4. Watershed Vision for Salmon Recovery

Habitat, harvest, and hatchery management are expected to work together to bring about recovery of the two Stillaguamish Chinook salmon populations.

Guiding Principles for the Stillaguamish Watershed Chinook Salmon Recovery Plan

The SIRC adopted the following guiding principles for the Stillaguamish Watershed Chinook Salmon Recovery Plan in August, 2002:

- Integration: The plan shall address water quality and salmon recovery issues in an integrated manner, consistent with the intent of the 1990 Watershed Action Plan and the origins of the SIRC.
- Fairness: The plan shall promote fair treatment and shared burden of cost for rural, urban, business, private, local, state, federal and tribal constituencies.
- Science: The plan shall use the best available science to make technical determinations. Existing watershed plans and analyses should be used as the core basis of this planning information. At the request of the SIRC, the Stillaguamish Technical Advisory Group will evaluate disagreements on best available science.
- Scope: Chinook salmon recovery shall be the primary emphasis of the plan within a broad ecosystem restoration context designed to enhance the watershed for all native freshwater and marine aquatic fisheries.
- Evaluation: Recovery shall be measured by criteria that are broadly accessible and that promote sustainability as well as fish population targets or water quality standards.
- Community: Recommended planning actions shall integrate scientific principles with community, social and economic values including but not limited to the protection and preservation of agriculture and rural quality of life. Community resources, such as volunteers, landowners and local knowledge, should be a part of plan implementation.
- Landownership: All landowners holding farm, forestry, recreation and residence properties may request fair compensation for the use of their land in restoration.
- Regulation: The plan shall seek to support actions that improve enforcement of current growth management and environmental

regulations and make them more effective rather than proposing new regulations. Non-regulatory efforts that promote salmon recovery are necessary elements of the plan.

- Commitment: Actions shall be backed by financial and work plan commitments of implementing organizations and shall be designed to have measurable results.
- Education: Communication of problems, proposed actions and results to all ages of the public shall be defined as part of plan implementation in order to facilitate public comment and plan development.
- Cooperation: The plan shall recognize the individual efforts of agencies and organizations and promote cooperation among them.
- Balance: The plan shall balance long-term goals while recognizing the need for short-term actions.

Watershed Goal

The purpose of listing the Puget Sound Chinook salmon as Threatened under the ESA is to restore a self-supporting population that does not require legal intervention to maintain its existence (NMFS 2000). Within the Stillaguamish Watershed, the primary goal is to restore healthy, viable populations of Chinook salmon to a level where natural population production is healthy enough to support recreational and commercial fisheries. The relative health and viability of the population will be judged by its VSP parameters: abundance, productivity, population structure, and diversity (NMFS 2000). These factors are essential to a viable salmon population and depend on properly functioning habitat.

The SIRC has chosen to focus their efforts at this time on the implementation of a 10-year strategy aimed at moving toward recovery of Chinook salmon populations in the Stillaguamish Watershed. This strategy includes specific habitat, harvest, and hatchery management actions, as well as policy and regulatory commitments and conditions. The benefits of individual habitat management actions have been modeled using EDT to generate estimated Chinook salmon population gains that will result in achieving 30% of the TRT planning targets. Details of the 10-year action plan are included in Chapter 5. Implementation of these actions over the next decade will allow for ongoing planning, monitoring, and adaptive management to achieve long-term recovery of the species.

Beyond the initial 10-year recovery strategy and implementation of its recommended actions, an adaptive management approach will be used to determine the necessary actions to achieve long-term Chinook salmon recovery objectives. The health and viability of the Stillaguamish Chinook salmon populations will be judged by the Viable Salmonid Population (VSP) parameters and ongoing progress toward reaching the TRT planning targets. Necessary long-term strategies and actions for habitat, harvest, and hatchery management will be adopted as appropriate.

In support of the guiding principles above, the 10-year watershed goal chosen by the SIRC in April 2004 is based on a number of planning assumptions:

- The SIRC promotes restoration of natural ecosystem processes and properly functioning conditions in the watershed with local stakeholders participating in natural resources decision-making.
- The 10-year goal will move the watershed toward properly functioning conditions and the Shared Strategy planning target for Chinook salmon while recognizing the extended time period recovery will require.
- An ambitious approach will be taken to build on current momentum and minimize reliance on uncertain future implementation.
- Proposed watershed actions are designed to be reasonably achievable by local organizations within the 10-year period.
- Significant funding from regional, state and federal sources will be requested to complete projects. Without this external funding, the goal will not be achieved.
- The SIRC will analyze opportunities for policy and regulatory coordination, especially in the areas of local and forest land use policies, and identify regulatory gaps related to habitat and watershed protection that will need to be addressed for consistency and effectiveness of ongoing watershed restoration projects.

Habitat Strategy

Habitat improvement is a major component of Chinook salmon recovery in the Stillaguamish Watershed. Habitat recovery requires an understanding of the relationships between land use practices, watershed-scale processes, habitat conditions, and Chinook salmon requirements. Protection, restoration, and re-connection of habitat and watershed functions, as well as more effective regulatory enforcement, further data collection, and research, are necessary elements in addressing habitat problems throughout the watershed.

Habitat linkages and restoration of lost habitat and related watershed functions will play a major role in the recovery of Chinook salmon populations. Table 8 demonstrates some of the linkages between habitat-forming processes, land use, resulting habitat conditions, and response by Chinook salmon in the Stillaguamish watershed.

Table 8. Habitat Linkages

Habitat-forming processes	Affected by land use	Resulting habitat conditions	Chinook salmon population response
Delivery of water	Removal of 35-40% of the historical forest cover, 15-20% permanently[21]	Increases peakflows that blow out large woody debris, erode banks; eroded banks and upland areas contribute greatly increased sediment loads that fill pools, intrude redds, further simplify habitat[22].	Reduced habitat diversity and complexity leads to reduced survival of juveniles; reduced egg survival, survival to emergence; reduced adult holding capacity; potential pre-spawning mortality from increase temperatures.
	Construction of dikes, levees, revetments; cutting off side-channels, sloughs, blind tidal channels[23]	Increases portion of channel network/habitat that is exposed to high-energy flows; directly reduces edge, side-channel, slough, and blind tidal channel habitat critical for juvenile rearing[24]	This has the most dramatic effect on the currently configured Chinook salmon populations in the Stillaguamish. These land use actions directly reduce critical juvenile rearing habitat causing estuarine density-dependent mortality and reducing fitness of emigrating smolts contributing to low ocean survival rates[25].
	Filling or isolating beaver ponds, riverine and palustrine wetlands[26]	Reduces floodplain detention and retention storage increases flood magnitudes, particularly in lower river, and increases flow velocities that blow out large woody debris, erode banks[27]	Reductions in habitat diversity and complexity caused by high magnitude and high velocity stormflows reduce density-dependent survival of juvenile Chinook salmon[28]; evidence is gathering for juvenile Chinook salmon use of freshwater off-channel habitat which these land use actions directly reduce.
Delivery of wood	Removal of 35-40% of the historical forest cover in the whole watershed and likewise in the	Removal of riparian forests prevents new woody debris from recruiting, reduces habitat diversity and complexity, reduces	Reductions in physical habitat diversity and complexity caused by high magnitude and high velocity stormflows reduce density-dependent survival

[21] See Pollock and Kennard (1998), Purser et al. (2003) and Simmonds et al. (2004)
[22] See Lisle and Eads (1991), Rhodes and Purser (1998), and Collins (1997)
[23] See Bortleson et al. (1980)
[24] See COE (2000) and STAG (2000)
[25] See Collins (1997) and Collins and Sheikh (2003)
[26] See Pess et al. (1999)
[27] See Crance (1988)
[28] See STAG (2000)

Habitat-forming processes	Affected by land use	Resulting habitat conditions	Chinook salmon population response
	riparian area, 15-20% permanently	channel roughness leading to increased streamflow velocities; contributes to high stream temperatures[29] .	of juvenile Chinook salmon; contributes to potential for density-independent adult pre-spawning mortality from high stream temperatures.[30]
	Removal of in-channel wood by streamside landowners, "poachers," and government agencies	Reduces habitat diversity and complexity, reduces channel roughness leading to increased streamflow velocities	Reductions in physical habitat diversity and complexity resultant from high magnitude and high velocity stormflows reduce density-dependent survival of juvenile Chinook salmon.
Delivery of sediment	Removal of 35-40% of the historical forest cover in the whole watershed and likewise in the riparian area, 15-20% permanently	Eroded banks and upland areas contribute greatly to increased sediment loads that fill pools, intrude redds, further simplify habitat	Increases direct density-independent mortality in redds and reduces density-dependent survival of juveniles; reduces adult holding capacity [31].
	Extensive (lots of road miles all over the basin) and intensive (high density of road miles in specific basins) roading[32]	Has contributed to increased frequency of landslides and increased delivery of fine sediment directly from unpaved and/or poorly drained road surfaces; increases the potential for intrusion of fines into redds; fills pools.	Suffocates or entombs eggs and juveniles (source of density-independent mortality)[33]; pool filling reduces density-dependent survival of juveniles and leads to reduced adult holding capacity

Unconstrained floodplain reaches are highly productive habitats for anadromous salmonids (Stanford and Ward 1992). In addition, off-channel areas adjacent to floodplains have been shown to be important rearing habitats for salmonids during high winter flood events (Tschaplinski and Hartman 1983). Fragmentation of habitat and the resulting isolation of populations affects the long-term viability of salmonids. In addressing habitat fragmentation and connectivity for the Northern Spotted Owl, Thomas et al.

[29] See Spence et al. (1996)
[30] See Healy in Groot and Margolis (1991)
[31] See Reeves et al. (1989)
[32] Roading is defined as the construction of road surfaces, cut banks, fill slopes, drainage facilities and the maintenance thereof. There acute dramatic changes from construction and chronic multi-parameter effects from the maintenance of road systems in watersheds. See Spence et al. (1996), Collins (1997), and Sharma and Hilborn (2001).
[33] See Bjornn and Reiser (1991)

(1990) outlined several general principles that are equally applicable to salmon recovery planning (Spence et al. 1996):

- Large blocks of habitat are preferable to small blocks.
- Blocks of habitat that are close together are superior to those that are far apart.
- Contiguous blocks are preferable to fragmented habitats.
- Corridors linking habitats function better when they resemble the preferred habitat of the target species.

Thus, the first objective of this habitat strategy is to prevent further fragmentation of aquatic habitat. The second objective is to improve the connectivity between isolated habitat patches. The third objective is to protect and restore areas surrounding critical salmon habitat from further degradation, allowing for the expansion of existing refugia such as:

- Preferred spawning areas
- Off-channel floodplain habitat
- Estuary and marine shoreline habitat
- Complex sloughs and undisturbed blind tidal channels
- Natural riverbanks

Harvest Strategy

To ensure that Washington based commercial and recreational fisheries do not impede Chinook salmon rebuilding and recovery, the co-managers adopted the Puget Sound Harvest Management Plan (Puget Sound Indian Tribes and Washington Department of Fish and Wildlife 2004). Consistent with the overall goals of the Stillaguamish Watershed Chinook Salmon Recovery Plan, harvest of Chinook salmon will occur in a manner that will have a high probability of not impeding the capability of the North Fork and South Fork Stillaguamish Chinook salmon populations to rebuild to levels that will support directed harvest and other benefits.

The following general principles guide the details of the harvest strategy:

- Harvest management alone cannot rebuild Stillaguamish Chinook salmon populations. Harvest management must work together with habitat and hatchery management to support a viable recovery plan.

- Development of an appropriate harvest management plan will require increased knowledge of the production function. One principal goal of the monitoring and adaptive management plan will be to assure the collection of appropriate information to monitor, and revise if necessary, the production function.

- All sources of fishery-related mortality count equally in assessing the exploitation rate. These include pre-terminal fisheries directed at Chinook salmon such as those in Canada and in the ocean off of Washington state, pre-terminal fisheries with incidental mortality of Chinook salmon such as the north Puget Sound sockeye fishery, recreational fisheries directed at Chinook salmon such as the Puget Sound winter blackmouth fishery, hook-and-release mortality in selective recreational fisheries, and incidental harvest of Stillaguamish Chinook salmon in terminal fisheries directed at hatchery stocks. All mortality will be assessed in terms of adult equivalent mortality – as the reduction in the number of adult fish (or biomass of eggs in the new model) that would reach the spawning grounds in the absence of fishing[34].

Harvest Management Plan

The harvest management guidelines for Stillaguamish Chinook salmon include an exploitation rate objective and a critical escapement threshold. The exploitation rate objective is the maximum fraction of the production from any brood year that is allowed to be removed by all sources of fishery-related mortality, including direct take, incidental take, and non-landed mortality. The exploitation rate is expressed as an adult equivalent rate, in which the mortality of immature Chinook salmon is discounted relative to their potential survival to maturity.

Analysis specific to North Fork Stillaguamish Chinook salmon was completed to develop the exploitation rate objective to reflect, to the extent possible, the current productivity of the stock. Brood year recruitment (i.e., number of recruits per spawner) was estimated, for brood years 1986 through 1993, by reconstructing the total abundance of natural origin Chinook salmon that were harvested or otherwise killed by fisheries, or escaped to spawn. The resulting brood year recruitment rates were partitioned into freshwater and marine survival rates. The future abundance (i.e. catch and escapement) of the stock was simulated for 25 years, using a simple population dynamics model, under total fishery exploitation rates that ranged from 5 percent to 60 percent. In the model, production from each year's escapement was subjected to randomly selected levels of freshwater and marine survival, and randomly selected levels of management error. Each model run (i.e. for each level of exploitation rate) was replicated one thousand times, and the set of projected population abundances analyzed to determine the probability of achieving the management objectives. The simulation for North Fork Stillaguamish

[34] A formula for adult-equivalent exploitation rate is (R-E)/R, where R is the total number of fish (or biomass of eggs in the new model) that would have returned to spawn naturally in the absence of fishing and E is actual number (or biomass of eggs) that did spawn naturally given the fishing pattern.

Chinook salmon, across a range of exploitation rates (Table 9), indicated that total exploitation rates below 0.35 met the recovery criteria.

Table 9. Summary of results of 1,000 runs of the simulation model at each exploitation rate.

Exploitation Rate	Probability of Falling Below Critical	Probability of Recovery	Median Escapement Ratio	Median Escapement
0.00	1%	96%	2.75	3,597
0.05	1%	96%	2.81	3,377
0.10	1%	96%	2.76	3,165
0.15	2%	95%	2.66	2,964
0.20	2%	95%	2.56	2,758
0.25	3%	93%	2.57	2,418
0.30	4%	92%	2.48	2,210
0.35	6%	92%	2.46	1,920
0.40	7%	91%	2.29	1,686
0.45	11%	87%	2.14	1,444
0.50	17%	80%	1.92	1,180
0.60	41%	52%	1.04	648
0.70	73%	12%	0.27	259
0.80	94%	0%	0.02	55

The fishery management objective for the 2000 management year was to realize an exploitation rate that, if imposed consistently over a future time interval:

- Would not increase the probability that the stock abundance would fall below the critical escapement threshold, after 25 years, by more than five percentage points higher than were no fishing mortality to occur; and
- Would result in at least an 80% of greater probability of the stock recovering (i.e. escapement exceeding the current level) after 25 years.

Stock recovery, for this analysis, was defined as the average spawning escapement for the final three years in the simulation period exceeding the average for the first three years in the simulation period (Rawson 2000).

At the present time, there is very little information concerning the productivity of the South Fork Chinook salmon population other than the fact that the average abundance of this stock has been approximately 50% of the North Fork Chinook salmon population based on relative escapement. Incorporating this lower estimate of abundance, and assuming the same productivity (i.e. recruitment rates), the simulation model predicted that exploitation rates below 35% met the first management objective. The probability of rebuilding at this exploitation rate was 96%. This analysis indicates that a target exploitation rate of 0.35 would also be appropriate for the South Fork Chinook salmon population.

The Washington co-managers have set an exploitation rate guideline of 0.25, as estimated by the FRAM simulation model, for the Stillaguamish Chinook salmon management unit. According to the simulation model, this level of exploitation results in a 4% risk of the management unit falling below the critical escapement threshold of 500, and affords a 92% probability of recovery (i.e., that spawning escapement will exceed the current average level).

The low abundance threshold for North Fork Chinook salmon is 500 natural-origin spawners. Reconstruction of the total brood abundance of adult Stillaguamish Chinook salmon suggests that escapements of 500 (+/- 50) can result in recruitment rates ranging from two to five adults per spawner (Rawson 2000). The genetic integrity of the stock may be at risk and depensatory mortality factors may affect the stock when annual escapement falls below this threshold to 200 (NMFS Biological Opinion 2000). The critical threshold for South Fork Chinook salmon is undetermined pending further analysis of data. However, recent preliminary DNA analysis indicates a critical population threshold at 100 spawners per year (Spidle, unpublished data; Appendix G).

The low abundance threshold for the Stillaguamish management unit is based on the 1996-2002 average fraction of the natural escapement for the years 1996-2002 in the North Fork. This average was .813 (range: .770 - .852). Thus a management unit escapement of 500/.813 = 615 would, on average, include 500 North Fork fish. The range of management unit escapement thresholds computed this way is 586 to 649. Based on this, we have selected a low abundance threshold of 650 for the Stillaguamish management unit. Whenever spawning escapement is projected to be below this level, fisheries will be managed to either achieve the critical exploitation rate ceiling, or exceed the low abundance threshold.

Long-Term Harvest Management Plan

The co-managers will continue to collect and evaluate the information necessary to develop a long-term harvest management plan for Stillaguamish Chinook salmon. This plan will be based on updated assessments of the productivity and capacity of the Stillaguamish system. The basis of the plan will be production functions for each population relating recruitment biomass to the biomass of natural spawners or fertilized eggs on the spawning grounds. The long-term harvest management plan will be designed to provide long-term maximum sustainable harvest from the entire management unit under the constraint that the viability and diversity of the production of each stock will not be jeopardized. This program may use information collected as part of regular monitoring, but it may also include special monitoring or assessment in addition to the monitoring program.

Hatchery Strategy

North Fork Stillaguamish

The Stillaguamish Chinook Salmon Natural Stock Restoration Program is a state- of-the-art program designed to protect and help restore naturally spawning Chinook salmon from the North Fork Stillaguamish. By removing adult Chinook salmon that would naturally spawn in unstable, degraded habitat and providing the progeny of those fish with a stable environment within the hatchery, additional survival benefits are obtained for a given group of eggs and sperm. The release of hatchery-reared smolts provides additional adults back to the watershed to buffer the decline of natural spawners due to the poor habitat conditions and the low productivity of the natural environment.

The objectives of the hatchery program are:

- To insure the short-term preservation and long-term restoration of native Stillaguamish River Chinook salmon populations to levels that will sustain fisheries, non-consumptive fish benefits, and other related cultural and ecological values; and
- To provide technical information through the US/Canada Indicator Stock Program on harvest rates and locations, migration timing, and productivity for north Puget Sound summer/fall natural Chinook salmon populations.

The initial intent of the program is to help preserve the listed population by releasing up to 220,000 sub-yearling North Fork Stillaguamish-origin summer Chinook salmon each year (STAG 2000). Specific performance standards for the Stillaguamish program are: 1) initially maintain and then increase the total abundance of the composite natural/hatchery summer Chinook salmon population; 2) as habitat improves, increase the ratio of natural origin spawners vs. hatchery origin spawners on the spawning grounds; 3) produce adult hatchery fish that are similar to natural-origin fish in morphological and life history traits; and 4) maintain the genetic diversity of the population (HGMP 2000).

The hatchery program initially began adipose clipping and coded wire tagging all of the fish released from the program. In 1997, due to conservation concerns, the decision was made to drop the adipose clip, but continue to coded wire tag the fish. This decision was based on anticipated selective hatchery harvest fisheries and the regional implementation of 100% electronic sampling for all Chinook salmon fisheries. Failure by Canada and Alaska to implement 100% electronic sampling, combined with the importance of the

Stillaguamish indicator stock, and improvements in escapement have resulted in returning to adipose clipping and coded wire tagging all natural stock restoration fish released by the hatchery.

“The Stillaguamish coded wire tag group is one of the best Chinook tag groups we have in Puget Sound for estimating exploitation rates because a large portion of the North Fork Stillaguamish is actually sampled for coded-wire tags. In many other systems no, or very few, in-river tag recoveries are included in the exploitation rate analysis (Rawson, personal communication).”

The benefits of the program include reducing the risk of extinction to the wild Chinook salmon population by increasing the total (hatchery plus wild) abundance of the population and increasing the numbers of natural origin recruits back to the spawning grounds. Based on the NOAA Fisheries and co-managers assessment of population declines and habitat degradation, the Stillaguamish Chinook salmon populations would likely further decline and go extinct without the intervention of the natural stock restoration program (NMFS 1999).

The current program size was the result of a number of factors. The first was a concern about the long-term ability of the natural population to survive given the high 1980s harvest rates and poor freshwater conditions. Another factor was the risk associated with taking too many fish into the hatchery and having something go wrong. The number of adult broodstock needed to release enough coded wire-tagged fish to provide statistical power to the indicator stock program was also considered.

Recently completed EDT modeling supports the hypothesis for the current hatchery natural stock restoration program. Modeling results indicate that "without the hatchery supplementation, escapement declines (in the North Fork) to less than 100 fish after about 30 years. With the hatchery program, escapement varies due to harvest, flow and marine survival variability (within the model), but does not decline. The model suggests that the hatchery program is providing a conservation benefit by keeping total spawning abundance above 500 fish” (Mobrand Biometrics 2005; Appendices H and I).

The following EDT model run graphs of North Fork Stillaguamish Chinook salmon escapement (Figures 15 and 16) are the result of inputting known 1983-1998 data for peak flow events, harvest rates, estimated low marine survival ,and the extreme low escapements. The first model run was done without a hatchery program being operated. The second model run included the operation of the existing natural stock restoration program. Both model runs include random variability, within the defined parameter limits. The blue portion of the graphs represent wild/natural spawners and the red color represents adult returns from the natural stock restoration hatchery program.

Figure 15 North Fork Stillaguamish Chinook Salmon Escapement with No Hatchery Program

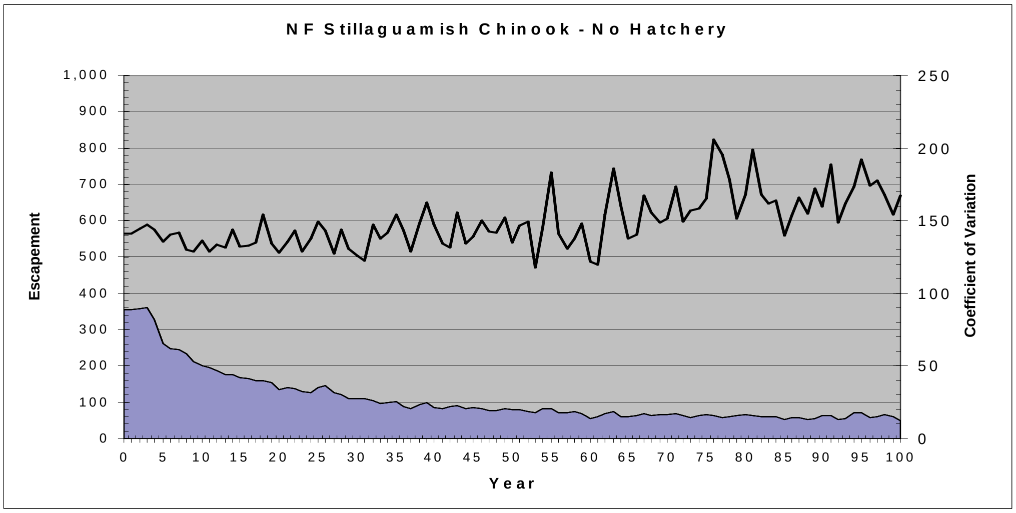
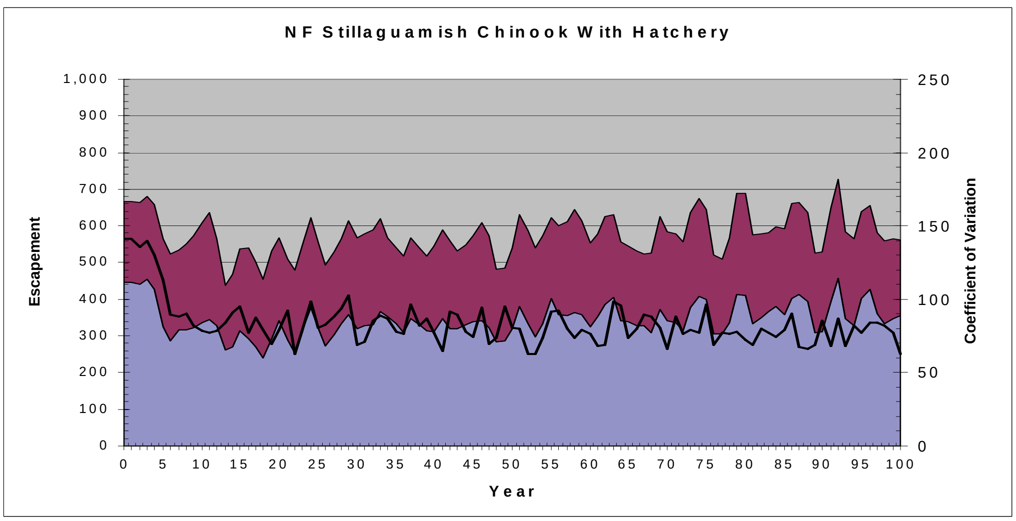


Figure 16 North Fork Stillaguamish Chinook Salmon Escapement with Hatchery Program



The Hatchery Scientific Review Group has developed a habitat, harvest and hatchery management tool, the “All H Analyzer” (AHA model) (www.hatcheryreform.org). Preliminary model runs of the North Fork Natural Stock Restoration Program suggests that the current program size minimizes hatchery impacts such as fitness loss to the natural population. The program results in having the correct ratio of hatchery-origin spawners (HOS) to natural-origin spawners (NOS) in both the broodstock and on the spawning grounds to fully integrate the hatchery restoration program with the naturally spawning population.

The goal for the natural stock restoration program is to see four consecutive years of natural origin escapements over 700 into the North Fork

Stillaguamish and its tributaries. The 700 NOS target was based on setting an escapement number above the 500 NOS minimum escapement low abundance threshold included in the 2004 Puget Sound Harvest Management Plan. That 500 NOS harvest management target was set based on several studies that indicated that annual escapements below 500 NOS's would pose a risk for the population (Allendorf et al. 1997; McElhany et al. 2000; HSRG 2005). The co-managers chose a number above 500 to allow for some protection/buffer in the event that the population went into steep decline with suspension of the natural stock restoration program.

The adaptive management plan for the natural stock restoration program is to monitor the spawning escapement numbers and geographic distribution of those fish within the watershed. Should the natural origin spawning escapement fall below 500 fish for four consecutive years, the co-managers will evaluate either restarting the natural stock restoration program (if it has been de-activated) or expanding the scope of the existing program to preserve the genetic diversity of the population.

Hatchery management has evolved significantly over the last twenty years to reduce disease risk and improve genetic fitness. The 1999 listing of Puget Sound Chinook salmon has focused attention on the effects of hatchery programs on natural populations, in particular as they may affect the genetic fitness and survival of natural populations. In cooperation with Washington Department of Fish and Wildlife (WDFW) and NOAA Fisheries, the Stillaguamish Tribe has developed a Hatchery Genetic Management Plan (HGMP) for the Harvey Creek Hatchery program. The HGMP comprehensively describes the short- and long-term operating and monitoring procedures that ensure the program is consistent with recovery goals for the North Fork Stillaguamish population and the Puget Sound Evolutionarily Significant Unit (ESU).

The HGMP and associated monitoring and evaluation plans provide a management framework for the program, such that genetic and ecological risks associated with artificial production and supplementation can be researched and evaluated. This information can then be used to modify the program to reduce or eliminate the risks. The HGMP may or may not call for immediate changes in hatchery practices or production objectives. NOAA Fisheries is expected to review the co-managers' Hatchery Management Plan, of which the HGMP is an integral part, with respect to conservation criteria established by the ESA's 4(d) rule.

Although the review of all Puget Sound HGMP's is still in process and no final authorization by NOAA Fisheries has been issued, the preliminary review of the Stillaguamish Chinook Natural Stock Restoration Program by Tim Tynan of NOAA Fisheries noted the following: "From a review of estimated natural recruit per spawner and Stillaguamish hatchery Chinook contribution data, the program clearly is helping to sustain the listed population in the midst of severe freshwater habitat degradation resulting from surrounding land use practices. Protocols applied through the program appear adequate to minimize the risk of genetic change and loss of genetic diversity and fitness within the propagated populations, and among regional Chinook populations" (Tynan 2000).

In addition to the review of the HGMP by NOAA Fisheries, an independent science panel of fisheries experts, the HSRG panel, also reviewed the Chinook salmon natural stock restoration program. Their evaluation includes the following observations: "This program is consistent with short-term and long-term goals. The program appears to be reducing the risk of demographic extinction of summer Chinook salmon in the North Fork Stillaguamish River. The demographic benefits of this program outweigh the risks. The program has a high likelihood of achieving its goals, particularly if pre-spawning mortality and disease transmission can be controlled, and potentially reduced, at the Harvey Creek Hatchery. This is a valuable program that has the potential to provide very important long-term conservation benefits (HSRG 2002)."

In the HSRG's upcoming report to Congress, the panel made the following statements: "It is clear that the co-mangers in the Stillaguamish/Snohomish region fully understand and subscribe to the principles and concepts developed in the Hatchery Reform Project. Goals are clearly articulated, credible progress has been made (or will soon be made) to implement reforms and the infrastructure necessary to track progress and assure success over time is evolving. In the near-term, the greatest value is likely to be produced from investment in those regions where the co-managers are most prepared to implement hatchery reform. The co-managers in those regions – most notably the Stillaguamish/Snohomish, but also Hood Canal, Eastern Straits, and North Coast regions – have demonstrated a firm understanding of the process of hatchery reform and have made the decisions to implement change (HSRG 2005)."

Michael Ford (NOAA) and Kip Killebrew (Stillaguamish Tribe) completed the preliminary 1999 draft Benefit Risk/Assessment Tool for the Stillaguamish Natural Chinook Restoration Program. That assessment utilized watershed specific data, broodstock information, escapement /spawner ground surveys, and coded wire tag information from the Tribe's Hatchery Genetic Management Plan to complete the assessment. In addition to this assessment, a preliminary analysis of North Fork microsatellite DNA data by Willy Eldridge of the Northwest Indian Fisheries Commission has further documented that the Tribe's restoration hatchery program is succeeding at maintaining genetic diversity (Eldridge and Killebrew, unpublished data; Appendix F).

The co-managers will utilize recently created models to evaluate ecological interactions and the corresponding risk assessment and minimization (Busack et al. 2005). In addition, the program's potential impacts of domestication and inbreeding depression will be evaluated using new modeling being developed by NWIFC and WDFW. These factors and the associated risks can then be evaluated against the risk of extinction modeling efforts underway by Greene (personal communication, 2005) and Mobrand Biometrics (2005; Appendix I).

South Fork Stillaguamish

The SIRC believes that the limiting factors contributing to poor freshwater survival in the North Fork Stillaguamish are also affecting freshwater survival in the South Fork Stillaguamish. Therefore, the survival data and models outlined in the North Fork Stillaguamish section of this chapter are applicable and appropriate for the South Fork Stillaguamish as well.

The Hatchery Scientific Review Group has recently completed a technical white paper "When Do You Start A Conservation Hatchery Program?" that provides guidance based on a population's effective size as to when that population is at risk. A review of that document and recently completed DNA analysis on the South Fork Chinook salmon population has indicated that "the SF Stillaguamish fall run of Chinook is not at genetic risk requiring immediate remediation in a new hatchery program. A restoration program should be considered when the long term (1986-present) harmonic mean run size drops to 180 fish per year, which would equate to an escapement of 100 adults per year each year from 2005-2011 (Spidle, unpublished data; Appendix G)."

"The Chinook salmon from the South Fork Stillaguamish River have a healthy effective population size, at the least, as evidenced by microsatellite data. It is possible that the effective population size of the population has been inflated by strays, perhaps of Green River (hatchery) origin. The South Fork population remains genetically differentiated from the complex of Green River derived populations (Spidle, unpublished data; Appendix D)"

Integrated Strategy

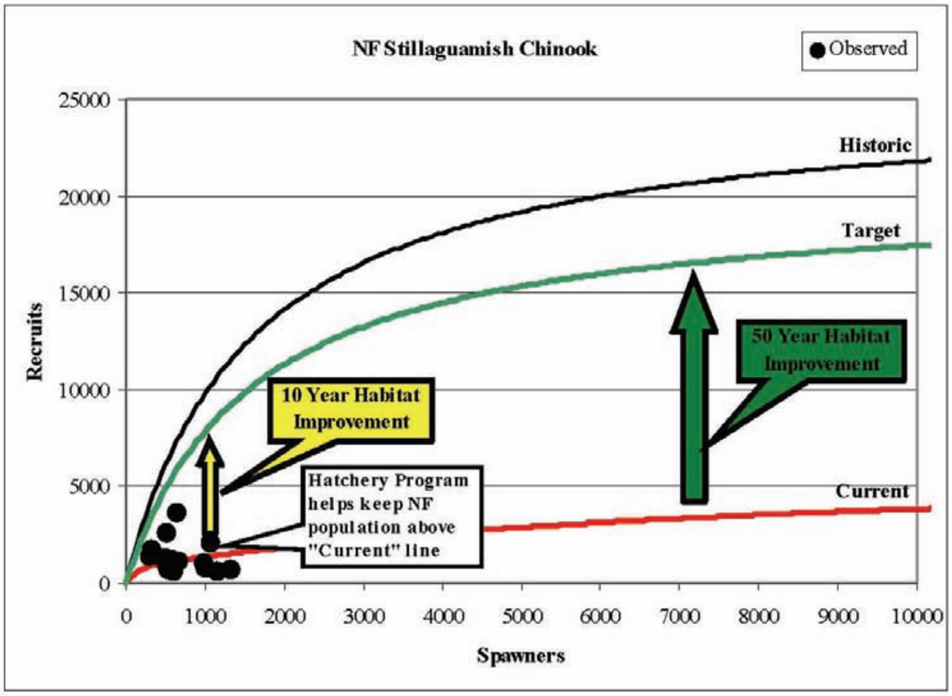
The Stillaguamish Watershed Chinook Salmon Recovery Plan includes habitat management, harvest management, and hatchery management actions. The plan discusses how the actions in each area are expected to affect the four VSP parameters of the two Chinook salmon populations in the Stillaguamish system, following the technical guidance for developing salmon recovery plans (Puget Sound Technical Recovery Team and Shared Strategy Staff Group 2003).

An essential part of this plan is a demonstration of how the actions in habitat, harvest, and hatchery management are expected to work together to bring about recovery of the populations. Although the benefits of harvest management (i.e., increased escapement) are realized almost immediately, significant increases in habitat productivity will take decades to occur. The best evaluation of whether habitat protection and restoration efforts are successful or not in the Stillaguamish Watershed will be if increases in Chinook salmon population productivity occurs over time. The planning targets for Stillaguamish Chinook salmon populations reflect a condition of restored habitat and a range of harvest scenarios. As long as habitat conditions are restored to planning target levels, that habitat, along with harvest management, will provide VSP consistent with recovered populations.

In the Stillaguamish Watershed, the inter-relationship between habitat, harvest, and hatchery management can be examined by looking at the effects of various recovery actions on the populations under different scenarios. The current status and recovery targets for the two Stillaguamish Chinook salmon populations can be expressed graphically in terms of spawner-recruit curves from the output of Ecosystem Diagnosis and Treatment (EDT) modeling (Figure 17). This figure shows the current status, recovery target, and historic population numbers for the North Fork Stillaguamish Chinook population.

As demonstrated in the spawner-recruit curve, there is an upper limit on the number of fish the system can produce under any particular scenario. This upper limit is based on habitat condition limitations. It follows, then, that the way to increase the upper limit is to improve habitat conditions.

Figure 17. Expected population response if habitat improves and harvest is managed at a low maximum exploitation rate.



The integration of the habitat, harvest, and hatchery recovery components of the plan are driven by the monitoring status of the two Stillaguamish Chinook salmon populations. Consistent negative changes over time in the trends in abundance of the two populations will initially trigger short-term adaptive management modifications to the hatchery and harvest management plans. These two components of the plan can be modified the most quickly and will potentially show a more immediate population response, in comparison to changing habitat restoration activities. It is imperative that immediate measures are taken in order to maintain effective population size. Habitat restoration measures are likewise important, but can take longer to become effective.

Adaptive harvest management triggers have been established for declining escapements so that should the total (both North Fork and South Fork) Stillaguamish Chinook salmon escapement drop below the critical threshold of 650 fish, fisheries will be managed to either achieve the critical exploitation rate ceiling, or exceed the low abundance threshold. The short-term strategy is to harvest at less than the maximum sustainable harvest rate so as not to impede recovery.

In addition to these harvest management triggers, the hatchery program adaptive management plan is set up to respond to steadily declining trends, over several years, in North Fork Chinook salmon escapement to below 500 natural origin spawners. Recently completed DNA analysis of the South Fork Chinook salmon population has indicated that " the South Fork Stillaguamish fall run of Chinook is not at genetic risk requiring immediate remediation in a new hatchery program. A restoration program should be considered when the long term (1986-present) harmonic mean run size drops to 180 fish per year, which would equate to an escapement of 100 adults per year for each year from 2005-2011 (Spidle, unpublished data; Appendix G). Should either of the populations decline to these levels, the co-managers would develop plans to either activate or expand natural stock restoration programs to provide enough natural origin hatchery releases to maintain the population above the critical threshold based on current survival estimates. In addition, to meet HSRG guidelines on broodstock mining and to avoid the founder effect and inbreeding depression concerns, no more than 25% of the run will be used for broodstock annually. The exception to this target would be a catastrophic decline in the population that endangered its immediate survival, in which case genetics specialists would be consulted to determine the appropriate broodstocking level.

While further reductions in harvest rates and increasing the output of hatchery natural restoration smolts is expected to bring the population above the critical low abundance threshold in the short-term, additional habitat restoration activities will need to be implemented to improve the productivity of naturally spawning fish. The currently proposed recovery plan relies in a significant way on the improvement of habitat conditions to improve productivity, capacity and equilibrium abundance. Productivity, or recruits per spawner, is determined primarily by freshwater, estuarine, and marine survival related to habitat conditions. Adaptive management of habitat restoration and protection is driven by the assessment of which component(s) of the freshwater and estuarine habitats are not meeting plan goals and objectives for implementation or effectiveness or are indicative of unsupported assumptions or hypotheses about watershed, riparian, in-channel, or estuarine function in the Stillaguamish Watershed. Ecological conditions can be re-assessed regularly by using Ecosystem Diagnosis and Treatment (EDT) modeling with new effectiveness assumptions and new actions in new recovery scenarios.

The recovery trigger/goal for modifying the North Fork hatchery natural stock restoration program is to see four consecutive years of increasing natural origin escapements over 700 into the North Fork Stillaguamish and its tributaries. The 700 NOS target was based on setting an escapement number above the 500 NOS minimum escapement low abundance threshold included in the 2004 Puget Sound Harvest Management Plan. That 500 NOS harvest management target was set based on several studies that indicated that annual escapements below 500 NOS's would pose a risk for the population (Allendorf et al. 1997; McElhany et al. 2000; HSRG 2005). The co-managers chose a number above 500 to allow for some protection/buffer in the event that the population went into steep decline with suspension of the natural stock restoration program.

Habitat improvements and constrained harvest levels should allow the population to recover to self-sustaining levels that support directed harvest in most years. If the Chinook salmon populations show a positive response to habitat recovery efforts, the co-managers will determine the future need and size of Chinook hatchery programs to meet other management objectives such as the U.S./Canada Indicator Stock Study and interim harvest goals.

As the populations recover, the long-term integrated strategy is to continue to monitor abundance and spatial distributions through spawner ground surveys, and productivity through operation of the smolt trap to ensure that all components of the population are improving.