snohomish River in 1981, the Cedar River in 1984 and 1985, the Green River from 1978-1981 and 1990, and the Nisqually River from 1980-1991. These high harvest rate fisheries clearly started earlier than the beginning of separate wild and hatchery steelhead data collection, and represent harvest rates in line with those typically allowed on Olympic Peninsula rivers for the past 25+ years.

Figure 2. Puget Sound Steelhead ESU. Figure obtained July 17, 2004 from: (http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm)

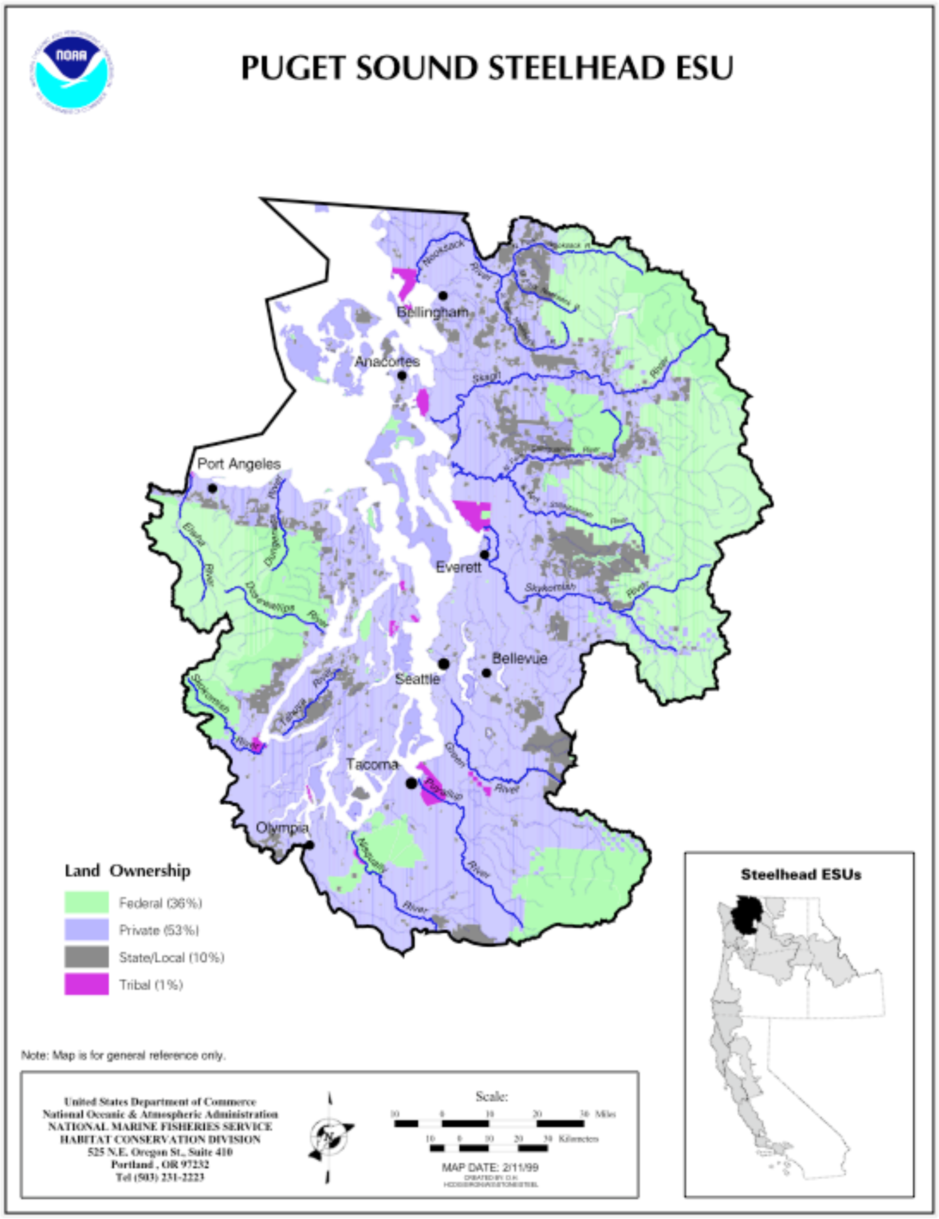


Figure 3. Skagit River Run Reconstruction Data

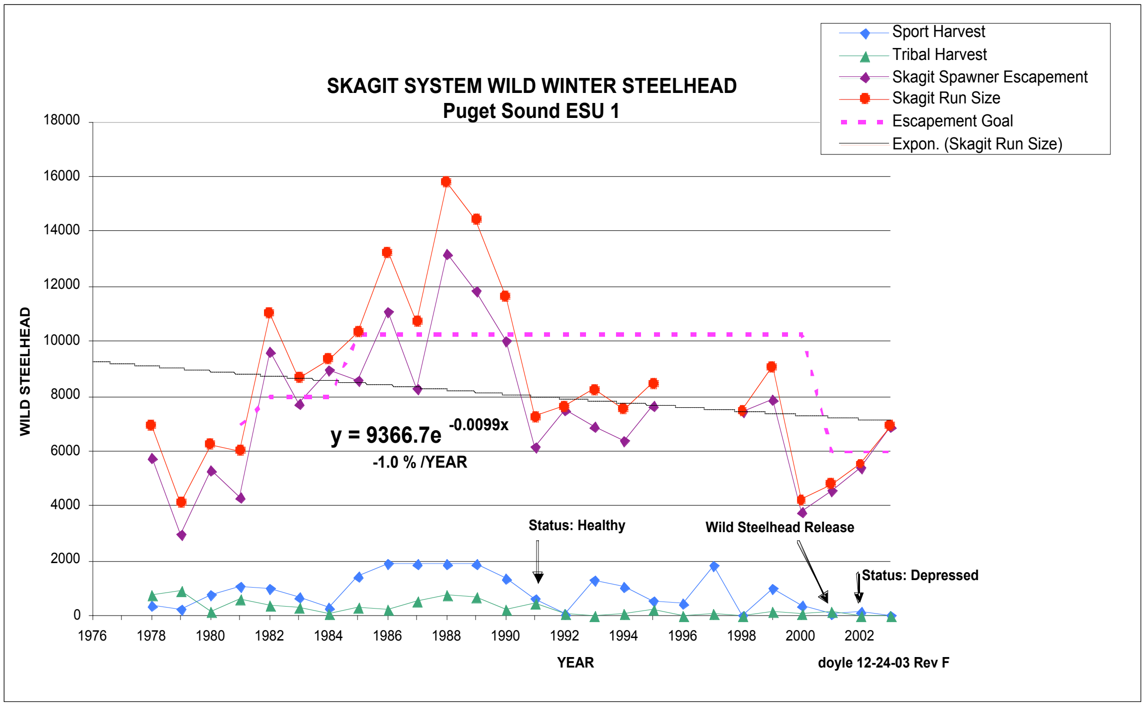


Figure 4. Stillaguamish River Run Reconstruction Data

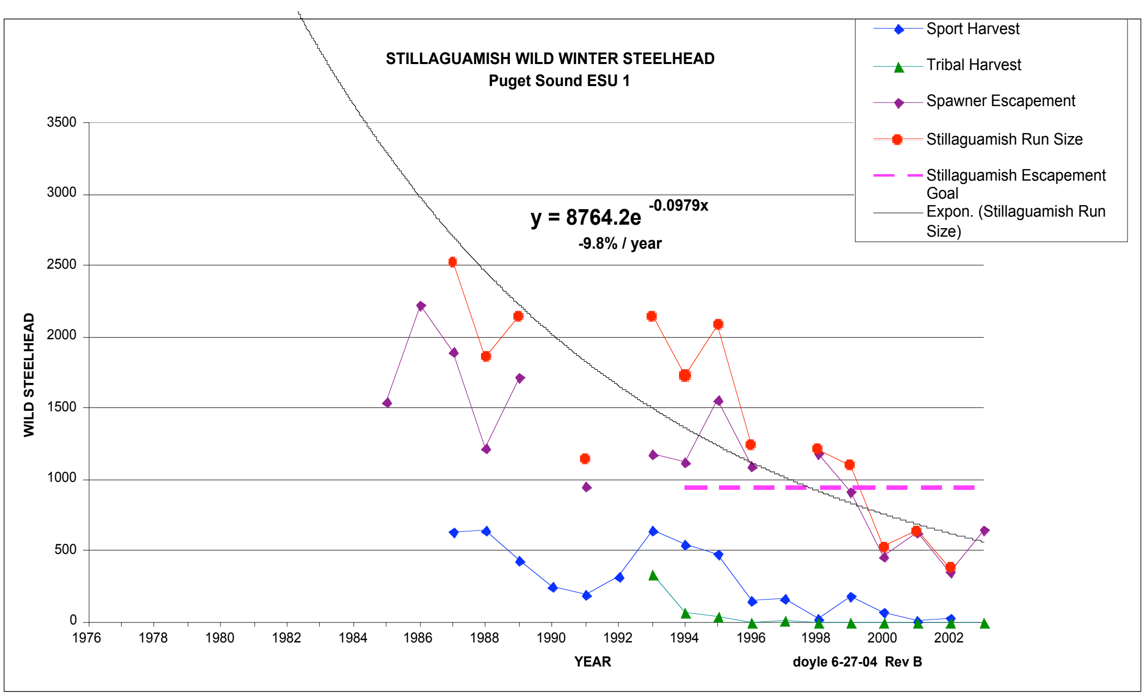


Figure 5. Snohomish River Run Reconstruction Data

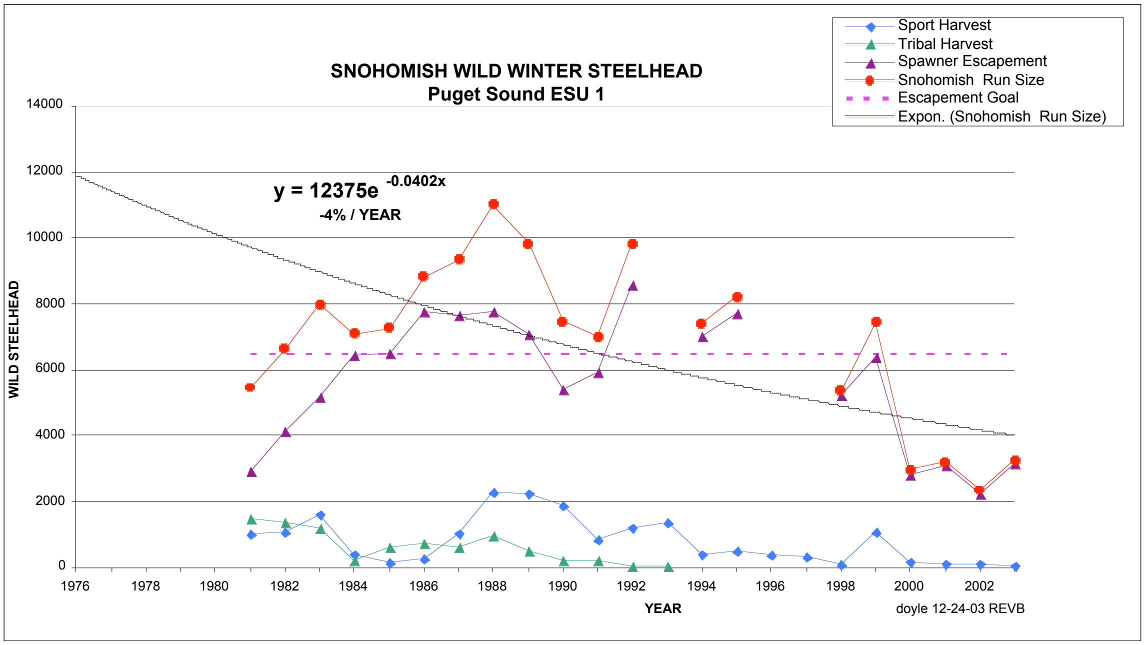


Figure 6. Green River Run Reconstruction Data

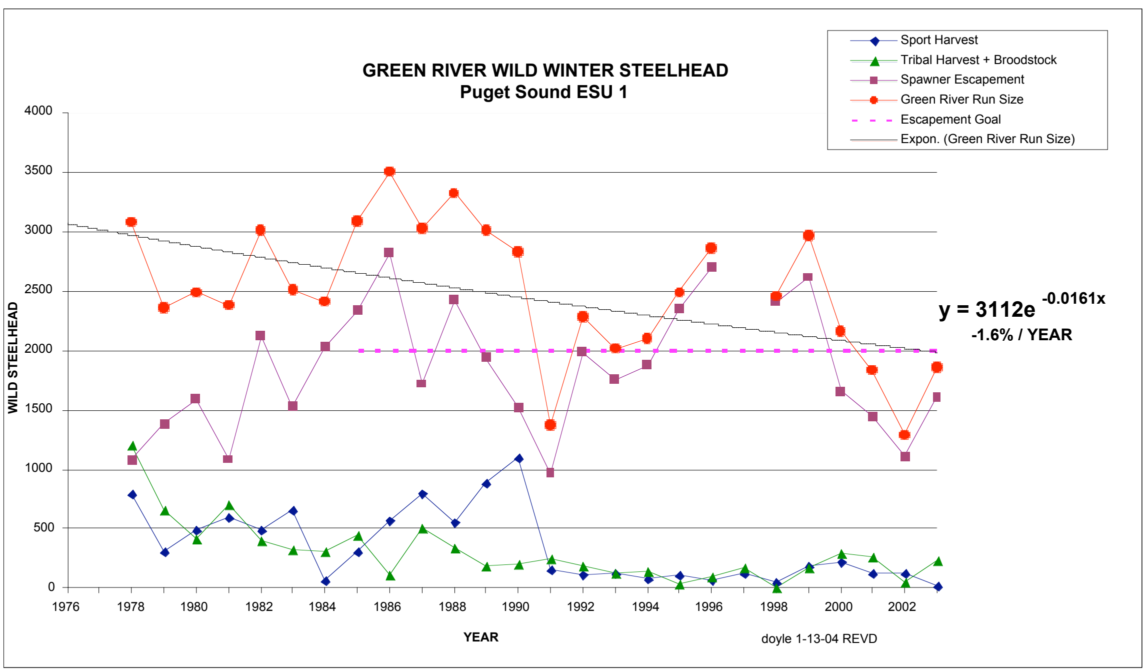


Figure 7. Puyallup River Run Reconstruction Data

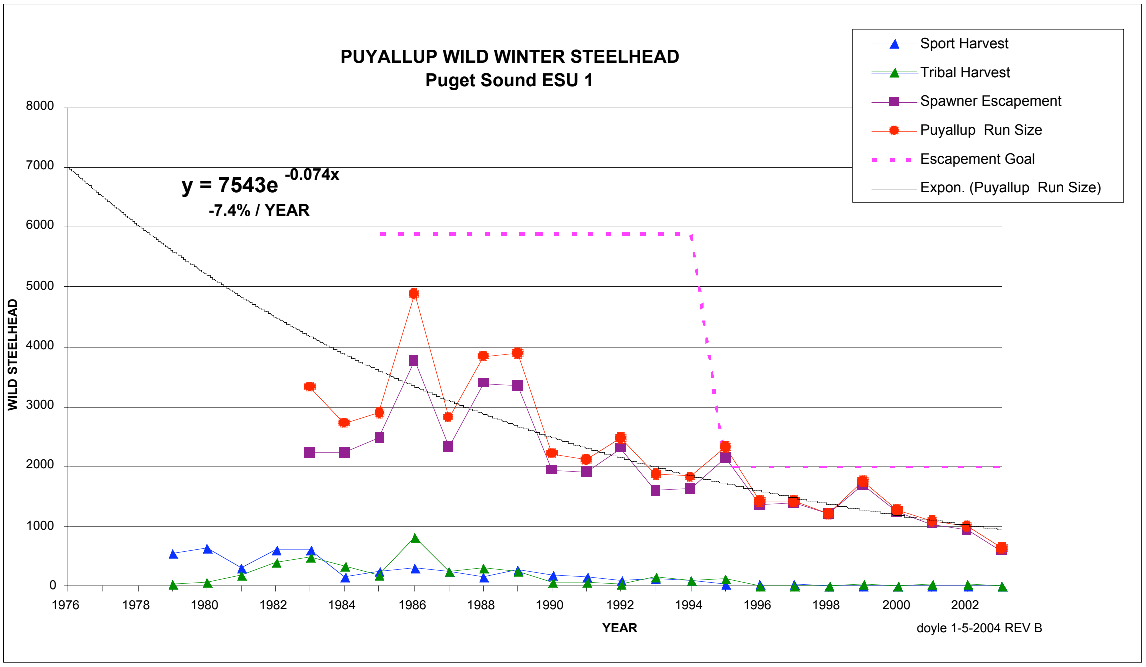


Figure 8. Nisqually River Run Reconstruction Data

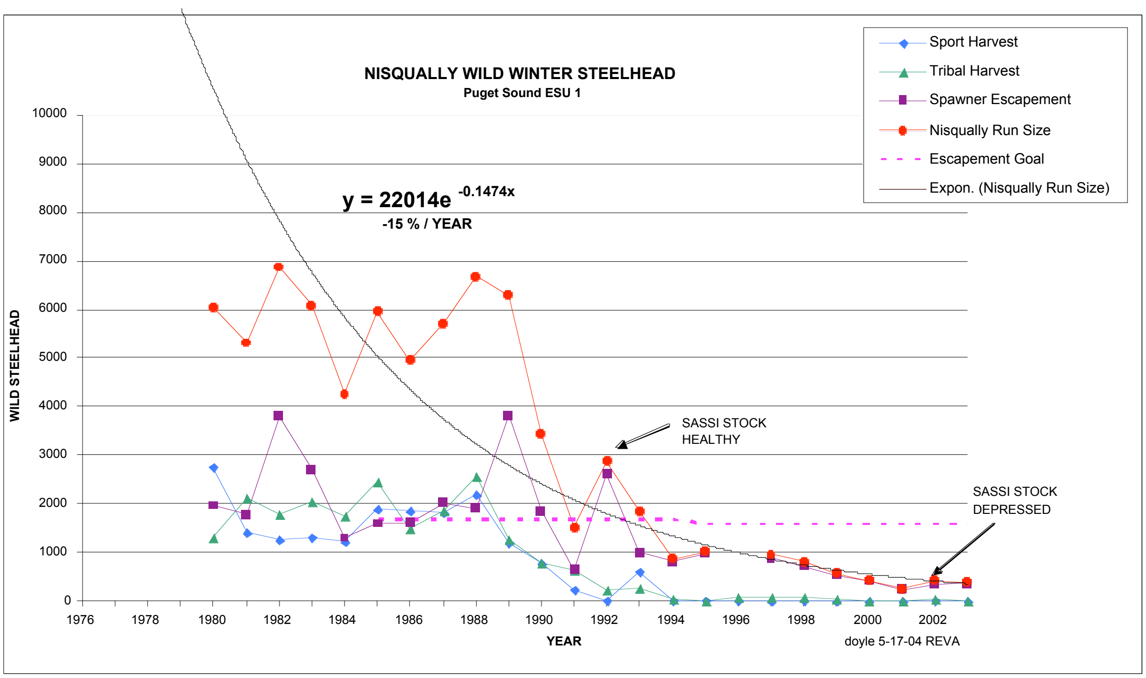
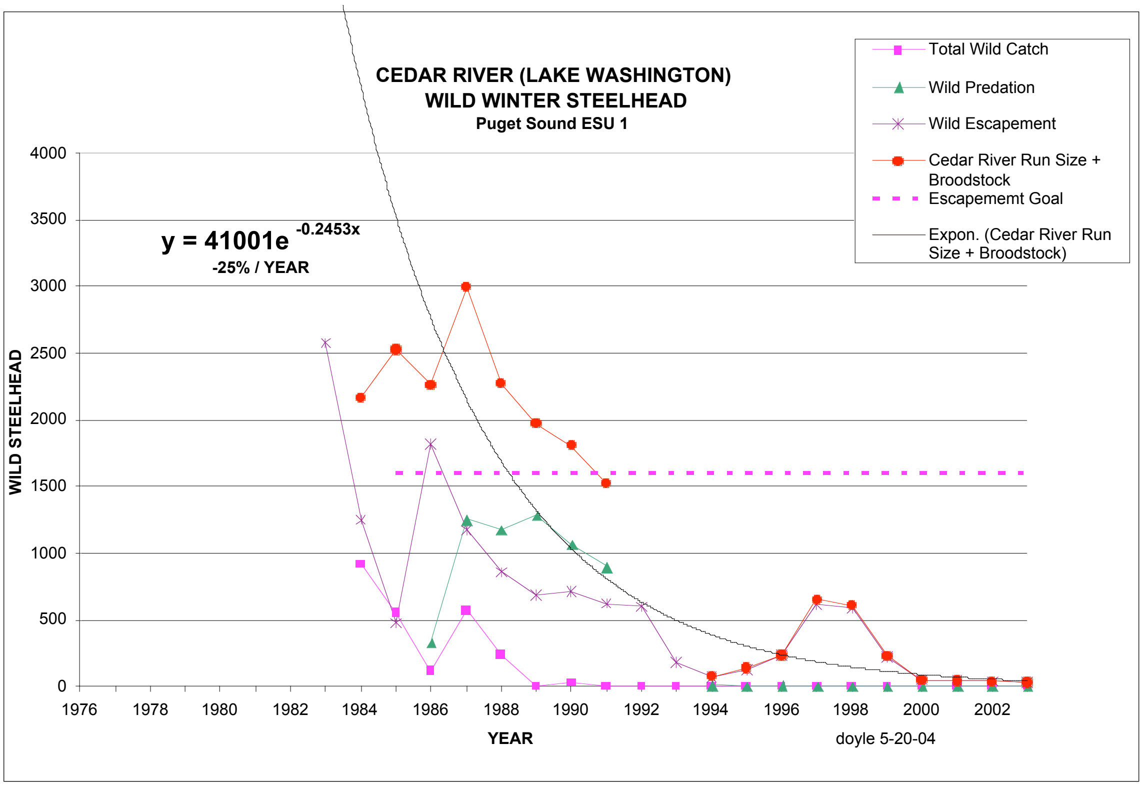


Figure 9. Cedar River Run Reconstruction Data



Rivers of Hood Canal (such as the Quilcene, Dosewallips, Hamma Hamma and Skokomish Rivers) and of the Eastern Strait of Juan de Fuca, including the Dungeness and Elwah Rivers, are all in the Puget Sound ESU and have been closed for many years to wild steelhead fishing due to depressed stocks.

Causes for the recent declines in Puget Sound steelhead productivity and abundance are not known, but retired WDFW fisheries biologist Curt Kraemer (2004) believes that exceptionally poor marine survival rates starting in the 1990s are a major contributing factor. It should also be noted that, even thought Puget Sound stocks have been in decline for at least 15 years, there have been no research or evaluation programs initiated by the agencies to investigate the causes for Puget Sound wild steelhead declines. In 2005, based on their concern for these stocks and the lack of government action, sport fishing groups initiated a smolt tracking study and contributed matching funds to investigate the reasons for this decline (Boynton, 2005).

Wild steelhead stocks in the southern region of British Columbia, considered similar and contiguous to Puget Sound in stock characteristics, topography, and geography, are experiencing similar steep declines. Stocks are in their lowest condition in 30 years and the limiting factor, based on 30 years of research on the Keogh River, has been attributed to low marine survival (Hooton, 2004). These stocks have not experienced the degree of habitat degradation of Puget Sound watersheds, but are exposed to similar weather and oceanic conditions that regulate the productivity of the two areas. There is no scientific explanation for why stocks in the Georgia Basin and Puget Sound are in a steep and very serious decline. However, if new research can determine the reason for the Puget Sound and Georgia Basin declines, it may assist agencies in preventing depletion of other stocks through improved management approaches.

Busby et al. (1996) evaluated the Puget Sound ESU for potential listing from data through 1994. Of the 21 independent winter stocks for which the Biological Review Team (BRT) had adequate adult escapement information to compute trends, 17 were declining and 4 were increasing during the available data series. While similar information was not available to assess the status of summer runs, there was a stated cause for concern regarding their sustainability. The BRT concluded (Busby, et al., 1996) that the Puget Sound steelhead ESU was neither presently in danger of extinction nor was likely to become endangered in the foreseeable future. However, the BRT also concluded that the recent trends in stock abundance were predominately downward; possibly due to recent climate conditions and that the trends of the two largest stocks (Skagit and Snohomish Rivers) had been upward.

One decade later, Wright (2004a) found Puget Sound had undergone additional and major declines. Four entire geographic regions-- Juan de Fuca Strait, Bellingham Bay, Hood Canal, and South Puget Sound-- were approaching functional extinction with no recent runs being large enough to be resistant to adverse environmental conditions and depensatory mortality risks. Only the Skagit River system still had a population with productive capacity that could withstand these biological risks. However, even the Skagit

River wild steelhead population has been in decline for decades and has fallen below its escapement goal in 3 of the last 5 years. In 2002, the WDFW reclassified the Skagit stock from healthy to depressed. Clearly, many of the stocks in Puget Sound are at risk of extirpation without further protection and some are now approaching or have reached, dispensatory mortality and functional extinction levels.

B. Southwest Washington ESU

Busby, et al., (2000), in the National Marine Fisheries Service review of the status of steelhead, found both the long term and short term trends of abundance and production in this ESU to be downward. Most rivers of the Southwest Washington ESU (Figure 10) are experiencing wild steelhead run-sizes and spawner escapements only slightly better than those of Puget Sound. Wild steelhead in the major tributaries of the Chehalis System (which contains the Chehalis, Wynoochee, and Satsop), failed to make escapement most years from 1989 to 1998 (Figure 11). The WDFW allowed only Wild Fish Release (WFR) fishing beginning in 1997 for the sport fishery, and harvest impacts were significantly reduced during the recent period of stock rebuilding. Stocks increased above their spawner escapement goals from 1999 to 2003.

Wild steelhead returns to the Humptulips River (Figure 12) experienced steep run-size and escapement declines from 1985 to 1997, falling from a high of about 7,000 to just over 1,000 wild fish. Spawner returns in the Humptulips increased in 2002 and 2003 and exceeded their escapement goal. As in the Chehalis system, WDFW allowed only WFR fishing on the Humptulips beginning in 1997 and improved runs can be seen since its inception in both rivers. Most of the other rivers or combined systems in this ESU have fallen well below their required escapements. We have included graphs of the Willapa Bay Systems (Figure 13) and Grays River (Figure 14) as examples.

Figure 10. Southwest Washington Steelhead ESU. Figure obtained July 17, 2004 from: (http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm)

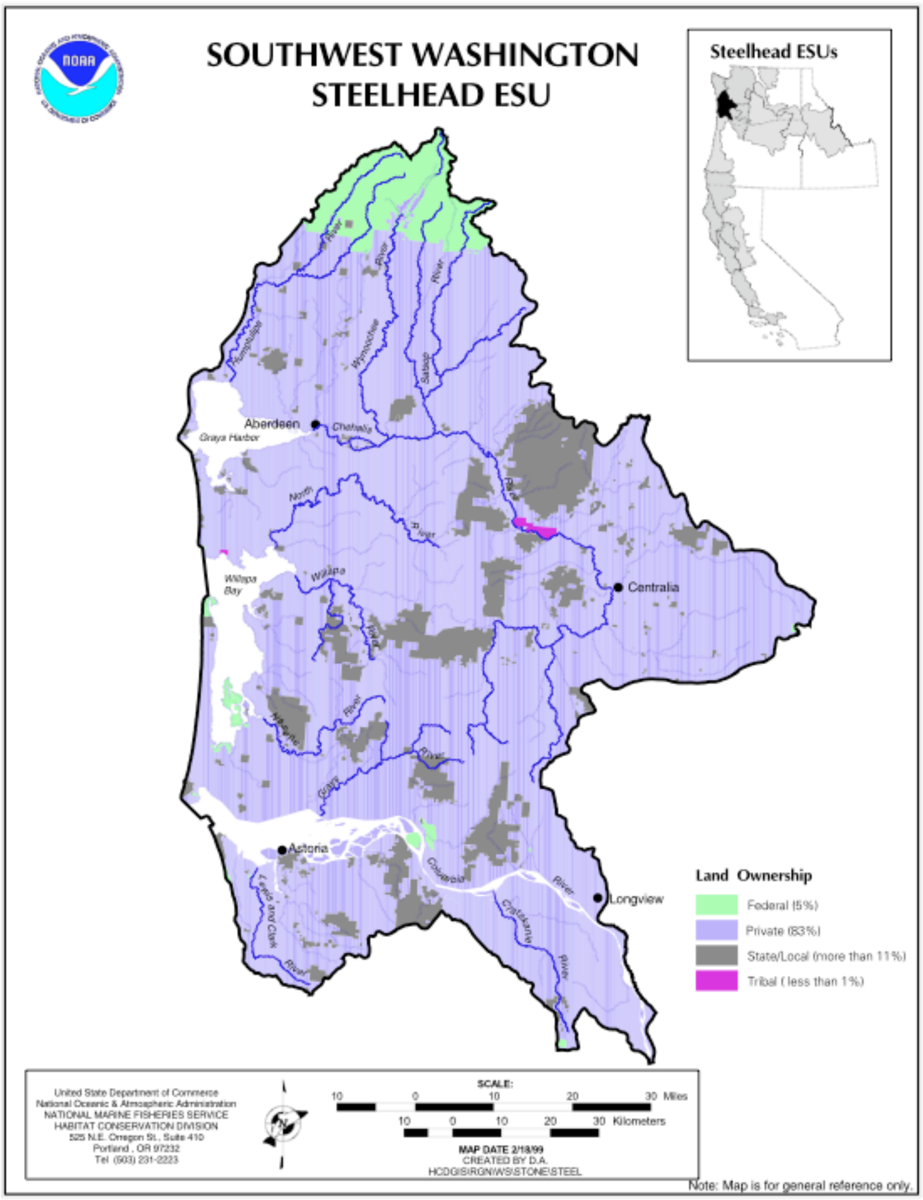


Figure 11. Chehalis System Run Reconstruction Data

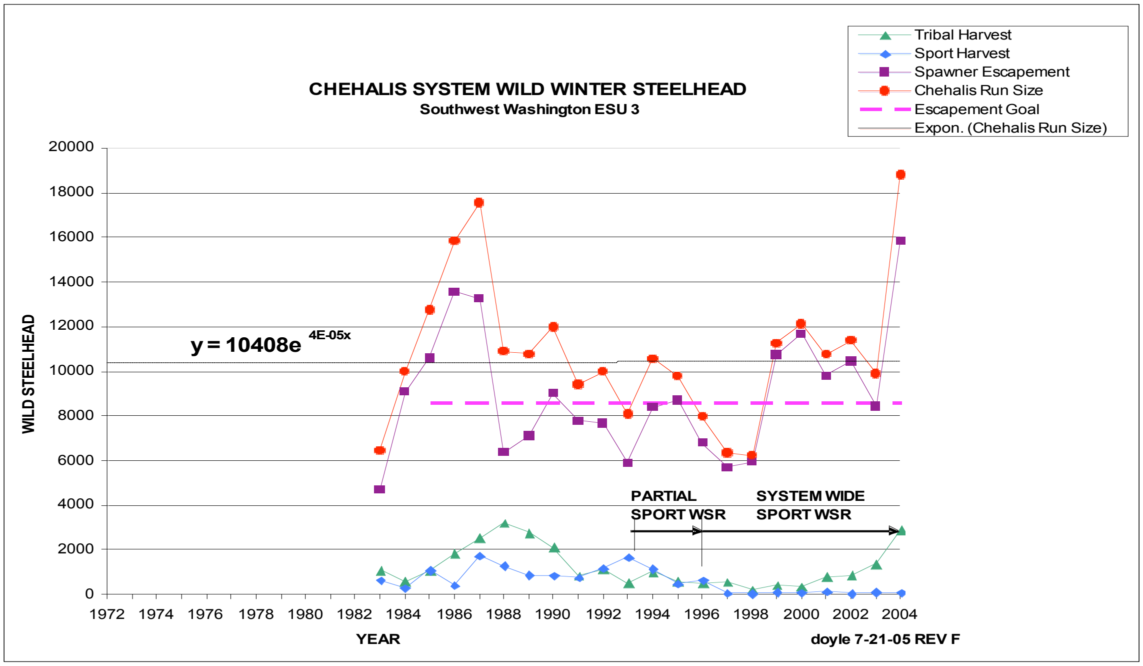


Figure 12. Humptulips River Run Reconstruction Data

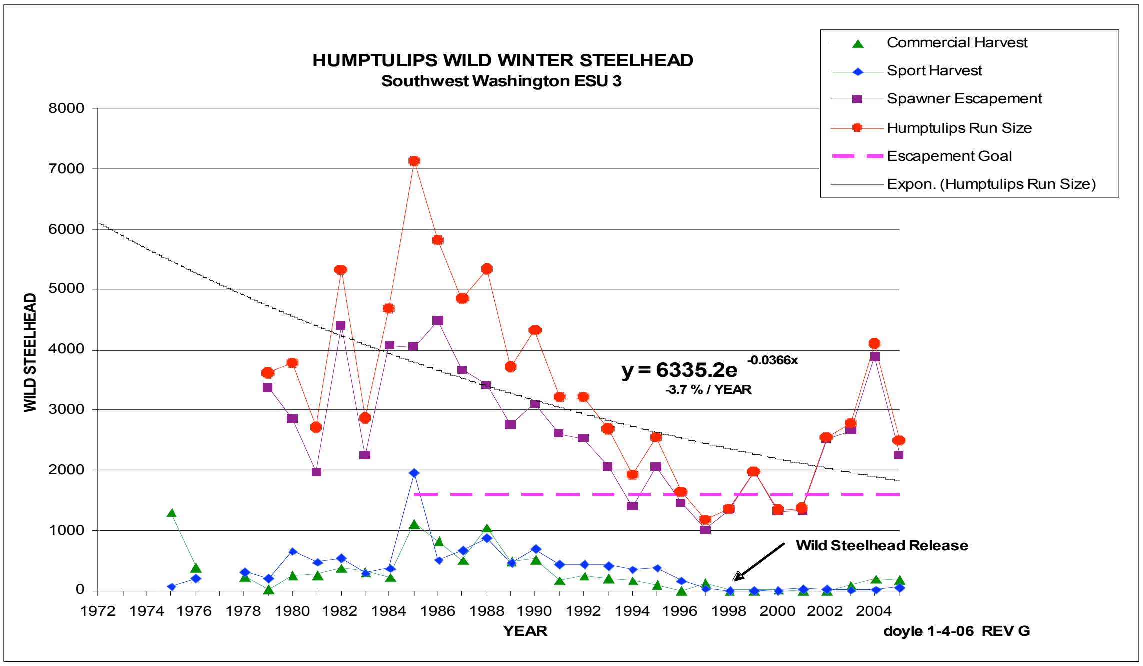


Figure 13. Willapa Bay Systems Run Reconstruction Data

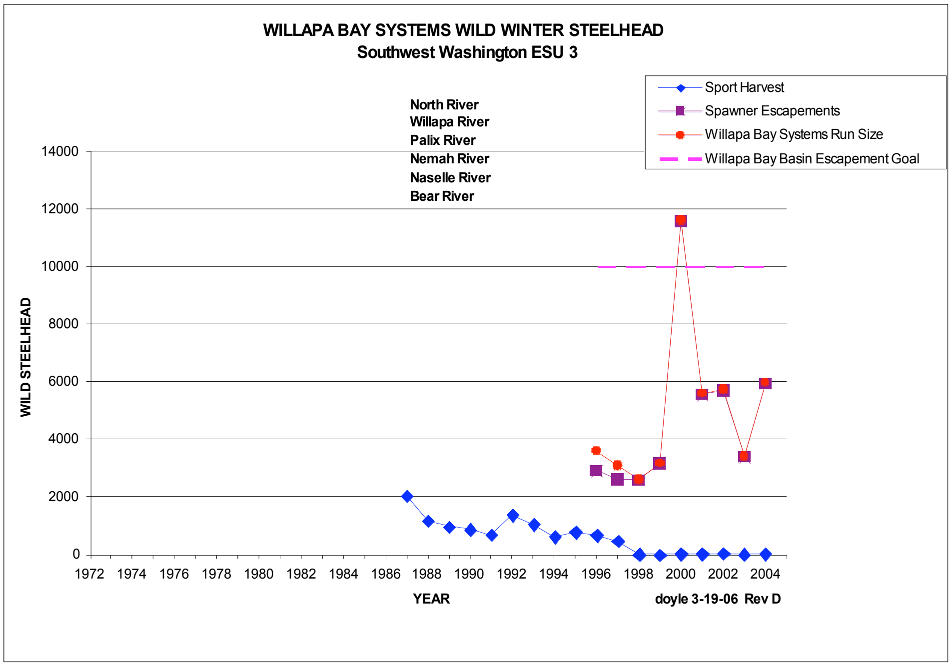
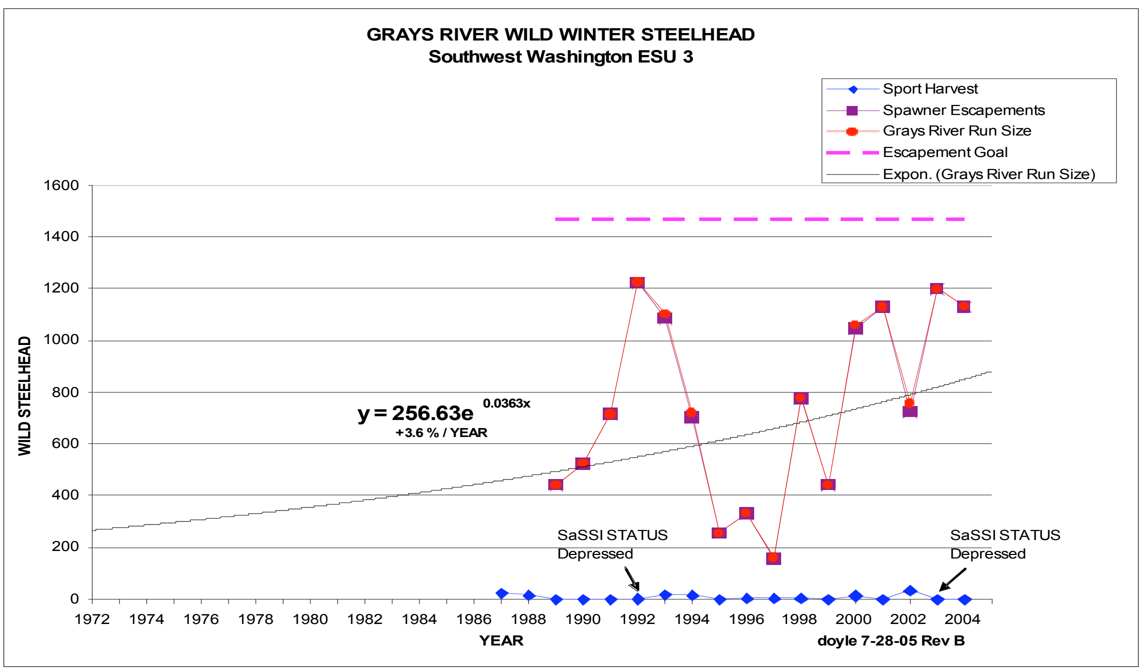


Figure 14. Grays River Run Reconstruction Data

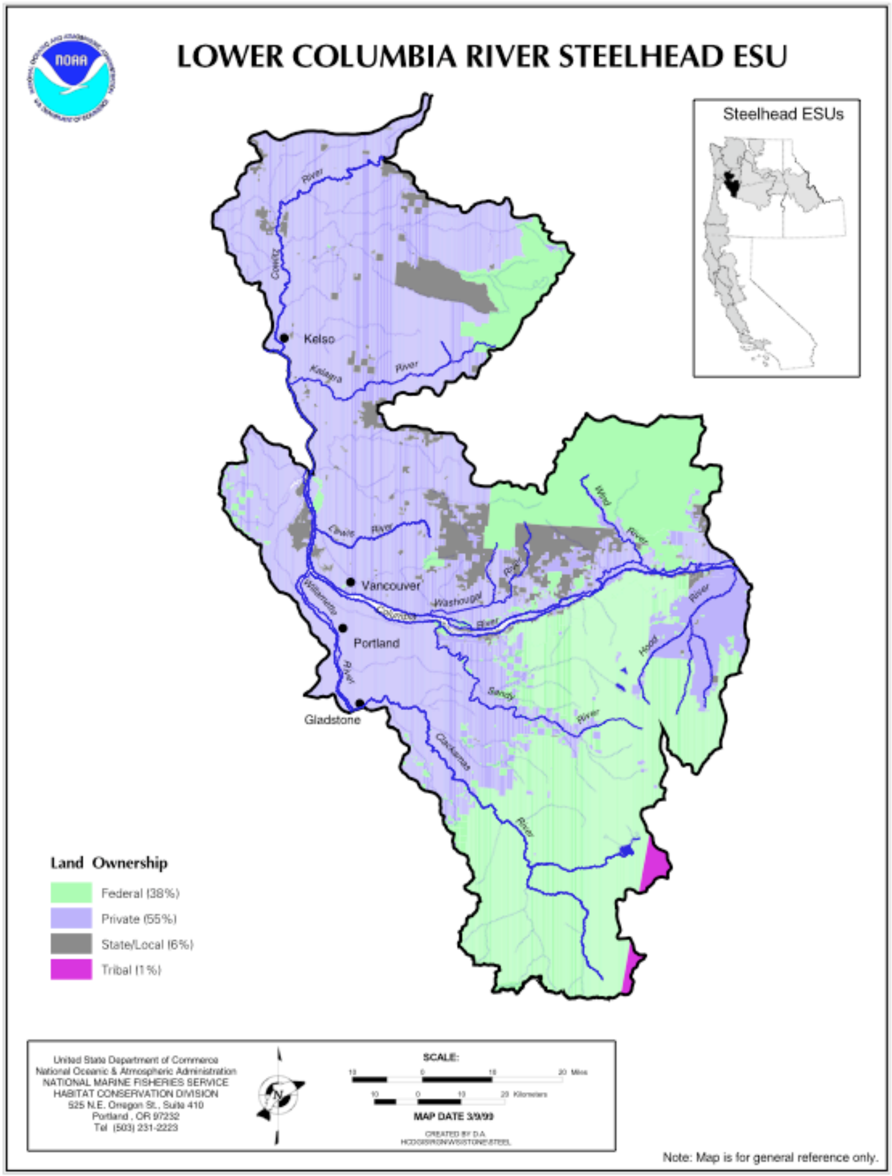


C. Lower Columbia ESU

The Lower and Middle Columbia River ESUs, as well as the Snake River Basin ESU, are listed as Threatened by NOAA fisheries. These areas contain the highest number of Depressed or Unknown stocks (mainly summer steelhead stocks) within Washington State (Wilson, 2004).

The latest Biological Opinion issued by the National Oceanic and Atmospheric Administration (NOAA, 2005) on the Lower Columbia ESU (Figure 15), included spawner abundance information for 11 rivers, 8 in Washington and 3 in Oregon. In Washington, the South Fork Toutle, Kalama, and Washougal Rivers have witnessed improved returns since ESA listing (with no harvest) to the point of making their required escapements. The North Fork Toutle, North Fork Lewis, and Toutle, have weak runs and have shown minimal progress towards recovery in the last decade, even while improved ocean survival is helping some of the other steelhead runs in rivers tributary to the Columbia River. The North Fork Lewis River has generally had fewer than 100 spawners since 1996, the North Fork of the Toutle has had fewer than 300 spawners most years and with some years less than 100, and the main Toutle has generally had fewer than 200 spawners.

Figure 15. Lower Columbia River Steelhead ESU. (Figure obtained July 17, 2004 from: http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm)



The Kalama River's wild winter run steelhead experienced a period of run declines from the early 1980s until the late 1990s (Figure 16). A Wild Fish Release regulation was instituted on the Kalama in 1990. Run sizes and spawner escapements increased each year from 1998 to 2003 and now significantly exceed the escapement goal. However, the Cowlitz System, a river that until recently produced catches of 1,400 to over 8,000 wild steelhead, has declined since 1996 to runs generally below 1,000 fish and less than 15% of its required escapement (Figure 17). The Coweeman, a tributary to the Cowlitz, fell to less than 10% of its required escapement in the 1990s and now continues to rebuild, but generally produces only 50% of the spawner requirement (Figure 18). The Washougal River was badly depleted during the late 1980s and 1990s and has recently had several years of higher escapement since closure of the harvest fishery. However, Washougal River run-sizes are still not large enough to sustain a fishery.

Figure 16. Kalama River Run Reconstruction Data

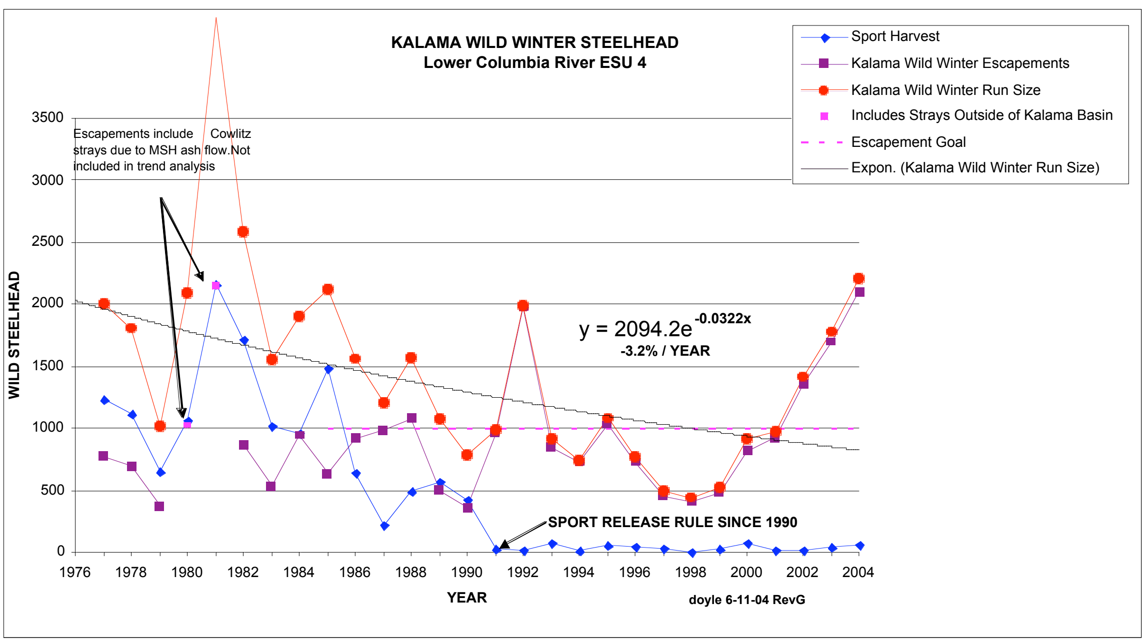


Figure 17. Cowlitz River Run Reconstruction Data

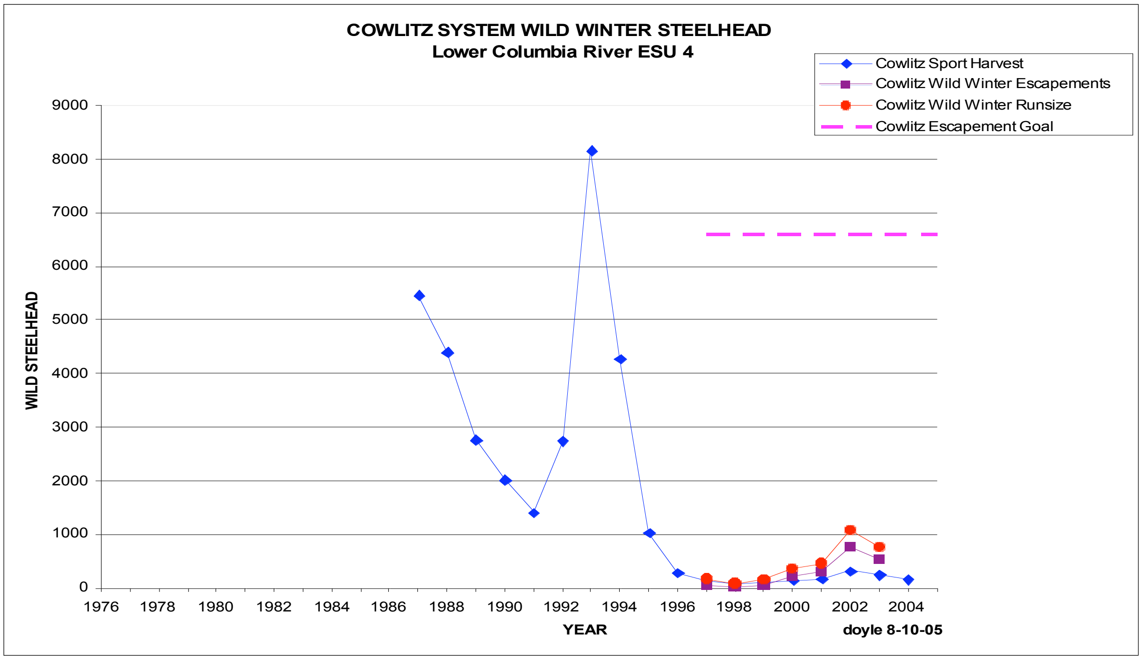
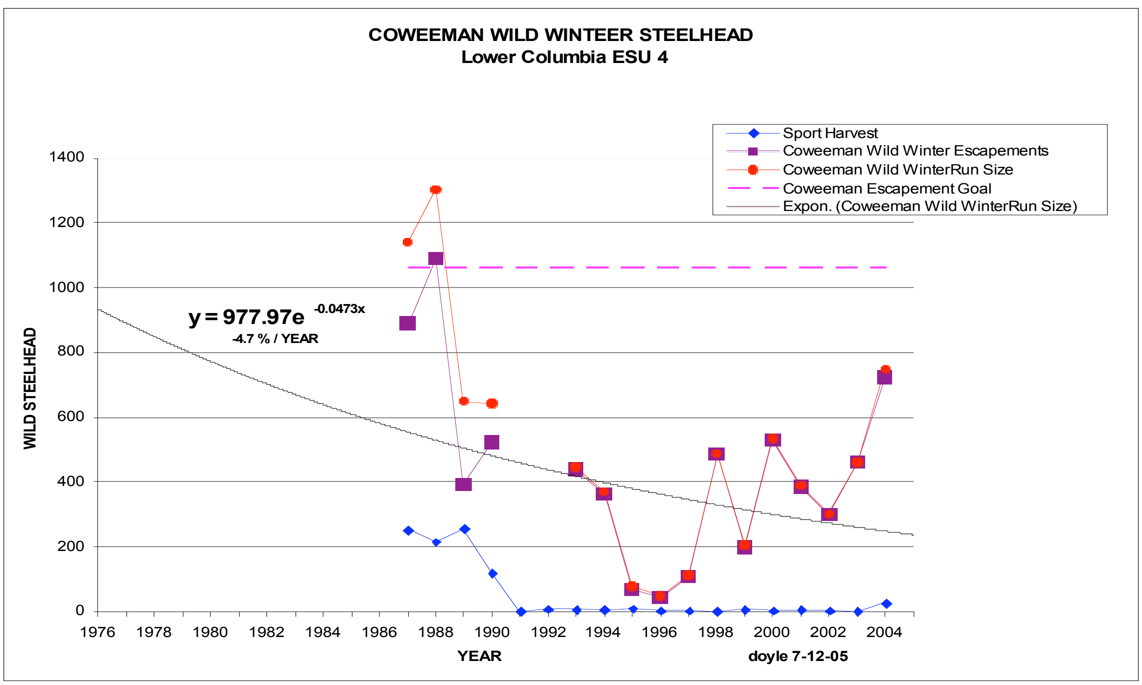


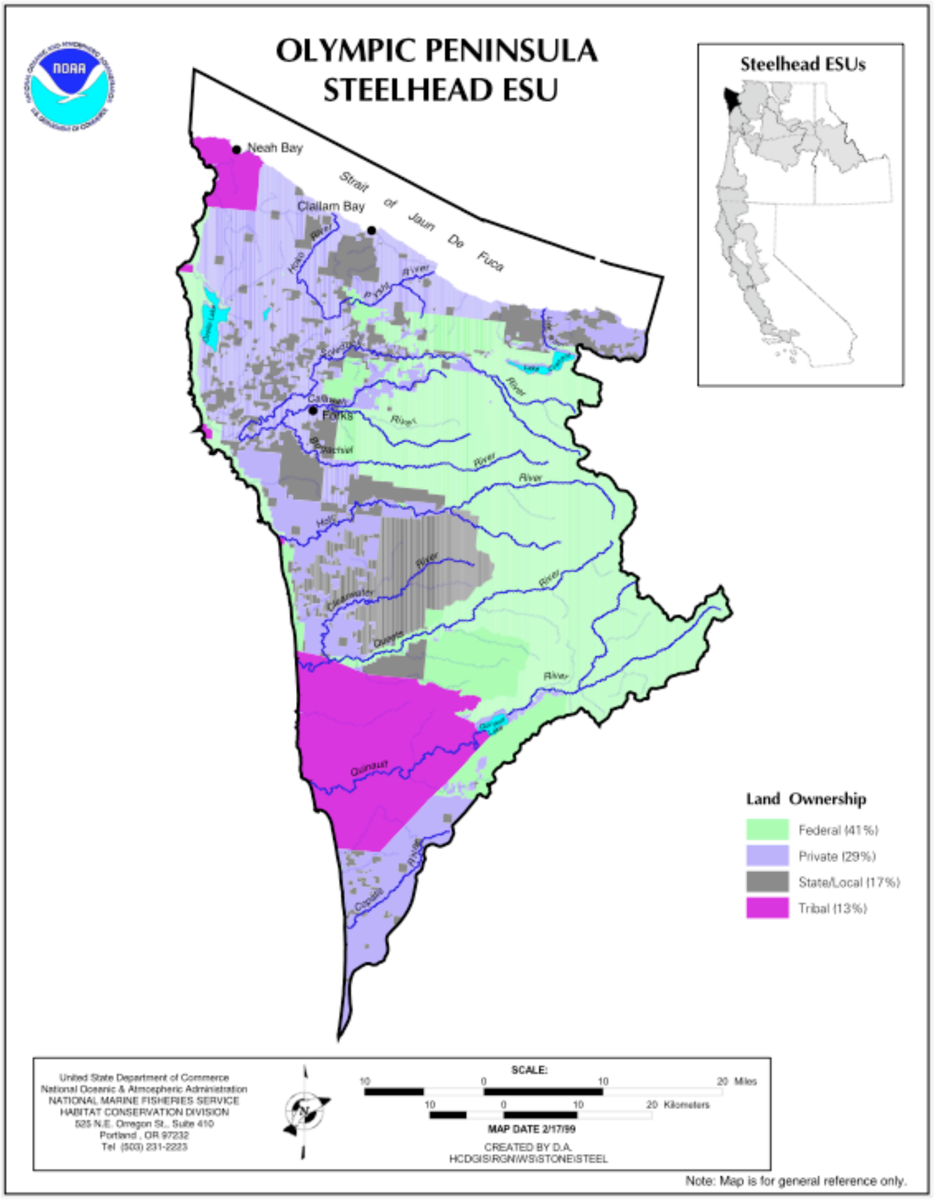
Figure 18. Coweeman River Run Reconstruction Data



D. Olympic Peninsula ESU

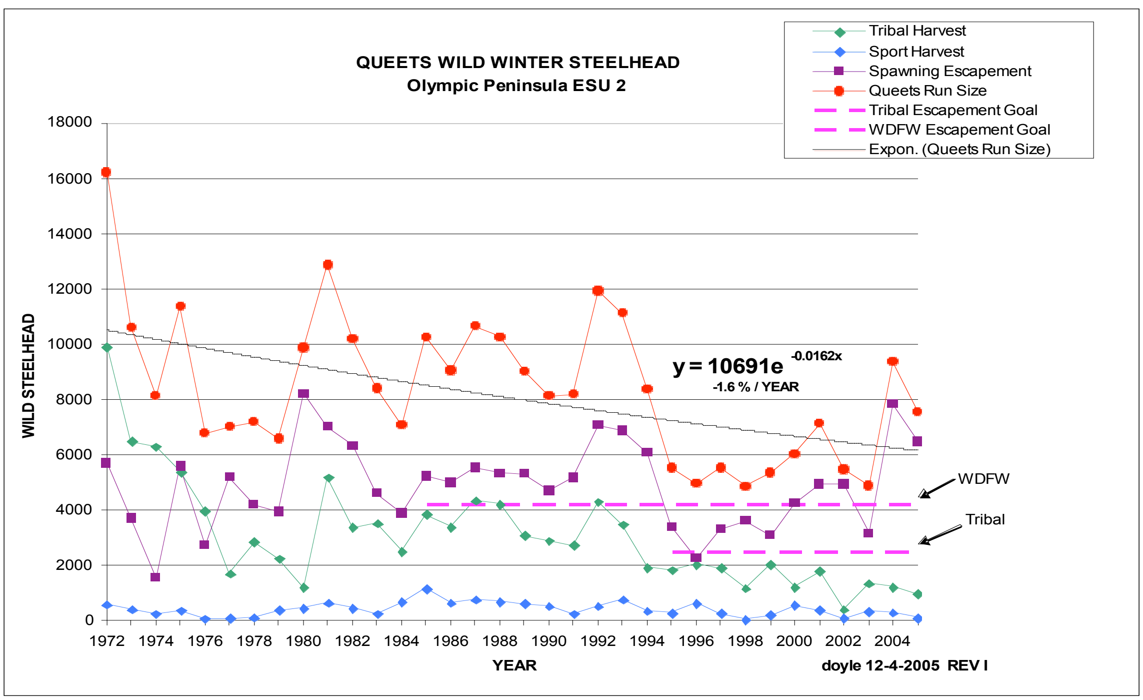
Since separate wild steelhead data collection began in the mid-1970s, WDFW run reconstruction data indicate the major Olympic Peninsula ESU rivers (Figure 19) have always had total wild steelhead run sizes that exceeded their respective escapement goals. However, actual spawner escapements have not always met the escapement goals due to the combined harvest impacts of sport and tribal fisheries. Two examples are the Queets (Figure 20) and the Hoh (Figure 21) Rivers where annual management planning and harvests have repeatedly reduced the escapements below the WDFW determined spawner escapement goals established in 1985 (Gibbons et al., 1985). Run reconstruction graphs for the Quinault (Figure 23), Hoh, and Queets Rivers show that the total runs to these rivers were generally twice their present size in the 1990s when escapements were maintained at levels moderately above their escapement goals.

Figure 19. Olympic Peninsula Steelhead ESU. (Figure obtained July 17, 2004 from: http://www.nwr.noaa.gov/1salmon/salmesa/stlhesum.htm)



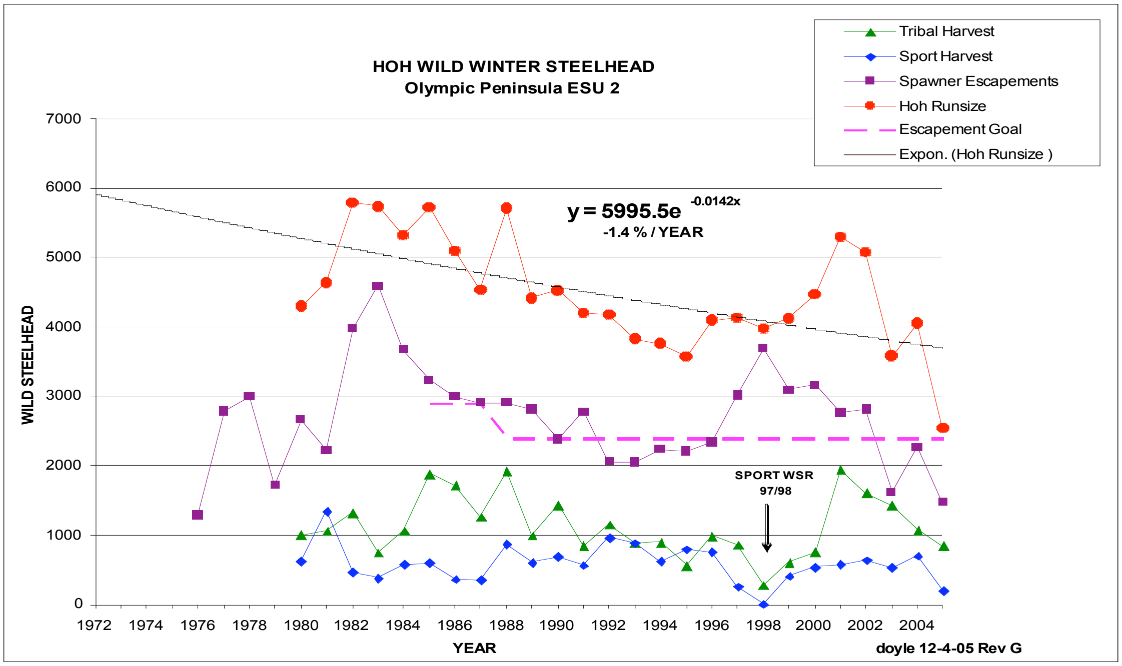
The Queets River (Figure 20) has been managed for spawner escapements below its WDFW modeled escapement goal for the last 10 years due to tribal insistence that the rivers productivity has declined. The WDFW modeled escapement goal was 4,200 fish (Gibbons, et al., 1985) but the wild run has been managed for an escapement of 3,100 wild steelhead since the mid-1990s (Note the two escapement goals plotted on Figure 20). The escapement to the spawning grounds has been below the WDFW goal in 6 of the last 11 years. Additionally, the tribal catch has generally comprised over 80 percent of the harvest. The run data since 1994 suggests that if in fact a decline in productivity has occurred, it is in part due to the high annual harvest and the reduced planned escapement, since the total run and the escapement have fallen to about half the size of the previous decade (Figure 20).

Figure 20. Queets River Run Reconstruction Data



In recent years, the combination of overly optimistic pre-season run-size forecasts and intense MSH-driven harvest fisheries have placed the Hoh River's wild steelhead run and fishery at risk. Estimated total run-sizes from 1980-2005 have always exceeded the spawner escapement goal of 2,400 wild fish, but actual escapements have been below this goal in 8 of the past 14 years. Near record-low escapements have been recorded in 2 of the past 3 years. In 2002/03 the Hoh River spawner escapement (Figure 21) was only 1,616 wild fish, or nearly 33% below the escapement goal. Over harvest in 2003/04 due to an overly optimistic pre-season run forecast also drove the Hoh River's spawner escapement that season below the escapement goal, where the estimated run-size was 4,710 fish, but the escapement was 2,268 fish. For 2004/05, the pre-season Hoh River run size forecast was 4,221 fish, and the co-managers agreed to a harvest of 1,395 fish for the Hoh tribe and 668 for sport fishers. The pre-season harvest plan called for a targeted wild steelhead escapement of 2,360 fish, or 40 fish below the escapement goal. This aggressive harvest planning left no room for run forecast or harvest estimation error. Unfortunately, the pre-season forecast was extremely optimistic, and post-season the actual run-size was determined to be only 2,540 fish. Tribal fishers harvested an estimated 851 fish, and sports fishers harvested an estimated 208 wild fish, leaving the second lowest Hoh River wild steelhead escapement ever recorded at 1,480 fish, or 40% below the escapement goal.

Figure 21. Hoh River Run Reconstruction Data



Recognizing that the Hoh River run has declined, the co-managers agreed to a reduced 2005/06 pre-season run size forecast of 3,034 wild steelhead. This projection appears conservative until one recalls the 2004/05 total run was only 2,540 fish.

The basic problem facing co-managers is the fact that their planning process assumes that pre-season run-size and harvest forecasts will be accurate, while in reality that is rarely the case. The risk of overfishing is further compounded by the fact that it is almost impossible for the co-managers to provide accurate in-season run–size assessments. A clear method for reducing the risk of over harvest is to first acknowledge the fact that the pre-season run-size and harvest forecasts are actually estimates with the expectation that errors can be large, and then to develop harvest plans with enough “wiggle room” that the potential errors will not result in seriously low escapements. This is quite contrary to the harvest plans used in the 2004/05 season on the Hoh River where the planned fishery aimed for an escapement that was 40 fish below the escapement goal. The pathway for reducing the risk of overfishing is crystal clear-- significantly reduce harvest rates and plan for fisheries that will leave a significant escapement buffer above the escapement goal given the pre-season run-size and harvest forecasts.

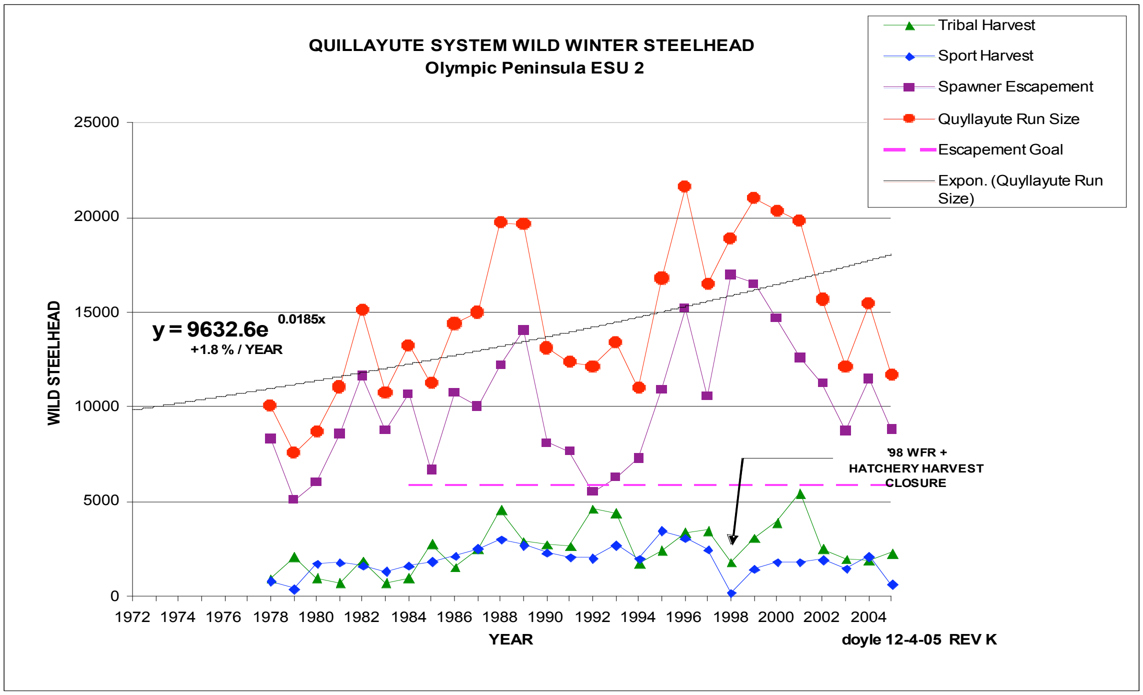
The Quillayute River System includes 5 important rivers on the Olympic Peninsula -- the Quillayute, Sol Duc, Bogachiel, Calawah, and Dickey Rivers. This system now produces over half of the wild steelhead sport harvest in Washington. The combined system has shown up and down cycles in productivity since 1978 and a decline in escapement from 1998 to 2003 (Figure 23). These rivers have achieved their required spawner escapements so far because past fishing efforts and catches have been low in comparison to the total wild steelhead run size. However, as fishing efforts continue to climb on the Olympic Peninsula due to other river closures in Washington, the rivers in this productive system will be more heavily fished and their spawner escapements pushed closer to their respective escapement goals.

Historical records (WDG, 1956, 1957) show the winter runs to the Quillayute River and its tributaries either peaked in December and January or had large runs during those months prior to the initiation of large hatchery run fisheries. The hatchery runs, which began in the early 1960s, returned in late November, December and January (see Section 6-D, Life History and Population Diversity) and created a mixed stock fishery. The December- January component of the wild run, which historically provided over 30% of the total wild harvest on the Sol Duc River, has been reduced to about 16% of the total run in recent years (Bahls, 2004).

Bahls (2004) suggests the escapement goal on the Sol Duc may be too low to provide an accurate gauge of the historic or potential production. This suggestion was based on the limited data and questionable assumptions used to develop the escapement goal as well as the fact that the early portion of the run was already significantly depressed from historic levels. The escapement goal for the entire Quillayute River system appears too low since the calculated equilibrium point from data collected during the Gibbons et al., (1985) study is about 15,900 wild steelhead (Hahn, 2003). Recent total runs have exceeded the equilibrium point in 9 out of the previous 16 years by as many as 6,000 fish.

.

Figure 22. Quillayute System Run Reconstruction Data



To provide additional information on the status of Olympic Peninsula stocks, additional graphs have been included. These graphs include the Quinault (Figure 23), Hoko (Figure 24) and Physt Rivers (Figure 25).

Figure 23. Quinault River Run Reconstruction Data

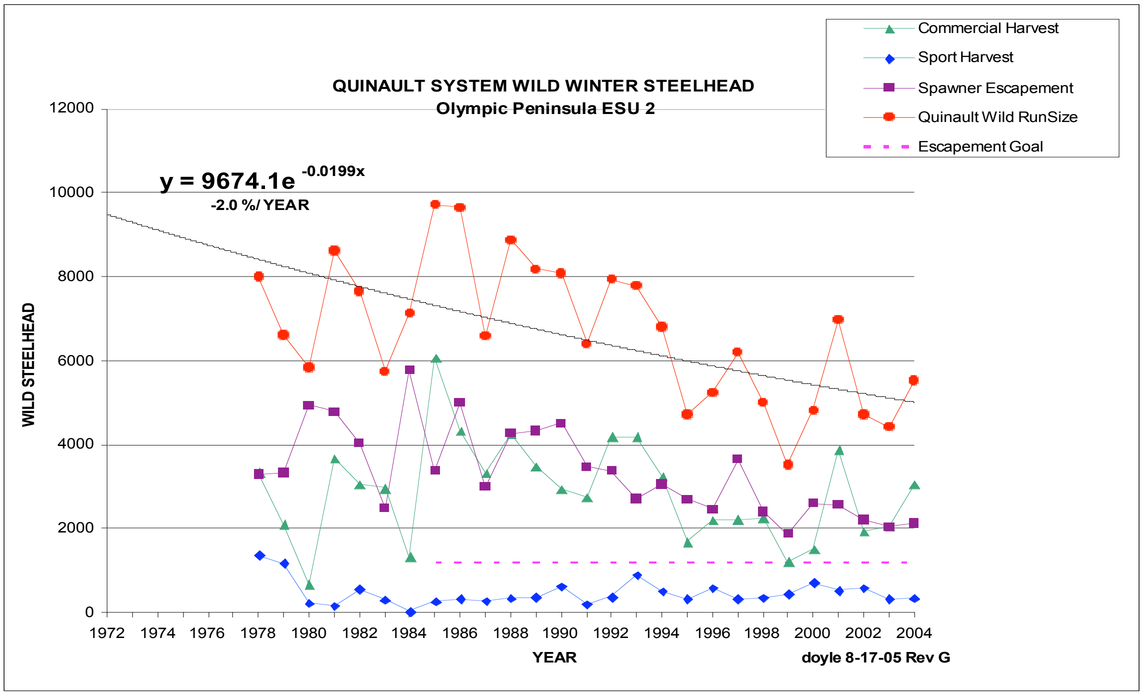


Figure 24. Hoko River Run Reconstruction Data

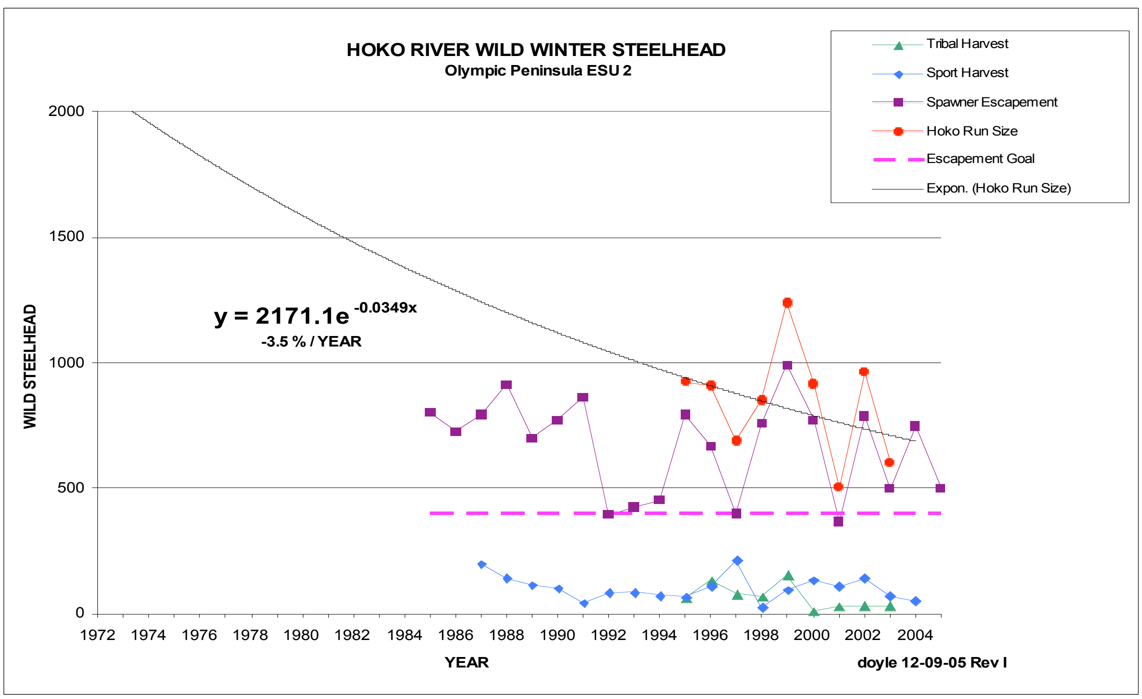
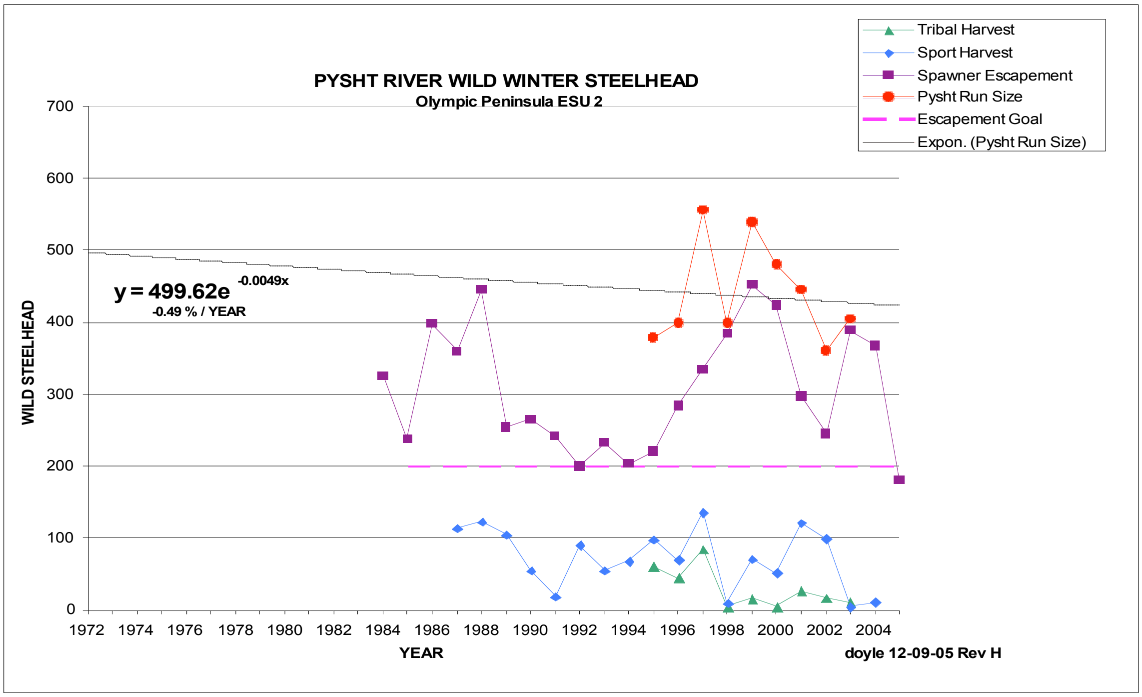


Figure 25. Pysht River Run Reconstruction Data



The disparity between sport and tribal harvest in the 2003/2004 Hoh River harvest records is common for wild steelhead harvests on the major rivers of the Olympic Peninsula. Graphs of the reconstructed runs and harvests on the Queets, Hoh, Quillayute, and Quinault Rivers (Figures 20 through 23) show the tribal commercial take of wild steelhead significantly exceeds 50% of the total harvest. This disparity is due to pre-season planning where the co-managers and policy makers agree to river allocations of up to 80% of the wild fish harvest to the tribes. A typical outcome of yearly negotiations for harvest on the Queets River is to allocate 37% of the run to the Quinault tribe and 9% to the state sport fishery, or in this case, 81% tribal and 19% sport harvest. (Quinault Fisheries Division and WDFW, 2003). For the Hoh River, the 2004 court order (an order confirming an agreement made between the Hoh tribe and the State of Washington); (US v Washington, 2004) stipulates the state/tribal harvests to be 1%/9% of the run when the pre-season prediction is below 2,600 fish, 10%/10% at a run of 3,000 fish, 15%/20.5% at a run of 3,800 fish, and 15%/35% at runs of 4,880 fish (US v State of Washington, 2004).

For the Hoh River, the 2004 agreement also stayed the issue of foregone opportunity, a legal question that influences annual negotiations and reduces the state's ability to gain an equal allocation and save more wild fish for escapement. This issue will influence negotiations in disfavor of the state and the wild fish until resolved by the courts. These agreements and annual plans raise two major conservation issues for steelhead: at low pre-season predicted run sizes (below 2,700 wild fish) there will be a planned harvest impact (to allow for an incidental catch) even when the run will not make escapement; and, at all higher run sizes, the plan provides for all fish above the minimum escapement goal to be taken. These agreements further assure that during any year when the pre-season run prediction is predicted too high, or there is an over-harvest of an allocation, the run will not make escapement.

For wild steelhead and other salmonid resources in Washington that are ESA listed or in decline, this allocation and harvest policy increases the risk of further resource declines. Instead of erring on the side of building and maintaining resilient populations, the policy continues to manage steelhead stocks at constant risk. If 50% of the catch on these rivers was allocated to the sport fishery, any unharvested portion of their allocation would escape to the spawning grounds and help to rebuild and maintain these populations at their former higher abundance, diversity, distribution, and more resilient levels via sustained productivity.

5. An Examination of Recent Harvest Impacts on Olympic Peninsula Rivers

Despite the fact that the annual harvest limit for wild steelhead was reduced in 2001 from 30 to 5 wild fish to reduce harvest impacts, and many fishers now release all wild fish to save spawners, the total annual sport harvests did not decline on the Hoh and Quillayute systems the following years (Table 2). This is likely due in part to the closures of wild fish harvest fisheries on the Columbia River and its tributaries, in Puget Sound, in Southwest Washington, in Oregon, and in southern British Columbia. As these areas and rivers closed due to ESA listings or to runs failing to meet escapement goals, many guides and sport fishers relocated some or all of their fishing activities for wild winter steelhead to the Olympic Peninsula, where several rivers are still open to killing wild steelhead.

Table 2. Change in Sport Catch of Wild Steelhead Following the Reduction in the Limit to 5 Fish. (Numbers in bold face are 2-season totals for years before and after the regulation change.) (Data from WDFW)

	Quinault River		**Queets River**		**Hoh River**		**Quillayute River**	
	Catch	Run Size	Catch	Run Size	Catch	Run Size	Catch	Run Size
1999/0	717	4,822	534	6,022	542	4,468	1,919	20,479
2000/1	450	6,979	390	7,141	629	5,344	1,790	19,809
	1,167	**11,701**	**924**	**13,163**	**1,171**	**9,812**	**3,709**	**40.288**
2001/2	462	4,593	95	5,475	613	5,039	1,932	15,665
2002/3*	327	4,420	383	4,913	543	3,540	1,568	12,724
	789	**9,013**	**478**	**10,388**	**1,159**	**8,579**	**3,500**	**28,389**

*Preliminary data and some data are missing from April catches

The Olympic Peninsula rivers remain classified as "healthy". By definition, a healthy stock meets spawning escapement goals most years and is normally open for harvest. Stock and run protection does not normally occur until rivers fall below escapement for several years and the classification is changed to "depressed" or "critical." However, a review of the major Olympic Peninsula rivers shows the long term run-size and escapement trends for most of them are in decline.

The Wild Steelhead Coalition believes that a more conservative harvest policy should be employed for rivers such as those on the Olympic Peninsula that are experiencing a period of declining run sizes and escapements and are close to, and frequently failing, to meet escapement goals. Stocks in decline or those experiencing escapements near or below escapement goals should be categorized as "*stocks of special concern*" and managed much more conservatively than directed by MSH guidelines. The Hoh River experience in 2002/03, 2003/04, and 2004/05 demonstrates that a natural temporary reduction in stream or ocean productivity, combined with intense harvests and overly optimistic run-size forecasts, can reduce, in one year, a "healthy" Olympic Peninsula stock to an undesirably low spawner escapement.

There is no biological, social, or economic justification for placing the few remaining stocks in Washington that are now classified as "healthy" at a high risk of under-escapement. The highly undesirable situation now confronting Puget Sound, where in recent years all rivers but the Skagit system have had only hatchery fish seasons and have been closed early at the end of February to rebuild depleted wild runs, should serve as a clear warning to those in support of continued MSH harvest policies on the Olympic Peninsula rivers. The intense harvests like those promoted by MSH probably seemed sustainable on productive Puget Sound streams in the 1970s and early 1980s. However, they proved to be not only unsustainable, but also likely contributed to sustained depleted run-sizes for wild stocks that have yet to respond to completely closed fisheries and elimination of hatchery programs. Chronic under-escapement on Olympic Peninsula streams and the fishing closures they bring would lead to severe economic hardship for Peninsula communities (after the December and January hatchery runs) in February, March, and April when wild fish fisheries attract many steelhead anglers.

6. Some Considerations for a New Harvest Policy

The tenets of MSH were developed by fisheries scientists in the mid-20th century and incorporated into fishery management policy by many agencies. It is widely recognized that the early implementation of MSH-influenced policies allowed an important shift to science-based management (Larkin, 1978). Unfortunately, the MSH theory and models developed over 50 years ago have not changed substantially with time. The results of management with these models have not been well monitored and evaluated for their effectiveness nor have they incorporated new knowledge of fish population biology, environmental cycles, habitat decline, and the growing records of steelhead and salmon declines. In this section, our observations of the problems with MSH theory and the effects this type of management has on wild stocks are discussed.

It has become abundantly clear that MSH theory and harvest models have not provided adequate protection for wild steelhead in the 20th and 21st centuries because they are too simplistic and allow high harvest rates that are unsustainable. These models do not annually or temporally account or plan for environmental variation, management error, the role of genetic and life history diversity in stock resilience and productivity, or the rebuilding of depleted tributary or seasonal runs. Rather, the models are rigid numbers-based equations and provide management tools that were developed to provide maximum harvests from a population without adequate considerations for long term stock health or the sustainability of annual fisheries. A recent review by Quinn (2005) of Pacific salmon and steelhead populations in Washington found only 37.5% healthy, 16.1% extinct, 22.2% in jeopardy, and 24.2% of unknown status. Quinn also found that steelhead (10 listed ESU's) and chinook salmon (9 listed ESU's) were in the greatest jeopardy.

A. Atmospheric and Oceanic Cycles

Ocean and river productivity constantly changes, often without warning, and at present, there is no demonstrated ability to forecast these changes before they occur (Mantua and Francis, 2004). Natural climate and weather-related variations and cycles can cause large changes in the riverine and ocean carrying capacity, in parr, smolt and juvenile survival and, in the generational abundance of steelhead spawning populations. Some environmental cycles, such as the Pacific Decadal Oscillation and the El Niño are now well-documented natural phenomena that influence ocean productivity. One recent study of the ocean survival of Oregon hatchery coho (from smolt release to adults returning) found annual survival to be as low as 0.5% and as high as 12% over a 30-year period (Logerwell, et al., 2003).

MSH harvest is designed to reduce stocks each year to a model calculated escapement goal, leaving no buffer for the lower productivity periods. This type of management errs on the side of maximum annual harvests when productivity is high. By the same token, it also sets the stage for low recruitment and abundance, potential depletion and ESA listings, as well as fishery closures when productivity declines.

It is through a richness of genetic and life history diversity that steelhead have historically adapted to changing environmental conditions. The erosion of genetic and life history diversity through intense harvest practices, habitat loss, and hatchery interactions, has led to a loss of resilience in our wild steelhead populations to environmental changes. The only way to plan for the unpredictable low productivity cycles that are sure to be part of the future is to manage wild stocks for maximum sustained diversity and abundance, rather than maximum sustained harvest (Mantua and Francis, 2004).

B. Management Error

For the few western Washington rivers predicted to have runs above their escapement goals, a harvest plan is prepared each year by the co-managers. Normally, this plan calls for the take of all wild steelhead predicted to return above the escapement goal. This annual management planning does not provide any buffer for an over-prediction of the impending run or for the potential of an over-harvest of the planned allocations. The in-season tribal and sport harvest are not totaled until months after the fishing season is over. In addition, many of the mortality impacts are not accounted for.

The detail provided for the Hoh River in Chapter 4 is an example of how quickly a run can be placed at risk from management error and in the absence of in-season run up-dates and catch data. Table 3 shows the differences in the Hoh River pre-season predictions and actual run sizes for the last 9 years (Gross, 2005).

Table 3. Pre-season Run Predictions and Actual Run Sizes for the Hoh River

Season	Pre-Season Run Prediction	Actual Run Size	Difference
1997-98	3,514	3,977	463
1998-99	3,936	4,123	191
1999-00	4,156	4,468	312
2000-01	4,684	5,351	667
2001-02	5,186	5,125	-61
2002-03	5,310	3,568	-1742
2003-04	4,710	4,053	-657
2004-05	4,221	2,540	-1681
2005-06	3,034	NA	NA
standard error* for the 8 year period			**934**

* Note that the standard error is calculated here as the square root of the sum of the mean squared errors of forecasts made in the 1997-2004 period.

The pre-season estimate and post-season reconstructed run data show that the present methods for estimating the impending run are imprecise and yield errors that are large enough to place stocks at risk every time the riverine or ocean productivity temporarily declines. Pre-season harvest planning techniques and negotiations have not developed the ability to predict the natural environmental and productivity changes needed to avoid continuing biological and depletion risks. Realistically, the resources are not available today to accurately predict or monitor the annual run sizes or the in-season catches and may never be available, given the annual uncertainty of weather and ocean conditions along with the normally limited management budgets of the co-managers.

In addition, the post-fishery management system does not account or estimate non-recorded mortalities, which includes illegal take, catch and release (CnR) mortality (which is approximately 10% of the released fish), net drop out of fish that die later, or for marine mammal take from nets. Present fishery records do not provide correct information on the complete runs for use in management planning or for calculating MSH parameters, including escapement goals.

Graphs of the Puget wild steelhead decline indicate that the initiation of the decline was not instantaneous, but occurred over several years before stock abundance fell further and reached a point of depression. If harvest fisheries had been closed at the onset of the decline and as the reconstructed runs began to reach or go below the escapement goals, with all mortality impacts accounted for, a higher escapement goal had been applied, it appears probable that further decline of these runs could have been avoided. The Hoh River and other Olympic Peninsula Rivers now show run-size trend similarities to those during the Puget Sound decline, especially with productivity and abundance declining in several rivers along with missed escapement goals. At the present time, more precise and accurate accounting can be incorporated into annual harvest planning, and planned harvest impacts should be set much lower to provide for a margin of error to ensure the long-term health and stability of the wild fish populations.

The wild steelhead escapement goals in use today were calculated from data collected in the late 1970s and early 1980s (Gibbons, et al., 1985). These goals are considered too low by many biologists as they do not represent, nor were they developed from, the historical (pre-1970) steelhead productivity and run-sizes. The WSC does not suggest any flaw in the manner in which this work was done, but it is clear that the data used is biased from periods of depleted steelhead populations.

If one looks back at the harvests of the 1950s and considers that those early numbers did not include spawner escapement or incidental mortalities, it is not difficult to see that the historical peak runs were larger than during the period when MSH parameters were developed. In many cases, the peak catches alone in the 1950s were equal to or higher than the total reconstructed runs (catch and escapements) in recent years (WDG, 1956, 1957). Some striking examples highlighting the magnitude of depletion include: the Skagit River, which had harvests as high as 22,000 wild fish in the 1950s compared to the peak total run in the mid-1980s of 16,000 fish; the Stillaguamish River with a historical high harvest of 2,200 compared to a recent high total run-size total of 2,500 fish; the Green River with a historical high harvest of 15,572 compared to recent high run-size of 3,500; and, the Puyallup River with a historical high harvest of 18,496 compared to recent run-size totals of 5,000 fish.

This data and the management error discussed in this section yield two generalizations. First, the total runs in the earlier years, before hatchery fish additions, were generally much higher than the more recent period (since 1980) when the escapement goals were calculated. Second, escapement goals calculated from complete reconstructed runs of catch and spawner escapements (including estimates of non reported harvest, catch and release mortalities, net drop out, marine mammal take, etc) would be much higher. The use of more complete, longer-term spawner-recruit data in productivity assessments would serve management and the resource better.

C. Flawed Theory

The prolonged and region-wide wild steelhead declines in Eastern Washington, the Columbia River and its many tributaries, and in Puget Sound and Hood Canal, serve as stark examples of the limitations and failures of MSH concepts and management policies. MSH theory predicts that a low spawner abundance will promote a relatively high recruitment and that the relatively low number of spawners and their progeny would be relieved of the negative impacts of competition from juvenile steelhead and other salmonids. This simple relationship has failed to hold true for the many wild steelhead populations that continue to experience low productivity during periods of low spawner escapements. The Puyallup, Nisqually, Cedar, and many other Hood Canal and Strait of Juan de Fuca rivers, have fallen far below their escapement goals. These rivers have shown a continuous state of depleted run-sizes since the 1990s in spite of closed fisheries and have not adhered to the MSH theory of increased production when population levels are low.

The concept of models predicting higher rates of growth at lower abundance is called compensation. However, in declining populations, depensation, or reduced population growth rates, may occur when runs are at a low abundance and are not able to replace themselves from generation to generation (Wright, 2004b). Any number of natural or anthropogenic causes can lead to depensation mortality including competition with other species, predation, and low reproductive success. According to Wright (2004a), the four geographic regions of Puget Sound: the Juan de Fuca Strait, Bellingham Bay, Hood Canal, and South Puget Sound, are now all approaching functional extinction with no recent runs large enough to be resistant to adverse environmental conditions and depensatory mortality risks. Only the Skagit Basin run-size appears large enough to be somewhat resistant to potential depensatory mortality and extirpation risks.

D. Life History and Population Diversity

The four pillars for wild salmon and steelhead recovery and maintenance of strong and healthy populations are abundance, life history and genetic diversity, spatial distribution, and productivity. Abundance, by itself, provides a safety net for populations during periods of poor productivity. A broad distribution of spawners across rivers and tributaries allows for different habitat properties to create a diverse set of steelhead life histories through the process of natural selection. This distribution across various habitats, as well as the distribution across time, results in the genetic diversity that is critical to persistent steelhead populations by supporting a capacity for adaptation. Life history and genetic diversity clearly provide improved population resiliency and stability in the face of environmental changes, whether those changes include a localized flood episode, a landslide, a regional drought, or a period of poor ocean productivity. Without a broad suite of life history forms, a wide distribution across many streams and rivers, and a regional abundance of wild steelhead composed of many distinct yet abundant populations, single natural or human caused events or multi-year changes in ocean productivity can quickly endanger a population. Finally, productivity is the ability of steelhead populations to replace themselves. Simple replacement, with or without a harvest fishery, is not sufficient for populations in the face of environmental changes over prolonged periods of times. In order for a depressed population to recover, the productivity must sustain at levels sufficiently greater than 1 recruit per spawner (McElhany, et al., 2000).

The life history forms of wild steelhead are far more diverse than those of other salmonids. Distinct seasonal runs, multiple year classes within a run, repeat spawners, juveniles that spend 1 to 3 years rearing in the river, progeny that may residualize and become rainbow trout (the resident form), rainbow trout that often spawn with adult anadromous fish and can also produce anadromous fish, half-pounders in many southern rivers, repeat spawners, precocious parr, and river specific genetics, have all evolved to provide greater resiliency and stability for wild steelhead populations. Many components of this diversity, like the percentage of repeat spawners, the multiple runs within a given population, and the role of resident rainbows, are not considered by MSH models and fisheries plans. Yet, all of these components of life history diversity are the basis for wild steelhead survival under both favorable and adverse conditions. It has become more evident in recent years that this diversity of life history forms is as important as high abundance for wild steelhead to maintain healthy populations (SRSR, 2004).

Before discussing steelhead life history problems in Washington, we offer the following statement from Lichatowitch (1999). "With each small population that disappears, with every run that becomes extinct, biodiversity----- the very quality that has enabled the salmon to withstand ice ages, mountain uplifts, lava flows, changing ocean conditions, and the whole onslaught of the industrial economy-----is lost. Tragically, it is this biodiversity that habitat destruction, over harvest, and the technology of hatcheries have systematically whittled away for over 100 years. If the Pacific salmon [and steelhead] are to survive, they will need all of their evolutionary biodiversity that remains. And they will need healthy rivers where that biodiversity is nurtured and maintained."

One well documented example of lost population diversity and resiliency in Washington is the depletion of the early wild winter runs (December and January) to the Quillayute River System and to other Olympic Peninsula and Puget Sound rivers. An independent report (McLachlan, 1994) and a report by WDFW staff (1996) concluded that, based on the sport catch, there has been a significant reduction of the historical December and January runs of wild winter steelhead to the Quillayute River system. Table 4 provides a comparison of the monthly winter runs for three rivers (Bogachiel, Sol Duc and Calawah) as well as their combination to form the Quillayute River System. Information is from the sport catch data found in the WDFW staff report (1996). The Quillayute River System early sport catch for December and January has declined from 40.8 to 18.8 percent of the total season catch. Historical catches (1953-54 to 1960-61 seasons) were well distributed across the winter run period with a low in April and a high in March. Recent catches (1990-91 to 1994-96 seasons) were low in December and peaked in March with the winter run skewed towards March and April which, combined, increased from 38.7% to 59.15% of the catch (Figure 26). The full run timing was not always complete from past sport harvest records because some rivers, or sections of rivers, were not open each year through the end of April. Also, the catch does not always reflect the time fish entered the river. Fish that enter the river in the early months may not be caught until later in the season.

Figure 26. **Percent of the annual recreation wild steelhead harvest taken by month form the Quillayute system Rivers during historical (1953/54 to 1960/61) and recent (1990/91 to 1994/95) time periods**.

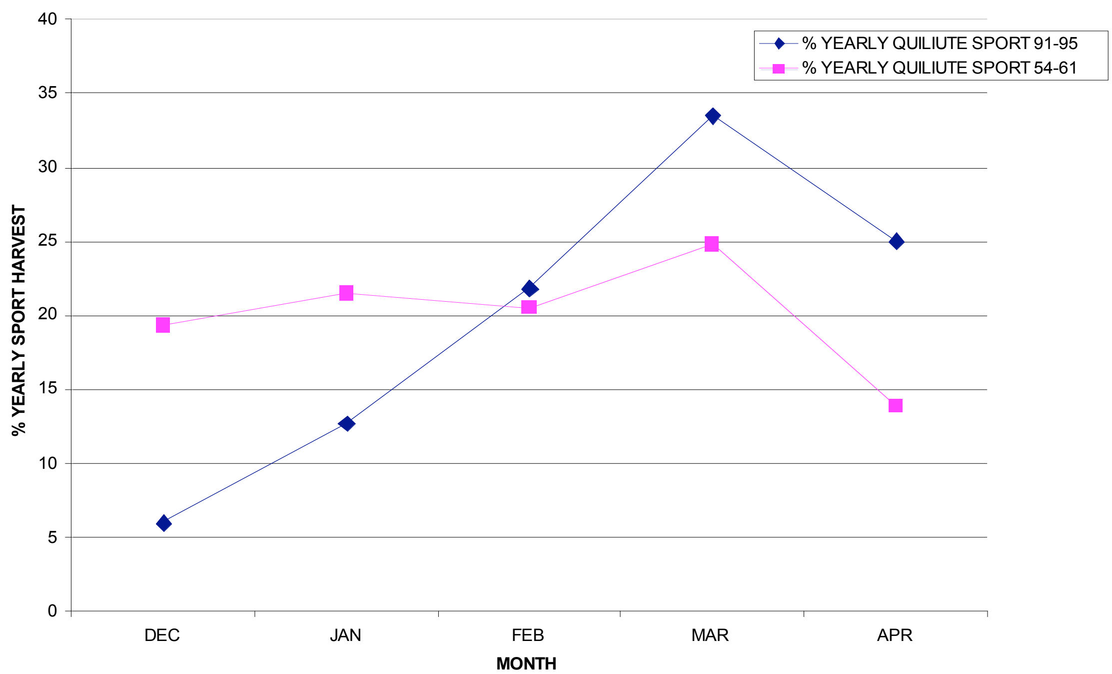


Table 4. Percentage of the annual recreational wild steelhead harvest taken by month from the Quillayute System rivers during historical (1953/54 to 1960/61) and recent (1990/91 to 1994/95) time periods.

Month	Bogachiel/ Quillayute River		Sol Duc River		Calawah River		System Total	
Percent	Hist. %	Rec. %	Hist. %	Rec. %	Hist. %	Rec. %	Hist %	Rec. %
December	16.1	10.0	22.0	3.1	17.4	5.0	19.3	6.0
January	18.2	11.3	24.0	13.8	22.0	17.8	21.5	12.8
February	19.2	18.6	22.2	24.5	15.1	23.9	20.5	22.0
March	28.9	33.5	21.3	34.1	28.9	33.0	24.8	33.8
April	17.7	26.6	10.9	24.5	16.2	20.2	13.9	25.3

This table compares the historical and recent catches presented in Appendix C and Table 2 in the WDFW 1996 report "An Analysis of the Natural Return Timing of Wild Winter Steelhead in the Quillayute River System." There were some differences in the season length or section of the rivers open between recent and historical times. However, these differences were minor and should not affect the overall conclusion that may be drawn from this information. The reader can note those minor differences by comparing the numbers we used with those in Table 2. We also did not include November catches, since they were available only during the recent period.

The best explanation for the seasonal run timing change is found in the changes in angler effort and catch after the beginning of hatchery fish runs that were timed to return during the early winter period. Between the late 1950s when wild steelhead were the basis for the fishery and the period between 1962 and 1969 when hatchery fish first returned in substantial numbers, the number of anglers increased 63 percent and the catch increased 53.1 percent (Royal, 1972). Records of 1945-to-1979 tribal catch from the Quillayute River System compiled from WDFW file data by Bill McMillan (2004) show the tribal catch increasing from 1961 through the late 1970s with most of the catch occurring during November, December, and January.

Accordingly, the increased sport and tribal fisheries that targeted hatchery fish during the months of November, December and January, resulted in a mixed stock fishery on hatchery and early wild fish. Planned and realized harvest rates for hatchery stocks are typically around 80% to 90%, which were too high for the wild stocks that were present during the hatchery harvest periods. It has been long understood that fishing at a high yield for the larger or more productive stock will result in depletion or extermination of the smaller or less productive stock (Ricker, 1958). In the case of the early Olympic Peninsula steelhead runs, the hatchery runs grew and became more abundant than the wild fish during the early months. Also, where few fish from the hatchery run were needed as brood stock, the wild stock required a much larger spawning population. A minimum of 40% of the equilibrium or maximum population was found to be the average level of spawners needed to sustain MSH yields in the models of 17 Western Washington Rivers in the Boldt Case area (Gibbons, 2005). Consequently, harvest on both hatchery and wild stocks at the rate allowable for hatchery fish depleted the abundance and spawning population of the early winter wild steelhead runs.

This scenario of depleted early winter runs in December and January has been played out on many, if not most, other western Washington rivers since most have been subjected to similar hatchery practices and harvest management planning. Other major rivers documented through sport harvests to have strong early-returning winter run steelhead in the 1950s include the Chehalis, Cowlitz, Elwa, Green, Hoh, Humptulips, Lewis, Naselle, Puyallup, Queets, Quinault, Satsop, Sauk, Skokomish, Skykomish, Snohomish, Snoqualmie, Stillaguamish, Toutle, Wenatchee, and Yakima (WDG Bulletins, 1956, 1957). By 1985, DeShazo found several rivers in Puget Sound depressed in relation to their respective escapement goals, including the Skagit, the Snohomish, and the Green River systems. He found the most probable cause of this condition to be the over harvest of wild steelhead while attempting to harvest hatchery fish (DeShazo, 1985).

Not all rivers have early wild steelhead runs. The WDFW (1996) examination of the few rivers where there are counting stations showed the winter run peaking in March in Snow Creek (1976-77 to 1993-94 seasons), April in the Kalama River (1976-77 to 1994-

95 seasons), and May in the White River (1953-54 to 1995-96 seasons). Observations of run timing have also been made in south coastal British Columbia rivers. Withler (1966) studied 8 rivers and found winter steelhead entering rivers during all winter months with the peak during January and decreasing numbers during February. The least numbers were during March. Five rivers peaked during December or January and two peaked in February. One river with high glacial melt flows during June through September had all winter returns in April and May.

Hooton (1983) found the sport catch on the popular rivers on Vancouver Island to be in a steep decline in the 1970s and early 1980s with the declines during the first half of the winter season the most noticeable. He attributed this situation to increasing fishing effort, anglers harvesting (rather than releasing) a higher portion of their early versus late season catch, and the fact that early runs tend to spawn earlier, thereby subjecting their eggs to frequent and severe freshets. To protect steelhead stocks, Vancouver Island regulations restricted fishing to selective gear and catch and release of summer fish in 1978 and winter fish in 1980. Winter run regulations further changed to a December 1 to March 1 catch and release basis in 1981.

Fish managers have regulated wild winter fisheries throughout western Washington since the initial use of MSH models in 1985 for a number based abundance (total annual escapement goal) without a consideration for the seasonal components of the run. If runs were making their MSH spawner escapements, then the model parameters were satisfied and no additional requirements were deemed necessary. Hence no management effort has been made to protect and restore the early runs.

The early winter runs, if restored, would improve population abundance, diversity, and productivity, and improve wild steelhead resiliency to unfavorable environmental events and low productive periods. The present and continued loss of the early runs in rivers where they were once abundant may prevent healthy runs from making their spawner requirements as they are harvested closer and closer to their escapement goals. This condition may also cause severe depletion of a single run or an entire ESU if and when unfavorable environmental changes take place for spawners in the late run period.

Behnke (2002) described two subspecies of rainbow trout including coastal rainbow trout (*O. mykiss irideus*) and the inland redband rainbow trout (*O. mykiss gairdneri*).

Both subspecies display two fundamental life history patterns, including anadromous (sea-run) and freshwater resident forms. The anadromous form, or steelhead, display summer and winter run life histories. The freshwater resident forms complete their entire life cycle in freshwater, although some fish may undertake extensive migrations within watersheds prior to spawning. This information is enlightening since another example of lost diversity in wild steelhead is the fishing mortality of wild steelhead parr and smolts and rainbow/redband trout on anadromous rivers. Even where the minimum size limit for these fish is 14-inches, anglers using bait and lures with barbed hooks will cause a high hooking mortality of juvenile steelhead and rainbow/redband trout (Trotter, 1995; Kraemer, 2004).

A growing body of literature and observations indicate that sympatric freshwater resident rainbow trout and precocious parr steelhead males are an important component of the anadromous steelhead spawning population (Blouin, 2003; Kostow, 2003; Seamons, et al., 2004, McMillan J., 2004). Seamons, et al. (2004) sampled a small winter steelhead population (Snow Creek, Washington) at a weir and recorded numerous missing parents. Of all juveniles sampled, 39% were missing one parent, most of which were males. The authors hypothesized that the missing male parents were precocious male steelhead. Similar results were found by Blouin (2003) in the Hood River, Oregon, and indicate precocious parr are an important male mate source for female steelhead.

An emerging body of research also suggests rainbow trout do mate with steelhead and, in some cases, the two forms are genetically indistinguishable. Several observations of small rainbow trout males sneaking (a mating tactic used by small males to mate with females) on female steelhead have been documented during recent interviews with biologists in the Columbia River basin (Kostow 2003). In addition, genetic analysis of sympatric rainbow trout and steelhead life history forms in the Walla Walla River, demonstrated that in some portions of the river basin the two forms were genetically indistinguishable. This finding then suggests mating between the two forms is common (Narum, et al., 2004). Behavioral observations in the Quillayute River system, found that male trout did mate with female steelhead and, that mating interactions between the two forms was extensive during the latter portion of the spawning season in the upper reaches of the watershed (McMillan, J., 2004). Similar observations have been recorded in the Cedar River (Foley, 2005).

That rainbow trout mate with steelhead should not come as a surprise as extensive research on sympatric resident and anadromous brown trout (*Salmo trutta*) and Atlantic salmon (*S. salar*) has demonstrated the two forms commonly interbreed and that resident males are an important mate source for anadromous females (Flemming 1996, Flemming, et al., 1997). Although our understanding of the reproductive relationship between resident and anadromous *O. mykiss* is limited, it is becoming clear that the two forms do interbreed and that in some cases resident males father numerous anadromous offspring.

Resident rainbow trout can also produce steelhead during favorable times and this may assist in the recovery of extinct or depleted populations (*Osprey* Staff, 2000; *Osprey* Staff, 2001; Kostow, 2003). Hatchery raised crosses of steelhead and rainbow trout smolts in the Grande Ronde basin were studied to determine the percent of each cross that exhibited outmigration by following their downstream migration past the Snake River and Columbia River Dams. Steelhead x steelhead smolts had the highest rate of detection (39%) while rainbow trout x rainbow trout had the lowest (4%). The female steelhead x male rainbow trout cross had the second highest rate of detection at 27% and the male steelhead x female rainbow trout migrated at a 15% rate (Ruzycki, et al., 2003; Kostow 2003). Also, it should be noted that the Washington Department of Fish and Wildlife considers the conservation of resident coastal rainbow trout an important component for restoring the depleted native steelhead resource in the Cedar River (Marshall, et al., 2004).

This interaction between the two *O. mykiss* forms is likely an evolutionary survival adaptation. For example, many steelhead populations are typically skewed towards the female sex (54% to 82%) (Kostow 2003) because female steelhead are more likely to survive to repeat spawn than male steelhead (Burgner, et al., 1992; Olsen and French, 2000). While large size increases reproductive success in the female sex, the same is not necessarily true for males. Small males can achieve a high level of reproductive success for two reasons. First, steelhead display a sneak-guard mating system whereby large guards control access to females via aggression while smaller, less aggressive males, use the sneak tactic to steal fertilizations from satellite positions. The sneak tactic is well known and is highly successful (L`Abbee-Lund, 1989; Thomas et al., 1997, see Flemming, 1998). Second, smaller males tend to invest more energy in gonad growth compared to their larger counterparts, which means that smaller males may actually produce more sperm per body size than larger males (Vladic and Jarvi, 2001). The combination of behavioral and physical mechanisms suggests *O. mykiss* has evolved dual life histories to fully utilize the diverse habitats of a watershed (e.g., small trout can spawn in small streams that steelhead can't access, while steelhead can spawn in large streams where scour is too great for small trout redds). This ensures population viability during times when freshwater survival is good and marine survival poor and vice versa (Pavlov, et al., 2001; Kostow, 2003; and, Pearsons, et al., 2003).

E. Ecological Needs of Steelhead in Freshwater

A large and significant amount of the nutrients needed for raising the parr and fry of steelhead and salmon is brought back by adults from the sea to western Washington and Columbia Basin rivers. These are collectively called marine-derived nutrients. These nutrients enter the watershed and riparian zones as salmon and steelhead die and decompose. Cederholm, et al. (2000) documented 137 species of birds, mammals, amphibians, and reptiles that are partially dependent on salmon, as predators or scavengers of the various stages of salmon life. These species later die and return nutrients to the watershed as part of the riverine food web cycle.

Gresh, et al. (2000) indicate that only 3 % of the marine-derived biomass once delivered by the decomposition of returning adult salmon is currently reaching Pacific Northwest river basins. The low abundance of wild anadromous salmon in depleted or ESA listed runs along with heavy harvest of fishable stocks, are responsible for this loss. Among the many ecological benefits derived from rebuilding spawning escapements for wild salmon and steelhead are increased nutrient levels in Washington rivers through steelhead and salmon decay. In turn, this would increase freshwater production of steelhead and other salmonids as well as produce a healthier ecosystem. Spawning adult steelhead and salmon also "engineer" their streams by digging redds, a process that moves fine sediments from spawning gravels. The process of digging redds also adds nutrients from the stream bed into the water column where they become available to fuel increased stream productivity (Moore, 2006).

7. Recommendations of the Wild Steelhead Coalition

While some biologists and authors have written opinions on what they believe is the unstoppable demise of wild salmon and steelhead, not all experts are writing wild stocks off for our future. In his recent book on *The Behavior And Ecology of Pacific Salmon and Trout*, Tom Quinn (2005) has disagreed with these pessimists and has written that: "Given the high fishing rates, habitat loss and degradation, careless transfers of fish among basins, overzealous hatchery propagation and other stressors, the remarkable thing is not that salmon are in danger but that they persist at all. It is my view that their chances of recovery are good if we only take our collective foot off their necks."

The Wild Steelhead Coalition also believes there is still hope for protecting and recovering most of our wild steelhead stocks and, a majority of steelhead anglers are now supportive of progressive changes in management, including WFR. In 2001, a WDFW survey of sport fishers showed that 49.3% preferred Wild Fish Release for steelhead, 11.5 % preferred releasing all steelhead, including hatchery fish, 2% preferred closing the fishery, and 33.9% preferred continued harvest (with 3.4% having no opinion). Combined, nearly 65% of those with an opinion preferred either WFR or closure, even when a river would be expected to meet spawning escapements. Most anglers have seen the demise of wild fish and fisheries in their home rivers and prefer that the co-managers take the hard steps now needed to allow these fish stocks to return to their former health and abundance. Clearly, the politics are now on the side of protecting wild fish and the management changes needed to recover the many depleted stocks.

To this end, the Wild Steelhead Coalition believes that optimizing the balance between quality steelhead fishing opportunities and protecting wild steelhead and their ecosystems begs for a shift away from MSH policies of the past towards a greater use of Wild Fish Release and selective gear regulations. Wild steelhead policies should change their focus from maximum sustained harvest to a new goal of first enhancing the resilience of wild steelhead populations and, where fisheries will not significantly endanger stock resilience, provide sustainable recreational fisheries. To its credit, WDFW has already made significant changes in this same direction on rivers such as the Kalama, Humptulips, and Chehalis. In these systems, the shift away from MSH harvest to catch and release fisheries has been followed by increasing run sizes and better quality fishing opportunities. Now it is time for a proactive shift in wild steelhead management on Washington's few remaining rivers that continue to remain open for MSH fisheries on wild steelhead.

The Wild Steelhead Coalition proposes the following management plan to help restore wild steelhead populations and maintain healthy fish runs and quality fisheries. We believe this plan promotes an improved balance between harvest, quality fishing opportunities, and the conservation of Washington's wild stocks and their supporting ecosystems.

A. Wild Steelhead Management Plan

I. **<u>Management Goals</u>: To conserve, preserve, protect, and restore the natural diversity, abundance, distribution, and productivity of wild steelhead populations and, wherever possible, manage for sustaining and quality steelhead fisheries.**

II. **<u>Wild Steelhead Management Model</u>**

In order to realize our management goal, we envision a Wild Steelhead Management Model that is focused on the following (7) objectives:

1) *Striving for annual wild steelhead escapements that significantly exceed Maximum Sustainable Harvest (MSH) escapement goals.*

Define escapement goals in order to support increased abundance, increased genetic and life history diversity, increased productivity and an increased spatial and temporal distribution of wild spawners. A reduction in the abundance, productivity, and life history diversity of distinct spawning populations and metapopulations reduces a population's resilience to environmental events and threatens its long term persistence. Genetic diversity, which is closely linked with abundance and space-time life history diversity in steelhead populations, is the foundation for the natural selection processes that ultimately allows populations to adapt to changing environments and recover from short-term environmental injuries. We support managing for escapements significantly greater than MSH-defined escapement goals because abundance, productivity, diversity, and distribution of spawners is tightly linked with the resilience of naturally spawning populations in the face of environmental variations such as floods, mudslides, extreme temperature, low flow events, and changes in riverine, estuarine, and marine food-webs.

A low abundance of spawners also places fisheries at risk. As abundance declines to levels below escapement goals on individual rivers, wild stock fisheries will close. This scenario has already been realized in the great majority of Washington's wild steelhead rivers. Larger escapements and increased population diversity and time-area distribution can provide population buffers against temporary natural and human-caused events. Hence, wild steelhead fisheries may bridge or extend through these declines if wild populations are managed for higher escapements. Managing for escapements above standard MSH estimates will buffer the risk and uncertainty associated with the harvest management imprecision and acknowledged data gaps in steelhead-population evaluations. Managing wild steelhead populations at abundance levels closer to their carrying capacity will allow managers the ability to better evaluate the role and status of steelhead populations within the dynamic, multi-species ecosystems in which they exist.

2) *Improving protections for rearing juveniles, migrating smolts, and rainbow trout.*

We support this goal because the abundance of fry, parr, and smolts is tightly linked with the natural productivity and resilience of wild anadromous fish populations in the face of unfavorable events during juvenile freshwater rearing periods. Increased protections can be offered with time-area closures to protect migrating smolts, and selective fishery rules (single barbless artificial only) can increase the protection for smolts, parr, rainbow trout and other resident fish that are part of steelhead ecosystems over impacts caused by barbed and baited hooks. Rainbow trout, the resident form of *O. mykiss*, have been documented in some ESU's to be an important component of the anadromous steelhead spawning population. Recent evidence also suggests rainbow trout may also provide a reservoir population for helping stock recovery when the anadromous form is depleted.

3) *Recovering seasonal runs and other life history traits.*

Rebuilding all life history traits in native stocks will vastly improve stock resilience as well as abundance and distribution and is a goal necessary to realize full recovery of depleted and declining runs and preventing declines in runs that are presently considered healthy. We support management efforts to rebuild the early runs in December and January that are now depleted due to overlapping hatchery runs and mixed stock fisheries that have occurred since the early 1960s. We further support rebuilding all tributary and mainstream runs that have been reduced due to harvest, habitat changes and other factors. These activities will allow rivers to maintain maximum resilience during low productivity cycles and other unfavorable environmental events and will help return stocks to peak abundance during periods of high productivity, will enhance natural fisheries, and provide natural buffers during periods of declining productivity.

4) *Offering fisheries that focus on maximum sustained recreation (MSR), rather than maximum sustained harvest (MSH), for wild steelhead.*

Our definition of MSR is to maximize angler opportunities to fish for, rather than harvest, wild steelhead. At the other extreme, MSH theory and policies aim to support maximum harvests that reduce escapements to MSH escapement goals. At the MSR extreme, Wild Steelhead Release (WSR) fisheries aim to offer fishing opportunities with much lower impact rates (typically, catch and release mortality for winter steelhead is less than 10%) and the potential for longer fishing seasons and significantly more recreational opportunity. In order to optimize the trade-offs between increasing fishing opportunities and minimizing fishing impacts on the abundance and life history diversity of spawners, fishing impacts must aim at cumulative mortality rates that are less than those that result from MSH policies. In recognition of the social expectations for some harvest fisheries, our management plan also offers harvest fisheries when criteria for higher abundance, productivity, stock diversity, and distribution are satisfied.

5) *Minimizing the negative impacts of hatchery programs.*

In the recent past, expert scientific panels have offered detailed studies with recommendations for science-based hatchery reforms. The WSC strongly supports a systematic implementation of these hatchery reform recommendations.

The Hatchery Scientific Review Group (HSRG) has developed a suite of principles and guidelines for minimizing the negative impacts of hatchery operations on wild steelhead. The HSRG's final report offers a state of the art science-based framework for operating hatcheries to attain our management goals. For Puget Sound, the Strait of Juan de Fuca, and the Washington coast, the HSRG offers facility-specific recommendations for reforming current hatchery practices in order to attain each facility's goals.

Among the most important HSRG recommendations for hatchery reform is the call for developing a system of wild steelhead management zones in a network of significant steelhead river basins. Likewise, in the Independent Scientific Advisory Board (ISAB) report of the NW Power Planning Council (released in 2003)), one of the key recommendations was an urgent need to develop *"robust experiments with the unsupplemented reference streams"* in order to adequately quantify the benefits and/or impacts of hatchery supplementation of native salmonid stocks throughout the basin.

NOAA Fisheries Salmon Recovery Science Review Panel (RSRP) has issued several reports of panel meetings discussing *"how modification or closure of hatcheries provides…opportunities to investigate the experimental effects of hatcheries on wild populations."* These recommendations would be consistent with the overall social and legal mandates listed as justifications for many programs, particularly given the value such options would have for the other ongoing supplementation experiments. Serious evaluation of these potential alternatives should be undertaken.

The HSRG report, ISAB Review, and the RSRP reports provide exceptionally valuable blueprints for significant and positive reform of steelhead hatchery programs in general. The findings and recommendations of the three panels should be applicable to most if not all hatchery programs throughout the region.

We recommend that managers utilize Hatchery Reform: Principles and Recommendations of the Hatchery Scientific Review Group report (HSRG, 2004), the Review of Salmon and Steelhead Supplementation (ISAB; 2003), and applicable SRSR reports (SRSR: 2003, 2004) as guidelines in developing reasonable reforms to major functions of current steelhead hatchery programs.

6) *During prolonged periods of low productivity and declining population's, fisheries managers and researchers should have the funding to conduct research*

into the causes for declines that can lead to the development of science-based recovery plans.

Wild (and hatchery) steelhead populations from Puget Sound and British Columbia's Georgia Basin watersheds experienced steep population declines over the past decade. Yet, there are few research programs either planned or underway in Washington that aim to understand the causes for these declines. For Puget Sound stocks, it is not known how much of the recent declines are due to drops in freshwater versus marine productivity, while studies of the Keogh River Steelhead population on Vancouver Island point to major reductions in marine survival and annual smolt production. Recovery planning for these populations should be supported with research programs that aim to better understand the fundamental factors that have contributed to these declines. In many if not all cases where steelhead populations are undergoing significant declines in abundance and/or productivity, recreational harvest and recreational WFR fisheries should be restricted at least until decline factors are understood.

7) *Developing a system of Wild Salmonid Management Zones within each described population (Evolutionary Significant Unit (ESU)) to protect and restore fully functioning ecosystems for anadromous and resident aquatic species.*

As noted above, recent expert panel reviews recommend the development of Wild Steelhead Management Zones, which they define as significant river basins where no hatchery steelhead are planted, to protect the genetic integrity of wild steelhead populations. The WSC supports this recommendation and also believes that this idea should be expanded to include all wild salmonids in order to protect and restore the integrity of complete ecosystems and further document their value to salmonid productivity and resilience. Wild Salmonid Management Zones should be designed in such a way that fishing opportunities are provided when and where resident and anadromous fish populations are abundant enough to sustain carefully regulated and fully monitored fishing impacts.

The WSC recommends the following policies that promote our Wild Steelhead Management Goals and our Wild Steelhead Management Model. These recommendations are based in part on MSH parameters and on recent management planning used in the Skagit River Basin in Washington.

B. Harvest Management Policy

I. Harvest Impact Model

1. Estimate the harvest impact (mortality) for Wild Steelhead Release (WSR) fisheries. Do this by surveying angler effort and catch rates, apply a 10% mortality rate for fish that are caught and released, and count estimated WSR impacts as sports fishing harvest. The 10% mortality rate rests at the conservative end of estimates from studies conducted on Vancouver Island and in the Vedder River during brood stock collections and catch and release steelhead fisheries (Nelson, et al. 2005). Catch and release mortality rates, by gear, should be studied in several areas in Washington to develop specific rates for use on different races and regions of wild steelhead.

2. The estimate of the total run size for each river, often called the reconstructed run, should include all harvest impacts. These impacts should include the sport catch and release mortality, the sport harvest (if any), an estimate of the unrecorded harvest, the tribal harvest, and the net drop out and delayed mortalities. Where appropriate, such as in the Columbia River fisheries, marine mammal mortalities must be considered. WDFW should conduct studies on several rivers to determine the total catch and release, unrecorded, and net drop-out mortalities in Washington.

3. <u>All fisheries should be conservatively planned and prosecuted in order to guard against escapements falling below desired spawning escapement goals</u>. Allow only WSR fisheries for run sizes between 100% and 150% of the MSH-defined escapement goal. Allow up to a 10% total harvest impact for the combined impacts of sport WSR and tribal take (including incidental mortalities). For run sizes projected to be more than 150% of the escapement goal, allow a cumulative 50% harvest impact on the segment of the run above 150%.

4. When making pre-season run-size forecasts for harvest planning, include error estimates that are based on the history of pre-season forecast errors. In order to manage conservatively, the "official" pre-season forecast number must reflect the estimated run-size less the *standard error* as determined by past forecast errors for that specific stock (see Table 3 for the standard error in Hoh River run-size forecasts).

5. Allow only selective gear and WSR fisheries between 100 and 120% of the escapement goal; as well as in all listed ESU's and ESU's petitioned for listing. For runs predicted to be in this category, managers should plan very conservatively to guard against escapements falling below the minimum escapement goal.

6. Allow only barbless hooks during all steelhead fisheries in order to minimize catch and release mortality for adult and juvenile steelhead and non-target by-catch (resident trout, char, whitefish, etc.) River systems should only be open to harvest fisheries if the mainstem and all tributaries meet a minimum of 90% of their respective escapement goal.

II. Wild Fish Harvest Tag System

1. For rivers qualifying for a wild steelhead harvest fishery, there will be a predetermined number of harvest tags provided that, when combined with all other fishing impacts, will produce a total mortality that matches the desired cumulative harvest impact goal.

2. Anglers may be issued (or draw) one tag or two tags when wild steelhead abundance is high, similar in design to deer tags. These tags will be placed permanently in the jaw of wild steelhead. These tags will be numbered and entered on the report card. Tags may need to be river specific to assure an excessive catch does occur on any specific river.

3. An angler obtaining a harvest tag must have that tag and their report card (stamped/coded harvest tag issued) in possession while fishing. If an angler uses their harvest tag, they may only continue fishing during the defined hatchery run seasons for each river. A report card (or the license) for anglers not obtaining harvest tags will be coded WSR only.

4. No replacement harvest tags will be issued.

5. WDFW will charge, at a minimum, enough to cover the administrative costs of the tag (and drawing) system. WDFW should also charge for a steelhead fishing endorsement to provide improved management, research, and enforcement for steelhead.

III. ESU Timing Closures

1. In addition to the closures required by managers, all western Washington rivers (Olympic Peninsula, SW Washington, Lower Columbia and Puget Sound) will be closed to wild steelhead harvest during December and January.

2. Other ESU’s should be reviewed for seasonal, mainstem, and tributary closures needed to protect spawning steelhead. In addition to these recommended closures, we should consider summer closures on many of our smaller streams and in Columbia River thermal refugia areas to reduce mortality on adults as well as juveniles as a result of low water flows and high water temperatures.

IV. Enforcement

1. Violators of harvest rules will lose their fishing license for 1 full year for their first violation and 3 years for the second. This penalty also includes the excising of adipose fins by sport fishers. We suggest that anyone who takes a wild fish in violation of law should be subject to the same penalties as a hunter that takes big game animal during the closed season. Presently, a hunter who takes big game during the closed season loses their hunting privileges for a minimum of two years in addition to any criminal or civil penalties. We believe an endangered steelhead or salmon is at least as valuable as a common game animal.

2. Adequate enforcement is a high priority on all steelhead streams. Management agencies need to provide sufficient enforcement on all rivers to stem the illegal harvest of wild fish. The Law Enforcement Division will develop an enforcement plan each year for the protection of endangered stocks of steelhead. This enforcement plan will clearly identify "what, when, and where" the enforcement will be allocated. In addition, each year the enforcement division will provide a year-end report of activities and results of efforts to protect endangered stocks.

3. "Eyes in the Woods/Stream Watch" volunteers should be available for observation on all rivers. WDFW should be strongly encouraged to support this program through established fishing organizations. Each region should have a designated "stream watch officer" who would be the main point of contact for the public.

V. Rainbow Trout Fisheries

1. ESU's/rivers having wild populations of steelhead should not be open to the harvest of rainbow trout unless research has shown the resident wild form of *O. mykiss* does not spawn with steelhead in that area. If trout fisheries occur in these ESU's/rivers, only selective gear and catch and release for rainbow trout may occur. Every management option should be used to minimize the hooking mortality of steelhead parr, smolts, and rainbow trout. Fisheries for rainbow trout may occur when they are part of a scientifically based recovery plan for a specific ESU or river. New science on the interaction of steelhead and rainbow trout will be used to alter this section when warranted.

2. Rainbow trout (resident forms) will not be planted in rivers having anadromous wild steelhead, unless such planting is part of a scientifically based recovery plan.

3. All juvenile steelhead and migrating smolt should be protected from harvest.

VI. Hatchery Management

1. HSRG principles and recommendations should be fully implemented. These include:
   - A robust system of monitoring and evaluation (M&E) for hatchery performance.
   - Adaptive management that makes use of what is learned from M&E
   - Science based decision-making
   - Wild steelhead management zones (significant river basins having no hatchery releases for any salmonids).
   - A clear distinction between ***segregated*** **and** ***integrated*** programs as defined by the HSRG.

2. Except in cases where wild stocks are being supplemented with the goal of recovering severely depleted wild stocks, hatchery smolts should not be released in any river falling below its wild steelhead escapement goals for more that two consecutive years. This temporary process is aimed at reducing negative impacts (disease, competition, predation, and interbreeding between hatchery and wild fish) of hatchery smolts and recruits on wild fish during periods of low wild stock productivity and preventing mixed stock fisheries. This measure would also be combined with fishery closures.

3. Implement hatchery-evaluation experiments related to selected hatchery closures and unsupplemented reference streams, as recommended by the HSRG, the ISAB, and the SRSR.

4. Existing integrated hatcheries should be fully evaluated for their impacts on wild steelhead before new hatcheries of this type are planned. This evaluation should include fitness of the hatchery and wild stocks, the ability of the program to maintain genetic and life history characteristics of the wild population, and in-river and marine competition.

5. The productivity of marine waters should be studied and understood to assure hatcheries do not release too many fish when productivity is low, create excessive competition, and reduce the survival of wild fish.

8. Conclusions

The Wild Steelhead Coalition believes that the time is long past due for the co-managers to adopt management approaches that err on the side of protecting wild steelhead populations and their resilience, and in doing so, focus on protecting and restoring the wealth that wild steelhead bring to our watersheds. To that end, the Wild Steelhead Coalition believes that optimizing the balance between quality steelhead fishing opportunities and protecting wild steelhead ecosystems begs for a shift away from the MSH policies of the past towards a greater use of Wild Fish Release (WFR) and selective gear regulations. It is clear that changing harvest management schemes alone cannot guarantee the recovery of depleted wild steelhead populations, but it is also clear that WFR policies place less stress on wild steelhead populations than harvest oriented fisheries. Increasing the use of WFR while reducing harvests will yield immediate economic benefits by continuing to offer quality and longer fishing opportunities. At the same time, a shift towards a greater emphasis on WFR policies will yield real ecological benefits by directly reducing fishing impacts on the abundance, life history diversity, and spatial distribution of adult spawner populations. Additional ecological benefits will also come from a greater use of selective gear regulations that will increase the protection of resident rainbow trout, rearing parr, migrating smolts, and other non-target fish populations that are critical parts of steelhead ecosystems. These changes will benefit the ecosystems and fisheries by improving the productivity and resilience of wild steelhead populations and the ecosystems in which they exist.

Shifting away from MSH policies towards an increased emphasis on WFR and selective gear regulations will also offer significantly better trade-offs in the constant management challenge to optimize the balance between fishing impacts on wild stocks and providing quality fishing opportunities. To this end, a shift away from a goal of maximizing the harvest of wild steelhead to a focus on maximizing the wealth that wild steelhead bring to their watersheds is a philosophy that promises to benefit the future of Washington's wild steelhead while also attracting the widespread support of the citizens of the state.

The Wild Steelhead Coalition also believes there is still hope for wild steelhead to be protected and that even the most unlikely anglers can be educated to protect wild fish. For example, in 1996, the well known Montana writer and novelist Thomas Mc Guane recounted his experience on an Oregon river where he was catching and releasing the steelhead he caught. He realized that he was being watched by a nearby angler "in rubber barn boots and a worn out mackinac coat" who finally told Mc Guane that he had "been trying to catch a fish for my old folks to eat for four days and I haven't had a bite. Can't you let me have just one fish?" Mc Guane thought about it and agreed to give him the next steelhead he caught. Some time later, as Mc Guane landed a "bright, wild, native male" his companion looked at the fish and before Mc Guane could say a word said, "Oops, he ain't fin clipped. That's a native. Put him back." (Mc Guane, 1996)

9. **Appendices**

Appendix 1: Glossary of Terms

1. *Biological Opinion*. A written statement, often in a special report, issued by NOAA on fisheries and other issues related to listed species under the Endangered Species Act.

2. *Co-managers*. Federal, state, county, local, and tribal agencies and governments that cooperatively manage salmonids in the Pacific Northwest.

3. *Compensation*. Traditional fish population models predict higher rates of growth and productivity at lower population levels due to reduced interspecific competition.

4. *Critical stock*. A stock of fish experiencing production levels that is so low that permanent damage to the stock is likely or has already occurred.

5. *Depressed stock*. A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

6. *Depensation*. The opposite of compensation occurs when populations are at low levels and growth and productivity is reduced due to competition with the other species, predation, low productive success, impaired aggregation, conditioning of the environment, efficiency of food locations and impaired aggregation. Depensation can lead to extinction of a species under any of the above actions.

7. *Distribution*. The spatial arrangement of a species or a meta population within its range. At the stock level this means, for the riverine environment, the tributaries, and mainstream areas traditionally utilized for reproduction and rearing of young fish.

8. *Diversity*. The amount of different traits expressed by a species, the amount of genetic variation within a stock of fish, and the variety within ecosystems such as species. In this paper we speak to life history diversity, genetic diversity, and biodiversity as important mechanisms that provide resilience to the survival and productivity of salmonids.

9. *Endangered species.* Any species of plant or animal defined through the Endangered Species Act as being in danger of extinction, throughout all or a significant portion of its range and published in the Federal Register.

10. *Escapement*. The portion of a fish population that survives natural and fishing mortality to reach its natural spawning grounds.

11. *Escapement goal.* The number of fish, as defined as a parameter of a fish reproduction model (MSH model), that is necessary to return and spawn to maintain maximum sustainable yield.

12. *Equilibrium point.* The upper level of recruitment that, above that level, will not produce more recruits in the next generation.

13. *Evolutionary Significant Unit (ESU).* A distinct population or metapoplation of Pacific salmon or steelhead, and hence a species under the Endangered Species Act.

14. *Functional depletion.* A species or stock that has been reduced to a low abundance and low level of productivity. This stock will naturally become extinct in time or be subject to extinction through depensatory mortality.

15. *Mixed Stock Fishery.* A harvest management technique where different species, strains, or races of stocks, or wild and hatchery fish, are harvested together. Caution must be exercised to properly manage the smaller or weaker stock to prevent depletion and possible extinction.

16. *Maximum Sustainable Harvest (MSH).* The largest average catch that can continuously be taken from a stock during existing environmental conditions. For species with a fluctuating environment and recruitment, the maximum will vary and may be obtained by taking fewer fish in some years than others. Also called Maximum Sustainable Yield (MSY).

17. *Natural Equilibrium*. A maximum population abundance that will not increase (in the next generation). Such a stock and its production of eggs, fry, and juveniles is generally considered to be at its carrying capacity.

18. *Rainbow Trout.* The resident form of *O. mykiss* that may live in any part of a river or its tributaries. It may disperse locally and may spawn with the anadromous form of *O. mykiss*, but is generally considered non-migratory.

19. *Recruits.* The total number of fish of a specific stock and year class (s) available at a particular stage of their life history, generally as adults. An example would be the number of adults that become available to a fishery at a specific time and area.

20. *Smolt.* The salmon or steelhead development state between parr and adult when the juvenile is adapting to the salt content of the marine environment.

21. *Steelhead.* The anadromous form of *O. mykiss*. This form spends its early life history (generally 1 to 3 years) in freshwater, then migrates to sea where it will spend several years (generally 2 or 3) before returning to its natal river to spawn.

22. *Threatened.* The whole population, or a metapopulation of fish defined as an ESU, in danger of becoming endangered.

23. *Wild Fish Release (WFR) and Wild Steelhead Release (WSR).* In the context of this report, WFR and WSR are intended to indicate the release of wild fish/steelhead for conservation purposes. This definition would contrast with Catch and Release Fisheries (CnR) that are designed to save fish for improved fishing opportunity.

Appendix 2: A Review of the Literature and Other Historical Information on Steelhead Catch Card Bias During the 1940s and 50s in Washington.

There is a difference of opinion and some confusion over the use of the sport steelhead harvest numbers produced from steelhead catch cards during the 1950s. In general, WDFW biologists suggest the sport catch statistics found in the Washington State Game Department (WDG) *Bulletins* from those years should be corrected for bias to 60% of the recorded catch. Others have argued that the numbers are reasonably correct based on the literature and that reducing them masks our understanding of the historical wild steelhead population sizes (McMillan B., 2004). Since the numbers from the WDG *Bulletins* represent only sport catch and no escapement was determined for those years, any use of the historical catch numbers would be an underestimate of the early runs. The WSC reviewed the literature and talked to WDFW biologists and biometricians on the subject to decide what bias correction, if any, should be applied in this paper.

The catch card system was initiated by WDG in 1947 and only covered the wild winter steelhead season during the months of December through April. In 1962, the catch card system was placed on an annual 12-month basis. In 1970, a $2.00 fee was charged for the card. In 1962, significant numbers of hatchery fish entered the catch, which encouraged more individuals to fish for steelhead. The number of fishers increased 63%, the catch increased 53%, and the catch-effort decreased slightly. These changes may have affected the turn in rate and accuracy of the catch card through time. During this period, WDG used a linear projection factor each year to estimate the total catch as about 25 % to 30% of the cards that were turned in annually (Royal, 1972).

The Oregon Game Commission investigated the bias in their steelhead catch card system (Hicks and Calvin, 1964). These investigators concluded that nonreporting anglers catch fewer fish and the percent deviation of the catch determined from catch cards averaged 16.9% high for 1960 to 1969.

In 1966, WDG surveyed 5% of the fishing license holders with a questionnaire and found very little catch card reporting bias. These results showed there were 4.9% fewer anglers than calculated from returned cards and the questionnaire reported catch was 1.5% higher than the catch calculated from catch cards (Royal, 1972). WDG also conducted studies of individual rivers. Some of these studies were flawed due to sampler intensity and their instructions to anglers, which inflated the normal return rate of cards. One study on the North Fork of the Stillaguamish River in 1963 and 1964 was conducted without any encouragement of anglers to turn in their cards. Study results added verification to the accuracy of the catch card system from the estimates of total catch it produced for these years (Royal, 1972).

Generally speaking, these early studies suggest the catch card bias was low for the early years of the wild steelhead fishery, especially before change in the card system occurred and hatchery fish increased the effort in 1962.

In 1976, WDG developed a model to measure catch card bias and tested it with WDF salmon punch card data (Burns, 1976). WDF had collected salmon catch information from non-reporting fishers by conducting several prompts to these fishers to turn in their cards. The study found a 40% bias (overestimate) in the estimates of the annual salmon catch. In 1978 and 1979, Hahn (1980) conducted a similar study on steelhead catch cards and harvest estimates using one survey and 3 questionnaires that prompted non-reporting fishers to turn in their catch card or remember their catch. The total catch information was analyzed using a power curve. Hahn further suggested the questionnaire technique had some flaws as some anglers falsified their data and others did not remember their catch. This study produced a 49% bias (excess) estimate of the harvest for the years studied. These two more recent studies indicate there was considerable bias in the use of catch cards for estimating annual steelhead catches during that time. For this reason, Hahn (1980) and Burns (1976) recommended using creel surveys to obtain the best estimates of the catch.

The studies by Burns and Hahn indicate that a linear analysis of catch cards would produce a high bias in the catch estimates in the 1970s. The early studies seem to indicate that the bias in the catch estimates produced from catch cards, if it existed, was low, especially before the changes in the card system occurred and the hatchery fish returns brought increased effort beginning in the early 1960s. Also, the 1994 Grandy Creek EIS used uncorrected sport harvest numbers for all years prior to 1960 and bias corrected numbers after that period (WDW, 1994), indicating the early records were correct or must be treated differently than those after 1960.

Based on this review of the literature and other historical information, the WSC has elected to use uncorrected catch numbers for the 1950s as reported in the WDG *Bulletins.* Catch information for years after 1960 was used directly as provided by WDFW (Gill, 2004; Leland, 2005).

.

Appendix 3: List of Figures

Figure	Page

Appendix 4: List of Tables

10. References

Bahls, P. 2004. A Tale of Two Rivers: Assessing the current status of wild steelhead in the John Day and Sol Duc Rivers. *Osprey*, 49:1, 4-7

Behnke, R.J. 2002. *Trout and Salmon of North America*. New York, NY: The Free Press.

Berryman, Jack W. 2004. The Plight of Washington's Wild Steelhead. *Northwest Fly Fishing*, 6:2 (Summer, 2004): 26-27, 85.

Berryman, Jack W. 2005. Update on Washington's Wild Steelhead. *Northwest Fly Fishing*, 6:4 (Winter, 2005):17-19.

Blouin, M. 2003. Relative reproductive success of hatchery and wild steelhead in the Hood River. Report to Oregon Department of Fish and Wildlife, Portland, OR.

Boynton, H. 2005. Personal Communications. Steelhead Trout Club of Washington.

Brown, Bruce. 1982. *Mountain in the Clouds: A Search for the Wild Salmon*. New York, NY: Simon and Schuster.

Burgner, R.L., J.T. Light, L. Margolis, T. Okazake, A.Tautz and S. Ito. 1992 Distributions and origins of steelhead trout (Oncorhynchus mykiss) in offshore waters of the North Pacific ocean. *Bulletin No. 51, International North Pacific Fisheries Commission*, Vancouver, B.C. Canada

Burns, D. 1976. Theoretical Aspects of Bias Associated With Punch Card Estimates of Sports Catch. FWS Cooperative Contract No. 14-16-0001-5776-FS. Progress Report. Wa. Dept. Game.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S., R.S. Waples, F.W. Waknitz, and I.V. Lagormarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-27. Seattle, WA.

Busby, P.J., T.C. Wainwright, and G. J. Bryant. 2000. Status Review of Steelhead from Washington, Idaho, Oregon, and California. In: *Sustainable Fisheries Management: Pacific Salmon*. New York, NY. Lewis Publishers.

Cederholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W.H. Graeber, E.L. Greda, M.D. Kunze, G.G. Marcot, J.F. Palmiasno, R.W. Plotnikoff, W.G. Pearcy, C.A. Simenstad, and P.C. Trotter. 2000. *Pacific Salmon and Wildlife – Ecological Contexts, Relationships, and Implications for Management.* Special Edition Technical Report, Prepared for D.H. Johnson and T.A. O'Neil (Manag. Dirs.), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia.

DeShazo, J.J. 1985. Thirty Years Of Hatchery Steelhead In Washington: Harvest Management Problems With Commingled Wild Stocks. Washington State Game Department. (Text of a presentation to the North Pacific Chapter of the American Fisheries Society, March 27, 1985).

Flemming, I.A. 1996. Reproductive strategies of Atlantic salmon: ecology and evolution. *Rev. Fish. Biol.,* 6:379-416.

Flemming, I.A., Lamberg, A., and Jonsson, B. 1997. Effects of early experience on the reproductive performance of Atlantic salmon. *Behav. Eco*. 8: 470-480.

Flemming, 1998. Pattern and variability in the breeding system of Atlantic salmon (S. salar), with comparisons to other salmonids. *Can. J. Fish. Aquat. Sci.* 55(suppl. 1): 59-76.

Foley, S. 2005. Personal Communications. Washington Department of Fish and Wildlife.

Gibbons, R.G., P.K.J. Hahn, and T.H. Johnson. 1985. Methodology for Determining MSH Steelhead Spawning Escapement Requirements. Washington State Game Department, Fisheries Management Division.

Gibbons, R. 2005. Personal communications. Washington Department of Fish and Wildlife.

Gill, R. 2004. Personal Communications. Washington Department of Fish and Wildlife.

Gresh, T., J.Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast Pacific ecosystems: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. *Fisheries,* 25(1):15-21.

Gross, M.R. 1991. Salmon breeding behavior and life history evolution in changing environments. *Ecology,* 72: 1180-1186.

Gross, M. 2005. Personal Communications. Washington Department of Fish and Wildlife.

Hahn, P. 1980. Memo to Jack Ayerst, Gary Garrison, Jim Deshazo and Bob Gibbons. 1978-79 Steelhead Punch Card Questionnaire, Progress Report. Wa. Dept. Game. May 14.

Haig-Brown, Roderick. 1939. *The Western Angler: An Account of Pacific Salmon & Western Trout in British Columbia*. New York, NY: Derrydale Press.

Hatchery Scientific Review Group (HSRG). 2004. *Hatchery Reform: Principles and Recommendations of the Hatchery Scientific Review Group*. Hatchery Scientific Review Group, April.

Hicks, R. H. and L. D. Calvin. 1964. An evaluation of the punch card method of estimating salmon-steelhead sport catch. *Tech. Bull*. 81. Oregon State Univeristy, Corvallis.

Hooton, R.S. 1983. Steelhead Management on Vancouver Island. J.M. Walton and D.B. Houston, Editors. In, *Proceedings of the Olympic Wild Fish Conference*.

Hooton, B. 2004. Abstract and oral presentation at the 2004 West Coast Steelhead Meeting, Port Townsend WA. (abstract and presentation are online at: http://www.psmfc.org/meetings/steelhead_present.html)

Independent Scientific Advisory Board (ISAB). 2003. Review of Salmon and Steelhead Supplementation. ISAB 2003-03, June 4, 2003. (Report is on line at: http//www.nwcouncil.org/library/isab/isab2003-3.htm.)

Kostow, K. 2003. Factors that Influence Evolutionary Significant Unit Boundaries and Status Assessment in a Highly Polymorphic Species, Oncorhynchus mykiss, in the Columbia River. Oregon Department of Fish and Wildlife Information Report # 2003-04. 1-122.

Kraemer, C. 2004. Personal Communications. Washington Department of Fish and Wildlife.

L'Abbee-Lund, J.H. 1989. Significance of mature parr in a small population of Atlantic salmon (S. Salar). *Can. J. Fish. Aquat. Sci*., 46: 928-931.

Larkin, P.A. 1978. An epitaph for the concept of Maximum Sustained Yield. *Trans. Am. Fish*. Soc., 106:1-11.

Leland, R. 2005. Personal Communications. Washington Department of Fish and Wildlife.

Lichatowich, J. 1999. *Salmon Without Rivers: A History of the Pacific Salmon Crisis*. Washington, D.C.: Island Press.

Logerwell, EA, NJ Mantua, P. Lawson, RC Francis, and V Agostini. 2003. Tracking environmental processes in the coastal zone for understanding and predicting Oregon coho (Oncorhynchus kisutch) marine survival. *Fisheries Oceanography*, 12(3): 1-15.

Mantua, N. 2002. Seas of Change: Can We Save Wild Steelhead and Salmon By Predicting Ocean Conditions? *Osprey*, 43:1 , 5-9.

Mantua, NJ, and RC Francis. 2004, Natural climate insurance for Pacific northwest salmon and salmon fisheries: finding our way through the entangled bank. In, E.E. Knudsen and D. MacDonald (Editors). *Sustainable Management of North American Fisheries*. American Fisheries Society Symposium, 43:127-140.

Marshall, A.R., M. Small, and S. Foley. 2004. Genetic relationships among anadromous and non-anadromous *Oncorhynchus mykiss* in Cedar River and Lake Washington-implications for steelhead recovery planning. Progress Report to: Cedar River Anadromous Fish Committee and Seattle Public Utilities.

Mayor, Jeffery P. 2003. "Steelhead, Crab Dominate Hearing." *Tacoma News Tribune,* December 11.

McGuane, Thomas. 1996. Where I Think We Are Now. *Fly Rod & Reel*, 18:3 (May/June): 36-38, 80.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 pp.

McMillan, Bill. 2004. Personal Communications. Washington Trout.

McMillan, John. 2004. The Mating System Structure and Mating Tactics of Sympatric Steelhead and Resident Rainbow Trout on the Olympic Peninsula. West Coast Steelhead Meeting, Port Townsend, WA, 2004. (Abstract and presentation are online at: http//www.psmfc.org/meetings/steelhead_present.html)

McMillan, John. 2004. Personal Communications. Wild Salmon Center.

McLachlan, B. 1994. Historical Evidence Indicating the Natural Return Timing of Quillayute Winter Steelhead with Reference to the Present Return Timing. A Preliminary Report to the Washington Wildlife Commission. January 22, 1994.

Montgomery, David R. *King of Fish: The Thousand –Year Run of Salmon*. Boulder, CO: Westview Press, 2003.

Moore, J.W. 2006. Animal ecosystem engineers in streams. BioScience 56:237-246.

Narum, S.R., C. Contor, A. Talbot and M.S.Powell. 2004. Genetic Divergence of sympatric resident and anadromous forms of Oncorhynchus mykiss in the Walla Walla River, USA. *J. Fish Biology*, 65: 471-488.

Nelson, T.C., Rosenau, M.L., and Johnson, N.T. 2005. Behavior and Survival of Wild Hatchery-Origin Winter Steelhead Spawners Caught and Released in a Recreational Fishery. *N. American J. Fisheries Mgmt*., 25: 931-943.

Nehlsen, Willa, Jack E. Williams, and James A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. *Fisheries*, 16(2).

NOAA. 2005. Endangered Species Act (ESA) Section 7 – Supplemental Biological Opinion. Consultation Number F/NWR/2004/00224.

Olsen, E.A. and R.A. French. 2000. Hood River and Pelton Ladder Evaluation Studies. Bonneville Power Administration project number 1988-053-04. Bonneville Power Administration. Portland, OR.

Osprey Staff, 2000. Ventura Steelhead Impatient for Dam Removal. *Osprey*, 37:3.

Osprey Staff, 2001. Southern Steelhead Found in San Mateo Creek. *Osprey*, 38:6,7.

Pavlov, D.S., Savvaitova, K.A., and Kuzishchin, K.V. 2001. Theoretical aspects of the problem of the distribution pattern and the formation of life-history strategy of Mikizha (Parasalmo mykiss Walbaum), Salmonidae, (Salmoniformes) on the Kamchatka Peninsula. *Doklady Biological Sciences*, 379: 344-346.

Pearsons, T.N., Phelps, S.R., Bartrand, E.L., and McMichael, G.A. 2003. Gene flow between resident and anadromous rainbow trout in the Yakima River basin: ecological and genetic evidence. In, Howell, P. and D. Buchanon (Editors). *Proceedings of the Inland Rainbow Trout Workshop*, 1-9. Oregon Chapter Amer. Fish Soc., Princeton, OR.

Quinault Fisheries Division and WDFW. 2003. Stock Status and Harvest Management Plan for Steelhead Returning to the Queets River in Winter 2003-04. December.

Quinn, T.P. 2005. *The Behavior and Ecology of Pacific Salmon and Trout*. Seattle, WA: American Fisheries Society in association with University of Washington Press.

Rathbun, R. 1899. A Review of the Fisheries in the Contiguous Waters of the State of Washington and British Columbia. *United States Commission of Fish and Fisheries Commissioner's Report*, Part 25: 253-350.

Ricker, W.E. 1958. Maximum Sustained Yields from Fluctuationg Environments and Mixed Stocks. *J. Fish. Res. Bd. Canada*, 15(5). 991-1006.

Royal, Loyd A. 1972. An Examination of the Anadromous Trout Program of the Washington State Game Department. Washington Department of Game.

Ruzycki, J.R., M.W. Flesher, R.W. Carmichael, and D.L. Eddy. 2003. Oregon Evaluation Studies, Lower Snake Compensation Plan. Oregon Department of Wildlife. Portland, OR.

Salmon Recovery Science Review Panel (SRSRP). 2003. Report for the meeting held July 21-23, 2003. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA. Report is on line at: http//www.nwfsc.gov/trt/rsrp_docs/hatchery_experiments_final_report.pdf.)

Salmon Recovery Science Review Panel (SRSRP). 2004. Report for the meeting held August 30 to September 2, 2004. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA. (Report is on line at: http//www.noaa.gov/trt/rsrpreportsept30_2004e.pdf.)

Salmon Recovery Science Review Panel (SRSRP). 2004. Report for the meeting held December, 2004. Southwest Fisheries Science Center, National Marine fisheries Service, Santa Cruz, CA. (Report is on line at: http//www.noaa.gov/trt/rsrp_docs/rsrpreportdec04finalwbios.pdf.)

Seamons, T.R., Bentzen, P., and Quinn, T.P. 2004. The mating system of steelhead (Oncorhynchus mykiss) inferred by molecular analysis of parents and progeny. *Env. Biol*., 69: 333-334.

Thomas, D., Beall, E., and Burke, T. 1997. Alternative reproductive tactics in Atlantic salmon: factors affecting mature parr success. *Proc. R. Soc. Lond*. B., 264:219-226.

Trotter, P. 1995. Hooking Mortality in Trout: A review of the scientific studies. *Fly Fisherman*, 26:3 (March, 1995):

US v Washington. 2004. Stipulation and Order of Continuance, Subproceeding 03-1, No. C70-9213. States District Court Western District of Washington at Seattle. (A 3 Year Agreement between the Hoh Tribe and the State of Washington on the Hoh River Wild Steelhead Harvests).

Vladic, T.V. and T. Jarvi. 2001. Sperm quality in the alternative reproductive tactics of Atlantic salmon: the importance of the loaded raffle mechanism. *Proc. R. Soc. Lond. B. Biol. Sci*., 268(1483):2357-2381.

WDW. 1994. Final Environmental Impact Statement for Grandy Creek Trout Hatchery, Volume 11, Technical Appendices. Appendix B (Corrected pages to Technical Appendix B-2 of DEIS), 30 pp (on pages 16-18).

WDFW. 1996. WDFW Staff. An Analysis of the Natural Return Timing of Wild Steelhead in the Quillayute River System. Report to the Washington Fish and Wildlife Commission, December.

WDG. 1956 and 1957. *Game Bulletins*, 8(1) and 9(1).

Wilcox, W.A. 1896. Notes on the Fisheries of the Pacific Coast in 1895. *United States Commission of Fish and Fisheries Commissioner's Report*, Part 22: 575-659.

Wilson, Amilee. 2004. "Steelhead Stock Status in Washington State, " Pacific Coast Steelhead Meeting, Port Townsend, WA, March, 2004 (Abstract and presentation are online at: http://www.psmfc.org/meetings/steelhead_present.html)

Withler, I.L. 1966. Variability in Life History Characteristics of Steelhead Trout (Salmo gairdneri) Along the Pacific Coast of North America. *J. Fish. Res. Bd. Canada*, 23(3).

Wright, S. 2004a. Petition List Puget Sound Steelhead (Anadromous *Oncorhynchus Mykiss*) as n to an Endangered or Threatened Species Under the Endangered Species Act (ESA).

Wright, S. 2004b. A Critical Flaw in the American Fisheries Society Initiative to Protect Marine, Estuarine, and Diadromous Fish Stocks: Failure to Account for Depensation. Center for Biological Diversity, Oakland, CA.