Historic Steelhead Abundance: Washington NW Coast and Puget Sound

(With Particular Emphasis on the Hoh River)

Bill McMillan
Field Biologist, Wild Fish Conservancy
40104 Savage Rd.
Concrete, WA 98284
(360) 826-4235

Determining Escapement Goals to Rebuild Wild Steelhead Populations:

What Role Should Stock Recruit Analysis Have?

Nick Gayeski
Resource Analyst, Wild Fish Conservancy
P.O. Box 402
Duvall, WA 98019
(425) 788-1167

Prepared for the Wild Salmon Center
May 2006

Acknowledgments

This paper was the vision of Pete Soverel, founder of the Wild Salmon Center. He was concerned that recent Hoh River land purchases made on Washington's Olympic Peninsula (through the coordinated efforts of the Western Rivers Conservancy and Wild Salmon Center with the support of Washington Department of Natural Resources through Section 6 funding under the supervision of the U.S. Fish and Wildlife Service) may ultimately fail to help restore Hoh River steelhead populations back to anything like historic numbers. He felt one reason for this may be the lack of an appropriate history from which to assess the present status of Hoh River steelhead, and for want of that history steelhead managers may not provide sufficient escapement for effective restoration to occur even if all available habitats were returned to a high level of salmon and steelhead productivity. Knowing that Puget Sound steelhead were petitioned for listing with growing evidence its steelhead populations were but small fractions of their former abundance, he felt comparisons with Puget Sound rivers and other Olympic Peninsula rivers may help to fill in historic gaps in the Hoh River historic record.

The resulting Hoh River steelhead history is a work in progress. Over time some of the present gaps may fill with new findings. A number of people provided sources of data to draw from:

Of particular importance were copies of older historic documents provided by Jim Myers, Research Fishery Biologist in the NOAA Conservation Biology Division at the Northwest Fisheries Science Center in Seattle. These included reports from the U.S. Commission of Fish and Fisheries with information on Washington fisheries dating to 1888, somewhat later U.S. Bureau of Fisheries Reports, and the earliest reports of the State of Washington Department of Fisheries and Game. Jim also provided an unpublished analysis of some of that older historic data which was immensely helpful.

Bill Gill, Fish and Wildlife Biologist with the Steelhead Section of the Fish Program of the Washington Department of Fish and Wildlife in Olympia, went to great effort to provide steelhead tribal catch records dating to 1934, sport fishing records to 1947, hatchery smolt release records to the early 1950s, and managed to put together a steelhead database updated to 2004 or 2005 for all of the Puget Sound and North Coast Olympic Peninsula streams.

Nick Gayeski, Resource Analyst for Wild Fish Conservancy in Duvall, provided many connections and pertinent suggestions and authored the detailed section on escapement goals and stock recruitment analysis provided in Part IV and Part V.

Glenn Thackray, Department of Geology at Idaho State University in Pocatello, provided his 1996 PhD dissertation regarding glaciations of the western Olympic Peninsula as well as other papers and geologic maps.

Nate Mantua, with the Climate Impacts Group of the Department of Atmospheric Sciences at the University of Washington, provided copies of several pertinent papers and figures and patient explanations of PDO cycles and their relationship to salmon productivity.

George Pess, Stream Ecologist with NOAA Fisheries at the Northwest Fisheries Science Center in Seattle, provided numerous papers regarding geology, habitat relationships to fish populations, and salmon and steelhead colonization and evolutionary considerations.

Sam Brenkman, Chief Fisheries Biologist for Olympic National Park at Port Angeles, provided a summary of physical characteristics of Olympic Peninsula river basins and the data from snorkel surveys he has led to count steelhead in Olympic National Park.

John McMillan, Salmon Ecologist, and James Starr, Fisheries Biologist, out of the Forks office for the Wild Salmon Center provided much information regarding the extensive snorkel surveys they have done on the Hoh and Quileute river systems and detailed steelhead, salmon, and habitat information regarding those same streams.

Kurt Beardslee, Executive Director of Wild Fish Conservancy in Duvall, provided numerous ring binders filled with steelhead resource material from the Wild Fish Conservancy library.

Xan Augerot, Director of Science for the Wild Salmon Center in Portland, provided much relevant information through her book *Atlas of Pacific Salmon* as well as reviews of the drafts.

And Bill Bakke, Executive Director of the Native Fish Society in Portland, provided many helpful literature suggestions.

Table of Contents

Table of Contents

Historic Steelhead Abundance: Washington NW Coast and Puget Sound

(With Particular Emphasis on the Hoh River)

Extended Summary

For want of use of sufficiently long histories, fisheries managers of each new generation have commonly made decisions based on the status of the fishery they inherited when their profession began. A "history begins with me" style of management leads to what has been termed "the shifting baseline syndrome" in which a progressively diminished resource is passed on to each new generation of biologists who come to accommodate and to manage for perpetual resource depletion. The result has been a global fisheries disaster as described by Daniel Pauly (1995) in his paper, Anecdotes and the Shifting Baseline Syndrome of Fisheries, published in *Trends in Ecology and Evolution*.

The purpose of this paper is to provide a more complete historic perspective from which to manage for perpetuation of Hoh River steelhead as but one indicator of a larger ecosystem that will eventually determine the future of all species contained within it. Because of the long lack of using a sufficiently old baseline from which to determine management decisions, some of that Hoh River history is now largely irrecoverable. In its absence, a composite of histories from a number of related sources was drawn from as a means of piecing together the historic gaps from which the status of a functioning salmon and steelhead ecosystem of intertwined species and habitats can begin to occur within the adaptive context of geological and biological time – past, present, and future.

The historic steelhead data used in this paper have come from differing reports from the Commissioner to the United States Commission of Fish and Fisheries (1892, 1898, and 1900); U.S. Bureau of Fisheries reports (1900, 1904, and 1923); the early reports of the Washington State Department of Fisheries and Game's Division of Fisheries (1890-1920, 1928, and 1932); tribal catch compiled by Washington Department of Game from 1934-1978; sport catch and stocking data from Washington Department of Game (1948-1978; and 1962-1984) and Washington Department of Wildlife (1987-1993); 1978-2005 sport catch and tribal fishery records from the Washington Department of Fish and Wildlife historic steelhead database (2006); and the salmon and steelhead stock assessment inventories for Washington (SASSI 1994; and SaSSI 2003). These represent the cumulative records found from differing agencies responsible for fishery management in Washington at differing historic eras.

Much of the available historic information found for steelhead in Washington State has not been used for management purposes for 35 years or more. There are now sometimes doubts among fishery managers regarding its relevance to the present, its authenticity, its accuracy, or how to interpret it as meaningfully useful … if, in fact, it has any usefulness at all. Seldom considered is that older data represent the record of what cutting edge science was 35, 50, 75, 100, and 125 years ago and that the data collected

today will similarly be considered outdated and useless 100 years from now unless fishery science learns how to maintain a useful thread of connectiveness over time.

Older data can, and must, be used if fishery resources such as steelhead are to have a long term future. As the case presently is, steelhead in Washington State are being managed for a graduated diminishment to extinction as was found in the development of this Hoh River steelhead history. In fact, one race of steelhead, summer runs, may already be functionally extinct among several steelhead populations on the Olympic Peninsula. This is despite the fact that the summer race of steelhead on these streams often return to those sections of watersheds that are considered pristine in Olympic National Park.

The geologic histories of the river basins of the Olympic Peninsula west coast were found to be particularly complex and none more so than that of the Hoh River Valley where six separate alpine glacial events advanced and retreated between 17,000 and 70,000-110,000 years ago during the Wisconsin glacial era. Differing areas of refugia for salmon and steelhead existed during the Wisconsin period, including areas north of the glacial ice sheet advances and retreats such as the Queen Charlotte Islands. During the Wisconsin glacial events, sea level was much lower than present. The Olympic Peninsula coastline at the mouth of the Hoh River was 22-25 miles offshore 21,000-22,000 years ago, and no glacial advance down the Hoh Valley ever reached closer than 7.5 miles of today's coast leaving a river beyond the glacier terminus that was sometimes as long as it is today.

Although much of the ancient Hoh River valley is now drowned beneath the Pacific, it is known from pollen and beetle records archived in glacial layers that life continuously persisted in the Hoh Valley with conditions that resemble those found in tundra landscapes in Alaska and Russia's Kamchatka Peninsula today. In the case of the Hoh River, there was also a large lake created by a former glacial retreat that persisted for 30,000 years (73,000-43,000 years ago) which could have created a particularly productive salmon and steelhead ecosystem not unlike the more recent history of Lake Quinault or the Situk River system in Alaska.

Whether the Hoh River provided a refugium for salmon and steelhead continuously, or even partially, through the Wisconsin glacial era does not appear to have been considered in the available literature. However, in the absence of investigations to effectively examine the evidence one way or the other, it must remain a consideration. From the information available, it is apparent that science is still on the peripheral edge of understanding the evolutionary sequence of North Pacific Rim salmon and steelhead distribution before, during, and after the Wisconsin era.

Olympic Peninsula human history is also traced from aboriginal colonization of North America via the Bering land bridge that is generally thought to have begun 12,000-15,000 years ago, but which may have begun 50,000-200,000 years ago. Those aboriginal cultures came to be altered through contact with differing agricultural civilizations whose explorations likely began with the Chinese between 1421 and 1423, but perhaps even as early as 499 AD.

Exploitation of what has been termed the "gift economy" of the aboriginal people of North America by the "industrial economy" of modern agricultural civilizations began with the Russian discovery of Alaska in 1741. From that point onward the aboriginal tribes along the North American West Coast were initiated into a 150 year assimilation into the industrial economy. Beaten, brutalized, subjugated, extorted, robbed, assaulted, or more genteelly cajoled or bribed, the initiation of aboriginal peoples into the industrial economy was one of join it or die. On the Olympic Peninsula, the latter became pervasive through sweeping epidemics, dramatic loss of population size, and resulting breakdown of the ability to defend their homelands or to maintain their cultures.

By the late 1800s with the advent of commercial fishing by the Quileute people, it was found that traditional practices had ceased, including abandonment of the fishing society and the first salmon ceremony. By 1900, the original North American gift economy had been fully replaced by the industrial economy no matter what the skin color or ethnic origin of the peoples then sharing the west coast of the Olympic Peninsula and the Hoh River Valley. It was not a matter of choice; it was a matter of the biological reality of adapt or die. There was no remaining place on the North American West Coast to escape to. The Olympic Peninsula was one of the last geographic areas to yield to colonization by agricultural civilization.

The history of this 150 year shift in economies on the North American West Coast was initially driven by the potential for wealth provided by sea otter furs, an animal with the same range around the North Pacific Rim as steelhead. One of their most abundant areas on the West Coast was around Point Grenville near the mouth of the Quinault River. By 1911 sea otters were extinct in Washington. They were thought to be extinct in North America by 1925 until a mother and pup were sighted in Alaska in 1931. They were reintroduced in Washington in 1969 and 1970. While numbers have slowly risen, their range remains limited primarily to the Olympic Coast National Marine Sanctuary. They remain listed as Endangered in Washington. The sea otter record remains as a lesson to learn from for steelhead management in Washington.

The Wild Salmon Center has focused salmon and steelhead restoration efforts on the Olympic Peninsula into the collection of data that can identify key habitat areas used by salmon and steelhead at varied life history stages and then to coordinate purchases of privately owned land in those areas. To date this has resulted in the purchases of 4,685 acres through the coordinated efforts of the Western Rivers Conservancy, Wild Salmon Center, Washington Department of Natural Resources, and Section 6 funding supervised by the U.S. Fish and Wildlife Service. The Hoh Trust will own and manage the land in perpetuity with a goal to ensure the Hoh River remains a stronghold for salmon and steelhead biodiversity by 1) ensuring that sufficient, functionally connected habitat exists to sustain robust native salmon and steelhead populations, 2) enough salmon make it back to the river basin to maintain healthy, functional ecosystems, and 3) local communities benefit from strong salmon runs and healthy ecosystems.

As indicated by the presently limited distribution of sea otters in Washington State (in a managed marine sanctuary), securing and protecting habitat areas as functioning ecosystems are critical. In the case of such widely ranging animals as anadromous fish, migrations to and from a protected habitat area must be sufficient to allow it to function as a salmon and steelhead driven ecosystem. Habitat purchases made to recreate functioning salmon and steelhead ecosystems are rendered ineffective without sufficient numbers of the key species that drive them.

In the development of the Hoh River steelhead history the following was found:

Comparisons of drainage areas and historic-to-current steelhead population estimates for Washington's Hoh, Stillaguamish, Queets, Quileute, and Quinault rivers (summer runs in red type); Alaska's Situk River; and for the cumulative steelhead populations of Puget Sound streams.

River or region	**Drainage area**	**Historic date**	**Historic steelhead numbers**	**Most current steelhead estimate**
Hoh	299 sq mi	1953	summer 507-837	~100 (surveys 1994-2005)
		1948-1961	winter 7,938-13,230 (avg)	4,501 (recent 5-yr avg)
Puget Sound	not applicable	1895	327,592-818,980	13,083 (recent 10-yr avg)
Stillaguamish	684 sq mi	1895	60,000-90,000	593 (recent 5-yr avg)
Queets	450 sq mi	1953	summer 1,204-2,007	~100 (recent 10-year estimate)
		1923	winter 48,980-81,633	6,188 (10-yr avg)
Quileute	629 sq mi	1972	summer 1,236-2060	~100-150 (surveys 2002-2005)
		1948-1961	winter 17,614 (avg)	14,568 (1962-2005 avg)
Quinault	434 sq mi	1953	summer 1,268-2,113	<50 (surveys 2005)
		1952	winter 19,000	4,892 (recent 5-year avg)
Situk	77 sq mi	1952	25,000-30,000	12,368 (2004 & 2005 avg)

The percent of the present steelhead population size to a known historic population size for each summer run population was:

- the Hoh River summer run is presently 11.9%-19.7% of that in 1953;
- the Queets River summer run is presently 5.0%-8.3% of that in 1953;
- the Quileute River summer run is presently 4.9%-12.1% of that in 1972;
- the Quinault River summer run is presently 3.9% of that in 1953.

Summer run steelhead populations on the west side of the Olympic Peninsula are clear case examples that alteration, or elimination, of habitat is not always the primary driver toward steelhead extinction. Instead, it can be, and often is, fishery management itself through hatcheries and harvest. This should be anticipated to be the case. A common mantra that has been repeatedly cited as the cause for salmon and steelhead depletions for at least 25 years now is the "four Hs": habitat, hydro, harvest, and hatcheries. On the west side of the Olympic Peninsula there are no hydroelectric dams so fishery problems are limited to the "three Hs": habitat, harvest, and hatcheries. Within the Olympic National Park on the west side of the Olympic Peninsula fishery problems are further limited to the "two Hs": harvest and hatcheries.

The percent of the present steelhead population size to a known historic population size for each winter run population examined was:

- the Hoh River winter run is presently 34%-56% of the 1948-1961 average;
- the Puget Sound winter run is presently 1.6%-4.0% of than in 1895;
- the Stillaguamish River winter run is presently 0.7%-0.9% of that in 1895;
- the Queets River winter run is presently 7.6%-12.6% of that in 1923;
- the Quileute River winter run is presently 82.7% of the 1948-1961 average;
- the Quinault River winter run is presently 25.7% of that in 1952;
- the Situk River fall/spring run is presently 49.5%-41.2% of that in 1952, and the historic low from 1960 to 1980 was 3.3%-6.0% of that in 1952.

Beyond the fact that all of the steelhead populations used for comparison have experienced declines from their historic population sizes, two factors stand out:

- the level of depletion is highest when the historic baseline is oldest;
- summer steelhead have especially high levels of depletion.

As might be anticipated, the closer the available historic baseline is to that time before industrial level exploitation of resources first occurred, the greater has been the measurable level of steelhead depletion since. This is the very reason for the pertinence of developing baselines sufficiently far back in history that they provide a useful background for conservation of steelhead to occur, from which to make management decisions for sustainable populations, and from which to develop steelhead recovery plans when necessary.

For Puget Sound and the Stillaguamish River, 1895 appears to be far enough back to provide an effective historic baseline for winter steelhead. The equivalent date for Olympic Peninsula rivers may be 1923 as shown for the Queets River, the earliest year steelhead harvest information was found there. The Queets winter steelhead pattern fits with those of Puget Sound and Stillaguamish River winter steelhead, but those of the other rivers do not. In this regard, the Queets steelhead history is particularly valuable as a comparative means for developing more appropriate baseline estimates for the other rivers of the Olympic Peninsula's west coast.

In the cases of the Hoh, Quileute, and Quinault winter run steelhead, and for all of the summer steelhead populations examined, no historical points were available from which to create a baseline earlier than the late 1940s, and more commonly the 1950s and 1960s. Because of this limitation, it is probable that these steelhead populations are even more depleted than is indicated.

It is apparent that the Olympic Peninsula summer steelhead populations examined are at the edge of extirpation. The Quinault population may be the most dire, with estimated returns of less than 50 fish for the entire watershed whose spawning destinations are further reduced in their split between the North and East forks – potentially less than 25 fish destined for each. The Clearwater population of the Queets system, and the Sol Duc and Bogachiel populations of the Quileute system, may be similarly low with only 2-3 dozen fish returning to each. In fact, the Quinault, Clearwater, Sol Duc, and Bogachiel populations may already be functionally extinct.

Straying hatchery steelhead have been known to be the greater part of summer steelhead catches in the Hoh, Queets and Quinault since 1979. The combined hatchery and wild catches of summer run steelhead have spiked far above what the wild catches alone historically were. With hatchery steelhead present in such large numbers there is the perpetual dilemma of a mixed stock fishery: if hatchery steelhead are sufficiently harvested to minimize their escapement to the spawning grounds, already depleted wild populations mixed with them will be harvested to extinction. If the hatchery fish are not harvested they will swamp the spawning grounds and also potentially eradicate wild steelhead as distinct genetic populations. In the case of the Olympic Peninsula, both of these mixed stock fishery consequences have been in effect for more than 25 years.

Although the Olympic Peninsula winter steelhead populations examined were not found to be as immediately threatened as the summer steelhead populations, or the winter steelhead populations of Puget Sound or the Stillaguamish River, they are managed under the same assumptions that are leading them to those same ends. This is particularly concerning due to the comparative lack of population growth and human development activities that have occurred on the west side of the Olympic Peninsula, and where most of the watersheds are Olympic National Park, Olympic National Forest, Washington Department of Natural Resources, and Indian reservation lands where it would be anticipated that managers are legally bound to effectively sustain resources for future generations. In the case of steelhead (and salmon) this is not being accomplished.

Because the historic baseline for the Queets River is the oldest for the Olympic Peninsula steelhead populations examined, and because the steelhead histories for all of them have been similar in the years since, its present wild winter steelhead run size average that is 7.6%-12.6% of that in 1923 may similarly represent the level of winter steelhead depletion that has occurred since 1923 on neighboring rivers. For instance, the Hoh River wild winter steelhead population, whose recent 5-year average run size is 4,500 fish, would have been about 35,000-59,000 fish in the early 1920s using the Queets River levels of depletion.

Unless it is recognized that significant steelhead depletion has occurred, there is no reason from which to implement management mechanisms whose goal is recovery rather than sustained depletion. Because of an inappropriate baseline, a management that accommodates continuing steelhead depletion is in effect on the Olympic Peninsula.

Although Olympic Peninsula winter steelhead populations have not yet collapsed to the levels of some other populations in Washington, the life history strategies that were historically characteristic to these populations have been just as radically reshaped by fisheries management. These alterations may critically minimize the ability of these populations to adapt to altered watersheds and to an altering climate, and may deny the potential for recovery.

For each river examined, a major shift in wild winter steelhead run timing was found to have occurred since the 1940s and 1950s with a pattern consistently the same:

- prior to the early 1960s wild winter steelhead returns peaked between December and February;
- wild winter steelhead run timing from the 1980s onward has increasingly shifted to March and April, with elimination of the early run component.

Early run timing is particularly important in order to provide a diversity of spawning time options which may vary from year to year as determined by differing weather and water conditions. Spawning surveys in the 1970s found a wide breadth of wild steelhead spawning time in the Clearwater River (sub-basin to the Queets) prior to hatchery returns. Spawning timing was found to vary with differing flow and water temperature patterns that can vary between tributaries (and to the mainstem), as well as between differing years. Peak spawning time was found to vary as much as 39 days between the warmest year (1978) and coldest year (1975) in the eight years of surveys. Yet river entry time for Queets basin steelhead remained the same all years. Steelhead spawning time in tributaries was found to be more evenly dispersed than in the mainstem, and early spawning was more prevalent in tributaries.

Logging has been pervasive on the Olympic Peninsula outside the National Park boundaries. The conversion of large areas of the Olympic Peninsula river basins from old growth to deciduous trees and immature second growth conifers has resulted in altered tributary hydrologies that are pervasively limited by summer low flows, or flows that go dry. Tributary flow conditions may become further aggravated by global warming, whose symptoms have been found to occur on steelhead spawning grounds in Russia. Although alterations in stream hydrology are known to have occurred, it has seldom been considered how this might relate to steelhead run timing, spawning timing, and emergence timing.

The altered hydrologies that have occurred through clearcut logging on the Olympic Peninsula resemble hydrologic conditions that can naturally occur in more arid climates. In southern Oregon's Rogue River basin steelhead largely depend on tributaries that commonly go dry by June. The habitat has selected for steelhead that spawn early, emerge early, and outmigrate early. As a result the Rogue River is a very productive steelhead system because the wild steelhead population retains a sufficient breadth of life history strategies (including early spawning and emergence) to take advantage of the habitat limitations available.

This is no longer the case on the Olympic Peninsula, nor other areas in Washington. Harvest pressures of 80%-95% have long focused on early returning steelhead in the effort to maximize harvest of hatchery steelhead. This has resulted in harvest of early returning wild steelhead at similarly high levels whose dominant historic return timing was also December through February as found in the historic tribal and sport catch records. A subsequent and pervasive run timing shift in wild winter run steelhead has occurred. Wild winter steelhead that return early have been nearly eliminated. Most wild steelhead now enter the Hoh River in March and April. This is confirmed by more recent sport catch data from throughout Washington rivers.

Steelhead run timing that begins in March or April precludes the ability of steelhead to spawn in January or February. In differing ethnographic studies it was found that the Quileute tribal "calendar" dating to ancient times identified the month of January as the beginning of steelhead spawning and that the spawning habits of certain fish were the most important single factor in determining the course of Quileute history. There had to have been significant reasons why the historic run timing of Washington steelhead was primarily December through February. Early spawning is one obvious consideration. Most early spawning in the Clearwater sub-basin of the Queets was in tributary streams prior to hatchery introductions, and it has been estimated that 75% of winter steelhead that once spawned in Washington's Skagit River Basin used tributary streams.

The available historic evidence indicates:

- most wild winter steelhead in Washington historically returned early (December-February);
- most wild steelhead historically spawned in tributaries;
- early wild steelhead spawning was once of greater importance than presently considered or managed for;
- conditions now favor early steelhead spawning even more than was historically the case;
- but early entry wild winter steelhead have been nearly eliminated.

Given these considerations, it is little wonder that wild winter steelhead populations may now be depleted from historic numbers, if for no other reason than the reshaping of their life history options through modern fishery management. What is worse, the habitat they return to has been altered to create conditions that favor early spawning to an even greater extent than was historically the case due to elimination of old growth forests, subsequently altered tributary hydrologies, and global warming.

Of particular comparative value regarding planning for wild steelhead recovery is the example of Alaska's Situk River near Yakutat. In 1952, despite a river basin size of only 77 sq. mi., 25,000-30,000 steelhead kelts emigrated out of the Situk after spawning as counted at a U.S. Fish and Wildlife Service weir. Yet, just one year later the steelhead population plummeted and was reported nearly non-existent in 1953 and 1954. This was due to the combined effects of attempted steelhead eradication efforts that occurred from 1930 into the 1940s; the initiation of sport fishing harvest in the 1940s; decreased returns of salmon related to an ocean cycle shift and related decrease in nutrients; and several years of record drought conditions that occurred. Steelhead numbers, estimated at 1,000-1,500, remained low for 30 years. Reduced to 3.3%-6.0% of the 1952 steelhead count, the magnitude of Situk steelhead depletion was not unlike that of Olympic Peninsula summer steelhead populations today, or the winter run steelhead of Puget Sound.

When management began to monitor the Situk steelhead population in the 1970s and 1980s, sport fishing was the primary harvest component, although total harvest rates were only in the range of 15%-35%. Despite these seemingly low harvest levels, they were evidently sufficient to keep the population from recovering.

With rising sport fishing pressure through the 1980s, Alaska managers responded with catch and release regulations in 1991 subsequently modified to a ban on bait and an annual limit of two steelhead over 36 inches in length in 1994. However, in effect, it remained a catch and release fishery with minimal harvest.

The Situk steelhead population has responded positively, increasing in increments by doubling each decade since the 1970s from 1,000-1,500; to 3,000; to 6,000; to over 12,000 steelhead in 2004 and 2005. The Alaska steelhead managers could have chosen hatcheries as the primary restoration tool, but did not. Without the added complications of a hatchery program and resulting mixed stock fishery combined with hatchery/wild interactions, the wild population has recovered to within 50% of its historic population size.

Although logging has occurred in the Situk basin and related roads have been built in the lower watershed, habitat remains mostly intact. The entire watershed is in Tongass National Forest and the headwaters are in designated wilderness.

The Situk River represents the potential of what could occur on the Hoh River, and other Olympic Peninsula rivers, if most of the watershed habitat were managed for recovery of an ecosystem driven by historic levels of salmon and steelhead.

The basic components resulting in a continuing Situk River steelhead recovery have been:

- altering steelhead harvest levels to well below those generally determined by MSY (commercial harvest limited to incidental catch during salmon fisheries;

sport catch and release in 1991; no bait & annual sport limit of two over 36" in 1994);

- increased numbers of salmon and nutrients beginning about 1989 (probable result of a PDO cyclic shift in ocean productivity);
- habitat that continues to be intact;
- no hatcheries; no hatchery releases; no hatchery straying (of known consequence).

Another useful example regarding salmon recovery efforts is provided by a comparison of the differences that occurred in management of British Columbia's Fraser River as compared to that which occurred over the same span of time on the Columbia River through U.S. management entities.

In the case of the Fraser River, $21.3 million was spent between 1937 and 1985. The approach taken by the International Pacific Salmon Fisheries Commission on the Fraser River in 1937 focused on stock-by-stock harvest management, habitat, and natural production. It resulted in a successful, sustained recovery program that brought Fraser River sockeye salmon that had been reduced to an average return of 3.3 million fish from 1917 to 1949 up to 5.6 million fish from 1949 to 1982, to 7.8 million fish from 1983 to 1986, and to 10.2 million fish in recent years. In 1990, 22 million sockeye salmon returned to the Fraser River system.

By contrast, over the same period of time the Lower Columbia River Fisheries Development Program increasingly came to focus on building more and larger hatchery facilities and transfers of hatchery stocks from the upper to the lower Columbia to accommodate the perceived realities of dam construction. About $3 billion was spent on Columbia River salmon recovery with an additional $50 million slated for yet more hatcheries and a further $1 billion to improve the passage of juveniles over the dams the hatcheries had helped to justify. Although hatchery advocates indicate that 80% or more of Columbia salmon production is now from hatcheries, the total run size has dropped to 5% of its historic abundance. At the same time, hatcheries were further contributing to the decline of wild salmon, creating a deadly spiral to extinction that managers failed to detect. As a result of Columbia River hatchery production emphasis, wild coho in the lower Columbia River have disappeared, populations of salmon and steelhead in other parts of the basin have become severely depressed, hatchery costs continue to mount, and there have been no tangible results.

The Columbia River may singularly be the greatest, and certainly the most expensive, failure in the history of fish and wildlife restoration that has ever occurred.

In *Rivers Without Salmon: A History of the Pacific Salmon Crisis*, Jim Lichatowich (1999) further indicated:

"Even when faced with the threat of Moran Dam in the 1950s [on the Fraser River], *the Canadians still relied on science and did not allow the hatcheries' promise of a quick fix to lure them into trading away the Fraser's mainstem. The commission's restoration program was based on the latest science, which stressed the importance of the salmon's stock structure and the importance of habitat*.

"On the Columbia, this scientific understanding was ignored…Instead, the Columbia River restoration program invested in a 'conspiracy of optimism,' clinging to the unfounded hope that hatcheries could restore the salmon."

Of the four Olympic Peninsula river basins examined regarding their steelhead histories, the Hoh River appears to have human use and ecosystem attributes from which restoration efforts might most thoroughly and rapidly occur. It has the largest remaining proportion of its basin in Olympic National Park (60%-65%) providing intact habitat; the commitment to hatchery salmon and steelhead has been less intensive; and degraded habitat outside the ONP may be more rapidly recoverable with significantly large land acquisitions already in place that are managed to provide for salmon and steelhead recovery.

The Hoh River may never have been as productive for salmon and steelhead as the neighboring Quinault, Queets and Quileute as determined from early 20th century cannery records. Because the Hoh River is the smallest of the four basins regarding drainage size, smaller salmon and steelhead run sizes would be anticipated. Also, the Hoh is considered the most dynamic coastal river with a perpetually altering river channel which may be a particular constraint on mainstem spawning and rearing productivity. This may trace back to the six glaciations that occurred and the influence the remaining glaciers still have on the Hoh in it origins from Mount Olympus. As a result, tributaries may always have been particularly important.

Given the known shifts that have occurred to steelhead entry timing, the extent of tributary habitat degradation, and the successful Fraser River and Situk River examples to draw from, any realistic potential for Hoh River steelhead recovery must include:

- the provision of sufficient salmon escapement from which to recreate a salmon driven ecosystem of which steelhead are particular benefactors from increased salmon nutrients;
- harvest alterations that will allow the rebuilding of historically dominant wild winter steelhead run timing from December through February without which steelhead may never rise above present levels due to the inability to make use of tributary habitat available to them;
- elimination of hatchery salmon and steelhead releases into the basin to reduce the consequences of mixed stock fisheries and to eliminate the potential for hatchery/wild interactions to occur;
- elimination, or minimization, of hatchery salmon and steelhead released into neighboring river basins in order to significantly reduce hatchery straying into the Hoh basin;
- habitat protection/recovery plans for tributaries on federally and state managed lands;
- strategic acquisitions of private lands as they become available;
- reinvestment of hatchery funding into more beneficial recovery options;
- management driven by sustaining fish diversity and functioning ecosystems, not sustained yield or harvest;
- more effective means of monitoring salmon and steelhead populations;
- assessments of the salmon and steelhead production potential for the entire basin if all available habitat were recovered combined with escapement goals set high enough to accommodate steady increases toward those levels.

Historic Steelhead Abundance: Washington NW Coast and Puget Sound

(With Particular Emphasis on the Hoh River)

Prepared for the Wild Salmon Center
May 2006

Part I. Historic Steelhead Abundance

The Shifting Baseline Syndrome

Daniel Pauly (1995) has described fisheries as a global disaster, one of the few that equally affect developed countries with well-established administrative and scientific infrastructure, newly industrialized countries, and developing countries alike. He explains that fisheries science has developed methods for estimating targets for management of these fisheries: initially Maximum Sustainable Yield (MSY), now annual total allowable catch (TAC) or individual transferable quotas (ITQ). However, in this emphasis on the behavior of fishers and fleets, it has tended to separate fisheries managers from biologists studying the organisms and/or communities resulting in models that factor out ecological and evolutionary considerations.

The evidence this occurs, Pauly explains, is represented by absence of:

"…an explicit model accounting for what may be called the 'shifting baseline syndrome'. Essentially, this syndrome has arisen because each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stocks at that time that serve as a new baseline. The result obviously is a gradual shift of the baseline, a gradual accommodation of the creeping disappearance of resource species, and inappropriate reference points for evaluating economic losses resulting from overfishing, or for identifying targets for rehabilitation measures."

There are examples of how other sciences have overcome this problem. Pauly indicates astronomy has used observations of sunspots, comets, supernovae or other phenomena from ancient cultures (such as the Sumerian and Chinese) recorded thousands of years ago making possible the testing of pertinent hypotheses. Since the days of Commodore F. Maury, oceanography has had protocols for consolidating scattered observations on currents and winds, and later on sea surface temperatures. The latter have enabled the extending of the Comprehensive Ocean and Atmospheric Data Set (COADS) back to 1870 with the inference that global warming is occurring.

Pauly points out that fisheries science has no similar formal approach "for dealing with early accounts of 'large catches' of presently extirpated resources, which are viewed as anecdotes." He uses the example of the report of a commercial fisherman being annoyed by bluefin tuna entangled in his mackerel nets in the waters of Kattegat in the 1920s because no market for them then existed. "This observation is as factual as a temperature record, and one that should be of relevance to those dealing with bluefin tuna, whose range now excludes much, if not all, of the North Sea." He indicates there are hundreds of similarly useful observations that can be drawn from the historical or anthropological literature.

The paper concludes:

"Developing frameworks for incorporation of earlier knowledge – which is what the anecdotes are – into present models of fisheries scientists would not only have the effect of adding history to a discipline that has suffered from lack of historical reflection, but also of bringing into biodiversity debates an extremely speciose group of vertebrates: the fishes, whose ecology and evolution are as strongly impacted by human activities as the denizens of the tropical and other rain forests that presently occupy center stage in such debates. Frameworks that ***maximize*** *the use of fisheries history would help us to understand and to overcome – in part at least—the shifting baselines syndrome, and hence to evaluate the true social and ecological cost of fisheries."* (Bold type added.)

The shifting baseline syndrome has commonly denied the ability of science to be an effective fishery management tool. Pauly is not alone in his concerns. Charley Drewberry (2004), provides examples of how discussions limited to the contemporary concept of peer-reviewed scientific literature in the decision making process related to salmon recovery may be denying information from which to make good decisions that should include findings from other disciplines of human knowledge:

"The formal peer-review process does not ensure the quality of the data, and neither does it guarantee the objectivity of science …", and *"…scientific data are not inherently more objective and certain than information from other pursuits, such as history. Virtually all philosophers of science have rejected the belief in objective facts* (data) *for the last half-century."*

In the state of Washington, modern management of steelhead (*Oncorhynchus mykiss*, or *Parasalmo mykiss*, depending on differing species interpretations at the international level) since the Federal District Court case of *U.S.* v. *Washington* was decided by Judge George H. Boldt on February 12, 1974 (Cohen 1986) has typically excluded catch data collected prior to that time in setting escapement and restoration goals.

For instance, the 1992 Washington State Salmon and Steelhead Stock Inventory, Appendix Two, Coastal Stocks (SASSI 1994), provided harvest and escapement data from which management mechanisms have been determined to guide equal division of salmon and steelhead harvest between tribal and sport fishermen in the state as dictated by the Boldt Decision while providing sufficient escapement to sustain wild stocks and fisheries (SASSI 1994). In the assessment of 40 coastal basin stocks of steelhead, only seven stocks of steelhead were shown to have data prior to 1978 and none earlier than 1968. For many smaller streams, and for the summer runs of the Quileute, Quinault and the Queets, steelhead data are not provided until the mid to late 1980s. Yet, based primarily on 5-20 year temporal windows, 18 (45%) of the coastal steelhead populations were described as healthy, only 2 (5%) depressed, and 20 (50%) unknown. In the 2002 stock inventory (SaSI 2003), 19 (47.5%) of the coastal steelhead populations were described as healthy, 4 (10%) depressed, and 17 (42.5%) unknown. Again the data rarely go back farther than 1978, and for many smaller streams and summer runs there are no historic data provided at all.

Given the evidence of a shifting baseline syndrome in fisheries science, and the importance ethnographic and old historic records have proven to provide other sciences, this paper will provide examples intended to extend the historic and prehistoric contexts for evaluating the wild steelhead of the Olympic Peninsula's Hoh River and present management goals for them as largely determined by Washington Department of Fish and Wildlife (WDFW) and the Boldt case Treaty Tribes (in this instance the Hoh Tribe). Because of the commonly scant historic records available, historic steelhead sources are drawn from other near-by Olympic Peninsula rivers (Quileute, Queets, and Quinault Rivers), and from Puget Sound and the Stillaguamish River where similar levels of historic resource uses and management have occurred. A comparison is further provided by the history of Alaska's Situk River which once had remarkable steelhead abundance and is now well into recovery after 30 years of depletion.

The existing distribution, diversity and numbers of steelhead in the Hoh River are put into the context of the geological/glacial record, the archaeological/anthropological and historical records of human occupation of the region, and the historic record of exploitation of a mammal once having nearly identical North Pacific Rim coastal range as steelhead, the sea otter.

Methods Used to Determine Historic Steelhead Numbers And Origin of the Data Used

The historic steelhead data used in this paper have come from differing reports from the Commissioner to the United States Commission of Fish and Fisheries (1892, 1898, and 1900); U.S. Bureau of Fisheries reports (1900, 1904, and 1923); the early reports of the Washington State Department of Fisheries and Game's Division of Fisheries (1890-1920, 1928, and 1932); tribal catch compiled by Washington Department of Game (WDG) from 1934-1978 (Taylor 1979); sport catch and stocking data from WDG (1948-1978; and 1962-1984) and Washington Department of Wildlife (WDW 1987-1993); 1978-2005 sport catch and tribal fishery records from the Washington Department of Fish and Wildlife (WDFW) historic steelhead database (WDFW 2006); and the salmon and steelhead stock assessment inventories for Washington (SASSI 1994; and SaSSI 2003). These represent the cumulative records found from differing agencies responsible for fishery management in Washington at differing historic eras.

COMMERCIAL CATCH DATA:

Regarding the commercial catches of steelhead in the state of Washington as recorded in the reports to the U.S. Commission of Fish and Fisheries and the early Washington Department of Fisheries and Game, they were generally listed by county, not by specific river, excepting for a few important exceptions. In an unpublished NOAA Fisheries report regarding Puget Sound historic steelhead abundance estimates, Myers (2005) relied primarily on early commercial fishery records from these 1889-1930 reports. Myers had initial concerns that the Puget Sound commercial catch might have included steelhead from the Fraser River to the North or other areas if caught in the open Sound? However, it was found in the details of these old reports that the majority of the harvest occurred in terminal fisheries (i.e., gill nets or pound nets) in Skagit, Snohomish, King, and Pierce Counties (Cobb 1911). This would indicate little probability that Fraser River steelhead were included in the catch estimates.

The commercial catch data were all recorded in pounds, not individual fish. To convert pounds of catch into number of steelhead requires determining the average weight per individual steelhead caught. Myers (2005) chose an average of 12 pounds per steelhead. When queried about that choice, he explained (Myers, per. com. 2005): "Rathbun (1900) indicated the average steelhead ranged from 8 to 15 pounds, with an extreme of 25 pounds." Myers split the difference between the averages. However, he also indicated that Pautzke and Meigs (1940) stated that the average of the "early run" was 6 to 8 pounds and fish as large as 16 to 18 pounds in the later run. Myers was unsure of how to accommodate that. Was the average late run fish 16 to 18 pounds or was that the outsized fish? He stuck with the middle of the Rathbun range.

Myers did not attempt to determine what proportion of the steelhead catch was early and what proportion was late. While that could not be determined from the earliest commercial catch data, it can be determined from the earliest available tribal and sports catch data that were recorded by month. From Figures 1 and 2, it is apparent that both sport and tribal catch data, prior to the initiation of major hatchery steelhead programs in Washington State, were dominated by December and January early return steelhead which Pautzke and Meigs indicated were 6 to 8 pounds. This was particularly so of the tribal catch timing.

Figure 1.

Sport Catch of Winter Steelhead in Washington State by Month: 1954-61 When Steelhead Returns Were Primarily Wild.

From L.A. Royal 1972.

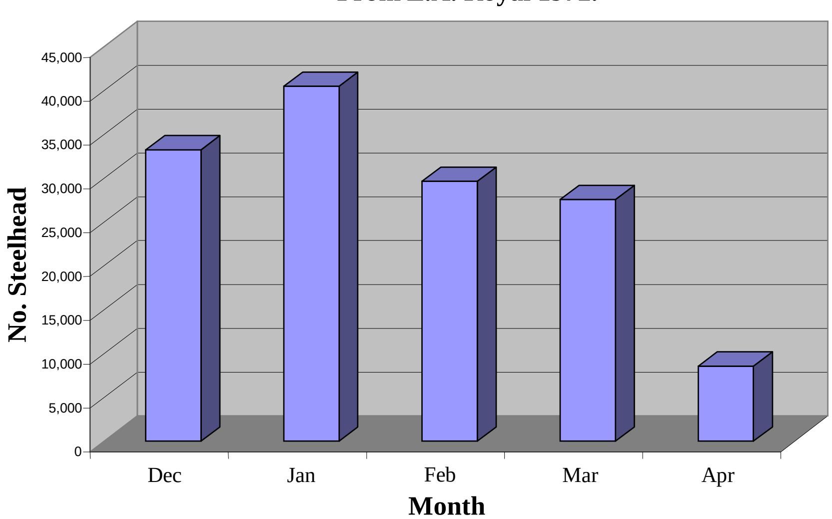
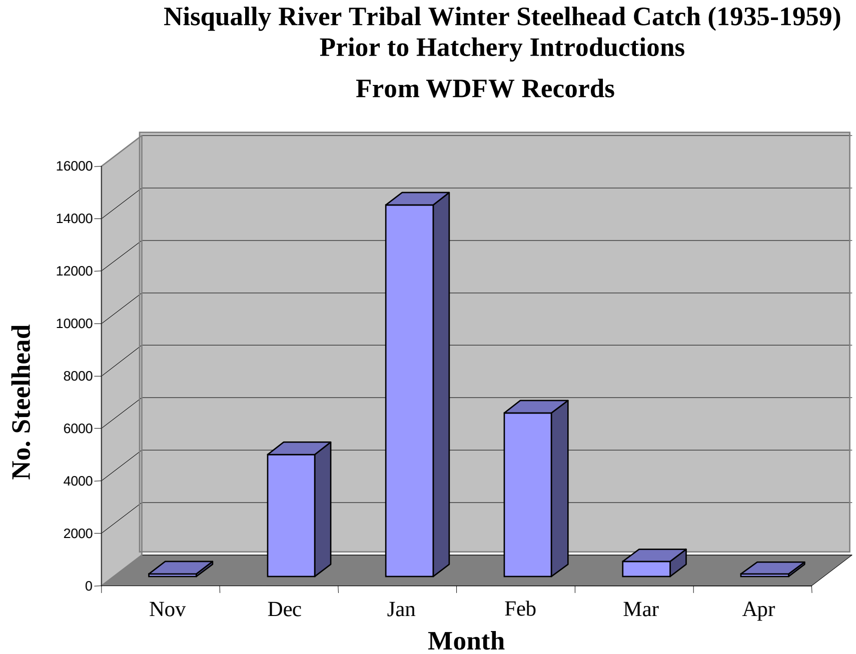


Figure 2.



Although the Nisqually River tribal catch data represent but one river (Figure 2), the tribal steelhead catch data prior to hatchery steelhead introductions were also skewed toward January (and often December) in the nine other rivers with records that early (Taylor 1979). Of the ten total rivers with early tribal catch data, five are from Puget Sound/Hood Canal (Nisqually, Nooksack, Puyallup, Skokomish and White) and five are from the Washington Coast (Chehalis, Hoh, Queets, Quileute and Quinault).

If the November, December, January component of the catch is considered "early," 53% of the Washington sport catch from 1954-1961 was early and 47% of the catch was "late," that being February, March and April. Regarding the Nisqually tribal catch from 1935 to 1959, 73% of the catch was "early" and 27% of the catch was "late."

The historic catch data, particularly the tribal catch, indicate that the size of steelhead caught in the early commercial fisheries would likely have been more toward the 8 pound range of the 8-15 pound average reported by Rathbun (1900) if the "early" steelhead average of 6-8 pounds reported by Pautzke and Meigs (1940) held true.

For the Queets River there is actual evidence of what historic individual winter steelhead size was per month, and over the breadth of the return span. In the handwritten notes of a Queets tribal steelhead catch record for the winter of 1933-34 (Taylor 1979), both the total poundage and numbers of steelhead caught were provided for each month that harvest occurred from December through April. 35% of the steelhead were caught in December with an average of 9.14 lbs. per fish; 37.5% were caught in January with an average of 10.15 lbs. per fish; 18% were caught in February with an average of 10.37 lbs. per fish; 9% were caught in March with an average of 10.06 lbs. per fish; and less than 1% were caught in April with an average of 9.18 lbs. per fish. The cumulative average was 9.82 pounds per steelhead.

Of comparative interest, in a study of Hoh River winter steelhead (Hiss et al. 1986), the average length of wild steelhead caught by tribal and sports fishermen was 29.5 in. A common fisherman's rule of thumb for steelhead weight is: a 24 in. steelhead weighs 4 lbs.; for every inch over that add a pound for steelhead up to 30 in. (Bradner 1950). By that rule of thumb, a 29.5 in. steelhead would weigh 9.5 lbs., indicating that Hoh River wild winter steelhead in 1986 were about the same average weight as those from the Queets River in 1933-34. Confirming that "rule of thumb" for some stocks of wild winter steelhead, Combs (1988) reported that on British Columbia's Chilliwack River, wild winter run steelhead that spent two years in salt water averaged 27.5 in. and weighed 7.5 lbs. and those that spent three years in salt water averaged 32 in. and weighed 12 lbs. as found in Maher and Larkin (1954).

However, life history differences commonly vary among wild steelhead populations from river to river, and even within populations annually (Table 1).

Table 1. Data from sport catch scale samples recorded by Larson and Ward (1954) and Maher and Larkin (1954) in Washington and southern British Columbia.

Saltwater Age Checks	Green 1940	Green 1941	Chehalis 1948	Hoh 1949	Hoh 1950	Cowlitz 1947	Cowlitz 1948	Chilliwack 1949-53
1-year	7%	15.3%	7%	3.5%	1.3%	3%	3%	0.5%
2-years	66%	67.4%	72%	82.5%	79.8%	66%	61.5%	49.9%
3-years	25%	14.8%	20%	14%	18.9%	30%	34.5%	48.8%
4-years		1.5%	1%			1%	1%	0.5%

For most rivers in Washington, there is not this level of information available regarding life histories spent at sea (or freshwater) for the differing wild steelhead populations and how this may correlate to average size of steelhead caught when recorded in commercial catch poundage. However, providing a bracketing range of what the poundage per individual steelhead could have been is one way of capturing what the actual numbers of steelhead were in the historic catch. In the cases of the Hoh and Queets rivers, an estimate of 9.8 pounds per steelhead is probably accurate and a bracketing range is not necessary, but on rivers such as the Nisqually or other rivers of Puget Sound or the West Coast of Washington the commercial poundage can be converted into numbers across a range of 8, 10, and 12 pounds per individual steelhead as capturing the range of possibilities within a population (or larger regional management units such as the Puget Sound ESU). That range would accommodate for the differing proportions of the population that may consist of 1-, 2-, 3-, and 4-year saltwater age steelhead, and their smaller or larger average size and weight per individual. The range method for converting commercial poundage into steelhead numbers is used in this paper if specific population information is lacking.

There are further considerations. Regarding determinations of what actual run sizes may have been from recorded commercial catch, Myers (2005) provides three reasons why the steelhead catch data may be a conservative reflection of actual steelhead numbers. First, during the late 1800s and early 1900s chinook salmon were the preferred species for canning, not steelhead. Secondly, steelhead have a protracted run time relative to chinook salmon and do not tend to travel in large schools making them less susceptible to harvest. Thirdly, winter-run steelhead return from December through March when conditions in rivers are not conducive to commercial fishing operations.

However, Myers (2005) also suggests a counter-consideration: Rathbun (1900) indicated that steelhead were being targeted by fishermen because the winter run occurred at a time when salmon fisheries were at a seasonal low.

The report of Wilcox (1898) provides further reasons why steelhead were commercially targeted:

"… Steelheads are the most plentiful and also the most valuable as market fish on account of their standing long transportation better than other species … prices received by the fishermen were (1895), for steelhead, 3 cents a pound; chinook, 2 cents a pound; silver, … average of 1 cent a pound; humpback, …average ½ cent a pound."

He later explains:

"The fresh-fish trade has within the few years of its existence seen many changes, many firms having started … their efforts, grow in size and importance, as shown by the shipments of fresh fish, in carload lots, to points east of the Rocky Mountains, as follows: 195,250 pounds in 1890; 690,210 pounds in 1891; 2,131,130 pounds in 1895. In addition… the carload shipments by express in 1895 were 2,120,874 pounds, distributed in small lots through the interior of Washington, Idaho, Montana, and Colorado, making the total shipments of fresh fish by rail from Seattle, in 1895, 4,252,004 pounds."

These are the economic reasons why steelhead became a target fishery and which likely led to the peak commercial catch of steelhead in 1895.

There is further evidence that the recorded commercial catch of steelhead and salmon was a very conservative estimation of what actual catch was. Although the fresh market was a valuable commercial niche steelhead filled, they were sometimes canned along with salmon. However, they were not the favored species for canning. Prime spring and summer chinook, or sockeye, were the targeted cannery species depending on the geographic area. Lichatowich (1999) indicates other species were often discarded if the preferred species was abundant. If the canneries or markets had met the limits they could use, those fishermen whose catch was brought in too late could only dump the entire catch overboard.

The discarding of catch would have been particularly true when the market was glutted in the years of greatest steelhead abundance such as 1895.

HISTORIC SPORT CATCH DATA:

In the NOAA Status Review of West Coast Steelhead (Busby et al. 1996), a number of problems related to interpretations of sport catch data were discussed. Although the discussion was under the Oregon Coast section, most of the implications could apply to any sport catch data collected at any point in history:

1) Numbers of fish caught do not directly represent abundance, which must be estimated by applying assumptions about fishing effort and effectiveness
2) Fishing regulations and socioeconomic factors determine fishing effort and effectiveness

3) Fishing effectiveness is a function of both angler skill and environmental conditions which affect behaviors of both fish and anglers
4) Estimates of catch may not be accurate despite non-reporting bias corrections to estimated catch from punchcard returns
5) The relationship of angler catch to spawner abundance is weak in some basins, although there is generally a positive correlation
6) Fishing effort has increasingly focused on hatchery fish with wild catch and release regulations imposed in many streams, thus recent trends may reflect hatchery production more than natural production

Nevertheless, the NOAA reviewers used sport catch trends in their steelhead analysis. They were often the only information available and were used in the assumption that changes in catch still provide a useful indication of trends in total population abundance. Where alternate trend data were available, those data were used instead (Busby et al. 1996). With these clarifications, the reviewers used angler catch data going back to the initiation of punchcards in Oregon in 1952.

However, despite the fact that Washington angler punchcard data go back to the winter of 1947-48, from which trends could be determined if put into historic context with available older tribal catch data and even earlier commercial fishing records, the sport catch data between 1948 and 1961 remain virtually unused.

The 1962 sport catch in the state of Washington provided the first evidence of a major increase in hatchery origin steelhead in the catch (Royal 1972). This was thought to be related to a complete changeover from a wet diet to a pellet diet in 1959 for rearing juvenile steelhead in Washington steelhead hatcheries. The improved diet was correlated with increased survival rate for smolts released in 1960 with most returning as adults two years later in 1962. Although Royal does allude to the possibility that favorable environmental conditions may have affected the high production to some extent, for the most part he considered the change to be due to improved hatchery technologies, especially the 1959 change of a diet, that led to larger, higher quality smolts that could better undergo the fresh-to-salt-water interchange with a minimum of stress. Just as importantly, it allowed juveniles to grow fast enough to reach optimal smolt sizes in one year, as an economic necessity, and early enough to outmigrate between late April and mid May as the optimal window of time determined in previous studies on Washington streams (Pautzke and Meigs 1940; and 1941; Gudjonsson 1946; and Larson and Ward 1954).

Although hatchery steelhead fry releases occurred on some Washington steelhead streams dating back to at least 1916 as found for King County's Green River (Taft's 1925), no apparent major increase in steelhead production at a state-wide level on Washington Rivers apparently occurred until 1962 as documented by Royal (1972). Prior to that time, he considered most steelhead in the Washington sport catch to be wild (Figure 1).

If 1947-1961 sport catch is not used for steelhead management purposes, a significant gap in wild steelhead history in Washington results for many streams. This can lead to false assumptions regarding what steelhead population abundance historically was at a time when habitat conditions and stream productivity may have provided better targets for managers of land, water, and fish resources to aim for.

The state of Washington's reluctance to use the historic catch data prior to 1962 is due to development of a non-response bias factor after the Boldt Decision in 1974. Development of the non-response bias factor was explained in an annual WDG steelhead sport catch summary sheet for 1974-75 (WDG 1975). The assumption is that anglers from 1947-1961 responded with punchcard returns in a similar way as have those anglers since the winter of 1974-75. If they did, it is thought that the 1947-1961 punchcard catch data need to be multiplied by 0.60 as the generally determined factor of non-response bias that has similarly been applied to the 1962-1974 punchcard data.

Hahn (WDFW 1996) indicates the 40% reduction in catch factor for non-response bias was based on an analysis of salmon (not steelhead) punchcard statistics that did not occur until 1977. The average correction for steelhead was 41% as later determined between 1978-79 and 1984-85. The non-response bias adjusts the reported catch by factoring in the finding that anglers who do not return their punchcards are typically less successful than those who do return their punchcards. This was determined by in-season "creel census" estimates calculated for some rivers from 1978 onward. It has resulted in an annually changing non-response bias factor as determined through those few census rivers studied each year since 1978, but it results in a static bias factor (0.60) that is applied, or recommended, for those years prior to that time and to rivers where no census occurred. For those few individual rivers where censuses have annually occurred since 1978, the census estimates are considered more accurate than the punchcard estimates. However, they require a separate table that summarizes those estimates.

The question arises, do the census interviews of anglers from a few rivers between 1978 and 2005 effectively hold true for anglers whose values, habits, ethics, angling motives, daily catch limits, angling competition, available steelhead to catch, and interview responses may all have been very different between 1947 and 1961? It would be surprising if this held true given the significant changes in sexual mores, divorce rates, proportion of those with college educations, levels of material and monetary affluence, and other facets of societal change that have significantly altered in Washington and the rest of the United States between 1950 and 2005.

Although there has been an implication since the Boldt Decision (1974) that there were no studies from which to determine what steelhead punchcard non-response bias may have been prior to 1975, that is not the case. Royal (1972) goes into considerable detail to assess the validity of the catch data he was provided from which to evaluate the Washington Game Department's anadromous fish program. Because of the reluctance by WDFW to use the old historic catch data, it is useful to examine Royal in detail. He analyzed several differing censuses and surveys that were used in the late 1950s and early 1960s which punchcard data were checked against for accuracy in those eras:

1959 (Royal 1972: 26-27):

An *" …experiment to evaluate the punch card system as applied to the catch of winter steelhead by river systems was conducted on the Washougal River in January, February, and March, 1959. Car counts, number of fishermen, and fishing success, separated by weekdays and weekends, including holidays were combined to arrive at an estimated catch of 850 steelhead for the period, compared with 878 calculated a year later from the punch cards. A comparison of the two sets of data shows very little bias error inherent in the punch card system as applied to the Washougal River for the study* *period involved. In this instance, no punch cards were marked in the field and the fisherman, when checked, had no reason to believe that he was contributing data for an experimental program."*

1962, 1963, & 1964 (Royal 1972: 24-25):

"In 1962, 1963, and 1964 a rack was placed across the mouth of the Elochoman River and a tagging program instituted which, in 1963 and 1964, more than fulfilled all the statistical requirements of a successful enumeration program. The program was not successful in 1962, since neither tagging nor recovery was consistent throughout the run … A calculated total of 2,947 steelhead entered the river in 1963 and 2,539 in 1964. The catch for the two years, as estimated from the punch cards, was 2,931 and 2,446, respectively, which was approximately the same as the calculated total run… In view of a substantial escapement in both years, the amount of escapement measured the bias error in the punch card system for the two years as applied to the Elochoman River. However, the bias error was created artificially, at least to a major extent, by the effect of the experimental operation. Constant creel checks – a total of 695 in 1963 and 828 in 1964 – accompanied by personal explanations of the project and the marking of all punches checked, would result in an artificial increase in the number of punch cards returned and related increase in the calculated catch because an average projection factor is used in making that calculation… Any influence other than normal exerted on the fisherman fishing a particular stream can cause a bias error, either positive or negative, depending on the nature of that influence. Since a catch of only 1,080 was recorded for the year preceding the three-year experiment and 1,660 for the year following, the normal bias error inherent in the punch card system for the Elochoman River appears to be quite low. Even when the bias error was increased artificially by the experiment, the exaggerated error remained relatively consistent for 1963 and 1964 and probably for 1962 as well, although accurate data on run size for that year was not available."

1963 & 1964 (Royal 1972: 27):

"In 1963 and 1964, an extensive sampling system involving road and creel checks was placed in operation on the North Fork of the Stillaguamish River to measure the catch of steelhead by this method compared with the catch as calculated from the punch cards… the calculated catch from the sampling method was 4,994 steelhead for … 1962-1963 … and 4,233 for 1963-1964. The punch card catch was 4,815 in 1963 and 6,786 in 1964. The latter figure appears to be the most reasonable one, since the punch card catch should be artificially high due to the marking of the punch cards during the field checks. Careful questioning of people actually involved in the execution of the experiment and the preparation of an unpublished report (Southward and Douglas, Washington Dept. of Game, 1965) fails to provide a logical answer for the low figure in 1963. One can only conclude that either the calculations made from the field sampling for 1963 were in error or some unknown factor was operative temporarily to create an error in the punch card results. The sensitivity to error of catch statistics computed by individual rivers can hardly be overemphasized…"

1966 (Royal 1972: 7):

"In 1966, the Washington Department of Game resampled 5 percent of the fishing license holders through a specially designed questionnaire … The results showed that 134,700 anglers actually fished for steelhead, compared with 140,375 calculated from the punch cards returned; or, a minus bias of only 4.2 percent chargeable to nonresponse. The total catch of steelhead, as calculated from the questionnaire, was estimated at 352,400 fish, compared with 347,100 calculated from the return of punch cards – a difference of only plus-1.5 percent."

Royal (1972: 28) concludes:

"…Since there is no guarantee that other sampling methods which involve only a portion of the population and require weighting to obtain total figures do not have errors also, one must conclude that no practical substitute for the punch card system has been designed as yet for general application. The validity of the total catch figures by season and by month appears to be established. Provided the use of calculated catches for individual rivers systems is restricted to trends or averages and accent is not placed on the catch for single years, these catches appear to have considerable value to management."

However, Royal (1972:8—11) forewarned of the altering angling situation and the potential statistical variables of comparing one angling era to another:

"While the punch card system for calculating total catch appears to be the most practical and economical method for estimating the total catch, the consistency of any inherent error depends upon the maintenance of the same system of operation. A modification of the system can upset the relationship of the resulting statistics with those of previous years. It is possible that a new reaction on the part of the public could result in a major error in calculations…"

"Observation of the characteristics of the steelhead fishery supports the contention that as numbers of available fish increase public interest reflected by intensity increases. On this basis the sudden rise in the catch of winter steelhead for the 1962 winter season in conjunction with the modification of the punch card system described earlier (adding summer steelhead in 1962, and charging $2 for a punch card in 1970) would be due to increase in the number of available steelhead rather than an error in the estimate related to the modification of the basic system.

"A second consideration …must be the rise in fishing intensity and its relation to the catch-escapement ratio … The data … show that for the period 1962-1969 the average number of fishermen actually fishing for steelhead increased 63 percent over that for the period 1954-1961, with the catch increasing 53.1 percent. The catch per unit dropped from 1.79 to 1.68, a decline of only 6.1 percent …

"…Competition … would tend to reduce the catch per unit but improved fishing gear, by increasing the efficiency of the fishery, would tend to increase the catch per unit at the expense of the escapement. General opinion of experienced fishermen favors the influence of competition as being the most important of the two factors, leaving the 6.1 percent actual decline in the Catch Per Unit for the period of 1962-1969 due to the failure of the total population to increase at least proportionately with the increase in fishing intensity. If this were so, the average annual winter steelhead catch for the period of 213,238 fish is 13,871 fish short of the theoretical average catch of 227,109 which

would have been recorded if the population size had increased sufficiently to maintain the C.P.U. in spite of the increase in fishing intensity …"

It is apparent from Royal, that from 1962 to 1969 considerable changes were occurring in the steelhead sport fishery compared to the previous era. These included increased numbers of hatchery fish available for harvest, increased numbers of anglers competing for them, increased efficiency of angling gear, decreasing C.P.U., and potential shifts that may be occurring in the relationship of projected punchcard catch to actual catch due to these changes. From Royal's time onward, there were further changes that included decreasing numbers of steelhead, special or emergency closures, and a gradually increasing trend to release steelhead rather than use for a subsistence purpose.

Regarding subsistence uses of fish and wildlife, many steelhead anglers from 1947 to 1961 constituted a generation that had gone through the Great Depression with wage and food shortages. Fish were looked on as a provision against starvation to be accumulated and stored. This was a very different background from the generations thereafter which had no similar national experience of shortages in wages and food or the sudden collapse from prosperity to poverty that could occur as in the stock market crash of 1929. Recording the catch of steelhead on a card was a secondary consideration to getting the fish into a freezer.

Hahn (WDFW 1996) used historic sport catch data to determine if early return wild winter steelhead in the Sol Duc River had significantly declined. He felt the time periods most useful for comparison were the 1950s (prior to much hatchery stocking but with the first records of sport fishery harvest) and after 1978 (when creel surveys allowed estimating the catch of wild steelhead). Although Hahn ended up applying the 0.60 non-response bias factor to the 1950s catch for comparisons to the catch after 1978, he nevertheless expressed concerns:

"…Comparing the two time periods still depends on the validity of the assumption that the adjustment for non-response bias was correct, however, I expect that it is approximately correct. A comparison of catch rates also assumes that the relative run sizes and exploitation rates are similar for the two time periods. The validity of this assumption is less certain."

Nowhere in Hahn's (WDFW 1996) analysis was there any indication of being aware of, or of considering, the statistical tests Royal (1972) used to confirm the apparent low level of non-response bias in the punchcard catch estimates of the late 1950s to mid 1960s.

Given the detail of the historic analysis by Royal in 1972, and given the questions posed by Hahn in 1996, in this paper the sport catch data from punchcards is used as it was originally collected, tabulated, and sometimes assessed by WDG between 1947 and 1961. And as suggested by Hahn, the sports catch data collected between 1962 and 1977 has not been included in the database, thus leaving a 16 year gap, excepting on those rivers where there was no history of hatchery steelhead. In the latter cases, for the period of 1962 to 1977, the 0.60 non-response bias factor was applied in the assumption that the steelhead sport fishery was in a transitional period requiring some sort of altered statistical response from the earlier era. From 1978 onward, the sport catch data as adjusted for non-response bias was used as collected by WDG, WDW, and WDFW and based on annual census surveys of a few rivers.

This seemed the appropriate use of historic sport data from differing eras that had very different environmental and biological conditions affecting the steelhead returns, differing origin steelhead available to catch, as well as very differing human socio-economic standards that may have determined the responses by anglers.

Hoh River Geologic Background
And Steelhead Evolutionary Considerations

During the Wisconsin glacial age, landforms and aquatic species distribution in the Pacific Northwest were greatly affected by glaciation and flooding that occurred 70,000 to 10,000 years ago (Busby et al. 1996). Although the Hoh River was just south of the maximum extent of the Juan de Fuca lobe of the Cordilleran ice sheet, six separate alpine glacial events advanced and retreated to and from the mountains along the river corridor between about 17,000 and 70,000-110,000 years ago (Thackray 1996; and 2001) shaping the valley as it is today. However, none of the six glacial advances reached the present coastline, each halting 12-48 km (7.5-30 mi.) distant from the river mouth at today's sea-level. The glacial chronology for the Hoh and neighboring Queets Valley and the land and river exposed in distance from today's coastline is provided in Table 2.

Table 2. Chronology of glacial advances on Hoh and Queets Rivers and differing glacier termini in distance from present coastline (Information from Thackray 1996).

Date or Period	Name of Event	Hoh Glacier Terminus Distance from Coast	Queets Glacier Terminus Distance from Coast
>780,000 yr BP	Wolf Creek	0-17 km offshore	6 km inland
just before last interglacial period	Whale Creek	0-13 km offshore	
between 90,000 yr BP and ca. 52,000 ^{14}CyrBP	Lyman Rapids	12 km inland	15 km inland
between ca. 39,000 and 36,000 ^{14}CyrBP	Hoh Oxbow Ø	? but more inland than Oxbow I and II	
between ca. 29,200 and 26,700	Hoh Oxbow I	24 km inland	34 km inland creating lake behind moraine
ca. 23,000 to 19,000 ^{14}CyrBP	Hoh Oxbow II	5 km inland of Oxbow I & had lake behind	
ca. 18,300 ^{14}CyrBP	Twin Creeks I	48 km inland & 4 km up S.F. Hoh	
after ca. 18,300 ^{14}CyrBP; maybe coincident with max. extent Puget Lobe in ca. 14,000 ^{14}CyrBP	Twin Creeks II	probably near Twin I on mainstem & 6 km up S.F. Hoh	

Booth et al. (2003) provide a curve of eustatic (global) sea-level differences that would have occurred at differing points of time during the Wisconsin glacial advances. 10,000 years ago, the global sea-level would have been about 60m (195 ft.) lower than present sea-level; about 18,000 years ago it would have been 120m (390 ft.) lower than present as shown in Table 3. Although regional isostatic depression from the advancing weight of the Cordilleran sheet in areas such as Puget Sound had significant local effects resulting in higher sea-levels occurring as the crust sank, areas at the periphery such as the western Olympic coastline could lift upward with less weight of ice to hold them down. At other points of time, such as when the ice retreated, regional isostatic rebound occurred when the crust was freed from the weight of the ice resulting in a lowering sea-level as the land lifted.

Table 3. Eustatic sea-levels at differing points in time from the last maximum advance of the Cordilleran ice sheet to the present (From curve in Booth et al. 2003).

Age (years before present)	Sea-Level (compared to present)
17,000-18,000 yr BP	~120 m (390 ft) lower
12,000 BP	~80 m (260 ft) lower
10,000 BP	~60 m (195 ft) lower
8,000 BP	~20 m (65 ft) lower
6,000 BP	~10 m (32 ft) lower
4,000 BP	~5 m (16 ft) lower

Thackray (1996) mapped the differing extents of land beyond the present coastline off the mouths of the Hoh and Queets River during the differing glaciations when sea-levels were lower than today. The maximum extent of what is now drowned river valleys would have been 21,000-22,000 years ago when the coastline was 35-40km (22-25 mi.) offshore from today and sea-level was 120m (390 ft.) lower (Shackleton 1987). This was during the Twin Creek I glaciation that terminated with a maximum extent just upstream of the junction of the South Fork on the mainstem Hoh (Thackray 1996) which is 48km (30 miles) from the present sea-level coastline. The total length of the mainstem Hoh River would have been about 83-88km (52-55 mi.), nearly the same length that it is today, but 35-40km (22-25 mi.) of it are now drowned.

Thackray (2001) determined that the most sustained glacial advances on the Hoh River occurred during cool but wet "enhanced moisture stades," while less extensive advances occurred during "reduced moisture stades," which were colder but much drier. This was determined by regional pollen records from the Hoh valley (Heusser, 1974). Heusser (1978) described pollen from the Hoh-Bogachiel divide that indicated cold, dry, tundra/park conditions shortly before 70,000 years ago and again after 24,000 years ago. In the Hoh valley, the pollen record indicated cold dry conditions between 23,000 and 11,500 years ago (Heusser 1974). Presumably this would have been similar tundra-like conditions as previously described.

There is also an insect record for the Olympic coast indicating their persistence through the Wisconsin period. A beetle study at the Kalaloch area indicated July temperatures were only 1ºC cooler than today between about 52,000 and 44,000 years ago (Cong and Ashworth 1996). Beetle assemblages prevalent between 32,500 and 20,000 years ago suggest a treeless environment 3ºC cooler than today.

The pollen data from a silt/peat cliff sequence near Kalaloch indicate that during the cold episodes grass pollen increased and tree pollen decreased in those periods roughly relating to the glacial advances on the Olympic coast (an interpretation of data from Heusser 1972, by Thackray 1996). The pollen evidence suggest a correlation with five of the glacial advances from 43,000 years ago to after the last glacial advance 17,000 years ago. The pollen persisted during and through each of the cold episodes.

An ancient Hoh River watershed area now lies drowned beneath the sea. From the pollen and beetle evidence, it is clear that life persisted along the Olympic coastal refugia. Could salmon and steelhead have similarly persisted? The pollen evidence suggest vegetative cover not unlike today's tundra landscapes in Alaska and Russia's Kamchatka Peninsula that are highly productive for salmon and rainbow and/or steelhead.

For a period of about 30,000 years (between about 73,000 and 43,000 years ago) there may have been particularly productive salmon habitat due to the presence of a large lake mapped by Thackray (1996) on the Hoh River beginning about 12km (7.5 mi.) upstream from today's coastline and extending about 36km (22.5 mi.) upstream to the entry of the South Fork. Sea-level was 49m (150 ft.) lower than today and the river would have extended about 20km (12.5 mi.) beyond the present coastline. The total mainstem length of the Hoh between the mouth and the lake would have been 32km (20 mi.) plus varying extents of the mainstem and South Fork above the lake to the glacier termini as well as tributaries to the river and the lake. If salmon were present there would likely have been sockeye salmon (*Oncorhynchus nerka*) related to the lake habitat providing conditions not unlike the highly productive sockeye and rainbow trout areas of Alaska's Bristol Bay today, or the combined high productivity for both sockeye and steelhead historically provided by Alaska's Situk River further south near the northern limit of present steelhead range (McMillan 2004).

It is known that steelhead of Puget Sound and Georgia Basin typically have a 60-chromosome karyotype while those of coastal stocks typically have a 58-chromosome karyotype (Thorgaard 1977; 1983; and Ostberg and Thorgaard 1994). Between the two geographic regions is Ozette Lake where steelhead have a 59-chromosome karyotype (McHenry et al. 1996 by per. com. from Carl Ostberg, University of Washington to Ned Currence, Makah Tribe). It has been suggested that Ozette Lake steelhead may represent a transitional stock between Puget Sound and the coastal Washington stocks to the south (McHenry et al. 1996).

During the late Wisconsin glacial advance the Cordilleran sheet separated around the buttress of the Olympics to create the Juan de Fuca lobe. It covered Vancouver Island and the Strait of Juan de Fuca well out into the Pacific, and advanced to just south of Ozette Lake at the ice sheet's greatest extent as shown on maps (Booth et al. 2003; Thackray 1996; and 2001). The Puget Lobe of the Cordilleran sheet extended south along the east side of the Olympic Mountains to just beyond Olympia and westward to about Elma. During the greatest extent of the ice, anadromous fish populations in these areas would seemingly have perished beneath the massive ice sheet.

Ozette Lake, whose center was only 10-12 miles north of the maximum southern extent of the Juan de Fuca lobe near La Push (as mapped by Thackray 2001), would have been ice covered for less time than Puget Sound. If Ozette steelhead originally perished, straying steelhead from the south would likely have recolonized it sooner than Puget Sound because the ice was off it sooner. The Puget Lobe advanced to Seattle by about 17,590 years ago; continued to its maximum extent south of Olympia 16,950 years ago; and retreated back north past Seattle by 16,575 years ago (Porter and Swanson, 1998).

The Cordilleran ice sheet covered Puget Sound for little more than a thousand years, and presumably Ozette Lake a much shorter period.

If refugia existed in river valleys of the Hoh, Quileute, Queets, and/or Quinault now beneath the sea, steelhead from there would have been the most likely to recolonize Ozette Lake and Puget Sound if the recolonization came via the sea. But did they necessarily recolonize via the sea?

For instance, complete recolonization of stream resident brook trout, *Salvelinus fontinalis*, that were entirely eliminated from the lower 1.9 km of the 6.3 km long Staunton River in Virginia by a debris flow associated with a massive streamwide flood in 1995, occurred within 2.5-3.0 years via gradual downstream movement of several hundred meters each year from the unaffected upstream watershed (Roghair and Dolloff 2005).

On a larger scale, Mt. St. Helens in Washington State explosively erupted on May 18, 1980. A massive debris avalanche and superheated pyroclastic flows moving at speeds of 250 miles per hour (354-402 km/hr) and reaching a temperature of 680ºF (360ºC) impacted 215 square miles (557 km^2) primarily in the Toutle River drainage. The main avalanche traveled down the North Fork Toutle 13.5 miles (22km) with deposits averaging 150 feet (46m) in depth (Lucas and Weinheimer 2003). Water temperatures were thought to be over 100ºF (37.8º C) (Lucas 1985).

In the first days and weeks after the eruption, aerial surveys suggested some lakes had been completely buried and that nothing could survive. All fish were thought to be dead (Lucas and Weinheimer 2003). However, in September of 1980 first evidence of fish survival was found with a gill net catch of 35 fish from Meta Lake in the blast zone (Crawford 1986).

In all, 77 percent of the streams in the Toutle Watershed used by anadromous fish were affected. Damage ranged from nearly complete devastation of streams in the upper North Fork covered by mudflow to a light dusting of ash in some smaller tributaries. Lucas (1985) reported fish corpses, still full of eggs and milt, littered the streambanks, especially the first year after the eruption. The aquatic food chain was severely limited with stream substrates in the more impacted areas void of all invertebrates.

However, some tributary streams outside the eruption zone remained in excellent condition providing a source for recolonization of both invertebrates and fish to more impacted areas by drift downstream. As Lucas (1985) remarked: "Darwin could not have devised a more ingenious test for 'the survival of the fittest'." Steelhead recolonized particularly well with their diverse life histories providing what was described as a "failsafe mechanism" evidenced by the differing years of adult ocean residence as well as differing freshwater residence times. By 1983 high densities of parr and older steelhead were found in numerous South Fork streams where steelhead primarily returned to spawn in the early years after the eruption. The first spawning survey occurred in 1984 resulting in an estimated spawning escapement of 828 steelhead in the South Fork Toutle. The escapement increased 116% to 1,807 steelhead in 1985 (Lucas 1985; and 1986).

By 1984 and 1985, Toutle River steelhead were rapidly recovering just 4-5 years after the Mt. St. Helens eruption. The effective conservation measures taken had primarily been to allow natural processes to occur in the first several years after the eruption that included little human access into the impacted drainage areas. However, scientific controls were very few during the early recovery period. What part adult life histories played in return from the ocean and subsequent spawning; what part juvenile steelhead with varied life histories that survived the eruption in some tributaries played; what part resident rainbow that may have persisted in less impacted headwater reaches may have played; and what part straying of adult steelhead from other watersheds contributed is not now known.

Given the proven ability of salmonids to rapidly recover and to recolonize massively impacted habitat they have been eliminated from poses several questions regarding steelhead persistence, recolonization, and evolution during and after glaciation on Washington's coastline and Puget Sound:

1) If Puget Sound and Ozette steelhead/rainbow recolonization was via coastal steelhead straying north following the last ice retreat, how did predominance of chromosome karyotypes of 59 and 60 occur from an ancestry that was primarily 58 chromosome karyotype and remained so through the same period of ice retreat?
2) Could former steelhead populations disconnected from salt water and isolated by the growing ice sheet have residualized into rainbow trout over a long enough span of time to diverge into differing chromosome karyotypes?
3) Could steelhead recolonization have then occurred at Ozette Lake and Puget Sound via a few resident rainbow populations that survived and evolved into 59 and 60 chromosome karyotypes at the terminus of the ice sheet in ponds, lakes, or small streams?
4) When the ice retreated might resident life histories of rainbow/steelhead have regained access to salt water via meltwaters into Ozette Lake and glacial Lake Russell (that became Puget Sound) resulting in a resumed anadromous life history with altered chromosome karyotypes?

Questions 2, 3, and 4 seem more possible for Puget Sound than Ozette. Ozette may have been beneath the edge of the Juan de Fuca lobe for less than 500 years, although even Puget Sound was beneath the ice for only a little over a thousand years. At the edges of the ice sheets, the affected local environments were under dramatic and rapid alterations. The associated biological adaptive stresses would have been at the very edge of species survival.

In *The Beak of the Finch: A Story of Evolution in Our Time*, Weiner (1996) describes the rapid alterations that have occurred among the populations of Darwin's finches on the Galápagos Islands in studies initiated in 1973 by Rosemary and Peter Grant. The changes were outwardly visible in the shape of the finches' beaks and then internally documented at the molecular level through the DNA of their blood. The evolutionary changes they documented among the finches had occurred within the span of 30 years of altering ocean currents and subsequent weather patterns resulting in remarkably wet series of years and suddenly remarkably dry years.

The Galápagos Islands are off of Peru near where one of the key pressure points in the global circulation system occurs called an El Niño event. Their frequency and intensity may be increasing with global warming. Darwin's finches must effectively adapt or die. The shape of their beak is the key to opening differing kinds of seeds. Thin pointed beaks are adequate tools during wet years when many kinds of seeds are available ranging from those with thin shells to those with thick shells. But in dry years only the drought tolerant plants, particularly cacti, with thick-shelled seeds survive and the finches with the shortest thickest bills survive best. The wet years result in healthy populations of all the species of finches and the diverse varieties of beaks, but the sudden dry years take those finches toward extinction that do not have short thick beaks to effectively crack seeds limited to those with thick shells. With increasing and more severe El Niños it is estimated that within "perhaps a century" three species will be reduced to a single population (Weiner 1996).

At the edge of the Cordilleran ice sheet there may have been a similar ecological vortex for biological stress as that on the Galápagos during global warming and intensifying El Niños. It would also have resulted in the necessity of adaptation or extinction for differing species, and for populations within species. One result may have been surviving resident life histories for steelhead as rainbow trout in remaining habitat niches isolated by the ice. Denied ocean access, the isolation of being ice bound in the altered environment may have quickly favored some characteristic tied to 59 or 60 chromosomes rather than the initial 58. When the ice melted, perhaps rainbows regained the sea and anadromous life histories resulted with altered chromosome karyotypes.

The alternative is that during initial recolonizations from the sea by steelhead straying from Olympic coast refuges (or those further south) into Ozette and Puget Sound, some survival trait was carried with the 59 and 60 chromosome karyotypes carried by a few anomalous coastal steelhead that favored their survival in the outrush of rivers from a landscape greatly altered by the massive Cordilleran sheet.

There is evidence from the west coast of the Kamchatka Peninsula that steelhead destined for some rivers leave the Sea of Okhotsk just at the time of river ice-up (late October or early November) and then travel beneath the early stages of ice to upstream overwintering destinations. A name has been coined by the Russians for these steelhead, "The Ice Travelers" (Savvaitova et al. 1973; 1996; and McMillan, 2001). The steelhead interact with resident and estuarine life histories in what appears to be a single, but diverse and complex, steelhead/rainbow population in each river (Savvaitova et al. 1973; McMillan 2001; Augerot 2005). It is thought this complexity of life history diversity may be more typical of the original inherent diversity of the species (*Oncorhynchus mykiss* as classified by North American taxonomists but *Parasalmo mykiss* as classified by Russian biologists) that may no longer be as well represented on the eastern side of the Pacific (Pavlov et al. 2001; and Augerot 2005).

It is apparent that ice has been a primary determinant of salmon and steelhead distribution and diversity (Augerot 2005). Steelhead/rainbow were described in Kamchatka long before they were in North America (Krasheninnikov 1755; Pallas 1811). Human population size, land and water alterations, and resource exploitation affecting steelhead/rainbow have progressed much more rapidly in North America since that time than in Kamchatka. Kamchatka may be the best remaining area from which to study steelhead/rainbow diversity (McMillan 2001) and may provide a critical link to understanding steelhead evolution and distribution that should be preserved as an archive of relict populations (Soverel et al. 1997).

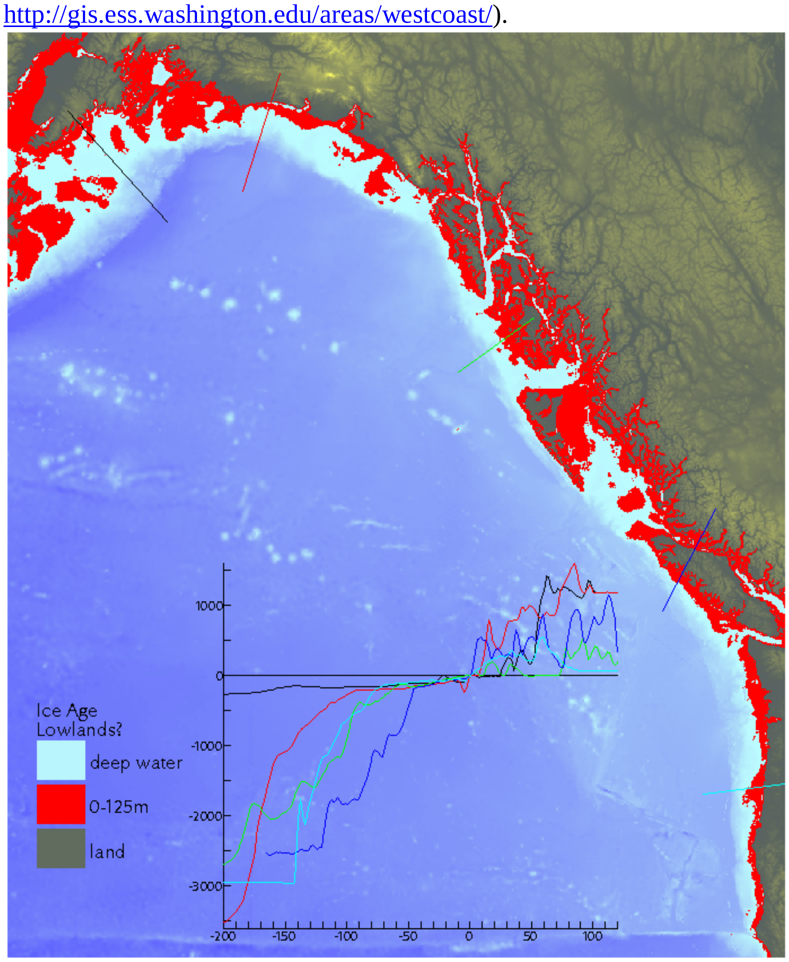
Although mitochondrial DNA analysis has determined steelhead/rainbow variation is greatest in their southern range (including the inland resident forms of California, Baja, and Mexico), which has been interpreted to mean a longer history there than in their northern Pacific range where advancing ice sheets between 60,000 and 10,000 years ago eliminated them with subsequent recolonization from the south

(McCusker et al., 2000), adaptive genetic variation does not always require vast amounts of time.

Burger et al. (1997) found that in addition to colonizing new habitats quickly following glacial recessions, genetic divergence of ecologically different forms of sockeye salmon can occur within relatively short (<2000 years) geologic time frames. This demonstrates that isolation can create relatively rapid divergence into diverse sub-populations during stressful environmental conditions.

Reduced population diversity can also occur rapidly. Weiner (1996) discussed how species diversity can quickly be simplified under stresses such as those facing Darwin's finches on the Galápagos Islands with global warming. Another example is that of the glacial refuge provided by the Queen Charlotte Islands off of British Columbia where sockeye salmon were found to be genetically distinct, but displayed reduced genetic variation, perhaps because of what was described as a "recent bottleneck" in population size (Beacham et al., 2006). The recent bottleneck was probably the last ice age. As shown in Figure 3, the North Pacific Rim may have provided a number of areas where anadromous fish refugia may have occurred when sea-levels were lower and sufficient habitat remained outside the extent of glacial ice.

Figure 3. The areas in red represent what would have been exposed land when sea-level was 125m lower during the last glacial maximum. Much of the red areas shown would have been ice free (Harvey Greenberg. 2006. University of Washington Department of Earth and Space Sciences http://gis.ess.washington.edu/areas/westcoast/).



In the case of steelhead/rainbow, the geographic origin of the species would appear to remain unclear. *O. mykiss* (or *P. mykiss*) origins might as easily have been from their northern range as well as their southern range.

The greater diversity remaining in the southern range may simply represent an archive of stored genetic material from northern origins. Due to their frequent resident isolation from anadromy during periods of warmer climatic trends (as presently represented by inland rainbow trout in California, Baja, and Mexico) the southern stocks could have diverged and diversified even further. While the remaining southern diversity may represent an older genetic history, they may not necessarily represent the geographic origin of the species.

An even older genetic complexity may have been erased through most of the rainbow/steelhead northern range by advancing and retreating ice through genetic simplification during repeated periods of population bottlenecks that occurred in more northern refugia beginning 70,000 to 60,000 years ago after the previous interglacial period. This apparently occurred with sockeye salmon on the Queen Charlotte Islands (Beacham et al. 2006) and potentially elsewhere in points of west coast refugia that could include the Olympic Peninsula. And McCusker et al. (2000) agree with McPhail & Lindsey (1970) that Kamchatkan trout (*O. m. mykiss* or *P. m. mykiss* in Russian taxonomy) may well have survived glaciation in a northern refuge.

Although Smith et al. (2001) did not find sufficient diversity in the coho of the Chehalis River system to support that it could have been a glacial refugium, other authors have found biological and distributional evidence for several fish species that suggest the Chehalis drainage did provide a glacial refugium (McPhail & Lindsey 1986; McPhail & Carveth 1993; McPhail & Taylor 1999; and Taylor et al. 1999). The Chehalis River system is considered the present northern boundary of the Southwest Washington ESU separating it from the Olympic Peninsula ESU (Busby et al. 1996). The Hoh River is part of the latter.

There remain many questions that biologists, geneticists, geologists, and geomorphologists could collectively discuss in future collaboration that might resolve whether Hoh River and other coastal Olympic Peninsula steelhead survived the Wisconsin advances in refugia and went on to recolonize Ozette Lake and Puget Sound, or what part the resident life history might alternatively have played. If Olympic coastal steelhead and residents both perished in one or more of the Wisconsin advances, recolonization would likely have occurred from surviving steelhead populations south of the Cordilleran extent of ice such as the Chehalis, Willapa area, or Columbia river tributaries. Learning how steelhead survived and recolonized streams after the retreat of the Cordilleran sheet may provide an understanding of how to better manage for steelhead now faced with another period of rapid climatic change.

Human Prehistory and a Question of the Future

The more conspicuous animals of modern North America, such as bison, wapiti, and moose, migrated across the huge land bridge of Beringia (or Bering land bridge) from Eurasia as provided by the late Pleistocene ice age (Tudge 1996). Human beings are generally thought to have followed about 12,000-15,000 years ago (Kingdon 1993;

Tudge 1996; Diamond 1997; Lichatowich 1999; and Rudgley 1999.). They spread steadily south entering South America about 11,000 years ago (Tudge 1996).

However, some are not inclined to dismiss evidence which suggest human occupation of the Americas 30,000-200,000 BP. As Rudgley (1999) points out, although passage to the New World is generally accepted as occurring 12,000-13,000 years ago, occupation of California >50,000 to 200,000 years ago might be easier to dismiss if the evidence for that dating had not come from the findings and tool identification by Louis Leakey, "the founder of the most famous 'dynasty' in the study of early man." The maker of such early tools would have been *Homo erectus* rather than *Homo sapiens*. Stringer and McKie (1996) cite mitochondrial DNA findings in Native Americans that indicate the "founding mothers" from Asia that migrated to America may have been only four women in the first group 21,000-42,000 years ago. They also indicate that tools and other remains date human arrival in the Americas 15,000-35,000 years ago, and analysis of Native American blood and proteins indicate the continent was settled 30,000 years ago in three different waves of immigration. Rudgley (1999) also cites references that indicate from the differing shapes of the teeth, differing DNA, and identification of at least three separate macro-families of languages in aboriginal Americans, there were at least three separate waves of migrations of distinct people from Asia.

By the end of the Pleistocene, about 10,000 years ago, human beings occupied most of the world's great land masses (Tudge 1996). Tudge discusses the impacts modern human beings had on their fellow creatures:

"…we know that in the late Pleistocene many large animals died out on three continents: while in the late Pleistocene and Holocene entire suites of creatures disappeared from islands worldwide…we also know that the creatures we see today…are a shadow of the faunas of comparatively recent but 'prehistoric' times. We know that the extinctions tended to follow the incursions of human beings. Did the animals simply fade away? Or did we kill them?"

"Of course we did. Or at least, our immediate ancestors did. I do not know whether they did it inadvertently as highly competent hunters who were also insouciant; or whether they what they did with regret; or whether they set out, as protomanagers of game… But whichever way they approached the task, the jury must find them guilty.

"…Other factors did play a part in the Pleistocene and post-Pleistocene extinctions… Climate alone might have done the trick here and there. Bt the *coup de grace*, and often the sole operant, was ourselves.

"And now the pace of extinction has increased. Now the world is so arranged, if 'arrangement' is the word, that the existence of every other creature is to some extent in our hands… So now we have the world at our feet – where do we go from here?"

As an extension to Tudge's question, three others come to mind:

- Have we learned to manage fish and game better through the supposed benefits of modern science than our primitive predecessors?
- Or have we so completely failed in the management goals for supposed renewable resources that we have, in fact, sped depletion of stocks and species into fast forward?
- If the latter, how do we accommodate restoration rather than further depletion?

Earliest Human Colonization on the Westside Olympic Peninsula

The Beringia passage of humans and other animal species required the lowering of the sea level provided by ice age cycles to create a bridge from Eurasia to North America (Diamond 1997; Kingdon 1993; Stringer and McKie 1996; and Tudge 1996). Human occupation of southeastern Washington State occurred at least 11,200 years ago as attested by evidence of almost continuous habitation of Marmes Rockshelter on the Snake River just before it was inundated by the filling backwater of Lower Monumental Dam in 1969 (Hicks 2004). The Marmes Rockshelter site would have been south of the Cordilleran ice sheet, whose maximum extent was described by Booth et al. (2003). Location outside the ice sheet have been a critical determinant of where human ice age occupation occurred, although the original crossings of Beringia would of necessity have been made by peoples well adapted to living with and traveling in vast reaches of snow and ice. The shelter itself was gouged out by the repeated Missoulian Floods during the rushes from ice dam collapses containing Lake Missoula (Dietrich 1995), 95-100 floods in all, over about a 2,000 year period between 15,700-13,500^{14}C yr B.P. (Booth et al. 2003). Human occupation was thereafter.

American Indians have resided on the Olympic Peninsula for at least 10,000 years (Wray 1997). As described by Lichatowich (1999), once human passage from the Beringia bridge occurred, there were two routes south. The Cordilleran and Laurentide ice sheets did not entirely meet leaving an ice-free corridor through present-day Alberta leading south into the Pacific Northwest. The other possible route was travel along the coast itself.

Although the original human record for the west coast of the Olympics may never be complete, the presently documented delay of more than 1,000 years regarding occupation of the Olympic coast from that in more southerly areas of Washington might be due to the timing and pattern of the glaciations during the last Ice Age combined with related alterations in sea levels that may have isolated it, or made it otherwise uninhabitable.

The ponderous geologic cycles of glaciers and related sea levels have largely determined the retreats, the adaptations, and the eventual re-colonizations of biological life along coast lines. This includes both human beings (*Homo sapiens*) and steelhead whose pre-histories, as well as more modern histories, may be closely linked on the western Olympics.

If steelhead and salmon persisted throughout the Wisconsin glacial advances, they would have had to move both up and down the valleys in unison with the glaciers. Both human beings and fish may have colonized the opening upstream valleys in the wake of that last glacial retreat on the Hoh (~17,400 BP). In fact, they would have been forced to do so by the flooding sea thereafter. Where and when original human occupation of the Olympic coast and river valleys originally occurred may now be beneath more than 100 feet of seawater. The stories of ethnographic record combined with increasingly better understanding of glaciations and sea-levels at specific points in time may provide a closer approximation of how and when original human colonization occurred than present limitations to the material record of archeological findings.

It has been estimated that 6,000 to 8,000 years ago most glaciers completely melted away (Easterbrook and Rahm 1970). Sea-levels (Table 3) may have been 10 m-20 m (32 ft-65 ft) lower and still rising, remembering that precise levels at the regional scale may differ from the eustatic sea-level (Booth et al. 2003). At that time, temperatures at the Humptulips River (next basin south of the Quinault) were slightly warmer than present (Easterbrook and Rahm 1970).

Whether temperatures 6,000-8,000 years ago were above the best productivity range for salmon and steelhead in both freshwater and saltwater is a consideration.

Lichatowich (1999) indicates a rapid warming began about 14,000 years ago with a peak 5,000-6,000 years ago. It would have been hot and dry. The climate shift toward the cool, moist maritime conditions of today began 4,000-5,000 years ago. 3,000-5,000 years ago, forests matured and climate, weather, habitat and evolving salmon would all have converged into an "ecological harmony" that produced the salmon abundance the Euro-American explorers reported in the late 18th and early 19th centuries.

Lichatowich (1999) notes that the first archaeological evidence of human salmon consumption in North America dates to 9,000 years ago as found on British Columbia's Fraser River. 7,000-8,000 years ago, indigenous people left evidence of harvesting salmon on the Columbia and Snake rivers. But evidence of people whose diets were dominated by salmon and steelhead does not occur until 6,000 years ago with the Namu people on the central coast of British Columbia. The indigenous technology of drying and smoking fish to preserve them for storage did not occur until 3,000 years ago which would have led to greater human population stability (no more feast or famine). In part, this progression may have been related to increasing abundance of salmon, but it could also have been determined by the time it took to develop fishing technology to effectively harvest salmon.

This sequence of events for Northwest salmon, steelhead, and indigenous people, as shown in Table 4, fits in well with the retreat of the last glacial advance on the Hoh River, but it does not take into account that there may have been a suitable salmon and human refugia from the very beginning of the first Wisconsin advance that may have been as distant in time as 90,000 years ago (Table 2). Although no known record suggests human beings were anywhere near the Hoh River that early, the record may not be so clear that salmon and steelhead may not have persisted throughout.

Leo Frachtenberg (1921) suggested that the original location of the Quileute tribe, now located on the west coast of the Olympic Peninsula, must be looked for at a point further east. In 1915-1916, he interviewed tribal members that told of Quileute travel far up the Sol Duc River by canoe to hunt. This included treks over the Olympic mountains as far as the Elwha River (Frachtenberg 1916; and Wray 1997). But the mountains were more than a travel route and represented something similar to a 'Mount Ararat' of native traditions as described in the account of a Great Flood that once separated the Quileute and the Chimakum into two tribes. Frachtenberg (1921) recorded that it was the mountains that provided their canoes refuge until the receding waters took the Chimakum northeast to present day Port Ludlow and Chimakum, and the Quileute west to the shores of the Pacific (Wray 1997). From his examination of the ceremonial societies of the Quileute and related Chimakum Indians, and the importance of the Quileute hunting society, he concluded that such an ancient society must have been developed by a people whose main occupation was once hunting (Frachtenberg 1921).

Table 4. Chronology of initial human migration to North America with eventual colonization on the western Olympic Peninsula.

Time or Period	Finding or Event	Source
>50,000 to 200,000 years ago	Ancient primitive tools found in California by Louis Leakey	Rudgley 1999
21,000-42,000 years ago	Mitochondrial DNA findings from Native Americans of four founding women who migrated to North America	Stringer and McKie 1996
15,000-35,000 years ago	Aboriginal tools and remains found at North American sites; differing shapes of teeth, differing DNA, & identification of at least three separate language macro-families among Native Americans indicate three waves of aboriginal migrations	Stringer and McKie 1996; Rudgley 1999
15,700-13,500 ^{14}C yr B.P.	Missoulian Floods occur 95-100 times on Columbia River during the latter Cordilleran ice sheet era	Booth et al. 2003
12,000-15,000 years ago	Most generally accepted period of North American aboriginal migrations across the Beringia land bridge	Kingdon 1993; Tudge 1996; Diamond 1997; Lichatowich 1999; and Rudgley 1999
11,200 years ago	Marmes Rock Shelter on Snake River in southeastern Washington is aboriginally occupied	Hicks 2004
10,000 years ago	Known aboriginal occupation of Olympic Peninsula	Wray 1997
9,000 year ago	First known salmon consumption by aboriginal people found on Fraser River British Columbia	Lichatowich 1999
6,000-8,000 years ago	Most glaciers melted away & Humptulips River area temperatures a little warmer than present	Easterbrook and Rahm 1970
5,000-6,000 years ago	Peak of hot dry period	Lichatowich 1999
6,000 years ago	Indigenous Namu people dependent on salmon diet on central British Columbia Coast	Lichatowich 1999
3,000-5,000 years ago	Ecological harmony occurs to create the salmon abundance reported by late 18th and early 19th century Euro-American explorers of Northwest	Lichatowich 1999

This is not the lone historic reference to an older heritage that included more inland locations than the present coastal sites of the Quileute and the related Hoh tribes. Albert Reagan (1917), described "an ancient midden heap …found on the Hoh River some 16 miles inland at a place called the 'bench,' on a benched area where the Olympic glacier made a stand on its retreat up the mountains from the coast." This would be near today's Oxbow area of the Hoh River. Although this site has not been documented in more recent archaeological history, Wray (1997) indicates it is reasonable to believe that as the alpine glaciers retreated, areas of glacial refugium may have been used as habitation sites.

There are also more references to the Great Flood. Wray (1997) suggests floods may have been real occurrences which the Olympic tribal mythological stories have been built on. Chris Morgenroth was married to a Quileute woman (Wray 1997). Morgenroth (1991) homesteaded on the upper Bogachiel in 1890 and later related a story from his wife about the Quileute taking canoes to Mount Olympus as refuge from a flood. James Swan (1870; and Wray 1997) related a story of a Great Flood from the Makah. The Klallam and the Twana also were recorded in the 1870s and 1880s as having traditions regarding a deluge (Eels 1878 and 1985; Elmendorf 1961; Clark 1953; and Wray 1997) as well as the Lower Elwha Klallam as recorded at a later date (Clark 1953; and Wray 1997).

If Leo Fruchtenberg was correct in his conclusion that the Quileute's original culture was that of inland hunters, not that of coastal sealers, whalers, shellfish gatherers, and halibut fishermen, with anadromous fish their dependable mainstay as described by Pettit (1950; and Wray 1997), this could mean that during the time of the original west coast tribal occupations at the foot of the receding glaciers, salmon were not yet present, or were too few and/or unreliable to sustain villages of people, or to build a culture around. It may have been mammoth, elk, and other large mammals that originally provided the necessary calories to sustain people as the glaciers retreated.

Then again, it is possible that the earliest village sites are no longer accessible for archaeological examination. They could be drowned beneath the Pacific because of sea-level changes during differing periods of glaciations and post-glaciations.

Early Non-Aboriginal Contact with the Olympic Peninsula And It's Aboriginal People

The generally presented history of non-aboriginal contact with the Northwest coast of North America is that of Europeans traveling by ship from the east to the west around the tip of South America from the Atlantic to the Pacific and then north. Although this history is in error, it is as follows:

In the case of Washington's Olympic Peninsula, initial European contact is thought by some to have been by a Greek pilot, Aspostlos Valerianos, who sailed under the name of Juan de Fuca for Spain. Although proof of this voyage is lacking, he claimed to sail into the waters that now bear his name in 1592 (Warren 1982).

A better documented voyage was that of Juan Perez Hernandez. While claiming territory for the Spanish Crown, a prominent mountain was viewed from his passing ship and named Santa Rosalia on August 11, 1774. It was not until 14 years later (1788) that the same mountain was sighted by an English trading ship captained by John Meares and given the name of Mount Olympus. Meares also named the Strait of Juan de Fuca, believing the story of its original discovery by the Greek-Spaniard pilot to be true (Brockman 1937; and Warren 1982). Of course, these land and water features had aboriginal names for many millennia prior to European "discovery."

In 1775, Bruno de Heceta anchored the *Santiago* and went ashore near the Quinault River to plant a cross for the possession of the land for Spain. Seven men from a sister ship, the *Sonora* captained by Bodega y Quadra, were killed during an encounter with three hundred Indians near what was then eulogized as the Island of Sorrows, now Destruction Island (Brockman 1937; Warren 1982; and Wray 1997). This was near the mouth of the Hoh River.

Captain James Cook was the first English navigator to explore the Pacific Northwest Coast. In 1778 he named Cape Flattery but somehow failed to find the Strait of Juan de Fuca (Warren 1982). During this last voyage of Cook's, he landed at Nootka Sound (which he named King George's Sound) where he described the natives and the furs of sea otter (Cook and King 1784). Of great historic significance, he then went north to Kodiak and other Alaskan islands in the continued bartering for furs from the natives and found that the sea otter pelts sold in China for immense prices and high profit. This set off a flood of English and Americans to the Pacific Coast seeking fortunes from the sea otter trade (Irving 1849; Warren 1982; and Dmytryshyn et al. 1988).

In 1787, Captain Charles Barclay, in the *Imperial Eagle* under the auspices of the East India Company, made the first documented discovery of the Strait of Juan de Fuca, to be named by John Meares the following year (Brockman 1937; and Warren 1982). With Barclay was his seventeen year old bride, the first white woman known to visit the area and who kept the ship's log (Warren 1982). Barclay later sailed south and found a river opposite Quadra's Isla de Dolores (Island of Sorrows). He named it the Destruction River after six men sent ashore for water met a fate similar to those from Quadra's *Sonora* in 1775. However, the names given by Quadra and Barclay were later mixed up, and on the official maps the island was labeled Destruction Island. The river Barclay saw retained its original name of Hoh (Brockman 1937).

John Meares, captain of the *Felice*, had the first documented contact with the Makah Indians in 1788 at Tatoosh Island (Gunther 1972). This was followed by the Spanish landing at Neah Bay in 1790 and their erection of a fort there in 1792 that was abandoned within a few months due to Indian hostility.

However, none of these early contact dates explains a smallpox epidemic among the Puget Sound tribes in 1782-1783. Nor does it explain the Quileute and Hoh experiencing a series of epidemics that began in 1782 (White 1980) unless one or more of the seven men killed by the Quileute at Destruction Island in 1775 were carriers.

As frequent as this history is presented, it typically excludes that the first documented European contact with the Northwest coast of North America was from the East, not the West, and that it may have been Russians who first made European contact with the Olympic Peninsula, Puget Sound, and the indigenous people. This could account for the otherwise poorly explained 1782 beginning of epidemics among Puget Sound tribes and the Quileute and Hoh.

In 1741, two Russian ships built on the Kamchatka Peninsula reached the Alaskan coast, led by the Danish Captain Vitus Bering. Mt. St. Elias was sighted near today's Yakutat in Alaska, and landfall was made at Kayak Island (Ford 1966; and Dmytryshyn et al. 1988). The Bering expedition included George Wilhelm Stellar, the first naturalist to describe the flora and fauna of the new world. Many plants and animals now carry his name. His is the only remaining description of the Stellar's sea cow that went extinct shortly after, and he provided the only description of an animal never seen by Euro-Americans before or after: Stellar's sea monkey (Ford 1966). This was 32 years before the sighting of Mt. Olympus by Juan Perez Hernandez.

The Bering expedition initiated Russian exploration and fur trade with the native tribes of the Northwest Coast. How early and how far south the Russian fur trading occurred is difficult to fully document. Over forty Russian companies worked the North Pacific from 1743 to 1799. Because so many of the ships from these profit ventures sank, there would have been no record of the extent of their travels. The history is further obscured by a Russian government that has commonly been secretive both before and after the revolution, and much was never written in the first place by Russian seafarers who were commonly illiterate. Many of the subsequent maps they created were inaccurate; what information that was disclosed was often purposely misleading to protect their fur interests; and much of what was initially recorded has been destroyed by fire or neglect (Dmytryshyn et al. 1988).

Anecdotal evidence would suggest that the Russians were trading with the tribal people along the west side of the Olympic Peninsula before other Europeans.

The combined number of voyages to the North Pacific by the Spanish, British, French, and Americans in the second half of the eighteenth century were far fewer than the number of Russian sailings, and British ships encountered the Russians in unexpected corners. The Russians had a permanent settlement on Kodiak Island by 1784 (Dmytryshyn et al. 1988), and the Russian-American Company occupied the Ross settlement in California for 30 years (Arndt 2004) before abandoning it in 1839 (Dmytryshyn et al. 1988). In 1808, it is known the Russian brig Saint Nicholas ran aground near La Push. After the crew shot and killed two Quileute they fled south on foot and went far up the Hoh for winter. Through both barter and force, they acquired salmon from the Indians (Hilson 1981).

Because other European nations more openly published their accounts, west European seafarers received credit for discoveries that had actually been made, or perhaps had been made, much earlier by Russian Argonauts (Dmytryshyn et al. 1988).

But the Chinese may have explored the Northwest American coast long before the Russians or western Europeans. In fact, there is a growing body of evidence documented by Gavin Menzies (2004) that the Chinese sent out four fleets combining into one vast armada in 1421 that resulted in the mapping of the world. The remains of the fleets returned to China in 1423. En route, four islands were mapped far out in the western Atlantic as found by Menzies on an old chart he came across in the James Ford Bell Library at the University of Minnesota. The chart was dated 1424 and signed by a Venetian cartographer, Zuane Pizzigano. Menzies, a retired Royal Navy submarine commander and navigator, recognized that the coastline of Europe was drawn with remarkable accuracy for a map of such an early date. On further examinations of the map, combined with navigational computations needed to adjust for some of the errors in longitude consistent with technological limitations in the 15th century, the mapping of Africa also turned out to be remarkably accurate. The four islands far out in western Atlantic were among the Caribbeans and included Puerto Rico and Guadeloupe. The map's date preceded the voyage of Columbus by 68 years.

In subsequent searches, Menzies (2004) came on other maps of surprising accuracy whose dates were inexplicably old by European historical accounts. The Piri Reis map of 1513 included an accurate rendition of the coastline of the southern tip of South America, depictions of wildlife that existed there, and even the coast of Antarctica and the islands between the two. The map's date was 15 years before Magellan "first" navigated the straits named after him.

Table 5 provides an historic chronology of non-aboriginal sightings and contacts regarding the Olympic Peninsula as it may have occurred in light of the recent findings by Gavin Menzies.

Menzies (2004) builds his case, map by map; from records of unexplained ship wrecks of great antiquity with woods for ship construction that are Asian species, not European; from accounts of plants and animals found very distant from their origins; and from DNA analysis of Amerindians in South, Central and North America that indicate Chinese heritage. He provides evidence that the third Ming emperor, Zhu Di, sent out these fleets to explore and map the world. Shipwrecks were common, and the survivors initiated scattered points of Chinese outposts along the coasts of the new world. He suggests that these Asian survivors would eventually have been absorbed into the local Amerindian populations, but not without those people having assimilated parts of Chinese culture and Chinese DNA in the exchange.

Table 5. Chronology of reported or documented non-aboriginal sightings of, or contacts with, the Olympic Peninsula.

Year	Name of Explorer	Related Event	Source
AD 499	Hoei-Shin, Chinese monk	Travel to the land of Fusang where a tree, fruit, bark used as paper, and people that write were described; all suggest Central America	Menzies 2004
1421-1423	Chinese Admiral Zhou Man	The 1507 Waldseemüller map of west coast of North America has a northern latitude equating with Vancouver Island; it predates European contact indicating Chinese origin & exploration	Menzies 2004
1592	"Juan de Fuca", Greek pilot of Spanish ship	Although not well documented, he may have discovered the Strait of Juan de Fuca	Warren 1982
Sometime after 1741 & before 1774	A merchant ship of Russia under ? command	A Russian ship under the employ of a sea otter fur dealer probably had contact with the west coast of Washington sometime after Commander Vitus Bering's discovery of Alaska in 1541 and prior to subsequent western European contact	Anecdotal probability from evidence provided by Dmytryshyn et al. 1988
1774	Juan Perez Hernandez, Spanish captain	Named a prominent mountain Santa Rosalia, today's Mt. Olympus	Brockman 1937; and Warren 1982
1775	Bruno de Heceta, Spanish captain	Claims land for Spain near mouth of Quinault River	Brockman 1937; and Warren 1982
1775	Bodega y Quadra, Spanish captain	His ship sailed with that of Bruno de Heceta; he named Destruction Island near Hoh River the Island of Sorrows for the killing of 7 of his men by Indians	Brockman 1937; Warren 1982; and Wray 1997
1778	English Captain James Cook	Named Cape Flattery but missed the entrance to the Strait of Juan de Fuca; documented trade with Indians for sea otter furs at Nootka Sound	Cook and King 1784; and Warren 1982
pre-1782	? (possible early Russian contact?)	Series of epidemics begins among Quileute, Hoh, & Puget Sound tribes in 1782	White 1980
1787	Captain Charles Barclay of East India Co.	First documented entry to Strait of Juan de Fuca; his wife first white woman documented to see Olympic Peninsula; 6 of his men sent ashore near Hoh River killed by Indians	Brockman 1937; and Warren 1982
1788	English Captain John Meares	Gave the present name to Mt. Olympus & named Strait of Juan de Fuca and first documented contact with Makah at Tatoosh Island	Brockman 1937; Warren 1982; White 1980
1790	Spanish explorers	The Spanish land at Neah Bay	Gunther 1972
1792	Spanish explorers	Spanish erect Neah Bay fort but abandon it within months due to Indian hostility	Gunther 1972

In the case of the Chinese exploration of the west coast of North America, Menzies (2004) indicates that one component of the Chinese fleet under Admiral Zhou

Man, having already circled the world from China to India and eventually on west to Africa, South America and Australia, then followed the northerly Pacific current and the southwest monsoons past China toward the Pacific coast of Canada. He finds evidence for this in the 1507 Waldseemüller map of the world in which the initial latitudes of the west coast of North America correspond to those of Vancouver Island many years before European exploration of the Pacific Coast. From there the remaining fleet went south with evidence of ship wreckage parts constructed of wood from south-east Asia at Neahkahnie, Oregon and up into the mouth of the Sacramento River in California. Others sailed on to effectively map Central America and the South American west coast before finding currents to take them back to Australia and then back north to China again.

Menzies (2004) found another map by a Venetian cartographer, Antonia Zatta, published in 1775 (before Vancouver or Cook's discoveries) depicting an island labeled "colonia dei Chinesi" that appears to be the Queen Charlotte Islands. He found that the Squamish Indians of Vancouver Island have more than forty words in common with Chinese; the Haida of the Queen Charlottes have DNA evidence of recent (post Bering Straits flooding) Chinese heritage; and Chinese artifacts have been discovered at Ozette Lake area on the Pacific Coast of Washington.

The historic record of Chinese exploration disappeared after the Ming dynasty emperor Zhu Di died in 1424. The previously suppressed influence of mandarins regained political power. In 1644, the Qing dynasty seized all the records of the voyages of exploration and had them burned as China entered its long, self-imposed isolationism. The few surviving maps Menzies (2004) found were previously little understood by historians that were not navigators. Their origin apparently came from a Venetian trader named Niccolò da Conti who boarded a ship with the Chinese fleet in 1421 at Calicut in southern India. He apparently brought back copies of some of the Chinese maps to Europe on the return of the fleets in 1423. They were then incorporated into the charts that guided the Portuguese explorers. It is increasingly apparent the early European "discoverers" of new lands (including Christopher Columbus), in fact, had relatively accurate charts showing destinations previously explored and mapped by the Chinese.

However, original Chinese contact with the west coast of the Americas may actually have been nearly a thousand years earlier. In AD 499, the report of a Buddhist priest named Hoei-Shin described the land of Fusang as twenty thousand li (eight thousand nautical miles) east of China. His report was regularly entered in the official histories of the Chinese Empire and subsequently became Chinese legend through innumerable tales of Hoei-Shin's exploits by poets and writers. He described a tree and fruit that match the maguey tree of Central America as well as the use of its bark as paper by a people that had written characters. Menzies (2004) finds that the description of the tree, the fruit, the bark for paper, and people that had writing all match up with the Olmecs, predecessors of the Mayans.

If Hoei-Shin did arrive on the west coast of Central America, would the currents across the Pacific from China first have brought him along the more northerly coast lines of British Columbia and Washington? This occurred with Zhou Man's 1421-1423 voyage before he sailed with the California current south? Although Menzies only briefly describes the Fusang legends and does not allude to contact in Washington, the ocean currents that determined early oceanic voyages suggest this may have been the case.

Menzies' rewrite of relatively modern human history, long accepted as unquestionable facts by Western historians right on into the early 21^{st} century, is an example of the need to perpetually readjust what we think we know about the past. He examined the same available records in university and private archives as life long professional historians. His navigator's eye, outside the conventional training of historians, caught what others had not. Regarding his addition to human history, parts of it will likely be accepted over time and parts discarded as newer bits and pieces supersede his findings. In this case, the original historic record was mostly burned during a Chinese political shift and all that remains are fragments from which to rebuild a new and more accurate information base.

This is analogous to fishery science today. Some modern fishery records have similarly been destroyed. Others have simply been filed away in drawers lost to convenient retrieval, or they are discounted as not meeting the criteria of modern scientific consideration when they are found.

Native American Cultural Modification and Eventual Assimilation Into the Euro-American Industrial Economy

How long ago did North American aboriginal cultures begin to modify due to absorption of outside technologies through contact with distant agricultural civilizations? And at what point were the aboriginal cultures so weakened by disease and reduced population size that they had little choice but to accept the necessity of becoming a constituent of the Euro-American industrial economy?

Although the first documented contact with the tribal people of the Olympic Peninsula was the killing of seven Spanish sailors at Destruction Island in 1775 (Brockman 1937; Warren 1982; and Wray 1997), that contact could only have been very brief for those seven men. The next record of contact found was in 1788 when the English ship *Felice* captained by John Meares anchored off Tatoosh Island and was met by the canoes of hostile Makah led by Chief Tatootche (Gunther 1972; and Wray 1997). This was followed by Spanish explorers landing at Neah Bay in 1790 and the subsequent building of a fort there by the Spanish in 1792 which was quickly abandoned due to continued Makah hostility. But it is also possible that Russian fur traders plying the Pacific Coast could have made contact prior to any of the Spanish or English explorers and left no record (Dmytryshyn et al. 1988).

Previous brutality and force exerted during Russian contacts with aboriginal people might explain the immediate hostility to the Spanish and English when their first ships arrived.

However, predating those possible and proven contacts by more than 300 years, the Chinese may have landed at the Olympic Peninsula and/or Puget Sound. In the Appendices of *1421: The Year China Discovered America*, Gavin Menzies (2004) indicates a record of "wool dogs" under the British Columbia and Washington section regarding evidence of Zhen He's fleets' visits to specific places.

There are several sources that document the use of dogs for woven wool by Indians along the Straits of Juan de Fuca. Wray (1997) cites that Captain Vancouver (1798) saw Indian dogs that "resembled Pomeranians" in his landing on the northern Olympic Peninsula in 1792, and that they were shorn close to the skin to make woolen clothing. Wagner (1933) indicates that in 1791 the exploring Spaniards described Indians at Port Discovery wearing wool blankets for warmth. White (1980) discusses the cultural changes that occurred among the Indians of Puget Sound, Whidbey Island, and the Olympic Peninsula among which he noted "the wool dog vanishing by the 1850s with the rise in trade blankets." Powell (1999) cites under the uses of cottonwood by the Hoh Indians, that a Hoh woman remembered a remaining furry dog called Libto ('Sheep') in the village when she was young and that dog wool had once been mixed with cottonwood down for weaving.

In the reference to Pomeranians, the historic breed was much larger than that of today, once weighing about 35 pounds prior to the time of Queen Victoria. Pomeranians are in the Spitz family of dogs of which the Chinese Chow Chow is also a member and the original dog of the Arctic used for pulling sleds (Tietjen 1987; Hughes 1990). Was the dog Captain Vancouver described that "resembled a Pomeranian" a sled dog that came south with the migration of people from Beringia to Washington, or was it a more recent introduction as brought to the Olympic Peninsula by the Chinese between 1421 and 1423?

There is no mention of unexpected types of dogs by Vancouver or other early explorers along the Pacific coast in trade with the differing tribes except in the Strait of Juan de Fuca vicinity. Potentially the dogs described by Vancouver were traded to this locale of tribal people by the Chinese for sea-otter skins, or even for salmon and steelhead to replenish depleted food supplies in their ships. The shearing and weaving of animal wool into cloaks and blankets requires development of spinning and weaving technologies. Was this taught by the Chinese, or did the spinning/weaving technology develop through independent invention in this one tribal locale of the Northwest coast? Whatever its origin, it predated European contact.

In the Makah and Quileute cultures, seal hunting was one of the more prestigious tribal occupations (Wray 1997) that came to be exploited early on by Russian, western European, and American entrepreneurial ventures. Commercial hunting of northern fur seals began in the late 1860s and the Makah were said to have easily adjusted their expertise. Schooners stopped at Neah Bay to pick up Makah seal hunters for expeditions to the Bering Sea. By 1888 the Makah owned at least ten schooners, and sealed from their own boats earning a lucrative living of $20,000 from seal hunting in 1880 and $44,000 by 1896 (Gillis 1974).

By 1789, Neah Bay was already a stopping point for European vessels and the Makah acted as middlemen from that time on in what might be considered an import/export operation. They bartered with other tribes to create a central receiving point for whale and dog fish oil. Oil became a profitable commodity loaded onto arriving ships. In 1852, 30,000 gallons of oil was purchased there by ocean vessels, and the Makah themselves produced about 5,000 gallons per year (Lane 1973; Swan [1870] 1972; and Wray 1997). Essentially, Neah Bay was the first West Coast oil refinery.

However, it may have been decimation of the Makah and other tribes in the wake of epidemics that broke down the ability to maintain their own cultural way of life leaving little option but to die out or to adapt to the tidal wave of human change they faced as is suggested by Diamond (1997).

Table 6. Chronology of breakdown of original cultures of tribal people of Olympic Peninsula and Puget Sound and eventual assimilation into Euro-American industrial economics.

Date	Description of What Occurred	Source
1421-1423	"Wool dogs" potentially brought to British Columbia/Washington by the Chinese & spinning & weaving of animal hair into wool	Menzies 2004
prior to 1775	Possible contact with Russian fur traders	Dmytryshyn et al. 1988
1775	Killing of 6 Spanish sailors by Quileute at Destruction Island	Brockman 1937; Warren 1982; and Wray 1997
1780	Quileute and Hoh population estimated to be 500	ICC 1974b
1782	Epidemics begin to reduce Quileute & Hoh population; smallpox reaches Puget Sound tribes	White 1980
1788	First documented contact with the Makah at Tatoosh Island by John Meares; initial Makah population estimated to be 1,800-2,000	Gunther 1972; Taylor 1963
1790	Spanish come ashore at Neah Bay	Gunther 1972
1791	Spanish explorers describe Indians wearing woolen blankets to keep warm at Port Discovery	Wagner 1933
1792	Description of Indians & dogs resembling Pomeranians shorn to the skin to make woolen clothing on the northern Olympic Peninsula	Vancouver 1798
1805	Syphilis reaches Puget Sound tribes	White 1980
1820s-1830s	Intermittent fever reaches Puget Sound tribes	White 1980
1840	Puget Sound tribal populations reduced by one-half	White 1980
1847	Measles reaches Puget Sound tribes	White 1980
1852	Hundreds of smallpox deaths & abandonment of Makah's Biheda Village	Lane 1973
1855	Makah, Quileute and Hoh sign first treaties; Quileute & Hoh population down to 300	Wray 1997; and White 1980
1850s	Cultural changes among Puget Sound, Whidbey Island, & Olympic Peninsula tribes; wool dog vanishes with the rise in trade blankets	White 1980
1863	Makah population reduced to 654 people; Neah Bay Indian Agency establishes goal to assimilate Indians into white society	Lane 1973; Taylor 1963
1860s	Commercial seal hunting begins; Makah become commercial sealers	Gillis 1974
1867	The Makah are taught commercial fishing from large fishing vessels	Lane 1973
1877	Commercial canneries open on Puget Sound where the Makahs shipped their catch (Quileute and Hoh too?)	Lane 1973
1870s	Makah's resource base begins to decline with the pressure of commercial fishing, sealing, and whaling & due to changing environmental conditions by human activities	Lane 1973
1883	La Push school begins & children given English & Biblical names	Pettit 1950
1888	Makah population down to 484 people	Collins 1889
1888	Makah own at least 10 schooners stimulating a lucrative living from commercial seal hunting	Gillis 1974
1889	Of 919 total commercial fishermen in Puget Sound & Strait of Juan de Fuca, 434 were Makah, about half of the total commercial effort	Collins 1889
late 1800s	Quileute traditional practices cease; fishing society & first salmon ceremony abandoned with advent of commercial fishing by Quileute	Pettit 1950
about 1900	Shaker religion begins at La Push; later pressured to abandon it	Pettit 1950
1912	Cannery built at Mora where Quileutes could sell their catch	Wahlgren 1998
1917	Cannery in operation on Hoh River	Cobb 1930
1942	Old tribal cultural organization of Makah societies forgotten	Colson 1953

From 1782 onward, the tribal populations of the Olympic Peninsula and Puget Sound were decimated by periodic outbreaks of diseases brought by Euro-Americans (White 1980): "smallpox reached Puget Sound in 1782 or 1783; syphilis in 1805; intermittent fever in the 1820s and 1830s; measles in 1847; and tuberculosis among the Quinault in 1907-08. By 1840 the population of Puget Sound was reduced by half."

The Makah prior to incursions of Euro-American culture and diseases had five winter villages: Neah Bay, Wayacht, Tsoo-yess, Biheda, and Ozette. Biheda was abandoned after the smallpox epidemic of 1852 killed hundreds of people. In 1863, the four remaining villages were reduced to 654 people (Lane 1973). Prior to the epidemics the Makah population was 1,800-2,000 people (Taylor 1963).

The Makah first signed a treaty in 1855. The reservation was enlarged in 1873 and again in 1893 to include Ozette Village which had been reduced to 64 individuals (Wray 1997). But Ozette Village was drastically reduced in 1896 when families were forced to move to Neah Bay where the children could attend school. The parents that did not comply were imprisoned (Colson 1953).

With establishment of the Indian Agency at Neah Bay in 1863 for the Makah and Ozette (later including Quileute and Hoh), the goal was to assimilate Indians into white society. Religious and curing societies were banned and Indian doctors were forbidden their practices under threat of jail. Children were isolated from tribal life at the Neah Bay boarding school, and one agent even proposed creating a separate reserve for people over 55 years of age to eliminate communication with the young (Colson 1953). By 1942, the old tribal cultural organization of societies was virtually forgotten and in her fieldwork Colson was unable to find any living men who had obtained a guardian spirit in recent years among the Makah.

In 1780 the population of the Hoh and Quileute was estimated to be 500 prior to a series of epidemics from 1782 onward (ICC 1974b). By 1855 the Hoh and Quileute were reduced to 300 (ICC 1974a). In 1893, the Hoh Indians requested a reservation that included both sides of the Hoh River, but the agent recommended the reservation only include the south side so as not affect white settlers upriver. The subsequent south side reservation excluded one of the Hoh burial grounds on the north side (ICC 1974b).

The Makah and other tribes of the area held a complex system of ownership rights to resources and specific hunting and gathering grounds that could be traded or shared by agreements through family heads until the end of the 19th century (Renker and Pascua 1989). This intricate system dissolved soon after the treaties were signed. The U.S. Government considered property tribally owned, not family owned, and the burgeoning wage economy was usurping the importance of the subsistence/trade economy (Lane 1973).

As Wray (1997) describes:

"The Makah were absorbed into the regional economic system. They earned wages hop picking on Puget Sound, cranberry picking near Ozette, cannery work, logging, and fishing. This method of procuring goods was centered on the individual and contributed to a shift from community ownership and solidarity to individual ownership. With the shift to the individual wage earner, status shifted from lineage to individual."

In 1883 a school was opened at La Push and many families from upriver areas and those at the Hoh moved there permanently. The first school teacher, Wesley Smith, gave common names to the Indian children from history books and the Bible. These family names are still carried by tribal members today. By the late 1800s, there had been a near abandonment of traditional practices (Pettit 1950). Among the Quileute, Pettit surmised that the fishing society and first salmon ceremony were discontinued with the advent of commercialized fishing.

In 1912, Samuel Morse established a cannery at Mora (Wahlgren 1998). The Quileute made a living for a few years selling fish to the cannery until most Washington rivers were closed to commercial fishing (Pettit 1950). By 1917 a cannery was in operation on the Hoh River (Cobb 1930).

The subsistence/trade economy of the Makah tribal culture was increasingly usurped by a burgeoning wage economy after the signing of the treaties. The 1863 report from the Indian agent at Neah Bay recommended it would be more profitable and beneficial to instruct the Makah to prepare fish for market than to become farmers. By 1867 they were taught commercial fishing techniques on a large fishing boat and the agent discussed acquiring a tribal vessel for them. By 1877 commercial canneries had opened on Puget Sound and the fish caught by the Makah were shipped to the canneries for processing. The Makah's exceptional resource base began to decline with the pressure from international commercial fishing, sealing, and whaling in the 1870s (Lane 1973).

The Shaker religion arrived at La Push about 1900 as reported by Pettit (1950). It incorporated aspects of Catholicism and Protestantism, and was a tribal attempt to meld their need for spiritual power with the views that were imposed on them. But the agent came to see even this attempt at a spiritual compromise as excessive and began to oppose their practice of it.

This depicts the pattern of how tribal cultures, initially lured (or even forced) into trading with persistent exposure to Euro-American levels of exploitation of resources, gradually altered with increasing dependency on being participants in what Lichatowich (1999) has described as the "industrial economy." The virtual loss of their original cultures was hastened by rapid population loss from epidemics of introduced diseases, and by the foreign education, religions, and languages forced on them under the frequent threat of imprisonment if resisted.

One result of the effectiveness of tribal cultural assimilation into the industrial level resource extraction of the late 19th century era is provided by Collins (1889):

"Neah Bay is located near Cape Flattery. Here there is an Indian reservation for the Makah tribe, which had a population of 484 in 1889. The Indians depend almost entirely upon the fisheries for a livelihood."

This sounds innocent enough until the levels of resource extraction the Makah fishermen were a prominent component of are examined between 1888 and 1900. In an 1888 tally of the 917 commercial fishermen engaged in the Washington coast or shore fishery of Puget Sound and the Strait Juan de Fuca, "287 owed allegiance to the United States, in addition to 434 Indians of the Makah tribe" (Collins 1889). The Makah were half of the entire 1888 commercial fishing effort.

19th & 20th Century Overland Exploration of the Olympic Peninsula And Early Settlement of the Hoh and Queets River Valleys

Homesteaders began to settle in the territory of the Quileute Indians in the late 1870s according to Pettit (1950). However, Wahlgren (1998) indicates that Dan Pullen and Frank Balch arrived at the mouth of the Quileute in 1872, and Alanson Wesley Smith arrived in 1873 after serving as a cook at Neah Bay. Smith went on to become the first agent for the Quileute in 1883 (Wahlgren 1998). The few early settlers homesteaded along the coastal plain near the Quileute, but the interior Olympics remained little explored by Euro-Americans.

In 1888, Seattle, Washington was a city of about 30,000 inhabitants (Collins 1892). To the west was the jagged white horizon of the Olympic Mountains jutting above the blue waters of Puget Sound. The distance was little more than 30 miles, but at the time, the interior of the Olympic Peninsula may as well have been that of Africa. Within a year, the *Seattle Press* (Wray 1997), was to sponsor an expedition to cross the Olympics as a result of stories about Sir Henry Stanley's adventures into the Dark Continent sponsored by newspapers in New York and London (Warren 1982). Beginning in December of 1889, the Press expedition, six men led by James H. Christie, made a five and a half month trudge filled with miscalculations, hardships, and adventure in what was thought to be the first Euro-American passage through the Olympic Mountains (Wood 1967). Their route was up the Elwha River to Low Divide and then down the Quinault River to Lake Quinault. It was one of the worst winters in Northwest history.

But largely unknown, in September of 1878, Melbourne Watkinson, Benjamin and Charles Armstrong, George McGlaughlin, and Finley McCrae had preceded the Press expedition across the Olympics. They left from Hood Canal and crossed from a more southern route to the mouth of the Quinault in just eleven days (Warren, 1982). Nevertheless, the Olympic Peninsula was one of the last major land areas of the Lower 48 to be explored and settled.

Also, in October of 1889, S.C. Gilman and his father C.S. Gilman, ex-Lieutenant Governor of Minnesota, were poled in canoes up the Quinault River by Indian guides to near Mt. Constance. They climbed a few peaks and saw Mt. Olympus, hiked back down the Quinault, canoed along the coast to Pysht on the Strait of Juan de Fuca, then followed settler's trails back south to the Quinault again. Their adventure was eventually published in National Geographic Magazine in 1896 (Morgenroth 1991).

In 1885, Lieutenant Joseph P. O'Neil led five other men and cut a mule trail that is approximated by the present day Olympic National Park road to Hurricane Ridge, but O'Neil's project was interrupted by a military transfer. He returned in July of 1890 with an expedition that included three staff scientists from the Oregon Alpine Club. They punched a mule trail from Hoods Canal up the Skokomish River to O'Neil Pass and down the East Fork of the Quinault. It was O'Neil who first advocated that the Olympics were "absolutely unfit for any use except perhaps as a national park" (Warren 1982).

President Cleveland subsequently created the Olympic Forest Reserve in 1897, and in 1909, Teddy Roosevelt proclaimed the area a national monument. The Olympic Peninsula Highway was not completed around the western part of the Olympic Peninsula until 1931 (Warren 1982). In 1938 the Olympic National Park (ONP) was created as signed into law by Franklin D. Roosevelt (Morgenroth 1991).

Table 7. Chronology of 19th and 20th century overland exploration of the Olympic Peninsula; early settlement of the Quileute, Hoh and Queets River valleys; and establishment of Olympic National Park.

Date	Event or Fact	Source
1872-73	Homesteaders begin to arrive at mouth of Quileute	Wahlgren 1998
1878	Melbourne Watkinson, Benjamin and Charles Armstrong, George McGlaughlin, and Finley McCrae cross the Olympics	Warren 1982
1880s	First settlers at Forks Prairie	Morgenroth 1991
1885	Lt. Joseph O'Neil & five men cut trail approximated by present day road to Hurricane Ridge	Warren 1982
1888	Seattle population is 30,000 people	Collins 1892
1889	C.S. Gilman & son go up Quinault & hike to Mt. Constance	Morgenroth 1991
1889-1890	Press Expedition led by James Christie crosses Olympics	Wood 1967
1890	O'Neil expedition cuts trail across southern Olympic Mountains; O'Neil first suggests the mountains as a national park	Warren 1982
1891	Trail built from Forks Prairie to Bogachiel River & Hoh River & early settlement of Hoh River	Morgenroth 1991
1892	Early settlers at Queets River; trail from Hoh extended there	Morgenroth 1991
1897	President Cleveland designates Olympic Forest Reserve	Warren 1982
1909	Teddy Roosevelt proclaims Olympics as national monument	Warren 1982
1931	Olympic Peninsula Highway around Peninsula completed	Warren 1982
1938	Olympic National Park signed into law by Franklin Roosevelt; boundaries exclude lower Bogachiel & Hoh as lobbied by Chris Morgenroth	Morgenroth 1991
1953	Queets corridor & coastal strip added to Olympic National Park	ONP 2005

In 1890, 18 year old Chris Morgenroth, who had run away from his family in Germany to New York at age 14, found his way from Seattle, to Port Townsend, to Port Crescent, to Pysht, and then by 40 miles of trail to where 20 families had settled Forks Prairie a few years earlier (Morgenroth 1991). After hiking three days through dense forest to the south, he and a companion each staked claims in the Bogachiel River Valley. They helped each other build houses the same year and planted gardens, but there were no trails connecting them to Forks. Without a trail, the only other access for transport of goods was via the risk of hiring an Indian and canoe from the Trading Post at La Push and poling upriver. In early January 1891, he and two neighboring settlers laid out the ten mile trail line to Forks, later completed by a crew of fourteen within a week. That same January, he and six companions extended the trail from his homestead on the Bogachiel seven miles south until they came to the valley of the Hoh about 18 miles upstream from the mouth. The route was to become The Pacific Trail.

Three of Morgenroth's (1991) trail party immediately made claims along the Hoh River. The following year many made their way along those trails to stake their claims in the Hoh and Bogachiel valleys. Among the first to homestead at the end of the trail on the Hoh were the Huelsdonk brothers. It was in 1891 that Morgenroth (1991) met John Huelsdonk laboring under a heavy pack coming up a steep hill from Forks on the trail. They stopped to chat and Huelsdonk revealed he was carrying a #7 cast iron stove – the weight of which was well known to be 110 pounds. When Morgenroth acknowledged that was a heavy load, Huelsdonk explained, "Yes, it is heavy but I don't mind carrying the stove, it is the fifty pound pack of sugar in the oven that keeps shifting around that is giving me trouble." He continued to carry it the 25 miles from Forks to his newly built home on the Hoh; thus came the legend of "The Iron Man of the Hoh".

In 1892 there was news that a settlement was being established at the mouth of the Queets River, and from there the settlers traveled inland. A crew of seven was organized through the help of Jefferson County and the trail from the Bogachiel and Hoh was extended to the Queets (Morgenroth 1991). Eventually it would become a wagon road connecting the new settlements. In December of 1892, it was Morgenroth that climbed a tall tree to get a view from a ridge through heavy timber toward the Queets. With the help of a compass he drew the first map of the vicinity looking six miles from Nolan Creek on the Hoh, to Christmas Creek's junction with the Clearwater River. At the time he thought the Clearwater was the valley of the Queets, but when they found it several days later, the clear water told them it was not. The Queets was reported to be milky with glacial water and much larger in size. With considerable winter hardship, they eventually completed the trail down the Clearwater to the Queets and then hiked the 30 miles along the beach back to the Hoh and cross country back to their starting point on the Bogachiel.

Morgenroth (1991) proudly wrote, "We had been gone sixty days and had pierced the last unknown jungle of the western United States, locating and surveying some sixty miles of trail between the Bogachiel and Queets Rivers."

Morgenroth (1991) went on to serve a quarter century as a ranger in the Forest Service. In that position he became instrumental in promoting the ONP and determining the initial boundaries. The creation of the national park within those boundaries was subsequently signed into law on June 28, 1938. He died little more than a year after. He had lobbied ardently to eliminate inclusion of the Bogachiel and Hoh River corridors to protect the private holdings of his old homesteading friends. After his Forest Service retirement, he also worked for six years as Chief Lumberman for the Washington Pulp and Paper Corporation at twice his forest service pay. The company's future was directly tied to the amount of available timber that would remain open to exploitation outside park boundaries.

While the ONP was a vision Morgenroth believed in and devoted his energies toward, the river corridors his lobby efforts managed to exclude from the Park contained some of the richest biological attributes that many in the United States, including President Franklin Roosevelt, thought should be included. Although the Queets River corridor and Pacific Coast sections were added to the Park in 1953 (ONP 2005), exclusion of the lower Bogachiel and Hoh held firm. Nevertheless, 60%-65% of the Hoh River drainage now resides within the ONP and although pristine salmon and steelhead habitat was subsequently limited to the upper portions of the Mainstem and South Fork Hoh, the ONP remains an extensive legacy Morgenroth had a large part in creating.

The Early Depletion of a Species With Comparable Geographic Range to Steelhead And Eventual Extinction in Washington

Sea otter (*Enhydra lotris*) had a historic range as far south as Mexico, north to Alaska, west along the Aleutians to the Commander Islands to Kamchatka, and south to the Kuril Islands and Northern Japan. The sea otter population was an estimated 100,000-300,000 animals prior to Russian, European, and American exploitation began in 1741 with the Vitus Bering expedition's discovery of Alaska (Richardson and Allen 2000). After decades of protection from commercial harvest, the total sea otter population is now thought to be at least 126,000 (Gorbics et al. 2000). However, they have not reestablished in much of their former range (Richardson and Allan 2000).

Obviously, the low end of the original population estimate of 100,000 sea otters was far too low if the present population is 126,000 and much of their former range remains vacant. Is the top end of the original population estimate of 300,000 also too low? From this evidence, it would appear that the tendency may be to underestimate original abundance of wildlife (and fish) due to a scientific conservatism that can lead to a false sense of management success.

Because of the similar range of sea otters and steelhead around the North Pacific Rim, and because of their former abundance and coastal distribution along the Washington coast, the history of the sea otter decline to near extinction and the lengthy road toward recovery provides a useful historic perspective from which to evaluate the health of wild steelhead populations on the west side of the Olympic Peninsula.

Despite the sudden British and American sea otter interest stimulated by Cook's third and final voyage in 1778 (Warren 1982), it was the Russians who initiated the trade for, and more frequently extortion of, sea otter skins from Native Americans. The Russian sea otter expeditions began after the survivors of Bering's sailings returned from Alaska to the Kamchatka Peninsula in August of 1742 (Dmytryshyn et al. 1988). One of the men had secretly hidden a number of sea otter pelts beneath his bunk when the order had been made to cast all the skins overboard during their travails at sea. He smuggled the pelts ashore and sold them to the Chinese for fabulous prices and told all who would listen of the plentiful sea otters at Bering Island and the Aleutians. The word spread quickly among Russians (Ford 1966). For 36 years prior to Cook the Russians had a monopoly on the sale of sea otter pelts to China.

The Russian sea otter expeditions were not limited to the Aleutians and Alaska. Alexander Baranov, Russian trader and general manager of the Russian-American Fur Company, had agents build Fort Ross, 20 miles north of Bodega Bay in California, in the hope that the country would yield grain to feed the Russian outposts in Alaska (Dmytryshyn et al. 1988; Gibson 1969 & 1976; and Essig 1933). Presumably sea otter skins were collected by the Russians at many points in between. John Jacob Astor, of the American Fur Company at the mouth of the Columbia River, was a shrewd enough businessman to see an opportunity and did considerable business selling supplies to the Russians (Irving 1849). Fort Ross was abandoned by the Russians after 30 years in 1839 (Dmytryshyn et al. 1988; and Arndt 2004).

Cook's effective barter with the tribal people for sea otter furs, and resulting high profits when sold thereafter, set the example for future Pacific Northwest exploitation of fish and wildlife. Native Americans were used whenever possible to do the hunting or fishing from which Euro-American business adventures would profit. If the native people would not harvest at the levels desired, the companies would subsequently hire

Euro-Americans to harvest at more industrial-type levels. Decimation of animals to, or near, extinction sometimes resulted.

Table 8. Chronology of sea otter trade, subsequent hunting to near extinction, and the long road back toward recovery.

Date	Description of Event	Source
Pre-1741	Total sea otter population estimated 300,000	Richardson & Allan 2000
1741	Vitus Bering expedition brings back sea otter skins from Aleutians	Dmytryshyn et al.1988
1778	Capt. James Cook makes high profit in sale of sea otter skins to China setting off English/American interest in sea otter hunting	Warren 1982
1792	Capt. Robert Gray initiates American sea otter trade along the Olympic coast (likely from Quileute, Hoh, Queets or Quinault)	Richardson & Allan 2000
1809	Russian Fort Ross settlement near San Francisco provides supplies for more northern Russian outposts with probable sea otter hunting at all points between	Dmytryshyn et al. 1988; Gibson 1969 & 1976; Essig 1933; and Arndt 2004
1800-1830	Sea otter hunting most important industry on the Pacific coast	Ford 1966
1830	Sea otter so rare Baron von Wrangell, of the Russian American Company, persuades his government to forbid the use of firearms to help protect the remaining animals	Ford 1966
1839	Russians abandon Fort Ross	Dmytryshyn et al. 1988
1867	Russians sell Alaska to United States; slaughter of Alaskan sea otter resumes after Russian conservation interlude	Ford 1966
1888	30 sea otters commercially harvested in Puget Sound	Collins 1892
1911	Total take 12 sea otter skins from a fleet of 31 schooners; sea otter extinct in Washington	Ford 1966; Richardson & Allan 2000
1925	North American sea otter thought extinct	Ford 1966
1931	An Aleutian sea otter and pup found; recovery effort begins	Ford 1966
1969-1970	59 sea otter reintroduced in Washington	Richardson & Allan 2000
1999	After 30 years, 605 sea otter found in Washington limited to northern Olympic Peninsula mostly in Marine Sanctuary	Richardson & Allan 2000
2000	Entire Pacific sea otter population now thought to be 126,000	Richardson & Allan 2000

For instance, in the United States, beaver (*Castor Canadensis*) were reduced from pre-European population estimates of 60-400 million to near extinction by 1900. After a century of reintroductions, they are now estimated at 6-12 million (Naiman et al. 1988). Although the native tribes were often reluctant to kill beaver at the rate the British and American fur companies desired in the early 19th century, some tribes such as the Piegan and Nez Perce did so willingly, and overall the native tribes were induced to contribute to the beaver decimation (Ott 2003).

As early as 1832 the fur companies were shifting their trade to buffalo robes as beaver numbers and the beaver market fell. The hides of American bison (*Bison bison*) were initially brought to upper Missouri River trading posts by the Indians to exchange for goods (Utley 1997). Even in the 1830s, it is estimated that 2-3 million bison were being killed per year, primarily by the Indians. The slaughter by both whites and Indians only increased thereafter, most animals entirely wasted (Hewitt 1919). By 1855 the Irish nobleman Sir St. George Gore was hunting the plains for sport and personally killed 2,000 buffalo in three years (Utley 1997). The market hunters followed. By 1884 the last shipment of buffalo robes occurred. In 1889 the number of plains buffalo was down to 635 animals with another 200 woodland buffalo in Yellowstone Park (Hewitt 1919).

For the first third of the nineteenth century sea otter hunting was the most important industry on the Pacific coast. They were so abundant in San Francisco Bay they could be hit on the head with an oar, but in ten years of competitive hunting the entire population was exterminated there. Shortly after, they ceased to exist anywhere on the American mainland (Ford 1966). Corey Ford indicated they were so rare by 1830 in Alaska and the Aleutians "that Baron von Wrangell, of the Russian American Company, persuaded his government to forbid the use of firearms and protect the remaining animals by rigid conservation measures."

But the slaughter resumed when the United States purchased Alaska in 1867 and American hunters ignored the Russian ban employing high powered rifles and eventually scopes. The waste was described as appalling due to wounding animals at great distances with no recovery. When the American government sought to contain the hunting to Alaskan natives, white men took Aleut wives and claimed the right to hunt. By 1911, the total take was just a dozen skins from a fleet of 31 schooners. In 1925 an exhaustive search revealed no sea otter remained in North America. They were thought to be extinct (Ford 1966).

Then in 1931, Frank Dufresne (soon to be director of the Alaska Game Commission) was led in secrecy by Chief Makary Zaochney from the Aleut village on Amchitka Island to the sighting of a single sea otter – a female with a baby clasped to its chest. As Corey Ford (1966) described, "America's rarest fur animal had begun its long struggle back from oblivion." Also, a few evidently remained in California (Richardson and Allen 2000).

The first record of sea otter trade in Washington was the exchange of copper sheets for their skins by Spanish explorer Manuel Zuimper at Neah Bay, Dungeness Bay, and Discovery Bay in 1790. In 1792 Captain Robert Gray traded copper and iron for sea otter skins somewhere along the Olympic Peninsula coast in 1792. His ship, the *Columbia*, was the first outfitted for sea otter trade in America (Richardson and Allen 2000).

Gray undoubtedly dealt with one of four tribal groups: Quinault or Queets (single linguistic group [Wray 1997]); or Quileute or Hoh (single linguistic group [Wray 1997]).

Sea otters were extinct in Washington from 1911 to 1969. Between 1969 and 1970, 59 seat otters from Amchitka Island were reintroduced at Point Grenville (just south of the mouth of the Quinault River) and Neah Bay. While the number of sea otters on the Washington coast had increased to 605 in 1999, their range is limited to the northern Olympic Peninsula from Destruction Island (off the Hoh River) to Neah Bay, with a few sightings elsewhere. Most of this current range is in the Olympic Coast National Marine Sanctuary in habitat considered relatively pristine (Richardson and Allen 2000).

The present limitation in range was not historically the case. Sea otters were previously found throughout Washington when all habitat was pristine. While

Richardson and Allen (2000) found no historic record of sea otters *within* Puget Sound, nevertheless, 30 sea-otter pelts were recorded in the 1888 tally of harvest from various Washington commercial enterprises in Puget Sound as reported to the United States Commission of Fish and Fisheries (Collins 1892). If and when the Washington population is at least 500 sea otters for five consecutive years it will be considered for delisting from the State Endangered status to Threatened. Delisting to Sensitive status can be considered if the population reaches 1,850 (Richardson and Allen 2000).

Once a species is reduced below a certain level, the road back is long, slow and difficult.

Hoh River Steelhead

Present Hoh River Watershed and Habitat

The Hoh River originates from six active glaciers on the east, north and west slopes of Mt. Olympus in its rapid westward descent to tidewater in just 56 miles [90km] (Powell 1999; and McHenry et al. 1996). The watershed area is presently 299 sq. miles (Phinney et al. 1975; Houston and Contor 1984; and McHenry et al. 1996), although in times prior to the last glaciations the Clearwater River of the Queets System may once have been a tributary of the Hoh flowing north through what is now the Snahapish River valley (McHenry et al. 1996). Hoh River flows range from a minimum of 396 cfs up to a maximum of 51,600 cfs with an average summer flow of 1,060 cfs and average winter flow of 3,200 cfs (Phinney et al. 1975).

Average annual precipitation in the area of the Hoh River Basin is 225cm (90 in.) near the Pacific Coast to 600cm (240 in.) in the Olympic Mountains (Phillips and Donaldson 1972). This is considered the greatest precipitation in the conterminous United States (NOAA 1978). The combination of moderate temperatures, steep slopes, short drainages, and great annual precipitation means that rivers of the western Olympics rise and fall very rapidly with frequent high flows. The Hoh is considered the most dynamic of the coastal rivers (Houston & Contor 1984).

The Hoh River is considered part of the Olympic Peninsula evolutionarily significant unit (ESU) in the Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California (Busby et al. 1996). Hoh River steelhead are part of a group of steelhead populations in the ESU that are substantially reproductively isolated from other populations, and contribute substantially to the ecological or genetic diversity of the biological species.

The Olympic Peninsula ESU is characterized by habitat, climatic, and zoogeographical differences of other species of fish and amphibians between it and adjacent ESUs indicating a faunal shift in the vicinity of the Chehalis River Basin. In the case of the Hoh River and its neighboring Olympic Peninsula coastal basins, they receive more precipitation than any other area in the range of west coast steelhead. One manifestation of the ecological difference between the Olympic Peninsula and the adjacent Puget Sound ESU to the north and east is the shift in vegetation zone to that of Sitka spruce (*Picea sitchensis*) from western hemlock (*Tsuga heterophylla*) (Busby et al., 1996). The resulting temperate rainforest is dominated by Sitka spruce, red alder, western red cedar and Douglas fir in the lowlands and transitions to western hemlock and silver fir in the higher elevations. Big leaf maple is also an important component of the rainforest, and black cottonwood stands are associated with the numerous wetlands and bogs (Franklin and Dyrness 1984).

The Hoh River uniquely experienced six differing advances and retreats of alpine glaciers during the last (Wisconsin) glaciation (Thackray 2001). The glaciations resulted in the strongly U-shaped valleys of the Mainstem and the South Fork creating a series of relict river terraces that influence the tributaries (McHenry et al. 1996). This has led to four distinct riverine habitats that strongly influence juvenile fish production: Main river channel, side-channel, terrace tributaries and valley tributaries (Sedell et al. 1984) where fish use is determined by the physical structure of the habitat (Table 9):

Table 9. Riverine habitat types, life history stage and species utilization of the Hoh and Queets rivers as defined by Sedell et al. (1984) and from McHenry et al. (1996):

Habitat	Species	Use
Mainstem	Chinook, coho	Primarily spawning
Side-channel	Chinook, coho, steelhead	Primarily spawning
Terrace tributary	Coho, steelhead	Spawning and rearing
Valley tributary	Steelhead, cutthroat	Spawning and rearing

One biological expression of the Hoh River watershed and its geologic history is wild steelhead as determined by available habitat, and habitat quality.

Houston and Contor (1984) indicate 60% of the Hoh drainage is within the ONP, while McHenry et al. (1996) indicate 65% of the drainage is within the ONP beginning at about river mile 30 (48km) on the Mainstem and about river mile 5 (8km) on its main tributary, the South Fork. Although the upper Hoh River watershed is protected within the ONP where the forests and sections of rivers that run through them are considered essentially pristine (Houston and Contor 1984), the most productive fish habitats outside the park have been degraded by land use practices (McHenry et al. 1996). The greatest impact to the Hoh River ecosystem has occurred via mass wasting events triggered by logging on steep and unstable slopes (McHenry 2001).

The Western Rivers Conservancy (WRC) has worked collaboratively with the Wild Salmon Center (WSC) and with the support of Washington Department of Natural Resources (DNR) has purchased 4,685 acres of Hoh River habitat downstream of the National Park boundary as of March 2006 (per. com. Josh Kling, Western Rivers Conservancy, March 15, 2006). The land was purchased with Section 6 (money provided for conservation of ESA listed species) funding under the supervision of the U.S. Fish and Wildlife Service. The Hoh River Trust will own and manage the land in perpetuity with a goal to ensure the Hoh remains a stronghold for salmon and steelhead biodiversity by 1) ensuring that sufficient, functionally connected habitat exists to sustain robust native salmon and steelhead populations, 2) enough salmon make it back to the river basin to maintain healthy, functional ecosystems, and 3) local communities benefit from strong salmon runs and healthy ecosystems (Wild Salmon Center 2005).

The breakdown of land ownership in the Hoh River Basin is provided in Table 10. The table includes the range of acreage sizes that were found from differing sources (none of which could be identified as being absolutely definitive) regarding ownership.

The differing accounts of acreage sizes are likely due to shifts in land sales and exchanges that have occurred at differing points in recent history.

Table 10. Land ownership in the Hoh River Basin (acreage ranges found from differing sources are in parenthesis).

Land Owner	**Acreage**	**Percent of Basin**
Olympic National Park	(109,597-124,384)	(60%-65%)
DNR State Lands	(39,496-47,085)	(20%-25%)
Private Lands (Industrial timber and misc. small holdings)	(24,508-26,527)	(12%-14%)
Hoh River Trust purchases	4,685	~2.5%
Jefferson County	1,583	<1%
Hoh Tribe	443 originally signed (332-466)	<1%
Olympic National Forest	196	<1%
Basin Total	~191,360 (190,005-192,480)	100%

Developing a Hoh River Steelhead History As a Necessary Basic for Effective Conservation and Restoration

While the history of the settlement of the Hoh Valley by Euro-Americans and the adjacent areas of the Olympic west coast is easily enough traced, the history of the subsequent use of the fish resources and what anadromous fish numbers may have been at the time of early settlement is more obscure. It takes considerable digging into old records to estimate.

Initial fishing by explorers and settlers was primarily subsistence, but sometimes sport. Chris Morgenroth (1991) colorfully described the early steelhead sport fishing on the Olympic Peninsula with typical fisherman's bias regarding a favorite river and method:

"The rivers were full of fish all year round with varieties of stream trout, salmon and steelhead. The Bogachiel, I soon discovered was a superb fishing stream. Unlike the Hoh and Queets Rivers, which were milky glacier-fed streams, the Bogachiel was clear except for being muddied by a heavy rainfall. No stream in the Olympics can compare with it for fishing. I found the best method for catching the great fighting steelhead was to ride a pony out into the middle of the stream and fish downstream from his back. That way I never had to get wet as the pony was far more sure-footed than I. Fastening the fishline to the saddlehorn was an advantage too."

This would have been shortly after Morgenroth's initial homestead claim on the Bogachiel in 1890 and may be the first recorded description of sport fishing for steelhead on the Olympic Peninsula. A year later John Huelsdonk was backpacking a woodstove into his homestead (Morgenroth 1991) where the legendary "Iron Man of the Hoh" may have similarly fished for steelhead, or perhaps he chose more efficient methods learned from the Indians still traveling up and down the river past his homestead to provide winter subsistence. By 1917 a fish cannery was in operation on the Hoh (Cobb 1930) providing a local station from which to quickly convert steelhead and salmon into cash, although the opportunity for shipping steelhead for the salt-packed or fresh fish markets may have been provided much earlier. A supply post was described at the mouth of the Quileute by at least the 1880s (Morgenroth 1991). Both Indians and settlers may have been able to ship fish to Grays Harbor or Puget Sound from this supply post to canneries already in operation (Collins 1892; Wilcox 1898; and Cobb 1930) and fresh fish markets as well.

The Euro-American industrial economy would have begun to impact Hoh River steelhead with operation of the cannery in 1917, and may have begun to some degree with the available shipping at the mouth of the Quileute by the 1880s. It is this historic background from which subsequent analysis of what Hoh River steelhead numbers once were must take into account.

That latter 19th century to the early 20th century was a period of time when there was a shift in Olympic Peninsula economies. Lichatowich (1999) has described the Northwest aboriginal culture as once driven by the "gift economy." The gift was not as we now understand it as an acquired possession. The aboriginal gift included the obligation of passing the gift on – of giving back to the giver in like kind. If too much was taken, the individual acquired a heavy "debt" of obligation to give it back.

This significantly differs from what might be called the "take economy." The individual taker benefits most by taking, not by giving back. The more that is taken, the more individual capital is accumulated along with subsequent prestige and power in the Euro-American industrial economy.

The history of Northwest steelhead, as depicted by their population declines since the 1890s, is largely explained by this shift to an economy in which the takers are rewarded, not the givers. There have been no innocents in this shift: not sport fishermen; not fishing guides; not commercial fishermen; not agriculturists; not timber harvesters; not businessmen; and not the Indian tribes once stripped of their economic/cultural past.

SUMMER RUN STEELHEAD

Although both summer and winter runs of steelhead are native to the Hoh River, little is known where the summer run steelhead spawn except that it is probably in the upper reaches in the ONP (McHenry et al. 1996; and SASSI 1994).

However, there are at least two examples from personal experiences the author of this report can draw from regarding historic numbers and location of summer run steelhead in the upper Hoh River (examples similar to that provided by Pauly [1995]):

1) A home movie taken by a recreational horse packer from Washougal, Washington named Herman Munch was shown in 1960. It depicted his two 12-14 year old sons playing several steelhead near Hoh Creek on the upper Hoh River. The movie was taken in August in the mid- to late-1950s. Munch indicated the steelhead were then plentiful.
2) A Boy Scout troop was encountered at Hoh Lake in August, 1962. The previous day, several of the boys and one of the scout leaders had hiked the steep trail down to where Hoh Creek enters the Hoh River. Several steelhead had been hooked, but none were landed due to the boys having light trout tackle. The entire troop returned to the Hoh the following day as reported by one adult and 2-3 boys that elected to remain in camp.

In both of these instances, multiple summer run steelhead were hooked by boys who had never hooked steelhead before. It suggests a relatively large number of summer steelhead were concentrated near the entry of Hoh Creek during two differing summers between 1955 and 1962. As little as it may be, it is more site-specific than information found in management literature sources (SASSI 1994; SaSI 2003; and Busby et al. 1996).

The 1992 SASSI (1994) indicates summer runs are native to the Mainstem Hoh, the South Fork, and tributaries, and that they are a distinct stock based on the geographic isolation of the spawning population with a return timing of May through October and a spawn timing thought to be from February through April. It is indicated that since only a few stream miles are used, the native summer steelhead stock "is comprised of a historically small number of steelhead."

However, previous information in the same report indicates little is known about where summer steelhead spawn because it has not been monitored for spawning escapement. As a result there is no spawning escapement goal, yet it is said to be a small stock that could be especially vulnerable to any negative impacts (SASSI 1994). In both 1992 and 2002 the stock status was listed as "unknown" with no genetic analysis available (SASSI 1994; and SaSI 2003).

Two questions occur regarding the information provided in these reports:

1) How can it be determined that only a few stream miles are used, and what the habitat limitations on productivity actually are, if it is not known where they spawn?
2) How protect steelhead life history diversity in the Hoh as exemplified by the summer run without monitoring or escapement goals?

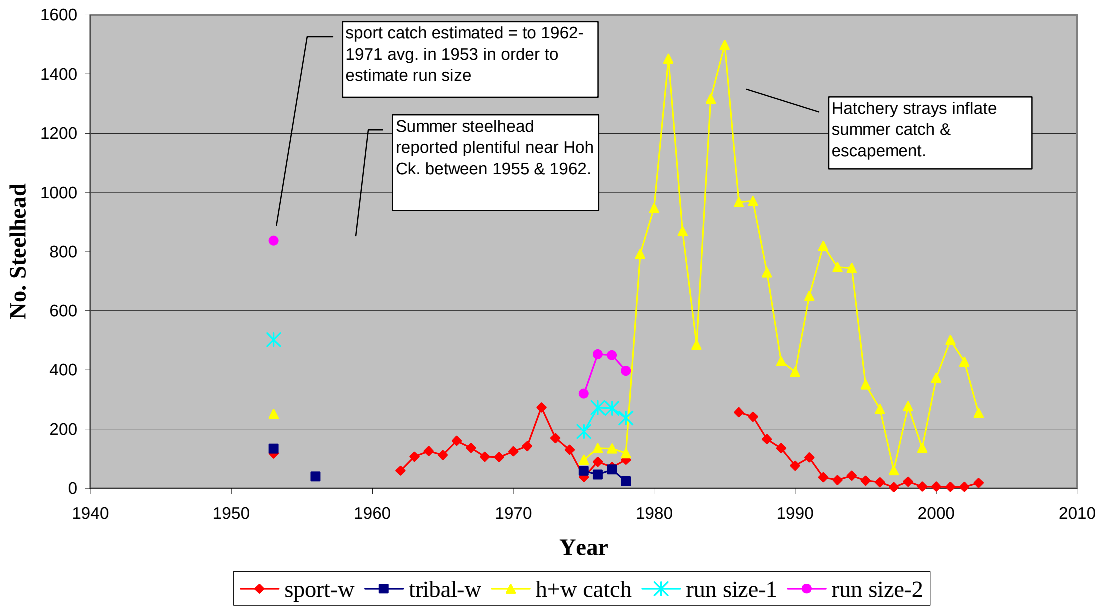
There is limited information regarding catch of wild summer steelhead on the Hoh River from tribal catch records dating to the 1950s (Taylor 1979) and from the earliest sport catch records of summer runs beginning in 1962 from WDG (1948-1978; and 1962-1984) and WDFW (2006). The sport catch records are corrected for non-response bias as determined from surveys that did not begin until 1977 (WDFW 1996), so there remains some question regarding at what point the assumed non-response bias of that time similarly applies to older sport catch data. If the non-response bias of 1977 did not similarly apply to the early1960s, the sport catch may have been considerably higher than represented from the early to late 1960s (Figure 4).

Although there have been no hatchery releases of summer steelhead into the Hoh basin, hatchery summer steelhead stray into the Hoh from the neighboring Quileute system that are caught in substantial numbers in the sport and tribal fisheries (SASSI 1994). The initiation of summer steelhead hatchery smolt releases, however, did not occur in the Quileute until 1977 (WDG 1948-1978) with first returns in 1979. Sport harvest of wild summer steelhead was reported separately from hatchery steelhead beginning in 1986 (SASSI 1994). So in actuality, there are wild summer steelhead sport catch data from 1962-1978 and from 1986-1991. From 1992 onward, sport fishermen were required to release wild summer steelhead throughout Washington (SASSI 1994).

The earliest data points in Figure 4 are determined from the tribal catch of 133 wild summer steelhead in 1953 and a computed sport catch estimate. The sport catch for 1953 was estimated to be about the same as the 10 year average sport catch of wild summer steelhead caught in the Hoh River between 1962-1971 (118 steelhead). The resulting total catch estimate was 251 wild summer run steelhead. In his analysis of historic commercial harvest of steelhead in Puget Sound from 1889-1925, Myers (2005) used a harvest rate range of 30%-50% to estimate what the total run size may have been. If that is applied to the 1953 historic catch, the wild run size to the Hoh River in 1953 was 502 summer run steelhead @50% harvest, or 837 summer run steelhead @30% harvest, as depicted by "run size-1" and by "run size-2" on Figure 4.

Figure 4.

Hoh River Summer Steelhead History (1953-2004)
[Total Catch of Wild Steelhead =50% of Run Size-1; and =30% of Run Size-2;
Hatchery Strays from Quileute Included in 1979-2004 Total Catch]



These estimates may be conservative. The Hoh River tribal catch in 1953 was limited to the month of October (Taylor 1979). Apparently no other tribal fishing effort occurred in the summer steelhead return period that year. Regarding sport catch, the Hoh River is often glacially discolored in the summer. While this would not hinder tribal catch, it could reduce the ability of sport fishing methods to effectively catch summer steelhead. This would result in an even higher expected escapement. These considerations, combined with the previous examples that many summer steelhead were near Hoh Creek between 1955 and 1962, indicate that the historic wild summer steelhead population may not have been as "small in numbers" as suggested by the SASSI (1994) report. Of further consideration, summer steelhead numbers may have been depleted even by 1953 from harvest pressures that occurred 25-50 years earlier, before and during the time when a cannery was in operation on the Hoh River beginning in 1917 (Cobb 1930). Summer steelhead would have been an incidental catch during commercial fisheries that targeted on salmon in September and October.

From Figure 4, it is apparent that the sudden increase in Hoh River summer steelhead catch beginning in 1979 is the result of high numbers of hatchery steelhead straying from the Quileute River system where they were first stocked as smolts in 1977

(WDG 1948-1978). The subsequent decline in Hoh River wild steelhead catch from 1985 onward would be the anticipated time-lag expected if negative results occurred to the wild stock resulting from hatchery/wild spawning and rearing interactions. There are no identified barriers mentioned for the upper Hoh River and upper South Fork Hoh River (SASSI 1994; McHenry et al. 1996) that might deter hatchery summer steelhead from entry to wild summer steelhead spawning grounds thought to be in those areas. The hatchery steelhead numbers in the catch similarly declined in that same period. It was suggested in the 1992 SASSI (1994) that this potential problem of hatchery/wild interactions from straying Quileute hatchery summer runs into the Hoh should be better examined, but ten years later such studies still had not occurred (SaSI 2003).

Actions to limit the effects of potential overharvest of wild summer steelhead in a mixed stock fishery did not occur until 1992 when wild summer steelhead catch-and-release sport fishing regulations were implemented statewide. This was well after the wild sport catch was on a trend to bottom out (as evident in Figure 4) and did not include more protective measures for wild summer steelhead in the tribal catch.

Ever since the late 1980s the sport catch trend has been that of a wild summer steelhead population headed toward zero, and the mixed stock catch of the Hoh Tribe suggests a similar trend.

There have been two independently collected data sources that further confirm the low numbers of wild Hoh River summer steelhead that now return to destination areas shared with hatchery summer run steelhead (most likely strays from the Quileute basin of Skamania stock origin). Table 11 provides snorkel count data collected on the South Fork Hoh River by the ONP during the expected return time of summer run steelhead (Brenkman 2006). The WSC has similarly collected snorkel survey data from the South Fork Hoh during the expected return time of summer run steelhead (McMillan and Starr 2006). While the WSC surveys were limited to those 5.8 miles of the South Fork Hoh from the ONP boundary to its confluence with the mainstem, the ONP surveys were of variable lengths per year as high as 13 miles above the mouth. In both sets of snorkel surveys, hatchery summer steelhead have been counted in proportionally significant numbers that have several times outnumbered wild steelhead counted.

As recorded in Table 11, in the 10 years of ONP surveys from 1994 to 2005 (no surveys in 1997) an average of 28 summer steelhead was counted per year (using the high count of 29 in 2001). Hatchery and wild steelhead were recorded separately in 2002 and 2003 by the ONP snorkelers. Of the summer steelhead counted, 54% were of hatchery origin in 2003, and 27% were of hatchery origin in 2002. Because the ONP snorkelers covered 10-13 miles of the South Fork Hoh each year from late September to early October, it would appear likely that these hatchery origin summer steelhead remained at upstream areas where wild summer steelhead are thought to spawn throughout the winter. They would then have competed with wild steelhead on the spawning grounds.

The WSC snorkel surveys covered the lower 5.8 miles of the South Fork Hoh outside the ONP. In each of the four years wild and hatchery steelhead were recorded separately. Of the summer steelhead counted, 50% were hatchery in 2004, 63% were hatchery in 2002, 67% were hatchery in 2001, and 0% were hatchery in 2000. The WSC surveys found that hatchery steelhead outnumbered, or were equal to, wild steelhead on entry to the South Fork Hoh in three of the four years.

Table 11. Snorkel surveys during the expected return time of summer run steelhead in the South Fork Hoh River by Olympic National Park and the Wild Salmon Center (1994-2005)

Surveyed by:	Date	Location in RM	Steelhead (wild)	Steelhead (hatchery)	Steelhead (undetermined origin)
ONP	Jun 9-Sep 21, 2005	6.5-4.8			38
ONP	Sep 23-24, 2003	13.1-0.0	28 (46%)	33 (54%)	
ONP	Oct 1-3, 2002	13.1-0.0	56 (73%)	21 (27%)	
ONP	Oct 29-30, 2001	~6.5-0.0			9
ONP	Sep 17-18, 2001	12.2-0.0			29
ONP	Sep 27-29, 2000	13.7-1.5			13 (12"-26")
ONP	Sep 9-13, 1999	13.7-1.5			10
ONP	Sep 22-23, 1998	12.9-0.0			25
ONP	Sep 24-25, 1996	9.55-1.5			16
ONP	Aug 30, 1995	9.55-~2.3			15
ONP	Oct 4,5, & 13, 1994	9.8-0.0			19
WSC	Oct 4 & 5, 2004	5.8-0.0	3 (50%)	3 (50%)	
WSC	Oct 18, 2002	5.8-0.0	3 (37%)	5 (63%)	
WSC	Oct 10, 2001	5.8-0.0	1 (33%)	2 (67%)	
WSC	Oct 6 & 11, 2000	5.8-0.0	30 (100%)	0 (0%)	

Table 12. Snorkel surveys by the ONP at closer term intervals to document extent of passage time of summer run steelhead through the South Fork Hoh River (June 9-September 21, 2005)

Surveyed by:	Date	Location in RM	Steelhead (wild)	Steelhead (hatchery)	Steelhead (undetermined)
ONP	Jun 9, 2005	6.5-4.8			0
ONP	Jun 23, 2005	6.5-4.8			0
ONP	Jul 5, 2005	6.5-4.8			2
ONP	Jul 13, 2005	6.5-4.8			0
ONP	Jul 2, 2005	6.5-4.8			1
ONP	Jul 27, 2005	6.5-4.8			2
ONP	Aug 4, 2005	6.5-4.8			2
ONP	Aug 15, 2005	6.5-4.8			8
ONP	Aug 23, 2005	6.5-4.8			13
ONP	Sep 16, 2005	6.5-4.8			7
ONP	Sep 21, 2005	6.5-4.8			3
Total					**38**

In 2005, the ONP snorkel surveys of the South Fork Hoh River were conducted at about 1-2 week intervals between RM 6.5-4.8 (Table 12). The more frequent surveys depict the run timing of summer run steelhead up the South Fork with earliest entry on July 5th and peak entry between August 23rd and September 16th. This particular section of the South Fork Hoh was chosen as an index reach by the ONP due to the habitat diversity it represented that included deep pools and because of the relative high abundance found in that section in previous surveys (Sam Brenkman, per. com. April 2006). However, it is not fully known if the index reach represents a primary oversummering destination where steelhead may accumulate in growing numbers without migrating onward until spawning time, or whether it remains in the migration corridor with a primary oversummering destination further upstream. If the index reach is an oversummering destination area the snorkel counts would primarily represent an accumulation of steelhead with the peak August 23rd count (13 summer steelhead) representative of a high proportion of the South Fork Hoh population size in 2005. However, if it is primarily a migration corridor, then the population indicator would be the sum of the counts for each snorkel survey (38 summer steelhead). Differentiation of wild from hatchery steelhead was not attempted during the 2005 index reach counts of the South Fork Hoh by the ONP, but Brenkman indicated that hatchery steelhead were probably present based on previous counts when those distinctions were made.

As an example of the value of certain habitat specifics for oversummering steelhead, in October of 2000 a total count of 30 wild summer steelhead was made during the two WSC surveys of the lower South Fork Hoh (Table 11). This compared with an ONP count of only 13 steelhead (including some larger probable resident rainbow) in the upstream reaches. The combined WSC and ONP counts were 43 summer run steelhead in the fall of 2000. However, in 2002 the counts flip-flopped with a total of 77 summer steelhead (56 wild) found in the upper reaches by the ONP and only 8 summer steelhead (3 wild) found by WSC in the lower reaches. The high count by WSC in 2000, compared to very low counts in years thereafter in the lower South Fork, was directly related to deep pools associated with the cover of log jams (John McMillan, per. com. April 2006). However, in the winter of 2000/2001 a large flood event triggered slides, debris flows, and subsequent channel changes that eliminated 85% of the large pools formed by logjams that had previously existed on the lower South Fork Hoh downstream of the ONP boundary creating extensive reaches with a shallow plane bed. The lower South Fork is now minimally used by summer steelhead except as a migration corridor. The low WSC counts of adult summer steelhead found in this section since that flood event well document the effects of the habitat alteration.

Of particular concern are the ONP snorkel counts of 10-29 total summer steelhead between 1994 and 2001 from Table 11 when differentiation between hatchery and wild steelhead was not attempted in the surveys. If the 2002 and 2003 proportions of hatchery origin steelhead remained similar from 1994 to 2001, they would have composed 27%-54% of the mixed population of wild and hatchery steelhead destined for the spawning grounds. Potentially the hatchery percentage could even be as high as 67% if the WSC lower South Fork Hoh data are used (McMillan and Starr 2006).

From 1994-2005 the total wild (when available) summer steelhead counts for the South Fork Hoh have been:

2005…….38 (wild and includes probable hatchery)
2004…….3 (wild)
2003…….28 (wild)
2002…….59 (wild)
2001…….30 (one known wild and the other 29 includes probable hatchery)
2000…….43 (30 wild, remainder include probable hatchery and a few rainbow)
1999…….10 (wild and includes probable hatchery)
1998…….25 (wild and includes probable hatchery)
1997…….No surveys
1996…….16 (wild and includes probable hatchery)
1995…….15 (wild and includes probable hatchery)
1994…….19 (wild and includes probable hatchery)

The 1994-2005 mean snorkel count per year was 26 summer steelhead (ONP and WSC combined in 2002, 2001, and 2000). Other than in 2004, 2002, and 2001, the counts included an undetermined number of hatchery steelhead. The ONP total count of only 38 summer steelhead, hatchery and wild combined, during the 11 separate snorkel surveys over the entire expected return period in 2005 is particularly concerning. It indicates a very small wild summer steelhead population, potentially as small as 17-28 fish if 27%-54% of the total population was hatchery as suggested by the 2002 and 2003

ONP surveys, or as high as 63%-67% as suggested by the WSC surveys in 2002 and 2001.

Although there have been no mainstem Hoh River snorkel surveys, the catch data from Figure 4 indicate that wild summer steelhead can be expected to be in very low numbers throughout the basin. As with the South Fork, they likely cohabit upstream spawning destinations with hatchery summer run steelhead that outnumber them, or are equal to their numbers as found in three of the four years of WSC surveys; or with hatchery steelhead composing 27%-54% of the summer steelhead population as found in the two years of ONP surveys when wild and hatchery fish were separately identified. This is a management prescription to wild summer steelhead extinction (total population size in the basin likely ~50-100 at best) and leaves the pristine habitat where summer steelhead are thought to be destined comparatively void of historic wild summer steelhead that once returned there. This is an example of excellent habitat largely vacant of the anadromous fish stock that had evolutionarily evolved to fill it.

WINTER RUN STEELHEAD

Wild winter steelhead in the Hoh River, South Fork Hoh, and tributaries are native and a distinct stock based on the geographical isolation of the spawning population (SASSI 1994; and SaSI 2003). Spawning is reported to be primarily distributed in the river channels with significant numbers spawning in the five largest surface tributaries. Small numbers of earlier entry wild natives are thought to spawn in headwaters of all the significant tributaries which include Braden, Nolan, Anderson, Lost, Winfield, Alder, Elk, Clear, and Slate creeks. The run timing is indicated as December through May and spawn timing mid-February to mid-June. The wild winter stock was considered healthy in both 1992 and 2002. There has been no genetic analysis of Hoh River steelhead.

Beginning with the 1984-85 season, a WDW escapement goal of 2,400 winter steelhead was set. Wild winter steelhead spawner escapement has been monitored since the 1975-76 season and wild run size has been monitored since the 1979-80 season. Between 1985 and 1992 (eight years) the escapement goal was met or exceeded seven times (SASSI 1994).

Winter steelhead are more abundant and attain a larger average size than summer steelhead in the Hoh as reported by McHenry et al. (1996). They indicate that production of this stock is considered native, although 100,000 hatchery smolts from the Quinault River are planted in the system each year. Interaction between the native and hatchery stocks is considered minimal because the hatchery fish return earlier than the wild run, and they are managed for high exploitation rate (up to 95 percent) in terminal sport and commercial fisheries.

The SASSI report (1994) indicates the combined sport and tribal fisheries exploitation rate is about 80 percent, and also concludes that because of the high exploitation rate, healthy wild spawner escapement and the separation in spawn timing between the hatchery (January and February) and the wild fish (mid-February through May), the potential for interbreeding is limited.

The conclusions drawn by McHenry et al. (1996) and the SASSI report (1994) from catch and escapement data collected between 1976-2002 regarding supposed differences in run timing between hatchery and wild steelhead, differences between hatchery and wild spawning time, and the adequacy of the determined wild winter steelhead spawning escapement goal all require scrutiny in light of available wild steelhead observations and catch data that go back to a time when hatchery steelhead did not return to the Hoh River long before monitoring of escapement began in 1976. Figures 5, 6, 7, 8, and 9 provide the historic record of Hoh River wild winter steelhead numbers and run timing as determined from tribal and sport catch records dating to 1944 (data from Taylor 1979; WDG 1948-1978; WDG 1962-1986; and WDFW 2006).

Figure 5.

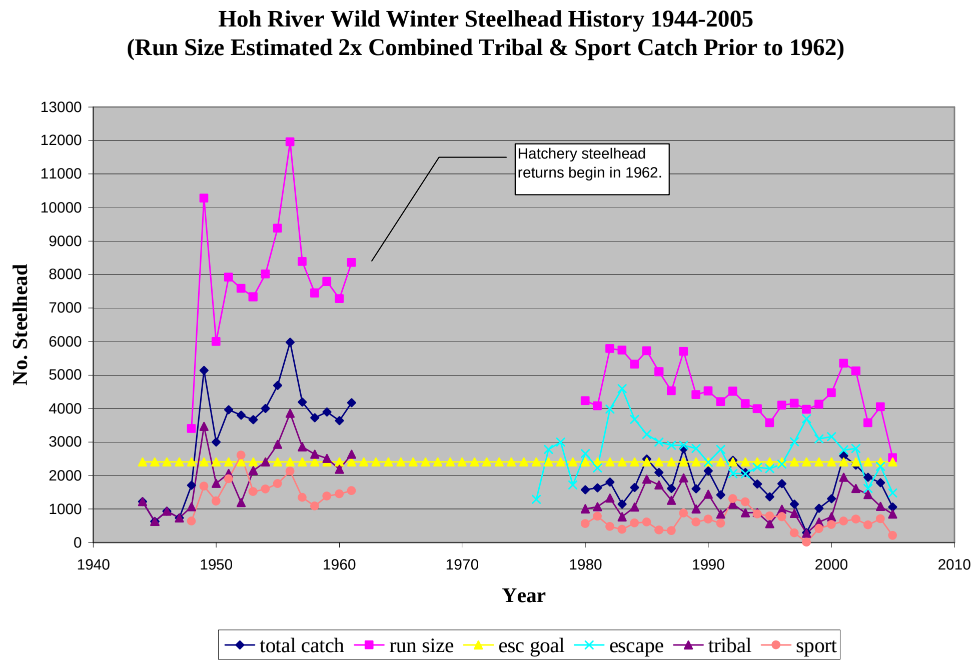
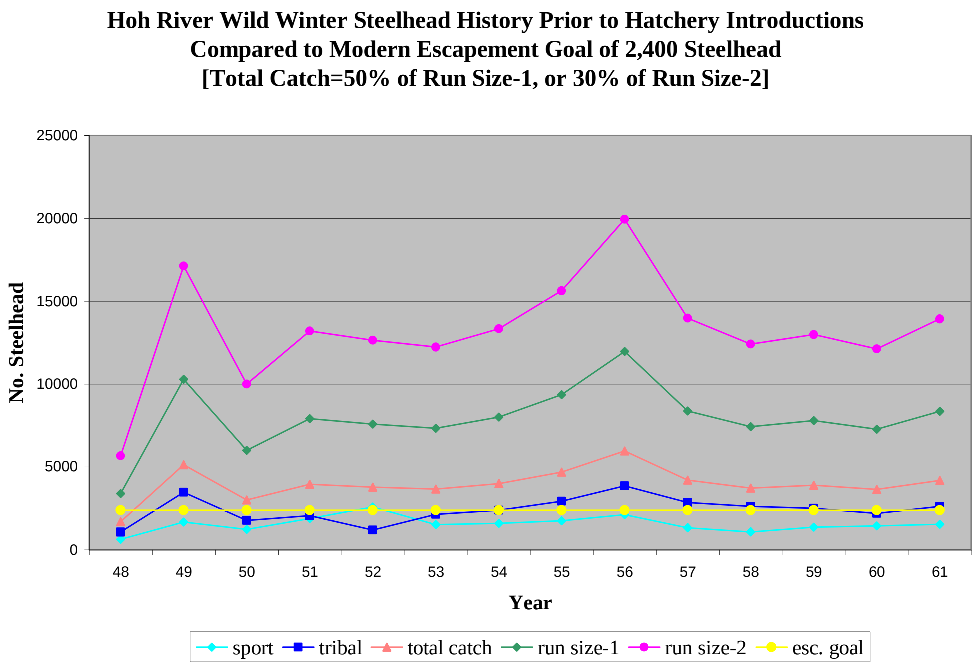


Figure 5 provides a graphic depiction of the known history of Hoh River wild winter steelhead based on available tribal and sport catch records from 1944 to 2005. It also includes the escapement estimates based on spawning ground surveys from 1976-2005. The modern escapement goal of 2,400 wild winter run steelhead is added to provide a reference point between the two periods of time when only wild winter steelhead returned to the Hoh River prior to 1962, and the modern management era after the Boldt Decision when wild and hatchery numbers were determined from catch analysis from 1980 to 2005. The run size trend since 1980 is one of gradual decline with numbers well below the period from 1948 to 1961.

Because spawning surveys did not occur prior to the Boldt Decision, wild steelhead spawning escapements and run sizes could only be estimated from catch data. Myers (2005) used a harvest rate range of 30%-50% to determine his estimates of historic Puget Sound steelhead run sizes from commercial catch records. In this report the more conservative 50% figure has generally been used, as is the case in Figure 5 (the total catch doubled to estimate run size). However, Hiss et al. (1986) determined that Hoh River harvest rates were 33% for wild winter run steelhead in 1983-84, and 43% in 1984-85. The average between the two would be 38%, more toward the 30% range than the 50% range. Figure 6 provides the earlier Hoh River wild winter steelhead history that displays both the 30% and 50% harvest rates and the differing run size outcomes from 1948-1961 when both sport and tribal catch data were available. The present escapement goal is 18%-30% of the average historic run size between 1948 and 1961.

Figure 6.



The difference in average catches and run sizes for the 1948-1961 eras, 1980-2005 eras, and most recent 5-year period are shown in Table 13. Tribal catch is now 58% of that prior to 1961, sport catch is 35% of that prior to 1961, and average run size is 31%-52% of that prior to 1961.

Table 13. Differences in average catches and run sizes of wild winter steelhead on the Hoh River among three periods of time. Average run size estimates in the 1948-1962 time period are computed for both 50% and 30% harvest rates in the absence of spawning surveys and escapement determinations.

Period of Time	Avg. Tribal Catch	Avg. Sport Catch	Avg. Total Catch	Avg. Run Size
1948-1961	2,408 wild steelhead	1,561 wild steelhead	3,970 wild steelhead	50% harvest ~7,938 30% harvest ~13,230
1980-2005	1,125 wild steelhead	608 wild steelhead	1,725 wild steelhead	4,501
2001-2005	1,385 wild steelhead	553 wild steelhead	1,938 wild steelhead	4,126

Hiss et al. (1986) examined the potential problem of hatchery winter steelhead impacts on the native stock in the Hoh River. While it is commonly assumed that hatchery steelhead return primarily from December through February, they found that hatchery steelhead were about 85% of the catch from December through March but even as late as April hatchery fish still constituted 63% and 65% of the catch in the two years studied (1984-85 and 1983-84 respectively). Although they found that most of the wild winter run entered the fishery in March and April both years, they expressed concern that artificial selection against early wild returns to the Hoh may have occurred as a result of higher fishing effort focused on the early hatchery segment of the run and a subsequent shift of the run to a later timing pattern.

Figure 7.

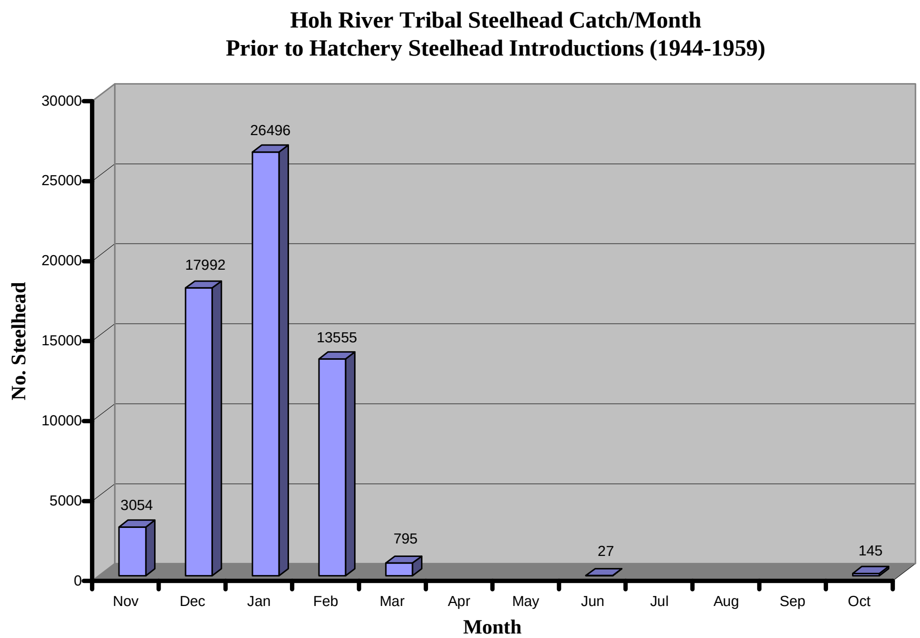
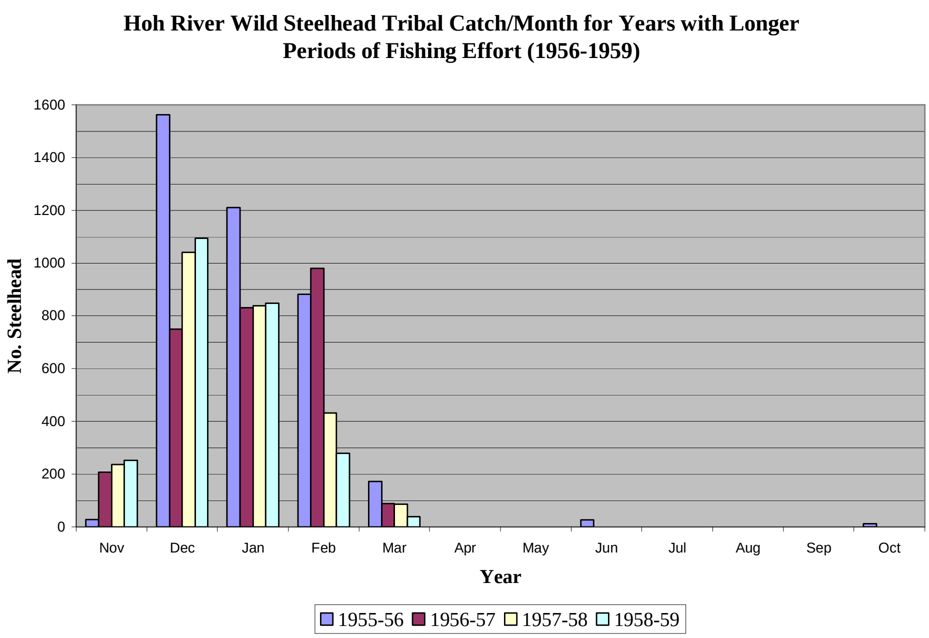


Figure 8.



In fact, the concerns expressed by Hiss et al. (1986) have occurred as demonstrated in Figures 7, 8, 9, and 10. The historically dominant Hoh River catch of wild winter steelhead in both the tribal and sport fisheries was in the months of December, January, and February prior to when hatchery returns began in 1962. This sharply contrasts with most wild winter steelhead entering the Hoh fisheries in March and April as found in the 1980s.

Figure 9.

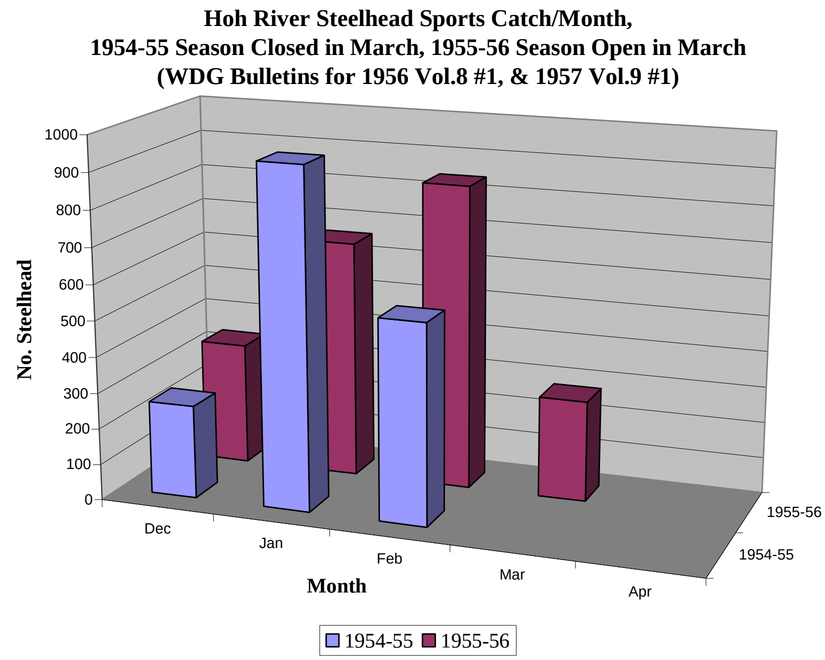
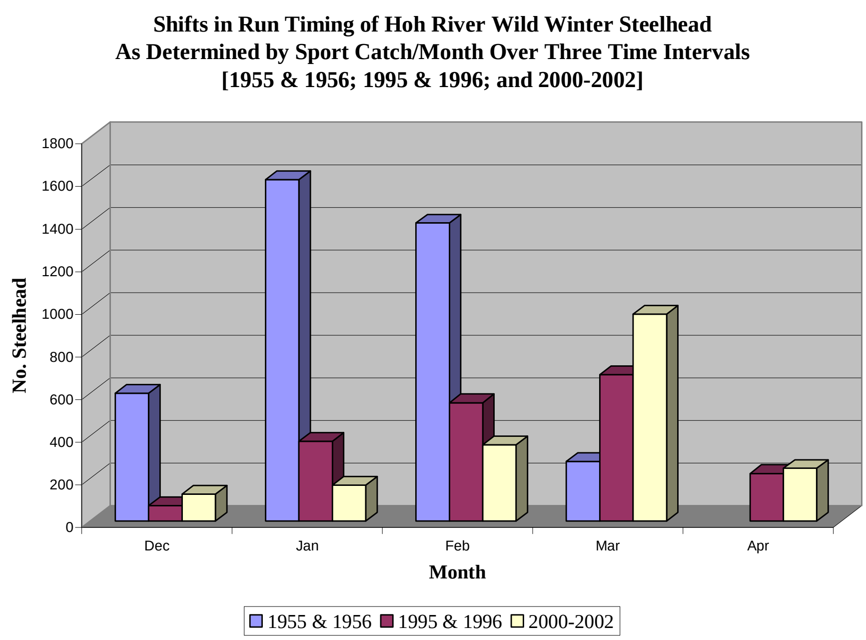


Figure 10.



Of further concern, 34% of the Hoh sport catch and 41% of the Hoh tribal catch in 1984-85 were hatchery fish whose origin could not be genetically accounted for as limited to the three stocks released into the Hoh River. In 1983-84 there was a catch of 4,327 hatchery fish in the Hoh whose origins similarly were unaccounted for. The hatchery strays as well as those hatchery returns from smolts released at lower sites in the Hoh basin were commonly caught in the sport fishery in the upper river. It was presumed that hatchery fish that returned to the upper Hoh remained in the system and potentially spawned there (Hiss et al. 1986).

From Figure 7, it is apparent that historic wild winter run steelhead entry to the Hoh River began in November as evidenced by early tribal catch records from 1944 to 1959. This is the same initiation of historic wild winter steelhead returns (November 15 through the winter to the following spring) documented in the commercial catch from Puget Sound rivers in 1895 by Wilcox (1898). The peak Hoh River catch was in the month of January followed by December and then February. The absence of significant catch in March and April is more likely related to lack of catch effort most years rather than an absence of wild steelhead at that time. Nevertheless, if greater numbers of steelhead actually returned in the spring months, rather than December and January, it seems probable that fishing effort would have focused more on that time period.

If large numbers of spring entry steelhead historically returned with the same pattern of today that is suggested by SASSI (1994) and McHenry et al. (1996), it would mean that the Hoh River winter steelhead run size was far larger than depicted from the tribal catch in Figures 5, 6, 7 and 8 during the 1944-1961 eras. At the very least, the early tribal catch data indicate there were large numbers of wild winter steelhead that entered the Hoh River in December and January. Even for the years when catch was better represented in the spring, as shown in Figure 8, the March catch remained small.

One possible explanation for the focused tribal fishing effort on the early component of the steelhead run might be that the early fish were in a more marketable condition with silvery, sea-fresh coloration than later steelhead that were more sexually mature and darker colored with potentially reduced fresh market value.

Regarding sport fishing effort in the spring, angling closures often occurred on rivers or in river sections after the month of February in Washington in the 1940s and 1950s. This resulted in more river miles closed to fishing and shorter seasons than commonly was provided after the 1960s (McLeod 1944; Frear 1956; and WDFW 1996). For instance as shown in Figure 9, the Hoh River was only open to sport fishing from December through February in 1954-55 but was provided an additional March season in 1955/56 (WDG 1956; and 1957). A short basic steelhead season was typical on Washington steelhead rivers of that era with late season extensions only sometimes provided. Presumably this was done to protect steelhead that were nearing a peak on the spawning grounds. Even with the extended March season in 1955-56, the catch of steelhead in March was only about 1/3 of that in January and February.

However, after hatchery steelhead were introduced into the Hoh River fishing effort was increasingly targeted on the early component of the run to maximize harvest of returning hatchery steelhead. McHenry et al. (1996) indicated up to 95% hatchery steelhead exploitation, and the 2002 SaSI (2003) indicated about 80% hatchery steelhead exploitation. As a result, the once dominant early run timing of wild winter steelhead as depicted in the 1955 and 1956 sport catches (Figure 9) and tribal catches (Figures 7 & 8) has increasingly shifted over time to later run timing as depicted in Figure 10. By1995 and 1996 the run timing depicted by sport catches had shifted from a January sport catch peak 40 years earlier to a February/March peak; just 5-6 years later in 2000-2002 the peak had completely shifted to March with a near elimination of the original December and January run timing component that had once been prominent contributors to both tribal and sport catches.

What is also apparent in Figure 10 is that not only has the run timing shifted, but there has not been an equal proportional population shift in numbers of steelhead from early to later run timing. It would appear that December, January, and February steelhead have been increasingly eliminated with an overall reduction in the wild winter steelhead population size. This suggests that Hoh River habitat historically functioned at optimal wild steelhead production when early return (and probably earlier spawning) steelhead were the dominant return component of the population. Without them, significant early steelhead habitat destination areas may now be little used that later return (and probably later spawning) steelhead can not effectively fill.

The oldest information regarding historic steelhead spawning time on Olympic Peninsula rivers is from Frachtenberg (1916) in an ethnographic assessment of the Olympic Peninsula by Wray (1997): the lunar period that Euro-American calendars call the month of January was that period of time when the "beginning of the spawning of the steelhead salmon" occurred as recorded in the cultural memory of the Quileute Indians (which include the Hoh). Pettit (1950) further explained that the "spawning habits of certain fish have been the most important single factor in determining the course of Quileute history."

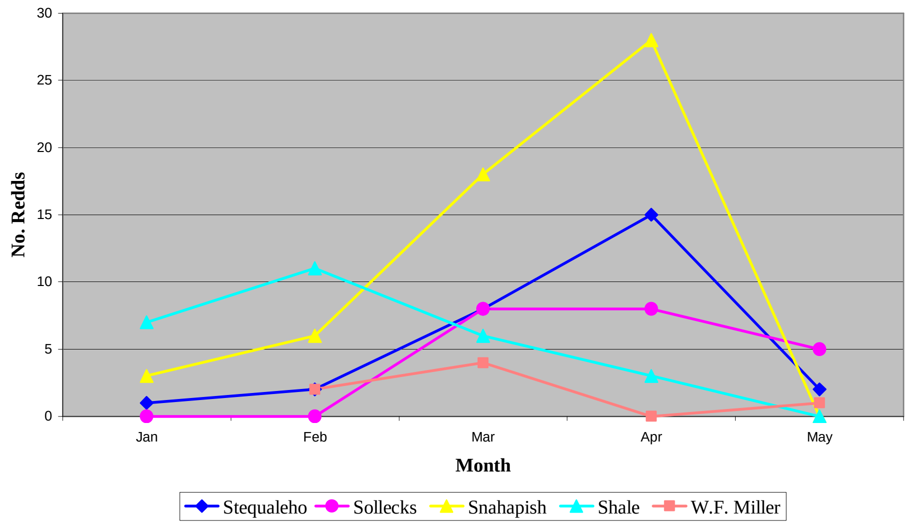
Quileute/Hoh survival depended on this knowledge. Steelhead would have been particularly vital to tribal people due to the lack of other anadromous fish returning during the critical late fall, winter, and late spring period. Over the centuries when lean return years occurred, when and where to expect steelhead during the months when human survival was most stressed would have been paramount. During lean return years, catching steelhead distributed in low numbers in winter-swollen mainstem rivers may not have provided a high likelihood of success using the tools available – fishtraps, dip nets, or spears as the typical tools listed by Powell (1999). In lean return years, steelhead might be more easily captured on their spawning redds in the confines of smaller tributaries beginning in January. This could explain the significance of early spawning steelhead maintained in the Quileute cultural memory.

Initiation of wild steelhead spawning in January is well documented in the more traditional scientific record as well. Burgner et al. (1992) indicate that all seasonal races of steelhead spawn at approximately the same time, principally January to May; Royal (1972) similarly describes that while freshwater life history of all types is essentially the same except for variation in time of entry into the rivers, spawning occurs from January through May. On the central and north Oregon Coast, Lindsay et al. (1991; and 1993) found wild winter steelhead entering small Siuslaw River tributaries for spawning beginning in December and continuing into June, while Troop and Wicker (1996) netted wild steelhead off their redds in the Necanicum River from early January through April. A study of Calawah and Sol Duc River wild winter steelhead spawning found that redd construction began January 2nd and ended July 8th (McMillan et al. [in press]).

Although Cederholm (1984) found that Clearwater River (a Queets River sub-basin) wild winter steelhead spawned in both tributaries and the mainstem from January through June in surveys from 1973 to 1980, prior to when major returns of hatchery steelhead began, he found that early spawning was more prevalent in the tributaries surveyed than in the mainstem. It was also found that spawning timing correlated with the wane of peak streamflows in November and December and with the first increase in water temperatures. Peak spawning was initiated at a sustained daily mean of 7.0° C (44.6° F) and earliest spawning began at about 5.0° C (41.0° F) as indicated in the thermographs.

Figure 11.

Wild Steelhead Redd Counts
From Five Tributaries of the Clearwater River in 1978



During the eight years of surveys on the mainstem Clearwater, Cederholm found the peak spawning period was separated by 39 days from the warmest mean water temperature year (1978) and the coldest mean water temperature year (1975). Despite the differences of earlier spawning time during the warmer flow year and later spawning in the colder flow year, peak steelhead entry time to the Queets River as determined by tribal catch remained the same through all eight years. This would indicate that spawning time was determined by river and tributary conditions *after* initial entry and that early entry may be very important in order to accommodate warmer water temperature patterns that occur some years which shift the entire spawning peak for the steelhead population forward.

Cederholm (1984) found steelhead spawning in January was more prevalent in the warmer flow year of 1978 in both the mainstem and tributaries. Shale Creek spawning peaked in January and February (Figure 11). This compared to peaks of February/March in West Fork Miller Creek, March/April in Stequaleho Creek and Snahapish River, and March/April/May in Sollecks River. In the mainstem Clearwater, January spawning occurred in the more upstream survey reaches that year.

If wild steelhead spawning begins in January, as indicated in the literature and Quileute tribal oral history, the early spawning period would directly overlap with the spawning time of hatchery origin winter run steelhead (January and February) reported for the Hoh River in the 1992 SASSI (1994). Historically, when the wild steelhead catch was dominated by early return wild winter steelhead (Figures 7 and 8), early wild steelhead spawning would have been proportionally more frequent than today.

HISTORIC UNKNOWNS:

In the case of the Hoh River, there are no available catch or other abundance data prior to 1943-44. However, it is known that a fish cannery operated on the Hoh River from 1917 to at least 1921 (Cobb 1930). Although no steelhead are shown to have been included in the record of the cases packed during those years, the existence of the cannery at that early date suggests early industrial-level exploitation of salmon and steelhead had already begun on the Hoh.

By the late 1880s most of the coastal streams of Oregon, Washington, and California "were being mined" for salmon and steelhead, and even in smaller streams they were harvested and shipped to the nearest cannery if one was not located on site (Lichatowich 1999). The industrial exploitation mentality was to plunder resources until there was too little to profit from and then move on to the next site. Those who chose to remain were left the dregs.

The only available shipping of large quantities of canned products at that time from the remote west coast of the Olympic Peninsula to consumer markets in Seattle, Portland, Victoria, or Vancouver B.C. would have been by ship or large tribal canoes. The highway around the Olympic Peninsula was not completed until 1931 (Morgenroth 1991) and the only overland access to the Hoh and Queets rivers in 1925 was still via trail and packhorses (Taft's 1925). The greatest value of steelhead was the fresh fish market, not canned (Wilcox 1898). About half (434) of the 917 fishermen listed as selling fish commercially in 1888 from the coastal and shore fisheries of Puget Sound were Indians of the Makah tribe alone (Collins 1892). The same year at Shoalwater Bay, of 208 commercial fishermen 113 were Indians; at Grays Harbor, of 236 commercial fishermen 15 were Indians.

The Hoh Tribe was left with a 443 acre reservation on the south side of the river mouth in 1893 (Powell 2000). Their seasonal movements to camps, fish traps, and ancient village sites in travels up and down the river was increasingly denied (Wray 1997). The Native American lifestyles that provided sustainable uses of resources, had to give way to the flooding tide of the industrial economy (Lichatowich 1999), and the Indians themselves had no choice but to become a tool of that industry to survive just as had previously occurred during the era of sea otter exploitation which left that species extinct in Washington.

Although there is no record of what original salmon and steelhead abundance may have been on the Hoh River prior to the 1940s, there is evidence of what the original abundance may once have been from the comparative record in the early years of fish resource exploitation on the nearby Queets River, Puget Sound rivers, and the more distant but well documented steelhead abundance of Alaska's Situk River that will follow.

A THREATENED HOH RIVER WILD STEELHEAD FUTURE:

Habitat Alterations, Habitat Assessments, and Altered Salmonid Productivity

Many tributaries where steelhead do, or once did, spawn and rear in the Hoh River basin are outside the ONP and have been severely degraded by mass wasting events related to logging. Slope failures during 1989-1990 along Huelsdonk Ridge mobilized 243,000 yds^3 of sediment, 34 percent of which ended up directly in salmon habitats of the South Fork Hoh (McHenry et al. 1996). Between 1981 and 1990 a total of 139 separate mass wasting events were counted along Huelsdonk Ridge alone. These landslides have increased 6-7 times over historic levels and have been found to be associated with clearcutting (63%) and roads (27%) (Schlichte 1991). On the South Fork Hoh, 87% of juvenile steelhead reared in off-channel habitats along the valley floor (Sedell et al. 1984) before the impacted tributaries subsequently deposited their loads of debris and silt into these areas after mass wasting events.

A habitat assessment for the Hoh, South Fork Hoh, and 17 Hoh basin tributaries is provided in Table 14 regarding eleven attributes (Smith 2000): fish access to the stream, flood plain quality, sediment quantity, sediment related to road density, sediment quality in amount of fines, channel stability, instream large woody debris, riparian quality, amount of pools, water quality (including temperature), and flow stability. Of the 122 habitat quality assessments made for the streams or sections of streams listed, 73 (60%) were rated as poor, 26 (21%) were rated as good, and 23 (19%) were rated as fair.

Table 14. Assessment of habitat attributes of the Hoh and South Fork Hoh rivers and 17 tributaries in the Hoh River basin as rated good, fair, or poor (those attributes that have not been assessed remain blank) [from Smith 2000].

Stream Name	access	flood plain	sed. quantity	sed. road density	sed. quality fines	channel stability	instream LWD	riparian	pools	water quality	flows
Hoh Riv		poor	poor in middle			poor	poor in lower good in upper	poor in lower good in upper			
Braden Ck			poor	good	fair		poor	poor	good	poor	poor
Nolan Ck	poor	fair	poor	fair			poor	poor	fair	poor	poor
Anderson Ck			poor	good	fair		poor	good	poor	poor	poor
Lost Ck			poor	good			poor	good	good	poor	good
Winfield Ck		fair	poor	good			poor	poor	fair	poor	poor
Hell Roaring Ck	poor	poor in EF				poor-good	good				
Alder Ck	poor	poor	poor	fair	fair	poor	poor	fair-good	fair	poor	good
Elk Ck				fair	fair		poor	poor	good	poor	poor
Willoughby Ck			poor	fair		fair	fair-poor	poor	poor	poor	good
Pins Ck			poor	fair			poor	poor	good	poor	good
Dry Ck		poor					poor				
Spruce Ck		poor	poor		poor	poor	poor	fair			
Canyon Ck			poor				poor	fair		poor	
Owl Ck		poor	poor	fair		poor	poor	good	poor	poor	poor
Maple Ck		poor					poor	poor		poor	
Jackson Ck							good	good			
Mt. Tom Ck		fair					good	good			
S. F. Hoh Riv		fair					poor in lower good in upper	fair in lower good in upper			

Among Hoh River basin tributaries impacted with one or more mass wasting events are: Alder, Willoughby, Tower, Spruce, Canyon, Canyon Springs, H-3900, Winfield, Dry, Maple, Owl, Washout, H-1070, Virginia Falls, Iron Maiden, McQuarry, Split, Line, Hoot, Boundary, and Shelter Creeks (McHenry et al. 1996). The combination of clearcutting, roads, and subsequent mass wasting events result in increased sediment delivery that widens and reduces the depth of stream channels with reduced pools, reduced summer water volumes, and reduced water quality due to summer temperature increases (Smith 2000). Fisher, Willoughby, Rock, Elk, Canyon, Anderson, Alder, Line, Maple, Nolan, Owl, Split, Tower, and Winfield creeks were all Hoh River tributaries listed by DOE (1998) for having high summer water temperatures. Because of this all are listed as "poor" in Table 14 (Hoh River habitat assessment in WRIA 20) regarding water quality. In the case of Winfield Creek, in August of 1999 water temperatures were 16°-19° C and dissolved oxygen was 3-5 mg/L resulting in high mortality of salmonids as found by John McMillan of the Hoh Tribe (Smith 2000).

One of the more important habitat attributes for providing sustained stream flows, particularly during late summer and early fall when precipitation through rainfall is least available, is the overstory mass of old growth conifers where fog collects and then drips providing up to 35% of annual precipitation (Norse 1990). This vital 35% of annual precipitation through fog drip is lost with the clear cutting of old growth forests (Smith 2000). Once clear cut, old growth can only be regained with a long-term commitment toward forest recovery that requires the sustained efforts of multiple human generations. The headwaters of Hoh basin tributaries frequently go subsurface which may be related to the high percentages of tributary watersheds that were once old growth and are now hydrologically immature forest (Smith 2000). 79% of Braden Creek, 67% of Anderson Creek, 64% of Nolan Creek, and 61% of Elk Creek are all above the 60% level of hydrologically immature forest considered poor for water quantity which is further compounded by the effects of roads.

Potentials for Habitat Recovery

Although 60% of the habitat assessments made in the Hoh basin are rated poor (Smith 2000) with subsequent reductions in steelhead production potential, long-term planning for habitat recovery can eventually restore lost attributes that have primarily occurred outside the ONP. This can occur in either of two ways:

1) Develop stringent regulations and enforcement of land and water uses by public and private land owners that will allow habitat recovery to occur.
2) Buy out private land holdings in the watershed that most affect habitat quality in the Hoh River basin and combine them with public lands redesignated specifically for salmon and steelhead habitat refuges in which natural processes are allowed to provide for recovery, and/or preservation, of the habitat and its aquatic resources.

Option one has a dubious historical record as exemplified by the presently degraded habitat in which the Hoh River, despite 60% of habitat outside the ONP being degraded, is actually a best case example as compared to other river basins in Washington.

The second option provides greater assurance that long-term habitat restoration goals can be achieved once the land base is taken out of the shifting political arena of public land policy changes. The purchases of 4,685 acres of land that have occurred in the Hoh basin through the collaboration of WRC and WSC with the support of DNR is now in the ownership of the Hoh Trust which can provide a stable core of habitat for salmon and steelhead in the Hoh basin outside the ONP that will increasingly improve over time with an eventual return to ONP like conditions. As future priority habitat areas are identified and become available they will also be gradually acquired (WSC 2006).

As a major landholder of vital fish habitat in the Hoh basin, WRC and WSC will increasingly convene with public land and resource managers to establish improving land use practices, particularly focusing on tributary forest areas where habitat degradation has been most severe, and to encourage development of sport and tribal harvest levels and more contained hatchery practices that will allow for recovery of self sustaining ecosystems and the biological diversity and abundance they historically supported. The WSC already has, and will continue to perform research in the Hoh basin from which to better understand how, why, and when habitat is used by differing fish species, what their numbers are, and the complexity of biological diversity represented by differing species, their interrelationships with each other, and the importance of life history differences within species.

Alterations in Steelhead through Fishery Management

However, habitat recovery alone will not result in restoration of depleted Hoh River steelhead. Summer run steelhead in the Hoh basin are thought to be primarily destined for the upper watershed (SASSI 1994; McHenry et al. 1996) which is in the ONP, and which is considered essentially pristine (Houston and Contor 1984). Yet it is apparent from Figure 4 and Tables 11 and 12 that despite pristine habitat destinations in the upper Hoh River and South Fork Hoh, returns of wild summer run steelhead in the Hoh River basin are on a trajectory that may already be approaching functional extinction. Pristine habitat alone does not suffice.

It is also apparent that wild summer steelhead returns to the Hoh River have declined at the same time that straying hatchery summer steelhead from the Quileute system documented in the tribal and sport catches have dramatically risen. Snorkel counts also clearly indicate that hatchery summer steelhead are commonly returning in larger numbers to the historic habitat reaches for wild summer run steelhead in the South Fork Hoh. This suggests two likelihoods working in combination against Hoh River wild summer run steelhead:

1) Over exploitation in a mixed stock fishery that targets hatchery fish with the cumulative effect to drive the natural population down to eventual extinction (Brannon et al. 1999).
2) Hatchery/wild interactions due to hatchery steelhead escapement to the spawning grounds with resultant decreases in spawning success in hatchery/wild crosses (Reisenbichler and McIntyre 1977; Chilcote et al. 1986; Leider et al. 1990; and Miller et al. 2004), and subsequent juvenile rearing interactions created by naturally spawning hatchery steelhead whose juveniles do survive long enough to reduce wild juvenile steelhead numbers that must compete with them with subsequent wild population declines as found on Oregon's Clackamas River (Kostow et al. 2003).

Regarding Hoh River wild winter steelhead, there has been a pronounced shift in run timing from a catch that peaked in December, January, and February in the 1940s and 1950s (Taylor 1979; WDG 1956; and WDG 1957) to a catch that now peaks in March and April dating back to at least 1984 (Hiss et al. 1986). This shift to later entry time minimizes the potential for spawning that historically occurred in January and February which may be a particularly important adaptive trait to spawning in tributaries (Cederholm 1984; McMillan 2001).

As indicated in the 1992 SASSI (1994), "small numbers of earlier wild natives appear to spawn in headwaters of all the significant tributaries." These tributaries include Braden, Nolan, Anderson, Lost, Winfield, Alder, Elk, Clear, and Slate creeks (SASI 2003). Spawning escapement estimates, and presumably spawning ground surveys, did not begin until 1978 (WDFW 2006). It would follow that early spawning wild steelhead were much more prevalent in the headwaters of these tributaries prior to the time when wild steelhead entry time shifted to March and April from the historic timing that peaked in December, January, and February.

Steelhead Biological Relationships to Habitat

Early entry time and early spawn timing may be a particularly important component of wild steelhead population diversity in order to maximize tributary spawning and rearing opportunities.

Early spawning in small tributaries was determined to be a critical necessity for Oregon's Rogue River steelhead in order to accommodate emergence and outmigration by June when many of the tributaries went dry (Everest 1973).

Cederholm (1984) found that more wild steelhead spawned early (beginning in January) in the tributaries of the Clearwater River (Queets system) than in the mainstem. He provided evidence that streamflows and water temperatures were primary determinants of when steelhead spawn, and that steelhead have minimized redd losses through winter-spring spawning that avoids major freshets and floods in fall and early winter that cause resulting higher mortality of fall spawning salmon eggs. However, that resultant egg-to-fry success is counter balanced by fry that emerge 3-5 months after chinook and coho. This creates a particular disadvantage for later spawning steelhead with fry emergence so late that the juveniles are of small size going into their first winter.

As a specific example of the magnitude of temperature differences between mainstems and tributaries on the Olympic Peninsula, on March 4, 2006, Pete Soverel (per. com. March 4, 2006), founder of the Wild Salmon Center, took water temperature readings from the mainstem Queets River and Phelan Creek (about 1.5 miles upstream of Matheny Creek). Phelan Creek has a western exposure and was running 46° F while the mainstem Queets was running between 40° to 41° F. While the mainstem Queets was just reaching the water temperature range Cederholm (1984) found initiated wild steelhead spawning (41° F), Phelan Creek was already above the water temperature at which peak spawning was found to occur (44.6° F). Lower Phelan Creek is within the ONP Queets River corridor and was described by Soverel as a narrow deep channel with clear, spring-like water, clean gravel and flowing strands of green algae. It is a low gradient section of the creek where it flows across the terrace between the valley wall and the Queets River providing high quality spawning and rearing habitat.

Cederholm (1984) found there were differing peaks in spawning time for steelhead that return to individual tributary streams. Emergence would also occur at differing times, rather than in one large peak, resulting in a staggered use of the food chain by rearing steelhead.

In *The Run of the River,* Mark Hume (1992) describes the importance of managing for breadth of spawning timing and the resulting staggered emergence of fry regarding sockeye salmon as found at the Karluk Lake and River system in Alaska:

"*The timing of spawning runs is crucial to the survival of their fry because it determines when the young fry will emerge from the gravel and enter the lakes in which they spend the first year of life…"*

"The crucial nature of timing was demonstrated for biologists at Karluk Lake, in Alaska, where an enormous sockeye salmon stock was wiped out by overfishing. The Karluk run went from 5.6 million fish in the 1880s to 500,000 in the last 35 years…

"…After decades of frustrating failure, fish scientists in Alaska began to think of Karluk as a Rubic's cube…

"In a 1985 (actually 1987) *paper, J.P. Koenings and R.D. Burkett, of the Alaska Department of Fish and Game, said they came to realize the key to the puzzle lay not in the river, but in the lake below and in the timing of fry emergence.*

"All prior attempts (at restoration) *had focused on getting more adults back to the spawning grounds.*

"What they came to understand was that the Karluk stock had once been comprised of up to 20 separate groups of sockeye, all of which were intricately adapted to the environment. The groups spawned at different times, and the timing of their fry emergence was perfectly synchronized to the forage production in the lake.

"…Karluk sockeye were … producing fry that converged on the lake in (staggered) *waves over the summer after emergence, making optimum use of the nutrients available. Overfishing reduced the Karluk stock to three or four age groups, and then enhancement efforts had concentrated on propagating those groups. The result…was that fry arrived in the lake in a few great lumps* (or peaks), *causing overcompetition for the nutrients at some times, and leaving the lake lightly used at others. The fish were out of synch with the lake – and the result was poor survival for fry."*

The lead author in the paper Hume (1992) quoted from is the present Director of WDFW, Dr. Jeffery P. Koenings. One might hope he would require his fishery managers to apply this same concept (of his own discovery) in the recovery efforts used for Washington's wild salmon and steelhead populations: the need to recover the full breadth of salmon and steelhead entry and spawning time in order to provide for staggered fry emergence.

Although steelhead do not depend on lakes for fry-to-smolt survival, streams and rivers are no less limiting in their productivity. This undoubtedly explains the historic broad breadth of spawning timings of differing species, and diversity within species, of salmon and steelhead in their utilizations differing areas of rivers and creeks for spawning, emergence, and rearing so as to maximize the ability to make use of the limited nutrient levels they represent at any one time.

Regarding the importance of early tributary spawning as documented by Cederholm (1984) on the Clearwater River, it has been estimated that approximately 75% of winter steelhead that spawn in Washington's Skagit River Basin use tributary streams (Phillips et al. 1980; Phillips et al. 1981; and Woodin et al. 1984).

The question immediately arises, has focused harvest on early return and early spawning wild steelhead minimized the ability to fully utilize 75% of the most productive steelhead spawning and rearing habitat in Washington's rivers?

Table 15 provides a comparison of water temperature data recorded at ten-day intervals on five tributary streams and the mid Skagit River during the temperature peak of late afternoon from February 9th to April 15th of 2002 (McMillan 2005). In this instance the purpose was to demonstrate that the lone major tributary with a southern exposure in the Birdsview section of the mid Skagit River had a higher mean temperature from early February to mid April than did the mainstem Skagit River and four tributaries with northern exposures in the same section of river. Regarding the mainstem Skagit, its water temperatures do not greatly fluctuate due to coming out of a series of reservoirs on its upper mainstem. There are also two reservoirs behind hydroelectric dams on the Baker River six miles upstream of where the temperatures were recorded. Therefore the Skagit's winter water temperatures are commonly warmer, and its summer temperatures colder, than what the historic flows may have once been under natural conditions.

Table 15. Mid-Skagit River and five mid-Skagit River tributaries: water temperatures in Fahrenheit taken at ten-day intervals in late afternoon.

Stream	2/9	2/19	3/2	3/12	3/24	4/3	4/15	Mean
Grandy Creek (faces south)	40.5	40.5	41.0	40.0	44.25	46.0	42.25	**42.08**
Mid-Skagit River	39.0	39.5	39.5	38.5	43.75	44.0	40.5	**40.68**
Finney Creek (faces northwest)	39.0	39.5	38.5	38.5	42.5	45.0	40.75	**40.54**
Mill Creek (faces north)	38.5	38.5	37.5	38.0	40.0	40.0	39.5	**38.86**
Pressentin Creek (faces north)	38.0	38.5	36.5	37.5	39.75	40.25	39.0	**38.50**
O'Toole Creek (faces north)	38.0	38.0	36.0	37.0	39.5	39.75	38.75	**38.14**
Air Temp.	43	40	49 25 Low	39	53	64	45	

The tributary with the southern exposure (Grandy Creek) averaged 1.5° F warmer than the Mid-Skagit and the northwesterly facing tributary (Finney Creek), and 4° F warmer than the coldest of the northern exposure tributaries (O'Toole Creek). While the southern exposure tributary was approaching the lowermost temperature of 41° F by early February that steelhead spawning began in the Clearwater system (Cederholm 1984), the coldest of the northern exposure tributaries never did get above 39.75° F even by April 15th. This demonstrates the complexity of differing habitats and the necessity of having equally diverse entry, spawning, and fry emergence times to make most effective use of their individual habitat attributes. On the Skagit River there are numerous tributaries with southern exposures other than Grandy Creek where warmer water temperatures and early spawning might be anticipated.

On southern Washington's Wind River, it was found that the southern exposure of Panther Creek drainage provided a 41° F temperature on February 18, 1988 with active steelhead spawning occurring despite heavy snow on the ground (McMillan 2001). By contrast, several nearby tributaries were running 38°-39° F with no evidence of spawning activity. It had previously been found that only low numbers of wild steelhead spawned in Panther Creek (Lucas and Nawa 1986; Lucas and Pointer 1987). This may have been because WDG spawning surveys were not typically occurring until March 15th and later. This was after much Panther Creek spawning had already occurred.

There is also evidence that hatchery/wild steelhead spawning interactions may particularly occur in tributaries as found on the Washougal and Wind rivers because flows and warmer tributary water temperatures favor early spawning (McMillan 2001). Because Chambers Creek hatchery stock of winter steelhead has been specifically selected for early spawning (Crawford 1979), the warmer temperatures typical of some tributaries (such as Chambers Creek itself once historically represented) may be spawning destinations that are particularly selected by hatchery steelhead which stray or otherwise spawn in the wild. It has also been shown that because of the protracted spawning time of males, both hatchery origin and wild, it denies the ability to separate wild and hatchery steelhead from spawning together with tributaries potentially being the sites where this may most commonly occur during the earliest periods of steelhead spawning (McMillan 2001) between December and February.

Steelhead Relationship to the Abundance of other Salmon Species

Among the early references that cite the importance of salmon returning in large numbers to provide nutrients to the Olympic Peninsula's rain-leeched watersheds was Bruce Brown's *Mountain in the Clouds* (1982). Since then the relationship of increased watershed nutrients through abundant salmon carcasses after spawning has been well documented (Kline et al. 1990; Bilby et al. 1996; Johnston et al. 1997; Gresh et al. 2000), with coho and steelhead being particular benefactors of salmon carcass and salmon egg nutrients (Bilby et al. 1998) due to their longer freshwater residency prior to smolting.

Present reductions of steelhead from historic numbers may be related to depleted numbers of Pacific salmon that now return to the Hoh basin. This has been identified as one possible cause for steelhead declines in Washington's Skagit River where there are presently an estimated 375-437 salmon carcasses per sq. mile in the accessible areas of the basin if they meet their escapement goals and if they are distributed evenly throughout (McMillan 2004). By comparison, Alaska's Situk River steelhead population is proportionally much greater than that of the Skagit for its basin size which may be related to its having an estimated 6,500 salmon carcasses per sq. mile (as computed in the Situk section later in this paper). Rearing juvenile steelhead in the Skagit basin have less than 7% of the available salmon eggs, carcasses, and nutrients per sq. mile than their juvenile equivalents in the Situk basin.

Pre-1980 historic sources regarding Pacific salmon returning to the Hoh River are limited, but occasionally revealing. The cannery that operated at the mouth of the Hoh from at least 1917 to 1921 packed chinook, coho, and chum salmon in relatively modest and equal quantities – from 20 to 500 cases of each species annually, depending on the year (Cobb 1930).

As has been previously indicated, limiting fishery history to a time scale of 30-40 years can lead to false assumptions. The harvest of chum salmon from 1967 to 1991 by the Hoh Tribe ranged from a high of 218 in 1972 to a low of 8 in 1991 (SASSI 1994). In that period of time chum were in apparent low numbers and still declining. Based on this relatively recent history dating to 40 years ago, it has been assumed that:

"Because of the Hoh River's limited estuary, this stock may have never been very abundant (Personal communication, Jim Jorgensen, Hoh Tribe)." (McHenry et al. 1996).

However, the Hoh River cannery records indicate that chum salmon were present in commercially viable numbers during its five year period of record (1917-1921). In 1919, 332 cases of chum were packed (Cobb 1930) with 48 one pound cans per case (15,936 pounds). Average individual chum salmon weight is nine pounds as reported by Wydoski and Whitney (1979). If wastage was 50%-70%, using the range of cannery wastage suggested by Jim Myers (per. com. in 2005 indicated ~50% chinook wastage at canneries and ~70% wastage for smaller sized fish such as steelhead), a catch of 3,541-5,902 chum salmon was processed at the cannery. If the catch represented 30%-50% of the run size, as estimated by Myers (2005) for Puget Sound steelhead, 7,082-11,804 chum salmon returned to the Hoh basin in 1919 at a 50% harvest rate, or 11,803-19,673 chum salmon returned at a 30% harvest.

Even this estimate of somewhere between 7,000-20,000 chum salmon returning to the Hoh in 1919 may be conservative. It does not include those chum salmon caught for subsistence use by the Hoh Tribe. Also, because chum salmon had a lower market value (chum sold for half a penny per pound while steelhead sold for three cents per pound in 1895 [Wilcox 1898]), there may have been considerable wastage of catch brought to the cannery by fishermen. As was described by Lichatowich (1999), if more salmon were caught for the available market with the refusal to buy them at the cannery, the fishermen could only resort to dumping their entire catch.

Chum salmon alone would have provided a significant nutrient base in 1919 for rearing steelhead in the mid and lower Hoh River. That nutrient base is now virtually absent with chum numbers generally less than 100 fish in the catch. In 1975 chum salmon were identified as using the mainstem Hoh, Winfield Creek, and Elk Creek (Phinney et al. 1975). Today there are no escapement goals for chum salmon and escapement is not monitored (SASSI 1994; McHenry et al. 1996). There are no indicated plans for restoration of this once important species to the Hoh River ecosystem. The Hoh River is presently managed for chum extinction.

Pink salmon were identified in the Hoh basin as late as 1975 at sites that included the mainstem Hoh, Winfield Creek, and Elk Creek (Phinney et al. 1975). There is no early record that could be found regarding historic pink abundance. In alternating years they likely once numbered at least equal to chum salmon if the returns had similar patterns to other rivers in Washington that had both species. They would once have provided another significant source of nutrients for rearing steelhead in the mid and lower

Hoh basin. Pink salmon are not even mentioned as historically existing in the Hoh basin in the WDFW stock reports (SASSI 1994; SaSI 2003) or by McHenry et al. (1996).

It is evident from the management literature that pink salmon are already considered extinct. There is no acknowledgment of their existence and no plans for restoration. However from a functioning ecosystem perspective, restoration of pink salmon should be a high priority for their nutrient contribution to the basin.

From Hoh tribal sources it is apparent that both chum and pink salmon were once important to their fisheries (Powell 1999):

"The first stream on the Hoh on the north side (t'idixasa', meaning unknown). The mouth of the first small stream entering the Hoh on the north side is no longer clearly visible from the village, but older Hohs remember it as 'Herbie's grounds' and that 'the water would shoot right out and make an eddy, you could set a net there. Humpies and dog salmon. Not many any more.' [Helen Lee]*"*

"The second settlement on the Hoh was T'sixIlalAkwa, meaning 'high bank', which was called tse-qhilk-lay-ah-auah located a little below the precipitous riverbank, between Braden and Nolan Creeks. There was a fishtrap here in traditional times, spanning the river and a single multi-family longhouse… This greater family group depended heavily on the fishtrap associated with the house. Billie Hudson told anthropologist Dr. Daugherty that he put up (smoke-preserved) lots of smelt and 100 salmon in 1947: coho, dogs, steelhead, kings, fall silvers…"

In 1920, 370 cases of silverside (coho) salmon were packed at the Hoh cannery (Cobb 1930) with 48 one pound cans per case (17,760 pounds). In 1889 the average coho in the Puget Sound catch was 7.5 pounds (Collins 1892) and in 1895 it was 8-8.5 pounds (Wilcox 1898). For the purposes of this report, 8.0 pounds (the median between the reported averages) has been used. If wastage was 50%-70%, using the range of cannery wastage suggested by Jim Myers (per. com. in 2005), a catch of 4,400-7,400 coho was processed at the cannery. If the catch represented 30%-50% of the run size, as estimated by Myers (2005) for Puget Sound steelhead, 8,880-14,800 coho salmon returned to the Hoh basin in 1920 at a 50% harvest rate, or 14,800-24,667 coho salmon returned at a 30% harvest.

The 1920 cannery pack did not include coho caught by the Hoh Tribe for subsistence use. It has also been found that 66.8% of Hoh River coho were harvested in various British Columbia fisheries in 1986 (McHenry et al. 1996). How many were being intercepted in 1920 in British Columbia fisheries is unknown, but potentially a significant number that never reached the Hoh River.

The Hoh tribal harvest of coho from 1973 to 1991 ranged from a low of 66 in 1983 to a high of 6,701 in1973 (SASSI 1994). Run size estimates only went back to 1983 and ranged from a 1983 low of 8,315 to a 1984 high of 13,468. Harvest rates varied from 15%-50% from 1983 to 1994 (McHenry et al. 1996). The run size estimates did not include the catch estimated from British Columbia before the coho reached the Hoh.

The run size range that returned to the Hoh River in 1920 was 15,000-25,000 coho; from 1973 to 1991 it was 8,500-13,500 coho, approximately 50% of the 1920 estimate. Nevertheless, coho stock status is considered "healthy" (SASSI 1994). If escapement has been similarly reduced, today only about half of the coho nutrients are available to rearing steelhead in terrace side channels and tributary creeks (common coho spawning and rearing areas [SASSI 1994]) that were available in 1920.

In 1920, 524 cases of chinook were packed at the Hoh cannery (Cobb 1930) with 48 one pound cans per case (25,152 pounds). The catch may have consisted primarily of spring/summer chinook to compete with Columbia River "Royal Chinook" that had the highest canned salmon market value (Dietrich1995), although it may also have included fall chinook.

In 1895 the average size of chinook in the Puget Sound commercial catch was 20 pounds (Wilcox 1898). If chinook salmon cannery wastage was 50% as indicated by Jim Myers (per. com. in 2005), 2,515 spring/summer chinook were processed in 1920 at the Hoh River cannery. If the catch represented 30%-50% of the run size, as estimated by Myers (2005) for Puget Sound steelhead, then 5,030 spring/summer chinook returned to the Hoh River basin in 1920 at a 50% harvest rate, or 8,383 spring/summer chinook returned at a 30% harvest rate.

Spring/summer chinook would have been a particularly sought after target of the Hoh Tribe subsistence fishery in 1920. Because of their size and high food quality, the spring/summer chinook would also have been the target of subsistence fisheries of the Hoh Valley settlers. For these reasons, the cannery record may far under represent the actual chinook catch in the Hoh basin in 1920.

Hoh River run size estimates for spring/summer chinook from 1973 to 1991 were lowest in 1980 at 1,065 and highest in 1989 at 6,906 (SASSI 1994). No catch data by the Hoh Tribe were provided. The run size estimates of about 5,000-8,500 chinook that may have been primarily spring/summer chinook returning to Hoh basin in 1920 compares to a range of about 1,000-7,000 from 1973 to 1991. The 19 year mean run size was 2,463 spring/summer chinook from 1973 to 1991, 30%-50% of that in 1920 if the cannery pack was primarily spring/summer chinook.

If the 1920 chinook cannery catch included fall chinook, the comparative combined spring/summer and fall chinook run sizes between 1973 and 1991 were a low of 4,381 in 1985 and a high of 15,588 in 1989. The 19 year mean run size of 6,712 Hoh River combined chinook stocks between 1973 and 1991 would compare favorably with that of 1920 if the cannery pack represented the only harvest of chinook (which seems unlikely given the high quality food source spring/summer chinook would have represented for both tribal members and settlers in the Hoh Valley in that subsistence fishery era).

Sockeye salmon were also historically once present in the Hoh River basin (WSC 2005), but no older historic data was found regarding one time abundance, and there is no record of their one time existence in the WDFW stock reports (SASSI 1994; SaSI 2003). These would have been riverine sockeye, with no major lowland lake system in the Hoh basin. However, during the Hoh Valley glaciations a large lake once existed for 30,000 years (Thackray 1996).

Today, in the functional absence of chum and pink salmon in the lower and middle reaches of the Hoh basin where they were once present, there is now a void of nutrients that those salmon eggs and carcasses once provided for rearing steelhead. It is also apparent from the evidence of the Hoh cannery record that coho salmon are now half or less their historic numbers with a subsequent loss of 50% or more of coho egg and carcass nutrients available to rearing steelhead in terrace channels and tributaries where coho are particularly inclined to spawn. There is also reason to believe that spring/summer chinook that were the primary salmon stock that returned to the upper Hoh basin and upper South Fork Hoh sub-basin may be only 30%-50% of historic numbers with subsequent 30%-50% nutrient reductions in the 60%-65% of remaining Hoh River basin habitat that is considered essentially pristine in the ONP.

Recovery of Hoh River Steelhead Diversity and Restoration of Sufficient Steelhead Numbers to Utilize Habitat Destinations

The shift in the entry time, loss of tributary habitats, hatchery/wild spawning interactions, and subsequent minimization of early spawning may all have contributed to the decline in the Hoh River wild winter steelhead population as shown in Table 13: the average tribal catch of 2,408 wild steelhead in 1948-1962, went down to an average of 1,125 in 1980-2005 (47% of the previous average); the average sport catch of 1,461 wild steelhead in 1948-1962, went down to an average of 608 in 1980-2005 (42% of the previous average); and the average run size of wild steelhead of 7,938-13,280 in 1948-1962, went down to an average of 4,501 in 1980-2005 (between 57% and 34% of the previous average).

The shifts in wild steelhead entry time, and drops in catch and population size, coincide with the period of time when hatchery steelhead began to return to the Hoh River in 1962. Since then, a high harvest rate of 80%-95% has targeted on hatchery steelhead that were thought to return earlier than wild steelhead (SASSI 1994; McHenry et al. 1996). But the historic evidence indicates wild Hoh River steelhead primarily returned in November, December, January and February with a December/January peak (Taylor 1979; WDG 1948-1978; and WDG 1956 and 1957), the same as hatchery steelhead. They would similarly have experienced harvest rates up to 95%, a classic example of a mixed stock fishery whose cumulative effect is to drive a natural population down to eventual extinction (Brannon et al. 1999). This has likely resulted in the shift to later wild steelhead entry and later spawning that has occurred (Hiss et al. 1986) with the potential that specific habitat niches favoring early spawning have been denied sufficient escapement to be productive.

During this same historic period, Hoh River tributary streams have been impacted by timber harvest resulting in degraded habitat conditions (McHenry et al. 1996) that early entry and early spawning steelhead may be most able to utilize.

WRC, WSC, and the Hoh Trust have begun to reverse the process of habitat losses in the Hoh River basin through land purchases with a long-term vision for ecosystem restoration that includes diverse and abundant fish populations. For that vision to succeed it will require the cooperation of the salmon and steelhead managers. Improving habitat can't perform as anticipated unless it has increased escapement of wild salmon and steelhead to take advantage of it, and just as in the case of restoring sockeye salmon to Karluk Lake, diversity of run timing, spawn timing, and juvenile emergence timing will all be required (Koenings and Burkett 1987) to make effective use of the breadth of steelhead habitat diversity represented by the Hoh River basin.

Present emphasis on hatchery steelhead programs, both within the Hoh basin (Hoh Tribe winter steelhead releases) and in neighboring basins (Quinault Nation winter steelhead releases into the Quinault and Queets basins, WDFW winter and summer steelhead releases into the Quileute basin, and the Olympic Peninsula Guides Association Snyder Creek winter steelhead releases into the Sol Duc sub-basin), represent major limiting factors regarding expected success of investments in habitat recovery in the Hoh River basin and the other basins of the North Coast of the Olympic Peninsula. It is apparent from the hatchery winter steelhead findings of Hiss et al. (1986) throughout the Hoh basin, and from the widespread presence of straying hatchery summer run steelhead in all of the major North Coast basins and sub-basins from releases limited to the Quileute basin, that elimination of hatchery releases from only one major river basin would not necessarily prevent significant widespread hatchery/wild steelhead interactions within that basin or its sub-basins. Nevertheless, the Hoh River basin, with major habitat purchases in process, provides good reason to begin elimination of hatchery releases into the Hoh River, and to at least reduce hatchery smolt releases into neighboring basins to reduce straying.

As described by Brannon et al. (1999) regarding recommendations by the National Research Council (NRC 1996):

"The NRC recommended that hatcheries should be dismantled, revised, or reprogrammed if they interfere with a comprehensive rehabilitation strategy designed to rebuild natural populations of sustainable anadromous salmon … Hatcheries should be excluded or phased out from regions where the prognosis for freshwater habitat rehabilitation is much higher."

Nowhere is habitat more recoverable in the Lower 48 than on the Hoh River and the other river basins of the North Coast of the Olympic Peninsula where much of it is already pristine in the headwaters within the ONP. A primary argument for investing in hatcheries is due to lost habitat, yet hatchery salmon and steelhead can result in the creation of yet another layer of continuing loss of habitat productivity. Hatchery salmon and steelhead escaping into the wild can overwhelm smaller wild populations resulting in good habitat that is increasingly vacant of a specific wild stock. This is apparently what occurred regarding lower Columbia River wild coho salmon that are now extinct in most of their former range (Flagg et al. 1995). This may already have occurred with summer run steelhead in the upper Hoh River basin within the ONP as previously evidenced, and may be similarly occurring with wild winter run steelhead destined for smaller tributaries, whether inside or outside the ONP.

Securing habitat with the purpose of long-term restoration eliminates the basic argument for perceived hatchery dependency and the varied risks to wild salmon and steelhead associated with hatcheries.

Presently there is no escapement goal for wild summer steelhead returning to the Hoh River system whatsoever. This is despite the Washington steelhead managers' acknowledgment of the vulnerability of small summer steelhead populations (SASSI 1994).

Regarding Hoh River wild winter run steelhead, the present escapement goal of 2,400 wild winter steelhead has resulted in a long sustained decline in run sizes since 1980 (Figure 5) and has not provided a return to run sizes that occurred between 1948 and 1961 prior to hatchery steelhead returns began. The present escapement goal is 18%-

30% of the historic average run sizes of the 1948-1961 era. Furthermore, the actual magnitude of Hoh River wild winter steelhead decline may be hidden by the lack of catch data earlier than 1944. This will become apparent in the examination of other steelhead populations that have catch data to earlier periods of time. (Regarding escapement goals and stock recruit analysis of more recent history for the Hoh River [1978-1999], a more detailed discussion and related figures are provided by Nick Gayeski in Part IV and Part V.)