Part II. Historic Steelhead Abundance

Other Comparative Steelhead Histories

I. Puget Sound

Salt packing of salmon and steelhead in the Northwest began at the beginning of the 19th century with the Northwest Company, a large fur trading organization. It was continued by its successor, the Hudson's Bay Company. Initially the use of the salt-packed fish was for subsistence winter use by employees and for local sale. But as shipping developed on the Pacific coast a considerable export trade in salted salmon began with the Hawaiian Islands, Australia, China, and Japan. After the Canada/U.S. boundary was established in 1846, a number of small traders and fish packers succeeded the Hudson Bay Company in Washington State. A salmon packing operation was described at Point Roberts in 1853. In 1873 a salmon fishery at Mukilteo was putting up fish in barrels with the operation later moved to Seattle to take the late run of salmon up the Duwamish. In one haul of a seine in the Puyallup, fifteen hundred good large salmon were reported. The first salmon cannery on Puget Sound was in 1877 at Mukilteo (Cobb 1930).

The industrialized level of salmon and steelhead exploitation in Washington had begun. In 1889 90,570 lbs. of steelhead were recorded in the Puget Sound commercial catch record (Rathbun 1900). By 1895 it had leapt to 1,965,552 pounds (Wilcox 1898). From that peak in 1895 the catch plummeted thereafter as recorded from the old catch records by Myers (2005) up to 1925.

With the increasing depletion of sea otters on the West Coast from the 1830s onward, the focus on resource extraction for profiteering visions shifted to timber and anadromous fish in the latter 19th and early 20th century. The Reports of the Commissioner, Hon. Marshall McDonald, to the United States Commission of Fish and Fisheries go back to 1888-89 and include "the collection of statistics and other data relating to the commercial aspects of the river, shore, and sea fisheries of the Pacific coast of the Unites States, exclusive of Alaska." (Collins 1892)

Regarding the historic commercial steelhead catch, nets of two types were typically used at the river mouths and on upstream: pound nets that were set and operated in the way of a trap; and gill nets that were generally set, or less often drifted from a boat. Some of these were apparently operated by the canneries built at virtually every river mouth, and others were apparently operated by independent fishermen. These fishermen included Native Americans and U.S. citizens, but one-third was non-citizens with origins from most European countries, Russia, China, Japan and South America. The total number of fishermen recorded in the fisheries of Washington in 1888 was 3,530 of which 1,739 were apparently U.S. citizens, 612 Native Americans, and 1,179 non-citizens from other countries (Collins 1892).

The wastage of salmon and steelhead incurred during this early era of West Coast fisheries and canneries is now hard to envision. Cannery production lines had to work at maximum efficiency when many companies competed for the market share. Because fish were cheap, surplus salmon were kept on hand so as not to idle 200-400 workers on the factory line. This resulted in surplus salmon commonly dumped on the cannery floor where many spoiled before being shoveled back into the river. Furthermore, once the canneries met their limits, those fishermen who couldn't sell their catch had little option but to dump the fish overboard (Lichatowich 1999).

In the analysis of the commercial fishery records from the late 19th and early 20th centuries the amount of wastage that occurred in comparison to the actual catch that was processed and recorded means that far more fish were harvested than the actual records would indicate. Also, the commercial catch record does not include early sport catch, or subsistence catch by tribal people and pioneer residents along the rivers of Washington who likely depended on salmon and steelhead. Therefore the steelhead numbers suggested by these old commercial fishery records must be considered well below what actual abundance was.

Of further consideration, the commercial fisheries were probably limited to the mouths of the major rivers where numbers of returning fish provided a better catch/profit per amount of fishing effort. Although the smaller streams did not individually have large numbers of steelhead, cumulatively they probably once did when their habitat was not as compromised by culvert blockages, agricultural ditching, urbanization, timber harvest, and etc. Statistically counter balancing the lack of steelhead data from small streams in the early commercial catch, the 1978-2004 record is not as complete as might be expected from modern fisheries science due to lack of data collected. One prominent example is the Nooksack River, a major Puget Sound river basin, where there is no tribal steelhead harvest record combined with an apparent absence of spawning surveys from which to determine wild steelhead escapement.

However, the catch and escapement data from 1948 onward likely provide a more complete overall steelhead record for Puget Sound than the reported catch from the early commercial fishery.

The history of Puget Sound steelhead catches and run sizes is provided in Figures 12, 13, and 14. The commercial catch from 1889 to 1925 is followed by the next available data from tribal net fisheries of 1935-1959 (Taylor 1979) combined with the catch recorded on punchcards from sport fisheries of 1947-1959 (WDG 1948-1978). The early tribal fishery record was limited to six rivers, but the sport catch data was from 30 rivers and creeks. The 1978-2004 combined sport, tribal, and escapement record (WDFW 2006) was for 22 rivers and creeks. Table 16 provides the list of streams.

Table 16. The 30 rivers and creeks from which wild steelhead catch and/or escapement data were used (and period of time the data was available) to determine Puget Sound steelhead run sizes.

Coulter Ck. 1948-2004	Duckabush R. 1948-2004	McDonald Ck. 1948-2004	Quilcene R. 1948-2004	Stillaguamish R. Sys. 1948-2004
Dakota Ck. 1948-2004	Elwha R. 1948-2004	Morse Ck. 1948-2004	Samish R. 1948-2004	Tahuya R. 1948-2004
Deschutes R. 1948-1959	Goldsborough Ck. 1948-1959	Nisqually R. 1935-2004	Skagit R. Sys. 1948-2004	Union R. 1948-2004
Dewatto R. 1948-2004	Green R. Sys. 1948-2004	Nooksack R. 1935-2004	Skokomish R. 1935-2004	Lake Wash. Sys. 1948-2004
Dosewallips R. 1948-2004	Hamma Hamma R. 1948-2004	Percival Ck. 1948-1959	Snow Ck. 1948-1959	Whatcom Ck. 1948-1959
Dungeness R. 1948-2004	Kennedy Ck. 1948-1959	Puyallup R. Sys. 1954-1959	Squalicum Ck. 1948-1959	White R. 1950-1959

There was no attempt to determine what wild steelhead catch or run sizes may have been from 1960 to 1977 when hatchery steelhead returns began and no method had yet been applied to differentiate the contributions of wild and hatchery fish from the total catch. From 1978 onward if any numerical data were available for wild steelhead catch or escapement they were included even though they may not have represented a complete count for that individual year.

Regarding the historic commercial steelhead catch recorded in pounds, Figures 12, 13, and 14 provide a range of what the average size per steelhead in the catches likely was: 12 pounds per steelhead; or 10 pounds per steelhead; or 8 pounds per steelhead. However, at least one historic source indicated that Olympic Peninsula steelhead were exceptional for their size. Bradner (1950) indicated coastal Olympic Peninsula steelhead, "run large – their average being 8 pounds with many over 15 pounds and 20 pounders not rare." Because Bradner was a Puget Sound area angler and writer, it must be assumed that Puget Sound steelhead were somewhat smaller. Therefore an 8 pound average per steelhead is likely most representative for Puget Sound when compared to the Queets River average of 9.8 pounds per steelhead in the1934 tribal catch (from notes in Taylor 1979), and the reported average of 29.5 inches (about 9.5 pounds) for Hoh River wild steelhead determined from the combined sport and tribal catch found by Hiss et al. (1986).

Because the catch data prior to 1978 did not include escapement estimates, run sizes for the figures were computed by multiplying the catch by two. This may also be conservative. Myers (2006) used a harvest rate range of 30%-50% in his Puget Sound steelhead considerations. Using that range, he determined that the historic peak run size of steelhead to Puget Sound destinations was 327,592-545,987 fish. 50% would be the low end as was used in the Figures by multiplying the catch by two to estimate the run size. Using the more conservative 50% estimate, the peak Puget Sound run size at 8 pounds per fish would have been 491,388 steelhead; 393,110 steelhead at 10 pounds per fish; or 327,592 steelhead at 12 pounds per fish. A 30% harvest would yield significantly higher run sizes at 818,980, or 655,183, or 545,987 steelhead respectively. Hiss et al. found that harvest on the Hoh River was actually 33%-44% depending on year, or a 38.5% average. However, it is possible that a higher harvest rate occurred in the 1890s when steelhead harvest pressures may have been at a Puget Sound peak.

Myers (2005) indicated steelhead run sizes fell to levels commonly less than 10,000 steelhead in the1920s as determined by the declining commercial catch, and conjectured that many marginal or ephemeral populations may have already disappeared. Run size estimates for Puget Sound stocks in the latter 1980s to mid 1990s were reported to be greater than 45,000 wild steelhead (Busby et al. 1996). This equates with the small peak at that time in Figures 12, 13, and 14. However, after the mid 1990s the data collected indicate the run sizes have declined with a 10 year average from 1995-2004 of 13,083 wild steelhead. The low was 5,918 in 1997 and the high was 26,497 in 1995. In the 5 years from 2000-2004 the run sizes have been 11,000-15,000. This is a population size similar to that of the 1920s when the loss of marginal or ephemeral populations was considered possible. In 2004 Puget Sound steelhead were petitioned for listing under the Endangered Species Act (ESA) and in 2005 that petition was accepted for review (NOAA 2005).

Figure 12.

Puget Sound Wild Winter Steelhead History 1889-2004 [Commercial Poundage Divided by 12 lbs/Steelhead 1898-1925 & Run Size Estimated To Be 2x Catch 1889-1959]

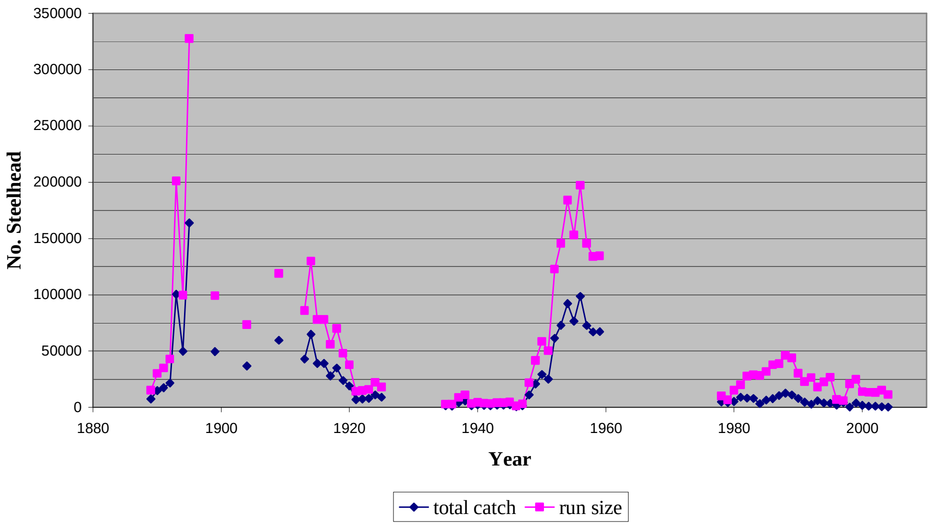
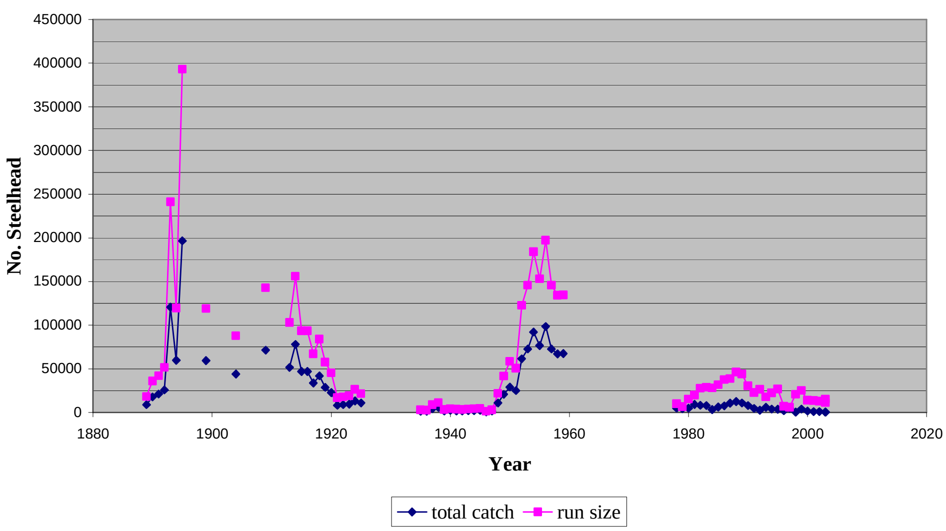


Figure 13.

Puget Sound Wild Winter Steelhead History 1889-2004 [Commercial Poundage Divided by Avg. 10 lbs/Steelhead 1889-1925 & Run Size Estimated To Be 2x Catch 1889-1959]



Beamish et al. (1999) found that changes in ocean conditions related to global climate events impact the dynamics of regional salmon stocks and migration patterns as determined from recreational coho catches from the Strait of Georgia and off the west coast of Vancouver Island in the 1990s. The regional changes in ocean conditions were found related to westerly winds in October, November, and December and to an increase in relative sea level height with a shift that occurred beginning in 1989. A major climate change is also thought to have occurred in 1989 (Beamish et al. 1997*a*, and 1997*b*) determined from indicators such as Southern Oscillation index and the Aleutian Low Pressure index.

The result in the 1990s was that coho that had formerly remained in the Strait of Georgia contributing to fisheries there, migrated south and completely out of the Strait of Georgia entering fisheries on the west coast of Vancouver Island instead. Numbers of coho returning to spawn declined. Although active management started in 1995, the sport fishery in Georgia Strait had already collapsed. Why the coho abandoned the Strait of Georgia, which was unusual compared to previous history, remains unknown, but might be related to availability of preferred food items or even avoidance of a competitor. There was little doubt the behavior change was related to change in climate (Beamish et al. 1999).

These regional and larger ocean patterns need to be fitted into determinations of salmon and steelhead catch patterns regarding periods of abundance and declines. The migration pattern of Puget Sound steelhead is presently unknown judged from the dearth of evidence in the literature. However, the Georgia Strait and west coast of Vancouver Island coho findings may have relevance to Puget Sound steelhead, although from Figures 12, 13, and 14 it is apparent that the most recent low level of Puget Sound steelhead predates 1989.

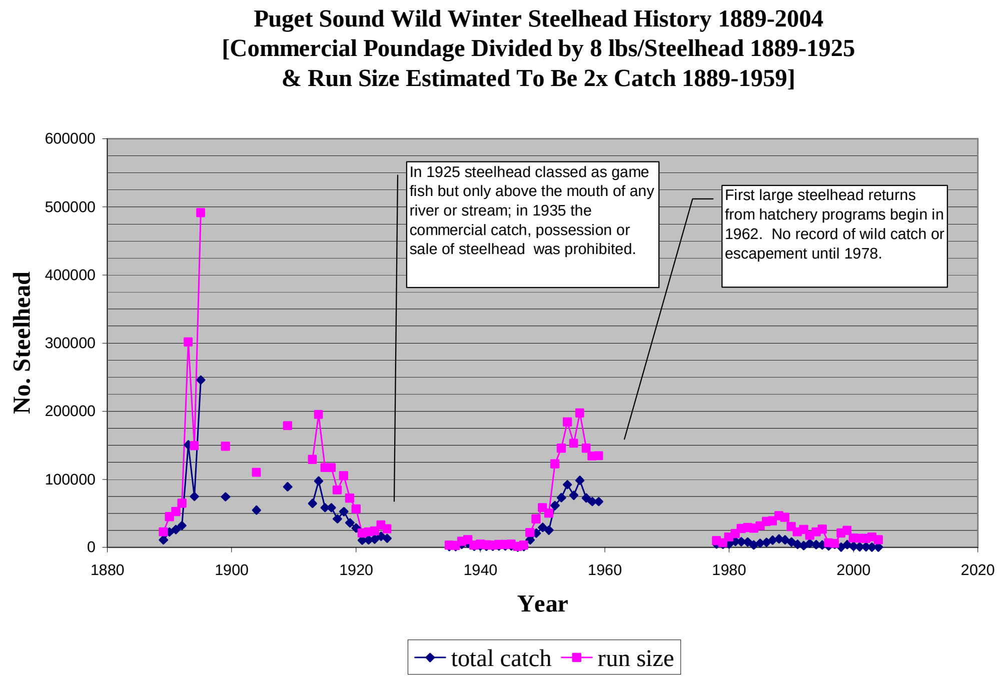
Hare et al. (1999) examined what has been called the "inverse production regimes" of Alaska and West Coast Pacific salmon. From 1977 through the early 1990s, ocean conditions have generally favored Alaska stocks and disfavored West Coast (Washington, Oregon, and California) stocks of United States salmon. What causes changes in marine survival of Pacific salmon at these differing regional levels?

Numerous recent studies indicated fluctuations in climate are the ultimate source. Indices have been developed to measure differing large-scale aspects of Pacific climate. Mantua et al. (1997) labeled the phenomenon of decadal-scale climate regime shifts in the North Pacific (and resulting dramatic shifts in salmon production) as Pacific Decadal Oscillation or PDO. The PDO was described as a pan-Pacific, recurring pattern of ocean-atmosphere variability that alternates between climate regimes every 20-30 years with abrupt reversals. Other indices of climate variability include the El Niño-Southern Oscillation (ENSO) and the winter Aleutian Low (AL) pressure cell (Hare et al. 1999).

Hare et al. (1999) concluded that unfavorable ocean conditions were confounding recent management efforts to increase West Coast Pacific salmon production, and effective recovery of at-risk stocks may await the next reversal of the PDO. They recommended that managers continue to limit harvests, improve hatchery practices, and restore freshwater and estuarine habitats to protect these populations during periods of poor ocean productivity.

Comparison of climate regimes such as provided by the long-term pattern of the PDO shifts to the long-term changes in abundance of Puget Sound wild winter steelhead can help to determine if the steelhead population shifts between high and low levels are primarily related to climate changes or from other factors such as over harvest, loss of habitat, or due to hatchery steelhead introductions. Hare et al. (1999) indicated the PDO index provides the best correlation for salmon to climate comparisons. They provide chinook, coho, chum, pink and sockeye catch histories for their PDO comparisons, but they did not provide a steelhead catch history.

Figure 14.



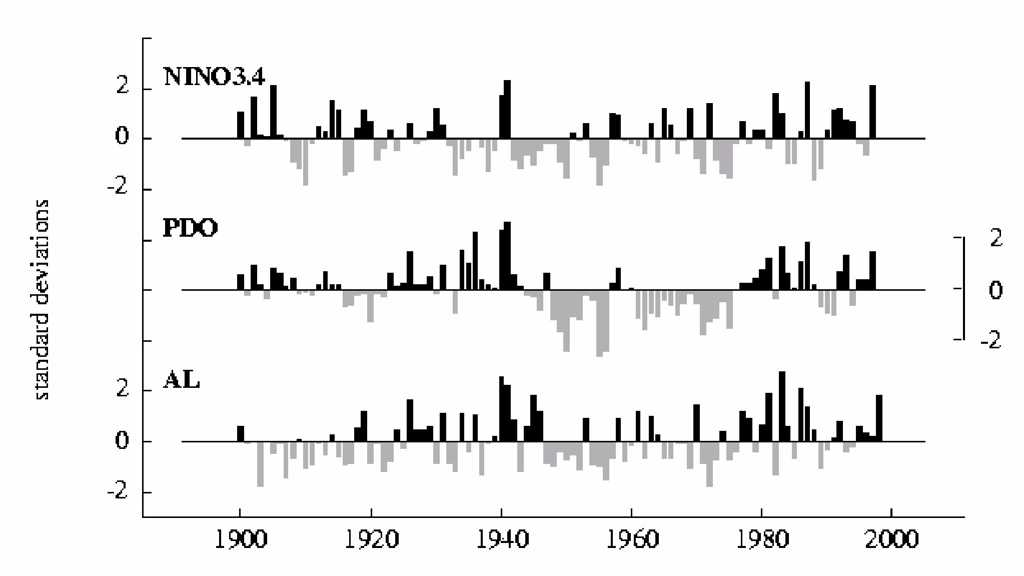


Figure 15. Annual mean NINO3.4, PDO, and Dec. - Mar. mean AL climate indices. Positive values are shaded in black, negative in gray. For NINO3.4 and the PDO, positive values indicate a positive, or warm, phase of the cycle. For the AL, a positive value indicates an enhanced Aleutian Low, i.e., lower surface pressure. All time series have been standardized with respect to the 1900-1997 period of record. **See text for definition of each index.** [From Hare, S.R., N.J. Mantua, and R.C. Francis. 1999. Inverse Production Regimes: Alaska and West Coast Pacific Salmon. *Fisheries* 24, 1: 6-14.]

The long-term catch data for Puget Sound wild winter steelhead provides the opportunity to compare it with the same PDO index used by Hare et al. (1999) in Figure 15. Comparing Figures 12, 13, and 14 with Figure 15, it would appear there is a correlation between the high steelhead catch period of the early 1950s to early 1960s and the negative PDO phase (cold cycle) in gray from the late 1940s to the late 1950s. The positive PDO phase (warm cycle) in black from the early 1920s to the mid 1940s roughly coincides with the sustained low catch of steelhead from the early 1920s to the late 1940s. The relatively short peak in catch between about 1910 and 1918 roughly coincides with the negative PDO phase (cold cycle) from about 1915 to the early 1920s.

However, the lack of wild steelhead catch and escapement data from1960 to 1978 deny the ability to determine what the patterns of abundance or decline were in that period of time and how they compared to those before and after. It is known that hatchery steelhead sport catch in Washington was high from 1962 to about 1971 (Royal 1972; and WDG 1948-1978) and subsequently dropped State-wide to a lower plateau from 1972-79 (WDG 1948-1978; and WDFW 2006). But these patterns would not necessarily represent what occurred with the wild populations that were potentially adversely impacted by the introductions of hatchery steelhead. As with Hoh River summer and winter wild steelhead histories (Figures 4 and 5), declines in the Puget Sound wild steelhead populations (Figures 12, 13, and 14) follow the first large returns of hatchery steelhead beginning in 1962.

What is apparent from Figures 12, 13, and 14 is that no matter which average weight per steelhead is used to estimate the run size of wild steelhead from the total catch between 1889 and 1925, the historic wild steelhead trend for Puget Sound populations is toward zero. The high catch and run size periods for wild steelhead coinciding with higher PDO cycles are on a trend that is half or less than the peak for the previous cycle.

The Steelhead Density Barrier Limitation

Loyd Royal's (1972) examination of the anadromous trout program of the Washington State Game Department identified a phenomenon he termed as a density barrier which limits the expansion of a steelhead population beyond a certain level of productivity in which an increasing number of hatchery steelhead smolts released does not necessarily result in larger adult returns, but may actually result in a declining smolt to adult return ratio:

"…the total Green River catch does not vary to a major extent from year to year (despite increases in hatchery smolt releases displayed in the report) *which could indicate a density barrier to population expansion that tends to mask all other variables related to survival. If true, this is a most frustrating influence in meeting the demands for increasing the winter steelhead population. Unless the density barrier, if it exists as indicated, can be eliminated all benefits from further expansion and improvement of fish cultural operations will be nullified."*

Royal's (1972) warning has proven prophetic. In 2004, both Washington Trout (2004) and the Wild Steelhead Coalition (Mantua et al. 2004) provided detailed comments to the Lower Skagit River Steelhead Acclimation and Rearing Facility Draft Environmental Impact Statement. In both of those analyses of the Skagit River's hatchery steelhead program, and the long decline and eventual collapse of the Skagit River wild steelhead population, a mutual collaboration between the two investigative groups identified one of the primary limiting factors in both hatchery and wild steelhead productivity in the Skagit basin was WDG's, WDW's, and WDFW's long history of perpetual escalation of hatchery steelhead smolt releases. This has culminated in 500,000-600,000 winter steelhead hatchery smolts annually released into the Skagit basin (plus additional summer steelhead smolt releases) in the latter 1990s and early 2000s. Beginning with the 1999-2000 winter steelhead return, the wild population and hatchery returns both subsequently collapsed and have remained at low levels. An analysis of the hatchery smolt release numbers into the basin and the resulting catches, escapements, and run size estimates related to the corresponding hatchery steelhead smolt release years found a significant relationship in reduced numbers of returning hatchery and wild steelhead for those years with higher hatchery release numbers as shown in Figure 16.

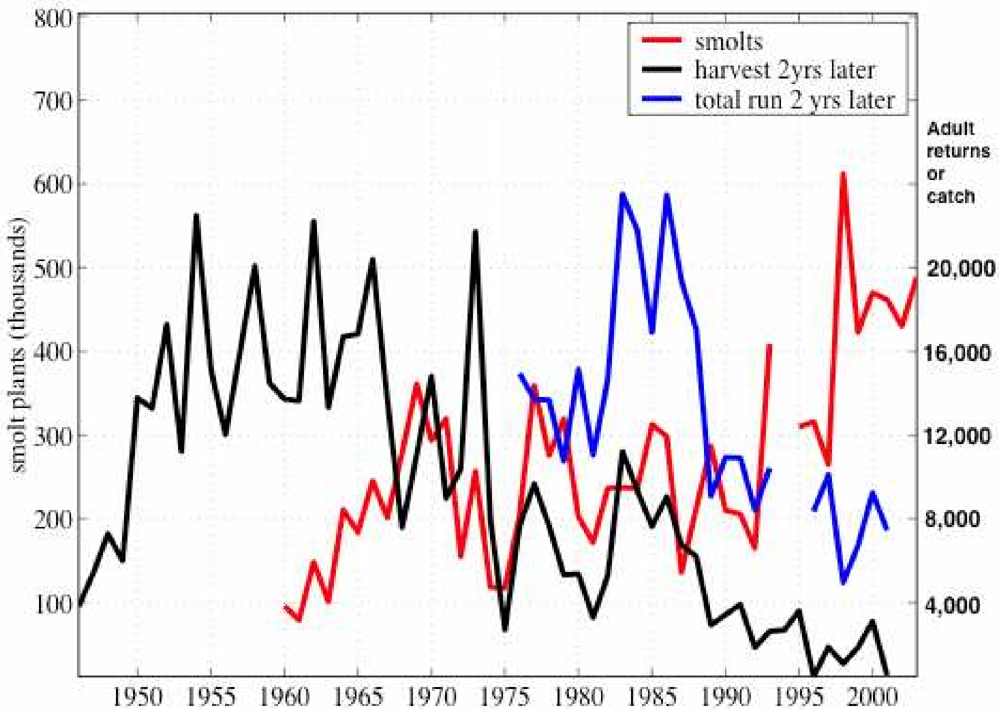


Figure 16: Annual smolt plants, annual harvests (wild+hatchery), and total annual steelhead run-size (harvest+escapement) for the Skagit Basin. The harvest and run-size data are shifted 2 years back in time to aid in the direct comparison with annual smolt releases.

Data provided by Bill McMillan and Washington Trout. Plots were created by Nathan Mantua, Ph. D., VP of Science and Education for the Wild Steelhead Coalition.

As is apparent in Figure 16, once hatchery smolt releases began in the Skagit Basin, an inverse relationship has evolved in which the escalating line of smolt releases intersects and crosses the descending line of total steelhead population run sizes. Further analyses resulted in plots created by Nathan Mantua, Ph.D. (University of Washington Department of Atmospheric Sciences and VP of Science and Education for the Wild Steelhead Coalition), and Stephen C. Conroy (Honors degree in Biochemistry and Ph.D. in protein chemistry from University of Aberdeen, Scotland) finding a strong negative association with hatchery steelhead smolt releases from 1976 to 2000 as the release numbers escalated. A similarly strong negative association with the 1976-2000 escalating smolt releases was found for annual total steelhead run sizes (both hatchery and wild combined) and for annual wild steelhead run sizes (escapement plus catch) by both analysts working independently with the Skagit Basin data.

In his earlier analysis, Royal (1972) found an apparent density barrier already occurring in the Green, Skagit, North Fork Stillaguamish, and Skykomish River basins of Puget Sound related to hatchery steelhead smolt releases. For rivers with relative low and non-escalating steelhead hatchery smolt releases, and/or small watershed size, he found little or no evidence of the density barrier occurring (Elwha, Samish, and Lyre rivers).

A steelhead production density barrier may well explain a significant part of the decline in Puget Sound wild steelhead numbers as evidenced in Figures 12, 13, and 14 after the modern hatchery program began with first adult returns in 1962 and escalating hatchery smolt releases thereafter. Such a barrier would diminish the ability of Puget Sound stream basins to effectively produce historic numbers of steelhead until hatchery steelhead numbers are reduced to allow the full productivity of wild steelhead to be expressed. Exactly where that steelhead production barrier occurs in the life histories of steelhead is presently not known, although hatchery smolt residualism (smolts that do not outmigrate and remain in the basin where released to compete with rearing wild steelhead) may be a significant contributor.

This has similarly been found elsewhere. In response to a toxic railroad spill on the Cheakamus River on the southern British Columbia coast in 2005, Bruce R. Ward (2006) provided a paper recommending that British Columbia's Ministry of Environment allow wild steelhead to recover on their own rather than to attempt the risk of attempting to restore Cheakamus steelhead through artificial fish culture:

"(Describing the problems of smolt residualism in the Keogh River on northern Vancouver Island) *A major difference in salmon and steelhead culture after release is the failure of some steelhead smolts to migrate and remain in-river as residents, or 'residuals'… These fish can displace wild parr, consume wild fry, and some even survive the summer and winter to spawn with wild adults…Despite a low-river release, downstream of the Keogh fish fence (blocking upstream migration of these hatchery smolts for several weeks), several thousand of 20,000 to 30,000 hatchery smolts failed to migrate and became resident in summer."*

"The residualism phenomenon has been observed in other Vancouver Island …streams (Quinsam and Little Qualicum rivers), particularly in the spring drought of 2004. Several thousand residuals were observed in these two systems following their release from on-site hatchery rearing facilities. Regional biologists further reported this same behaviour ***in most rivers where hatchery smolts are released … at times swamping the wild parr in numbers, leaving little doubt of substantial density-dependent effects on wild steelhead*** *(and others), particularly when wild recruitment is low."* (Bold type added here for emphasis.)

It can be anticipated that the problem of hatchery steelhead smolt residualism and density-dependent effects on wild steelhead is occurring with Puget Sound steelhead populations and those rivers on the Olympic Peninsula Coast where large numbers of hatchery steelhead smolts are released (in the case of the Keogh River, even releases of "only" 20,000-30,000 smolts created a significant residualism problem).

II. Stillaguamish River

The Stillaguamish River has a drainage area of 684 square miles and has an average annual rainfall of 30"-40" near the coast and more than 100" in the mountain headwaters (Army Corps of Engineers website). It has two major forks, the North Fork and South Fork, and major tributaries include Pilchuck Creek, Deer Creek, Squire Creek, and Canyon Creek. The Stillaguamish System has native populations of both summer and winter run steelhead (SASSI 1994; and SaSSI 2003), but this report will only cover its winter steelhead history.

Wilcox (1898) described the Stillaguamish River as having:

"… quite a run of steelhead which are fished for at its lower end. Silver salmon and humpback are also found, but, on account of low prices at Seattle, are not taken. Chinook and blueback salmon are only represented in the river by an occasional straggler, there being no run of these two species. Fishing is all by set and drift gill nets, worked from the mouth of the river up to Stilvana (Silvana ?) Station, 6 miles. During 1895 twenty citizens of the county followed the steelhead run, taking 180,000 pounds; probably as much more was taken by men from other sections and by ranchers for home use."

Figures 17-21 provide the differing historic views that can be used by steelhead managers from which to determine the status of Stillaguamish River wild winter run steelhead. Figure 17 is the historic perspective currently used by WDFW and the Treaty Tribes (SASI 2003). With this limited historic data (with no tribal catch record of wild steelhead excepting for 1996 and 1998-2003 when catches were zero), the state and tribal fishery managers have indicated a commitment to a priority in the State of Washington toward a Wild Stock Restoration Initiative (WSRI) as described in the 1992 SASSI (1994) with a goal to:

"Maintain and restore healthy wild salmon and steelhead stocks and their habitats in order to support the region's fisheries, economies, and other societal values."

Even in Figure 17, the future of Stillaguamish wild winter steelhead is a trend toward depletion based on an Index Area of the North Fork Stillaguamish upstream of Deer Creek. Despite this trend, in 1992 the SASSI (1994) report declared this stock of steelhead "healthy." The status was finally altered to "depressed" in 2002 (SASI 2003). However, if the managers had used the longer historic catch perspective provided by Figure 18 (even though limited to angler catch), they would have had a better indicator for cause to be concerned in 1992 regarding Stillaguamish River wild winter steelhead.

Figure 17.

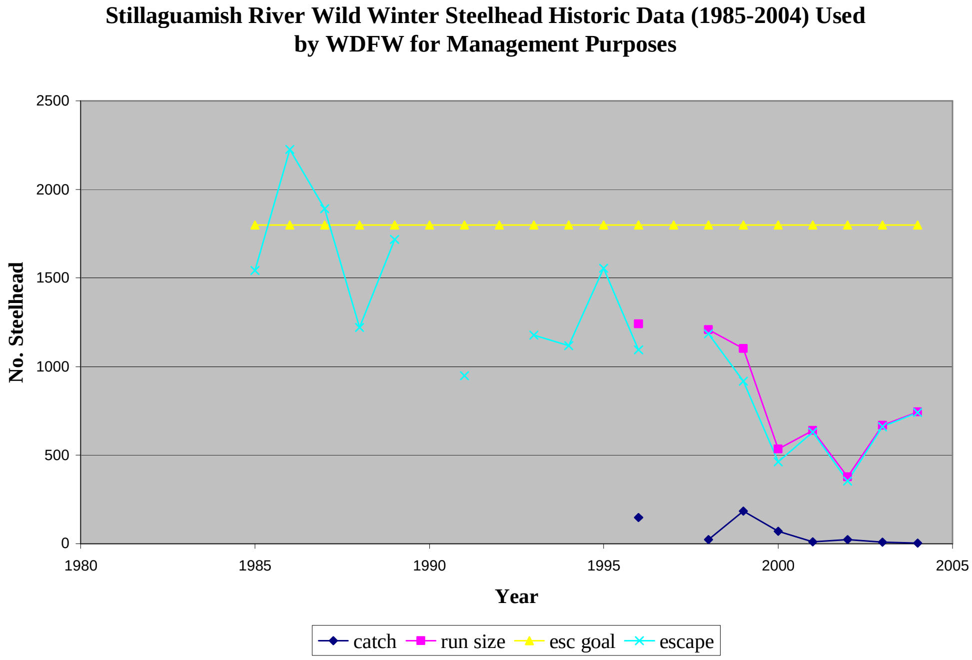
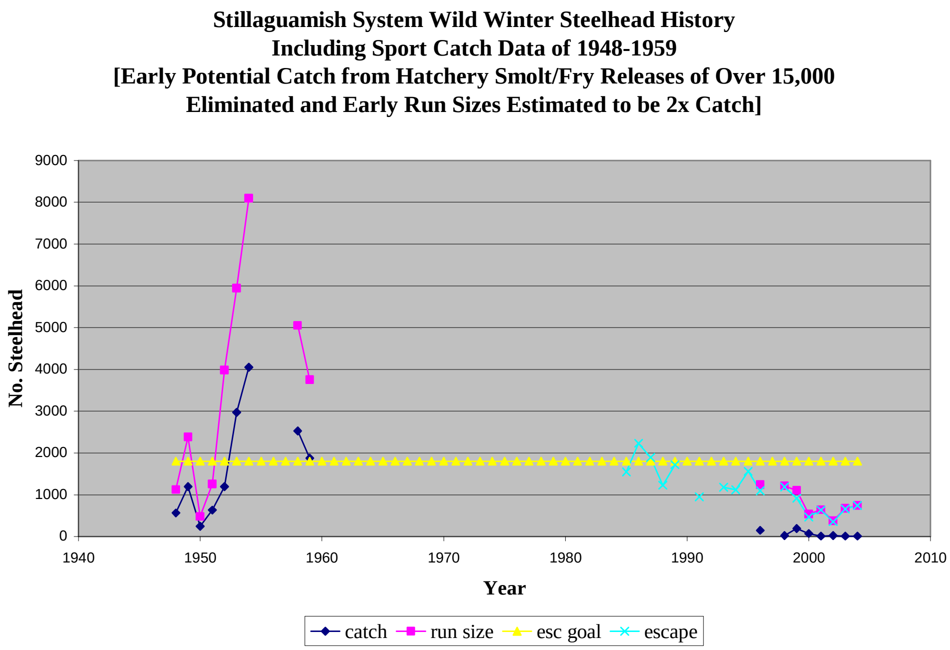


Figure 18.



As Daniel Pauly (1995) had warned, a shifting baseline can conceal the actual magnitude of depletion. In the case of Stillaguamish wild winter steelhead, the magnitude of depletion does not become clear until Figures 19, 20, and 21 which include the commercial catch record of 1895 (Wilcox 1898).

Figure 19.

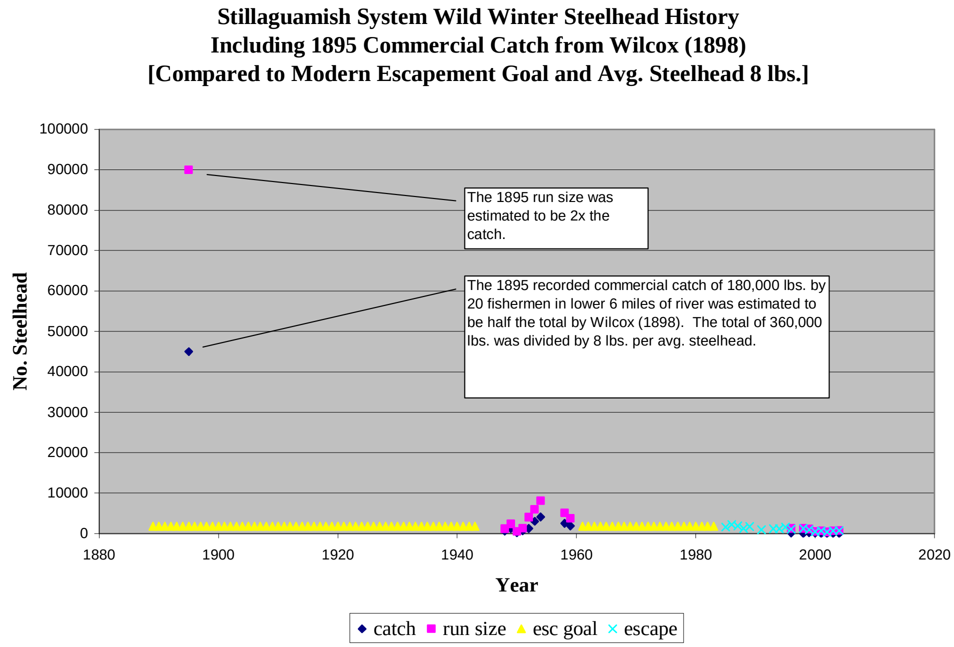
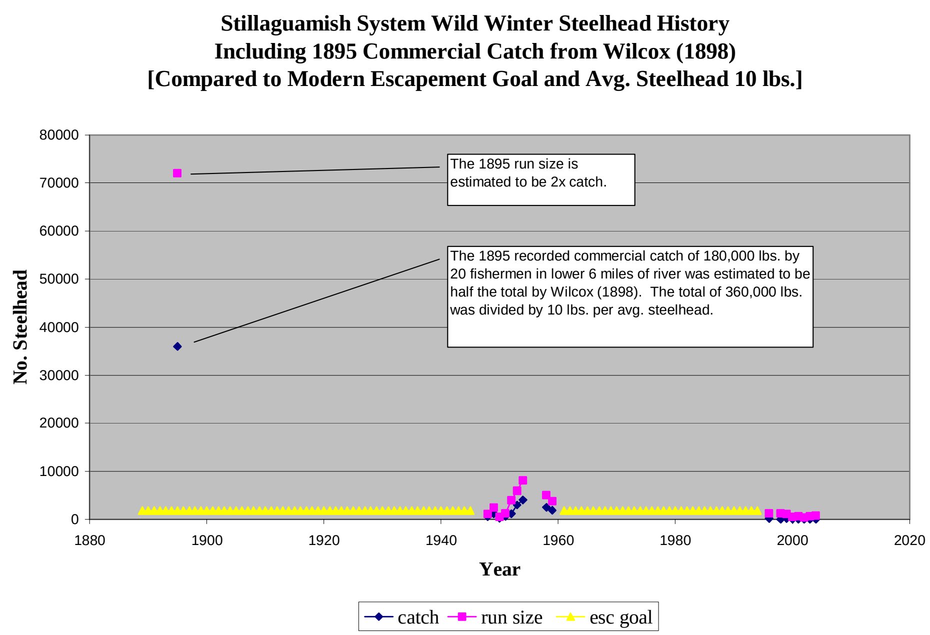
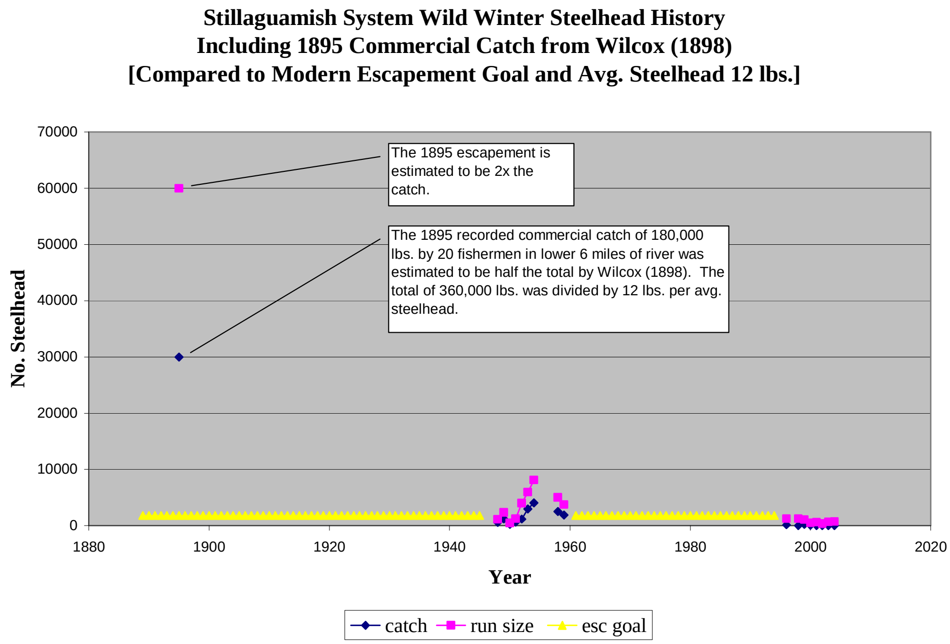


Figure 20.



The commercial poundage caught (360,000 lbs. total) has been divided by an average steelhead weight of 8 pounds in Figure 19 with a resulting catch of 45,000 steelhead; by 10 pounds in Figure 20 with a catch of 36,000 steelhead; and by 12 pounds in Figure 21 with a catch of 30,000 steelhead. If the run size is estimated to be twice that of the catch, 90,000, 72,000, or 60,000 steelhead would have returned to the Stillaguamish River in 1895 depending on the average weight of each steelhead. This compares with a 5-year average run size of only 593 wild winter steelhead (2000-2004) with a sport catch average of 23, a tribal catch average of 0, and an estimated escapement average of 569 steelhead (WDFW 2006). The 2000-2004 average wild winter steelhead run size was 0.6%, 0.8%, or 1.0% (as depicted in Figures 19, 20, and 21 respectively) of that in 1895, and the targeted escapement goal for perpetuation and/or restoration (1,800 wild winter steelhead) is only 2%, 2.5%, or 3% of the 1895 run size.

Figure 21.



This is a far different level of concern from that depicted in Figure 17. Although the worst case escapement of 354 wild winter steelhead in 2002 was only 20% of the 1,800 steelhead escapement goal, it is counterbalanced by an escapement of 1,185 wild winter steelhead just four years previous in 1998 – 66% of the targeted escapement goal. While there is cause for concern, it does not suggest the potential that wild winter steelhead of the Stillaguamish River may be approaching the extinction levels indicated by Figures 19, 20, and 21.

It is clear that computed escapement goals only have value as a useful management tool if they are put into valid historic context.

In February of 2006, a WDFW news release (WDFW website) indicated an early closure of the sport fishery due to a run size predicted to be 36% of the spawning escapement goal of 1,800 wild winter steelhead. With catch and release of wild steelhead required by sportsmen and probably no tribal fishery (as has been the case since 1998), it would be a run size of 648 steelhead, slightly more than the 5-year average with a miniscule increase in percentages of 0.7%, 0.9%, or 1.1% of the 1895 run size if the average steelhead was 8, 10, or 12 pounds respectively.

Yet, in 1992 WDFW (SASSI 1994) rated Stillaguamish winter steelhead as "healthy" and in 2002 (SaSSI 2003) only lowered it to "depressed." One might well wonder what it takes to classify a steelhead population as "threatened" or "endangered" in Washington.

III. Queets River

The Queets River is 51 miles (82km) long and drains 450 sq. miles with an average winter flow of 8,000 cfs. and an average summer flow of 1,015 cfs. Its maximum flow has been as much as 130,400 cfs and its minimum flow down to 368 cfs (Phinney et al. 1975). Its major tributaries include the Clearwater, Sams, and Salmon rivers and Matheny Creek. The majority of the tributary watersheds lie outside ONP and have been extensively logged and roaded, while 28% of the Mainstem is within the park and heads on the south side of Mt. Olympus (McHenry et al. 1996).

Altogether, 34% of the Queets basin is within the ONP (Houston and Contor 1984). The U.S. Forest Service owns 84% of Matheny Creek watershed, 73% of the Sams River watershed, and 30% of the Salmon River watershed and some acreage near the town of Queets at RM 23 (Smith and Caldwell 2001). In the Clearwater sub-basin Washington DNR lands comprise 79% of the ownership and about 20% are privately owned. Quinault Indian Nation lands, of which the Queets Tribe is an affiliate, include the lower eight miles of the Queets River and the estuary and 54% of the Salmon River drainage.

Both winter and summer steelhead are native to the Queets River basin. Two separate spawning stocks of each are thought to occur: wild summer steelhead in the Queets River and Clearwater River and wild winter steelhead in the Queets River and Clearwater River although there is little or no information available to confirm they are genetically distinct stocks (SASSI 1994). However, genetic analysis has since indicated Queets winter steelhead are similar to Chambers Creek hatchery stock (SaSSI 2003).

SUMMER STEELHEAD

The 1992 SASSI (1994) report indicates that native Queets and Clearwater summer steelhead stocks were historically small runs limited by their habitats although little is actually known about where the fish spawn beyond the assumption it is in the upper reaches of both rivers. The run timing of the wild summer run is said to be from May through October and distinct from the run timing of the winter stocks (November through April), although with some overlap in May. The stock status report also indicates that adult pre-spawning summer runs congregate in the upper sections of both the Clearwater and Queets in late summer and fall as determined from sport catch data. The Queets summer steelhead stock is thought to comprise most of the wild summer steelhead in the Queets River basin. The summer steelhead sport catch from the Clearwater River is typically small by comparison (WDFW 2006).

The area near Tshletshy Creek on the upper Queets River has long been known as a summer steelhead destination by sports fishermen in July, August, and September as reported by Frear (1956). Bradner (1950) indicated that in August many summer-runs were caught at the mouth of clear tributaries such as Sam's River. The wild summer steelhead sport catch from the Queets River from 1962 to 1978 (WDG 1962-1986) confirmed the run timing indicated by Frear and Bradner as shown in Figure 22. But the Clearwater River wild summer steelhead sports catch from 1962 to 1978 (WDG 1962-1986) had a run timing skewed toward the fall, September and particularly October

(Figure 23). This supports the possibility that the Clearwater stock is distinct from that in the Queets based on the differing run timings.

Figure 22.

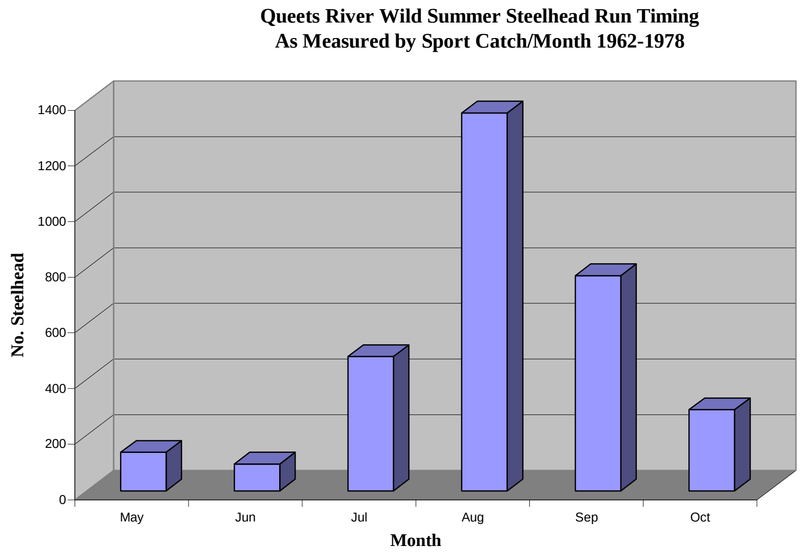
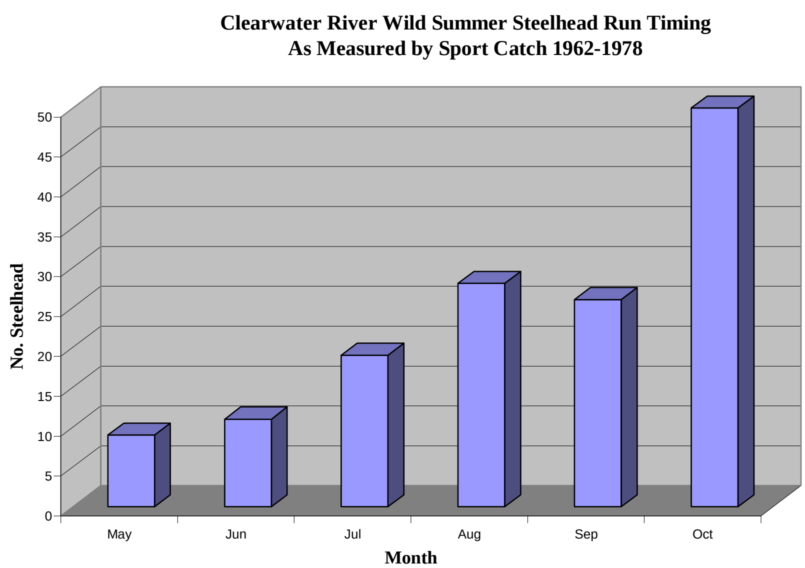
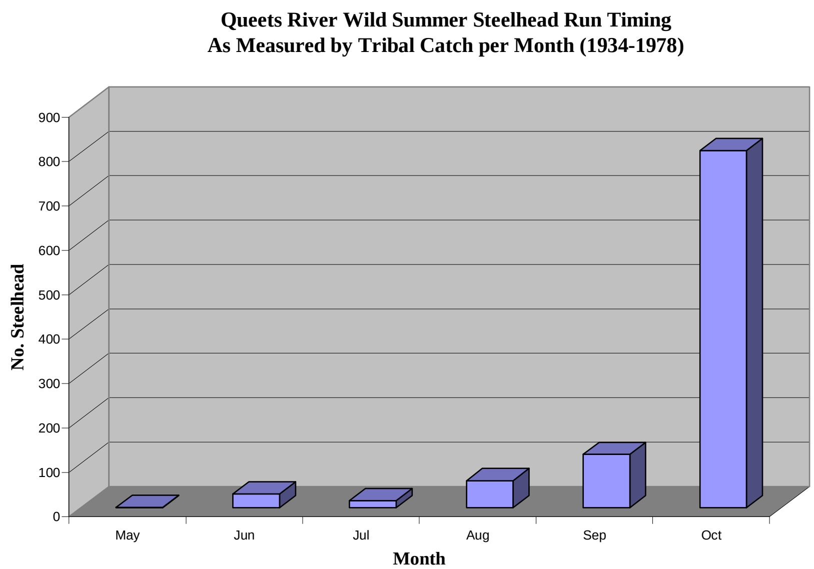


Figure 23.



The tribal catch records from 1934 to 1978 (Taylor 1979) indicate a summer steelhead run timing that is heavily skewed toward October as indicated in Figure 24. This suggests an historic stock whose river entry included a fall run timing similar to that reported from rivers on Russia's Kamchatka Peninsula (Savvaitova et al. 1973) and Alaska (Johnson 1991) as well as a smaller, more typical summer run with a timing of June to September. The Queets tribal catch occurs in the lower mainstem Queets as compared to the Queets mainstem sport catch that occurs primarily in the upper river, especially near Tshletshy Creek. The Clearwater sport catch occurs within the isolation of the Clearwater sub-basin. The Clearwater catch has typically been small compared to the sport catch of the Queets, and nearly non-existent in recent years.

Figure 24.

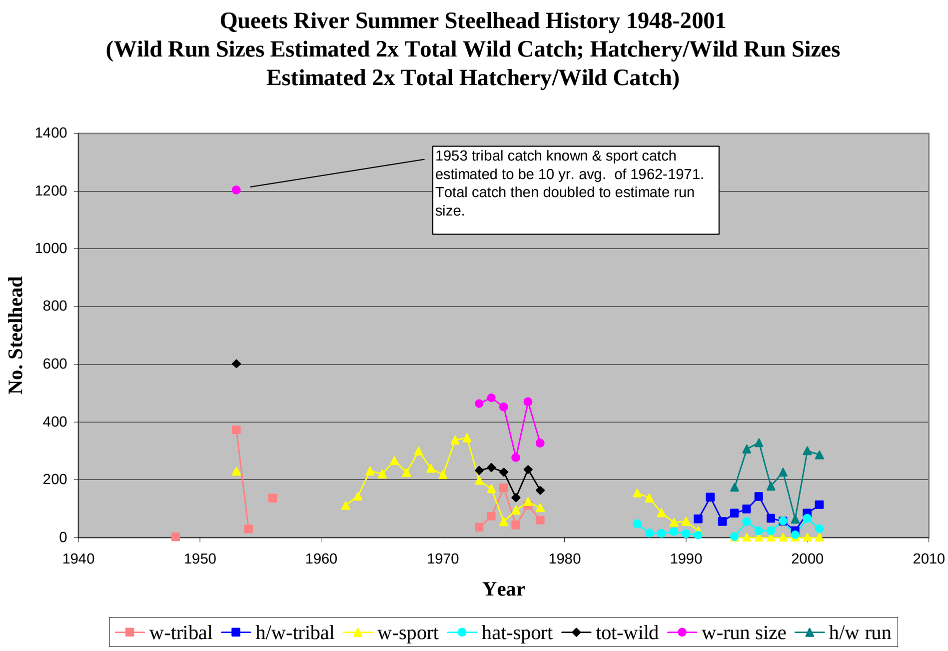


The question arises, does the tribal fishery primarily intercept those wild summer steelhead bound for the Clearwater River? The dominance of the October tribal catch suggests this may be the case. If so, has the tribal catch overharvested the Clearwater stock whose numbers are small and potentially declining toward a zero population level? The high October tribal catch from 1962-1978 was likely due to the historic fishery focus on wild coho with a return time in the Queets System from September through December (SASSI 1994). Since the early1980s the tribal fishery has targeted on hatchery coho that return to the Salmon River of the Queets with an earlier run timing of September to mid-October (SASSI 1994). The tribal coho fisheries of both eras would have included wild summer run steelhead that return in the fall which was clearly evidenced in the summer steelhead catches reported.

Although hatchery summer steelhead smolts are not stocked in the Queets basin, hatchery summer run steelhead from other rivers stray into the Queets River (Houston and Contor 1984; and SASSI 1994). The origin of these fish are likely from the Quileute system where they have been annually released since 1977 (WDFW 2006) with adult returns beginning in 1979. 1979 is when large numbers of straying hatchery summer steelhead began in the Queets basin, as well as in the Hoh and the Quinault as indicated by Houston and Contor (1984).

Queets River historic summer steelhead data are limited to tribal and sport catch records. There have been no spawning escapement estimates and there is no escapement goal (SASSI 1994; SaSI 2003). However, in 1953 the tribal catch was 373 steelhead (Taylor 1979) as depicted in Figure 25. The entire catch was in the month of October that year with apparently no other tribal catch effort that summer. Summer steelhead sport catches were not recorded until 1962, but the 10-year sport catch average from 1962-1971 was 229 summer run steelhead from the Queets River basin. If that sport catch estimate is used to represent the 1953 summer steelhead sport catch, it results in a total catch of 602 wild summer steelhead in 1953. If harvest was 50% of the run size, 1,204 wild summer steelhead returned to the Queets basin in 1953. If the lower harvest range of 30% is used (Myers 2005), 2,007 wild summer steelhead may have returned in 1953. The more conservative run size estimate is depicted in Figure 25, although the higher estimate may more effectively represent what the Queets basin wild summer steelhead populations were prior to the beginning of industrial-scale resource exploitation in the latter part of the 19th century and early 20th century. The Puget Sound and Stillaguamish River steelhead populations in that earlier era were clearly more abundant than in the 1950s. However, there are no earlier summer steelhead data than the 1950s and 1960s for Washington coastal rivers that could be found, and the more conservative 50% harvest figure is sufficient to indicate a great depletion has occurred.

Figure 25.



The run size of wild summer steelhead that returned in 1953 as computed from catch data, suggests the Queets basin populations were larger than the usual connotation of the term "small" used in WDFW stock reports (SASSI 1994; SaSI 2003). However, there has been a profound decline since 1953 as evident from Figure 25, and certainly *small* fits what the present populations likely are.

In 1980, when the author of this report was employed in a fishing tackle store, he had several discussions with a man in his 50s who began fishing with his father and brother at Tshletshy Creek's entry to the upper Queets in the early 1950s. For more than 25 years their family had kept a cache tied off in the trees where they returned to camp regularly each summer after hiking to the site. He described Queets River steelhead as the "glue" that kept he and his brother's families together after their father died, both of them traveling from California to renew their ties to each other and the legacy of the Tshletshy camp. But in the summer of 1979 they made the decision not to return thereafter. The number of fishermen packing into Tshletshy Creek had steadily mounted from the late 1960s onward. He indicated the fishing began to collapse by the early 1970s which he attributed to too many steelhead being harvested by the increased number of anglers focusing on the Tshletshy Creek destination area for summer run steelhead. That initial collapse in the summer steelhead sport catch is clearly evident in Figure 25.

However, it is the catch data trends from 1985 to 2001 (Figure 25) that are particularly alarming. The wild summer steelhead stocks of the Queets and Clearwater would appear to be approaching population levels near zero. Because sport fishing has been limited to wild steelhead release since 1992, the wild sport catch has understandably reached the zero level. Nevertheless, the sport catch trend from 1985 to1991 was already approaching that level.

Of particular concern is the continuing line of the hatchery component of the sport catch (Figure 25). At several points it intersects the tribal catch which is not broken out into wild and hatchery components. Because the tribal catch includes both hatchery and wild components, and because at several points the level of the tribal catch is often the same as that of the sport catch, it must be assumed that most of the tribal catch is also hatchery steelhead. It has been noted that since 1979 summer steelhead catches on the Queets, Quinault, and Hoh rivers have been dominated by hatchery fish straying from unknown sources (Houston and Contor 1984). Furthermore, the combined hatchery/wild run sizes from 1994 to 2001 (average run size of 233 fish) are little over half of what the wild run sizes were without hatchery steelhead from 1973 to 1978 (average run size of 412 fish), and the 1973-1978 wild run sizes averaged only 21%-34% of the range estimated for 1953 (1,204-2,007 fish).

If the tribal catch is an effective sample size of the mixed hatchery and wild summer steelhead populations returning to the Queets basin, it is apparent that only a very small number of wild steelhead are returning. Those that do escape would be further reduced into two populations returning to their individual spawning grounds. This would be of particular concern for the Clearwater River stock which has been identified as the least numerous (SASSI 1994). Although no snorkel surveys have been done to attempt to monitor Queets basin summer steelhead, the ONP is planning to do so in 2006 (per. com. Sam Brenkman of the ONP in 2006). The available data suggest present run sizes of wild summer steelhead returning to the Queets basin are no more than 100 steelhead, Queets and Clearwater populations combined. The Clearwater population may be two dozen or less. The question arises, is the latter already extinct for all practical purposes? Without spawning ground surveys or other mechanisms in place to monitor that possibility, there is presently no way to know.

WINTER STEELHEAD

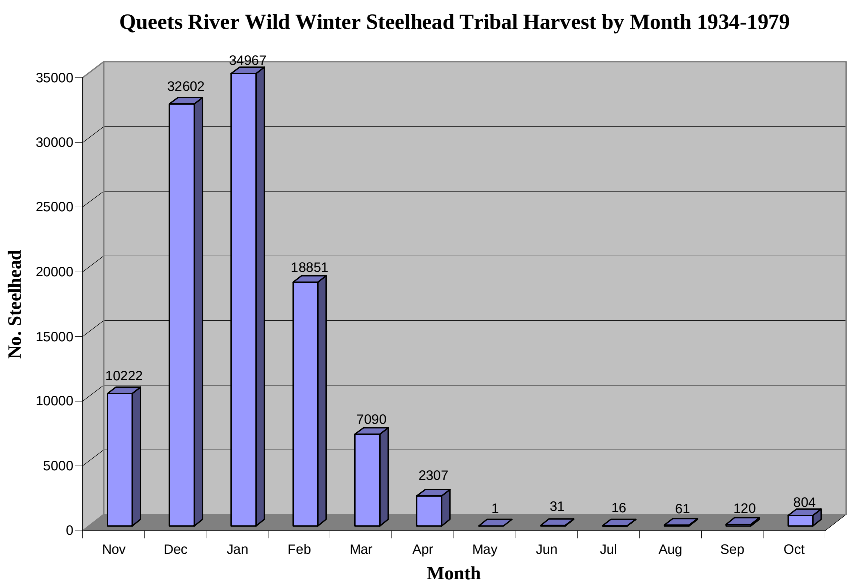
The wild winter run steelhead stocks of the Queets and Clearwater rivers are both considered "healthy" (SASSI 1994; and SaSI 2003). This is despite genetic analysis indicating their similarity to Chambers Creek Hatchery stock (SaSSI 2003).

Hatchery winter steelhead returns began to be recorded in the Queets River catch in 1979 with an upward jump in numbers beginning in 1981 (WDFW 2006). However, a record of actual hatchery smolt releases does not occur until the spring of 1984 (WDFW 2006) with stock origins from the Quinault Nation Lake Quinault Hatchery and the Quinault National Fish Hatchery at Cook Creek (SASSI 1994). About 150,000-200,000 hatchery winter steelhead smolts are planted into the Queets River system annually (SASSI 1994; WDFW 2006), and other hatchery winter steelhead adults stray into the basin (SASSI 1994). It is thought that the high exploitation of the hatchery fish in sport and tribal fisheries and differences in spawn timing between hatchery fish (January and February) and wild fish (February through June) minimize the potential for inbreeding.

Nevertheless, Queets system winter steelhead are genetically similar to Chambers Creek Hatchery stock and those of other rivers of the North Coast of the Olympic Peninsula (SaSSI 2003). Cederholm (1984) did spawning surveys in the Clearwater sub-basin from 1973 to 1980 prior to when significant hatchery returns occurred. He found that wild steelhead spawning began in January in both the mainstem and tributaries with a higher percentage of early spawning in the tributaries. It is apparent that there is significant overlap between hatchery and wild spawning times. Furthermore, the long period of time that male steelhead remain in a system with multiple spawnings (Shapovalov and Taft 1954; Withler 1966) further increases the likelihood of hatchery and wild steelhead spawning interactions (McMillan 2001).

Regarding supposed separation of run timing to provide harvest of hatchery steelhead without impacting wild steelhead, the historic tribal catch data (Taylor 1979) clearly indicate that most wild steelhead had the same early run timing as hatchery winter steelhead as shown in Figure 26. It would appear virtually impossible to heavily harvest hatchery steelhead without similarly harvesting wild steelhead that also peaked in the Queets River and other Olympic Peninsula rivers in December, January, and February.

Figure 26.



From 1905 to at least 1927, a fish cannery was in operation on the Queets River (Cobb 1930). Steelhead were listed as canned in less than half the years from 1912 to 1927 when there was a record of how many cases of each species were packed. As indicated previously, steelhead brought higher prices sold fresh and it was the preferred market. Because of that, most steelhead probably were not canned but sold for the fresh market. Therefore, they may not have always shown up in the commercial catch record. Nevertheless, in 1923, 1,500 cases of steelhead were packed at the Queets cannery (Cobb

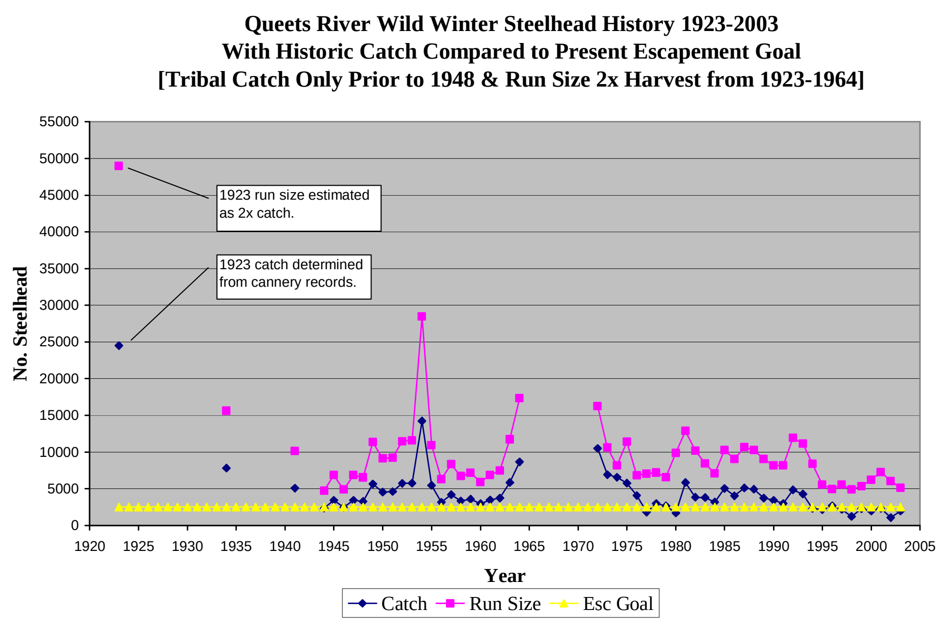
1930) with each case containing 48 one pound cans (72,000 lbs). Myers (2005) indicated that although 50% wastage is figured for chinook during canning, because steelhead are smaller and thinner wastage may have been ~70%. This would mean that 240,000 pounds of steelhead had been processed by the cannery on the Queets River (the nearby Quinault and Hoh Rivers had their own canneries). The average steelhead in the Queets River tribal catch in 1934 weighed 9.8 pounds (hand written notes in the data sheets from Taylor 1979). The steelhead catch processed at the cannery in 1923 would have been 24,490 steelhead. If harvest was 50% of the run size, the return would have been 48,980 steelhead; if harvest was 30% of the run size, the lower end of the harvest range used by Myers (2005), the Queets River return would have been 81,633 wild winter steelhead that year.

Even these may be conservative figures. As Wilcox (1898) indicated for the Quinault River in 1895:

"…quite a large number of salmon are taken by Indians for their winter supply of food, and a small amount … was sold to buyers…"

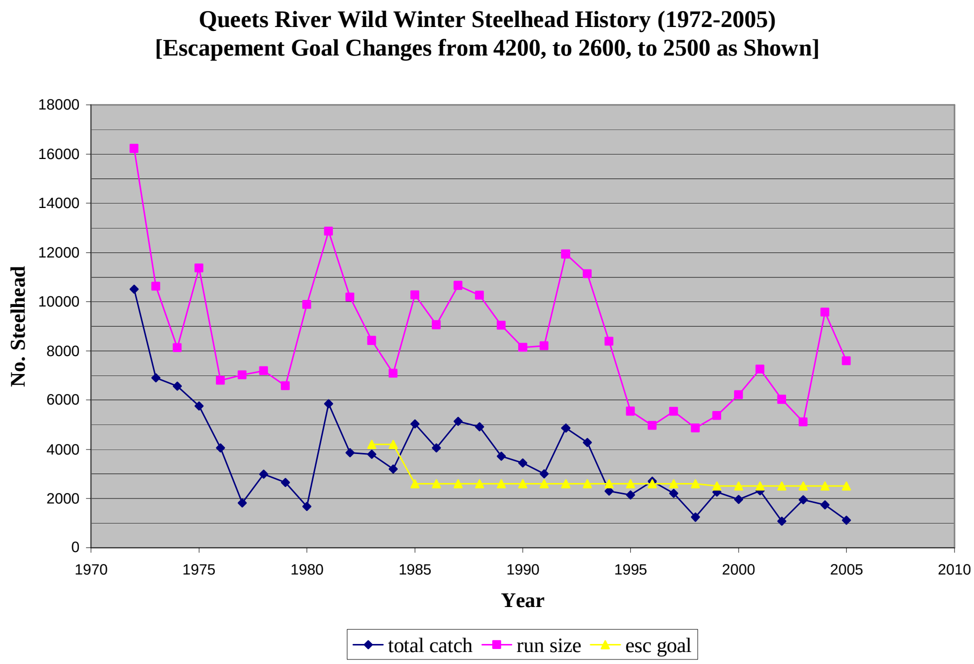
It would be anticipated that a considerable number of steelhead caught on the Queets River in 1923 were used by the Indians for their own winter food supply rather than sold to the cannery. Also, the presence of the cannery on the Queets River meant shipping was available that could have accommodated the sale of steelhead to a more distant fresh fish market. Visiting fish buyers may have commonly exploited tribal fishermen in the same way as occurred with sea otter furs, beaver, and bison. This would not be recorded in the cannery pack.

Figure 27.



As shown in Figure 27, even using the more conservative 50% harvest range, the 1923 Queets River wild winter steelhead catch and run size were much higher than any recorded from 1934 to 2004. However, the steelhead history chosen by Washington's steelhead managers begins in 1972 (SASSI 1994) as shown in Figure 28. The escapement goal was initially set at 4,200 wild winter steelhead in 1984-85 according to the 1992 SASSI report (1994); although two other sources indicate the escapement goal was 2,600 steelhead that same year (Cooper and Johnson 1992; and Johnson 1992). Beginning in 1998/99 the Queets River wild winter steelhead goal was reduced to 2,500 (WDFW 2000). The 1923 run size was an estimated 48,980-81,633 wild winter run steelhead. Today's escapement goal is 3%-5% of that historic run size. Is an escapement goal that is 3%-5% of the historic run size an effective target from which to manage for recovery, or to provide for sustainable fisheries?

Figure 28.



Queets River Salmon

One of the present day limiting factors for wild steelhead is likely the depletion that has occurred in salmon. Juvenile steelhead have been found to be particular benefactors of salmon nutrients through their carcasses and their eggs (Bilby et al. 1998).

The Queets River was once a more productive salmon river than present. The runs included an apparently robust sockeye population as found in cannery records (Cobb 1930). They would have been a river spawning life history with no lake system having been in the Queets drainage for thousands of years. However, a large glacial lake was once present in the Queets Valley (Thackray 1996) and the historically large riverine population of sockeye may be a biological artifact dating to that ancient lake. Today sockeye in the Queets River are not even considered in the WDFW stock assessment reports (SASSI 1994; and SaSSI 2003). For management purposes they apparently no longer exist. Smith and Caldwell (2001) indicate they are "healthy" but paradoxically indicate they are in low numbers. Houston and Contor (1984) indicate Queets River sockeye were fewer than 100 fish per year by 1974 to 1981.

The Queets cannery records from 1912 to 1927 provided the number of cases packed by species each year (Cobb 1930). Each case contained 48 one pound cans. Using the criteria indicated by Myers (2005; and per. com. 2005), cannery wastage was estimated as 50% for large salmon such as chinook, and 70% for smaller salmon such as steelhead, and harvest was estimated to be 30%-50% of the run size. Average weight per species for chinook, sockeye, and coho is from Wilcox (1895) as found for Puget Sound salmon. Average chum salmon size is from Wydoski and Whitney (1979). The species, year of high catch, number of cases, total pounds of catch processed, average weight per salmon, number of salmon harvested, and computed run size ranges are provided below:

Species	Year	Cases	Total Lbs.	Avg. Wt.	Harvest	Run Size
Chinook	1925	1,745	167,520	20 lbs	8,376	16,752-27,920
Sockeye	1915	1,512	241,920	7 lbs	34,560	69,120-115,200
Coho	1912	2,500	400,000	8 lbs	50,000	100,000-166,667
Chum	1914	1,020	163,200	9.5 lbs	17,158	34,316-57,193
Pink	no record of a catch					

For comparisons, today's numbers are:

Species	Est. Run Size
Chinook, sp/su	~500-1,000
Chinook, fall	~5,000
Sockeye	<100
Coho	2,500-9,000
Chum	<200
Pink	<100

It's apparent that the Queets River salmon driven ecosystem virtually no longer exists. This compares to the experience of salmon abundance by Private Harry Fisher in September of 1890. When separated from a U.S. Army survey party, lost and wandering along the Queets, he was at first concerned he may starve to death but soon found he could chase down and spear all his needs. Bruce Brown (1982) quoted Fisher's journal:

"Eagles and ravens were quite numerous today, and the dog salmon running lively."

This is the same Queets River where tribal biologists insist today that what few chum (dog) salmon return are merely strays from the Quinault River or Gray's Harbor (SaSSI 2003). They no longer number more than 200. In 1914 there was a return of 35,000-57,000 as computed from the cannery record that year (Cobb 1930). Fisher recorded in his journal the next day:

"I might as well have selected a camp in Barnum's Menagerie so far as sleep was concerned. Located near a shoal in the stream, great salmon threshed the water all night long, in their effort to ascend the stream. Wild animals …snapped the bushes in all directions, traveling up and down in search of fish."

Brown (1982) describes the rarity of the river spawning sockeye salmon of the Queets when he accompanied a tribal biologist on a two day spawning survey. He was elated when he saw one in Paradise Creek, one lone sockeye. In 1915 there was a cannery pack of over 1,500 cases of sockeye indicating a run size of 69,000-115,000.

Today what wild coho salmon may exist in the Queets and Clearwater are thought to be a composite that have may have spawned with multiple stocks of hatchery coho introduced into the Queets basin. The harvest reliance is on a hatchery stock returning to the Salmon River with run sizes of 10,000-12,000 per year (SASSI 1994). In 1912, 2,500 cases of coho were packed at the cannery (Cobb 1930), a run size of 100,000-166,667.

Today Clearwater River spring/summer chinook are considered "critical" with 1-5 dozen escaping to spawn (SaSSI 2003). The only Queets River wild salmon run remaining that may actually be sustaining itself with some hope of a longer term future are fall chinook now numbering maybe ~5,000 (interpreting escapement into run sizes from SaSSI 2003) as compared to a total chinook run size in 1925 of 17,000-28,000 as computed from the cannery record (Cobb 1930).

This is a river with 34% of its drainage in national park land. Most of the rest is Olympic National Forest, Washington Department of Natural Resources, and Quinault Indian Nation land – virtually all managed for industrial level resource extraction except for the ONP.

Queets River Basin Habitat

McHenry et al. (1996) indicate that although logging on the western Olympic Peninsula dates to the late 1800s, the liquidation of the majority of the old-growth forests was surprisingly recent and rapid. During the 1960s and 1970s Washington Department of Natural Resources (DNR) initiated an aggressive logging campaign designed to rapidly convert the ancient forests to tree farms in the Clearwater basin. To access resources miles of substandard logging roads were constructed. In the spring of 1971, two massive landslides from the newly constructed logging roads devastated Stequaleho Creek in the upper Clearwater basin.

Smith and Caldwell (2001) indicate the impacts of timber harvest and road building on the rate of landslides and the effects of road sediments on instream sediment conditions have been well studied in the Clearwater Basin. Cederholm et al. (1981) found significant amounts of fine sediments had accumulated in spawning gravels in the sub-basins with high road densities resulting in a rapid decrease in salmonid egg survival. Debris torrent events caused by road failure in a tributary of the Snahapish River basin in 1979 had an extreme impact on the cutthroat trout population followed by only a partial recovery at half their pre-torrent numbers (Scarlett and Cederholm 1996). In the Matheny Creek sub-basin there are a large number of in-channel disturbances from timber management-related mass wasting events triggered by clear-cuts or roads (U.S. Forest Service 1995). Similar descriptions of habitat damage are listed in the Salmon and Sams River sub-basins (Smith and Caldwell 2001).

It is apparent that much of the Queets River basin outside the ONP has been severely degraded by logging and related road construction. This, combined with harvest targeted on early return steelhead in a mixed stock fishery composed of both hatchery and wild steelhead that return at the same time, and further compounded by hatchery/wild interactions resulting from overlapping spawning time periods, have all been contributors to diminishing run sizes that have averaged 6,188 wild winter steelhead from 1995 to 2005, only 7.6%-12.6% of the historic 1923 run size. Additionally, 1923 was during a PDO index warm cycle. PDO warm cycles have been found to be relatively unproductive for salmon in the North Pacific (Hare et al. 1999).

Overharvest and habitat degradation can work in unison to thwart recovery. It has been indicated that populations harvested for high sustained yields may take longer to recover from environmental disturbances (Beddington and May 1977; and Cederholm et al. 1981).

As long as the Queets River escapement goal remains at 2,500 wild winter steelhead, 3%-5% of the historic run size, there is no incentive to solve the factors presently limiting the ability to achieve wild steelhead recovery in the Queets River. The escapement goal is set so low, and the time frame chosen for representation of wild steelhead history so limited (as portrayed in Figure 28), that it gives the general impression of relative wild steelhead health rather than severe depletion as exposed by the longer time scale in Figure 27.

What possible motivation is there to set adequate habitat protective measures, or to invest in habitat acquisition for restoration, or set tight limitations on hatchery production, when it appears that Queets River wild steelhead are meeting, or nearly meeting, their determined escapement goals? This is a management scenario to wild steelhead extinction in what may be one of the last best remaining salmon and steelhead habitat areas in the Lower 48 States with 34% of the basin pristine within the boundaries of a national park and no urban or agricultural lands anywhere near the Queets River watershed. If managers cannot achieve steelhead recovery here, they can not achieve it anywhere in the Lower 48.

IV. Quileute River

The Quileute River basin is 70.5 miles (113.km) long with a drainage area of 629 sq. miles. The average winter flow is 12,090 cfs with an average summer flow of 1,000 cfs. The maximum recorded flow has been 101,800 cfs with a minimum of 271 cfs (Phinney et al. 1975). The Quileute system is comprised of four main forks, the Dickey (86 sq. miles), Sol Duc (219 sq. miles), Bogachiel (111 sq. miles), and Calawah (129 sq. miles) rivers. Overall, 30% of the Quileute basin is within the ONP including 32% of the Sol Duc basin, 29% of the Bogachiel basin, 20% of the Calawah basin, and none of the Dickey basin (Houston and Contor 1984).

The Bogachiel and Sol Duc head near Bogachiel Peak and Seven Lakes Basin respectively. The Dickey River heads from lower coastal hills and Dickey Lake. The Calawah River splits into the North Fork, South Fork, and Sitkum River whose basins are contained between the Bogachiel and Sol Duc rivers.

The Quileute system has three wild summer steelhead stocks (Sol Duc, Bogachiel, and Calawah) and four wild winter steelhead stocks (Quileute/Bogachiel, Sol Duc, Dickey, and Calawah) that are considered distinct and native as identified in the 1992 SASSI (1994) although all four winter stocks have been found to be genetically similar (SaSSI 2003).

SUMMER STEELHEAD

Run timing of the summer steelhead stocks is thought to be May through October. They are described as historically small runs of fish limited by their habitats (SASSI 1994). However, as elsewhere on the Olympic Peninsula, summer steelhead spawning escapement is not monitored and no escapement goal has been identified. It is apparent that little is actually known about what the limitations of their habitat might be. The stock status is also unknown. About 40,000 hatchery summer steelhead smolts are described as being stocked in the Quileute River system annually (SASSI 1994) beginning in 1977 (WDG 1948-1978). However, the actual smolt release data indicate numbers typically range 40,000-60,000 (WDFW 2006). The level of interactions between hatchery and wild fish on the spawning grounds is described as unknown. Among the limiting factors listed is freshwater habitat degraded by forest management activities. The latter would be particularly prevalent in the North Fork Calawah River and the Sitkum River that are outside the protection of the ONP.

Figure 29.

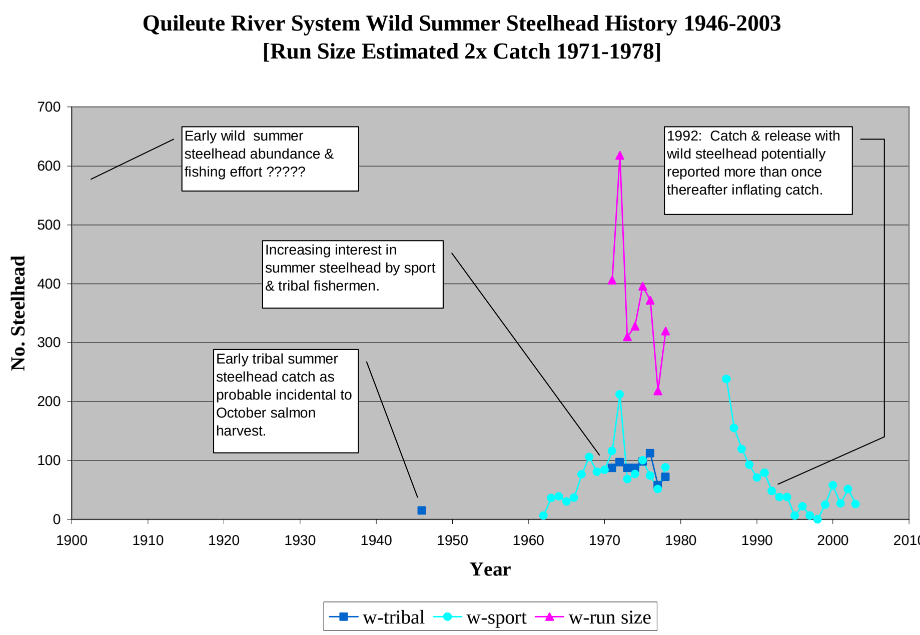
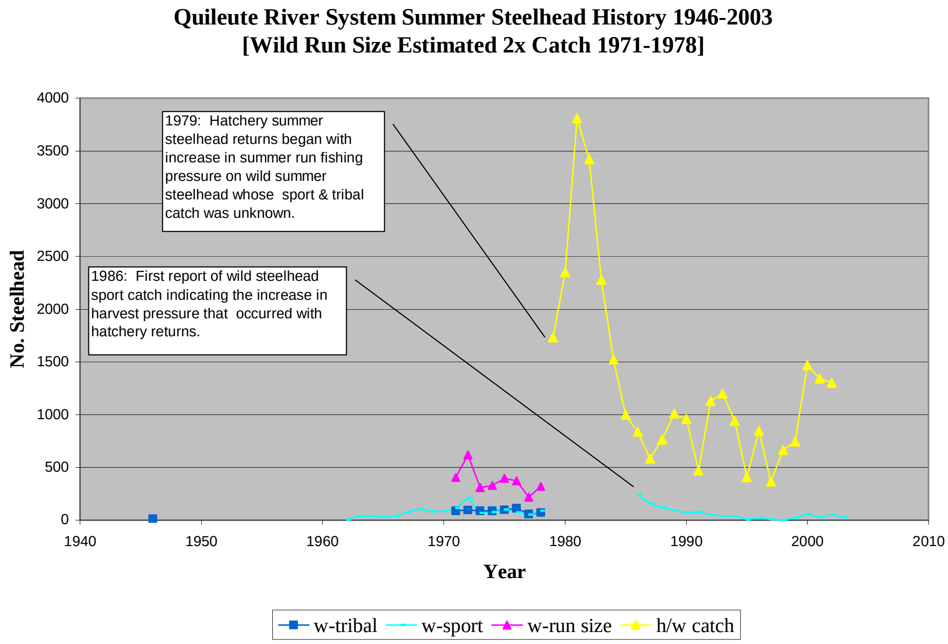


Figure 29 displays the catch/run size trends for Quileute wild summer steelhead from 1946 to 2003 with data from the available sport and tribal fishery records (WDG 1948-1978; Taylor 1979; and WDFW 2006). Figure 30 displays the difference in summer steelhead harvest scale once hatchery summer steelhead were introduced to the Quileute system with smolt releases in 1977 (WDG 1948-1978) and the first adult returns in 1979 (WDFW 2006). Notations have been added to both figures from which to better draw conclusions from the data.

Regarding time scale, wild steelhead information for the Quileute system is primarily limited to 1962 onward when sport catch for summer run steelhead was initially recorded on punchcards in Washington (Royal 1972). The lone data point prior to that is the tribal catch of 15 summer run steelhead in October likely incidental to a more primary target of salmon. Chinook, sockeye, coho, pink, and chum salmon were all included in the records from Mora cannery on the Quileute River from 1912 to 1915 (Cobb 1930) and the summer through fall run timing of summer steelhead would have coincided with the migrations of all five salmon species that once returned to the Quileute system.

Figure 30.



Specific fishing interest in summer steelhead, as measured by both sport and tribal catch, began to increase in the Quileute system from the mid 1960s through the mid 1970s (Figure 29). The combined sport and tribal catch of 618 wild summer steelhead in 1972 provides the best indicator of what earlier historic run sizes may have been. If catch was 50%, the run size was 1,230 fish; if catch was 30%, the run size was 2,060 fish using the harvest to run size range used by Myers (2005). This is undoubtedly a low historic estimate. Summer steelhead catches in the 1950s from the Hoh and the Queets indicate summer steelhead were even more abundant in that earlier era, and the pattern of wild steelhead run sizes going back to the early 20th century or late 19th century, when available, indicate that steelhead were much more abundant in Washington at that time than in the 1950s.

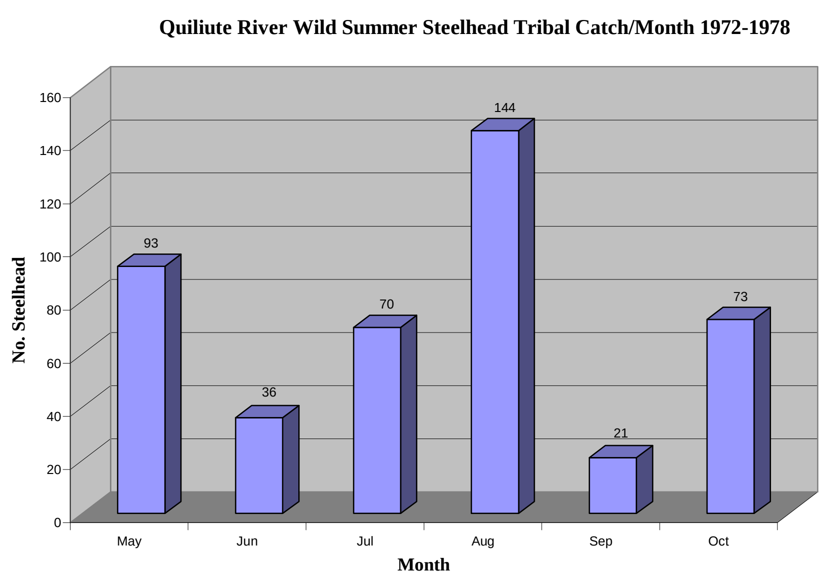
It is apparent that summer steelhead catch effort dramatically increased from 1979 onward in the Quileute system when the introduced Skamania stock of hatchery summer runs began to return (Figure 30). However, because the wild component of the catch was not broken out of the total sport catch on punchcards until 1986, what the impact of that increased catch effort may have had on the wild summer steelhead populations destined for the Sol Duc, Bogachiel, and Calawah sub-basins can only be suggested by the relatively high level of the sport catch in 1986 which was on the long slope of a decline thereafter. No surveys have ever been made to document wild summer steelhead escapement to the spawning grounds (SASSI 1994), and there is no tribal record beyond the combined hatchery/wild catch that is included in the total hatchery/wild catch along with the hatchery/wild sport catch in Figure 30.

From 1992 onward, sport fishermen in Washington were required to release wild summer run steelhead. Released wild steelhead were recorded on punchcards until that policy was discontinued after 2003. Some wild steelhead released by sport fishermen were probably caught and recorded more than once. This would have resulted in a somewhat inflated sport catch of wild summer steelhead from 1992 onward as recorded on punchcards. The recorded sport catch releases of wild summer steelhead ranged from a low of zero in 1998 to a high of 58 in 2000 (WDFW 2006). If that catch indicator was inflated, it raises grave concerns regarding what the wild Quileute system summer steelhead status may actually be:

- Do enough wild summer steelhead return to each of the three or more spawning destinations represented by the Sol Duc, Calawah, and Bogachiel sub-basins to sustain future returns?
- If and when the few wild summer steelhead reach their spawning destinations, will hatchery origin steelhead occupy their spawning grounds in greater numbers as is suggested by the total hatchery/wild catch?

Figure 31 provides the Quileute River wild summer run steelhead run timing as recorded in the Quileute tribal catch from 1972 to 1978 (Taylor 1979), and Figure 32 provides the wild summer run steelhead run timing for each of the destination sub-basins, the Bogachiel, Calawah, and Sol Duc, as measured by sport catch per month during a five year period of relatively high catches between 1968 and 1972.

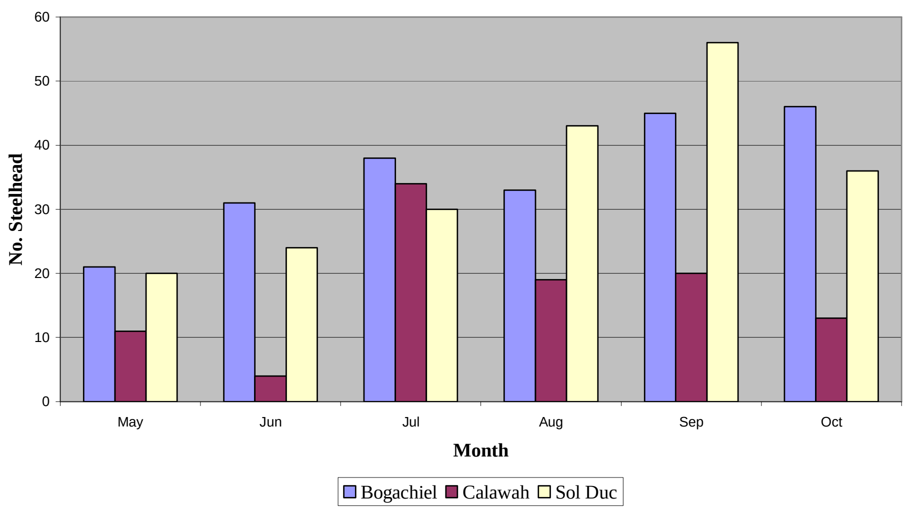
Figure 31.



The tribal catch would have occurred in the Quileute downstream of the entries of the summer steelhead sub-basin destinations. The higher proportion of the tribal catch in May (Figure 31) might include late entry winter steelhead combined with spawned out kelts on their ocean return. Otherwise, the pattern of the tribal catch in the lower Quileute system indicates a gradually building entry toward an August peak that diminishes in September followed by a late secondary peak in October.

Figure 32.

Bogachiel, Calawah, & Sol Duc Wild Summer Steelhead Run Timing
1968-1972
As Measured by Sport Catch/Month



The sport catch in the three sub-basins (Figure 32) reflects similar wild summer steelhead run timing in the Bogachiel and Sol Duc that progressively builds throughout the summer to a late summer and fall peak. But the Calawah wild summer run peaks more suddenly in July with a somewhat lower plateau through late summer and fall. If run timing is indicative of some inherent genetic differences, the Calawah wild summer steelhead population may be distinct from that of the Bogachiel and Sol Duc. This may in part be explained by the high gradient and multiple falls of the Sitkum River which is the dominant return destination for wild Calawah summer runs as explained by John McMillan, salmon ecologist for the Wild Salmon Center's Olympic Peninsula field station, who snorkel surveyed the Calawah/Sitkum sub-basins in September and October of 2002, 2003, and 2004 when maximum summer steelhead numbers would be expected (per. com. John McMillan, 2006). The WSC counts are provided in Table 17.

The Sitkum River is a small sub-basin of very limited habitat. The Sitkum sub-basin is further broken into what may be a number of separate habitat niches created by a series of bedrock falls. The last of these is a total barrier at RM 9.9. The falls at RM 7.2 is particularly significant, but the wild steelhead effectively ascend it, as well as three other waterfalls downstream of it that are all at least seven vertical feet in height (per. com. John McMillan and James Starr of the WSC, 2006). These same falls apparently exclude 98% or more of hatchery summer steelhead creating a natural genetic reserve for wild summer run steelhead.

In the three years of surveys, only one hatchery steelhead has been found upstream of the four major waterfall barriers as recorded in Table 17. That lone hatchery steelhead was part of a wild count of an estimated 70 wild summer steelhead that were otherwise wild, or less than 1.5% of the total entry above the series of selective waterfalls. By contrast, in 2003 a total of nine hatchery steelhead was counted in the lower Sitkum downstream of the series of falls, or 38% of the total 24 steelhead counted in the Sitkum that year.

Table 17. Sitkum & Calawah River snorkel survey results (McMillan and Starr 2006)

Date	Stream	RM of surveys	Steelhead (wild)	Steelhead (hatchery)
Oct 4th wk, 2002	Mainstem Calawah	(entire)	52	213
Oct 4th wk, 2002	S. F. Calawah	(entire below ONP)	25	1
Oct 4th wk, 2002	N.F. Calawah	(entire)	2	0
Sep 12-19, 2002	Sitkum	RM 0.0-7.5	4	0
Oct 3rd wk, 2003	Mainstem Calawah	No survey	--	--
Oct 3rd wk, 2003	S.F. Calawah	(entire below ONP)	2	0
Oct 3rd wk, 2003	N.F. Calawah	(entire)	8	2
Sep 20-23, 2003	Sitkum	RM 0.0-9.9	15	9 (all below falls)
Oct 2nd wk, 2004	Mainstem Calawah	(short index reach)	4	6
Oct 2nd wk, 2004	S.F. Calawah	(short index reach)	0	0
Oct 2nd wk, 2004	N.F. Calawah	(short index reach)	0	0
Sep 29, 2004	Sitkum (lower index)	RM 0.28-0.32	0	0
Sep 29, 2004	Sitkum (mid index)	RM 6.75-6.89	0	0
Sep 29, 2004	Sitkum (upper index)	RM 8.66-8.84	30	1
Sep 29, 2004	Sitkum (outside index areas)		40	0

The Sitkum River may presently be the only wild summer steelhead destination on the west side of the Olympic Peninsula where the population size may be holding its own and where hatchery summer run steelhead have not compromised their ability to do so. Although small numbers of coho also enter the Sitkum, occupying surprisingly steep habitat that can be as much as 18% gradient over short reaches as determined by a few pods of juvenile coho (potentially a unique stock), no coho have been found above the series of higher falls, nor have any cutthroat trout (*Oncorhynchus clarki clarki*) [per. com. John McMillan, 2006]. Deepest penetration upstream is limited entirely to summer steelhead as apparently selected for by the isolation created by waterfalls, and which almost entirely exclude hatchery steelhead entry as well.

Passage into the Sitkum River is also determined by rainfall and related discharge patterns that create or deny entry past the waterfalls. 2002 was the 2nd driest year in Forks, Washington weather records kept since 1935, and 2003 was among the 10 driest years (per. com. John McMillan, 2006). In 2002, the entire lower 10 miles of the North Fork Calawah River went subsurface except for one pool (which held two wild steelhead). Other less extensive areas of the Calawah system also went dry. Snorkel surveys on October 29, 2002 found only four summer steelhead had made entry to the Sitkum (all wild), while 79 wild summer steelhead were found in other parts of the Calawah sub-basin along with 214 hatchery origin summer steelhead (213 in the Mainstem Calawah and one in the South Fork Calawah). By that late date, it was assumed all 214 of the hatchery steelhead would remain dispersed in the Calawah system and would naturally spawn.

Most wild steelhead counted in the mainstem Calawah in late October of 2002 were thought to have made entry to the Sitkum River with the first November freshets, and a few likely went beyond into the uppermost South Fork Calawah (per. com. John McMillan, 2006). The only evidence of wild summer steelhead spawning in the Calawah system as observed in WSC surveys have primarily been in the Sitkum River along with some evidence in the South Fork Calawah in its upper reaches in the ONP (per. com. John McMillan, 2006). The South Fork Calawah upstream of the Sitkum's entry has potentially selective waterfall features, but they are not thought to be as limiting in size or number as those of the Sitkum.

In 2003, only 15 wild summer steelhead made it over the falls into the upper Sitkum while nine hatchery steelhead lingered in the lower Sitkum. Unfortunately, counts in the mainstem Calawah could not be made that year (per. com. John McMillan, 2006), but eight wild summer steelhead and two hatchery summer steelhead were counted in the North Fork Calawah, and two wild summer steelhead were counted in the South Fork Calawah. The wild steelhead found in the North Fork Calawah may have eventually gone to the Sitkum once flows allowed passage with the first late fall freshets.

In contrast to the extreme drought year of 2002 and the slightly less severe drought of 2003, freshets occurred in both July and September of 2004 (per. com. John McMillan, 2006). This apparently provided good passage into the upper Sitkum. Instead of entire river counts in 2004, index reaches were chosen due to time limitations and the risk of high flows suddenly occurring in the fall which can terminate the ability to do long snorkel survey reaches. A total of 30 wild summer steelhead and one hatchery steelhead were counted in the short index reaches for the lower, mid, and upper Sitkum. In order to access those index reaches, other areas of the Sitkum were similarly observed en route with an estimated count of another 40 wild steelhead.

The rest of the Calawah system was also broken up into index reaches. In the short mainstem Calawah index reach, four wild and six hatchery summer steelhead were counted. As in 2002, it indicated that hatchery steelhead outnumbered wild steelhead in the mainstem. Neither wild nor hatchery summer steelhead were found in the other short index reaches.

The snorkel surveys probably did not count all of the summer run steelhead in the Calawah River system in 2002, the lone year an entire system survey was accomplished (excepting the South Fork Calawah in the ONP which is not snorkel surveyed). From the data collected in the WSC snorkel surveys, it is estimated that about 100 wild steelhead may have escaped to reach the Sitkum River in 2002 and 2004 (per. com. John McMillan, 2006). That is a small population in a small, rugged stream reach, but it apparently remains little compromised by hatchery steelhead entry and is sustaining itself.

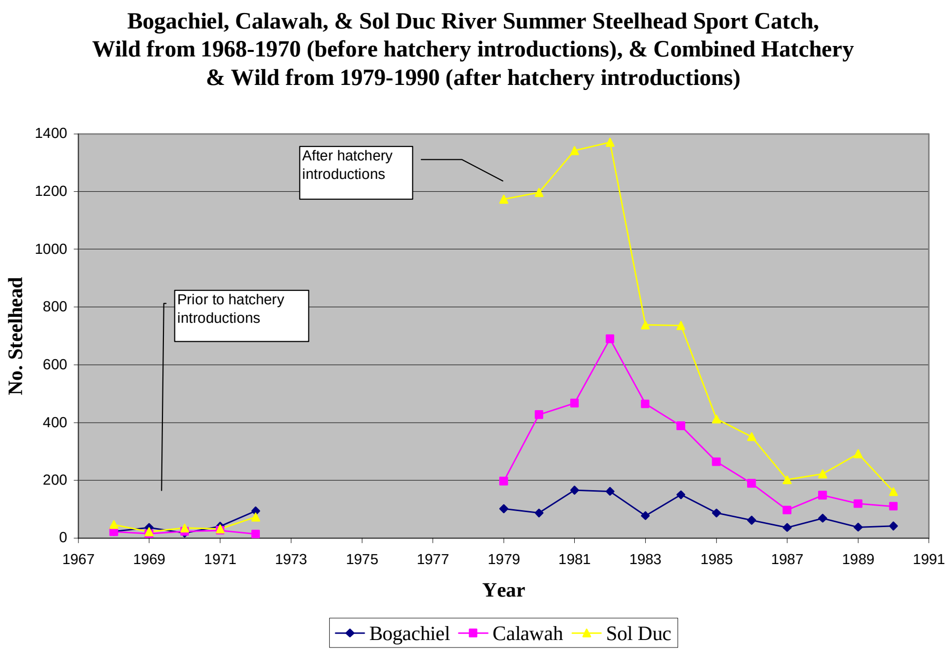
There is a similar instance of water fall barriers virtually eliminating hatchery summer steelhead entry to historic wild summer steelhead habitat on the upper Washougal River, a sub-basin of the Lower Columbia River. Upstream of Dougan Falls, Washougal River snorkel surveys from 1985-1991 found 0%-4% of the summer steelhead annually counted had missing adipose fins that would be indicative of hatchery origin. However, immediately downstream of Dougan Falls the steelhead counts were annually composed of 5%-40% hatchery origin steelhead (McMillan 2001).

Electrophoretic analysis of Washougal River summer run steelhead later supported the snorkel survey findings. No genetic evidence of interbreeding between hatchery and wild steelhead was found to have occurred in samplings upstream of Dougan Falls (Phelps et al. 1994). Although resulting high mortality of hatchery/wild steelhead crosses may result in so few surviving progeny that they may never show up in the samples taken for genetic testing (McMillan 2001), it remains that such crosses have been found to occur in a number of Washington streams (Phelps et al. 1994).

Figure 33 illustrates the magnitude of the problem of hatchery summer steelhead that may escape to spawn in the Sol Duc and Calawah rivers, in particular, since hatchery summer steelhead introductions began in the Quileute system in 1977 (first adult returns in 1979). If the sport catch was representative, the Calawah/Sitkum historically had the smallest of the three Quileute stocks of wild summer steelhead.

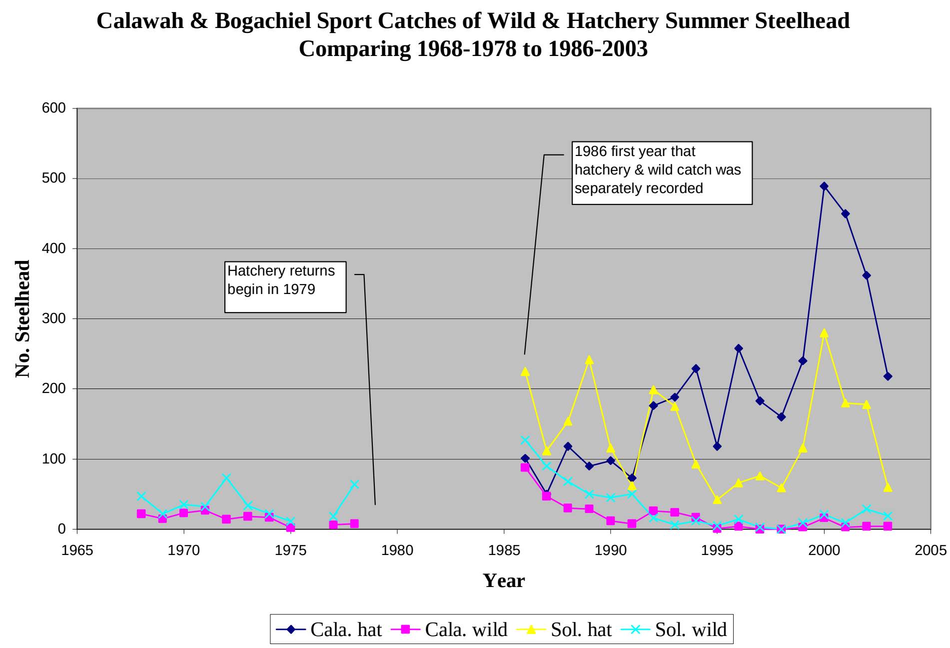
Figure 34 portrays the Calawah and Sol Duc River sport catches of wild steelhead from 1968-1978 (prior to hatchery introductions) and from 1986-2003 when anglers could separately record wild from hatchery steelhead on their punchcards once hatchery steelhead were marked with a missing adipose fin. Particularly high is the catch of hatchery steelhead in the Calawah as compared to the reported wild catch, although the number of Sol Duc hatchery steelhead caught is also high (remembering that from 1992 onward wild summer steelhead had to be released but could be reported on the punchcard). It is apparent from this, that if it were not for the wild summer steelhead isolation in the Sitkum provided by the waterfalls, it could be a particularly threatened wild population, potentially even more so than the Sol Duc population presently is.

Figure 33.



A curious aspect of Figure 34 is the comparatively high number of wild steelhead initially caught in both the Calawah and Sol Duc in 1986 and 1987 after hatchery summer steelhead were adipose clipped. This was after 8 and 9 years of even higher hatchery returns having occurred as shown in Figure 33. It could represent the component of the hatchery catch that may have had a life history of three years at sea (rather than the more typical two years) which would not have been adipose fin-clipped on return in 1986, although that would not explain the sport catch that still remained somewhat high in 1987. It might also mean that in some years hatchery steelhead spawning in the wild had more success at effectively rearing and later returned as "wild" adults with adipose fins. Only genetic analysis at the time would have detected that potential.

Figure 34.



The Sitkum River above the falls represents the lone summer steelhead habitat niche on the west side of the Olympic Peninsula where it is known that virtually no hatchery summer run steelhead are presently entering to compromise their ability to effectively sustain themselves. This is reflected in their larger population size compared to snorkel survey results from other west side Olympic Peninsula summer steelhead habitat areas (Brenkman 2006; McMillan and Starr 2006).

Sam Brenkman (per. com. 2006) indicated that ONP snorkel surveys were extensive in 2005 and wild summer steelhead populations in other areas of the ONP were found to be even lower than those recorded for the South Fork Hoh in Table 12:

"…our observations from 2005 revealed low numbers of adult steelhead from June thru September in several rivers including Bogachiel, N. Fk. Quinault, E. Fk. Quinault, and Sol Duc in reference reaches of Olympic National Park. My crew conducted ~65 surveys in 6 rivers and covered over 350 rkm's last year. We will repeat the sampling effort in 2006."

The magnitude of how low those numbers in the other tributaries of the Quileute system are is revealed by the ONP counts in the Sol Duc and Bogachiel sub-basins.

In 2005 the ONP did ten snorkel surveys of the upper Sol Duc River in an index reach from RM 62.7 to RM 60.0 just upstream of the Salmon Cascades between May 2nd and September 12th (Brenkman 2006). This section was chosen as the presumed destination of Sol Duc wild summer steelhead, which is also the destination for the wild summer run of coho. However, only one summer steelhead was counted, that being on

July 28th. Whether that lone summer steelhead was wild was not determined. Although there was a peak count of 15 steelhead on May 2nd, it consisted entirely of what were thought to be winter steelhead (many of them returning kelts), not summer steelhead. The second highest count was May 31st which was four more outmigrating winter steelhead kelts.

From June 1st to September 15th of 2005, the ONP did ten snorkel surveys of the Bogachiel River from the confluence of Indian Creek to the ONP boundary (about six miles) [Brinkman 2006]. Only one summer run steelhead was counted. It was identified as wild.

The Sitkum wild steelhead population remains small by any self sustaining steelhead population standard, but its counts are comparatively robust to those of the Sol Duc and Bogachiel and compared to other wild summer steelhead populations on the Olympic Peninsula. The Sitkum's fragile future rests not in management mechanisms presently in place, but solely in the natural providence of waterfalls.

Habitat threats in the Sitkum basin include past logging in the Olympic National Forest with remaining deteriorating roads that should be abandoned, culverts removed, and the beds water-barred and revegetated (per. com. John McMillan, 2006). No part of the Sitkum basin is included in the ONP. The basin should be managed for long-term restoration of an old growth forest to maximize protection of the steep walled canyon. The importance of the Sitkum River warrants classification as a bio-reserve with fishery management criteria put into place to permanently insure that hatchery steelhead are not released there and that snorkel surveys continue to annually monitor the escapement levels and any alterations that may occur in the fish numbers, species, and stock origins (hatchery or wild).

The Sitkum River stands out as a key stock of wild steelhead and key habitat area that should be targeted for maximized protection that would of necessity include focused enforcement due to the vulnerability of steelhead in such a small stream during lengthy oversummering.

The present plight of Quileute system wild summer steelhead is out of context with its recorded sport fishing history. Claude Kreider (1948) described the expected fishing for the Sol Duc River in the book *Steelhead*:

"Excellent for both winter and summer steelhead, as well as resident trout through the summer …"

Kreider indicated he collected his information from the Fish and Game Departments, local sources known for reliability, or from his own experience of rivers in the three states whose steelhead fishing he wrote about.

In a fishing guide book to the State of Washington, Frear (1956) listed 34 of the best summer run steelhead streams which included two Quileute tributaries that were likely spawning destinations: the Calawah River was described as best in May and June in the upper river; and the Sitkum River (tributary of the South Fork Calawah) was described as best in August, September and October.

These historic sources indicate wild summer steelhead were abundant enough to sustain sport fisheries that were described by a coast wide steelhead writer as "excellent" in the Quileute system prior to 1948 and well enough known to be included in a list of 34 summer steelhead angling destinations in a 1956 Washington State fishing guide. The 1972 combined sport and tribal catch of 618 steelhead substantiates that a relatively large summer steelhead population once returned to the Quileute system as a whole with a 1972 run size that would have been 1,236-2,060 wild summer steelhead depending on whether harvest was 50% or 30% of the run size. In earlier times they were undoubtedly even higher, but no older historic record could be found than one small tribal catch in 1946 with fishing effort limited to October.

Today wild summer steelhead are a depleted rarity with the limited habitat area of the Sitkum River providing the last stand for wild summer steelhead with a population of no more than 75-100 and the combined Quileute populations elsewhere now no more than 25-50, at best, as suggested by snorkel survey findings.

WINTER STEELHEAD

The Quileute system is considered to have four distinct winter steelhead stocks that return to the Quileute/Bogachiel, Calawah, Dickey, and Sol Duc rivers (SASSI 1994) although all are genetically similar (SaSSI 2003). Although the WDG (1948-1978) records examined did not indicate a hatchery planting history into the Quileute system until 1960, Bahls (2004) indicates that in 1953 and 1956 there were releases of Chambers Creek origin hatchery steelhead into the Sol Duc River sub-basin. However, hatchery steelhead programs prior to development of the Oregon dry pellet diet put into use in 1960 in Washington evidently had limited success and did not significantly contribute to overall statewide returns (Royal 1972).

At the time of the 1992 SASSI report (1994), about 150,000 hatchery winter steelhead smolts were planted in the Quileute River system annually, but since that time the average has been over 200,000 (WDFW 2006). According to WDFW there is little contribution to the wild stock from hatchery fish spawning in the wild. Because of high exploitation rates on the returning hatchery adults of about 80%, healthy spawner escapements, and the difference in spawn timing between hatchery fish (January and February) and the wild fish (mid-February through May), it is also thought the potential for interbreeding is limited (SASSI 1994).

However, in a study of steelhead mating in the Calawah and Sol Duc rivers, wild winter female steelhead were found spawning from January 2nd to July 8th (McMillan 2006 [in prep.]).

Peter Bahls (2004) expressed considerable concern about hatchery steelhead returning to the Quileute system. He recommended an evaluation of the hatchery straying rate into the Sol Duc River from the Bogachiel hatchery facility which may threaten the genetic integrity of the early timed portion of the wild winter run. He also recommended ceasing operation of the Snyder Creek wild brood stock rearing pond facility on the Sol Duc River (operated by Olympic Peninsula Guides Association) due to the lack of significant contribution to the catch (about 2% of the sport catch in 1994-95 and 1995-96), for taking wild spawners off the spawning grounds, and due to unknown genetic risks to the wild population. Bahls (2004) further suggested:

"Evaluate the strategy of 100 percent wild production versus continued hatchery supplementation for long term sustainability and production of winter steelhead in the

Quileute system. The major concerns in the Sol Duc River revolve around the impacts of hatchery production facilities in the Quillayute, in terms of mixed stock fishery in depressing the early timed portion of the wild run and potential genetic impacts from straying of hatchery fish. Restoration of the early timed run to the Sol Duc River along with higher escapements in the basin, may provide more fish for harvest than currently provided with hatchery supplementation and at much lower risk to the survival of the wild populations."

The escapement goal of 5,900 wild winter steelhead for the Quileute River system was set beginning in 1984-85 (SASSI 1994). During the 1978 through 1992 return years, the wild winter steelhead run in the Quileute system has comprised of 14.3% sport harvest, 16.7% tribal harvest, and 69.0% escapement. Overall harvest averaged 31% of the total run size.

As depicted in Figure 35, from 1978 to 2005 wild winter steelhead returning to the Quileute River system have often well exceeded the escapement goal of 5,900 fish, although available catch records of wild winter steelhead between 1948 and 1961 (WDG 1948-1978), indicate overall run sizes were somewhat higher than present during that earlier Quileute era prior to sustained hatchery steelhead returns if catch was assumed to be about 30% of the run size (as is the case in recent history). The sport catch was on an apparent upward progression from 1948 to the mid 1950s, and from 1953 to 1961 exceeded the tribal catch. This may reflect an increase in steelhead sport fishermen that occurred in that period of time. Steelhead sport fishermen in Washington increased 63% from 1954-1961 to 1962-1969 (Royal 1972). The particularly low sport catch in 1948 may reflect the relative lack of sport fishing pressure at that time which could have resulted in a higher escapement and higher subsequent run size than depicted.

Figure 35.

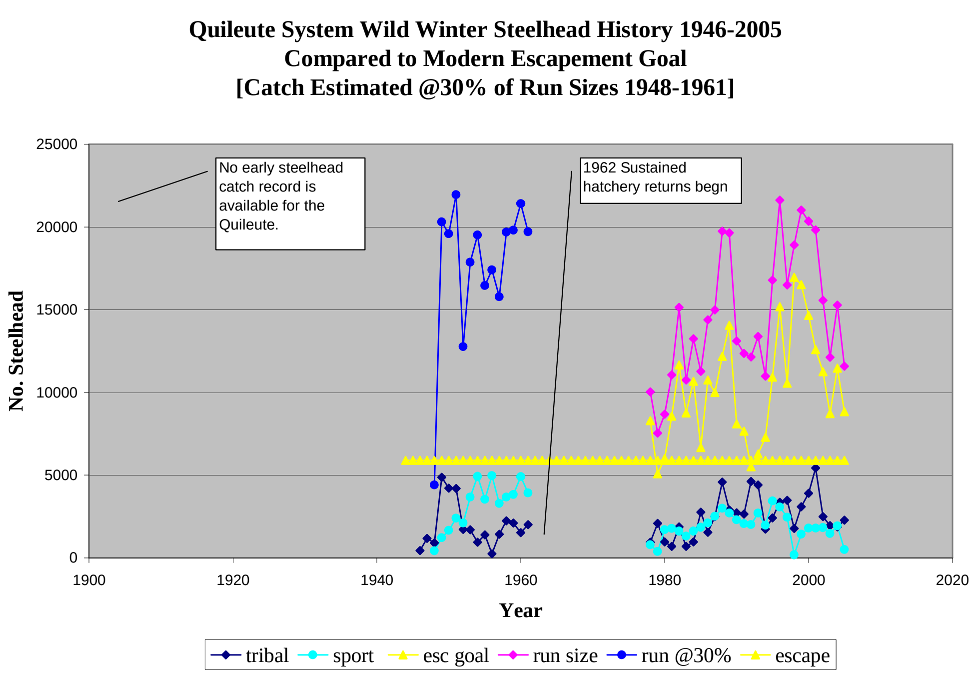
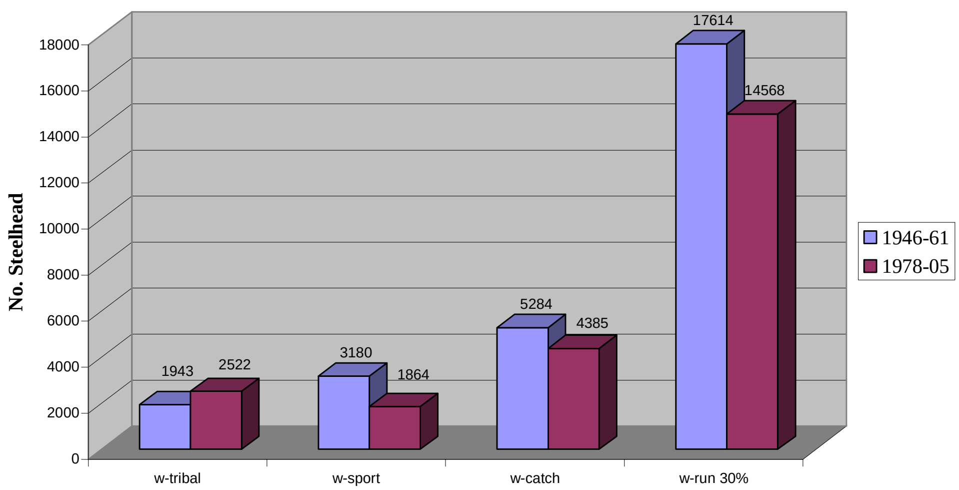


Figure 36 compares Quileute River system wild winter steelhead average catch and run size differences that have occurred between 1946-1961 (prior to sustained hatchery steelhead returns) and 1978-2005 (after sustained hatchery steelhead returns). The average wild tribal catch has increased from 1,943 to 2,522 (30% more); the average wild sport catch has decreased from 3,180 to 1,864 (41% less); the total average catch has decreased from 5,284 to 4,385 (17% less); and the average run size has decreased from 17,614 to 14,568 (17% less).

Figure 36.

Quileute River Wild Winter Steelhead
Comparisons of Average Catch and Run Sizes:
1946-1961 prior to hatchery introductions (catch est. 30% run size);
1978-2005 after hatchery introductions

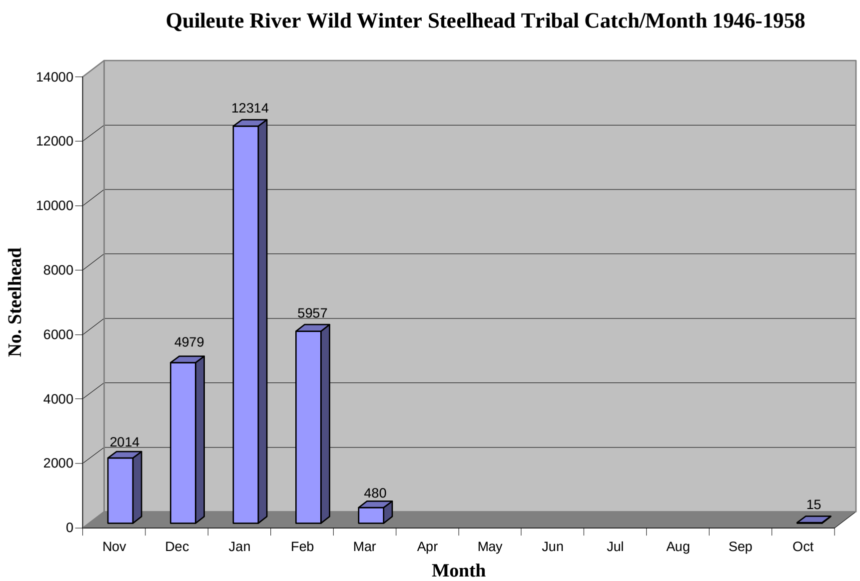


From the available numerical record depicted in Figure 36, Quileute system wild winter steelhead appear to have held their own better than other wild steelhead populations in Washington. The losses that have occurred appear comparatively modest. In this respect, the Quileute system is an anomaly rather than the norm in the state. However, without an historical baseline that documents the beginnings of industrial level commercial fisheries in the Quileute system regarding steelhead harvest, present assessments of the steelhead stocks remain obscured by that lack of historic perspective.

No catch record for steelhead earlier than the tribal catch of 1946 was found for the Quileute River system. As previously indicated, a cannery was in operation at Mora near the mouth of the Dickey River from 1912 through 1917 (Cobb 1930). This meant that shipping was available to potential fresh fish markets which Wilcox (1898) indicated were preferred for steelhead. This could explain their absence in the Mora cannery record. Given the large historic catch of steelhead packed on the Queets River in 1923 (Cobb 1930), and given the declines of virtually all other wild steelhead populations in Washington that have records to the early 20th century (or earlier when available), it is reasonable to assume the Quileute system has also experienced a significant decline in wild winter steelhead since that point in time for which no record now exists.

Of particular concern, there have been measurable alterations that have occurred to the Quileute wild steelhead stocks. The historic run timing of wild steelhead as measured through tribal catch from 1946 to 1958 has dramatically altered as depicted in Figure 37 (data from Taylor 1979). The wild steelhead began entry in November and obviously peaked in January with virtually the same run timing as that described for hatchery steelhead of Chambers Creek stock origin (Crawford 1979; and DeShazo 1985).

Figure 37.



Bahls (2004) indicates: "…a marked hatchery return timing experiment found that 186 of 397 (47 percent) of the wild steelhead that returned from December through April of the 1954-1955 season returned in December and January." The experiment Bahls referred to was on the Sol Duc River and did not include the November catch of the 1954-1955 historic wild winter steelhead return (Figure 37) because the sport fishery did not begin until December while the tribal catch occurred throughout the year. If the November component had been included, it would be safe to assume that at least half the wild winter steelhead returned prior to February in 1954-1955.

Because wild Quileute winter steelhead had the same run timing, and because they were subjected to the same high harvest rates (about 80%) in a mixed stock fishery that targeted hatchery steelhead (SASSI 1994), it might be anticipated there would be a gradual elimination of wild steelhead with similar run timing as that of the hatchery steelhead. Subsequent figures will demonstrate this has indeed occurred (Figures 39, 41, 43, and 45).

The Washington steelhead managers (and tribal managers) well knew the run timing of wild winter run steelhead in the state by at least 1979. A detailed analysis of tribal catch during that period of time was made by WDG when both the tribal and state managers were developing more coordinated harvest plans in the wake of the Boldt Decision. This is evidenced by a report from Bill Taylor (1979) of WDG to John Bishop of National Marine Fisheries Service dated January 30, 1979. All of the historic tribal catch figures provided in this report come from that data. Despite that tribal catch evidence, a mythology continued to perpetuate within WDG, WDW, WDFW, and all of the tribal fishery managers in the Boldt Case area of Washington that protection of wild steelhead was being provided by focusing harvest on the early component of the winter run as is clear from the development of the subsequent salmon and steelhead stock reports (SASSI 1994; and SaSSI 2003).

Furthermore, WDFW (1996) was warned of the consequences of the results of focusing harvest on the early run component of steelhead returning to the Sol Duc River in 1994 in a report to the Washington Wildlife Commission from Brian McLachlan. Nevertheless, the warning was subsequently trivialized by WDFW in the body of the response to the Commissioners (and McLachlan) despite the separate consulting report in Appendix D of that response in which Dr. Peter Hahn concluded (bold type is Dr. Hahn's):

*"**The sport catch of wild winter steelhead in the Sol Duc River in December does seem to be significantly lower now than in the 1950's.** We can explore other adjustments to the data but the differences in December are so great that I believe they will remain. The next task is to figure out why there is this difference for December. I suggest some possible explanations of immediate cause … These are (in order of decreasing likelihood …):"*

"1. Fewer early timed wild fish now return to the river and therefore fewer were available to catch and keep …

"…I was involved in many tribal –state negotiations from 1978 to about 1984. The general pattern was to concentrate net fishery effort in December and January in order to harvest early timed hatchery steelhead, with lower effort fisheries extending into the subsequent months. It appears that there were substantial harvests in November through February for the 1950's. I recommend that you graph these and discuss their implications...

"One last thought. You should probably emphasize in numerical and graphic form the quantity of hatchery steelhead harvested in the Quillayute River System (both sport and tribal), and estimate the amount of wild steelhead lost. Current and proposed management policies can then be considered along with wild and hatchery stock benefits and losses."

Apparently, Dr. Hahn's advice was never taken by WDFW, and perhaps the advice was too subtly made. Dr. Hahn never did forthrightly state the actual problem he was hinting at: focus of harvest on the early run of hatchery steelhead was equally targeting the historically dominant early component of the wild steelhead as well with gradual elimination of the latter.

There never have been any subsequent management changes to alter the consequences of overharvesting the early component of the wild steelhead return in the Quileute system, or elsewhere in the Washington, in the 12 years since McLachlan took the time and care to submit his report to the Wildlife Commissioners. The graphs Dr. Hahn suggested WDFW create a decade ago, regarding sport and tribal harvests with consideration of the consequences, are the central provisions of this report. The Quileute system is particularly complex with four major sub-basins. The tribal fishery is limited to the short reach of the Quileute itself. It is a mixed stock fishery on four stocks of wild steelhead destined for differing sub-basins further compounded by large numbers of hatchery steelhead. In the absence of where wild stocks in the tribal catch are annually destined, sport catch and escapements are the remaining measures with associated risks of not knowing the run sizes to each sub-basin.

Individual Quileute Sub-basin Winter Steelhead Comparisons:

The Quileute system is made up of four major sub-basins each with its own identified stock of steelhead (SASSI 1994). Winter steelhead comparisons are provided for each regarding differences in sport catch patterns, contribution of hatchery fish, escapements, and shifts in run timing that have occurred. Figures 38, 40, 42, and 46 provide the sport catch and escapement patterns. Figures 39, 41, 43, and 45 demonstrate the run timing differences that have occurred as a result of the joint management of steelhead by WDFW and the Quileute tribal fishery managers. The run timing shifts that have occurred are least apparent on the Dickey River (although that is based on very little historic data) but very prominent for the wild steelhead of the Bogachiel, Sol Duc, and Calawah.

Figure 38.

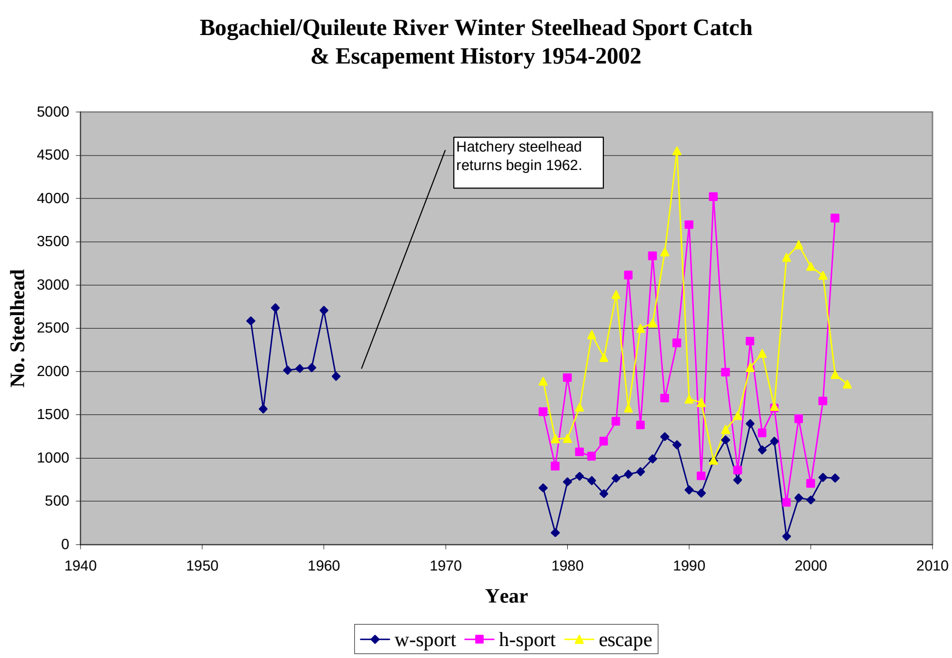


Figure 38 provides the recorded sport catch and escapement history of the Bogachiel/Quileute River sub-basin from 1954 to 2002 (data from: WDG 1948-1978; and WDFW 2006). Because the tribal fishery only takes place in the mainstem Quileute, where the catch might have been destined could not be determined for individual sub-basins. This also means there can be no run size estimates for each individual sub-basin of the Quileute system from which to monitor the success or failure of whether escapement levels are effectively sustaining the wild steelhead population size of each.

Figure 39.

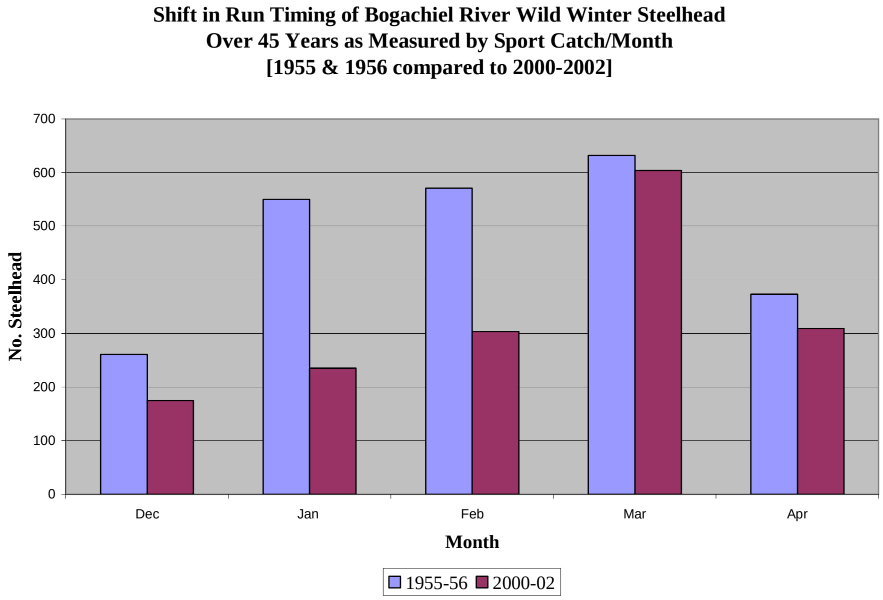


Figure 39 depicts the shift in wild winter steelhead run timing that has occurred in the Bogachiel/Quileute River as determined by sport catch per month for the combined years of 1955 and 1956 as compared to the combined years of 2000, 2001 and 2002 (data from: WDG 1956; 1957; and WDFW 1994-2002).

Figure 40 provides the recorded sport catch and escapement history of the Sol Duc River sub-basin from 1954 to 2002 (data from: WDG 1948-1978; and WDFW 2006). As with the Bogachiel/Quileute, the tribal catch that may have been destined for the Sol Duc could not be determined.

Figure 40.

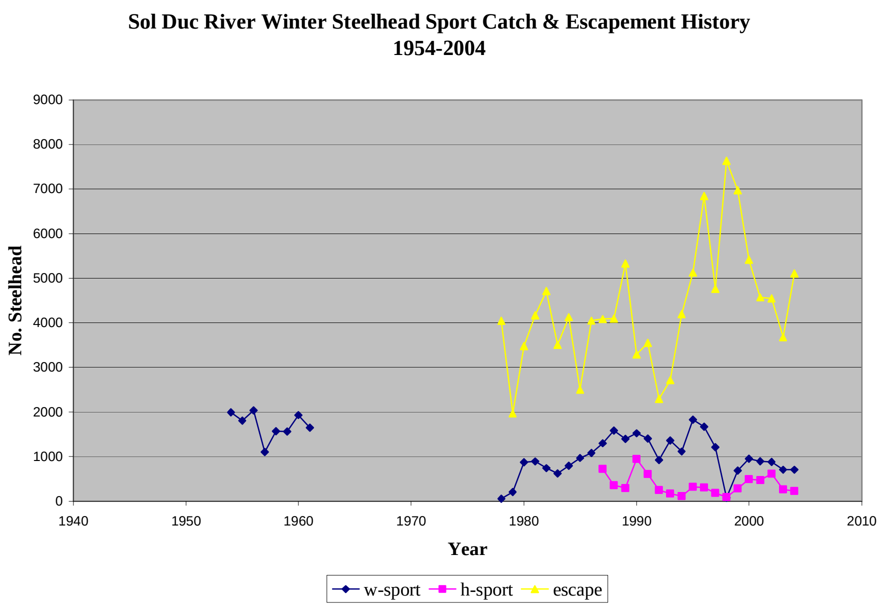


Figure 41 depicts the shift in wild winter steelhead run timing that has occurred in the Sol Duc River as determined by sport catch per month for the combined years of 1955 and 1956 as compared to the combined years of 2000, 2001 and 2002 (data from: WDG 1956; 1957; and WDFW 1994-2002).

Figure 41.

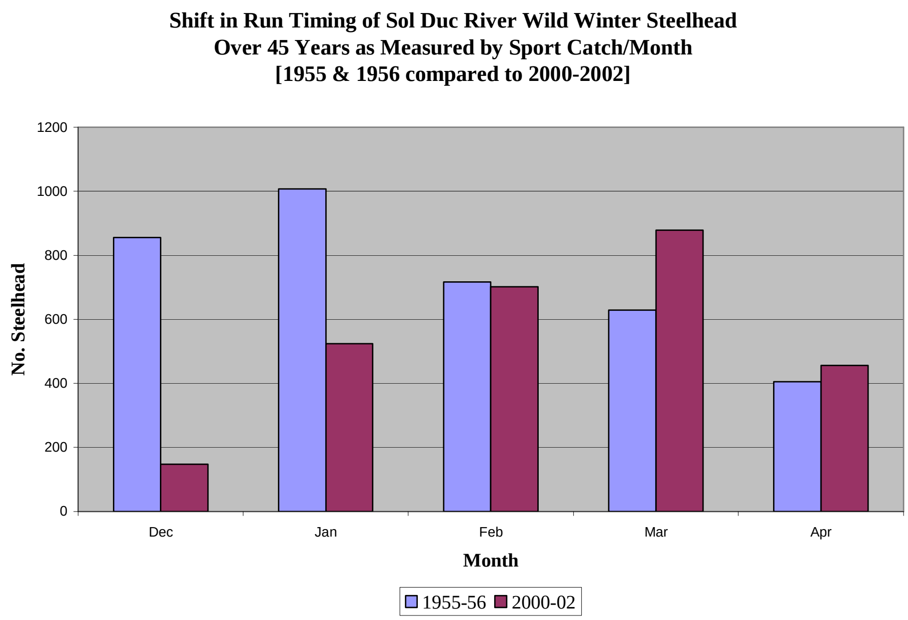


Figure 42 provides the recorded sport catch and escapement history of the Calawah River sub-basin from 1954 to 2002 (data from: WDG 1948-1978; and WDFW 2006). As with the previous sub-basins, the tribal catch destined for the Calawah could not be determined.

Figure 42.

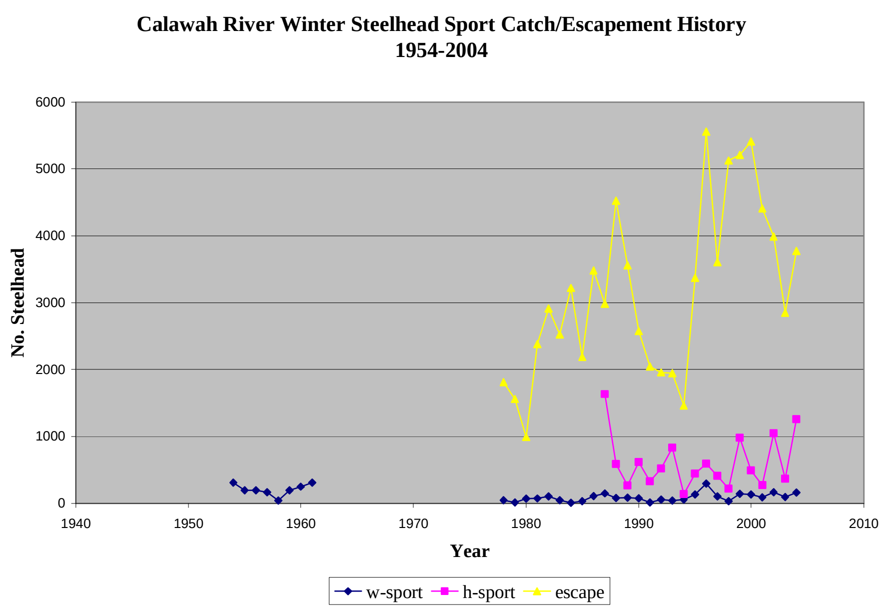


Figure 43 depicts the shift in wild winter steelhead run timing that has occurred in the Calawah River as determined by sport catch per month for the combined years of 1955 and 1956 as compared to the combined years of 2000, 2001 and 2002 (data from: WDG 1956; 1957; and WDFW 1994-2002).

Figure 43.

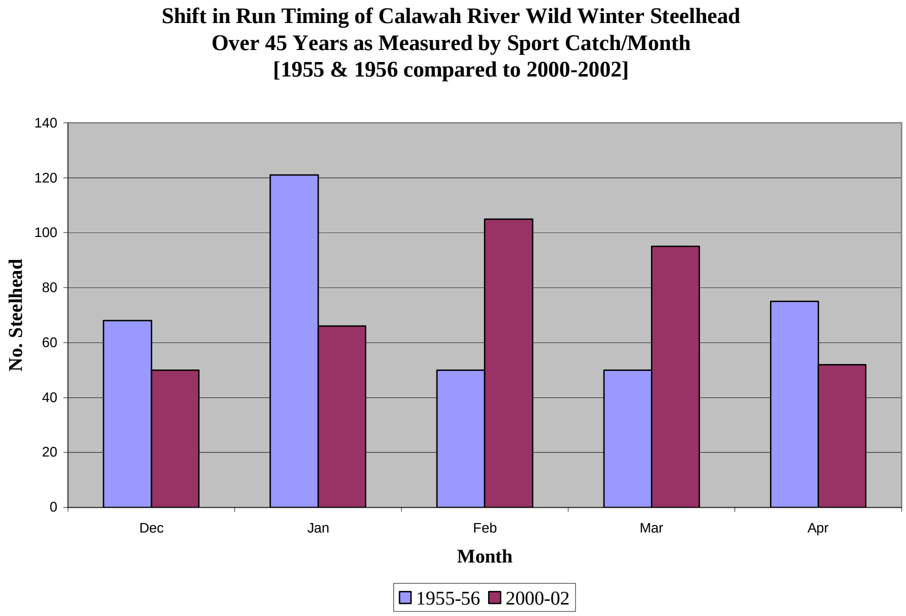


Figure 44 provides the recorded sport catch and escapement history of the Dickey River sub-basin from 1954 to 2002 (data from: WDG 1948-1978; and WDFW 2006). As with the previous sub-basins, the tribal catch destined for the Dickey could not be determined.

Figure 44.

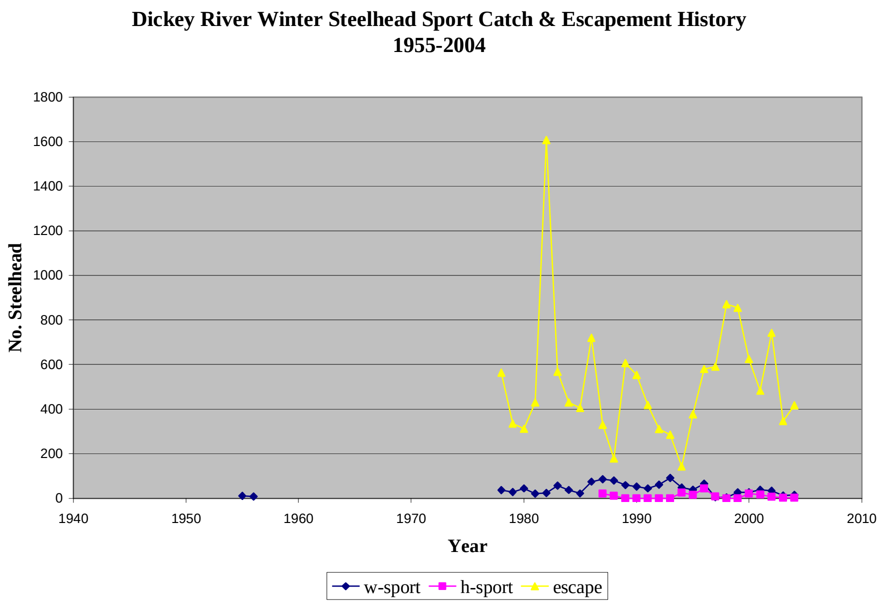
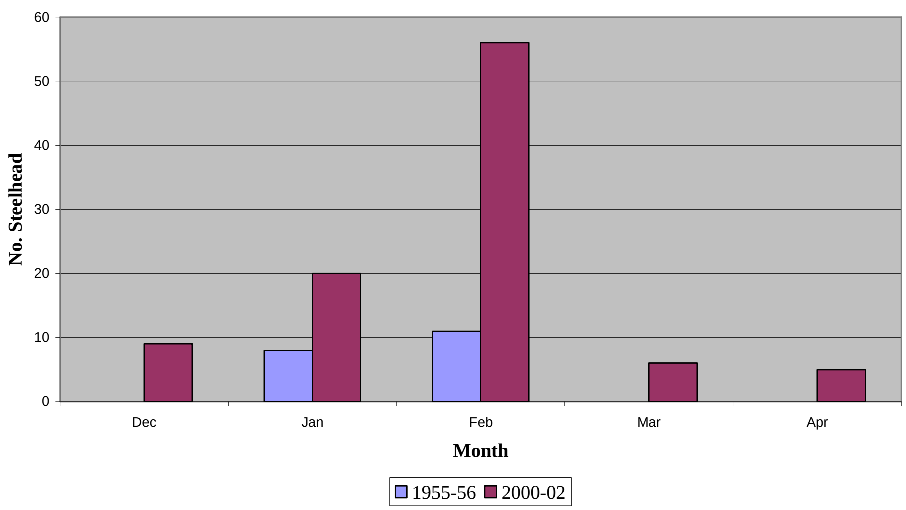


Figure 45 depicts the shift in wild winter steelhead run timing that has occurred in the Dickey River as determined by sport catch per month for the combined years of 1955 and 1956 as compared to the combined years of 2000, 2001 and 2002 (data from: WDG 1956; 1957; and WDFW 1994-2002).

Figure 45.

No Apparent Shift in Run Timing of Dickey River Wild Winter Steelhead Over 45 Years as Measured by Sport Catch/Month [1955 & 1956 compared to 2000-2002]



From Figure 38 it is apparent that the wild winter steelhead sport catch from 1978 to 2002 in the Bogachiel/Quileute has significantly declined from that of 1954-1961 (the limited period of presently available sport catch data for the Bogachiel sub-basin as separate from that of the Quileute as a whole) [WDG 1962-1986; WDW 1987-1993; WDFW 1994-2002; WDFW 1996]. From 1978 to 2002 the hatchery sport catch of steelhead has been highly erratic, sometimes far below the catch of wild steelhead prior to 1962 and sometimes far above it. Wild escapement has also been highly erratic suggesting some relationship may exist with the hatchery returns. The erratic patterns of hatchery catch and wild escapements into the four Quileute system sub-basins characterize the figures for each (Figure 38, Figure 40, Figure 42, and Figure 44).

Table 18 compares those limited years prior to Bogachiel River hatchery introductions to those years thereafter: the 1978-2002 sport catch of wild steelhead averaged only 36% of the 1954-1961 catch; and the 1998-2002 sport catch of wild steelhead averaged only 24% of the 1954-1961 catch. Adding the average 1978-2002 catch of 1,823 hatchery fish to the average Bogachiel/Quileute catch of 799 wild steelhead provides a combined sport catch average of 2,622 steelhead (hatchery plus wild), only 417 more than provided by the 1954-1961 sport catch limited to wild steelhead returns. Furthermore, the wild catch is continuing to drop over time as evidenced by the most recent five year average (1998-2002), a combined hatchery and wild catch of 2,110 steelhead, which is about 100 less steelhead than the average 1954-1961 catch of wild steelhead.

Table 18. Bogachiel River average wild and hatchery steelhead sport catch comparisons

Avg. Bogachiel wild winter sport catch 1954-1961	2,205 wild steelhead/year
Avg. Bogachiel wild winter sport catch 1978-2002	799 wild steelhead/year
Avg. Bogachiel wild winter sport catch 1998-2002	538 wild steelhead/year
Avg. Bogachiel hatchery winter sport catch 1978-2002	1,823 hatchery steelhead/year
Avg. Bogachiel hatchery winter sport catch 1998-2002	1,615 hatchery steelhead/year
Avg. Bogachiel combined hat+wild sport catch 1978-2002	2,622 hat+wild steelhead/year
Avg. Bogachiel combined hat+wild sport catch 1998-2002	2,153 hat+wild steelhead/year

On the average, the total sport catch of Bogachiel steelhead (hatchery plus wild) has benefited little or nothing in total numbers of winter steelhead caught since the hatchery steelhead program began in 1962 as compared to the wild steelhead sport catch alone from 1954 to 1961. Wild steelhead contribute significantly less to the Bogachiel catch now, at least if catch is strictly measured by harvest, than they did prior to sustained hatchery steelhead returns that began in 1962.

On the other hand, this does not take into consideration that sport fishermen are increasingly releasing wild steelhead, and incremental sport fishing regulation changes on the west coast of the Olympic Peninsula have also encouraged this. The level that catch and release of wild steelhead now contributes to the wild steelhead sport catch is presently difficult to measure in Washington, but it may be highly significant, not consistently recorded, and little evaluated. Catch and release has proven a very necessary sport fishing management mechanism, even in states as little populated as Alaska and Montana. In fact, many already consider sport harvest of wild steelhead an antiquated concept out of synch with the natural resource limitations and human population realities of Washington State and long overdue on the Olympic Peninsula.

Sport catch alone can't provide an evaluation of total run size changes that may or may not have occurred to wild steelhead of the Bogachiel/Quileute in the absence of knowing how many wild steelhead destined there are caught in the tribal fishery. But the sport catch record does indicate that hatchery steelhead have failed to effectively supplement the sport fishery with levels of historic harvest opportunity. The sport catch has remained largely the same for 50 years except it is now composed of about ¼ the former number of wild steelhead which have been replaced with hatchery steelhead.

From Figure 39 it is apparent that a dramatic shift in Bogachiel/Quileute wild steelhead run timing has occurred over the past 45 years. The December, January, and February returns are significantly reduced, leaving about the same historic proportions in March and April that now stand out as graphic peaks. This run timing shift may have long term consequences yet to be fully realized in eventual wild steelhead declines.

Early run timing, early spawning and early emergence may be especially critical in watershed areas that commonly go dry as found on the Rogue River (Everest 1973). It is necessary for juvenile steelhead to emerge from the gravel early enough to avoid the redds going dry and to accommodate downstream migration to watershed areas that remain wetted before being trapped by resulting low flows and killed by dewatering. One of the limiting factors to salmon and steelhead production on the Bogachiel-Calawah has been described as chronic minimum low flows (Phinney et al. 1975).

The staggered run timing, spawn timing, and juvenile emergence timing found so critical by Koenings et al. (1987) for sockeye salmon to take best advantage of limited nutrient resources in Karluk Lake undoubtedly has similar applications to other salmonid species. Every natural food web has finite limitations with resulting natural selection of species, races and stocks to optimize its utilization. Timing is everything in a balanced ecosystem. That timing has been greatly altered for steelhead on the Olympic Peninsula and elsewhere in Washington State through 40 years of steelhead management that has focused harvest on the earliest component of the wild winter steelhead populations.

The only historic sport catch data presently available from WDFW regarding wild steelhead from the Sol Duc River (as separate from the Quileute system) prior to sustained hatchery introductions into the Quileute system was that found from 1954-1961 (WDFW 1996). Those data are graphed in Figure 40 as a comparison to Sol Duc steelhead sport catch and escapement data from 1978-2004 (data from WDFW 2006).

Table 19 compares those limited years prior to hatchery introductions to those years after hatchery introductions: the 1978-2004 sport catch of wild steelhead averaged only 57% of those caught in 1954-1961; and the 1998-2004 sport catch of wild steelhead averaged only 41% of those caught in 1954-1961. Even by adding the average sport catch of 372 hatchery fish per year to the Sol Duc wild steelhead catch, the total remains well below that of the wild steelhead catch of 1954-1961. Furthermore, the wild catch is continuing to drop over time as evidenced by the most recent seven year average from 1998-2004.

Table 19. Sol Duc River average wild and hatchery steelhead sport catch comparisons.

Avg. Sol Duc wild winter sport catch 1954-1961	1,707 wild steelhead/year
Avg. Sol Duc wild winter sport catch 1978-2004	978 wild steelhead/year
Avg. Sol Duc wild winter sport catch 1998-2004	697 wild steelhead/year
Avg. Sol Duc hatchery winter sport catch 1987-2004	372 hatchery steelhead/year
Avg. Sol Duc hatchery winter sport catch 1998-2004	350 hatchery steelhead/year
Avg. Sol Duc combined hat+wild sport catch 1987-2004	1,350 hat+wild steelhead/year
Avg. Sol Duc combined hat+wild sport catch 1998-2004	1,047 hat+wild steelhead/year

Unfortunately, because of the unquantified portion of the Quileute tribal wild steelhead catch that is destined for the Sol Duc, it is not known if the wild run size is holding its own, or if it is in decline as is similarly the case with the sport catch. While escapement has held its own, or has even increased somewhat (Figure 39), the overall run size for each of the Quileute sub-basins remains of concern.

On average, hatchery steelhead have contributed relatively little to the sport catch on the Sol Duc as is evident in Figure 40. The relative lack of hatchery steelhead catch probably reflects similarly low returning numbers of hatchery steelhead to the Sol Duc sub-basin. This may be one reason its wild steelhead catch has remained proportionally higher than that of the Bogachiel/Quileute. From Tables 18 and 19: The 1978-2003 Bogachiel/Quileute wild sport catch was 36% of what it was in 1954-1961, and further declined to 24% in 1998-2003; the 1978-2005 Sol Duc wild sport catch was 57% of what it was in 1954-1961, and further declined to 41% in 1998-2005. The less significant decline in the wild sport catch (as measured by harvest) may provide an indicator that the Sol Duc's wild steelhead run size has held up better than may be the case on the Bogachiel/Quileute due to less potential for hatchery/wild interactions to occur. However, it could also reflect that catch and release may be more prevalent by sport fishermen on the Sol Duc than on the Bogachiel/Quileute, or could indicate other potential variables.

More clearly measurable is the dramatic change in Sol Duc River wild winter steelhead run timing that has occurred over the past 45 years as shown in Figure 41. The December sport catch is now about 17% that of historic numbers and the January sport catch is 52% of historic numbers. By contrast the March sport catch is now about 40% greater than was historically the case and April is 13% greater. Only February remains little changed. A run timing that once peaked in January and December now peaks in March. A limited nutrient base as represented by the Sol Duc sub-basin would theoretically be under-utilized by emergent steelhead resulting from reductions in December and January run timing, and over-utilized by emergent steelhead resulting from increased March and April run timing. This would presumably be the case if the run timing and emergence of wild winter steelhead was in the most productive balance of nutrient utilization 45 years ago.

However, any nutrient base supposition would also have to take into account what alterations may, or may not, have occurred in Sol Duc River habitat as well as the nutrient loading provided by salmon carcasses that now occur as compared to what existed in 1955 and 1956, or more importantly, the habitat and nutrient loading that occurred prior to industrial level exploitation of Quileute River system fish resources sometime prior to the 20th century.

Because of the scale of the graphics in Figure 42 it is not readily apparent that the sport catch of Calawah wild winter steelhead has dropped from an average of 205 in the eight years from 1954 to 1961, to an average sport catch of 89 wild winter steelhead in the 27 years from 1978 to 2004. This drop in the wild steelhead sport catch coincides with proportionally larger catches of hatchery winter steelhead that have occurred the past 27 years. The hatchery sport catch has commonly been triple or more the catch of wild steelhead on the Calawah which may also indicate considerable escapement of hatchery steelhead into the Calawah spawning grounds with elevated potential for hatchery/wild spawning interactions. Nevertheless, Calawah wild steelhead escapement has been proportionally higher than in the Bogachiel/Quileute and Sol Duc sub-basins.

The run timing of Calawah wild winter steelhead has clearly altered over the past 45 years as depicted in Figure 43. 26% fewer wild winter steelhead now return in December and 45% fewer wild winter steelhead now return in January. However, 110% more wild winter steelhead now return in February than did in 1955 and 1956 and 90% more now return in March, while 31% fewer wild winter steelhead now return in April.

One of the primary limiting factors to salmon and steelhead production for the North Fork Calawah, in particular, has been annual dewatering of its midsection in summer (Phinney et al. 1975). Early entry, early spawning, and early wild winter run steelhead emergence may be especially critical in the Calawah system to minimize redds going dry and to accommodate early enough emergence by juveniles so they can effectively migrate to other areas of the watershed that remain wetted throughout the summer and fall just as was found to be necessary for Rogue River steelhead by Everest (1973). Calawah wild winter steelhead run timing, with the reductions in December and January, have particularly increased in February (Figure 43). This may be the best adjustment they can make to accommodate relatively early spawning and emergence under the stresses of adjustment to loss of earlier entry.

As with the Bogachiel and Sol Duc sub-basins, early return steelhead have been proportionally reduced in numbers. However, unlike the previous two sub-basins, February and March returns have dramatically increased while April returns have decreased. Although there have been significant shifts in run timing, the overall numbers of wild Calawah winter steelhead have remained similar between the two time periods of comparison, while on the Bogachiel and Sol Duc overall numbers of wild winter steelhead fell over the same two time periods reflecting the loss of the early run component. On the Calawah, the increase in February and March run timing made up for the early run timing loss.

In the case of the Calawah, the wild winter steelhead have shown a resiliency to loss of early run timing that Bogachiel and Sol Duc wild winter runs have not. The Calawah in this respect would appear to be the anomaly rather than the norm. Reductions in wild steelhead numbers coinciding with run timing shifts have occurred on the Hoh, Queets, Bogachiel/Quileute, and Sol Duc, as well as virtually all streams in Washington with tribal fishery records dating prior to hatchery introductions (Taylor 1979).

The Dickey River sub-basin apparently had very little historic sport fishing pressure. Only two years, 1955 and 1956, were broken out from the overall Quileute system sport catch records that were available (WDG 1948-1978; WDG 1962-1986; WDW 1987-93; WDFW 1994-2002; and WDFW 2006). The wild catch has increased somewhat since that time as shown in Figure 44, perhaps reflecting increased access into the sub-basin and/or a general increase in steelhead sport fishing. However, most recently (since 1997) the wild catch has dropped to an average of 17 wild steelhead caught by sport fishermen compared to an average catch of 51 wild steelhead in the 19 years between 1978 and 1996. The sport catch of hatchery steelhead from the Dickey has remained at a sustained low level. It is unknown if this is due to relatively few hatchery steelhead returning there throughout the period of record keeping, or if it is a result of relatively few sport fishermen choosing to fish the Dickey.

From Figure 45, it is not possible to determine if a shift in Dickey River wild steelhead run timing has occurred due to the low numbers initially recorded there in 1955 and 1956. There is insufficient baseline from which to make a comparison.

Alterations in wild steelhead run timing have occurred on the Quileute system (and elsewhere in Washington) since sustained hatchery returns began in 1962. The resulting mixed stock fisheries have focused 80%-plus harvest rates on the early steelhead returns (SASSI 1994). This may have triggered complex results.

January and February wild steelhead spawning, as recorded by Cederholm (1984) in the Clearwater River (in tributaries in particular), would require November, December, and January wild steelhead run timing through the lower Quileute to reach upstream spawning destinations. However, December and January wild steelhead run timing has been dramatically reduced in the Bogachiel and Sol Duc in particular. On all Olympic Peninsula streams examined in this report, wild steelhead run timing has become more concentrated into the months of February, March, and April. Of necessity, spawning and fry emergence would similarly be compressed into later dates. Historically, fry emergence would have been more evenly distributed over a longer, more staggered period to take advantage of the available nutrients in the food web. Vital to that food web are salmon carcasses (Brown 1982; Bilby et al. 1996; and Bilby et al. 1998).

Historic Salmon Abundance and Missing Nutrients for Quileute Steelhead

The Quileute system once had significant returns of all five species of Pacific salmon (Phinney et al. 1975), but today pink salmon are not even mentioned as existing, chum harvests are less than 100 fish annually in sport and tribal fisheries and no longer managed for, and Lake Pleasant sockeye are no longer managed for (SASSI 1994). Yet, as late as 1975 a small run of pink salmon occurred in the mainstem of the Bogachiel downstream of the entry of the Calawah River, and a small run of river-race sockeye salmon was described using the lower reaches of the North and South Forks of the Calawah Rivers as well as several of their tributaries (Phinney et al. 1975).

In 1915, 826 cases of pink salmon were packed at the Mora cannery on the Quileute with 48 one pound cans per case (39,648 pounds) [Cobb 1930]. The average pink salmon in Puget Sound in 1895 weighed four pounds (Wilcox 1898). Their small size would suggest using 70% wastage as estimated for steelhead by Myers (per. com. 2006) which would mean a total catch of 132,160 pounds. That poundage divided by four pounds per fish would indicate a catch of 33,040 pink salmon and a total run size of 66,040 pink salmon in 1915 if catch was 50% of the run size, or 110,133 pink salmon if catch was 30% of the run size (using the 50%-70% range of harvest to run size indicated by Myers [2005]). That nutrient level represented by pink salmon in alternating years is now absent.

In 1915, 192 cases of chum salmon were packed at the Mora cannery at 48 one pound cans per case (9,216 pounds) [Cobb 1930]. Using Myers' (per. com. 2006) range of wastage in canning of 50%-70%, a catch of 18,432-30,720 pounds of chum salmon was processed. Wydoski and Whitney (1979) indicate that Puget Sound chum average 9 pounds each indicating a catch of 2,048-3,413 chum and a total run size of 4,096-6,826 chum salmon that returned in 1915 if catch was 50% of the run size, or 6,827-11,377 chum salmon if catch was 30% of the run size. The nutrient level annually represented by chum salmon is also now missing.

What the historic numbers of sockeye salmon once were to Pleasant Lake can't be determined by the Mora cannery records due to only one year of packing sockeye with only 15 cases reported. River-race sockeye also once returned to the Calawah (Phinney et al. 1975).

In 1914, 1,968 cases of silverside (coho) salmon were packed at the Mora cannery at 48 one pound cans per case (94,464 pounds) [Cobb 1930]. Although Puget Sound coho were said to average 7.5-8.5 pounds (Collins 1892; and Wilcox 1898), in the Shoalwater Bay fishery (Grays Harbor area) the coho were said to average 12 pounds (Collins 1892). Quileute system fall coho are commonly large while the summer coho are typically smaller (per. com. John McMillan, 2006), so the range of 8-12 pounds may be appropriate. If cannery wastage was in the range of 50%-70% as indicated by Myers (per. com. 2006) the coho catch processed at the cannery was 188,928-314,880 pounds representing 23,616-39,360 coho if they averaged 8 pounds each, or 15,744-26,240 coho if they averaged 12 pounds each. The total run size would have been 47,232-78,720 coho (mid-range being 62,976 at 8 pounds each) to 31,488-52,480 coho (mid-range being 41,984 at 12 pounds each) if catch was 50% of the run size; or 78,720-131,200 coho (mid-range being 104,960 at 8 pounds each) to 52,480-87,467 coho (mid-range being 69,974 at 12 pounds each) if catch was 30% of the run size.

The 1992 SASSI (1994) reported that terminal run sizes of combined wild and hatchery fall coho to the Quileute system from 1980 through 1991 ranged from 4,126 to 18,861 coho with an average of 15,574. Natural summer run coho run sizes to the Sol Duc River, where they are native, averaged 1,825 fish from 1982 through 1991, and the hatchery return averaged 7,310 summer coho for a total of 9,135 summer coho. The fall and summer combined run sizes from 1982 through 1991 averaged 24,709 total coho representing 39%-59% of the coho that provided nutrients in 1914 (using the mid-range figures) if catch was 50% of run size, or an absence of 17,275-38,267 coho. If catch was 30% of the run size, 1982-1991 nutrients from coho carcasses were 24%-34% of those in 1914, or an absence of 45,265-80,251 coho.

The combined losses of pink, chum, and coho has resulted in 87,411-201,761 fewer salmon returning to the Quileute River system as compared to 80-90 years ago. This loss of nutrients has undoubtedly reduced the ability to produce steelhead smolts that average two years of instream rearing before migration to the Pacific.

Resident Rainbow, Smolt Residualism, and Precocious Parr

It has been found on the Sol Duc and Calawah rivers that male resident rainbow trout appear to be an important component of the wild steelhead spawning population (McMillan et al. [in press]). This was found particularly so in the upper portions of these rivers in May and June during a time period when female steelhead were frequently found without available male steelhead for mates. However, some male rainbow trout were found among the spawning population throughout the spawning season (January 2-July 8) and throughout the lower, mid, and upper Mainstem sections snorkel surveyed.

Shapovalov and Taft (1954) also reported resident rainbow spawning with steelhead, and rainbow trout were found to be part of a mixed *Parasalmo mykiss* population with resident, estuarine, and anadromous life histories that spawn together in rivers of Russia's Kamchatka Peninsula (Savvaitova et al. 1973; Savvaitova et al. 1996; McMillan 2001; Augerot 2005). Resident rainbow have also been reported spawning with steelhead in Washington's Washougal River (McMillan 1988; and 2001), and by Pearson et al. (2003) in the Yakima River system.

In Kamchatka the male/female proportional differences within the varied life history forms of rainbow seemed mathematically designed to spawn together with the anadromous group represented by mostly female steelhead, 67.9%; the estuarine (or coastal) group by male fish, 66.7%; and the river group also predominantly male, 82% (Savvaitova et al. 1995). In Kamchatka, two-thirds of the life history options for long term survival may be contained in resident and estuarine forms within the rainbow/steelhead population of mixed life history traits (McMillan 2001).

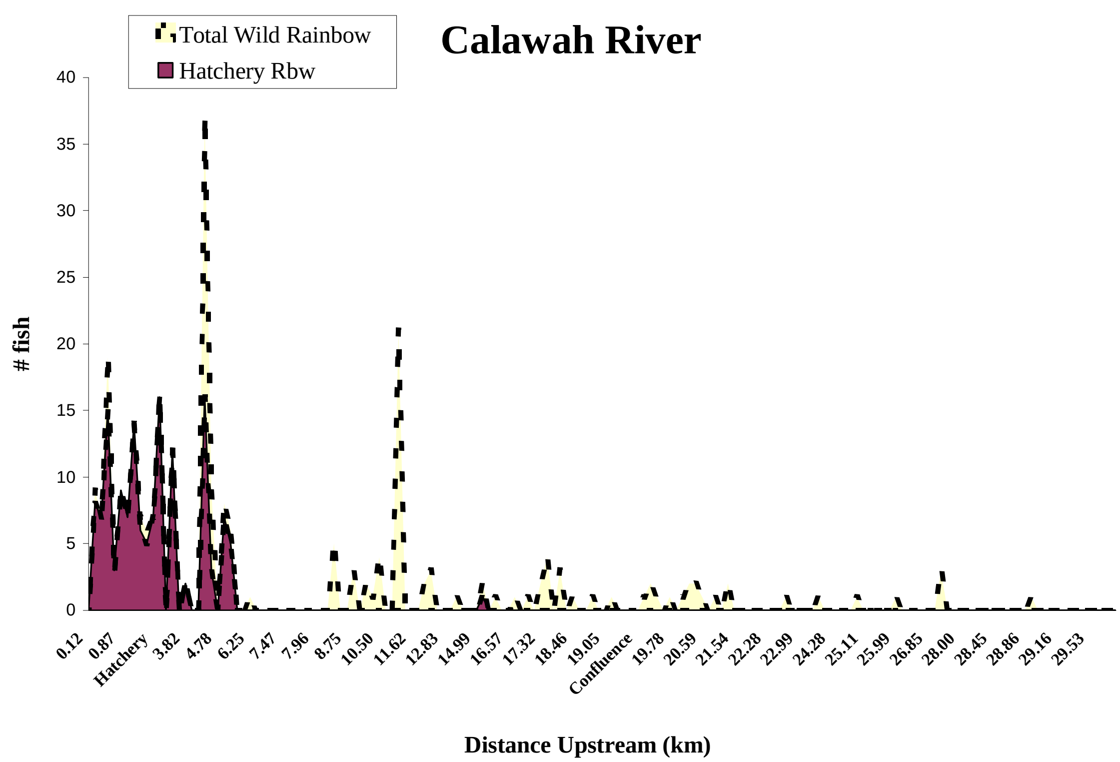
The prominent presence of resident rainbow among the mixed steelhead/rainbow spawning populations of the Sol Duc and Calawah rivers may partially explain the resiliency the Quileute system's wild winter steelhead population has retained as compared to the neighboring wild winter steelhead populations of the Hoh and Queets rivers. To date, the only known work that has attempted to partially quantify the resident life history component of Olympic Peninsula steelhead/rainbow rivers has been the WSC work by McMillan et al. [in press] and other unpublished data collected in the extensive WSC surveys of the Quileute and Hoh systems (McMillan 2006). The Sol Duc and

Calawah rivers were found to have a greater presence of resident life histories than the other rivers (per. com. John McMillan, 2006).

However, the WSC surveys have also found that resident rainbow of hatchery steelhead origin (which residualized rather than outmigrated as smolts) are especially prolific in the region of the middle Sol Duc near a hatchery rearing pond (McMillan et al. [in press]). Hatchery origin rainbow, and hatchery origin precocious male parr that do not smolt, have become part of the Sol Duc steelhead spawning population. Hatchery/wild spawning interactions are especially probable around the hatchery release site. Two such matings with female steelhead were observed at such sites in the WSC snorkel surveys. Similar observations have been made in the Keogh River (Ward 2006).

Figure 46 depicts the distribution of wild and hatchery rainbow trout found in snorkel surveys of the entire 29 km length of the Calawah River. Most of the hatchery rainbow trout were found in the lower 6 km of the Calawah. The hatchery site is located at about the 3 km point in the center of that 6 km section. The location of these adipose clipped trout indicates the likelihood they are pre-smolts and/or precocious parr that residualized after release from the steelhead rearing ponds. These fish are mature and can, and do, spawn with wild female steelhead as observed in the Calawah and Sol Duc rivers (McMillan et al. [in press]). Confirmation that such parr can effectively fertilize the eggs of steelhead was found by Seamons et al. (2003) on the Olympic Peninsula's Snow Creek where a significant genetic contribution by mature male parr was found to occur as carried by their progeny in the juvenile steelhead population.

Figure 46. The snorkel survey results of rainbow trout distribution found on the Calawah River (McMillan and Starr 2006)



Although wild rainbow trout may provide survival advantages for long term persistence of steelhead/rainbow populations, the presence of hatchery origin rainbow stemming from hatchery steelhead releases poses a counterbalancing threat. Spawning interactions between hatchery and wild steelhead with resulting low spawning success have been confirmed in both the Pacific Northwest (Reisenbichler and McIntyre 1977; Chilcote et al. 1986; and Leider et al. 1990) and the Great Lakes (Miller et al. 2004). Similarly low spawning success can be anticipated as a result of female steelhead spawning with hatchery rainbow and precocious male parr swarmed in areas of at least 6 km around hatchery steelhead releases sites as depicted in Figure 46 on the Calawah River. It should also be noted that there was also at least one hatchery rainbow sighting found 15 km up the Calawah (Figure 46). Several other large (>12”) hatchery rainbow trout have been found up to 20 km upstream of hatchery release points in the Sol Duc River (per. com. John McMillan, 2006). These fish are all assumed to be residualized hatchery steelhead parr because no other type of rainbow hatchery releases occur in the Quileute basin. In Oregon's Imnaha River residual steelhead smolts have been found to travel as far as 21 km upstream of their release site (Jonasson et al. 1995).

The combination of adult hatchery steelhead, hatchery origin rainbow trout, residualized hatchery steelhead smolts, and precocious hatchery origin parr can all combine to render otherwise pristine spawning and rearing habitat unproductive for wild steelhead that spawn, rear, and/or otherwise cohabit these areas.

The levels of steelhead smolt residualism for Chamber's Creek Hatchery stock (winter run) was 26.1% in 1991, 13.8% in 1992, and 19.6% in 1993 as found on release at Snow Creek on the northeastern Olympic Peninsula by Tipping et al. (1995). The hatchery stock of winter steelhead released into the Quileute system is of Chamber's Creek origin (SASSI 1994). However, under the "methods" section of the paper, it indicated (Tipping et al. 1995):

"Precocious (sexually mature) males, identified by darkened skin color and presence of sperm, were excluded from this experiment."

Why the precocious males collected at the South Tacoma Hatchery were culled out prior to the experiment is a mystery. It virtually negated much of the value of the experiment. It would have decreased the expected level of residualism, and it did not even attempt to quantify what those precocious parr numbers were. Nevertheless, it would provide the anticipated minimal level of residualism that might be expected from Chambers Creek origin smolt releases.

In the case of the Quileute system where recent hatchery winter smolt releases have annually been about 200,000 and hatchery summer smolt releases have been about 50,000 (WDFW 2006), at the 26.1% residualism rate reported by Tipping et al. (1995) in 1991, 65,250 residual smolts would annually result that do not migrate to the ocean. However, because the experiment reported by Tipping et al. did not include the precocious parr that were culled out, Royal's (1972) report of 44%-47% residualism found for hatchery steelhead smolts released into Washington's Elochoman River may better represent the expected residualism level on the Quileute system. Precocious parr were not reported to have been excluded from the Elochoman River study. Of the

250,000 steelhead smolts released annually into the Quileute,110,000-117,500 of those planted would fail to outmigrate at 44%-47%. Many of those would be precocious parr.

Most precocious parr were found to be males in the Keogh River (Werner 2003). They were found to stay "in the river forever." Those that residualized for other reasons remained in the river for one to two more years until they reached smolt size and outmigrated. In both instances the residuals will compete with, and prey on, wild fry and parr for one or more years. The most piscivorous individuals found on the Keogh River were the largest which were most commonly the large, precocious males.

In the Quileute system, many of the resident rainbow and precocious parr stemming from hatchery releases remained within several kilometers either direction from their release sites creating localized high densities as found in the WSC snorkel surveys (Figure 46). Those at the lower Calawah area near the entry to the Bogachiel could create predator swarms that consume wild juvenile salmon.

For instance Werlen (2003) found that about 1/3 of steelhead residuals of 250mm or more in length were piscivorous on the Keogh River in British Columbia consuming coho fry and coho smolts up to 80-100mm in length as found in their stomach contents. Residual hatchery steelhead, precocious parr, and subsequent resident rainbow on the mid Sol Duc could all be contributors that keep coho salmon populations below historic levels through juvenile predation as they migrate out of near-by Beaver Creek, Bockman Creek, Bear Creek, and potentially diminish juvenile sockeye salmon migrating out of Lake Creek a few miles downstream.

Hunter (1959) found that pink and chum fry were frequent food items of coho smolts and steelhead. The predator swarms of hatchery residuals may deny the ability for Quileute system chum and pink salmon to effectively reestablish due to high predation at emergence time. Without restoration of salmon to historic numbers, the lower portions of the Quileute sub-basins will remain nutrient starved and negate the ability to restore wild steelhead populations to the full productivity of what the available habitat could otherwise carry.

The mid Sol Duc hatchery release site is also an area intensively used by wild steelhead for spawning (per. com. John McMillan, 2006). Spawning interactions with precocious parr can be expected to be more common there as well as subsequent predation by the lingering precocious parr on juvenile steelhead as they come out of the gravel. At the lower Calawah hatchery area, most wild female steelhead late in the spawning season will not have anadromous mates as was found in lower river sections (per. com. John McMillan, 2006). Historically, wild male rainbow trout would have provided the female steelhead with mates. However, since sustained hatchery steelhead introductions began in 1960, it is more likely that hatchery origin precocious parr and hatchery rainbow trout will be present in the areas of hatchery steelhead releases.

Escapement Goal Assessment

The Quileute system has had the advantage of a higher overall escapement goal for steelhead than have the Hoh, Queets, and Quinault basins. To some degree this reflects the differing sizes of the watersheds as shown in Table 20, but not entirely.

Figure 20. Comparative drainage areas, linear miles, average flows, and average summer low flows of the Quileute, Hoh, Queets, and Quinault rivers (data from Phinney et al. 1975) compared to their wild winter steelhead escapement goals (from SASSI 1994; and WDFW 2006).

River	Drainage area in sq. mi.	Linear stream miles	Avg. flow in cfs	Avg. summer flow in cfs	Min. summer flow in cfs	Steelhead escapement goal
Quileute	629	751	4,450	1,000	271	5,900
Hoh	299	312	2,200	1,060	396	2,400
Queets	450	541	4,265	1,015	368	2,500
Quinault	434	559	3,700	1,080	320	1,200 (upper) none (lower)

Although the Quileute system has a larger drainage area and greater length in lineal stream miles than the Hoh, Queets, and Quinault, the differing escapement goals do not effectively represent the proportional differences except roughly for the Hoh. The Hoh River's drainage area is 48% of the Quileute's with 42% of the Quileute's lineal miles, and its escapement goal is 41% that of the Quileute's. However, the Queets River's drainage area and lineal miles are 72% of the Quileute's, but its wild winter steelhead escapement goal is only 42% of the Quileute's. The Quinault River's drainage area is 69% that of the Quileute's with 74% of the lineal miles of the Quileute. The only escapement goal for wild steelhead in the Quinault system is for those returning above the lake into the Mainstem, North Fork and East Fork. That escapement goal is only 20% of the Quileute system's.

However, average flows, average summer flows, and minimum low summer flows are also necessary measures of expected fish productivity. Minimum low summer flow is a particular limitation on productivity in the Bogachiel-Calawah (Phinney et al. 1975). For instance, in the drought summer of 2002, the entire lower 10 miles of the North Fork Calawah River went subsurface in the Quileute system (per. com. John McMillan, 2006). Thousands of juvenile salmon, cutthroat, and steelhead were found dead in the dewatered pools. The rearing juvenile steelhead from two age classes in those lower 10 miles of the mainstem (and tributaries that also went dry) were eliminated: the young of the year from spring emergence in 2002 that would have mostly outmigrated as smolts in the spring of 2004, and those of spring emergence in 2001 that would mostly have outmigrated in 2003 as smolts. Other areas of the Calawah system also went dry that year, and in the drought of 2003 some portions of the North Fork Calawah and elsewhere in the Calawah sub-basin of the Quileute also went dry, although not to the extent as that found in 2002.

The Calawah sub-basin of the Quileute has a long history of going dry (subsurface) that is in fact recorded in Quileute tribal history regarding the North Fork Calawah with stories of the magical underground Calawah. Phinney et al. (1975) indicated that the middle North Fork Calawah annually went dry. This is a natural limiting factor in the Quileute system which is not as prevalent in the other major river basins on the west side of the Olympic Peninsula as evidenced by the summer minimum flows recorded in Figure 20. Despite the Quileute's larger drainage size, its average flow (4,450 cfs) is not as proportionally large as compared to the other three rivers, and its average summer flow (1,000 cfs) is actually slightly less than any of the other three rivers. Of greater steelhead rearing consequence, the Quileute's minimum low summer flow (271 cfs) is only 68% of that for the Hoh River (396 cfs) and is significantly less than that of Queets (368 cfs) and Quinault (320 cfs) as well.

Because steelhead generally rear in freshwater for at least two years, average summer flows would be an expected constraining determinant of wild steelhead production. From this it would appear that actual steelhead productivity for all four of the major west side Olympic Peninsula Rivers would be less different from each other than drainage area and linear miles would indicate because of the similarity in average summer flows as a production constraint. When the sporadic extreme summer low flow years occur, the Quileute system wild summer steelhead population can be expected to be much more severely impacted than those of the Hoh, Queets, and Quinault suggesting even more equality of productivity than indicated by drainage area and linear miles alone.

In the setting of escapement goals for these four river systems, there appears to be little accounting of what the actual productivity for each basin is for steelhead based on more complex determinations than have thus far been taken into account. The Quileute basin's comparatively greater productivity in sustained wild winter steelhead run sizes since the 1940s may be explained by the provision of a greater escapement goal than has been provided on neighboring rivers. One of the driving constraints for the other three rivers may be escapement goals that have been set too low and harvests that have been too high.

In fact, even on the Quileute system, the present escapement goal and harvest level occurring may similarly be a constraint on productivity that has thus far been insufficiently analyzed. This could be creating an artificially limited ceiling on the expression of wild winter steelhead productivity.

Habitat

In 2004, Peter Bahls quoted a portion of the Summary from the Washington State Conservation Commission's (WSCC) Watershed Resource Inventory Area 20 (for the Sol Duc and Hoh watersheds) regarding habitat limitations for the Sol Duc River which would apply as well to the Quileute system:

"The Soleduck sub-basin lies partly within the Olympic National Park (upper reaches) and partly timber-managed, agricultural and residential development. The contrast between the pristine habitat conditions within the park is sharp compared to conditions further downstream. Outside of the park boundaries, numerous major habitat problems exist."

"Excessive sedimentation is a problem and stems mostly from landslides. High road densities are associated with the sedimentation problems. High levels of fine sediments are found in many Soleduck tributaries with degrade the quality of spawning habitat. Areas of 'poor' large woody debris and riparian conditions are other problems. The Soleduck drainage is naturally limited in wetland habitat, yet continued loss of wetlands and off-channel habitat occurs. Warm water temperatures are a problem in the summer, potentially impacting adult migration and spawning of summer chinook and a unique summer coho run. A large potential habitat problem is the over-allocation of water from the river. Contributing to summer low flows and warm water temperatures is the 'poor' hydrologic maturity (loss of fog drip, change in hydrology) outside the Park boundaries. Blockages are a known major problem within Gunderson and Tassel Creeks."

Phinney et al. (1975) also examined habitat limiting factors. For the Bogachiel-Calawah River they indicate:

"The primary limiting factor in this section in both the mainstems and tributary streams is low summer flow which affects rearing capabilities and impedes entrance of adult salmon. Gravel removal operations on the Bogachiel have resulted in local streambed instabilities and silt. Activities associated with logging on Dry Creek resulted in extreme erosion problems. Much of the silt settled in the Bogachiel River as well as in the bed of Dry Creek. Barriers to salmon migration are located on Murphy, Weedin, and South Fork Maxfield creeks…"

Regarding the North and South Fork Calawah Rivers Phinney et al. (1975) further indicate:

"Low stream flow is a major limiting factor to salmon production in this area, particularly in the middle reach of the North Fork Calawah which annually goes dry. A forest fire destroyed much of the North Fork watershed. This resulted in considerable siltation of the streambed materials… logging and road construction on the upper Sitkum River have resulted in siltation of the spawning gravels."

Monitoring Recommendations

In his assessment of Sol Duc River wild steelhead, Bahls (2004) provided a detailed list of monitoring recommendations by categories that are applicable to the entire Quileute basin:

"Life History:"

- *"Conduct research on juvenile life history. Very little information is available on juvenile use of freshwater and estuarine rearing habitats. A high priority is to conduct parr surveys during summer low flow in tributaries and the mainstem …to update the parr density data that was used to set the escapement goal.*

"Hatcheries:

- *"Evaluate the hatchery straying rate into the Sol Duc River. Hatchery strays from the Bogachiel hatchery facility appear to be a threat to maintaining the genetic integrity of the early timed portion of the wild winter run.*
- *"Cease operation of the Snyder Creek brood stock facility. It does not seem to be making a significant contribution to the catch and is taking wild spawners off the spawning grounds with unknown genetic risks to the wild population.*

"Harvest:

- *"Evaluate the strategy of 100 percent wild production versus continued hatchery supplementation for long term sustainability and production of winter steelhead in the Quillayute River system. The major concerns… revolve around the impacts of hatchery production facilities in the Quillayute, in terms of mixed stock fishery in depressing the early timed portion of the wild run and potential genetic impacts from straying of hatchery fish. Restoration of the early timed run…along with higher escapements in the basin, may provide more fish for harvest than currently provided with hatchery supplementation and at much lower risk to the survival of the wild populations."*

V. Quinault River

The Quinault River is 69 miles (111 km) long with a drainage area of 434 sq. miles. The average winter flow is 6,300 cfs with an average summer flow of 1,080 cfs. The maximum recorded flow has been 80,200 cfs with a minimum of 320 cfs (Phinney et al. 1975). The headwaters originate in the Olympic Mountains within the Mount Lawson and Enchanted Valley watersheds, the North Fork and the East Fork then joining to flow into Lake Quinault, a 3,729-acre natural lake. From the lake the Mainstem Quinault flows 33 miles to the Pacific Ocean (Smith and Caldwell 2001). The low terrain downstream of Lake Quinault contrasts with the steep slopes and high relief of the areas around Lake Quinault and the headwaters. 47% of the Quinault River basin is within the ONP (Contor and Houston 1984), which includes the north shore of Lake Quinault; 32% is within the Quinault Indian Reservation, 13% is U.S. Forest Service, and 4% is private landholdings with Rayonier Timberlands Company the largest private landholder (Smith and Caldwell 2001).

The Quinault River has both native summer and winter runs of steelhead that are considered geographically isolated populations (SASSI 1994).

SUMMER STEELHEAD

The Quinault River summer run is described as a historically small number of steelhead with a spawning distribution that is not well known (SASSI 1994). The same stock report indicates that sport catch data suggest pre-spawning adults tend to congregate in the upper reaches of the Quinault River by late summer and early fall with spawning generally believed to occur in those upper river reaches.

Syl MacDowell (1948) provides an interesting reference about Quinault summer run steelhead in *Western Trout* (page 62):

"Washington's Quinault has a summer run developed from fish introduced from the Rogue River."

Although the Quinault most likely had summer runs of steelhead thousands of years prior to this evident introduction, it is possible that Quinault summer steelhead may now include Rogue River heritage as well. MacDowell took much of his information from Dr. Paul R. Needham, Director of Fisheries of the Oregon Game Commission, and therefore it is likely an introduction of Rogue River summer steelhead into the Quinault prior to 1948 did indeed occur.

In 1922 the Upper Quinault River was stocked with 200,000 steelhead fry (Taft's 1925). It is possible these were from the Rogue River. However, fry plants of steelhead have a doubtful history of success. Royal's (1972) account of the gradual development of steelhead hatchery programs in the State of Washington indicated that the hatchery program did not result in significant adult returns until rearing of juvenile steelhead to smolt size occurred and growth was accelerated with the development of the dry pellet rearing diet in 1959. Taft's (1925) indicated "rainbows up to 36" were caught in the East Fork (Upper Quinault) by sportsmen. This was included in a description of trout fishing on the Quinault during July, August and September. At the time, summer steelhead were often confused with rainbow trout, and the large fish described had to have been summer run steelhead. They would have been caught prior to the book's printing in 1925, and would have pre-dated any adult returns that could have resulted from steelhead fry plants in 1922 (they would typically have to rear 2 years in freshwater and 3 years in salt water in order to return as 36" steelhead).

In the summer of 1959, the author of this report fished the Quinault briefly with his father near Graves Creek Campground. Two half-pounder size steelhead were caught (14" and 16"), a life history trait the Rogue River is noted for (Everest 1973). However, half-pounder sized steelhead were once a small component to a number of steelhead populations (McMillan 2001). Although the half-pounder life history is most commonly identified with Rogue and Klamath River steelhead populations (Burgner et al. 1992), they historically occurred on the Washougal River in Washington (McMillan 2001), and have been found reoccurring in the Tolt River (through snorkel surveys) after more restrictive angling regulations went into effect (Beardslee 1996; and McMillan 2001).

Photographs in the MacDowell book depict two summer steelhead caught from the Quinault that are posed against a fly rod described elsewhere in the book as 9-9 ½ feet in length. Two bamboo fly rods of the same length described were subsequently measured from the butt to the first guide. Comparing the lengths of the steelhead in the photograph to the placement of the first guide on the rod, one steelhead was 30-31 inches and the other was 26-27 inches, obviously larger than half-pounder size and larger than generally reported from the Rogue River. Recognizable from other photographs in the book is the area near the junction of Graves Creek on the East Fork Quinault.

Kreider (1948) indicated the Quinault had a fine run of steelhead in the summer season, and Bradner (1951) also indicated the Quinault had a fine summer run of steelhead from July onward in the mainstem and in the forks in August and September. He indicated most fish were caught about four miles upstream of Graves Creek in the canyon of the East Fork. This would be near the junction of O'Neal Creek.

Although the run timing of Quinault summer steelhead is generally thought to be May through October as found in other summer steelhead populations (SASSI 1994), this can vary by river as demonstrated by Withler (1966). The summer runs in three rivers of southern British Columbia had differing run timings. Winter and summer run steelhead entered the Capilano and Seymour rivers in equal numbers in the month of April, but on the Coquihalla River the graphed return period showed a well defined break between winter and summer returns with almost no steelhead entry in May. Coquihalla summer steelhead also continued entry well into the fall, some entering immediately prior to the arrival of the first winter-run fish as depicted in the figures from Withler (1966).

This later return timing would appear to be more likely with Quinault summer steelhead. A limited tribal fishery is reported to be directed on wild summer steelhead in July (SASSI 1994), and the tribal catch record commonly shows a large catch in October. Although, there is also a commonly prominent harvest of steelhead in May that has been included in the WDFW summer steelhead catch record from the Quinault (Taylor 1979; and WDFW 2006), there is reason to believe the May catch is primarily late winter steelhead, especially outmigrating kelts, that occurs during the tribal fishery targeting sockeye salmon. The Quinault sockeye are a unique stock with early entry beginning in January and peaking in May and June. The Quinault tribe has a focused fishery on the sockeye with small mesh gill nets that intercept steelhead (SASSI 1994). Presumably that peak target on sockeye in May and early June has resulted in the high tribal catch of incidental steelhead in May.

The high number of steelhead caught in the May tribal fishery on the Quinault River is most likely late winter steelhead and recently spawned winter kelts that are returning to sea as was found in the snorkel surveys by the ONP on the upper Sol Duc River in 2005 (Brinkman 2006). Also, Brenkman and Corbett (2005) found that 107 bull trout were killed as an incidental by-catch in the Hoh River tribal fisheries targeting winter steelhead and spring chinook from January to June of 2002. Their findings indicated that bull trout were intercepted in the tribal fishery during both upstream and downstream movements. The same can be expected to occur with outmigrating winter steelhead kelts in May and June during the Quinault tribal fishery for sockeye salmon.

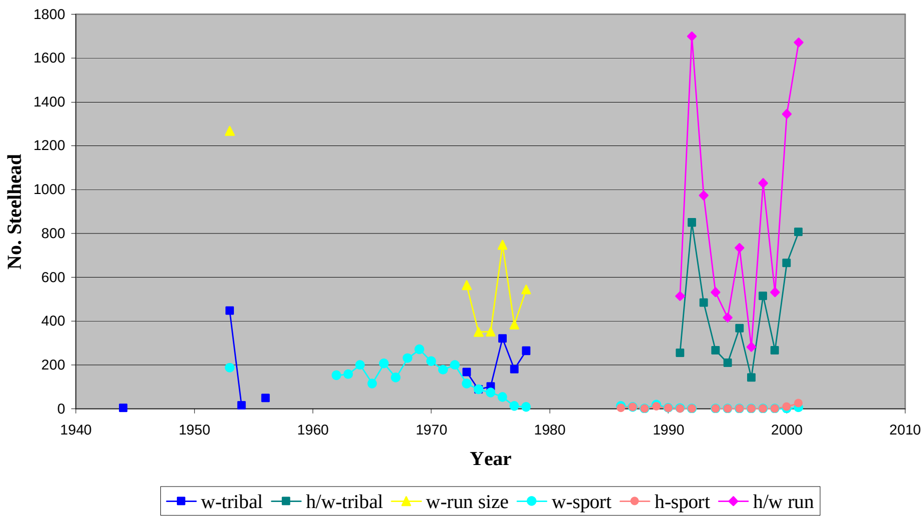
The directed fishery on summer steelhead by the Quinault tribe is described as July (SASSI 1994) which further reinforces the probability that the May and June catch is primarily incidental steelhead kelts. Because of this likelihood, the May catch by both the tribal and sport fisheries have been excluded from the data used for Figure 44 so as not to inflate the catch and run size estimates of summer steelhead that return to the Quinault River. However, the stock reports for Washington (SASSI 1994; and SaSSI 2003) include the inflated catch of probable winter steelhead kelts in May (as high as 1,800 fish with an average harvest over the previous 10 years to 1992 being 910 fish and the five year average harvest previous to 1992 as being 780 fish) which likely contributes to the unfortunate assessment of the Quinault summer steelhead as "healthy." Those assessments were in all probability skewed by the inclusion of winter steelhead kelts.

A catch of 447 wild summer steelhead in October of 1953 is the earliest recorded Quinault tribal catch of any substance (a catch of 2 was reported in October of 1944) [Taylor 1979], although it is probable there would have been more caught that were not recorded as incidental to the targeted sockeye salmon fishery that has been indicated to last into June (SASSI 1994). Although there is no record of sport catch of summer steelhead until 1962, for purposes of determining what the run size of Quinault summer steelhead may have been in 1953, the average sport catch of 187 wild summer steelhead from 1962-1971 was added to the 1953 tribal catch for a total catch of 634 steelhead. 1,268 wild summer steelhead returned to the Quinault system in 1953 if harvest was 50% of the run size, and 2,113 returned if harvest was 30% of the run size (the ranges used by Myers [2005]). With the lack of any earlier record to draw from, this is likely a conservative figure due to the evidence that Washington steelhead numbers in the late

19th century and early 20th century were much larger than the 1950s as previously indicated in this report (Puget Sound, Stillaguamish River, and Queets River).

Figure 46.

Quinault River Summer Steelhead History 1944-2002
[1953 Wild Sport Catch Estimated =10 yr.avg. from 1962-1971; Run Sizes Estimated 2x Catch]

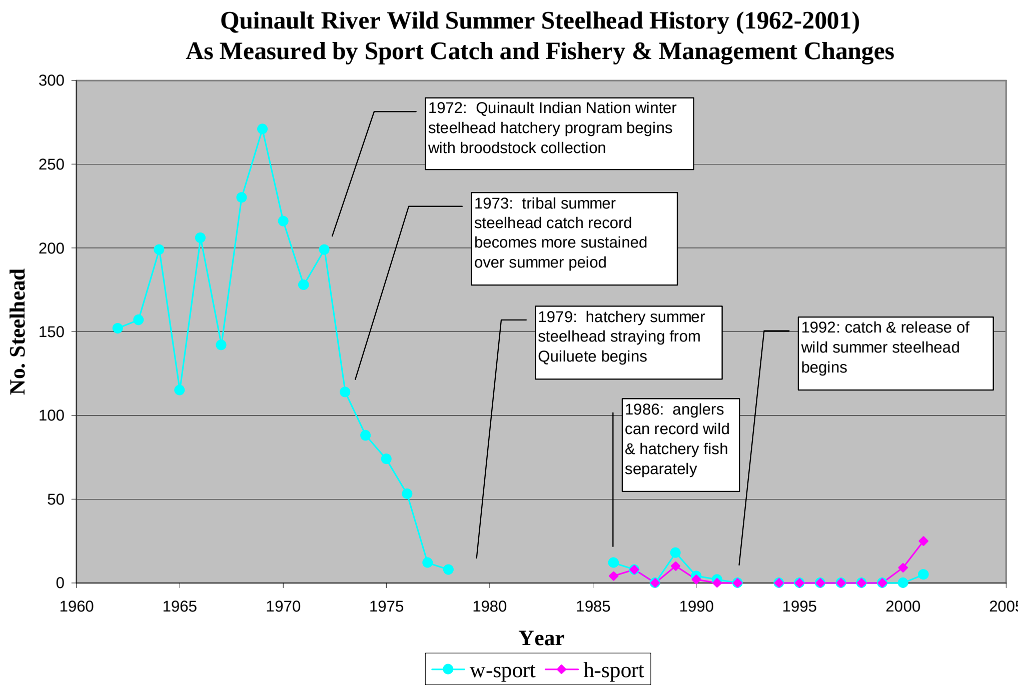


From Figure 46, it is apparent that wild summer steelhead in the Quinault sport catch began to steadily decline toward zero between the early 1970s and the late 1970s (WDG 1962-1986), although the Quinault tribal harvest of wild summer runs remained relatively steady at least until 1978 (Taylor 1979), just prior to when straying of hatchery summer steelhead into the Quinault would have begun from introductions into the Quileute system in 1977 (WDG 1948-1978). From 1979 into the early 1980s hatchery steelhead were found to outnumber wild steelhead in the catches of the Quinault, as well as the Queets and Hoh rivers (Houston and Contor 1984). Although there was a gap in the available tribal catch record from 1979 to 1990, from 1991 to 2002 prominent numbers of hatchery summer steelhead straying into the Quinault are evident from the sudden spikes and just as sudden drops in the mixed hatchery/wild tribal catch in Figure 46 (data from WDW 1987-1993; and WDFW 1994-2002). Hatchery steelhead also stray into the Quinault from Grays Harbor (Chehalis system) and the Columbia River (SASSI 1994). Beginning in 1992, wild summer steelhead were required to be released in the Quinault sport fishery (SASSI 1994) as elsewhere in Washington.

Figure 47 depicts the history of Quinault River wild summer run steelhead as viewed by the sport catch trend from 1962 to 2001 with key steelhead fishery and management changes that have occurred over that span of time.

The first Quinault Indian Nation (Lake Quinault Hatchery) winter steelhead releases were from wild broodstock taken from the Quinault River in 1972. The hatchery steelhead program quickly escalated and by 1980 over 400,000 yearling smolts and an additional 600,000 fingerlings were released into the coastal rivers within their usual and customary fishing areas (Wright 1993). By 1997, 589,800 hatchery steelhead smolts were released into the Quinault system alone (WDFW 2006). Releases of large numbers of hatchery steelhead fry are also made throughout the Quinault Indian Reservation on the Lower Quinault (SASSI 1994).

Figure 47.



Juvenile steelhead rear in Lake Quinault (Mobbs 1999). This may include summer steelhead. The annual addition of up to nearly 600,000 hatchery steelhead smolts plus large numbers of steelhead fry may be creating a density barrier within Lake Quinault and the Quinault River. This would be further compounded if smolt residualism levels are similar to those reported by Tipping et al. (1995) and Royal (1972), combined with other complex hatchery/wild interaction factors.

The only historic tribal catch records found for summer steelhead (Taylor 1979) indicate a relatively limited fishery that was primarily confined to October in just four years from 1941 to 1972 and in May for one year in that same span of time. By contrast, in each of the six years between 1973 and 1978 the tribal fishery took place in 30 of the 36 months of the potential summer return period. This was during the same period as the steep decline that occurred in the sport fishery as depicted in Figure 47. Whether this continuous harvest fishery has remained throughout the summer was not available in the fishery records accessed, but the high harvest rates of mixed hatchery and wild summer steelhead in the tribal fishery suggest continued monthly harvest through the summer steelhead return period still occurs.

Because the tribal catch of summer steelhead in the lower Quinault has not been broken out to differentiate wild from hatchery fish since hatchery straying likely began in 1979, the sport catch provides one remaining measure of the wild summer steelhead trend. Table 21 provides the numerical magnitude of the steep wild summer steelhead decline from 1972 to 1979 (data from WDG 1962-1986, but excluding the May catch if it occurred so as to exclude the possibility of winter run kelts):

Table 21. Quinault River wild summer steelhead sport catch decline from 1972 to 1979, prior to known hatchery straying into the Quinault.

Year	1972	1973	1974	1975	1976	1977	1978	1979
Wild summer steelhead caught	199	114	88	74	53	12	8	0

In the years from 1979 to 1985 there was no way to determine what part of the sport catch was wild and what part hatchery, although in 1979 neither was caught. From 1986 onward hatchery steelhead originating from state hatcheries were marked so origin could be determined (as indicated in Figure 47). In 1992 catch and release of wild summer steelhead was required throughout Washington, and beginning in 1993 released wild steelhead could be recorded on the sport catch punchcard (SASSI 1994). There is no evidence of any kind of recovery thereafter. Smith and Caldwell (2001) also indicated that Quinault River summer steelhead catch appeared to be declining with concern about this stock, although the May catch was likely included with the inflated numbers of winter steelhead kelts included masking the full level of depletion.

The most conclusive evidence of the decline in Quinault summer steelhead is that from the 2005 snorkel surveys by the ONP (Brenkman 2006). Brenkman (per. com. April 2006) indicated there is an angling history of summer run steelhead in both the North Fork and East Fork of the Quinault. Between June 27th and September 26th of 2005, the ONP made eight snorkel surveys on the North Fork Quinault from RM 2.7 to RM 0.0. Not a single steelhead was observed. Between June 14th and September 26th of 2005, the ONP made nine snorkel surveys of the East Fork Quinault with a peak count of eight summer steelhead on August 1st.

No attempt was made to differentiate hatchery from wild steelhead during the ONP Quinault counts (per. com. Sam Brenkman, April 2006), but if the recent sport catch record is representative, the ONP count may have been mostly hatchery steelhead. For instance, in 2000, all nine summer steelhead recorded in the sport catch were hatchery; in 2001, 25 of the 30 summer steelhead recorded in the sport catch were hatchery and only five were recorded as wild (data from WDFW 1994-2002). All would have been hatchery summer steelhead strays from the Quileute, Grays Harbor (Chehalis system), and/or the Columbia as found in the Quinault system (SASSI 1994).

From both the sport catch data and snorkel surveys, Quinault River wild summer run steelhead are approaching extinction levels. From a tribal catch in 1953 of 447 fish in the month of October, and a 1969 sport catch of 271 fish, the sport catch has been reduced to zero, or near zero; the tribal wild catch is presently unknown; and a high count of just eight summer steelhead (likely hatchery and wild combined) was found in 17 ONP snorkel surveys in 2005.

The run timing of Quinault River wild summer steelhead as measured by sport catch from 1962 to 1971 is depicted in Figure 48. The summer run sport catch was primarily from the upper Quinault River (SASSI 1994) upstream of Quinault Lake when significant numbers of summer steelhead still returned to historic destinations in the ONP. This was prior to Quileute system summer steelhead returns that began in 1979 from releases in 1977 (WDG 1948-1978). Subsequent straying of hatchery summer steelhead into the Quinault and other Olympic Peninsula watersheds occurred thereafter, outnumbering wild steelhead in the catches (Houston and Contor 1984).

Figure 48.

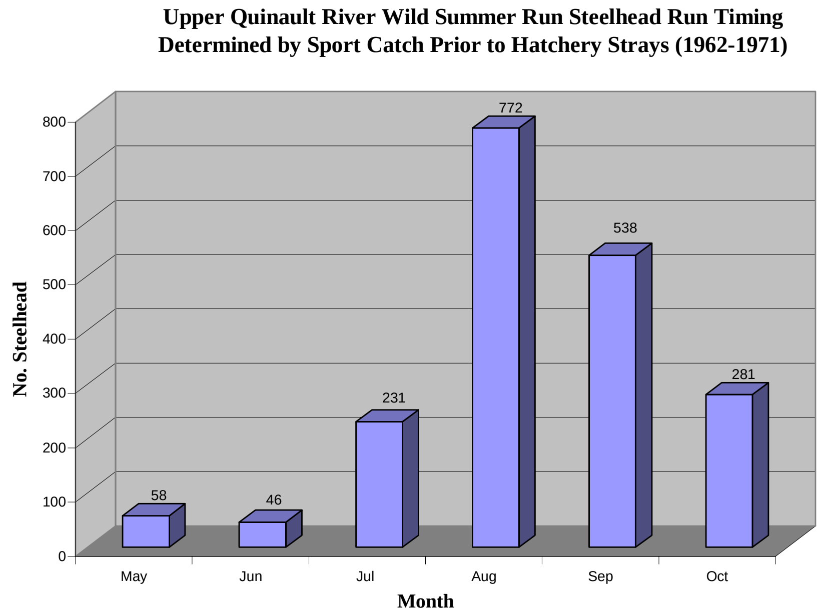
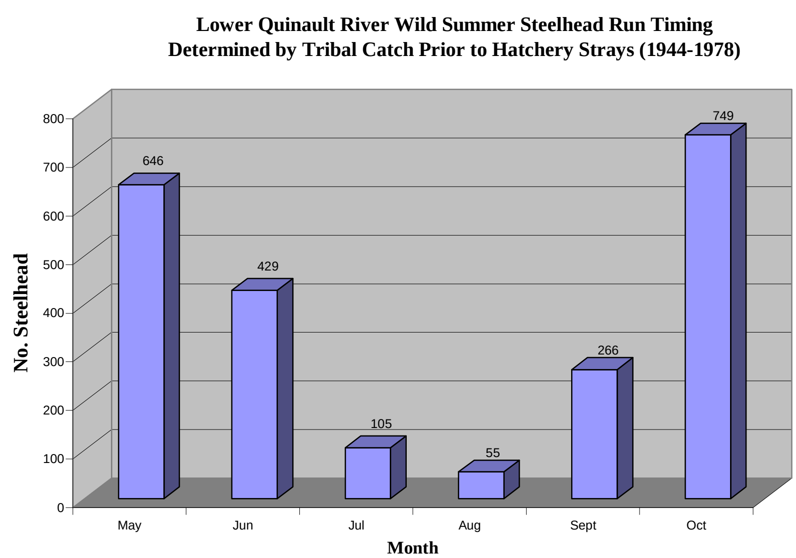


Figure 49.



The May catch has been included in both Figures 48 and 49 to demonstrate the differences in magnitude between the sport and tribal catches in the month of May. The peak of the summer run sport catch in the upper Quinault was August followed by September, then October, and then July. The May catch, although slightly higher than June, was relatively low. If the May sport catch in the upper Quinault was similar to the May snorkel survey findings from the upper Sol Duc River (Brinkman 2006), it was primarily late winter steelhead (commonly outmigrating kelts) rather than summer runs.

Wild summer steelhead run timing as determined by tribal catch in the lower Quinault River from 1944 to1978 (prior to returns of Quileute hatchery summer steelhead returns that began in 1979 with subsequent straying) is provided in Figure 49 which depicts the relatively large catches in May and June (data from Taylor 1979). This likely coincided with the targeted sockeye salmon fishery with the peak of the sockeye run occurring in late May and early June as described in SASSI (1994). Both the May and June catches were likely dominated by wild winter steelhead, especially downstream migrating kelts, as indicated by the findings of Brenkman (2006) on the upper Sol Duc, and similarly suggested by the interception of many bull trout going both upstream and downstream during the January to June tribal fisheries on the Hoh River (Brenkman and Corbett 2005).

WINTER STEELHEAD

Wild winter steelhead in lower Quinault River/Lake Quinault and the upper Quinault River are thought to be distinct stocks isolated from interactions with each other by the lake with little gene flow between them which is supported by genetic analysis (SaSSI 2003). The spawner escapement of wild winter steelhead in the Quinault basin are comprised of about 65% Quinault/Lake Quinault stock and 35% Quinault stock. The status of wild winter runs was listed as "healthy" in the WDFW stock assessment reports (SASSI 1994; SaSI 2003).

Of interest, the confirmed western-most limit of North American steelhead distribution during Pacific Ocean migration based on tagged fish recovery was a coded-wire-tagged fish from the Quinault River captured by a Japanese research vessel in 1989 that was 5,370 km (3,337 mi) from the river mouth (Dahlberg et al. 1989). Presumably this fish was from one of the two hatchery locations on the Quinault Indian Reservation (wild Quinault broodstock origin).

The first tribal releases of hatchery reared steelhead were of 1972 brood year Quinault River stock (Wright 1993), with fry releases that may have begun in 1972 and smolt releases by 1973. Adult returns likely began in the winter of 1974/75. In the 1992 SASSI (1994) it was reported that about 300,000 hatchery steelhead smolts were released into the Quinault system annually. However, the smolt releases into the Quinault system since that time have averaged about 430,000 per year with nearly 600,000 released in 1997 (WDFW 2006). The Quinault hatchery stock is of Quinault River origin with rearing occurring at the Quinault Indian Nation Lake Quinault Hatchery and the U.S. Fish and Wildlife Service Quinault National Fish Hatchery.

The 1992 SASSI (1994) report also indicates:

"Releases of large numbers of hatchery fry have occurred throughout the Quinault Indian Reservation on the lower Quinault River."

In the proceedings of the 1992 Washington Steelhead Symposium, Terry Wright (1993), of the Northwest Indian Fisheries Commission, indicated:

"The Quinault Tribe's annual production grew rapidly, and as early as 1980 they released over 400,000 yearling smolts and an additional 600,000 fingerlings into the coastal rivers within their usual and custom fishing area."

Releases of fry and pre-smolts are hatchery practices long ago identified for their historic lack of success at bringing back adult returns in early hatchery programs (Pautzke and Meggs 1940) and for creating competition with wild juveniles in which their "survival is probably deductible from that of the wild population" (Royal 1972). In the case of coho and steelhead, which typically rear respectively for one and two years before smolting, hatchery fry releases can be anticipated to so compromise wild juvenile production that eventual replacement of the wild rearing population with a hatchery-dependent population might be expected to occur. This apparently happened with coho on the lower Columbia River (Flagg et al. 1995). Despite the history of fry release failures and consequences, both smolt and fry releases are expected to contribute to natural production as determined in the stock assessments for Washington by the steelhead managers (SASSI 1994). Although the contribution to, or the potential deduction from the wild stock from hatchery fish spawning in the wild remains unknown (SASSI 1994), from the sheer magnitude of the Quinault hatchery steelhead program Wright (1993) indicated:

"In a case like this … there's no doubt that there's an awful lot of interbreeding going on between hatchery and wild fish. It is time that we start assessing that impact."

14 years after the 1992 symposium where Terry Wright (manager of the Enhancement Services Division of the Northwest Indian Fisheries Commission for 12 years at the time) recommended an assessment of the Quinault hatchery steelhead program, no such assessment has ever been made, nor elsewhere in Washington.

Figure 50 provides the wild steelhead catch history for the Quinault system compared to the only existing escapement goal that is limited to the Upper Quinault. The wild winter steelhead run sizes prior to 1975 (when no wild escapements were determined) have been estimated to be twice the total catch based on the estimate by Myers (2006) that harvest is 50% to 30% of the run size. In the case of the Quinault, modern harvest has been 47.6 % of the run size (SASSI 1994); very close to the 50% used for the pre 1975 estimates. Using the 50% criteria, the Quinault's highest run size between 1940 and 2003 was 19,000 wild winter steelhead in 1952. Run sizes were undoubtedly higher in the late 19th century and early 20th century as was found for those Washington steelhead populations examined earlier in this report that had harvest histories from 1895 to the early 1920s.

As is apparent from Figure 50, since the initiation of hatchery steelhead releases into the Quinault River in 1972, there has been a sustained downward trend in the wild winter steelhead run size returning to the Quinault system.

There is no stated escapement goal for the Lower Quinault/Lake Quinault stock of wild winter steelhead in the 1992 SASSI (1994) but there is an available escapement history from WDFW (2006). From 1978 to 1992 escapements ranged from 2,488 to 5,774 wild winter steelhead with an average of 3,999 fish reaching their spawning grounds; from 1993 to 2004, escapements ranged from 1,867 to 3,648 wild winter steelhead with an average of 2,519 fish reaching their spawning grounds, a reduction of 1,480 wild spawners (37%) over the past 12 years. Smith and Caldwell (2001) concur that lower Quinault River winter steelhead run sizes have significantly declined.

Figure 50.

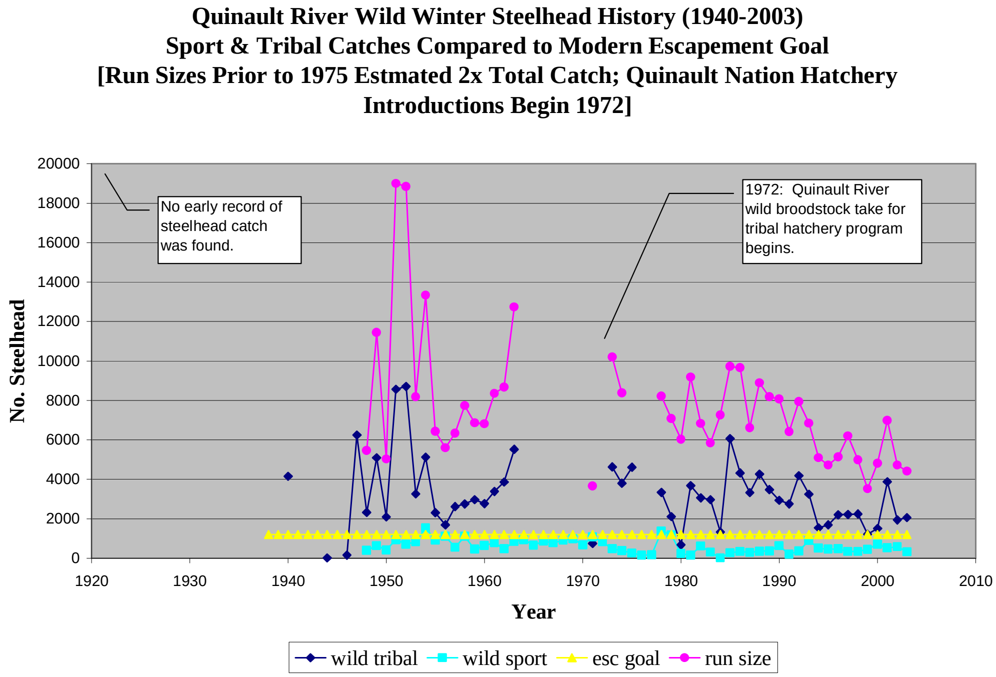


Figure 51.

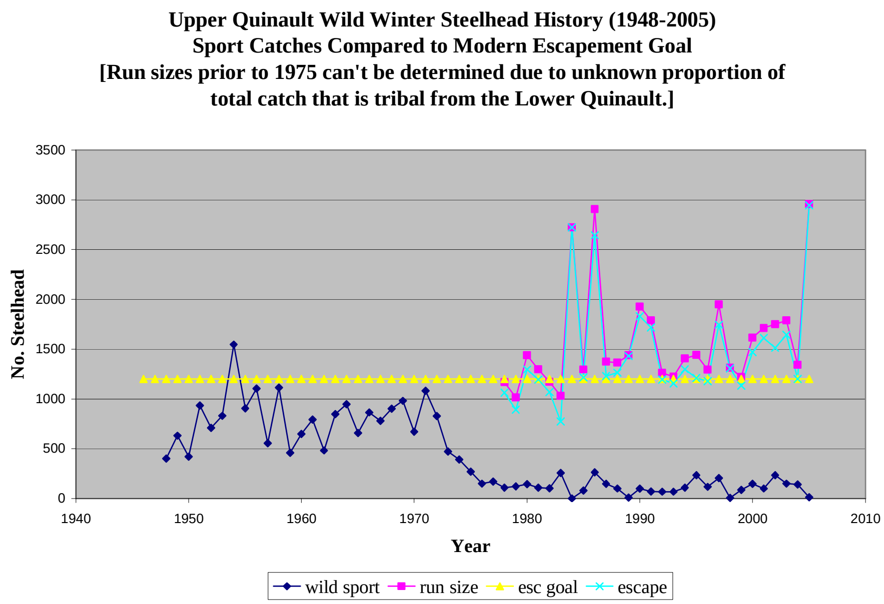


Figure 51 provides the wild steelhead sport catch history for the Upper Quinault River from 1948 to 2005 (data from WDG 1948-1978; and WDFW 2006) as compared to the established escapement goal of 1,200 wild winter steelhead and the actual escapement from 1978-2005. Wild run size estimates prior to 1975 could not be made due to an unknown proportion of the Lower Quinault tribal catch that may be destined for the Upper Quinault. The sport catch began a rapid and sustained decline beginning in the early 1970s and bottomed out in the early 1980s, where it has remained.

Table 22 provides the numerical magnitude of the wild winter steelhead depletion that occurred on the Upper Quinault from 1971 to 1982.

Table 22. The Upper Quinault wild winter steelhead sport catch decline from 1971 to 1982.

Year	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
Wild winter steelhead sport catch	1,081	826	471	390	269	148	169	108	122	143	107	101

In the 24 years from 1948 to 1971 the average sport catch of wild winter steelhead in the Upper Quinault was 802 fish per year; in the 11 transitional years from 1972 to 1982 the average annual sport catch dropped to 260 fish per year; and during the 23 years from 1983 to 2005 after the sport catch bottomed out it has averaged 116 fish per year, or 14% of that from 1948 to 1971. Although wild steelhead escapements have not altered dramatically from 1978 to 2005 on the Upper Quinault, there is no escapement history from which to make any comparisons before the sport catch bottomed in the late 1970s and early 1980s. The winter steelhead sport catch decline in the Upper Quinault reflects that of the wild summer run decline, although it has not yet bottomed out as low.

Smith and Caldwell (2001) also expressed concerns that run sizes of winter steelhead returning to the Upper Quinault River appear to be declining.

Unfortunately, no historic record earlier than 1940 was found for Quinault River steelhead. The Quinault cannery records from 1911 to 1928 do not indicate steelhead were canned which is explained by Cobb (1930):

"This stream (the Quinault) is especially noted for its long-continued annual run of Quinault salmon (O. nerka). These fish, which are noted for their especially red-colored flesh, make their appearance early in December, when the Indians generally catch them for their own use as they fear that if the whites got hold of the fish they might throw away the hearts. Should a heart be eaten at this time by a dog or chicken, the Indians believe the run would not come. In January when the fish begin to be abundant, all danger of this seems to have passed, for the Indians then usually have a considerable number for sale, and these are generally shipped to distant markets in a fresh condition by the buyers. As soon as the canneries open at Moclips, most of the fish are disposed of at that place. The run continues to July 1. May and June are the best fishing months."

"There is a fall run of Chinooks in this river, which usually arrive in August and ends about October 15.

"The silver salmon appear about October 1 and the run is generally over by November 15; the chum salmon appear about November 1 and the run is usually over by the middle of the same month, while the steelhead trout run between November 20 and May 1. None of the latter are canned."

This is a concise and important history of run timing of Quinault salmon and steelhead. It provides clues that steelhead were probably caught and sold, but not to the cannery. For instance, in the 1880s and 1890s the Quinault salmon catch was sold to buyers from Grays Harbor where canneries were in operation (Wilcox 1898) and probably for the fresh fish market as well. The fresh fish market was the preferred destination for steelhead (Wilcox 1898). This was similarly the case for many sockeye on the Quinault as evident from the quote from Cobb (1930). Cobb also indicates that buyers for fresh fish markets would have been available for the sale of steelhead on the Quinault. Such sales would not have shown up in the cannery records. However, a large steelhead pack of 1,500 cases was recorded at the Queets River in 1923 (Cobb 1930) [estimated as a catch of 24,490 steelhead]. This is evidence of what steelhead catches may have been on neighboring Olympic Peninsula rivers in that era. Those steelhead catches would have been more typically sold to the fresh fish market rather than to canneries.

Figure 52.

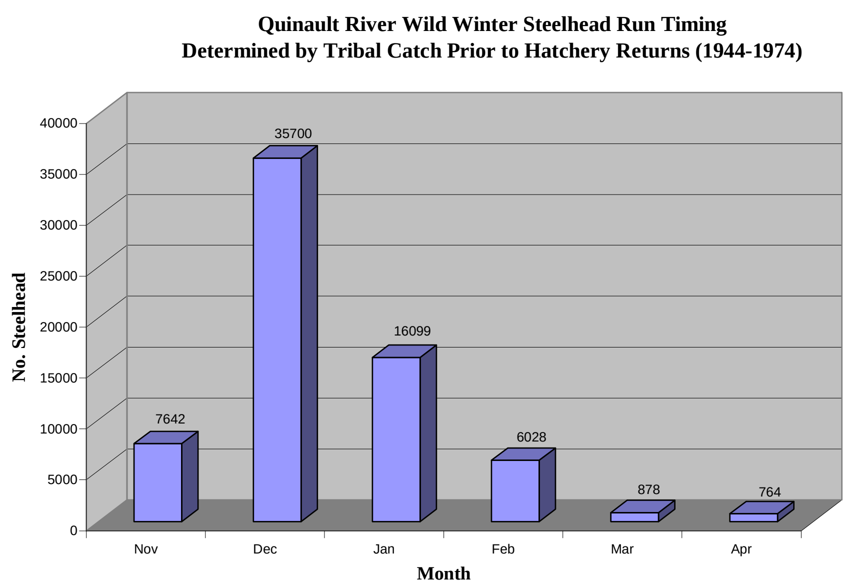


Figure 53.

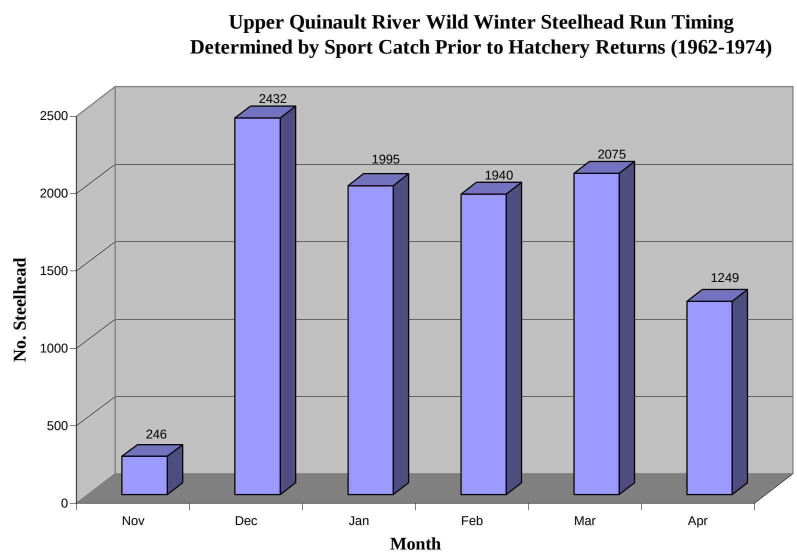


Figure 52 depicts the historic run timing of wild winter steelhead through the Lower Quinault River as determined from tribal catch records from 1944 to 1974 (data from Taylor 1979) prior to major hatchery introductions in 1972 (Wright 1993) with adult returns likely beginning in the winter of 1974/75. The tribal catch in the Lower Quinault River represents initial entry timing for the entire Quinault system with peak entry in December followed by January and then November. The March and April catches are very low, either depicting minimal movement through the Lower Quinault at that time, or reduced tribal fishing effort. Because sockeye salmon entry begins as early as January in the Quinault, with peak sockeye entry in May and early June (SASSI 1994), it would seem probable that tribal fishing effort remains relatively high in both March and April. If this is the case, the tribal net fishery probably reflects the actual run timing of wild winter steelhead through the Lower Quinault.

By contrast, Figure 53 depicts the historic run timing of Upper Quinault River wild winter steelhead as determined by sport catch records for the period when monthly catch records were available (data from WDG 1962-1986). As is apparent, the run timings indicated by the two fisheries are very different as separated by Quinault Lake.

One possible explanation is that the two stocks of wild steelhead had very different run timings. However, the more probable explanation is that after initial entry the Upper Quinault steelhead held over in Quinault Lake until shortly before spawning time and then resumed migrations to their spawning ground destinations above the lake. Given the very different run timing depicted by the sport catch from the Upper Quinault as compared to all of the other Olympic Peninsula rivers in this report, the latter seems the most probable. If this is the case, the run timing into the Upper Quinault may resemble the even distribution of spawning timing that may occur from January through May. The Quinault is the only river of the four basins examined that has a large lake separating the net fisheries from the sport fisheries.

Of particular concern, the Lower Quinault tribal fishery that targets sockeye salmon in May and early June, with significant catches of outmigrating steelhead kelts, could reduce life history diversities represented by wild winter steelhead that spawn multiple times. A similar concern was expressed by Brenkman and Corbett (2005) regarding interception of both upstream and downstream migrating bull trout in the tribal net fishery on the Hoh River where 107 bull trout were harvested as an incidental by-catch in the legal winter steelhead and spring chinook salmon commercial fisheries from January to June 2002.

Loss of Life History Diversity Through Harvest of Steelhead Kelts

It is not now known what proportion of wild steelhead populations once survived to spawn more than once that returned to North Coast Olympic Peninsula rivers before industrial scale fisheries occurred. A wide range of respawner rates is known to have historically occurred among the wild steelhead populations around the North Pacific Rim. Some of these are listed in Table 23.

It has been generalized that relatively high respawner rates only occurred among steelhead populations from Oregon southward (Busby et al. 1996), but this is obviously not the case as shown in Figure 23. In fact, the highest respawner rates found were both in the northern extreme of steelhead range, 79% on the Utkholok River in Kamchatka (Savvaitova et al. 1997) and 70% at Peterson Creek in Alaska (Harding and Jones 1991).

Table 23. Differing wild steelhead population respawner rates from around the North Pacific Rim and the investigators who documented them.

River	State, province, or nation	Year	Percent respawners	Investigator(s)
Hoh	Washington	1949	14.0%	Larson & Ward
Hoh	Washington	1950	6.7%	Larson & Ward
Hoh	Washington	1985	9.2%	Hiss et al.
Green	Washington	1940	5.0%	Pautzke & Meigs
Green	Washington	1941	6.9%	Pautzke & Meigs
Chehalis	Washington	1948	9.0%	Larson & Ward
Cowlitz	Washington	1947	4.4%	Larson & Ward
Cowlitz	Washington	1948	7.8%	Larson & Ward
Alsea	Oregon	1953	17.1%	Chapman
Alsea	Oregon	1954	12.4%	Chapman
Alsea	Oregon	1955	3.2%	Chapman
Oregon North Coast	Oregon	1955	27.9%	Bali
Oregon South Coast	Oregon	1955	53.3%	Bali
Coquille	Oregon	~1955	38.3%	Bali
Waddell Ck.	California	<1954	22.9%	Shapovalov & Taft
Alouette	British Columbia	1949-1958	14.4%	Withler
Coquitlam	British Columbia	1949-1958	5.4%	Withler
Chehalis	British Columbia	1949-1958	6.4%	Withler
Chilliwack	British Columbia	1949-1958	5.8%	Withler
Cheakamus	British Columbia	1949-1958	31.3%	Withler
Capilano	British Columbia	1949-1958	7.8%	Withler
Coquihalla	British Columbia	1949-1958	6.4%	Withler
Seymour	British Columbia	1949-1958	5.0%	Withler
Karta	Alaska	1983-1993	38.0%	Harding & Jones
Petersburg Ck.	Alaska	1972-1976	38.0%	Jones
Peterson Ck.	Alaska	1989	70.0%	Harding & Jones
Peterson Ck.	Alaska	1991-1992	51/0%	Harding & Jones
Sitkoh Ck.	Alaska	1982-1993	38.0%	Harding & Jones
Situk	Alaska	1983	25.0%	Jones
Situk	Alaska	1996	59%	Johnson
Utkholok	Kamchatka Pen. Russia	1972	~35%	Savvaitova et al.
Utkholok	Kamchatka Pen. Russia	1995	79%	Savvaitova et al.
Snatolvayam	Kamchatka Pen. Russia	?	58%	Pavlov et al.
Kvachina	Kamchatka Pen. Russia	?	63%	Pavlov et al.
Sopochnaya	Kamchatka Pen. Russia	1997-1998	39.7%	Pavlov et al.
Saichek	Kamchatka Pen. Russia	?	10%	Pavlov et al.

Steelhead and cutthroat differ from other species in the genus of *Oncorhynchus* in their potential to spawn more than once, which is termed in commonly unnecessary fishery science jargon as iteroparity as opposed to semelparity (limited to one spawning).

Semelparity has been described as one effective adaptive strategy by Schaffer (2004) in which:

"…the adaptive significance of 'big bang reproduction' (semelparity) whereby a single, often spectacular, bout of breeding is followed by the organism's obligate demise."

By contrast, in the same textbook on salmonid evolution, Stearns and Hendry (2004) describe the comparative adaptive strategies of iteroparity and semelparity:

"The evolution of risk-minimizing adaptations (bet-hedging) does not appear to have been given the attention in salmonids that it deserves. Iteroparous species have the potential to breed several times, spreading their risk temporally. They also tend to build several discrete redds in different areas, spreading their risk spatially (Barlaup et al. 1994). Pacific salmon, in contrast, are semelparous and build only a single redd, thus reducing their temporal and spatial spreading of risk."

Schaffer (2004) concludes regarding the different spawning strategies and development of simple models to predict reproductive consequences:

"…semelparous salmonids generally breed under higher densities than their iteroparous allies …(although) the situation is really quite complex … In short, the matter remains murky, for which reason, this essay concludes , not with an answer, but with an open question…"

Although predictive conclusions may remain elusive, the adaptive strength and resiliency of steelhead, despite relatively small population sizes as compared to many historically large populations of Pacific salmon, is generally agreed to be linked to their life history diversity. Busby et al. (1996) indicate:

"Oncorhynchus mykiss is considered by many to have the greatest diversity of life history patterns of any Pacific salmon species (Shapovalov and Taft 1954, Barnhart 1986), including varying degrees of anadromy, differences in reproductive biology, and plasticity of life history between generations."

Burgner et al. (1992) concur:

"Steelhead possess an array of life history features that reflect extreme adaptability to a wide variety of environmental conditions. These features combine to make steelhead life history the most complex and diverse of all the species of Oncorhynchus."

Much of that inherent life history diversity and subsequent resiliency of steelhead is lost with a reduction in respawner rates. It provides obvious benefits for increasing egg deposition for relative low fish population sizes. Most respawners are females (Shapovalov and Taft 1954; Pautzke and Meigs 1940; Bali 1958; Savvaitova et al. 1973; 1996; 1997; and Busby et al. 1996). For example, it was found on the Utkholok River in Kamchatka where poaching of Red Book listed steelhead had occurred with reduced anadromous population levels, one of the life history responses by steelhead was a significant increase in the respawner rate and subsequent adult returns heavily skewed toward females (Savvaitova et al. 1996; 1997; and Pavlov et al. 2001). There was also a corresponding response in higher levels of resident rainbow life histories that were predominantly male. The Russians found the population had adjusted with a self regulating "natural homeostasis." An increase in female respawners would maintain relatively high egg deposition, and the increase in the resident life history (predominantly male) insures fertilization.

Having been a member of the Russian-American expedition to Kamchatka the year this was discovered, the author of this report has since attempted to evaluate why reduced population levels of steelhead on the Olympic Peninsula, elsewhere on the Washington Coast, Columbia River, and British Columbia, have not similarly responded.

Many of the rivers in these North American areas, and the marine regions in their proximity, have histories of commercial fisheries that target chinook and/or sockeye salmon from May through June when it may be anticipated that wild winter steelhead kelts would be attempting to return to salt water. For instance, significant numbers of bull trout migrating in and out of the Hoh River were found as incidental bycatch mortalities in the tribal net fishery from January through June (Brenkman and Corbett 2005); significant bycatch of steelhead in the Quinault River by the tribal fishery targeting sockeye occurs in May and June (SASSI 1994); and snorkel survey observations by the ONP on the upper Sol Duc River and elsewhere on the Olympic coastal rivers in May have found that nearly all steelhead were late winter runs (mostly kelts) [Brenkman per. com. 2006]. It is apparent that many wild winter steelhead kelts attempting to migrate out of river systems are likely caught in significant numbers as incidental bycatch to commercial fisheries targeting other species.

In Kamchatka such spring fisheries, legal or otherwise, have not been mentioned to occur in the rivers where steelhead return. This may be related to swollen and debris filled flows, and potentially ice out as well, which coincide with steelhead kelt outmigrations. The outmigration peak may also occur before salmon fisheries begin in earnest. The latter is the case with Alaska's Situk River where steelhead respawner rates are high and commercial set gillnet fisheries don't occur in the estuary until late June, although some interception of late kelts does occur (Bain et al. 2003).

Sport fisheries may also have increasingly harvested significant numbers of earlier outmigrating, as well as later outmigrating, kelts on Olympic Peninsula rivers (and elsewhere). Peter Hahn (Appendices of WDFW 1996) provided historic sport fishing regulation comparisons from the 1940s and 1950s through the mid 1990s on the Quileute River system. Fishing seasons often ended for steelhead at the end of February or March 15 for entire Quileute sub-basins or large sections of them in the earliest era. Over time they have commonly been extended to April 15th or April 30th. On the Olympic Peninsula, although many river sections are closed to sport fishing for steelhead from mid April (or the end of April) through May, and by the first of June all steelhead are now required to be released to protect summer runs in Washington, previous sport harvest of kelts may have had a significant impact.

Harvest of kelts in both sport and tribal fisheries may have created a negative long term impact if higher respawner survival is a genetically passed trait through family lines. If this has occurred, it may take focused protection of kelts over many generations to potentially restore this trait with its obvious advantages for steelhead population recovery and productivity through an anadromous population shift toward increased female egg deposition. For natural homeostasis to occur, as found in Kamchatka, it would also require the coordinated protection of resident trout populations that are primarily male as found on the Calawah and Sol Duc rivers (McMillan 2006 [in prep.]) as well as in Kamchatka (Savvaitova et al. 1973; 1996; 1997; and Pavlov et al. 2001).

Historic Salmon Abundance, Reasons for Depletion, and Missing Nutrients for Quinault Steelhead

In *Mountain in the Clouds: A Search for the Wild Salmon*, Bruce Brown (1982) wrote:

"The Quinault salmon … were arguably the single most famous run on the Pacific coast of North America. When the whites arrived on the Columbia, they found that the choicest fish came not from that mighty salmon producer, but rather from a small river about eighty miles up the coast. In April 1813, a geographer for the Northwest Company named David Thompson wrote of his stay at the mouth of the Columbia that 'Concomly [a chief of the Chinook Tribe] brought a few beaver in trade, and some Queenhithe dried salmon, which were excellent – the best fish I have seen on the Columbia.' The Chinook Tribe, which owned the premier fishing grounds on the Columbia, esteemed the Quinault sockeye so highly that they used it as an all-purpose term of excellence. Whites after Thompson picked this up and mistakenly applied the name to the most prized of the Columbia's runs, the salmon now known as the Chinook. For half a century Chinook salmon were known as 'Quinnat,' and even today the name persists in Europe and New Zealand."

"It is difficult to determine exactly how large the Quinault sockeye run originally was. We know that early explorers shot the blueback for sport with their revolvers as the fish leaped from the waters of Lake Quinault, and the Quinault Indians traded them in dried form from the Columbia to Cape Flattery. The largest early catch reported was 367,260 sockeye in 1915, with an estimated run size that year of at least 600,000 fish."

In 1915 the records of the Indian agent showed that the Indians fishing on the north side of the Quinault river caught 219,654 sockeye salmon, while those on the south side caught 135,353 of these fish for a total of 355,007 sockeye salmon (Cobb 1930), slightly less than reported by the source used by Brown. If the run size was twice the catch, 710,014 sockeye returned to the Quinault in 1915 (over 100,000 more than the estimate provided to Brown), and this estimate does not include the considerable numbers used by the tribal members themselves as reported by Collins (1892).

Cobb (1930) further reported:

"This does not take into account the result of the fishing for the other species of salmon and steelhead trout which quite materially swell the total."

However, even by 1915 Quinault sockeye had been depleted as further documented by Brown (1982):

"…The run was probably larger once though, for that same year (1915) *a report to the U.S. Commissioner of Fisheries noted that 'the salmon [run] in the Quinaielt Lake and River has materially decreased in recent years.' With increased logging along the fishes' primary spawning grounds above the lake, the catch of sockeye in the Quinault fell to 15,665 in 1920, the 'smallest ever known to that time.'"*

Brown then continues with the description of failures to address the real fishery problems on the Quinault, the construction and operation of a fish hatchery instead, and the continuing decline of Quinault sockeye:

"The Commissioner of Fisheries' remedy for the problem on the Quinault was to construct a salmon hatchery on Lake Quinault, which…took place during the First World War. Although acutely aware from the Bureau of Fisheries' own reports of the damage logging was doing, he chose to avoid any direct confrontation with the loggers or the timber interest that stood behind them. Only when the hatchery itself was imperiled did the U.S. Bureau of Fisheries raise a timorous voice of protest. The rest of the time it was more than willing to use unchecked logging abuses as a justification for expanded hatchery work. 'While there is at present no positive proof of the efficiency of propagation as carried on by the [Quinault] hatchery,' a bureau report from the 1930s noted, 'it would seem, owing to the present hazardous conditions under which natural propagation must take place, that the hatchery should be of considerable value in maintaining the runs of sockeye."

"…The hatchery collected the eggs and sperm from the fish, mixed them and laid the fertilized eggs in the troughs. Upon hatching they were released into the lake. It was supposed that more juvenile sockeye in Lake Quinault automatically meant more adults returning later, but this did not prove to be the case.

"…The last of the great Quinault sockeye runs occurred during the 1940s. Old Indian fishermen at the Quinault village of Tahola still remember how thick the quick little fish were in those years, their weight in the nets, and the money they made. In 1941, Quinault Indian fishermen caught 509,140 blueback, the most on modern record. With a faraway war raging in Europe and Asia, it seemed for a few years that the world had passed the Quinault by. The sockeye ran strong in 1940, 1941, 1942, 1947, and 1949, but after that there were no more catches of 200,000 fish, and after 1956 there were no more catches of even 100,000 fish. When Lake Quinault hatchery was closed in 1947 it was revealed that the wild sockeye that once may have numbered 1,000,000 were now barely able to sustain one-tenth that."

In the five years from 1987 to 1991 Quinault River sockeye run sizes averaged 55,176 (SASSI 1994), and in the five years from 1996 to 2001 the run sizes averaged 24,028 (SaSSI 2003). The latter is 2.4% of the 1941 run size (if the run size was twice the catch of 509,140 fish), yet the Quinault sockeye run is listed as "healthy" in the 2002 SaSSI (2003) report. This does not even consider the fact that the sockeye run had already significantly declined by 1915 (Brown 1982).

The depletion in nutrients can only have been staggering from a sockeye salmon run reduced by 97.6% in the span of 65 years of industrial level resource extraction from the forests, and from the Quinault River and Lake Quinault.

What led to the demise of Lake Quinault sockeye?

As in most cases, it was a combination of over harvest, habitat alterations, and hatcheries. Yet none of these are as irreparable as dams which did not occur on any of the coastal rivers of the Olympic Peninsula. Although Brown (1982) did not address the impacts of harvest, he provided the evidence of it: "The run was probably larger once though, for that same year (1915) a report to the U.S. Commissioner of Fisheries noted that 'the salmon [run] in the Quinaielt Lake and River has materially decreased in recent years.'" Smith and Caldwell (2001) indicate that timber harvest did not begin "in earnest" until 1916 in the Quinault basin, after the runs were already reported in decline. Without dams, habitat alteration, or hatcheries, that leaves harvest as the probable mechanism of early depletion.

The Quinault tribe had been providing sockeye salmon to the Euro-American trade market since at least 1813 as Brown (1982) indicated with a quote from explorer David Thompson. When Thompson arrived at the mouth of the Columbia River, the Quinault salmon were already well known as the preferred fish for consumption. The historic importance of Quinault sockeye is so ingrained into Euro-American culture that the term "Quinnat salmon" is still applied mistakenly to chinook salmon 200 years later in Europe and New Zealand. It was in the early 19th century that the salt packing process was introduced by the Northwest Company and later continued by the Hudson Bay Company, for which the "Quinnat …sockeye salmon were the principal species employed in the earlier years (Cobb 1930)."

Sea otters were historically abundant in Washington between Point Grenville and Grays Harbor (Richardson and Allen 2000) and were described by Scammon (1870:70-71) as "the most noted grounds" for sea otter harvest between San Francisco and the Strait of Juan de Fuca. In 1792, Captain Robert Gray stopped somewhere along the Olympic Peninsula coast and the crew of his ship traded for sea otter pelts (Scheffer 1940). Point Grenville is just three miles south of Tahola and the mouth of the Quinault (Washington Atlas & Gazetteer, 1995, DeLorme, Freeport, Maine).

All of the evidence indicate that Tahola, at the mouth of the Quinault, would have been an obvious point for Russian, English, Spanish, and American ships to stop to trade for sea otter furs and to reprovision with available "Quinnat salmon" as the preferred food item available from West Coast native tribes. This undoubtedly began in the 18th century. The Quinault tribe would have profited early on in this trade for both sea otter and sockeye salmon they could provide in abundance to the many ships from foreign lands. The Quinault tribe had become an established part of the "industrial economy" by the beginning of the 19th century.

Sea otters went extinct in Washington by 1911 (Richardson and Allan 2000) strictly due to overharvest. Salmon depletion in the Quinault followed the same early trend of sea otter depletion. But salmon were more numerous with higher fecundity per individual. It took longer to deplete them, and other factors have been added along the way, but overharvest was the initial factor for reducing salmon numbers and making them that much more vulnerable to habitat alterations and hatcheries that have followed.

A salmon hatchery was built on Lake Quinault during the First World War. Brown (1982) explains:

"During the first two decades of its existence, the Lake Quinault hatchery was more bane than boon to the blueback. Assuming the runs of sockeye in different rivers were interchangeable, the hatchery imported sockeye eggs from Afognak Island in the Gulf of Alaska. As these Alaskan fish interbred with the bluebacks they dulled the native fishes' hereditary adaptation to the river, making the wild sockeye less efficient reproducers. The Afognak transplants were also heavily infected with a viral fish disease

known as IHN. Fisheries biologists like Larry Gilbertson speculate that IHN may not have been such a serious problem on the Quinault before the hatchery…"

There were also exotic fish introductions that could have upset the biological balance in Lake Quinault. Taft's (1925) indicates that there were the following hatchery releases:

"…1920. 40,000 Mackinaw fry and 237 silver trout (probably kokanee) *fry stocked, 1916, 7,750 Beardslee fry* (strain of rainbow from Lake Crescent)*, 1918, 27,000 Crescenti fry* (strain of cutthroat from Lake Crescent)*, 1922, 50,000 silver trout* (probably kokanee again) *fry."*

If the Mackinaw took hold for a time, they could have become particularly predatory on juvenile sockeye rearing in the lake, and the kokanee released could have added still more competitive stresses for a population of wild sockeye that was already struggling. For instance, in 1920 the catch of sockeye fell to 15,665, the smallest known at the time (Brown 1982). Through all of this, harvest apparently continued unabated.

The other salmon species of the Quinault basin have followed the sockeye trend. In 1911, a total of 5,000 cases of chinook salmon was packed at the Quinault cannery (Cobb 1930). At 48 one pound cans per case, it represented 240,000 pounds of chinook after processing. Myers (2005) indicated 50% wastage for chinook during canning meaning 480,000 pounds of chinook salmon were sold to the cannery. Wilcox (1898) indicated the average chinook was 20 pounds for Puget Sound waters, indicating 24,000 chinook were sold to the cannery. If the catch was 50% to 30% of the run size, the range used by Myers (2005), the Quinault chinook salmon run size was 48,000-80,000 fish, likely spring and fall stocks combined, in 1911.

In 1913, a total of 7,106 cases of coho salmon was packed at the Quinault cannery (Cobb 1930). At 48 one pound cans per case, it represented 343,688 pounds of coho after processing. Using Myers' (2005) range of 50%-70% wastage, it would represent 682,176-1,136,960 pounds of coho sold to the cannery. Wilcox (1898) indicated the average Puget Sound coho caught was 8-8.5 pounds. Using the heavier of the two, it would mean that 80,256-133,760 coho had been caught. The 1913 wild coho run size would have been 160,512-267,529 if catch was 50% of the run size, the lowest harvest rate suggested by Myers (2005). However, wild coho salmon returns only averaged 42,500 from 1936 to 1945 and the mixed stocks of what are now hatchery and wild fish (SASSI 1994) dropped further to 25,700 between 1978 and 1987 (Lestelle and Blum 1989). The present population of coho is thought to be a composite of hatchery and wild coho due to mass fry releases and hatchery straying throughout the system that has occurred. The Cook Creek hatchery stock is composed of various Puget Sound and north coastal coho stocks with early run timing to allow increased harvest rates, and no recent efforts to assess natural coho production and escapement goals have occurred since Quinault coho are managed to meet hatchery production needs (SASSI 1994). The present wild coho status is considered "unknown" (SaSSI 2003).

The 1978-1987 Quinault basin run size composite of both hatchery and wild coho mixed was 9.6%-16% of the 1913 run size. The implications suggest that wild Quinault coho may already be genetically extinct.

In 1923, a total of 6,756 cases of chum salmon was packed at the Quinault cannery (Wilcox 1930). At 48 one pound cans per case it represented 324,288 pounds of chum after processing. Using Meyer's range of 50%-70% wastage in canning, it would represent 648,576-1,080,960 pounds of chum sold to the cannery. If the average chum weighed 9 pounds as indicated by Wydoski and Whitney (1979), it would mean that 72,064-120,106 chum salmon had been caught. The 1923 wild chum run size would have been 144,128-240,212 fish if catch was 50% of the run size. However, from 1977 to 1991 the run sizes of chum salmon returning to the Quinault have only ranged from 4,594 to 25,798 fish with a five year average of 8,500 fish from 1987 to 1991 (SASSI 1994). Both harvest and escapement trends were still declining. Nevertheless, the Quinault River chum salmon were listed as "healthy".

The magnitude of the losses of sockeye, chinook, pink, and chum salmon that have occurred in the Quinault system are listed in Table 24.

Table 24. Comparative Quinault system salmon run sizes from historic numbers to present numbers and the magnitude of depletion.

Species	**Historic run size**	**Present run size**	**Magnitude of depletion**
Sockeye	710,014-1,000,000 (1895 & 1941)	24,028 (1996-2001)	minus 689,986-975,972 salmon 2.4%-3.4% of historic run size
Chinook	48,000-80,000 (1911)	5,400 fall; 1,153 spring (1987-1991)	minus 41,447-73,447 salmon 8.2%-13.7% of historic run size
Coho	160,512-267,529 (1913)	25,700 (hat+wild) (1978-1987)	minus 134,812-241,829 salmon 9.6%-16.0% of historic run size
Pink	Unknown	Unknown but minimal	Unknown but likely large
Chum	144,128-240,212 (1923)	8,500 (1987-1991)	minus 135,628-231,712 salmon 3.5%-5.9% of historic run size
Total salmon	>1,062,654-1,587,741	~63,628	minus > 1,001,873-1,522,960 salmon <4.0%-6.0% of historic run size

For its basin size the Quinault system would have been one of the most prolific salmon streams of the North Pacific Rim with returns of over 1,000,000-1,500,000 salmon (not counting the unknown numbers of historic pink salmon) prior to industrial level salmon harvests and alteration of habitat through industrial timber harvest on the Quinault Indian Reservation. The Quinault's remarkable historic productivity was undoubtedly directly related to Lake Quinault for its stabilization of flows downstream and provision of nutrient accumulation once provided by salmon carcasses. As indicated by Smith and Caldwell (2001):

"The lake is classed as oligotrophic (low nutrient levels, low productivity)…It is theorized that low numbers of returning adult sockeye have reduced the nitrogen and phosphorus formerly contributed by salmon carcasses upstream of the lake to the lake ecosystem, and that this may be contributing to low sockeye smolt production (Stockner 2000)."

The Quinault River is the worst case example regarding Pacific salmon depletion on the Olympic Peninsula as measured by sheer numbers (the Queets River salmon depletion may be higher by percentage of loss). As indicated above, the subsequent lack of their own nutrients limits sockeye salmon production in Lake Quinault. Declines in salmon abundance have caused a corresponding decrease in he amount of nutrients and organic matter delivered by salmon to the freshwater ecosystems (Bilby et al. 2001). Gresh et al. (2000) indicated that delivery of nutrients by salmon to watersheds in Washington, Idaho, Oregon, and California is about 6%-7% of historic levels. As low as that estimate is, the Quinault basin is even further below that level. It is known that steelhead are particular benefactors of decomposing salmon carcasses and their eggs (Bilby et al. 1998). Presumably steelhead production is severely limited by the great reduction in salmon nutrients that has occurred in the Quinault basin with present salmon run sizes less than 4%-6% of historic numbers as indicated in Table 24.

As indicated by Bilby et al. (2001):

"It is evident that Pacific salmon are not only a product of the ecosystems where they spawn and rear but also make a critical contribution to the ecological health and productivity of these systems. As such, they should be considered part of any comprehensive approach to restore freshwater habitat in the Pacific Northwest. Many efforts at habitat restoration now underway are attempting to couple improvements in land use practices with deliberate manipulations of channel form to produce the physical habitat conditions preferred by target species. These efforts cannot be successful if the streams lack the capacity to generate sufficient food to support the rearing salmon."

Habitat

Euro-American settlers arrived in the Quinault basin by the late 1880s with subsistence farming and grazing occurring primarily in the Lake Quinault and Cook Creek watersheds (Smith and Caldwell 2001). Cedar salvage logging from the 300-acre "Neilton burn" began in 1916, and railroad construction provided access to timber harvest in the Quinault and Cook Creek watersheds between 1917 and 1940. Extensive road construction occurred between 1950 and 1980 with related timber harvest. In 1978, the Quinault Nation began a program to reacquire lands on the reservation to return them to tribal ownership and management. Most all of the lands within the Quinault Indian Reservation and U.S. Forest Service ownership have been harvested at least once.

Bruce Brown (1982) provides yet another layer of description regarding the alterations to Quinault basin habitat. During the First World War the U.S. Army logged many Sitka spruce from above the lake for manufacture of war planes. Although it was selective cutting, it was thought to trigger river channel changes thereafter with increased braiding and wandering across the wide valley. However, it does not compare with what came thereafter as described by Brown:

"Logging, meanwhile, became steadily more widespread and destructive. The Quinault Indian Reservation, which occupies 190,000 acres…is generally considered to have been the most savagely logged area in the state of Washington. Beginning in 1922, reservation timber was sold by the U.S. Bureau of Indian Affairs in large blocks, which were progressively clearcut following the railroad logging practices of the day. Tens of thousands of acres were stripped of valuable timber in a continuous line as the rails pushed deeper into the wilderness. No effort was made to clear the heavy load of cedar slash that covered the land, or to reforest it, and in the 1930s a series of huge fires swept

and reswept the area until the mycorrhizal fungi were killed and the soil would support nothing but the brush deserts that cover it to this day…"

"The years right after the Second World War also saw another increase in logging activity. Using trucks instead of railroad flatcars to get the trees out of the woods, logging outfits were able to exploit steeper, previously inaccessible hillsides. Because of the terrain and road building techniques, mud slides became increasingly frequent along the rivers and streams of the Quinault Reservation …"

After describing the impacts of logging on the Washington Department of Natural Resources Lands in the Queets and Clearwater basins under the direction of Washington Commissioner of Public Lands Burt Cole, Brown continues:

"Not that DNR was the only guilty party …Logging on private land was generally worse, and worst of all was logging on Indian reservations, which are managed by the federal government. A report issued by the U.S. Fish and Wildlife Service in 1979 showed that 50 percent of recent logging operations on the Quinault Reservation had a direct and deleterious effect on salmon, killing them by 'suffocation, poisoning, starvation, thermal shock and disease.' Toxic cedar slash was left piled in streams, culverts were installed so that the fish would have to be able to fly to pass through them, logs were dragged through spawning gravel, and streamside vegetation was leveled, according to the report. In half these cases, the damage occurred after both the Bureau of Indian Affairs and the logging company had received official warning from Fish and Wildlife regarding the danger to salmon."

The largest block of habitat problems is in the Quinault Indian Reservation related to past logging. This is despite the habitat advantages of Lake Quinault as a flood buffer.

Lake Quinault averages 146" of rainfall per year. The lake acts as a moderating reservoir resulting in peak discharge flows that are 31% to 38% lower than the nearby Humptulips and Queets Rivers respectively that have no large lakes in their drainages (Quinault Indian Nation and U.S. Forest Service 1999).

Nearly all the land downstream of Lake Quinault has been clearcut (Quinault Indian Nation and U.S. Forest Service 1999) which increases the risk of high flow and low flow problems (Smith and Caldwell 2001). Annual water yields increase in the winter rainy season in the first ten years after harvest and roading (Harr 1983; Hicks et al. 1991). The combination of clearcutting and roading was predicted to result in a 21% increase in 10 year flood events in a model developed for the Deschutes River in Washington (La Marche and Lettenmaier 1998).

Smith and Caldwell (2001) also indicated that low flows can occur as a result of loss of large conifers. Large trees were found to collect moisture from fog, particularly in Sitka spruce zones such as the Quinault (Harr 1982). Fog drip can contribute 35% to annual precipitation beneath old growth canopies that returns back to streams (Norse 1990). That is now virtually gone on the lower Quinault and will take centuries to fully recover.

Several tributaries experience low flow problems on the lower Quinault, although it is not known to what extent they may be human caused (Smith and Caldwell 2001). Big and Prairie creeks have about 19% of dry channel; Inner Creek has 17% dry channel;

and No Name Creek has 9% dry channel (Quinault Indian Nation and U.S. Forest Service 1999). Whether human caused or not, such tributaries demonstrate the adaptive value of having early return, early spawning, early emerging steelhead to take advantage of what would otherwise be habitat limitations. In logged off watersheds, such steelhead characteristics would be particularly important due to more streams going dry creating conditions similar to that described by Everest (1973) for steelhead in the Rogue River basin. However, steelhead harvest throughout Washington has targeted early arrival steelhead for decades minimizing their ability to effectively reproduce in logged off watersheds.

Smith and Caldwell (2001) indicate that during the 1920s, logging began in the southern area of the Quinault basin using rail. Much gravel was removed from the rivers to build the railway system (Quinault Indian Nation and U.S. Forest Service 1999). Early logging typically included removal of trees to the stream edge with no remaining conifer buffer. As late as the 1970s and 1980s, logging near Taholah and Crane Creek also removed riparian vegetation despite regulations existing at the time to protect streamside buffers (Quinault Indian Nation and U.S. Forest Service 1999) as documented in Smith and Caldwell (2001). There was no indication whose management decision it was to log those buffers, although beginning in 1978 the Quinault Nation began acquiring Quinault Indian Reservation land for the purposes of ownership and management.

As of 2001, there had been no inventory of blockages that occur in the lower Quinault sub-basin. This was identified as a critical factor that needs to be addressed. It is thought that many culverts exist in the lower sub-basin associated with old roads which have not been assessed for fish access, and it should have a higher priority than other areas of the basin for fish access assessments (Smith and Caldwell 2001). This is entirely on the Quinault Indian Reservation, and since this land has been in the process of being acquired by the Quinault Nation for management purposes ever since 1978 (Smith and Caldwell 2001) it would be anticipated this might be a tribal fish management priority along with other habitat restoration activities, although no indication of that was found.

Smith and Caldwell (2001) indicate anadromous fish passage is blocked by the U.S. Fish and Wildlife Service Quinault National Fish Hatchery weir at RM 4.5 on Cook Creek. The hatchery started operation in 1968 (Busby et al. 1996; and Smith and Caldwell 2001). Anadromous migration into upper Cook Creek tributaries, such as Hathaway and Skunk Creeks is similarly blocked by the hatchery weir (Mobbs 1999a). The hatchery also withdraws water from Cook Creek and discharges effluent back into it, although work completed in 1997 has reduced the amount of settleable solids in the effluent (Mobbs 1999b). While maximum summer water temperatures are rated "good" at the hatchery intake, they are rated "poor" at the mouth 4.5 miles downstream. Because of this, water quality is rated "poor" in lower Cook Creek while upper Cook and Skunk Creeks are rated "good" (Larosa 1999). However, the hatchery weir blockage denies access to that remaining good habitat, about 6-7 linear miles as measured from maps (Washington Atlas & Gazetteer, 1995, DeLorme, Freeport, Maine), which may be some of the best remaining habitat on the Quinault reservation.

Smith and Caldwell (2001) listed numerous other problems in the lower 33 miles of the Quinault basin including abandoned roads and railroads that have drained and created ponds and wetlands; unregulated efforts to alter river channel locations and remove large woody debris to accommodate boat passage occurred as late as the early

1990s; one channelization effort included a bull dozer operating in the river in late summer where summer/spring chinook redds had been newly constructed; road densities have been underestimated and further assessments are greatly needed; large woody debris is far below historic levels which includes river spanning logjams removed from the mainstem river as late as 1933 by Conservation Corps crews; stream shading was below target levels in the mainstems of Prairie, Mounts, and Railroad creeks resulting in "poor" ratings; and although current forest practices are more protective than in the past, riparian zones already degraded need restoration activities.

Lake Quinault has been described as the primary feature in the Quinault basin (Smith and Caldwell 2001) that differentiates it from the other large basins of the Olympic Peninsula coast excepting for Ozette Lake and River system. Lake Quinault is 3,729 acres and up to 240 feet deep. The lake is used by spring/summer and fall chinook, chum, coho, and sockeye salmon as well as steelhead for migration, adult holding, and juvenile rearing (Mobbs 1999), although spawning has not been observed in the excellent gravel off of tributaries (Phinney et al. 1975; and Mobbs 1999). Overall, Lake Quinault is rated as generally "good" salmon habitat with no significant changes from historic conditions (Smith and Caldwell 2001), although this rating apparently does not take into consideration the nutrients that the present lack of salmon denies.

There has not been an extensive inventory of blockages in the Lake Quinault watershed region (Smith and Caldwell 2001), although three culverts at the time were known to require repair at the Higley, Slide and McCormick Creek crossings on the North Shore Road (WDFW 2000a) which may prevent access to what would be relatively pristine habitat within the ONP.

Sections of bank armoring (rip-rap), as evaluated for ONP in 1996, impact 1.55 miles of roads in the ONP, and does not take into account the armoring by private property landowners between Lake Quinault and the Quinault Bridge near Cannings Creek (Chadd 1997; and Caldwell 2001). The proximity of the road to the mainstem above the lake and associated bank armoring is thought to have caused extensive floodplain alterations (Smith and Caldwell 2001). Because side-channel and off-channel habitat between Lake Quinault and the Quinault River bridge is a prime spawning reach for sockeye salmon, and because bank armoring has been significant and has increased in the past 20 years, the floodplain conditions are rated "poor" (Smith and Caldwell 2001).

In years of good returns, it has been found that about half of the spawning population of sockeye salmon can be found in the side-channel habitats adjacent to the mainstem above the lake, while the other half uses the tributary spawning habitat (Smith and Caldwell 2001 via per. com. with Scott Chitwood, Jamestown S'Klallam Tribe). Chitwood also indicated the mainstem reach is highly important for spring/summer chinook and is used by fall chinook, summer steelhead, winter steelhead, coho, chum, cutthroat, and native char.

Considerations for Quinault Ecosystem Recovery

The Quinault and Queets salmon and steelhead based ecosystems are the worst case examples of the coastal Olympic Peninsula river systems examined in this report as determined by historic evidence of what the levels of depletion have been.

As for all rivers and regions of the state of Washington examined in this report, it has been apparent that lack of a sufficiently old historic baseline has been a significant reason for continuing declines of salmon and steelhead. In the case of the Quinault, Smith and Caldwell (2001) conclude:

"To summarize, known data indicate that spring/summer chinook levels are 'depressed', and coho salmon, lower river winter steelhead trout, and sockeye salmon have declined compared to historic levels. Fall chinook escapement levels have increased, and chum salmon, upper river winter steelhead, and summer steelhead abundance have not shown a statistically significant decline, although some concern exists about these stocks. Because about half of the salmon and steelhead stocks are below historic levels, nutrient cycling has likely been reduced and is rated 'fair' for the Quinault basin."

Such understatement of the magnitude of the problem is a primary limiting factor to restoration of salmon and steelhead ecosystems throughout Washington. Salmon and steelhead ecosystem recoveries will never occur until something like Table 24 is developed from which to create effective templates of where we currently are on a reasonably accurate historic scale since Euro-American exploitation began to rapidly alter biological balances that were once complexly intertwined and have become increasingly unraveled.

Until it is admitted that "Humpty Dumpty" is broken, there can be no putting him back together. To create mythologies and euphemistic misconceptions that Humpty Dumpty merely has a slight crack in him by displaying fictional pictures of his happy face, while carefully sweeping all his parts under the rug, is the equivalent of political and religious fanaticism in which long dead leaders are kept alive by carefully kept photographs, paintings, and sculptures for decades, centuries, and millenniums after their deaths to insure masses of human beings are manipulated to remain entrapped in a past that has no present reality. This is the present level of "science" guiding fishery management.

There are lessons to be learned from other disciplines. Archaeology and paleontology are among them. They are sciences of perpetually putting "Humpty Dumpty" back together. On hands and knees with small brushes, layer by layer the past is uncovered and fragment by fragment put back together. But first you need all of the pieces; and they need to be the right pieces. This is as much a key to restoration of living biological communities as it is to restoration of the likeness of the dead from the sum of the long buried parts.

It has taken 200-300 years to undo the Quinault ecosystem. It will likely take a similar investment in time to restore it. However, parts of it will recover more quickly than others once the decision is made to put "Humpty Dumpty" back together again rather than sweep all the parts under the rug. In the case of the Quinault, no relative "permanence" of habitat loss has occurred such as that through construction of a dam or conversion of large parts of the watershed to agriculture, industry, or urban/suburban development. Nor has any recent Mt. St. Helens volcanic event occurred or recent impact of glaciation. In fact, what has happened to the Quinault salmon and steelhead based ecosystem amounts to relative trivialities in the context of natural history and more recent human history driven by industrial level economics of resource extraction.

Despite these relative trivialities, the end effect has been a magnitude of wild salmon and steelhead losses (wild Pacific salmon now less than 4%-6% of historic numbers from Table 24) that rival those anywhere outside of total extinctions such as have occurred to salmon and steelhead upstream of Grande Coulee and other high dams.

The Quinault system was a remarkably productive salmon and steelhead system as late as 66 years ago when over half a million sockeye salmon were harvested in 1940. From the available history, it is apparent that dependency on hatchery programs has been "more bane than boon" as described by Bruce Brown (1982).

Cessation of hatchery programs can have positive results. Substantial releases of hatchery coho salmon were released into Puget Sound's Snoqualmie River from 1952 to 1972 (SaSSI 2003). After cessation of those releases, wild coho have responded positively from the available WDFW records dating to 1977 (SASSI 1994; and SaSSI 2003). The measure of coho returns in the Snoqualmie system is from surveys of index reaches where "cumulative fish days" are determined (SaSSI 2003). Between 1977 and 2003 wild coho returns in the Snoqualmie basin have ranged from a low of 10,183 in 1981 (SASSI 1994) to a high of 103,339 in 2003 as measured in fish days (SaSSI 2003). The trend has been upward with a 5-year average from 1986-1990 of 50,779 to a 5-year average from 1999-2003 of 71,738 (from data in SaSSI 2003).

It has also been found that coho genetic diversity remains in the Snoqualmie basin with at least two distinct populations identified, one in Harris Creek and another in Grizzly Creek, which are significantly different from each other and from any other wild coho populations analyzed in Washington (SaSSI 2003). Wild coho abundance is high in many Snoqualmie tributary creeks as described in a Washington Trout report regarding coho spawning survey findings (McMillan 1999). The same report documented increased coho numbers into habitat where culvert passage had been provided or improved, and other areas where similar coho responses to passage improvements still await increased escapement levels that may push them higher into the drainages.

The higher levels of wild coho abundance in Snoqualmie basin tributaries have also resulted in measurable nutrient advantages for the rearing wild juvenile coho in the same streams as compared to other basins with lower wild coho escapements. Bilby et al. (2001) found that juvenile coho sampled in Snoqualmie basin tributaries, which all had high coho carcass/km abundance levels, had higher N stable isotope ratios than tributaries of the Chehalis, Deschutes, Hoko, Clallam, Skagit, Dickey, Bogachiel, Soleduck, Hoh, and Willapa basins which had far lower coho carcass abundances. While the tributaries of the other ten river basins sampled had a range of only 1.2-78 coho carcasses/km, the tributaries of the Snoqualmie basin had a much higher range of 201-968 coho carcasses/km.

It is apparent that wild salmon abundance builds on itself if escapement is allowed to reach abundance levels that result in significant nutrient increases.

The increase in wild coho production on the Snoqualmie has occurred at the same time as human population increases and suburban development in the Snoqualmie valley have occurred, as elsewhere in King County. The Snoqualmie basin also has a long timber harvest history and agricultural use, both of which continue to occur and which has included a Weyerhaeuser headquarters in Fall City along the Snoqualmie River.

A recent U.S. Fish and Wildlife Service (USFWS) report provided the following history (U.S. Fish and Wildlife Service 1999):

"…Quinault hatchery was established in 1964 as part of a conservation partnership between the Service and the Quinault Indian Tribe to restore and enhance depleted salmon and steelhead runs on the reservation and in other areas along the north coast of Washington."

"…The Quinaults are a fishing people and when the runs began to thin badly in the early 1960s, there was cause for real concern.

"The decline in fish runs proved double edged; the Quinault tribe also permitted extensive logging on reservation land, causing a degradation in fish habitat that in turn took a heavy toll on the fish population. Combined with an increasing commercial harvest, the population drop grew staggering.

"Since then, said hatchery director Marjorie Park, herself a member of the Quinault tribe (as are five others of her seven-member staff), the hatchery has contributed significantly to a restoration of salmon and steelhead runs in the Quinault River, increasing a food supply and making contributions not only to the tribal fisheries but also to Indian, sport and commercial fisheries of the Pacific Northwest."

As indicated by the USFWS, the Quinault Indian Nation made two fateful decisions that impacted salmon and steelhead: 1) to log the reservation; and 2) commercially overharvest the salmon and steelhead runs with "staggering" reductions.

The USFWS account then reverses the historic record by indicating since initiation of the hatchery in 1964, it has contributed significantly to restoration of salmon and steelhead runs. Tables 21, 22, and 24 and Figures 46, 47, 50, and 51, all portray a very different wild salmon and steelhead history than the USFWS account: wild chinook, sockeye, coho, chum, and winter and summer steelhead populations have all plummeted.

It remains that the Quinault Nation can reverse what has occurred with an effective plan for long-term ecosystem recovery that would similarly include the U.S. Forest Service, private landholders, and the ONP who have all contributed to the unraveling of the Quinault basin ecosystem and who mutually hold the key to putting it back together again.

The Snoqualmie River coho example provides one component to opening the door to ecosystem recovery. A shift of fishery investments from hatchery production to habitat recovery both below and above Lake Quinault to the junction of the forks is another, combined with purchases of private land holdings along mainstem and tributary corridors for the purposes of insulating the Quinault salmon and steelhead ecosystem from further degradation. Harvests of all resources, whether fish, timber, minerals, or water, will require reevaluation in a shift from an industrial economy that simply takes for its own immediate monetary profit and eventual resource collapse, to re-creation of an economy that incorporates giving enough back to the ecosystem so it can recover and once again become self-sustaining with resulting profits spread over the long-term.

VI. Situk River

Alaska's Situk River is located 18 km (10.9 mi) southeast of the village of Yakutat (Clark and Paustian 1989) which has a population of 680 (2004 State Demographic estimate). It has periodically been the outflow for Hubbard Glacier's terminus into what is presently Russell Fiord. At this point in time, that is not the case and the Situk River is a small, stable, low gradient stream. It runs 35.4 km (22.0 mi.) from Mountain Lake, then to Situk Lake, and then to an estuary it shares with the Ahrnklin River before outletting to the Gulf of Alaska (Bain et al. 2003). The Situk has two main tributaries, both relatively small: the Old Situk River (20 km long [12.4 mi]) originates from a pond and the West Fork Situk (10 km long [6.2 mi]) comes out of Lake Redfield (Thedinga et al. 1998).

The Situk basin is characterized by a patchwork of spruce forest, muskeg, and willow and grass meadows. The U.S.D.A. Forest Service indicates the area has an annual rainfall of 151" and annual snowfall of 202". The entire length of the Situk below the lakes is low gradient dominated by long, slow pools. The steam substrate is almost entirely gravel. The channel is frequently blocked by debris jams of spruce that have been windthrown (although all of these blockages have been notched with 8'-15' gaps to accommodate small boat passage) [McMillan 2004].

The Situk River has a particularly active relationship with Hubbard Glacier as described by Thedinga et al. (1993):

"The advancing Hubbard Glacier dammed Russell Fiord near Yakutat, Alaska in May 1986 and created the world's largest glacier-formed lake. Rising water in the newly formed 'Russell Lake' threatened to overflow and flood the Situk River, one of Alaska's most productive salmon and trout rivers. Before flooding could occur, however, the ice dam burst. Based on tidewater glacier cycles, the ice dam is expected to rebuild eventually; overflow from 'Russell Lake' will probably flood the Situk River and drastically disrupt fisheries. Historically, the Hubbard and other glaciers that originate in ice fields of the St. Elias Mountains have repeatedly advanced and retreated over the past 7,000 years, alternately impounding and releasing an enormous lake in the Russell Fiord basin (Mayo 1988). Prior to 1986, the last damming of Russell Fiord and flooding of the Situk River ended in the mid-1800s (De Laguna et al. 1964). Flooding would change the present Situk from a small, clear, groundwater-fed river, to a large, unstable, glacial river. USFS hydrologists expect floodwaters to follow the same route of previous floods down the Old Situk River, into the Mainstem Situk River, then into the Pacific Ocean via the Lost River. The predicted flood zone will encompass nearly 70% of the Lost and Situk Rivers. After flooding, it is estimated that average flow will increase by a factor of 37 and the river will be turbid with fine glacial silt and sediment from erosion (Mayo 1988)"

The Situk River's relationship to Hubbard Glacier (and other glaciers) is not unlike the history of the Hoh River during the six known glacial events that went up and down it's valley during the Wisconsin glacial period. The Situk River as it presently is has only existed since the last glacial flooding ended in the mid-1800s, 150 years ago. Throughout, salmon, steelhead, char, and trout have persisted with what has been remarkable productivity for all species – at least since the end of the last flooding.

The Situk River is again predicted to become the outflow from "Russell Lake" when Hubbard Glacier, 92 miles long and the longest valley glacier in North America, once again dams Russell Fiord with more permanence than it briefly did in 1986 (and again in 2002). It is thought this will occur relatively soon. The resulting river will be 100 times larger than the present Situk and will resemble the glacial Taku River near Juneau (Humphry and Thedinga 1991). It's present width of 25 m will increase to 2,500 m. Although the initial years of flooding may devastate fish habitat in the flood zone with fish numbers reduced by 50%, in 3-5 years it would be predicted to stabilize into its old glacial outflow channels and over time potentially become even more productive than before due to the larger river size, although that could take a century or more.

Situk Hydrology, Drainage Area and Flow Compared to Olympic Peninsula Rivers

The Situk River is about 25 m wide (81 ft) and drains 200 sq. km (77.2 sq mi) [USFS 1985; and Thedinga et al. 1998]. [The information for the Situk River on the Alaska Department of Fish and Wildlife website indicates the drainage size is 124 sq mi, apparently an error created by multiplying 200 sq km by the km conversion factor of 0.6214 instead of the sq km conversion factor of 0.3861]. The drainage area originates from three lake sources of a combined 602 ha (1,488 a) [Clark and Paustian 1989] which provides considerable hydrologic stability (Johnson 2003). The average summer flow is 6 m3/s (212 cfs) [Clark and Paustian 1989], with an average annual flow of 10-15 m3/s (350-530 cfs) [Lamke et al. 1991].

For comparative purposes, the Ozette River and Lake Ozette on the Olympic Peninsula coast has similarities to the Situk River with its lakes. Its drainage size of 88 sq mi (228 sq km) [Phinney et al. 1975] is similar as well, although its length of 13.3 mi (21.4 km) is considerably shorter than the Situk's 22 mi (35.4 km) and its average low summer flow is only 50 cfs (1.4 m3/s) with an average annual flow of 500 cfs (14.2 m3/s). The Dosewallips River on the east side of the Olympic Peninsula has a somewhat larger drainage than the Situk River at 94 sq mi (243 sq km), and is somewhat longer at 28.3 mi (45.5 km), but it has a more similar average low summer flow at 200 cfs (5.7 m3/s) and average annual flow of 445 cfs (12.6 m3/s).

SITUK STEELHEAD HISTORY

Steelhead are found in 581 streams in the southeast region of Alaska where steelhead abundance is greatest (Lohr and Bryant 1998). Most of these streams are small. Estimates of escapement are made for 331 streams with just 56 of those estimated to have runs of over 500 steelhead. Only 12 streams are thought to have runs over 1,000 steelhead (Jones 1994; and Lohr and Bryant 1998).

Lohr and Bryant (1999) [regarding life history data] and Bain et al. (2003) [regarding historic data] were found to be complementing Situk River steelhead sources from which most of the following information was compiled along with a spreadsheet from ADF&G (2003a) and access to their website (ADF&G 2003 and 2006; and 2006a). Table 25 provides a condensation of much of that data:

Table 25. Situk River steelhead harvest and monitoring history, 1947-2005), from Bain et al. (2003) and ADF&G Situk Weir website data accessed in 2003 and 2006: Annual sport harvest, set net harvest,

subsistence harvest, total harvest, weir count (preferred monitoring count), peak float count (secondary monitoring count), total run size, and % of run size harvested.

Year	Sport	Set net	Subsistence	Total harvest	Weir count	Float count	Run size	% harvest
1947	?	?	?	?	300-500 min *	none	>500	?
1948	many anglers	?	?	?	no mention	none	?	?
1951	?	?	?	?	3000 min*	none	>3000	?
1952	?	?	?	?	25000-30000	none	>25000	?
1953	?	?	?	?	almost non-existent*	none	?	?
1954	?	?	?	?	very few*	none	?	?
1971	?	?	?	?	160*	none	>160	?
1974	?	<10	?	?	none	9*		?
1975	?	<10	?	?	none	84*		?
1976	?	<10	?	?	117*	114*	>117	?
1977	136	<10	?	>136	17*	245*	>381	<36%
1978	145	<10	?	>145	32*	241*	>386	<38%
1979	336	<10	?	>336	370*	567*	>903	<37%
1980	258	<10	?	>258	340*	694*	>952	<27%
1981	335	<10	?	>335	6*	1503*	>1838	<18%
1982	509	<10	?	>509	1830*	3005***	3514	~14%
1983	818	<10	?	>818	18*	220*	>1038	<79%
1984	673	<10	?	>673	50*	2151*	>2824	<24%
1985	336	<10	?	>336	891*	2048**	>2384	<14%
1986	494	<10	?	>494	222*	1367*	>1861	<27%
1987	454	42	?	~496	5*	3206	3702(?)	~13%
1988	833	173	?	~1006	1211*	2595**	3601(?)	~30%
1989	1086	219	?	~1305	5991	2251	7296	~18%
1990	591	72	?	~663	3652	1640	4315	~15%
1991	530	113	0	643	2526	979	3169	20%
1992	8 (C&R)	115	29	152	2976	883	3128	5%
1993	0 (C&R)	175	1	176	338*	3499	3675(?)	~5%
1994	42 (2-fish>36)	163	21	226	7854	4702	8080	3%
1995	48 (2-fish>36)	152	25	225	6680	6235	6905	3%
1996	54 (2-fish>36)	235	22	311	8510	6544	8821	4%
1997	na (2-fish>36)	na	25	na	7328	na	>7353	?
1998	na (2-fish>36)	na	3	na	5786	na	>5789	?
1999	na (2-fish>36)	na	?	na	9204	na	>9204	?
2000	na (2-fish>36)	na	11	na	6709	na	>6720	?
2001	na (2-fish>36)	na	na	na	6400	na	>6400	?
2002	na (2-fish>36)	na	na	na	6113	na	>6113	?
2003	na (2-fish>36)	na	na	na	7957	na	>7957	?
2004	na (2-fish>36)	na	na	na	12462	na	>12462	?
2005	na (2-fish>36)	na	na	na	12274	na	>12274	?

* Years of incomplete weir and/or float counts.
** Years when float counts between upper and lower river were separated by 10 days rather than consecutive days and thus less reliable.
*** Year of supplemented weir count with float count and sonar count estimates.

Bain et al. (2003) indicate that for its size, the Situk River is the most productive watershed in Southeast Alaska and supports the largest steelhead population. The resulting steelhead fishery is considered unique in the region because of its accessibility and high productivity. It was further reported that no systematic assessment of the steelhead stock was ever conducted prior to 1989, and in 1991 and 1992, low abundance of steelhead created public concern as to the accuracy of Alaska Department of Fish and Game (ADF&G) data. Credibility was not improved when errors were found in the data and various data sets produced conflicting results. The concerns resulted in ADF&G making improvements to the Situk counting weir combined with better methods for collecting abundance indices and reporting the results.

Both spring (ocean maturing) and fall (freshwater maturing) runs of steelhead return to the Situk River with 16% of the total number of spawners thought to be fall run (Johnson 1991). The fall-run enters from August through December (Jones 1993; and Johnson 1990) and overwinter primarily in Situk Lake or secondarily in the upper Situk River (Johnson 1991). The spring-run begins in March, peaks in late April and early May, with stragglers continuing into mid- to late June (Glynn and Elliott 1993; and Johnson 1991). The fall-run can begin to spawn as early as February (Johnson 1991), and spring-run fish can apparently spawn as late as July as evidenced by a very few late entry steelhead in late June and early July (ADF&G 2003 and 2006). Only bout 1% of kelt outmigration occurs through May 15 and 2/3 occurs after May 15 to June 1. Most of the rest have gone out by mid June, although a few emigrants are counted as late as mid-August when emigration is delayed by late snow pack and cold water temperatures (Johnson and Jones 2000).

Situk steelhead were found to have 22 distinct age classes (Johnson 1996). They live up to ten years, rear in fresh water for one to five years (most 3-4 years), and mostly return as 3-ocean fish with a range of one to six years (McHugh et al. 1971, 1972; Jones 1983; Glynn and Elliott 1993; Johnson 1996). Repeat spawning has been found to occur in 25% (Jones 1983) to 59% (Johnson 1996) of Situk River steelhead. Although first time spawners are typically divided equally between males and females, 80% of repeat spawners are females (Jones 1983; and Johnson 1996). This would indicate the overall steelhead return is female dominated. The Situk also has resident rainbow trout (per. com. Bob Johnson, ADF&G, 2003), although it is not known if they are interactive with the steelhead population, or whether the rainbow sex ratio is skewed toward males as is the case with some Kamchatka Peninsula rainbow/steelhead populations in Russia (Savvaitova et al. 1996; 1997;and Pavlov et al. 2001).

Developing an Effective Baseline and a Population Monitoring System

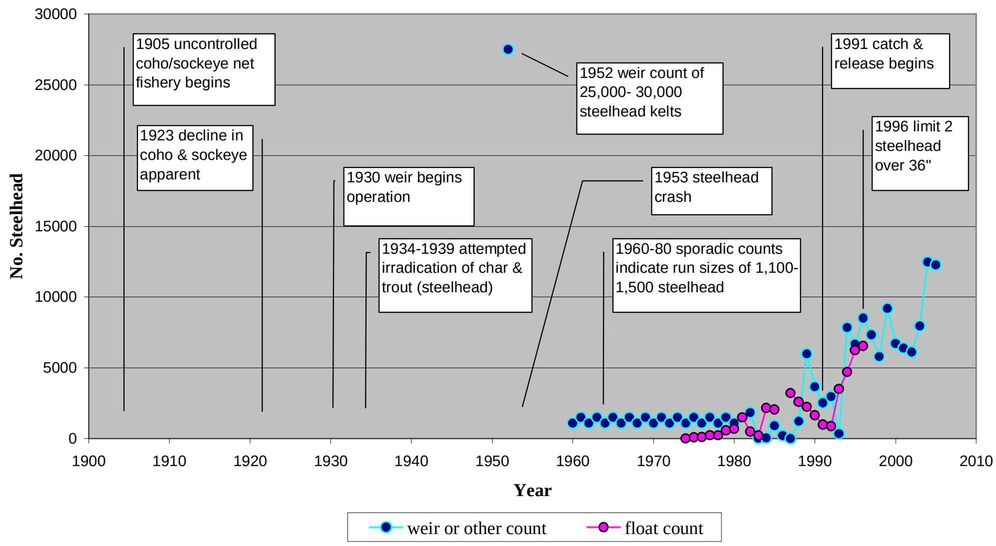
Between 1930 and 1955 the U.S. Fish and Wildlife Service (USFWS) operated a weir on the lower Situk River at RM 1.2 primarily to count returning sockeye salmon (although steelhead and trout observations and counts were made some years) [Bain et al. 2003]. In 1952, 25,000-30,000 outmigrating steelhead kelts were counted (Knapp 1952; Johnson 1990; and Bain et al. 2003), by today's standards an astonishing number for any river let alone one of the Situk's small size.

From 1956 to 1970 no weir was operated, but in 1971 and from 1976 to 1987 a weir was operated by ADF&G at RM 13.1 (at Nine-Mile Bridge) to again primarily count returning sockeye. However, steelhead were also counted as they passed both upstream and down. The resulting steelhead counts were low, one reason being that many steelhead spawn in the 13 miles of river downstream (Bain et al. 2003).

In 1988 the weir was moved back downstream to RM 1.2 (the original USFWS location) with continued operation there that has included an objective to count emigrating steelhead kelts (Bain et al. 2003), although in 1988 and 1989 the weir was put in too late to count most emigrants. In 1990 the weir was installed in early May and provided the first complete count of steelhead kelts going out (Johnson 1991). However, design of the weir in a way that was not breached by floods (Glynn and Elliott 1993), and that did not significantly delay steelhead migrations, did not occur until 1995 when a floating/resistance weir was installed (Johnson and Jones 2000).

Figure 54.

Situk River Steelhead History (1905-2005)
From Weir Counts, Float Counts, Other Counts, and Historic Reference Points (McMillan 2004; Bain et al. 2003; ADF&G 2006)



Although the comparative value of the weir counts is not continuous due to two differing locations on the river, due to differing emphasis on target species, and due to differing weir designs that altered effective function during high flows, there are supplemental data from "float counts" (details following below) that support the general trend provided by the weir counts (and other counts) as depicted in Figure 54 (data from Bain et al. 2003; ADF&G 2003 & 2006; and 2003a).

Weir counts of steelhead kelts emigrating from the Situk from the 1970s to mid 1980s were under 400 to 1,800 as provided in Table 25 (data from Bain et al. 2003; ADF&G 2003 and 2006; and 2003a). Although Bain et al. (2003) do not provide counts after 1996, a spreadsheet of the counts from 1988 to 2003 (ADF&G 2003a) indicate the 10-year average for 1990-1999 was 6,058 steelhead kelts (eliminating the 1993 count when the weir went in too late due to high flows) with a low count of 2,526 in 1991 and a high of 9,204 in 1999. In 2004 and 2005, respective counts of 12,462 and 12,274 steelhead kelts were counted outmigrating at the Situk River weir (ADF&G 2003 and 2006; and 2006a) with a 6-year average since 2000 of 8,653 steelhead.

The 2004 and 2005 weir counts of over 12,000 emigrating steelhead kelts compare with intermittent counts by ADF&G from 1960 to 1980 that indicated minimum escapements of 1,100-1,500 steelhead (Johnson 1990) with no data to suggest they were higher.

Prior to installation of the floating/resistance board weir in 1995, counts of steelhead obtained during float surveys were the primary metric of steelhead abundance in the Situk River (Bain et al. 2003). This was due to the expense of weir operations and the inability of the early weir to obtain complete steelhead counts due to high flows. Annually since 1974, a canoe, raft, or outboard-powered riverboat has been used to provide "float counts" of steelhead made by two or more observers on board (Bain et al. 2003). Prior to 1985 these counts were only made in the 13 miles downstream of Nine-Mile Bridge, but thereafter it was expanded to include the "Upper River" between the bridge and Situk Lake. It was found that "peak float counts" between May 8-18 provided the best indices (Johnson and Jones 1999). In 1989 and 1990, sonar experiments were also conducted in the hope of counting both immigrant and emigrant steelhead without affecting run timing, but the method proved problematic (Johnson 1991).

Because the fundamentals of float counts have remained unchanged, in the absence of good weir information in the early years of operation by ADF&G, they provide the best rough measure of abundance from which to determine the steelhead return trend dating to 1977 (Bain et al. 2003). The float count data of the late 1970s indicate steelhead numbers were frequently less than 1,000, doubled in the 1980s (sometimes over 2,000), and doubled yet again in the 1990s (4,000 to 6,000). As depicted in Figure 54 and listed in Table 25, the trend of doubling steelhead counts on the Situk each decade since the 1970s may still be in continuation.

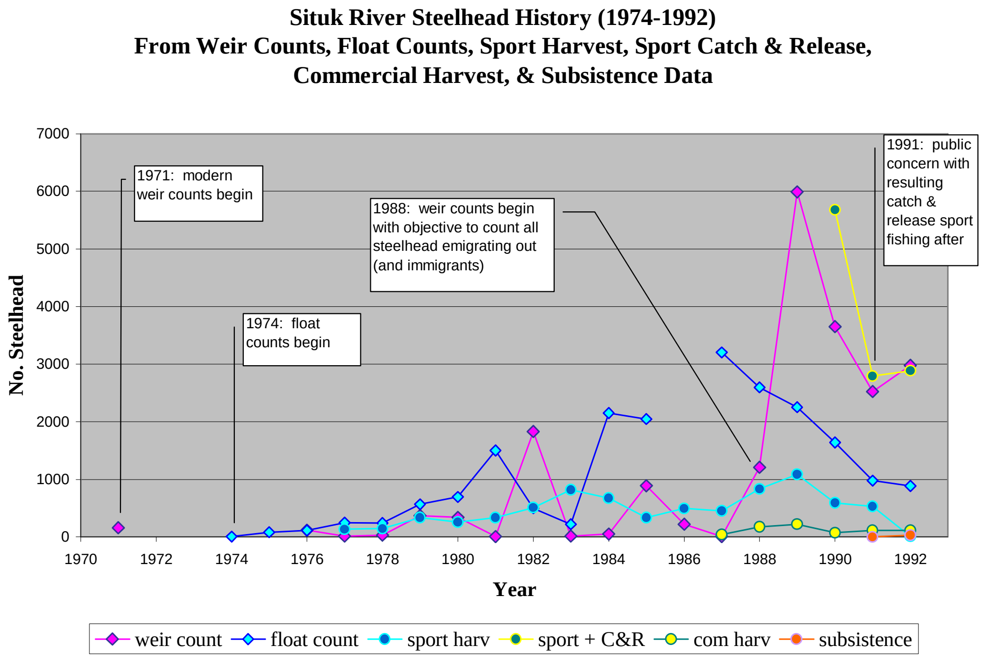
A Pivotal Point in Situk River Steelhead Management

A pivotal period in Situk River history was 1991 and 1992 when the public expressed concerns about low steelhead numbers (Bain et al. 2003). From the perspective of ADF&G, it could have been discounted as an unreasonable complaint at the time. Only 56 of the 331 monitored steelhead streams in Alaska have more than 500 steelhead and only 12 of those have more than 1,000 (Jones 1994). The Situk weir count in 1989 was 5,991 returning steelhead kelts after an estimated sport harvest of 1,086 steelhead (Table 25). It was the highest count in history *if* history was limited to that point in time when modern Situk steelhead data collection began with resumed weir counts in 1971 and float counts in 1974.

Figure 55 depicts the 1971-1992 Situk River steelhead history ADF&G could have chosen from which to make future management decisions, much as Washington steelhead managers have limited history to that point in time when escapement data were collected after the Boldt Decision, commonly beginning around 1978 and sometimes not until 1986 (SASSI 1994; SaSSI 2003; and WDFW 2006). Instead the ADF&G Situk steelhead managers made a reassessment of their own data and methods of data collection in 1991 and 1992 (Bain et al. 2003).

In his report of Situk River steelhead studies made in 1989, Johnson (1990) included the 1952 USFWS weir count. The record of that count was the probable motivation for moving the weir from RM 13.1 (where ADF&G renewed operation of a counting weir in 1971) to RM 1.2 in 1988 (the same location as the early USFWS weir abandoned in 1955). While no other specific record was found of when or why the 1930-1955 Situk weir data were accessed by ADF&G, however and whenever it occurred was an apparent contributor to Situk River management decisions and the resulting 20-30 year trend of a recovery line back toward steelhead population numbers documented in 1952. Situk River managers went far enough back in time to capture the type of fishery baseline Daniel Pauly (1995) recommended. It provided an historic baseline from which decisions could be made to manage for fish population recovery rather than a long continuous line of depletion toward extinction.

Figure 55.



There is one primary difference between ADF&G steelhead management and steelhead management in Washington State that is apparent from Figures 54, 55, and 58. There is no line representing an escapement goal at any point across the differing views of Situk steelhead history depicted. Recent Situk River steelhead management has not been driven by harvest (the historic exception will be covered later) or the related necessity of developing harvest formulas whose theoretical applications are thought to provide stock sustainability while providing high harvest rates.

The terms used in harvest driven fisheries are those of agricultural derivation, such as "stock", "stock-recruitment", "maximum sustained yield (MSY)", "maximum sustained harvest (MSH)", and etc. that have been applied to the wild and disorderly environment of forests, rivers and oceans rather than the contained, plowed, irrigated, and otherwise controlled environment of the farm yard. Harvest driven management has been a high risk experiment applied with virtual universal application throughout the anadromous waters of Washington State until fish populations inevitably collapse and often require outside intervention to implement heroic measures aimed at recovery. (In Part IV, Nick Gayeski provides detailed explanations of stock-recruitment equations and curves [such as those by Ricker or Beaverton-Holt] most commonly used to manage harvest driven fisheries and their inherent dangers to wild fish populations in the unruly wild environment that sustains them in the form of elegantly, but delicately, balanced natural ecosystems.)

Without the complications of a management driven by providing high harvest, ADF&G was freed of that constraint in the early 1990s when the public expressed concerns over what was perceived as declining numbers of steelhead. As is apparent from Table 25, between 1977 and 1991 Situk River steelhead harvest rates were most likely in the 15%-35% range (excepting 1983 when the run size estimates were likely low due to high flows), and the most substantial recovery has been coincident with very low harvest of 5% or less beginning with 1992.

The Historic Situk Weir Counts

Although Situk River steelhead managers apparently knew of and used the historic weir data to guide some of their decisions, such as moving the weir to the original downstream location in 1988 with the planned objective to count emigrant steelhead, ADF&G had doubts about the accuracy of the earlier USFWS reports. This was particularly true of the 1952 steelhead count regarding the sheer magnitude of numbers reported as compared to more recent counts (Bain et al. 2003). During the data review process for the 2003 paper by Bain et al., the author of the 1952 USFWS report was contacted. During that interview, it was finally verified that 25,000-30,000 steelhead had indeed passed downstream through the weir in 1952. The Appendix from Bain et al. (2003) provides a quote from the 1952 operation of the weir as reported by Lawrence Knapp (1952):

"A large migration of steelhead preceded the sockeye salmon, approximately 25,000-30,000 in number leading one to believe that this migration has been mistaken on numerous occasions for an early run of sockeye salmon by the natives."

"The weir had the effect of holding back large numbers of steelhead on their way back to the ocean after spawning. We had to stand on the weir at night with open gates and a lantern shining into the water over the gates before the steelhead would attempt going downstream. Very few would go through the gate headfirst but would allow the current to drift them through tail first. Before we hit upon this scheme we had almost reached the conclusion that they would either have to be seined and brailed over to the other side or remove a shore-most section of the weir. In years before large sections of the weir would wash away on frequent occasions, allowing the steelhead plenty of large holes to migrate downstream through. We were up several times all through the night allowing steelhead to escape downstream. Being curious as to how many passed through the gates during an evening, we made one count. Over 6,000 were counted through during one night. Very few Dolly Varden, as compared with the season before, were seen this season.

"The weir washed out at approximately 03:00 a.m. September 1…and large trees afloat swept about 2/3 of the weir about a mile and half downstream onto the tide flats and into the ocean. Standing on the riverbank, gazing upon a mangled weir is sufficient to cause a seed of inventiveness to germinate in the least inventive brain. We plan to try out a different type of weir construction for the coming season."

The 1951 and 1953 reports are equally illuminating (Knapp 1952; and 1953):

[1951] *"The weir had the effect of holding back numerous Steelhead on their way back out to sea after spawning. As high as 3,000 Steelhead have been estimated in front* *of the weir at one time. They are able to escape in large numbers, however, during high water when it is practically impossible to keep sections of the weir from washing out."*

"Hoards of Dolly Varden started their upstream migration in the middle of July and continued until the end of the salmon season. If they be classed as predators it would appear that they greatly overbalance the number of salmon that spawn in this river."

[1953] "Steelhead trout were almost non-existent this season."

Bain et al. (2003), while admitting that the 1952 count was accurate, are mystified by the subsequent decline immediately thereafter, and by the lack of similarly large counts in previous years:

"A run of this magnitude (25,000) appears to be anomalous given that the run in 1953 was 'very small' especially in light of information that indicates 25% to over 50% of the steelhead run is composed of repeat spawners. The weir was not installed until June 18 in 1951, when up to 3,000 steelhead were 'estimated in front of the weir at one time.' Compared to recent run timing, approximately 90 to 95% of the run typically would have emigrated by 18 June. It is possible that emigration was delayed in 1952 and that runs were of similar size in 1951 and 1953, but emigrated prior to weir installation."

"Interestingly, the years 1950, 1951, and 1954 were record dry years in Yakutat, when approximately one-half of the annual current average precipitation was recorded (National Oceanic and Atmospheric Administration data). This severe reduction of precipitation likely affected rearing steelhead survival. A similar drought during the summer of 1987 may have been at least partially responsible for the reduced numbers of steelhead noted from 1990 through 1992."

The authors then conclude:

"Given that exploitation of Situk River steelhead is now minimal because of fishing restrictions, it will be interesting to note the effect on run sizes."

The authors at the time did not know that the next two years, 2004 and 2005, would provide the largest documented steelhead counts on the Situk River since 1952, 12,462 and 12,274 steelhead respectively (ADF&G 2003 and 2006; and 2006a). The 2003 question has had an unexpectedly rapid answer, at least for the moment. The coming 10-20 years will determine if it was just a temporary aberration or whether a pivotal management decision to allow steelhead to reach their own abundance ceiling without a potentially self-limiting escapement goal will lead to complete historic population size recovery.

From Situk Abundance to Collapse, and a Question: Eradication Efforts and MSY Harvest – Are They Different?

In May of 2003, the author of this report had opportunity to experience the visual impact of a return of nearly 8,000 wild steelhead spawning in the small drainage area of the Situk River. It was an experience out of all context from 25 years of having done steelhead spawning surveys. My previous steelhead spawning observations had included two of the presently most productive coastal wild steelhead rivers in the Lower 48: the Salmonberry River (sub-basin of the Nehalem River) in Oregon, and the Quileute River basin in Washington. It was apparent from the redd densities, and visual steelhead densities in the Situk River, that no comparable steelhead spawning density occurs anywhere in Washington or Oregon coastal river basins. Yet, the Situk steelhead spawning density observed in May of 2003 was only 1/3 to1/4 of that which occurred in 1952.

There was no doubting the authenticity of the Situk River weir counts in 2003. It was an actual count of 7,964 spawned out kelts leaving the river (ADF&G 2003 and 2006). There was no vagueness of trying to determine how many steelhead redds to attribute to each female, how many redds actually had eggs or not, or what the proportion of males and females was from which to determine the actual escapement. The visual plethora of a river bottom cratered with continually overlapping redds was corroborative testament.

On returning in 2003, and further researching the Situk River history of attempted eradication of steelhead, the question occurred: Has steelhead harvest in Washington, as managed for under the accepted concepts of setting escapement goals using formulas such as MSY, been anything other than a more sustained perseverance of steelhead and Dolly Varden eradication efforts that were too quickly abandoned in the Situk River because they did not succeed fast enough? Are present harvest and escapement goals, exacerbated by hatchery steelhead in mixed stock fisheries and resulting juvenile and adult interactions, succeeding in eradication of steelhead in the long term in a way that more focused short term eradication efforts failed to do?

Throughout the previous portions of this report, run size estimates have been made under the assumption that harvest in Washington is typically 30%-50% of the run size as indicated by Myers (2006), and which commonly fit the run size and harvest data examined in this report. However, in actuality, the steelhead harvest rate is 80%-95% early in the winter season with the intent of harvesting hatchery fish (SASSI 1994; and McHenry et al. 1996). As has been repeatedly found in the historic data (WDG 1948-1978; 1956; 1957; Taylor 1979; and WDFW 1996), that same early winter time period was the historic peak of wild steelhead runs in Washington. What the 30%-50% overall harvest rate of steelhead fails to identify is that most all of that harvest has been focused on the historic peak return of wild steelhead while minimized during the period when wild steelhead entry was lowest later in the winter and spring.

Of further concern, as shown in Table 25, it appears that in the case of the Situk, harvest rates of 15%-35% (discounting 1983) of the run size may have created a production ceiling that minimized the ability of the steelhead population to increase beyond a certain level, although it may have been sufficient to lift it above the steelhead population lows that occurred from 1953 into the early 1980s.

The managed pattern in Washington of a sustained 30%-50% harvest (80%-95% on the historic wild peak) is clearly too high to expect anything other than continued steelhead depletion, no possibility for recovery to historic numbers, and a long term trend line leading to wild steelhead eradication for those rivers and areas with a sufficiently early baseline for comparison (see Puget Sound, previous Figures 12, 13, and 14;

Stillaguamish, previous Figures 19, 20, and 21; and Queets River steelhead, previous Figure 27).

Although Situk steelhead harvest rates since the mid 1980s have been low compared to Washington's harvest driven management foundation, this may not have been the case from the 1940s through the mid 1970s, and it certainly was not so in an earlier era when steelhead, rainbow trout, and Dolly Varden were targeted for eradication. As reported by Bain it al. (2003):

"Although the steelhead run to the Situk River is now considered a highly valued resource, government fishery biologists of the 1930s and 1940s considered steelhead and Dolly Varden simply as effective predators of sockeye salmon (the commercially more valuable resource). *During this period, steelhead and Dolly Varden were trapped and destroyed and bounties were paid in some instances for both species."*

From the Appendices of Bain et al. (2003) comes an excerpt out of the 1934 USFWS report by W.W. Kinsey:

"May 7 started construction of series of trout traps in connection with weir on Situk River …"

"These trout are migratory. Downstream run of large ones began May 15. Fair number taken with traps and seine. Due to extreme high water traps out of order and no trout taken May 26 to June 4. June 4 run of large trout finished, heavy run of smaller ones followed closely, and continued until July 10. July 10 moderate run of large ones up stream. A few small ones (down run) and a fair number of large ones (up run) taken until late July. August run too light to justify continuing…traps dismantled August 9th…

"<u>TROUT TAKEN</u>

"May-5,415; June-104,735; July-31,372; Aug-1,025; Total 142,547 Unit cost 48/100 cents."

Beyond the fantastic numbers of trout killed (142,547 steelhead, rainbow, and Dolly Varden), the USFWS report provides a record of emigration and immigration timing. Peak kelt emigration was May 15th, the same as reported at the Situk weir today for steelhead (Johnson and Jones 2000). Johnson and Jones (2000) also indicate that while 2/3 of steelhead kelts emigrate in May, most of the remainder go out from June 1 to mid June. Although 5,415 fish (probably mostly steelhead kelts) were killed in May of 1934, high water forced abandonment of weir and trapping operation from May 26 to June 4.

Operation of the weir itself in those days was reported to delay steelhead outmigration. Large numbers would stack above the weir refusing to move downstream (Knapp 1952). Only with considerable effort of using a lantern at night was Knapp able to get the steelhead to move downstream through the weir in 1952 (resulting in 6,000 steelhead in one night). In 1934, similarly delayed kelts would have gone out during the nine days when the weir and traps could not operate. For instance, in 2003, of a total 7,964 kelts, 7,563 (95%) had emigrated by June 4th (data from daily counts by ADF&G 2003 & 2006) which suggests a similar pattern reported in 1934: "June 4 run of large trout finished." Although kelt emigration timing through the Situk weir is variable from year to year, considering the weir delays and timing of high water, the majority of the kelt emigration in 1934 likely occurred when the weir went out.

The run of smaller downstream fish reported after June 4th was likely that of smolts (104,735 killed) [Kinsey 1934]. The smolt outmigration continued until July 10th and then a more moderate upstream run of large fish began which continued through July (31,372 mixed smolts and upstream bound adults killed). The latter may have been Dolly Varden, or perhaps the Situk once had a modest run of summer steelhead that was effectively eliminated. Most migrations of trout and char had ended by August 9th (1,025 killed) with the weir removed. There is no indication of what the proportions of steelhead, rainbow, and Dolly Varden were.

In 1934, fish were captured at the weir with two seine nets and a wire-netted trap as described in the report. A fyke net was available but unused that year. The nets and traps were incorporated into the operation of the weir. Explosives were also described. $1,500 was made available for the steelhead and Dolly Varden elimination that year by "Libby, McNeill & Libby." As described by Johnson (2003), these were funds from the local cannery whose primary interest was commercial sockeye and coho harvest which large numbers of steelhead trout and Dolly Varden were thought to diminish by eating salmon eggs and fry.

In 1935, 31,012 "Dolly Varden" were destroyed (Kinsey 1935), although it is not clear if steelhead, rainbow, and Dolly Varden were differentiated or lumped generically as "Dolly Varden." Only the larger trout were targeted because it was too hazardous to try and kill the smaller outmigrating trout (likely smolts) without similarly killing the salmon fry. This suggests that the previous year, many salmon fry had been killed during the focus on killing the small trout migrating out with them. If so, the killing of the steelhead and Dolly Varden the previous year had likely inflicted as much damage on the sockeye salmon they were trying to protect.

In 1939, 30,254 "Dolly Varden" were destroyed (Berry 1939), but again it is not clear if this included steelhead and rainbow. In 1940 the cannery quit funding the bounty.

From at least 1934 to 1939, a targeted elimination of steelhead, rainbow, and Dolly Varden occurred with "harvest" occurring at six or seven life history levels: anadromous adult immigrants; anadromous adult emigrants; anadromous juvenile emigrants (smolts); fluvial adult migrations within the river; fluvial juvenile migrations within the river; and resident local populations (adult and juvenile). The effort failed, but not for want of an intensive short term effort.

After the attempt to eradicate steelhead, rainbow, and Dolly Varden yet another steelhead harvest factor was introduced. In 1942, construction of an air base near Yakutat resulted in 10,000 servicemen stationed there during World War Two (Johnson 2003). The USFWS report indicates (Mortensen 1945):

"Although many trout have been taken out of the river in the past few years, by anglers of the armed forces from over the territory, there is still an abundance of rainbows and Dolly Varden."

"On a fifteen mile trip up the river by canoe, it was noticed that the river banks and deeper holes were full of trout. The rainbows were from twenty inches to thirty

inches in length, as many have been caught this season and measured. The largest was 35 and ½ inches.

"Several times during the summer fresh salmon eggs were dropped from the weir and in a very short time the water would be alive with small fish, using a long handled 18" dip net and at each try would get fifty to one hundred small rainbow and Dolly Varden trout.

"Many Humps spawned in front of the weir and due to low, clear water, a very good observation of the damage done by trout could be seen. A very small percentage of the salmon eggs reached the gravel to be covered.

"On three occasions while weir was in operation it was noticed that the Dolly Varden run was equal in numbers to that of sockeye.

"There has been no bounty on trout since 1939 and the increase has become very noticeable and seems that control measures are necessary."

Johnson (2003) indicated the World War Two airfield and subsequent soldiers stationed in Yakutat initiated the sport fishery there, and although the bounty was no longer paid, apparently the weir operators were still killing trout, steelhead, and Dolly Varden through the 1940s as indicated by Mortensen (1946; 1947; and 1948):

"[1946 including typing errors] …*Many large Dolly's were gilled in sockeye gear by outside fishermen and in the Situk/Ahrnklin inlet."*

"Using wire trout trap and baiting with salmon eggs, several hundred small rainbow and Dolly Varden were taken in a few hours.

[1947 including typing errors] "*It would be hard to estimate the number of trout in the Situk River, **but this year have gone all out to get as much information as possible*** [emphasis added for this report]. *We think that there is much damage being done to Salmon spawn by Dolly's Rainbow, and Steelhead.*

*"In using a 4-4-4-ft. trap with funnel and baiting with fresh salmon eggs, could take several hundred small Dolly's and Rainbow during the day. **Many of these were eight inches long*** [emphasis added for this report] …

"*The large rainbows and steelhead would gather in front of the weir about flood tide and have been an estimated number of from three to five hundred idling back and forth. These trout were from twenty to thirty inches in length. A few were caught that measured a little over thirty-five inches.*

"During our closed period (July 11 to 27) the Natives wanted to cook fish. Using a six fathom net, placed from weir to shore, 32 were entangled in less than one hour. When cleaned, all contained salmon spawn and a few weighing as much as seven pounds...

"[1948] *The Situk is one of the best sportsman streams in Alaska. During the past season there were many that flew in from Anchorage and Juneau, also anglers from Michigan and South Dakota. Of the many small fish that were checked by use of dip net, it was found Dolly Varden in the majority."*

1947 was a year the operators of the weir went "all out to get as much information as possible", apparently through a targeted effort to kill as many samples as possible ("harvest" in the name of science) to prove the theory that steelhead, rainbow, and Dolly Varden were a primary threat to salmon. The description of the many eight-inch fish would indicate smolts were continuously eliminated, evidently to check for salmon eggs in their stomachs. In the 1948 report, it was indicated that the majority of smaller fish (smolts) were Dolly Varden. The proportion of steelhead among the larger fish is unclear, although the catch by Native people in July, with a maximum size of seven pounds, suggests either Dolly Varden or rainbow, or potentially earlier fall-run steelhead (summer-run).

The descriptions indicate that two life histories of steelhead were targeted for elimination at the weir in the name of science: emigrating kelts and emigrating smolts. Respawners presently make up 1/4 to 1/2 of the Situk River steelhead run size, so the elimination of significant numbers of kelts would have considerable effect on the subsequent adult returns, especially the following year. The elimination of smolts would especially affect adult returns 3-4 years later (most Situk juvenile steelhead smolt at age 3-4). The growing sport fishing interest added yet another layer of harvest, that on immigrant spawners, so virtually all age classes and life histories except eggs and fry were being impacted by forms of "harvest" during the 1940s.

That steelhead were still able to respond with the large return in 1952 is remarkable after the previous 18 years of greater or lesser efforts to eradicate them, or to otherwise harvest them. Apparently already weakened in numbers, and perhaps depleted in life history diversity, the reported alterations in weather patterns resulting in droughts in 1950, 1951, and 1954 eliminated what little resiliency remained and the population suddenly crashed in 1953 and did not begin to recover until the 1980s.

Early habitat alterations are not mentioned beyond using explosives to remove a logjam about 12 miles upstream of the weir in 1934 (Kinsey 1934); and developed road access to the river did not occur until 1964 (Johnson 2003). Effects from swings in ocean productivity likely played a part (Bain et al. 2003), but the undeniable factors working on steelhead that were out of context with any previous history were varied forms of in-river eradication attempts as but one of several forms of harvest at multiple life history levels.

Managing for Ecosystems Rather than Harvest

In *The Song of the Dodo*, David Quammen (1996) described differing factors that can lead to extinction. Although he was primarily considering the vulnerability of species living on islands, it is increasingly realized that continents are also islands and that island biogeography and its related concepts have broader application. All populations fluctuate in size under the influence of two kinds of factors:

- *stochastic factors*, those that operate in a realm beyond human prediction and control (such as flood, drought, altering ocean currents, forest fires set by lightning, a disease epidemic or parasite infestation, volcanic eruption, ice ages, global warming, or etc.);
- *deterministic factors* involving straight-forward cause-and-effect relations that to some extent can be predicted and controlled (essentially human activities such as harvest, destroying habitat, introductions that increase competition, hybridization and/or predation, overzealous collecting of specimens, taking of eggs from the wild population, blocking migration routes, and etc.).

These two factors have interacted with increasingly lethal consequences for species worldwide. This is a major theme of Quammen's book.

On the whole, as long as a population is relatively large, stochastic factors result in survivable population fluctuations (Quammen 1997). But with inherently small populations, or populations once large and that have been severely reduced, an event or series of events of largely unpredictable origins can have species threatening results.

Quammen (1997) examines the work of Mark L. Shaffer (1978; 1981; 1987; and 1990) in his analysis of determining minimum viable population sizes and how wildlife uses landscape, specifically regarding the grizzly bear (*Ursus arctos*). For Shaffer the fundamental question was not so much what the critical size of an ecosystem is, but what the minimum critical population of each constituent species is. Quammen explains the case of Yellowstone grizzly bears as studied by Shaffer:

*"The greater Yellowstone ecosystem is a vast area of woodland and meadow and mountain slopes and river drainages encompassing not just Yellowstone National Park and Grand Teton National Park but also contiguous portions of seven national forests, several wildlife refuges, part of the Wind River Indian Reservation, and some Bureau of Land Management holdings, as well as bits of private and state land, most of it still wild enough to be hospitable to grizzly bears. Despite the patchwork of ownership status, these various pieces constitute a single ecological whole. Because the ecosystem is surrounded by developed terrain (including farms, ranches, barbed wire, towns, suburbs, highways, railroad tracks, irrigation canals, power lines, airports, golf courses, guardrails, trailer parks, malls, lumber mills, movie theaters, gas stations, gun shops, pizza parlors, parking lots, picket fences, barking dogs, traffic lights, stop signs, and concrete lawn ornaments), terrain that **isn't** so hospitable to them, the grizzlies of greater Yellowstone are effectively insularized. They stand discrete as a population, on a discrete ecological fragment…"*

In similar ways, this relates to the salmon and steelhead driven ecosystems of Alaska and the Olympic Peninsula. The Situk River presently provides a "time capsule" that represents Olympic Peninsula rivers at some point in the past, perhaps as late as the 1920s and 1930s. Olympic Peninsula coastal salmon and steelhead ecosystems remain conceivably recoverable to present Situk River conditions, although an effective course of action is more obscured by a greater complexity of interactive stochastic and deterministic factors that need to be unraveled.

Regarding Shaffer's work, Quammen (1997) identified four sources of uncertainty to which a population may be subject: demographic stochasticity (accidental variations in birth rate, death rate, and the ratio of sexes); environmental stochasticity (fluctuations in weather trends, in food supply, and in the population levels of predators, competitors, parasites, and disease organisms with which the species must cope); natural catastrophes (floods and fires, typhoons and hurricanes, earthquakes and volcanic eruptions, and etc. which aren't totally random in that they do have physical causes but they are so complex as to be virtually inscrutable, and the timing is unpredictable, and therefore these events loom as another sort of uncertainty); and genetic stochasticity (genetic alterations, particularly occurring when populations are smaller, can strip a population of the genetic variation that it needs to continue evolving; the resulting population, stiffened with uniformity, may remain seemingly stable so long as environmental circumstances remain stable; but when circumstances are disrupted, the population won't be capable of evolutionary adjustment; if the disruption is drastic the population may go extinct, such as can occur with environmental stochasticity and natural catastrophe).

In 1953 and 1954, the Situk River population of steelhead reacted to a combination of deterministic (human induced) and stochastic (natural) factors.

Between 1925 and 1954 several stochastic factors led to reduced Alaskan salmon and/or steelhead productivity. As previously discussed regarding Puget Sound, PDO cycles can determine expected salmon productivity from resulting ocean conditions that occur (Beamish et al. 1997a; Beamish et al. 1997b; Mantua et al. 1997; and Hare et al. 1999). A PDO warm cycle, correlating with an enhanced Aleutian Low (as shown in Figure 15), resulted in higher levels of Alaskan ocean productivity from the mid 1920s to the mid 1940s; it was followed by a PDO cold cycle with reduced Alaskan ocean productivity from the late 1940s to about 1976; it then shifted back to a warm PDO cycle and higher Alaskan productivity from 1977 to 1994 (Hare et al. 1999). The cyclic shifts occur every 20-30 years. Higher zooplankton biomass favoring feeding conditions for migrant Alaska-origin smolts occurs during the positive (warm) PDO cycles; it reverses to West Coast productivity during the negative (cold) PDO cycles (Hare et al. 1999).

A negative PDO shift could affect Situk River steelhead productivity in two ways:

- reduce smolt survival on reaching a less productive ocean;
- reduce salmon nutrients that return to the river to provide freshwater rearing.

As depicted in Figure 56, the actual case of the Situk River regarding salmon catch does not exactly correlate with the positive PDO cycle of maximized ocean productivity for Alaskan salmon (1925-1945). The largest Situk salmon catches were from about 1910 to 1924 with a lower level plateau from 1925 to 1945 before dropping off to the more anticipated sustained low from the mid 1940s through the mid 1980s (a 40 year low cycle). This may represent overharvest of coho and sockeye due to uncontrolled commercial net fisheries beginning in 1902 until the time early fishery managers placed gear and fishing time restrictions in the Situk Lagoon by 1927 (Johnson 2003). That early period of overharvest may have reduced Situk salmon and steelhead resiliency that reduced the ability to quickly respond to increased ocean productivity and prolonged the low cycles.

However, the reduced catch from 1925-1945 (in Figure 56) could also reflect effective controls on salmon harvest (begun in 1927) as compared to the previous 20 years of overharvest and too little escapement. The lower catch could mean more salmon actually returned to the Situk River spawning grounds and provided more nutrients for steelhead and Dolly Varden. This could have resulted in the attempt to eradicate them in the 1930s and 1940s when they both were apparently extremely abundant. The cannery, frustrated by the reduced catch resulting from the more controlled salmon fishery, may have turned to blaming trout as the cause for their lost profits.

Remembering that most initial spawning in the Situk River is by steelhead that are 6-7 years old (3-4 freshwater and 3-ocean), and the high contribution of respawners that would be seven to eight years old or more, the sudden 1953 drop in steelhead numbers roughly correlates with the equally sudden drop in salmon catch in 1947 (seven years earlier) as a result of the PDO shift to lower Alaskan productivity. This suggests a negative steelhead relationship that is driven more by reduced salmon numbers returning to the Situk River than to an immediate response to reduced ocean productivity.

Figure 56.

Situk River Salmon Harvest History 1905-2005
(From Bain et al. 2003 [Data from per. com. S. McPherson and Commercial Fisheries IFDB database]; about 62% of harvest was sockeye salmon.]}

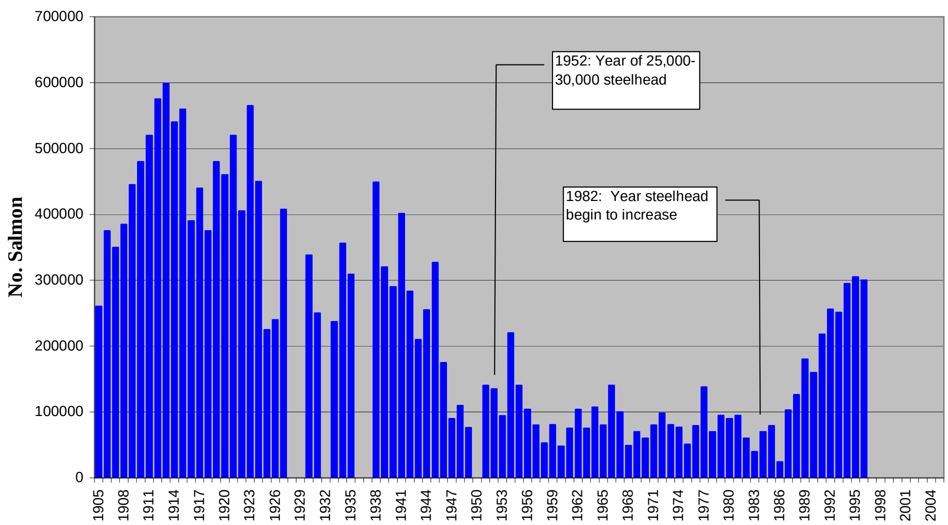
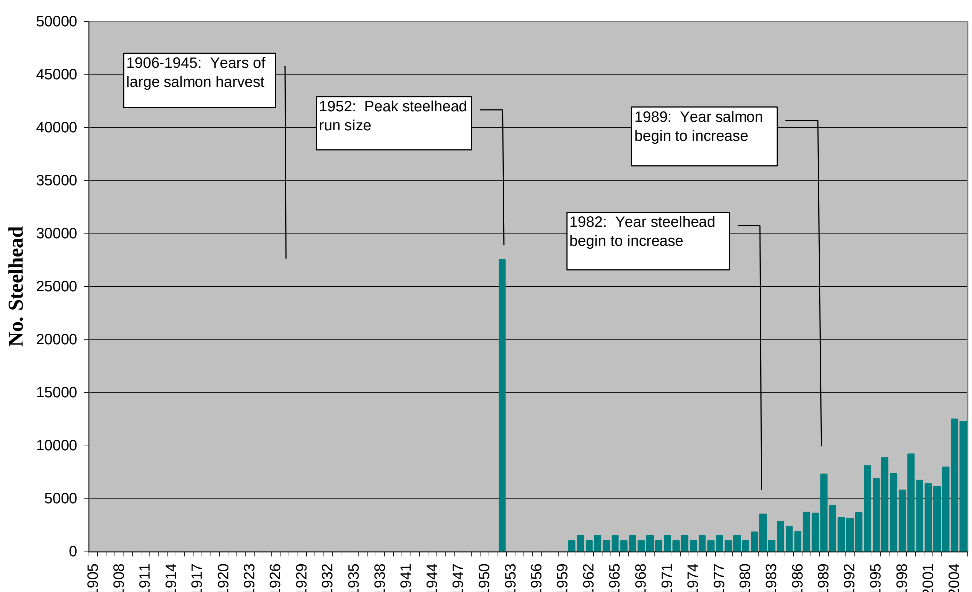


Figure 57.

Situk River Steelhead Run Size History 1905-2005
(Data from Bain et al. 2003; ADF&G 2003 & 2006; and ADF&G 2006a)



Steelhead runs sizes to the Situk River actually remained high for seven years after ocean productivity dropped off around 1945. This is depicted by the prominent spike of the 1952 steelhead run size in Figure 57. It is the earliest known reference point from which to compare steelhead numbers with the salmon catches in Figure 56. Although it is an isolated reference point, it may represent several years of higher steelhead productivity during the preceding 10-20 years.

If ocean productivity was most immediately responsible for reduced steelhead smolt survival, it would be anticipated that a steelhead collapse would have begun in 1948 or 1949, not 1953. The most common ocean age of Situk River steelhead on their initial spawning run is three years (or four for kelts after one year of reconditioning). As indicated by Bain et al. (2003), "it is probable that steelhead abundance over the long term is driven by the same factors driving production of other salmon species." However, the delayed timing of the steelhead response suggests an initial controlling factor that may differ from salmon (at least in the case of the Situk).

Weather also apparently played a role in the loss of Situk River steelhead rearing productivity. Half of normal precipitation occurred in 1950, 1951, and 1954, and a similar drought occurred in 1987 (Bain et al. 2003). Due to the long freshwater rearing of most Alaskan steelhead (3-4 years), the progeny from spawners dating from 1946 to 1954 would all have been affected by the long span of the droughts in the 1950s. It would also have affected rearing steelhead from 1983 to 1987 regarding the one year drought in 1987. This is the type of stochastic factor Quammen (1997) warned of that can suddenly occur and leave an already depleted population at the brink of extinction, or tip it over the edge.

Another stochastic factor occurred in 1958 demonstrating the potential for natural disasters to occur as recorded in the USFWS Situk report by George W. Hewitt (1958):

"An earthquake at 9:15 pm July 9th caused severe physical damage from Yakutat Bay to Lituya Bay. In the Situk River there were numerous waterspouts of subterranean origin. There were some channel changes which made the entrance difficult to navigate."

Evidently little is known about how this may have affected Situk River salmon and steelhead, although Bain et al. (2003) provide the following:

"…the gradual uplifting of the Yakutat Foreland (Combellick and Long 1983) and other geophysical events are responsible for some naturally ongoing habitat alterations. Since little historical information on production of steelhead smolts from the Situk River is available, effects of these changes in freshwater environments on steelhead stocks cannot be evaluated."

Whether the waterspouts described included geothermal activity was not mentioned, nor whether the Situk's water volume altered. It is known that in the relatively near future Hubbard Glacier will again dam Russell Fiord recreating the Situk River into a large glacial outflow. Presumably the 22 age classes found in Situk steelhead (Johnson 1996) provide the necessary diversity to adapt to dramatic shifts in hydrology as has previously occurred. A riverine spawning population of sockeye salmon in the Old Situk River is thought to be a remnant life history that was more prevalent when the Situk was last a glacial outwash river in the 1800s, and chinook salmon are rare in a river as small as the Situk in Alaska and may remain as part of its glacial river history (Lorenz 1994). Steelhead likely retain similar traits as the sockeye and chinook to draw from that are well adapted to a glacial origin system. That diversity to draw from includes: a range of spawning time from February (Johnson 1991) into July (entry data from ADF&G 2003 and 2006); ocean life histories of 1-6 years and freshwater life histories of 1-5 years (McHugh et al. 1971; 1972; Jones 1983; Glynn and Elliott 1993; and Johnson 1996); respawner rates of 25% (Jones 1983) to 59% (Johnson 1996); and females that spawn up to three times and males up to four times (Glynn and Elliott 1993).

Bain et al. (2003) indicate that scale samples were taken from Situk River steelhead in 1970, 1971, 1982, 1994, 1995 and 1996, although the 1995 and 1996 samples have not been aged. The 1996 sampling was from 1,028 fish in a year when 8,510 kelts were passed through the weir. Scale (or otolith) readings from Situk River steelhead during a higher run size year would provide a particularly useful tool from which to measure changes that may occur in life histories between years of low abundance (such as the early 1970s) and higher abundance (such as 1996).

To date it has been the Russian steelhead literature (with data collected from rivers on the Kamchatka Peninsula) that has best documented life history, phenotypic, and morphological changes that occur as steelhead populations fluctuate in numbers over time (Savvaitova et al. 1973; 1996; 1997; and Pavlov et al. 2001). The Russian ichthyologists appear to have the best grasp of steelhead being a measure of ecosystems, and the opposite as well (Augerot 2005). They have correlated the changes that occur in the animal with altering harvest, environmental, and climatic patterns that shift over time (Savvaitova et al. 1996; Pavlov et al. 2001; McMillan 2001; and Augerot 2005). When heavy harvest occurred with a decline of steelhead in a Kamchatka Peninsula river, it was found that the entire interactive rainbow/steelhead population altered with life history variations and morphological changes in an attempt to adjust to provide an overall population homeostasis (Savvaitova et al. 1997; and Pavlov et al. 2001; McMillan 2001).

Presumably periods of population stresses that are so great as to result in physical alterations in the fish and complete reversals in population life history structure, have effects throughout the ecosystem and result in periods when steelhead are particularly vulnerable. Added to this, the Russians found that all of the populations studied with an historic baseline of data had significantly reduced vertebrae counts, even in those populations where the anadromous life history was at former levels (Savvaitova et al. 1997; Pavlov et al. 2001; and McMillan 2001). It was thought this may be related to the pervasive factor of global warming affecting all of the Siberian river basins. To date the reduction in vertebrae has remained within the known limits of the species, but there is concern if the reductions continue that may not be the case (Pavlov et al. 2001).

Although the vocabulary used is not the same, the Russians have effectively documented the tensions between deterministic and stochastic factors described by Quammen (1997). They have collected baseline data from which a framework for conservation planning can occur using concepts from the field of biogeography. The Russian steelhead work would fit in well with Quammen's description of Mark Shaffer's (1978; 1981; 1987; and 1990) analysis of grizzly bear data for determining minimum viable population sizes as constituent species within an ecosystem

It will be vulnerability resulting from increasing layers of deterministic factors that will largely determine the future of 21st century steelhead populations that have commonly been managed down to historic low numbers and reduced levels of diversity from which one or more stochastic factors will be the straw that breaks the camel's back. In the case of the Situk River, these deterministic factors have not been inconsequential, but they were comparatively few. The knot to unravel has not been as complex as in Washington.

Considering the relative strengths of Situk River habitat, the sustained depletion of the steelhead population for 30 years after 1953 is an example of what "harvest" pressures alone can do. In the case of the Situk, harvest pressure was escalated to attempted eradication. Ironically, eradication failed due to the stochastic factor of annual high water events working against human planning. These high water events provided temporal windows for emigrating kelts to escape. Plans were further thwarted after 1934 due to the realized complexity of the ecosystem in which the targets of eradication, steelhead and Dolly Varden smolts, were inseparably mixed with the several species of more primary interest emigrating at the same time, salmon.

The purposeful culling out of undesirable adult steelhead and Dolly Varden as salmon predators on the Situk River may have had no more impact than conventional steelhead fisheries in Washington which harvest 30%-50% of the run size on an annual basis (the killing of smolts, particularly in 1934, was another matter, although it could be argued that the sport harvest of smolts and pre-smolts in "trout" fisheries may have an even more permanent long term effect). In fact, the Yakutat air base construction in 1942, and resulting sport fishing that occurred thereafter, may have had a greater impact on the steelhead population than the eradication effort. There was no record of the sport catch at the time, but fishing pressure was high enough to draw the attention of USFWS reports and it had a more sustained longevity than the eradication effort. While the weir was a stationary object whose use was limited by the temporal periods of effective operation and the spatial inability to move upstream or down to take advantage of steelhead abundance levels, sportsmen were not similarly constrained. Sport fishing also occurred over a longer season and would have harvested adult immigrants prior to reaching the spawning grounds as opposed to the weir's potentially less damaging effect of killing adult emigrants after they had spawned.

From Figure 55 and Table 25, sport catch was clearly the major component of harvest until catch and release regulations went into effect in 1991. Sport harvest primarily occurs during the spring fishery. Relatively few fall run steelhead are caught in the sport fishery, and even fewer harvested (Bain et al. 2003). The shift to catch and release regulations in the summer of 1991 resulted in minimal sport harvest from 1992 onward. This has occurred despite a regulation change allowing harvest of two steelhead over 36" per year since 1994 combined with a ban on use of bait. Apparently the regulation change resulted in a continued catch and release fishery for all practical purposes while minimizing the potential effects of mortality by eliminating bait. As hoped by the managers, the steelhead population has responded positively.

Table 26 provides a timetable of varied deterministic factors related to steelhead harvest on the Situk River, and historic reference points regarding steelhead population responses:

Table 26. Changes is Situk fisheries that may have affected steelhead and reference points of steelhead numbers

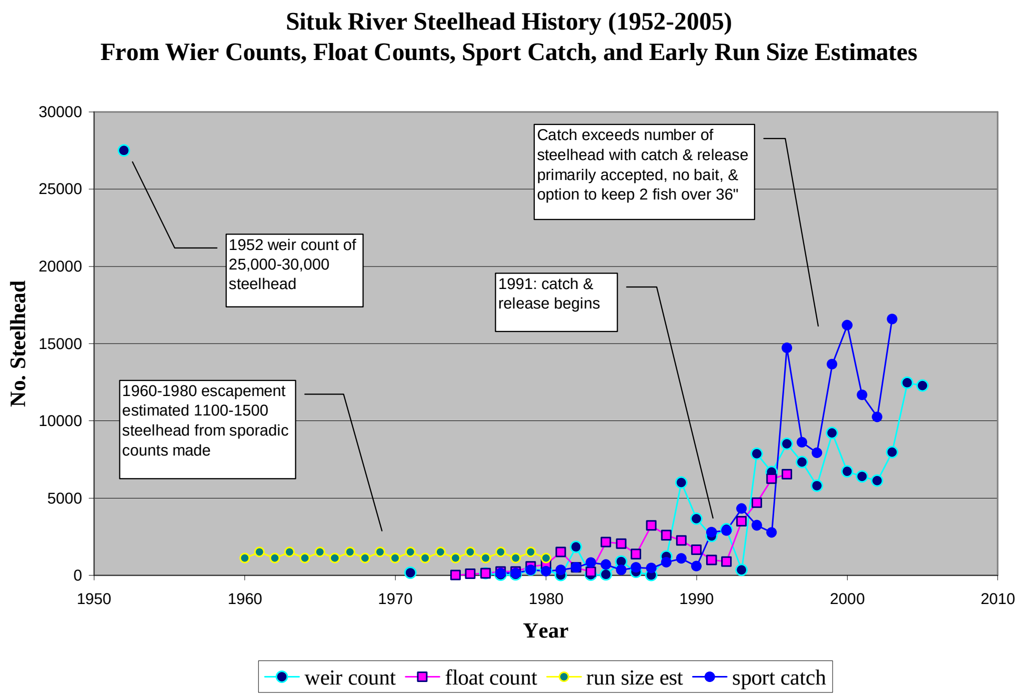
Year	Change that occurred, or event	Source
1902	Uncontrolled coho/sockeye commercial net fisheries begin	Johnson 2003
1927	Gear & fishing time regulations on net fisheries begin	Johnson 2003
1934	Eradication effort of steelhead & Dolly Varden begins with bounty paid	Kinsey 1934
1934	142,547 combined steelhead, trout, Dolly Varden killed of all sizes including 5,415 probable steelhead kelts in 3 weeks in May	Kinsey 1934
1940	End of steelhead & Dolly Varden bounty	Berry 1940
1940-1974	Steelhead sport limit (trout over 20") 3 fish per day	Bain et al. 2003
1942	Steelhead sport fishery begins with construction of WW II air base and 10,000 servicemen	Johnson 2003
1945	"…many trout (to 35.5") have been taken out of the river the past few years by anglers of the armed forces…"	Mortensen 1945
1947	Weir operators find it hard to estimate all the trout; use trap to take out several hundred 8" fish per day including steelhead smolts; report 300-500 steelhead idling in front of the weir up to 35" in length	Mortensen 1947
1948	One of best sportsman streams in Alaska, anglers from Midwest	Mortensen 1948
1950-1960	Decline in sport fishing effort with period of minimum number of anglers	Johnson 2003
1951	Weir holds back numerous steelhead on way back out, up to 3,000 at a time	Knapp 1951
1952	Difficulty getting steelhead past weir; count 25,000-30,000; 6,000 one night; very few Dolly Varden compared to past seasons	Knapp 1952
1953	"Steelhead trout were almost non-existent this season."	Knapp 1953
1954	"Very few mature steelhead were in the river again during this season."	Knapp 1954
1960	First sport fishing guide begins operation using all terrain vehicle access prior to roading	Johnson 2003
1960-1980	Steelhead run size estimates of around 1,000-1,500	Johnson 1990
1964	Logging road built to Nine-Mile Bridge site; pre-road guiding 300 anglers/season	Johnson 2003
1968	Improved road built to lower Situk Landing site; steady increase in anglers follows	Johnson 2003
1971	First modern weir count of steelhead was 160	Bain et al. 2003
1975-1979	Steelhead sport limit (trout over 20") reduced to 2 fish per day	Bain et al. 2003
1980	Steelhead sport limit (trout over 16") reduced to 1 fish per day	Bain et al. 2003
1980s	Situk fishing is nationally televised; promotions at outdoor expositions in Lower 48; harvest increases; up to 30 boats per day float the river with anglers	Johnson 2003
1985-1990	Voluntary catch & release results in 1,139-4,991 Situk steelhead released annually	Johnson 1991
1989	Sport harvest peaks at 1,086 steelhead	Bain et al. 2003
1991	Declining trend in weir & float counts; public concern; catch & release of steelhead required	Bain et al. 2003
1992	Steelhead sport harvest falls to near zero	Bain et al. 2003
1994	Steelhead annual sport limit 2 of over 36"; elimination of use of bait	Bain et al. 2003
1996	New high in modern weir counts of 8,510 steelhead kelts; catch & release of over 14,000 steelhead	ADF&G 2003 & 2006
1999	New high in modern weir counts of 9,204 steelhead kelts	ADF&G 2003 & 2006
2003	Over 16,000 steelhead catch & release	ADF&G 2003 & 2006
2004	New high in modern weir counts of 12,462 steelhead kelts	ADF&G 2003 & 2006

Figure 58 provides the Situk River steelhead history from 1952 to 2005 as depicted by weir counts, early run size estimates, float counts, and sport catch (sport harvest only from 1977 to 1989, and sport harvest plus steelhead caught and released from 1990 to 2003). The trend, by all three measures (weir counts, float counts, and sport catch), has been steadily upward ever since the early to mid 1980s in what has been decadal steps. But full recovery to the historic steelhead population size of 1952 remains only about 50% accomplished.

The Russians found that illegal commercially-motivated poaching activities with nets resulted in steelhead harvests sufficient to result in profound changes in rainbow/steelhead populations as found through altered morphological characteristics and shifts in life history strategies that occurred (Savvaitova et al. 1997; Pavlov et al. 2001; McMillan 2001; Augerot 2005).

It is probable that something like this also occurred to the Situk River steelhead population (potentially interactive with resident rainbow and estuarine rainbow) from at least 1934 through the 1980s. Reversing such profound changes in a population that has adjusted to depletions at differing life history points for more than 50 years may take considerable recovery time with shifts throughout the ecosystem.

Figure 58.



In Russia, the depletion of steelhead in some Kamchatka rivers may not have been significant until the collapse of the USSR began in the late 1980s with a subsequent economic collapse in the early 1990s as the human population struggled to survive any way possible – which included poaching of steelhead. The conservation efforts began in the mid 1990s (Savvaitova et al. 1996), and the steelhead populations there have responded positively in a short time (per. com. Pete Soverel, March 2006, founder of the Wild Salmon Center and leader of the Russian/American Kamchatka Steelhead Expeditions beginning in 1994). Nevertheless, harvest through illegal poaching remains the biggest identified threat to Kamchatka steelhead populations (Augerot 2005).

Situk Salmon Nutrient Levels

Thedinga et al. (1993) have indicated that the Situk River's unusually high salmonid productivity is derived primarily from the river's stable hydrologic regime, high base flow, low gradient, and high levels of dissolved nutrients (essentially salmon carcasses).

In 2003 the author of this paper made his first analysis of Situk River steelhead history comparing it with that of Washington's Skagit River (McMillan 2004). Since that time, the quality of data found regarding the Situk River has improved, and while the implications of the original paper remain correct, some of the specific details have turned out to be inaccurate. This was particularly true of the available information for computing the number of salmon carcasses distributed in the Situk River watershed.

The Situk River drainage size originally used in 2003 came from an ADF&G information source that indicated the basin area was 124 sq mi (ADF&G 2003 and 2006).

The newer information indicates the basin area is 200 sq km (Bain et al. 2003) [or 77 sq mi] with the evident probability that 200 sq km was the original information source in which the multiplication factor of 0.6214 for converting kilometers to miles had been used by ADF&G instead of the factor of 0.3861 for converting square kilometers to square miles. As a result, the salmon carcasses per square mile in the Situk basin are considerably higher than originally computed.

Table 27. Situk River salmon: harvest, escapement, and run size estimates

Species	Harvest estimate	Escapement estimate	Run size estimate	Source
Sockeye	1976-2002 avg 49,396	38,182-216,631 1976-2002 avg 77,987	67,000-302,000	Erickson and McPherson 1997 Clark et al. 2002
Coho	10,000-100,000	na	na	Erickson and McPherson 1997
Chinook	na	na	1,000-18,000	Erickson and McPherson 1997
Pink (odd yr)	na	na	30,000-500,000	Erickson and McPherson 1997
Chum	na	na	na	na
All salmon	historic to 600,000	avg ~500,000	na	Bain et al. 2003 Johnson (per. com. 2003)

The Situk weir's primary purpose is to provide counts of sockeye and chinook salmon for management purposes (Bain et al. 2003; and Johnson 2005). Pink salmon, the most abundant species, are counted on the odd years of return (ADF&G 2003 and 2006), but the weir is not operated when the majority of coho and chum enter, likely due to the difficulties related to high flow events. However, harvest of Situk origin coho is known to be 10,000 to 100,000 (Erickson and McPherson 1997). About 62% of the Situk salmon harvest from 1905 through 1996 has been sockeye (Bain et al. 2003), which is likely the species that provides the most profit per effort. It was indicated that coho are the other primary species commercially targeted (Bain et al. 2003). The escapement goal for sockeye as managed since 1995 has been 30,000-70,000 fish which is reevaluated every five years (Clark et al. 2002). In the modern weir counts dating to 1976, the 1977 sockeye escapement of 216,631 was the largest and the 1997 escapement of 38,182 the smallest with run sizes becoming smaller since the 1970s.

It is estimated that about 500,000 salmon return to the Situk River annually (per. com. Bob Johnson of ADF&G in 2003). In the absence of recorded escapements for coho and chum salmon this seems a reasonable figure from the numerical ranges of the other salmon species provided in the literature as shown in Table 27 which is primarily from modern weir count data beginning in 1976 (Clark et al. 2002). However, Figure 56 indicates 400,000-600,000 salmon were harvested between 1910 and 1924. If the 1913 harvest of ~600,000 salmon represented 50% of the run size, the higher harvest range suggested by Myers (2005), then 600,000 also escaped. Considering that the commercial catch focused on sockeye and coho, which would have left pink salmon (the most numerous species) and chum salmon little touched, it seems reasonable to suppose that prior to industrial scale harvests, salmon escapements to the Situk River may have been well over one million fish, and were likely near, or at, one million salmon in the first quarter of the 20th century.

With a drainage area of only 77 sq. miles, and average escapements of 500,000 salmon, the Situk River presently has the nutrients provided by about 6,500 salmon carcasses per sq. mile. As late as 1924, with an escapement that may have been near 1,000,000 salmon, there would have been about 13,000 salmon carcasses per sq. mile.

For comparative purposes, Washington's Skagit River has a total drainage area of 3,093 sq. miles with about 1,200-1,400 sq. miles accessible to salmon (McMillan 2004). If present escapement goals for salmon were met, the Skagit River would have returns of 524,400 salmon with the nutrients of 375-437 salmon carcasses per sq. mile, less than 7% of present Situk River carcass/nutrient levels, and 3.4% of the Situk's early 20th century carcass/nutrient levels. Very clearly, the Situk River is a salmon driven ecosystem. The Skagit River no longer is. It is not by accident that Puget Sound steelhead have been in a long steady downward decline toward extinction. The ecosystem that once evolutionarily sustained them no longer exists.

The coastal Olympic Peninsula river with the largest historic salmon run sizes is the Quinault River as is indicated in Table 24. Run sizes of 1,062,654-1,587,741 salmon once returned to the Quinault basin as compared to recent estimates of 63,628 salmon. The Quinault drainage area is 434 sq. miles, although an unquantified portion of the upper East Fork is inaccessible to salmon (Phinney et al. 1975). To adjust for the inaccessible areas of the basin, the drainage area used by salmon for the computations has been reduced to 400 sq. miles. Also, the historic number of pink salmon remains an unknown. Although it is indicated that pink salmon were not historically abundant in the Quinault (Smith and Caldwell 2001), throughout these historic searches it has been found that such assessments are not necessarily the case. Because pink salmon can be very abundant in their alternating years of return, their absence from the salmon carcass assessments for the Quinault may have resulted in a significant underestimate of salmon numbers.

Using the Quinault River salmon data available, if harvest was 50% of the historic run size, 531,327-793,871 salmon escaped to spawn with 1,328-1,985 salmon carcasses per sq. mile (using the high end of the 30% to 50% harvest range suggested by Myers [2005]). If the low end of the harvest range is used (30%), there were 1,860-2,779 salmon carcasses per sq. mile.

If the more recent Quinault salmon run sizes of 63,628 salmon have been harvested at the more modest 30% rate, 44,540 salmon escaped to spawn with 111 carcasses per sq. mile (4%-8% of historic Quinault carcasses per sq. mile), or if they have been harvested at the 50% rate, there have only been 80 salmon carcasses per sq. mile (3%-6% of historic Quinault carcasses per sq. mile).

Although historically the Quinault was a remarkably productive salmon ecosystem by most any other west coast standard, at its historic high it only had 10%-21% of historic Situk carcass levels (with the caveat that no estimate was attempted regarding what Quinault pink salmon numbers once were, or presently are, which may have been significant). Even by Alaska standards of salmon productivity, the Situk River is unusual. It is considered to be the most productive watershed for its size in Southeast Alaska (Bain et al. 2003). The Situk River historically was, and largely remains, in a class of its own. Perhaps this is a remaining artifact of the Situk River having been a much larger river 150 years ago. It remains a vital salmon driven ecosystem that warrants careful conservation efforts and the focus of future studies for the understanding it can provide.

The Comparative Recoveries of Situk River Steelhead and Salmon: An Example of Implementing Celtic Folk Wisdom

Although there is no firm data of what Situk River steelhead population numbers were prior to the one weir count in 1952, the eradication effort that began in 1934 clearly indicates that both steelhead and Dolly Varden were so abundant that they appeared to threaten a commercial salmon fishery that harvested 575,000 salmon just 10 years earlier and about 350,000 salmon that same year (Figure 56 from Bain et al. 2003). Steelhead had such low value that those incidentally caught were discarded or used for dog food (Johnson 2003). The target fishery was sockeye salmon which did not begin until June and most incidental steelhead would have been spawners and spawned out kelts whose flesh quality would have been perceived as inferior compared to other cannery options.

Seldom considered in any of the Situk River literature found is what proportion of the Situk steelhead population may once have returned in the fall, or even the summer. Today only a fall run is recognized, and it is thought to be about 16% of the total steelhead spawning population (Johnson 1991). It would have been the immigrant fall run (and potentially summer run) steelhead that would have taken the brunt of incidental harvest in the "uncontrolled sockeye and coho commercial fisheries" described as beginning in 1902 with a subsequent decline in those two species by 1923 (Johnson 2003). "Fair" and "moderate" upstream runs of migratory trout were described on July 10th and again later in July at the Situk weir (Kinsey 1934). This suggests steelhead with summer run timing may have once occurred, although it is not always clear whether the references are about steelhead or Dolly Varden.

As is evident from the examinations of the Olympic Peninsula streams, summer runs of steelhead are the first to reach lowest levels of depletion. This likely has to do with their often being the smallest component of the steelhead population combined with a run timing that occurs at the same time as commercial fisheries focused on salmon.

Without a pre-1952 record of Situk River steelhead numbers, it can only be surmised that fall run steelhead (and summer steelhead if they existed) would have been reduced by the same commercial harvest levels that noticeably depleted sockeye and coho populations by 1923. The incidental catch of Situk steelhead continues to occur in the commercial net fishery in August and September on the fall run, and fall run fish along with spring run fish are again incidentally harvested as emigrant kelts in the spring (Didier and Marshall 1991). Although the spring emigrants were the primary target of eradication efforts from 1934 into the 1940s, it is the fall run that has been subjected to the longest, steadiest pressure of harvest. Although present levels of harvest do not appear large or threatening from the data in Bain et al. (2003), that may not have always been the case. The fall run is the smallest sub-population of Situk steelhead (now known), therefore the most vulnerable, and potentially the one most reduced since the advent of industrial level harvest in the early 20th century.

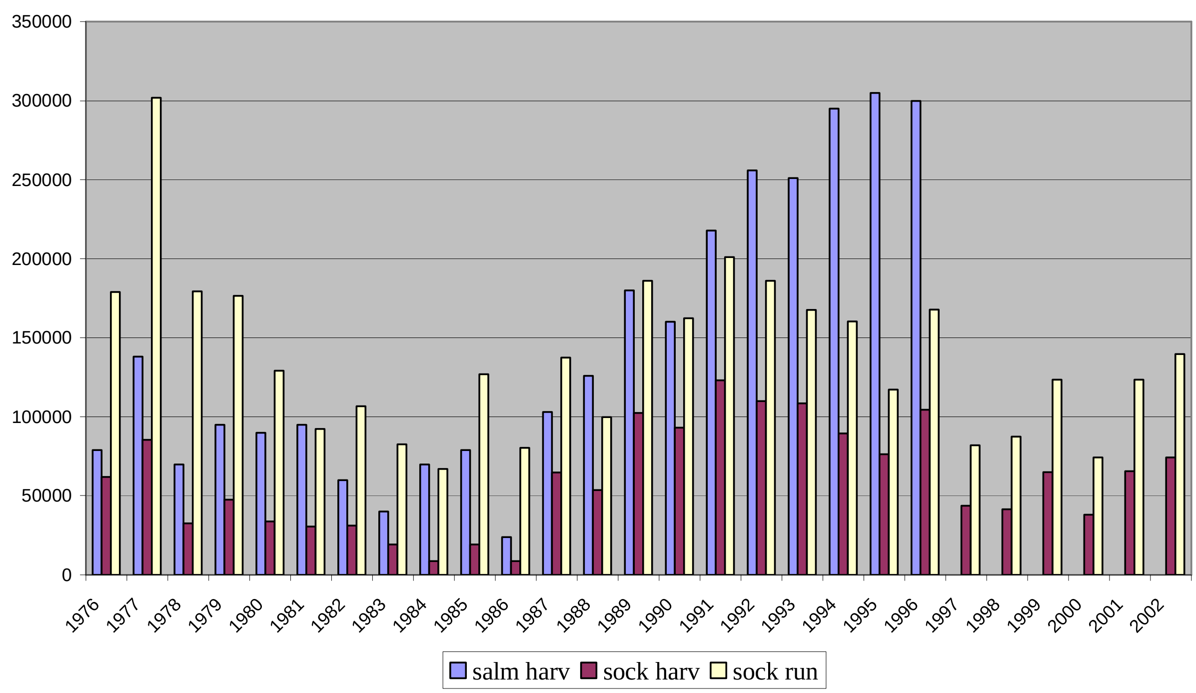
The only records found regarding early numbers of salmon have been the harvest data as depicted in Figure 56 (from Bain et al. 2003, which the authors acquired from the Commercial Fisheries IFDB database and per. com. with S. McPherson of ADF&G Sport Fish in Douglas). Presumably the old weir counts still exist for salmon, but the only weir data found were those from 1976 onward. While the salmon harvest records are important data, they do not depict the escapement after harvest from which to determine the actual run sizes. From the information by Johnson (2003), which indicates a decline in sockeye and coho numbers beginning around 1923 with resulting fishery management beginning in 1927, it cannot be well determined if declining harvest was the measure of that decline, or whether it was the lack of fish returning to the spawning grounds, or both.

Although no available record was found from which to compare overall Situk River salmon harvest to overall salmon escapement dating back to the early historic era, there is available information regarding Situk River sockeye salmon harvest combined with the Situk weir counts to provide escapement numbers and the total run size from 1976 to 2002 (Clark et al. 2002). These data have been compared to the total salmon harvest of all species as provided in Figure 59. While from 1987 to 2002 the run sizes essentially reflected the pattern of harvest, from 1976 to 1986 the patterns between run size and harvest were more divergent. One year,1977, the sockeye run size was dramatically greater than harvest and was out of all context with the general return patterns. Overall the pattern of sockeye harvest since modern harvest management began (perhaps 1976 as suggested by escapement data beginning then) has apparently balanced harvest and escapements to keep run sizes relatively consistent.

However, the pattern of sockeye harvest and run sizes is not consistent with the overall pattern of the salmon harvest of all species combined (Figure 59). For instance, as overall salmon harvest continued to increase from 1987 to 1996 with steady upward progression, sockeye harvest and escapement both rose from 1987 along with the general salmon trend, but after peaking in 1991 sockeye departed from the rising salmon trend with a long gradual decline. Because most of the remaining salmon catch has likely been coho (Bain et al. 2003), the coho trend from 1991 to 2002 has apparently been very strong, or perhaps increased harvest on one of the other species has occurred.

Figure 59.

Situk River Salmon History 1976-2002
Comparing Total Salmon Harvest, Sockeye Harvest, & Sockeye Run Size



Strictly measured by harvest data, the salmon runs (62% of harvest being sockeye and coho from Bain et al. 2003) never have fully recovered from the harvest pressure that occurred from 1905 to 1924 (Figure 56), although this may not be the actual case if significantly greater escapement has occurred since. From Figure 59, there may have been one modern year, 1977, when sockeye approached historic numbers as provided by the run size data rather than harvest. Unfortunately, the level of monitoring coho, chum, and pink salmon has not been as thorough as for sockeye and the overall trend of the Situk River salmon ecosystem remains obscure. Nevertheless, considering the limiting variables of ocean productivity through PDO cycles, it is apparent salmon catch levels, other than sockeye, have steadily risen since the late 1980s (after a long low period beginning in the latter 1940s), and are now relatively equal to the harvest levels of the period from 1925 to 1945, although still less than that of 1905 to 1924.

How much of salmon depletion or salmon recovery is related to fishery management is difficult to separate from the effects of PDO cycles. This is particularly difficult to determine without a record of actual population sizes for each species rather than only harvest. The one species which has a good data record from 1976 to present, sockeye, further confuses the picture. The recent divergent downward trend of Situk sockeye from the general salmon increase is difficult to explain from available information.

A primary question is, would the Situk River steelhead population have also responded positively over the past 20 to 30 years if harvest levels had remained at 15%-35% without implementation of catch and release regulations as a control on the major component of Situk steelhead harvest? Overall salmon harvests, and potentially run sizes, have also increased in roughly the same period of time as steelhead run sizes (as shown in Figures 56 and 57) and did not require virtual elimination of harvest to do so.

Because the available historic data for salmon is limited to harvest, and the primary indicators for steelhead are float and weir counts, it presents the dilemma of comparing apples to oranges.

Coming from a long line of craftsmen, tradesmen, and guildsmen of Scot and Irish ancestry, one is taught to build as well as possible with the materials available. While there is comparable Situk run size data for both salmon and steelhead from 1976 to the present, it is the equivalent to the good craftsmen who is provided an insufficient quantity of materials from which to build a house. The provided materials may be of fine quality, but they are only sufficient for partial framing. Nearby are straw, stone, lime, sand, and a hillside with clay: a hodgepodge of materials, but freely available. Up goes the house, part stone, part stucco, part brick, with the original few framing materials used for doorjambs, windowsills, and roof rafters topped with thatch. Human beings survive because they learn to make do. She who ignores what is available is a damned fool. This is the lesson from Celtic ancestry …and every other human ancestry that has survived long enough to procreate us.

Using the assumption, which may have certain flaws (such as using straw for a roof), that the salmon harvest trends and steelhead run size trends are of roughly equal value, the differences between the highs and lows are a different order of magnitude for steelhead as compared to salmon as shown in Table 28.

Table 28. Comparisons of differing periods of average harvests of salmon and roughly comparable periods of average run sizes of steelhead that have historically occurred on the Situk River, and the percentage of the historic high each period of time represents

Period of time	Salmon harvest average	% historic high	Period of time	Steelhead run size average	% historic high
1906-1924	470,000	100%	1906-1924	na	na
1925-1945	305,000	65%	1925-1952	27,500	100%
1946-1988	92,000	20%	1953-1981	1,250	4.5%
1989-1996	246,000	52%	1982-1993	3,376	14%
1997-2005	na	na	1994-2003	7,334	29%
			2004-2005	12,368	45%

The lowest known run sizes for steelhead were 1953 and 1954 (Knapp [1953; and 1954] indicated almost none) and 1960 to 1981 which was estimated by Johnson (1990) to be run sizes of around 1,000-1,500 fish annually. Using the median between the two, a run size of 1,250 steelhead is only 4.5% of the historic high of 25,000-30,000 steelhead counted in 1952 at the Situk weir if a median run size of 27,500 steelhead is used. Although 1952 is the only year of early data for steelhead comparative uses, the general pattern of the salmon catch would indicate that from around 1906 to 1945 the average steelhead run size would have been at least as high as 1952 (and likely even higher) if a PDO cycle that favors Alaskan productivity was occurring through that earlier span of time.

There is also the corroborative evidence of steelhead being so numerous they were a perceived threat to what may have been a run size of one million salmon in 1934. The motivation to initiate eradication of steelhead is actually stronger historic evidence of extreme abundance than the thin line of one year's data on a graph. Profit adventures such as canneries would only have supplied $1,500 (Kinsey 1934) during the Great Depression years unless there was substantial evidence that very large numbers of steelhead could threaten the continued profit from salmon.

As difficult as it is to presently conceive, the salmon pattern represented in Figure 56 suggests that in 1934 the steelhead population may have been *double* that of 1952 (55,000 steelhead), and in 1913 may have been *quadruple* that of 1952 (110,000 steelhead). Such implications will not be further pursued beyond the fact that we may presently have very little understanding of how steelhead, resident rainbow, and Dolly Varden fit into the original salmon driven ecosystems of the North Pacific Rim prior to industrial level resource extraction began.

The low period of Situk salmon catches was 1946 to 1988 with an average catch of 92,000 fish annually. That was 20% of the high period between 1906 and 1924. The prolonged steelhead low point was 4 times lower (as compared to the high) than was the case for Situk River salmon.

If one risks the assumption that the steelhead run sizes of 2004 and 2005 represent the coming average trend, steelhead will have recovered to within 45% of their known historic high. Salmon (limited to data that ended in 1996) have recovered to within 52% of their high historic catch (roughly comparable). However, while the 2004 to 2005 steelhead recovery represents a 10 fold increase over their historically low run sizes (1,250 fish between 1953 and 1981), the present salmon recovery represents less than a 3 fold increase over their historically low catches (92,000 between 1946 and 1988). If the

2004 and 2005 steelhead run sizes are ignored until there are more years of record, the 1994-2003 period of steelhead recovery was 29% of the historic high representing just under a 6 fold increase over the historic low point. In either case, steelhead made a significantly greater recovery (2-3 times greater) from their low point than did salmon.

Figure 60.

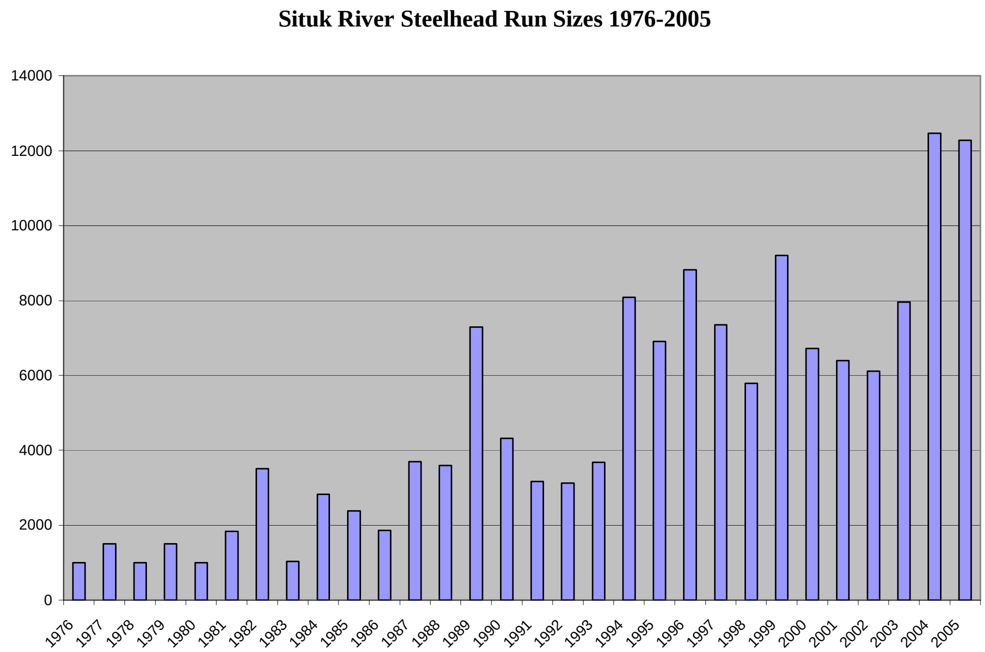
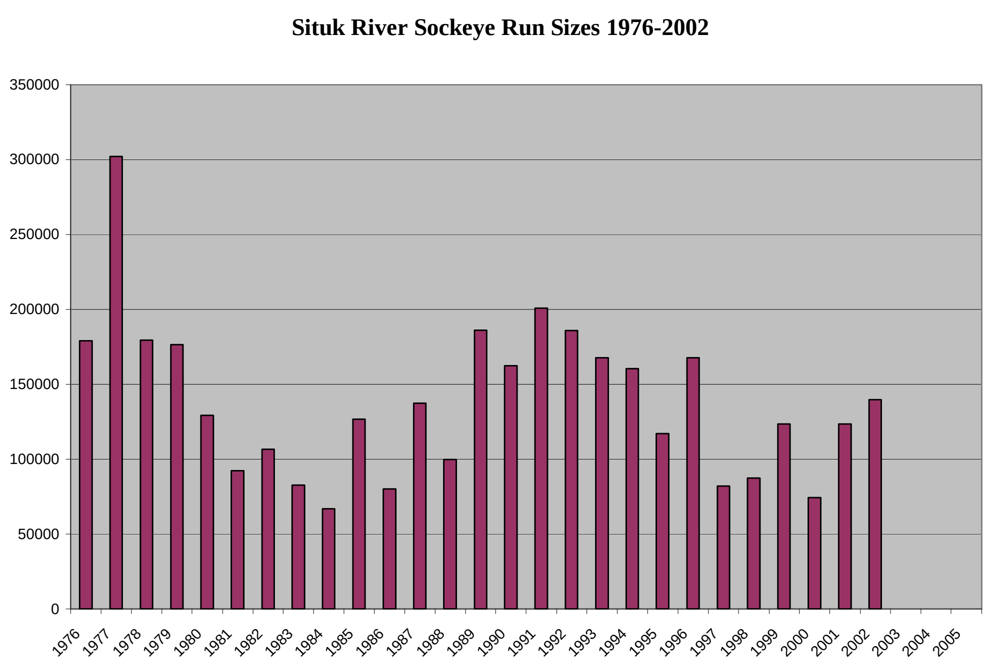


Figure 61.



As previously indicated, there is one salmon species for which there are data comparable to that of steelhead over a similar period of time. Figures 60 and 61 provide a comparison of "apples to apples" regarding sockeye run sizes and steelhead run sizes from 1976 to 2005. From this it is apparent that steelhead are on a very different trend line from sockeye in the time span examined. As steelhead have expressed sustained increases in run size numbers, the sockeye run size has gone into a modest reverse trend of slight decline. From a fishery management standpoint, the decision to stimulate steelhead recovery by nearly eliminating harvest and by improved monitoring of run sizes would appear to have been effective as independent from the present ocean cycle if the comparative sockeye trend is an effective measure.

Nevertheless, the combined salmon species harvest trend since 1989 remains roughly similar to that of steelhead and questions about ocean conditions remain a factor that obscures the ability to measure the effects of management decisions.

However, comparisons of the data included in Table 28 indicate that steelhead have experienced a significantly greater level of recovery as compared to their historic low point than have salmon on the Situk River. The steelhead low point was 4 times lower than the low point was for salmon as compared to the highs for each. This suggests that the focused effort to eradicate steelhead, combined with longer term sport harvest, had a significantly greater impact than the effects of commercial harvest had on salmon. Also, by nearly eliminating sport harvest, steelhead recovered to a greater degree from their low point than salmon did by using a controlled harvest formula such as MSY.

From the comparisons of steelhead to salmon in Table 28, combined with the comparisons provided in Figures 60 and 61, it would appear that shifts in PDO cycles that may, or may not, have determined the magnitude of Situk salmon recoveries do not fully answer the level of historic depletion that occurred with steelhead nor the level of recovery that has occurred since. Other mechanisms are apparently working in favor of a continuing progressive steelhead recovery. There have been two other known factors:

- altering harvest levels to well below those generally determined by MSY in 1991;
- increased numbers of salmon and nutrients beginning about 1989.

There may be other factors that have not been revealed in the literature accessed, but these two factors provide at least part of the materials for building a "house" from what is available in the time honored way of Celtic survival (and other surviving human ancestry) for a very long time.

Of equally significant consideration is the potential building material that was *not* used on the Situk River during the "house" construction for salmon and steelhead recovery:

- hatcheries.

This also makes sense from the time honored way of my Scotch ancestry in particular:

- that which is expensive and fraught with risk is beyond consideration.

Scotch ancestry has much to do with being "Scotch" dating to a time of conservative folk-economics that long resisted the high risk adventures inherent to industrial level economics shoved on them by a culture run amuck (from the Scotch perspective) on the south half of the island they shared.