2. Current Status of Stillaguamish Chinook Salmon Populations

Independent Populations

Chinook Salmon

In March 1999, Stillaguamish Chinook salmon and other Puget Sound salmon populations were designated as Threatened under the federal Endangered Species Act. Substantial evidence has been accumulated to document the decline of Chinook salmon in the Stillaguamish River watershed (STAG 2000). Estimates of historic Chinook salmon populations within the watershed prior to extensive land use changes provide reference points to compare with current Chinook salmon population trends.

Habitat modeling indicates that current populations are at about 7% of historical levels

Historic levels of Stillaguamish Chinook salmon abundance are estimated by habitat modeling to be approximately 25,000 fish in the North Fork population and 21,000 fish in the South Fork population (Mobrand Biometrics 2004; Rawson et al. 2004). Habitat modeling indicates that current populations are at about 7% of historical levels[2] (Mobrand Biometrics 2004). The recent 8-year average (1996-2003) combined North and South Fork population adult escapement (fish that survive and return to their watershed of origin) is 1,326 fish (Abundance & Productivity Tables; Appendix C). The escapement goal of 2,000 fish for the watershed (Ames and Phinney 1977) has not been met since 1976. Figure 3 shows the pattern of Stillaguamish Chinook salmon escapement between 1974 and 2003. These numbers include adult Chinook salmon produced by the Stillaguamish hatchery supplementation program (described in more detail later in this document). Escapements since 1993 have shown limited improvement, likely in response to significant reductions in harvest shown in Figure 10 later in this chapter.

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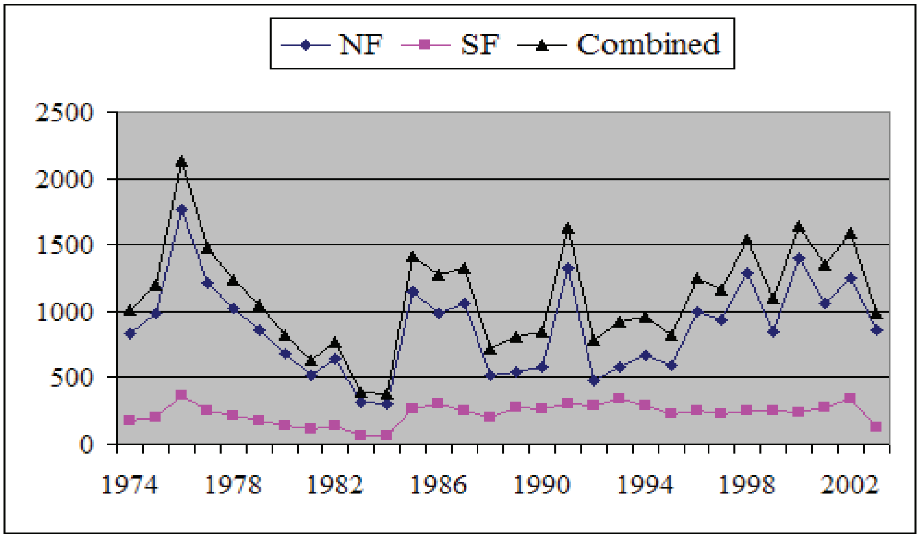
[2] Estimated current combined populations is 3,291; estimated historic combined populations is 46,153 (see Table 10).

Figure 3. **Chinook Salmon Escapement (including hatchery fish) 1974-2003 (Abundance & Productivity Tables)**



North Fork (Summer) Chinook Salmon

The North Fork Chinook salmon population has ranged from a high escapement of 1,768 fish in 1976 to a low escapement of 309 fish in 1984. The recent 8-year (1996-2003) average for North Fork Stillaguamish Chinook salmon escapement (including hatchery fish) is 1,080 fish. This average represents approximately 81% of the combined Stillaguamish natural Chinook salmon escapement (Abundance & Productivity Tables; Appendix C).

North Fork Stillaguamish Chinook salmon are an early timed (summer run) Chinook that are more closely aligned with Skagit River populations. This genetic relationship is supported by geologic information showing that the Sauk, a tributary of the Skagit, was connected to the North Fork Stillaguamish some 10,000 years ago (Marshall et al. 1995). “In addition to the genetic similarities, the age distribution and length-at-age of North Fork Stillaguamish Chinook are more similar to Chinook spawning in the lower portions of the Skagit River Basin than they are to Chinook in the South Fork Stillaguamish (Ruckelshaus et al. 2001).”

Eldridge and Killebrew (unpublished data) analyzed microsatellite DNA and found that although there had been significant introductions of Green River type hatchery Chinook salmon to the North Fork Stillaguamish between 1952 and 1974, “no legacy of Green River (hatchery) Chinook introductions was detected in the fishery, broodstock or on the spawning grounds in the years tested.”

South Fork (Fall) Chinook Salmon

The South Fork population has ranged from a low escapement of 65 fish in 1984 to a high escapement of 345 fish in 1993. The recent 8-year (1996-2003) average for South Fork Stillaguamish Chinook salmon escapement (including stray hatchery fish) is 246 fish. This average represents approximately 19% of the combined Stillaguamish natural Chinook salmon escapement (Abundance & Productivity Tables; Appendix C).

Analysis by Marshall et al. (1995) documented that the South Fork Stillaguamish Chinook salmon (fall run) population is more closely aligned with Snohomish Watershed Chinook salmon populations. This genetic connection is supported by geologic evidence that the South Fork Stillaguamish ran into the Pilchuck River area of the Snohomish Watershed in the recent geologic past. The genetic makeup of South Fork Chinook salmon is complicated by the outplanting of over 9 million fall Chinook salmon from outside the Stillaguamish Watershed during the 1957-74 time period (STAG 2000). The South Fork population has seen limited hatchery planting since 1976, with the Stillaguamish Tribe acclimating very limited numbers of North Fork summer Chinook salmon in the upper South Fork Stillaguamish above the Granite Falls fish ladder during 1991, 1993, and 1994 (STAG 2000). Based on recent spawning escapement numbers, a small number (<300) of naturally spawning, genetically discrete South Fork Chinook salmon appear to be self-sustaining at a low stable level within the current degraded environment. In addition, spawning surveys over the last several years have documented a number of stray Chinook salmon from outside the watershed (Rawson, personal communication).

Recently completed preliminary microsatellite DNA analysis for the South Fork population has indicated that the "South Fork population has a healthy effective population size and that although the data show (some) contribution from Green River hatchery Chinook, the population remains genetically differentiated from the large complex of populations that are mostly Green River derived. It is possible that the effective population size of the South Fork fish has been inflated by strays, perhaps of Green River origin" (Spidle, unpublished data; Appendix D). The question of the influence of straying into the South Fork Chinook salmon population may be resolved in the near future with the completion of genetic analysis of Green River hatchery and Snohomish River watershed DNA information.

Habitat Requirements of Chinook Salmon

Chinook salmon spend their earliest and latest life stages in freshwater river and stream habitats. While becoming sexually mature, Chinook salmon spend most of their adult lives feeding in saltwater, then return to the watersheds of their birth for reproduction. The freshwater requirements of Chinook salmon are reasonably well known, although many subtle and important details of the freshwater life histories of specific populations in the Stillaguamish Watershed remain unknown.

Environmental conditions required during adult upstream migration include adequate water quality and suitable streamflow velocity, temperature, cover and depth for successful passage. Chinook salmon also require large, deep cold pools for holding prior to spawning. Pess and Benda (1994) documented a strong association between pool habitat and spawning location within the Stillaguamish Watershed. Areas of the river that have usable spawning habitat, but no pool habitat, have very limited spawning. Pess et al. (1999) documented a 38% loss of pool habitat in the North Fork Stillaguamish since 1950.

The amount of flow within a channel can determine whether Chinook salmon adults have access to areas within the river system traditionally used for spawning. Substrate composition, in-stream cover, water quality, water quantity, and habitat area are important requirements for salmon during spawning. Healey (1991) suggested that fry and smolt production could be more related to the amount of good spawning gravel area than to the number of spawners.

Flow, temperature, substrate condition, and redd depth appear to be important factors in incubation and emergence success. Important environmental factors during incubation include the level of fine sediment transported by the river and the frequency, duration, and magnitude of flood flows during incubation. Excessive sediment can smother fish eggs and flooding can destroy redds. Juvenile Chinook salmon are principally found in all mainstem areas, including side channels and larger tributaries. As Chinook salmon fry migrate, they may inhabit the river's edge, backwater and off-channel habitats, side channels, or banks with cover (Healey 1991).

Chinook salmon also require healthy estuary and marine shoreline habitat for juvenile and adult stages of their life cycle. The estuary and marine shoreline areas within the photic zone (i.e., the depth of water to which photosynthetically active light can penetrate – about 30 feet) together comprise what is referred to as the nearshore. Puget Sound nearshore and open water marine environments provide four main habitat functions critical to Chinook salmon survival: food production and foraging; refuge (from predation, winter storms, etc.); areas for physiological adjustment between freshwater and saltwater; and migratory corridors. Salmon and bull trout move through the entire nearshore and marine ecosystem in Puget Sound seeking opportunities to feed, take refuge from various threats, and transition between freshwater and marine environments with minimal stress. In addition to estuarine habitat directly connected to the main river channels, many nearshore areas include "pocket estuaries" that provide additional estuary rearing habitat for juvenile salmon (Beamer et al. 2003). Pocket estuaries include tidal lagoons that are fed by small freshwater streams or seeps as well as the deltas of small Puget Sound tributary streams.

Factors Affecting Chinook Salmon Populations

Population and Land Use

Prior to European settlement, many Native American tribes utilized the Stillaguamish Valley, particularly from Barlow Pass to the river's mouth near Stanwood. Europeans first settled in the lower Stillaguamish basin in the early 1860s and began diking and draining the floodplain for agricultural uses (STAG 2000). Expanding population and land use practices have resulted in broad landscape alteration throughout the Stillaguamish Watershed. Removal of log jams in the river allowed access to upriver areas that were subsequently cleared and settled, giving rise to several small towns. Logging began in the lower watershed as early as 1863 and became more widespread as upriver navigation and access improved. By the turn of the 20th century, nearly all of the floodplain land on the mainstem had been cleared of trees and converted to agricultural lands. Most of the historic tidal-influenced salt marsh habitat was converted to agricultural uses through diking, ditching, and filling (Collins 1997).

Basin-wide land use within the Stillaguamish Watershed (Figure 4) is 76% forestry, 17% rural, 5% agriculture, and 2% urban (Snohomish County 1995). However, streamside land use within the hydrologically-connected areas utilized by anadromous fish (the anadromous zone) is comprised of 61% forestry, 22% rural, 15% agriculture, and 2% urban (Pess et al. 1999).

Figure 4. Future Land Use

Forestry

Forestry is the most geographically extensive land use in the Stillaguamish Watershed. Approximately 76% (530 square miles) of the 700-square mile watershed is either zoned for commercial forestry or is federal land managed for forest production and other uses (STAG 2000). Of the total forest land area within the watershed, approximately 150 square miles (28%) is private forest land, 110 square miles (21%) is state forest land, and 270 square miles (51%) is federal forest land.

Federal forest land primarily managed for timber production is designated as "Matrix". In the Stillaguamish Watershed there is a total of 11,377 acres in Matrix land (about 18 square miles), of which 11,198 acres is in the North Fork Stillaguamish River basin (French-Segelsen and Boulder Creek sub-basins) and 179 acres in the South Fork Stillaguamish River basin (Canyon Creek sub-basin). Some timber may also be harvested as a by-product of other forest management activities, such as thinning to promote late-successional forest conditions (Karen Chang 2005, personal communication. USDA Forest Service, Mt. Baker-Snoqualmie National Forest, Darrington Ranger District).

Forestry continues to be an important economic activity, but since the early 1990s the rate and extent of timber harvesting and forest road construction has declined from historic levels. This is due to a combination of factors, including changing regional and global market conditions, exhaustion of old growth timber supplies, and the implementation of state and federal environmental laws. Timber harvest on private, state, and federal forest land has been limited by the listing of Chinook salmon and bull trout, as well as other species including the northern spotted owl, marbled murrelet, and bald eagle, under the Endangered Species Act (Edwards 2003).

The scale of historic forest harvest activities and how forestry was historically practiced have contributed significantly to the decline in local salmon populations. Timber harvesting in riparian zones and on steep or unstable slopes, inappropriate forest road construction, and draining of forested wetlands have altered the delivery and rate of sediment and large woody debris transport, streamflow, temperature, and other important freshwater salmonid habitat conditions (Murphy 1995). Increased frequency and magnitude of high stream flows is due in part to the loss of forest cover from timber harvesting and the routing of surface runoff from forest roads into streams (Hartman et al. 1996). This has contributed to scouring upstream salmon spawning beds and smothering downstream spawning beds. Peak flows may also flush juvenile salmon out of normally slower moving portions of the river that are used for rearing habitat.

Extensive landslides and increased frequency and magnitude of high stream flows in the Stillaguamish Watershed are attributed in large part to past timber harvesting and forest road management practices (STAG 2000; WCC 1999). Landslides and other forms of surface erosion that may be natural or induced by past forest practices or other land use activities have contributed to increased sediment loading in tributaries, main channels, and the mouth of the river. An analysis of 1,080 landslides within the Stillaguamish Watershed revealed that 74% were associated with clearcuts and roads (Collins 1997). Many of the landslides which originate in glacial sediments are deep-seated and a chronic source of turbidity and suspended sediments. Increased sediment loading has reduced the amount and quality of deep holding pools, spawning gravel, and rearing habitat. Accretion of sediment at the mouth of the river has created extensive sand flats that may expose returning spawners and outmigrating smolts to increased predation.

Each of these forestry-related impacts on salmon habitat have contributed, along with impacts from other land uses, to the decline of historic salmon populations in the Stillaguamish Watershed and continue to limit the productivity of existing populations.

Agriculture

Farming is the most prevalent land use in the lower floodplain of the Stillaguamish Watershed (STAG 2000). Many key river and stream habitats in the watershed are on or near agricultural lands. Riparian areas and wetlands along the mainstem and larger tributaries have historically been converted to agricultural lands and are actively farmed. Significant portions of the floodplain have been cleared, diked, and drained for agricultural uses. Historic tidal-influenced salt marsh habitat was converted to agricultural uses through diking, ditching, and filling. Many rural parcels dispersed throughout the watershed include small non-commercial farming operations. Agricultural land uses relate to Chinook salmon recovery in the context of flood control, drainage infrastructure, and riparian/wetland area management.

Clearing of mature riparian vegetation and degraded riparian areas throughout the floodplain has had detrimental effects on existing habitat. Reduced channel complexity and loss of riparian forest contributes to reduced streambank and instream habitat. Channelization of streams, loss of wetlands, and the construction of drainage ditches in floodplain areas for agriculture has increased the magnitude and severity of peak streamflows, as well as increasing the amount of nutrients, pesticides, and sediment into stream reaches used by Chinook salmon. Many potentially productive sloughs and side channels have been isolated from the main channel on or near farms. Dikes, levees, revetments, and tide gates installed to protect agricultural lands from floods and tidal influences limit Chinook salmon productivity by restricting meander and floodplain processes that maintain and create habitats. Culverts and other barriers on agricultural lands restrict fish passage. Estuarine habitat is constrained by cut-off sloughs, hardened banks, sediment deposition, and non-native invasive plants.

Urban/Rural Land Use

Conversion of existing forest and agricultural lands to rural residential and urban uses contributes to declining salmon populations in the watershed. Currently, Snohomish County has a human population of nearly 637,500 and is growing at an annual rate of 2.7%.[3] The current population of the Stillaguamish Watershed is 58,441.[4] Continued population growth will place increasing pressure on hydrologic function, water quality and habitat quality. As evidenced in other Puget Sound watersheds, conversion of agricultural and forest lands to rural residential and urban uses results in loss of floodplain functions, channel migration, and other wildlife habitats, as well as a transition from biologically-based water quality problems to point sources and non-point sources of pollution. Increases in impervious surfaces (e.g., structures, concrete, and asphalt) created by urban development reduce natural infiltration of precipitation and increase surface runoff (Spence et al. 1996). Such urbanization negatively affects hydrologic function and water quality through lawn fertilizer and pesticide inputs, pet waste, household and municipal sewage discharges, industrial sources, and contaminated runoff from roads. Development activities also result in stream channelization, bank hardening, and poor habitat quality that negatively impact salmonids (STAG 2000). The permanence of this type of conversion contributes to a wide range of impacts that goes far beyond impacts to salmon.

Environmental Policies and Regulations

A broad framework of federal, state, and local laws, plans, and policies are designed to limit the environmental impacts of land use and development activities in the Stillaguamish Watershed. A common objective of this regulatory framework is to protect freshwater habitat and water quality, which is intended to help salmon populations recover to sustainable and harvestable levels. The following regulatory programs are related to habitat protection:

Growth Management

The Washington State Growth Management Act (GMA) was adopted in 1990 [RCW 36.70A] to address population growth and urban sprawl in rapidly urbanizing areas of the state. The GMA requires certain counties and cities to prepare comprehensive plans that outline land use management policies and provide a framework for long-range growth planning. In addition to addressing growth, the Act requires counties and cities to adopt development regulations to designate and protect critical areas based on the "best available science" [RCW 36.70A.060(2)].

Snohomish County, Skagit County, and the cities of Arlington, Darrington, Granite Falls, and Stanwood are all subject to the provisions of the GMA.

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[3] As of April 2003, according to the Washington State Office of Financial Management (OFM) - http://www.ofm.wa.gov/

[4] Estimate prepared by Tim Koss, Snohomish County Planning & Development Services, June 3, 2005.

Each of these local governments has prepared a comprehensive plan that projects future growth and ensures consistency of urban infrastructure (e.g., transportation, capital facilities, and utilities) through land use planning and zoning regulations. Local comprehensive plans aim to protect rural lands and critical areas including streams, wetlands, and wildlife habitat areas, reduce sprawl, and maintain productive agricultural, timber, and mineral resource lands. In addition, GMA requires inter-jurisdictional coordination in developing planning policies, which can be applicable to cross-jurisdiction watershed management and salmon habitat protection.

Snohomish County adopted Critical Areas Regulations (chapter 30.62 SCC) in 1995 to ensure designation and protection of the county's critical areas. Included in the designation of critical areas are wetlands, fish and wildlife habitat conservation areas (streams, threatened and endangered species habitats, etc), flood hazard areas, critical aquifer recharge areas, and geologically hazardous areas (erosion, landslide, seismic, and mine hazard areas).

Streams, wetlands, and their buffers in the Stillaguamish Watershed are protected under the critical areas regulations. Riparian buffers identified in Snohomish County regulations include a 150-foot critical area and an additional 150-foot riparian management zone on both sides of a stream if an ESA-listed species is present. Wetland buffers range from 100 feet for a Category 1 wetland to 25 feet for a Category 4 wetland. The critical areas regulations require a project applicant to identify all critical areas affected by the proposed development activity and to mitigate impacts associated with the development. Snohomish County is in the process of updating its Critical Areas Regulations, including a Best Available Science analysis and updated code requirements. The County has considered the outcomes of the concurrent Chinook salmon recovery planning process in revising these regulations.

Shoreline Management

The Washington Shoreline Management Act (SMA) was adopted in 1972 "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" [RCW 90.58]. The SMA establishes a balance of authority between local and state government. Cities and counties are the primary regulators of the Act. The Department of Ecology provides technical assistance and reviews local programs and permit decisions. Designated shorelines in Snohomish County include most streams and rivers over 20 cubic feet per second mean annual flow, lakes over 20 acres in size, marine shorelines, lands within 200 feet of the ordinary high water mark of these waterbodies, and their respective floodplains and associated wetlands. The County requires buffers and structural setbacks that range between 25 feet and 100 feet from the ordinary high water mark.

The Department of Ecology adopted new Shoreline Master Program (SMP) guidelines in 2003. These state rules are used by cities and counties as they update their plans to regulate development and use of shorelines. Amendments to the Shoreline Management Act were adopted in 2003 addressing integration with the Growth Management Act and the use of Best Available Science. These rules establish conditions for development in the floodplain. Snohomish County is scheduled to update its Shoreline Master Plan in 2005. The County is incorporating information from the local Chinook salmon recovery planning efforts into the restoration element of the Shoreline Master Plan update (Snohomish County Planning and Development Services, personal communication).

Forestry

In 2003, the SIRC completed an analysis of existing forestry policies and regulations as they apply to the Stillaguamish Watershed (Edwards 2003). This analysis was requested in recognition of the importance of forestry in the watershed. Below is a summary of the key forestry policies and regulations pertaining to Chinook salmon recovery in the Stillaguamish Watershed.

The Washington Forest Practices Act [RCW 76.09] regulates commercial forestry activities on all local government, state, and private forest lands. This is the most restrictive regulation of riparian areas on private forestry land in the U.S. (Forest Practices Draft HCP). The Forest Practices Act generally does not cover the removal of non-commercial sized trees or other vegetation, and includes a number of exemptions, including the removal of hazard trees and timber on parcels smaller than 2 acres. Local governments are preempted under state law from regulating commercial forest practices except in designated urban growth areas, lands platted after 1960, and on any other lands where the trees will be permanently removed. In these areas, local governments conduct the environmental review under SEPA and may condition these “conversion” type permits with their own local regulations (e.g., critical areas). Alternatively, with the approval of the Department of Natural Resources, local governments can adopt their own forest practices regulations provided they are at least as strong as the Forest Practices Act and the Forest Practices Rules [WAC 222].

The Timber, Fish and Wildlife (TFW) process to improve the regulation of forestry activities under the Forest Practices Act was initiated in 1986 and culminated in 1999 with the publication of the Forests and Fish Report. This report presented a comprehensive set of recommendations for improving the state’s forest practices rules. In 2000, the Forest Practices Rules were amended based on the Forests and Fish Report’s recommendations. These regulatory changes improved the standards and guidelines for riparian buffers and forest road maintenance. However, these rules only apply to large landowners (20 acres or more). The significance of this small landowner exemption is unknown because the total acreage involving such owners in the watershed has yet to be determined.

The Washington Department of Natural Resources Habitat Conservation Plan (HCP) was approved January 30, 1997, to protect state forest management activities from legal liabilities related to the Endangered Species Act. The HCP established standards and guidelines for state forest land management that the federal government (U.S. Fish and Wildlife Service and National Marine Fisheries Service) determined will adequately protect threatened and endangered species. The HCP includes a Riparian Conservation Strategy that limits timber harvesting and road building in riparian zones, unstable hillslopes, rain-on-snow zones[5], and wetlands. This strategy is the primary mechanism by which the HCP limits forestry impacts on salmon habitat in the Stillaguamish Watershed.

Timber harvest on federal lands is subject to the Northwest Forest Plan. This plan, adopted jointly by the U.S. Forest Service and the Bureau of Land Management in 1994, established a comprehensive ecosystem management strategy for federal forest land in the Pacific Northwest. The plan created a network of old-growth forest and riparian reserves to protect critical habitat and watershed processes. A central part of the Northwest Forest Plan is the Aquatic Conservation Strategy, which provides guidance for the management of aquatic and riparian habitat. This strategy has four major components: Riparian Reserves, Key Watersheds, Watershed Analysis, and Watershed Restoration. The plan contains explicit standards and guidelines that must be used to evaluate whether proposed projects or management actions “meet” or “do not prevent attainment” of the Aquatic Conservation Strategy objectives.

Agriculture

Commercial and non-commercial farmers work within a complex regulatory framework of federal, state, and local environmental rules that protect salmon and aquatic habitat. Some of these rules specifically address agricultural operations and land use. The following is a brief summary of the different types of agriculture in the Stillaguamish Watershed and the existing environmental policies and regulations that specifically address these agricultural activities.

In the Stillaguamish Watershed, commercial farming operations generally include dairies, other livestock, field and row crops, and plant nurseries (Henri and Waller 2004). There is also some aquaculture activity in the watershed. Federal regulations, such as the Clean Water Act, Endangered Species Act, and National Environmental Protection Act, apply to these farming operations. The Washington State Growth Management Act and the Shoreline Management Act also apply to agricultural operations, with some exceptions. The Washington State Dairy Nutrient Management Act

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[5] The “rain on snow zone” is the area between 1,000 and 3,000 feet in elevation (also referred to as the “warm snow zone”) which receives frequent snow build-up that melts shortly thereafter. Forest management in this zone can be designed to improve or maintain desirable snowmelt hydrographs.

specifically addresses commercial dairy operations. Landowners with farm plans follow the rules and best management practices published in the Natural Resources Conservation Service Technical Guidelines.

Under the Clean Water Act, commercial farming operations that discharge to surface waters from their production or processing area may be required to obtain a permit for storm water or industrial point source discharges of pollutants through the National Pollutant Discharge Elimination System (NPDES). Discharges to ground water may trigger a state waste discharge permit from the Department of Ecology. In addition, dairies, livestock raising operations, feedlots, and poultry houses may be classified as Concentrated Animal Feeding Operations (CAFOs) or Animal Feeding Operations (AFOs), and may be required to obtain specific permits based on size and historical management. These NPDES, CAFO, AFO, or state permits set requirements to protect water quality, use best management practices, and maintain records (USEPA 2003). Permitted facilities are inspected periodically by the Department of Ecology and livestock facilities are inspected by the Department of Agriculture for compliance (Mena 2005).

The Washington State Dairy Nutrient Management Act of 1998 (RCW 90.64) specifically applies to all licensed dairy operations. This law requires licensed dairies to develop and implement dairy nutrient management plans to prevent nutrient pollution of surface and ground water. Conservation districts were responsible for approving the completion of dairy nutrient management plans by July 1, 2002 and for certifying implementation of those plans by December 31, 2003. These plans are required to meet Natural Resources Conservation Service technical standards. The Snohomish Conservation District has provided technical assistance to Snohomish County farmers to help them develop and implement these plans. Newly licensed dairies are required to have an approved plan implemented within two years of getting their license. Dairies are subject to compliance inspections by the Washington State Department of Agriculture at least once every two years. In the Stillaguamish Watershed, dairy nutrient management plans have been approved for all of the commercial dairies and only one of those plans has not been certified (Bartelheimer 2005).

The federal Clean Water Act and the state Water Pollution Control Act also prohibit the discharge of pollutants from non-point sources such as contaminated field runoff, or degradation from animal access. Non-point source water pollution is regulated based on Total Maximum Daily Load (TMDL) limits, which have recently been established for the Stillaguamish Watershed (DOE 2004). A water quality cleanup plan is currently being developed by the Department of Ecology to address the water quality issues identified in the Stillaguamish Watershed TMDL study.

Pesticide use including agriculture is regulated under federal and state pesticide regulations. The Washington State Department of Agriculture is the lead agency for proper pesticide management and carries out inspections to ensure pesticide use is consistent with federally approved label information (Mena 2005).

The Snohomish County Growth Management Plan includes Critical Area Regulations that apply to farm land, with some exemptions for agricultural activities. The Snohomish County code exempts most on-going commercial agricultural activities from permits including tilling and plowing, drainage and dike maintenance activities, and minor wetland filling. Some farm structures and single family dwellings are also exempt from shoreline permits. In floodplains, most new development activities, including structures, ditches, and dikes are required to obtain flood hazard permits. Maintenance of existing ditches and dikes also requires flood hazard permits (Middaugh 2005).

To preserve and enhance the local agricultural economy, Snohomish County has produced an Agriculture Action Plan that identifies over-regulation as “one of the largest obstacles to sustainable and successful agricultural activities” (Snohomish County 2005). To address this issue, Snohomish County is working with the farming community and state and federal regulatory agencies to simplify and streamline the permitting process for agricultural activities. Snohomish County is also participating in a pilot project whereby state and federal permits are issued at the county level. This effort is intended to help local farmers compete more effectively in local, regional, and international agricultural markets. The SIRC has not yet reviewed the Snohomish County Agriculture Action Plan to analyze the potential affect of plan’s recommendations on salmon recovery.

Instream Flows

Instream flows are defined as the stream flows needed to protect and preserve instream resources and values, such as fish, wildlife and recreation. Instream flows are most often described and established in a formal legal document, typically an adopted state rule. Once formalized in rule, instream flows are used to determine whether water is available for new out-of-stream uses and regulate those new uses, and to define the stream flows that need to be met in the stream. The Washington Department of Ecology is developing water-management rules to help determine how water in a basin could be allocated for future uses for people while maintaining enough water to protect important fish species.

Instream Habitat Management

The purpose of the Washington State Hydraulic Code [RCW 77.55] is to protect fish and shellfish and their associated habitat by regulating activities that affect the bed or flow of the state’s salt and fresh waters. The Washington Department of Fish and Wildlife (WDFW) has the authority to enforce the Hydraulic Code for preserving, protecting, and perpetuating all fish and shellfish resources of the state. The law requires any construction activity that would affect the bed or flow of state waters to obtain a Hydraulic Project Approval (HPA) permit to ensure construction is done in a manner to prevent damage to fish and their habitat. HPA permits are issued by WDFW on a project-by-project basis.

Water Quality

The National Pollutant Discharge Elimination System (NPDES) is a permitting mechanism to carry out the objectives of the federal Clean Water Act to restore and maintain the chemical, physical, and biological integrity of the nation's waters. NPDES regulations are intended to manage discharges such as municipal, industrial wastewater, and stormwater sources. The Washington Department of Ecology is responsible for issuing NPDES permits for municipal stormwater discharges, as well as for construction and industrial-related discharges.

The Total Maximum Daily Load (TMDL) process is established by section 303(d) of the Clean Water Act. The TMDL process determines the amount of pollution loading a water body can receive and still remain healthy for its intended uses, such as industrial and agricultural uses, drinking, recreation, and fish habitat. States are required to identify sources of pollution in waters that fail to meet state water quality standards, and to develop Water Cleanup Plans to address those pollutants. The Department of Ecology is responsible for preparation of a list of impaired water bodies, referred to as the 303(d) list. A Water Cleanup Plan must be developed for each of these water bodies.

Stormwater Management

Snohomish County Code chapters 30.63A and 30.63B regulate clearing, grading, and other construction activities to minimize and/or mitigate impacts to waterbodies and natural resources from stormwater runoff. These regulations are intended to ensure that standards are met for water quantity and quality. The County does not currently use the Washington State Department of Ecology 2001 Stormwater Management Manual for Western Washington, but the County Code has been determined to be equivalent to the provisions included in the Department of Ecology's 1992 stormwater manual.

Noxious Weeds

The Washington State Noxious Weed Law [RCW 17.10] holds landowners, including counties and state land agencies, responsible for controlling weeds on their property. The Weed Law establishes State and County weed Boards who administer and enforce the weed laws. WAC 16-750 establishes the State Noxious Weed List fines and penalties. Federally owned lands are subject to the Federal Noxious Weed Act (Public Law 93-629). Education, coordination, and enforcement activities are carried out by the Washington State Noxious Weed Control Board, County Noxious Weed Control Boards, and the Washington State Department of Agriculture.

Habitat Limiting Factors

The habitat limiting factors for Chinook salmon populations in the Stillaguamish Watershed are grouped into six categories: riparian, estuarine, large wood, floodplain, sediment, and hydrology (STAG 2000). These limiting factors are described in detail below. Spence et al. (1996) provides additional context for understanding the effects of land use and land management activities on these habitat limiting factors. This section also includes several hypotheses for limiting factors in the nearshore and marine environment, as well as an overview of water quality issues in the watershed.

Spawning habitat is limited for Chinook salmon in the Stillaguamish Watershed due to poor gravel stability and high percentage of fine sediment levels resulting from extensive landslides and flooding in the watershed. Limited numbers of Chinook salmon are observed spawning below major landslides in the basin (Gold Basin on the South Fork and Steelhead Haven on the North Fork), presumably due to the impacts of fine sediment on these potential spawning areas (WDFW aerial spawner surveys, Stillaguamish Tribe unpublished data). While anecdotal evidence points to fine sediment limiting Chinook salmon spawning habitat in the Stillaguamish, a study is underway that will investigate the impacts of fine sediment on Chinook salmon habitat in the watershed.

Conversion of much of the floodplain to agricultural production, as well as forestry land uses throughout the watershed, have been a significant source of habitat loss and continuing degradation. The long-term absence of mature riparian vegetation throughout the floodplain has had detrimental effects on existing habitat. Losses of salt marsh and tidal channels from reclamation of tidelands, constricted channels, and cut-off sloughs have significantly reduced the quantity and quality of juvenile and adult salmonid habitat.

Riparian and upland clearing, ditching, and associated road construction have led to large changes in channel morphology, increased peak flows and stream temperatures, and have caused filling of holding pools, loss of wetlands, channel instability, and a reduction in large woody debris. These clearing-related activities have been the primary cause of reduced salmon egg-to-fry survival.

Riparian Areas

Riparian ecosystems perform a number of important functions that affect the quality and quantity of salmonid habitat. The presence (or absence) of woody riparian vegetation directly influences all life history stages of Chinook salmon. A properly functioning riparian forest provides shade, cover, and nutrient input/uptake; stabilizes stream banks; controls sediment; attenuates flooding; and contributes large woody debris and other forms of organic matter. Additionally, riparian vegetation provides a filter that reduces the transport of fine sediment to the stream. Riparian vegetation provides shade and an insulating canopy that moderates water temperatures in both summer and winter. Other benefits include habitat for terrestrial wildlife and improvement to water quality. These functions are impaired as riparian forests are cleared or otherwise altered.

Historical Conditions

At the turn of the century, deciduous trees (primarily red alder, black cottonwood, and big leaf maple) dominated the lower Stillaguamish River floodplain, accounting for 63% of individual tree species. Riparian timber harvest between 1870 to 1910 removed most, if not all, of the large conifers on the mainstem, lower South Fork, and North Fork up to Rollins Creek (Collins 1997). A decade later, riparian forests in nearly all of Church Creek, much of Pilchuck Creek, lower portions of the North Fork tributaries, and the South Fork valley up to Granite Falls had been logged. By the 1940s, most riparian areas in the Stillaguamish Watershed had been logged, with the exception of upper and middle Deer Creek and uppermost Jim and Canyon Creeks. Other riparian lands throughout the watershed have been cleared and converted to agricultural and urban land uses.

Factors of Decline

Most of the impacts to riparian zones in the Stillaguamish Watershed have been caused by the following actions:

- Deforestation. Removal of riparian vegetation has resulted in increased water temperatures and erosion, as well as reduced instream cover and food supply.
- Roads and railroads. Roads and rail beds were constructed along riverbanks and included substantial bank hardening, fill, and vegetation removal. Poorly designed and maintained roads and associated culverts have substantially contributed to riparian degradation and large-scale landslides.
- Land use. Conversion of forested lands to agricultural and residential areas has reduced the ecological value of associated riparian areas.
- Dike, levee, and revetment installation. The installation of flood and erosion control structures has resulted in dramatic modifications to riparian areas and disconnection of off-channel habitats from the mainstem. Maintenance of these structures often includes vegetation removal[6].
- Livestock grazing. Unrestricted access along riparian areas for livestock has led to trampling of native vegetation and significant degradation of riparian vegetation communities.
- Noxious weeds. The proliferation of invasive weed species has contributed to the suppression of native vegetation in riparian areas.

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[6] There is a risk of letting vegetation grow too big on dikes which may lead to failure. “Piping” occurs when roots get too big, the tree eventually dies, the roots rot, and a pipe is created that water can run through and weaken the dike.

Current Conditions

A considerable portion of the historically forested Stillaguamish riparian zone is composed of hydrologically immature vegetation due to forestry and agricultural land management practices. Almost all of the lower floodplain (area to the west of Interstate 5) is currently in agricultural use. Land cover data from 2001 show that just over half (52%) of the area within 300 feet of streams in the Stillaguamish Watershed is forested with hydrologically mature vegetation[7], as shown in Table 1 (Purser et al. 2003).

Table 1. Forested Riparian Cover within Stillaguamish Subbasins (Purser et al. 2003)

Subbasin	Nearstream Forest Cover (%)	Subbasin	Nearstream Forest Cover (%)
Gold Basin	79	Upper Pilchuck Creek	55
Upper SF Stillaguamish	79	French-Segelsen	50
Upper NF Stillaguamish	77	Middle NF Stillaguamish	48
Upper Canyon Creek	77	Harvey Armstrong Creek	39
Stillaguamish Canyon	72	Lower NF Stillaguamish	38
Boulder River	70	Lower Pilchuck Creek	36
Deer Creek	67	Lower SF Stillaguamish	34
Robe Valley	64	Port Susan Drainages	34
Jim Creek	57	Church Creek	20
Lower Canyon Creek	56	Portage Creek	19
Squire Creek	55	Lower Stillaguamish	16

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[7] Hydrologically mature indicates a combined deciduous and evergreen forest cover that produces an amount of runoff similar to the same watershed under native (historical) vegetative conditions.

Figure 5. Stillaguamish Watershed Subbasins

Estuary/Nearshore

Estuaries, including marine nearshore areas, provide a physiological transition zone for juvenile salmonids to adjust to saltwater environments, an important forage location, and cover for predator avoidance. Chinook salmon use estuaries for rearing and smoltification. Growth during estuary residence is critical to marine survival for Chinook salmon. Smolts (2 to 6 inches long) congregate in estuaries on their way downstream toward the main part of Puget Sound, where they acclimate to salt water in the brackish water of the estuary. They also benefit from cover provided by overhanging and emergent vegetation and abundant food sources such as crustaceans and aquatic insects. Salt marsh blind tidal channels, tidally-influenced sloughs, eelgrass beds, pocket estuaries, and shallow shoreline areas are also important estuary habitat.

Stillaguamish Chinook enter Port Susan and Skagit Bay from late winter to late spring and are found in the estuary until late summer (Stillaguamish Tribe, unpublished beach seine data). Stream-type Chinook salmon enter the estuary in the late winter/early spring, along with fry migrants, and move to the delta front where they stay for a brief time. Some bypass the delta altogether and move offshore immediately (Healy 1991). Ocean-type Chinook salmon arrive in late winter/early spring and rear extensively in the estuary. They move slightly offshore in the late June/July timeframe until late summer/early fall (Beamer *et al.* 2003). The following life history types are exhibited by ocean-type Chinook salmon: fry migrants use pocket estuaries extensively, delta-fry migrants rear extensively in the delta, and parr migrants use the delta sparingly.

<u>Historical Conditions</u>

Prior to European settlement (circa 1860), there were approximately 4,439 acres of salt marsh habitat connected to the Stillaguamish Watershed. By 1886, as a result of dike building, only one-third of the original salt marsh remained. By 1968, only 15% of the original salt marsh remained, with an associated loss in blind tidal channels (Collins 1997)[8]. During the period from 1886 to 1968, approximately 863 acres of new salt marsh was created through accretion of sediment into Port Susan and Skagit Bay from the Stillaguamish River (Table 2). These newly accreted salt marsh areas do not have the same well-developed blind tidal channel system and do not provide the same habitat quality as the original lost salt marsh (Collins 1997).

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[8] There has been no additional new dike building since 1968.

Table 2. Estimates of Historic and Current Salt Marsh Habitat in the Stillaguamish River Delta (Collins 1997)

Site	Salt Marsh (in acres)				
	1870 (Pre Settlement)	1886	1968 Original	1968 New	1968 Total
South of Hatt Slough	487	94	0	99	99
Stillaguamish Delta	1,045	170	99	386	485
Leque Island	475	214	85	220	305
East of Douglas Slough	1,293	211	114	0	114
West of Douglas Slough	673	496	369	0	369
Camano Island	466	292	0	158	158
Total	**4,439**	**1,477**	**667**	**863**	**1,530**

In addition to the salt marsh estuarine habitat connected to the Stillaguamish River, nearshore areas in Port Susan and Skagit Bay historically included a number of "pocket estuaries" that provided additional estuary rearing habitat for juvenile salmon. Pocket estuaries include tidal lagoons that are fed by small freshwater streams or seeps as well as the deltas of small Puget Sound tributary streams. In Port Susan and Skagit Bay, pocket estuaries were located at a number of sites, including Kayak Point and Triangle Cove. Many of these pocket estuaries have been either lost or modified due to human land use and shoreline modifications. The loss of pocket estuary habitat throughout Puget Sound has likely had a significant impact on the fry migrant life history type of Chinook salmon.

Historically, the open shoreline areas of the marine nearshore also provided important habitat for juvenile and adult salmonids. These open marine shoreline areas historically included mature riparian forests, active feeder bluffs, and small Puget Sound tributary streams. The marine riparian forest was a significant source of large woody debris, organic detritus, insects, and shade. Marine riparian forests were some of the first areas harvested for timber because they were close to navigable waters for transportation of logs to saw mills. Eroding bluffs supplied as much as 90% of the sediments that formed the depositional beaches and spits along the shoreline. Fine sand and gravel beaches provide critical spawning habitat for sand lance and surf smelt. Pacific herring deposit their spawn on eelgrass. All three of these forage fish species are important prey for juvenile and adult salmonids. These forage fish are also key links in the food chain between plankton and larger predators, including salmonids. Eelgrass also requires fine sand and gravel substrate for growth. Salmon and many other organisms use eelgrass beds as juvenile nursery areas and as refuge from predation. Eelgrass is also eaten by invertebrates, which are in turn prey for juvenile salmon. The small Puget Sound tributary streams supplied freshwater, organic debris, and sediment to the nearshore. Some of the Puget Sound tributary streams were also accessible for spawning, rearing, and foraging by salmonids. These small stream mouths are biologically productive areas within the nearshore and serve as pocket estuaries.

Factors of Decline

Many factors have contributed to the loss of estuarine and nearshore habitat, including:

- Construction of dikes and the associated loss of salt marsh habitat and blind tidal channels;
- Installation of tide-gates, flood-gates, pump-stations, weirs, and culverts;
- Construction of road, railroad, and utility crossings in the estuary;
- Loss of complex distributary channels, which has created a bottleneck and increased exposure to predation for juvenile and adult salmon at the mouth of Hatt Slough;
- Increased sediment deposition in the estuary due to upstream land uses;
- Draining and filling of wetlands, including pocket estuaries;
- Marine shore residential development and construction of bulkheads and groins;
- Removal of large woody debris and log jams;
- Development and deforestation of estuary and marine riparian areas; and
- Colonization of estuarine habitat by the non-native invasive cord grass *Spartina spp.*
- Water quality degradation, including high temperature and low dissolved oxygen;

During the past decade much has been learned about Puget Sound nearshore habitat conditions and how they influence the recovery of natal and non-natal salmonid populations. However, the relative importance of open shoreline nearshore areas is still not clear. Research on the use of the nearshore environment by Stillaguamish Chinook salmon populations is being conducted by the Stillaguamish Tribe Natural Resources Department and preliminary results have been reported (Stillaguamish Tribe 2005).

Current Conditions

The Stillaguamish Watershed includes 22 miles of marine shoreline. Approximately 75% of this shoreline has been armored.[9] Much of the Stillaguamish estuary has been converted to agricultural uses. Estuarine habitat in the watershed is constrained by cut-off sloughs, hardened banks, sediment deposition, and non-native invasive plants. Accretion of sediment into Port Susan has increased the size of the sand and mud flats at the mouth of the Stillaguamish River; presently there are more than 7,800 acres of unvegetated sand and mud flats (Stillaguamish Tribe, unpublished data).

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[9] The percent shoreline modification was derived from the Washington State ShoreZone Inventory (DNR 2001) using an approach recommended by the Washington State Department of Natural Resources, Nearshore Habitat Program staff.

The Stanwood wastewater treatment plant is located in the estuary and releases its effluent into the old Stillaguamish channel immediately south of Stanwood. Discharges will be released on a coordinated schedule with the tides, as agreed to by the Department of Ecology, allowing effluent to drain into the open waters of Port Susan and South Skagit Bay.

Compared to other watersheds in central Puget Sound, second growth forests in the nearshore area of the Stillaguamish watershed now provide relatively good marine riparian vegetation. However, much of this second growth forest has been cleared to provide unobstructed views of the Puget Sound. Large woody debris within the nearshore is also probably much less than what was there historically.

Many of the historical feeder bluffs are still intact, but attempts to stabilize some feeder bluffs using bulkheads at the toe of the slope to protect beach front and bluff top residential properties have probably reduced the rate and amount of sediment supplied to the beaches. Although depositional beaches and sand spits within the Stillaguamish open marine shore area have been developed for residential and recreational uses, recent forage fish spawning habitat surveys indicate that sand lance, surf smelt, and Pacific herring continue to spawn along the shoreline between McKees Beach and Warm Beach (WDFW 2004).

The mouths and potential spawning areas within the lower reaches of many of the Puget Sound tributary streams have been confined by culverts, ditches, and bank armoring. As a result of these stream channel modifications, the complexity and accessibility of these streams has been reduced significantly. Nevertheless, the nearshore areas around these stream mouths are biologically productive.

Large Woody Debris

Large woody debris is an important component of riparian and instream habitat. It provides cover, habitat complexity, and a source of food for aquatic insects, which are themselves sources of prey for salmon. Cover is an important element in rearing habitat used by Chinook salmon. Cover is defined as depth, large substrate, overhanging vegetation, undercut banks, woody debris, floating debris, and aquatic vegetation. In the Pacific Northwest, an important factor in complexity is large woody debris (LWD). LWD is generally meant to describe fallen riparian wood pieces that exhibit both large size (often >50 feet in length or >24 inches in diameter) and are found in complex wood jams. Once they are instream, these wood pieces are the basis for essential channel complexity and side channel formation. LWD creates both micro- and macro-habitat features, and is an important component throughout the drainage network from headwater streams to estuaries.

Historical Conditions

Giant rafts of logs are described in the history of Puget Sound settlements and were once present in the lower Stillaguamish River. Six log raft jams were located in a 16 km stretch of the mainstem prior to the turn of the 20th century (Collins 1997). Settlers and the Army Corps of Engineers removed all of the log raft jams to improve navigation and to allow for the settlement of upstream areas. Giant snags were also systematically removed from the lower mainstem for navigation purposes. By 1900, over one thousand snags and leaning riparian trees were removed, mainly downstream of Hatt Slough in the Old Mainstem. The removal of the giant log rafts may have contributed to destabilization of the heads of floodplain sloughs, a decrease in the frequency and magnitude of overbank flooding, downcutting of the mainstem channel, and an increase in the amount of sediment reaching Port Susan (Collins 1997).

Factors of Decline

Changes in the amount of LWD available for recruitment have been caused primarily by the following factors:

- Deforestation. Historic removal of riparian vegetation reduced the supply of wood to the river.
- Conversion of forested lands to agricultural and residential areas.
- Dike, levee, and revetment installation.
- LWD removal. Historically (and to a lesser extent today) it was a common practice to remove woody debris and snags from rivers in order to improve navigation routes and floodwater conveyance, allow livestock grazing, or to protect structures such as trestles and bridges.

Current Conditions

Instream wood has been documented in the Lower Stillaguamish and from the confluence of the North Fork and South Fork Stillaguamish up to Squire Creek and to Granite Falls. Wood counts per mile are well below properly functioning conditions (80 pieces per mile, according to NMFS 1996). Current counts average approximately 1 piece per mile in several of the river reaches sampled. Table 3 presents LWD distribution data by subbasin.

Table 3. Large Wood Counts in 5 Subbasins (Haas et al. 2003)

Subbasin	Main Channel Length Surveyed (miles) [10]	Pieces of LWD per mile
Lower Stillaguamish	21.5	0.8
Lower SF Stillaguamish	16.2	1.3
Lower NF Stillaguamish	14.9	1.1
Middle NF Stillaguamish	9.5	0.8
French-Segelsen	7.2	8.3

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[10] Survey data from the Lower Stillaguamish Includes Koch Slough and Hatt Slough but not the Old Stillaguamish Channel

Floodplain

Unconstrained floodplains provide some of the most productive habitats for anadromous salmonids (Sommer et al. 2001). Off-channel habitats in the floodplains of larger rivers are important refuge habitats for salmonids, reducing competition and providing refuge during high winter flood events. Floodplains are also a source of nutrients and organic matter for the food web. These areas filter floodwaters and provide depositional areas for fine sediment. Fragmentation of floodplain habitat and the resulting isolation of populations impact the long-term viability of salmonids (Wissmar and Timm 2003).

Stream and river channels and floodplains can be degraded and simplified by human actions that modify the landscape. This occurs directly through earth-moving projects or indirectly by land uses that alter natural processes that shape the stream channels and floodplains. Such changes can result in reduced pool depth and frequency, loss of side channels and sloughs, restricted channel migration, and reduced floodplain connectivity. These changes reduce the amount and/or quality of salmonid habitat (Regetz 2003).

Bank erosion has been a natural part of the evolution of river valleys for millions of years. Development in the floodplain has led to the need for bank protection. Flood control practices contribute to increases in streamflow velocity and energy that can lead to more destructive and costly bank failures.

<u>Historical Conditions</u>

The draining and filling of side channels along with hardening of stream banks has significantly reduced the quantity and quality of salmonid rearing habitat and biological productivity in the Stillaguamish Watershed. Two-thirds of this damage to floodplain habitat occurred between 1870 and 1886 (Collins 1997).

Additional alterations to the floodplain occurred between 1930 and the present, with the loss of more than one-third of the channel area occurring between 1933 and 1991. These alterations decreased the area that could potentially receive floodwaters, increasing the cumulative potential for catastrophic floods downstream. In addition, United States Army Corps of Engineers' records from 1955 to 1965 show over 33 miles of rip-rap placed within the watershed, with the majority of it placed on the mainstem of the Stillaguamish (Collins 1997).

<u>Factors of Decline</u>

The loss and degradation of in-channel and off-channel rearing habitat can be linked to processes that have been altered on a watershed scale, as well as processes and functions that operate in close proximity to rearing habitat. Several primary factors have led to the loss of floodplain connectivity, including the following:

- Channelization or straightening of streams
- Bank protection or armoring (e.g., rip-rap)
- Levee and dike construction
- Removal of snags, LWD, and gravel
- Railroad and road construction

Current Conditions

The floodplain has been disconnected from the river largely as a result of the construction of levees, dikes, and other flood control structures and bank modifications. Table 4 indicates the total miles of modified (hardened) banks in mainstem subbasins.

Table 4. Riverbank Modifications (Haas et al. 2003)

Subbasin	Bank Length (miles)	Miles of Modified Bank	% Modified Bank
Lower Stillaguamish	42	22.26	53%
Lower NF Stillaguamish	29.2	4.7	16%
Middle NF Stillaguamish	19.3	2.5	13%
French-Segelsen	12.4	1.7	14%
Lower SF Stillaguamish	31.9	4.5	14%

Sediment

Sediment transported from upland areas and from within the channel determines the nature and quality of salmonid habitat in streams, rivers, and estuaries. Landslides, bank erosion, earthflows, slumps, and creeps are major contributors of natural sediment delivery to streams. The development and persistence of channel features used for spawning and rearing depends on the composition and rate that sediment is delivered (Spence et al. 1996).

In freshwater habitat, the quality (gravel size and fine sediment composition) and stability of spawning habitat are key factors affecting Chinook salmon production. In general, fine sediment concentrations above 12% in the substrate reduce the amount and quality of salmonid spawning and rearing habitats and specifically impact embryo survival and emergence success in Chinook salmon. Levels at or below 11% are often encountered in relatively pristine habitats (Peterson et al. 1992).

Historical Conditions

During 1997, a landslide inventory was completed for the Stillaguamish Watershed (Perkins and Collins 1997). The inventory documented 1,080 landslides within the watershed between the early 1940s and the early 1990s, of which 851 delivered sediment to stream channels. Seventy-four percent of the 1,080 landslides were associated directly or indirectly with human disturbance, most commonly clearcuts (52%) or road construction (22%).

Factors of Decline

The following factors contribute to excessive sediment deposition in the Stillaguamish Watershed:

- Timber harvest, forest road construction and maintenance
- Landslides – natural and/or triggered by timber harvest

Current Conditions

Surveys of fine sediment in tributaries found that the Lower and Middle North Fork Stillaguamish River, Lower Canyon Creek, and South Fork Stillaguamish drainages exceeded fine sediment criteria (SWM 2002). Comprehensive data on precise sediment conditions in Chinook salmon production areas has not been collected downstream of these tributaries and priority sources of sediment impacts have not been identified.

Efforts are underway to address human-caused landslide activity by reducing harvest and road building on steep unstable slopes, as regulated by the DNR HCP and the 1997 Forest and Fish Rules. The two large deep-seated glacial landslides in the watershed (Gold Basin in the Lower South Fork, and Steelhead Haven in the Lower North Fork) are two of the largest contributors of sediment to the river. Impacts of these landslides extend downstream to the estuary. As a result, the Stillaguamish Flood Control District is frequently dealing with maintenance issues from the amount of fine sediment in the system.

Forest road density is an important indicator of watershed health. Forested areas with over two miles of road per square mile may not have properly functioning sediment and water delivery to lower watersheds (NMFS 1996).[11] Table 5 illustrates the extent of forest road networks that are underlain by unstable geology and built on greater than 30% slopes. The combination of unstable geology and steep slopes present an increased risk of sediment routing to streams and rivers.

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[11] There are 1,876 total miles of roads contained in 13 subbasins dominated by forestry land uses: Upper North Fork Stillaguamish, Deer Creek, Upper Canyon Creek, Robe Valley, French-Segelsen, Jim Creek, Upper South Fork Stillaguamish, Gold Basin, Middle North Fork Stillaguamish, Boulder River, Upper Pilchuck Creek, Squire Creek, Lower Canyon Creek.. The average road density of these watersheds is 2.9 mi/mi^2.

Table 5. Forest Roads Data by Subbasin (DNR 2002)

Subbasin Information			Miles of Forest Roads with Unstable Geology and Steep Slopes > 30%[12]				% Of all Roads at Risk
Road Density (mi/mi^2)	Area (mi^2)	Name	Federal Lands	Private	State DNR	Total	
3.2	54.3	Upper North Fork Stillaguamish	35.65	6.72	5.43	47.80	28%
2.6	67.9	Deer Creek	4.04	8.67	2.77	15.49	9%
1.8	38.8	Upper Canyon Creek	11.95	0.44	0	12.39	18%
3.98	24.3	Robe Valley	7.24	3.69	0.12	11.06	11%
3.06	29.6	French-Segelsen	5.55	0.41	1.19	7.15	8%
3.92	47.0	Jim Creek	3.90	2.79	0.29	6.98	4%
1.5	54.8	Upper South Fork Stillaguamish	6.37	0.09	0	6.46	8%
1.74	29.3	Gold Basin	6.27	0.04	0	6.31	12%
3.45	35.8	Middle North Fork Stillaguamish	0	1.98	3.77	5.75	5%
4.43	24.4	Lower Canyon Creek	0	2.64	.01	2.65	2%
.56	25.8	Boulder River	0.07	0.28	1.74	2.09	14%
4.08	46.0	Upper Pilchuck Creek	0	0.80	0.97	1.77	1%
1.22	26.1	Squire Creek	0.48	0.03	0	0.52	2%
	478.1	Totals	81.46	28.31	14.55	124.33	

In 2001, the Stillaguamish Tribe received a Washington Salmon Recovery Funding Board grant to develop a landslide hazard zonation map, to be used by resource managers as a decision-making tool for future land use activities in the Stillaguamish Watershed. Using the 1997 landslide inventory described above as a means to determine why and where landslide activity occurred previously, a GIS tool has been developed showing zones of high potential landslide risk for any future land use activity. This landslide hazard tool provides us with answers to three critical questions: 1)which areas have a high potential for landslide activity based on past land uses, 2) if a landslide occurs will it reach fish bearing waters, and 3) if it reaches fish bearing waters, what will the impacts be at all channel reaches downstream. The ultimate goal of this GIS tool is to reduce human-induced landslide activity in the watershed.

Both the data in Table 5 and the recent hazard zonation study point out areas of concern for timber harvest and road building, but field verification is necessary to confirm unstable areas.

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[12] Slope-stability maps for the Puget Lowland of Western Washington often use 15% slope as a stability threshold based on a consideration of the mechanics of failure and shear strength of a silt-clay bed (Dunne and Leopold 1978). Table 5 shows only forest roads that are underlain by unstable geology <u>and</u> are traversing greater than 30% slopes. Abandoned roads pose an additional threat in certain locations (e.g. road sections with culverts). Site-specific analysis is always necessary to determine the specific stability of a particular roadbed or its contribution to sediment regimes in a watershed.

Hydrology

Natural hydrologic processes are critical in creating and maintaining suitable habitat conditions. Hydrologic integrity is strongly correlated with upper watershed forest cover.

Instream flow is important for the upstream migration, holding, and spawning requirements for Chinook salmon adults. Juvenile incubation, emergence, and rearing requirements related to flow are fundamental for the continued survival and natural production of this species.

The stability of Chinook salmon spawning habitat is equally important. During high flow events, spawning gravel can be moved downstream (a process known as scour). The North Fork Stillaguamish River has shown a trend of increasing peak flows (Figures 6 and 7), both in frequency and magnitude, resulting in increased Chinook salmon mortality (Collins 1997; Beamer and Pess 1999). Changes in peak flow frequencies have been attributed to land use practices such as clear-cut harvesting, loss of wetland function, road construction, and rural development.

Figure 6. NF Stillaguamish peak flows summary 1920-2001 (Collins 1997, Snohomish County 2002)

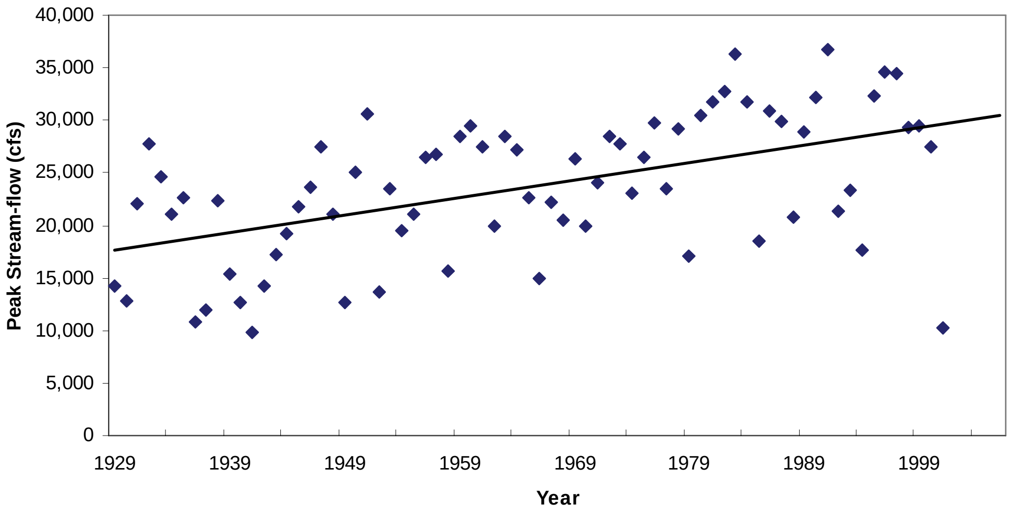
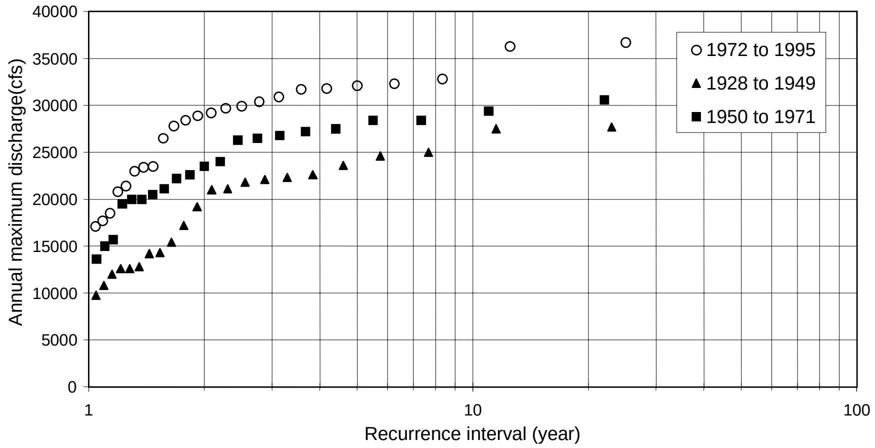
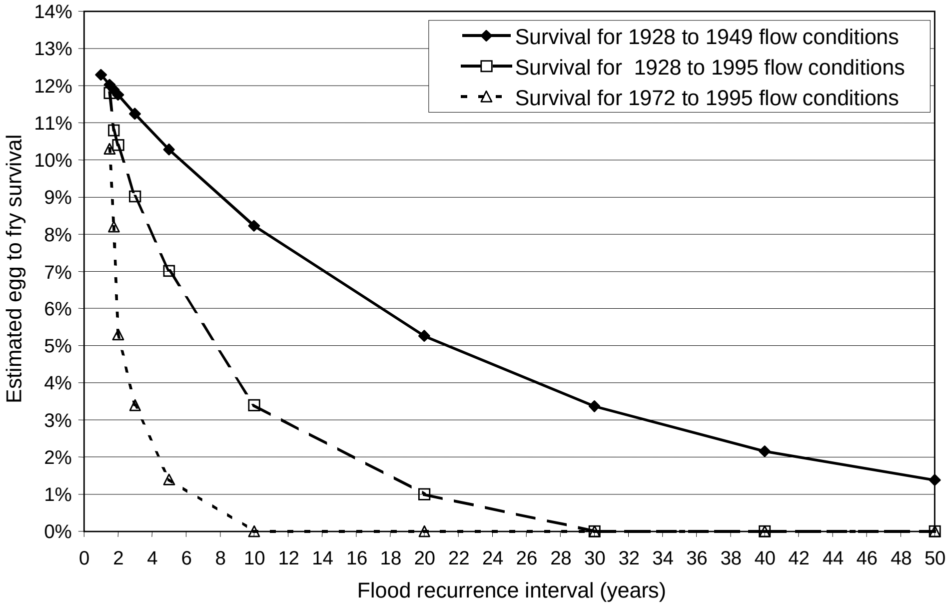


Figure 7. North Fork Stillaguamish flood recurrence interval (Beamer and Pess 1999)



Beamer and Pess (1999) concluded that peak flows can constrain adult Chinook salmon production even in years when flooding is not severe. Egg to fry survival is sensitive to changes in peak flow (Figure 8). The historic twenty-year flood event (1929-1949) has now become the two-year event (1972-1995). “This means that (currently) every broodyear of spawning Chinook has a 50% chance, rather than a (historic) 10% chance, of being exposed to (peak) flow events that correspond to egg to fry survival rates where the (Chinook) stock does not replace itself (Beamer and Pess 1999; Appendix E). Even without any kind of harvest, Stillaguamish Chinook salmon would have made the escapement goal only 3 out of the last 17 years (PMFC 1997).

Figure 8 Estimated egg to fry survival v. flood recurrence interval for the North Fork Stillaguamish (Beamer and Pess 1999)



<u>Historical Conditions</u>

Records have shown increasing peak flows in the North Fork Stillaguamish over time (Figure 6). Ten of the largest eleven annual peak flows on record occurred between 1980 and 1995 (Pess et al. 1999). Urbanization (Klein 1979; Booth and Jackson 1997) and agricultural activities (Hornbeck et al. 1970) have been shown to increase the magnitude and severity of peak flows (Wissmar and Timm 2003).

<u>Factors of Decline</u>

The factors of decline that have degraded hydrologic function in the Stillaguamish Watershed include the following:

- Deforestation. Clearing of mature forest vegetation and conversion of these lands to other land uses that do not support forest cover.
- Industrial Forestry. This land use may not support large blocks of hydrologically mature forest cover on a sub-basin scale and may contain forest stands ranging in age from seedling to mature. Clearing of mature forest vegetation over large areas of the watershed and construction and retention of roads in upland forest areas has reduced natural infiltration, thereby increasing runoff rates and peak flows.
- Filling and draining of wetlands and side channels has modified peak flows in tributaries.
- Construction of dikes, levees, revetments, and bulkheads on the mainstem and larger tributaries has reduced or eliminated floodplain connectivity and flood storage capacity.

- Surface water withdrawals and groundwater withdrawals in areas of direct hydrologic continuity, and policies that have allowed over-allocation of water resources.

Current Conditions

The amount of rainfall that is absorbed into the ground and eventually influences stream flow levels depends on the presence of vegetation. GIS analysis of land cover showed that approximately 53% of the entire Stillaguamish Watershed is hydrologically mature forest, within a range of 14% to nearly 85% on a subbasin scale (Table 6).

Table 6. Forested Cover within Stillaguamish Subbasins (Purser et al. 2003)

Subbasin	% Young Forest (0-27 years)	% Mature Evergreen Forest (>100 yrs old)	%Total Hydrologically Mature Forest
Gold Basin	12	51	85
Upper Canyon Creek	12	43	82
Boulder River	11	49	75
Deer Creek	20	28	75
Upper SF Stillaguamish	16	40	72
Upper NF Stillaguamish	23	27	70
Robe Valley	24	27	66
Stillaguamish Canyon	22	15	65
French-Segelsen	25	25	64
Jim Creek	24	18	60
Upper Pilchuck Creek	27	14	60
Squire Creek	20	32	56
Middle NF Stillaguamish	32	14	56
Lower Canyon Creek	29	15	51
Lower NF Stillaguamish	31	8	45
Harvey Armstrong Creek	29	7	40
Lower Pilchuck Creek	39	3	38
Lower SF Stillaguamish	30	7	34
Port Susan Drainages	37	4	31
Church Creek	31	1	19
Portage Creek	30	1	17
Lower Stillaguamish	28	1	14

Potential low instream flow in certain subbasins was identified as contributing to limiting Chinook salmon production. While the list is not complete, the following subbasins have been identified as having low instream flow:

- Stillaguamish River – lower mainstem
- Jorgenson Slough/Church Creek
- Pilchuck Creek
- NF Stillaguamish River - from Oso to Whitehorse

Water Quality

In addition to sufficient habitat, water quality is critical in protecting the various life stages of salmonids. There is research documenting non-lethal, but highly detrimental, effects on fish from chemical contamination of water (Baldwin et al. 2003). Water quality standards address human health and direct fish mortality, but not declines in fish abundance and productivity.

Human population growth in the Stillaguamish Watershed has led to increasing demands for more roads, wastewater treatment, and commercial activities. The most common water quality issues in the Stillaguamish include runoff from commercial and non-commercial farms, failing septic systems, land clearing and construction, road surface runoff, and over-allocation of water resources. Land use conversion, urbanization, and lack of or ineffective water quality best management practices (BMPs) have contributed to considerable non-point source pollution in the watershed (STAG 2000).

The Stillaguamish River has experienced a deterioration of water quality, in terms of both conventional and microbiological standards. Water quality monitoring in the watershed by Snohomish County, the Tulalip and Stillaguamish Tribes, and Washington Department of Ecology has found problem areas in the mainstem, North Fork, and South Fork Stillaguamish, and smaller tributaries. Snohomish County has conducted numerous investigations for nutrients, heavy metals, bacteria, and other toxicants, mainly in the lower portions of the river. The Stillaguamish Tribe’s monitoring efforts include recording water temperature, dissolved oxygen, turbidity, alkalinity, hardness, total suspended solids, pH, conductivity, and bacteria.

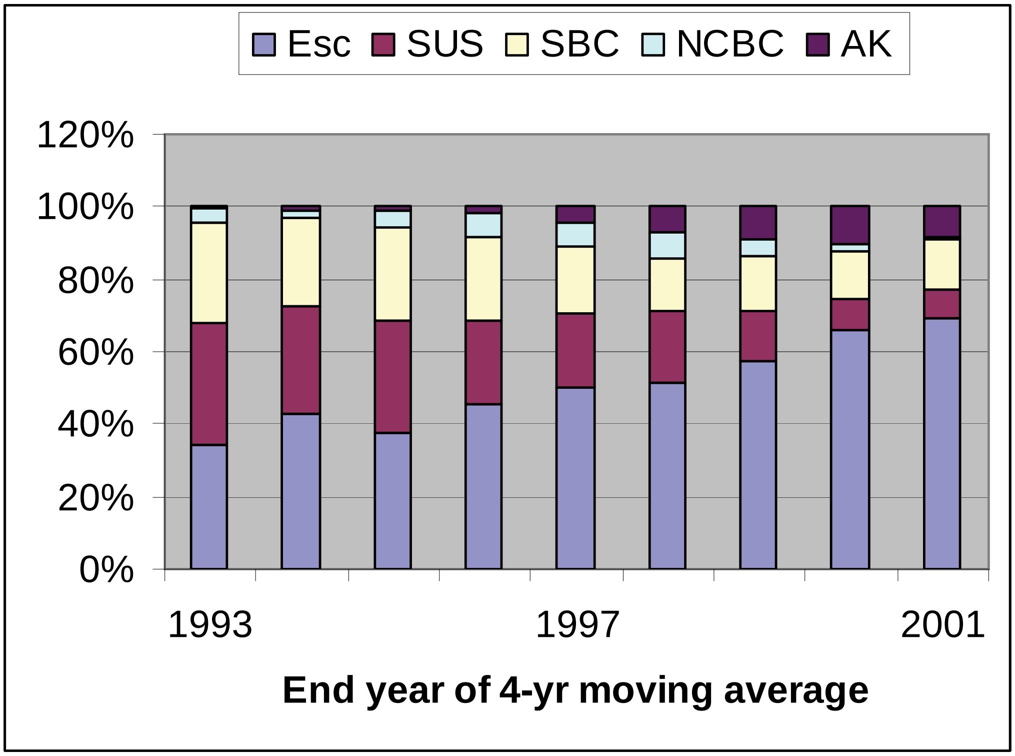
The Washington Department of Ecology is in the process of developing Total Maximum Daily Load (TMDL) cleanup plans for water bodies that do not meet state water quality standards. A TMDL establishes limits on pollutants that can be discharged to an individual waterbody and still allow state standards to be met. Ecology is developing TMDLs for the watershed that address the following water quality problems: temperature, fecal coliform bacteria, pH, and dissolved oxygen.

Harvest

Chinook salmon from the Stillaguamish Watershed are vulnerable to harvest in recreational and commercial fisheries throughout their adult range, from Alaska to Puget Sound. Canadian and Puget Sound fisheries have accounted for most (approximately 80%) of the historic and current harvest on Stillaguamish Chinook salmon populations, with Washington coastal and Alaskan fisheries accounting for harvest of the remaining portion (Figure 9). The Stillaguamish Tribe has not had a directed Chinook salmon fishery in the Stillaguamish River since 1982, the Tulalip Tribes have not had a directed fishery in Area 8A since 1984, and non-Indian commercial and sport fisheries directed at Stillaguamish Chinook salmon have been closed since the mid-1980s. Currently, fisheries are closed in most areas and during times when significant numbers of Stillaguamish Chinook salmon are present, or they are managed under regulations, such as gear restrictions or unmarked fish release requirements, that minimize the harvest of wild fish.

Under the Treaty of Point Elliott (1855) as interpreted by the federal district court (1974) and affirmed by the United States Supreme Court (1979), the State of Washington, through its Department of Fish and Wildlife, and the treaty tribes, through their tribal governments, share equal authority and responsibility for management of the salmon resource. This authority and responsibility includes assessment of stock status, setting of stock management objectives, development of fishery and enhancement plans to meet objectives, and implementation of plans through regulations and enforcement. Through custom, and with some legal basis, certain tribes are the principal managers of the salmon resource within certain river systems. For the Stillaguamish River, this is the Stillaguamish Tribe and the Tulalip Tribes. Thus, the co-managers for salmon stocks originating in the Stillaguamish Watershed are the treaty tribes and the State of Washington.

Figure 9. **Four-year moving average percentage distribution of total fishing mortalities among fisheries and escapement for Stillaguamish Chinook, 1993-2001[13]. (Pooling and averaging of data in Pacific Salmon Commission, Chinook Technical Committee, Report TCCHINOOK04-4 Table G.22)**



Due to high harvest rates and ongoing watershed disturbances, many Puget Sound Chinook salmon populations, including Stillaguamish Chinook salmon, exhibited declines in abundance and were ultimately listed as Threatened under the ESA in 1999. Given the ESA listing, all fisheries targeting wild Chinook salmon were prohibited in Washington's marine and fresh waters.

Fishery restrictions in local net and sport fisheries (terminal area fisheries) over the years have been effective, as shown by the decline in terminal area harvest rates (Figure 10). Each year since 1993, less than 10% of Stillaguamish Chinook salmon returning to the Port Susan / Port Gardner / Stillaguamish River area have been harvested, and all of this has been incidental to fisheries directed at other species or hatchery Chinook salmon.

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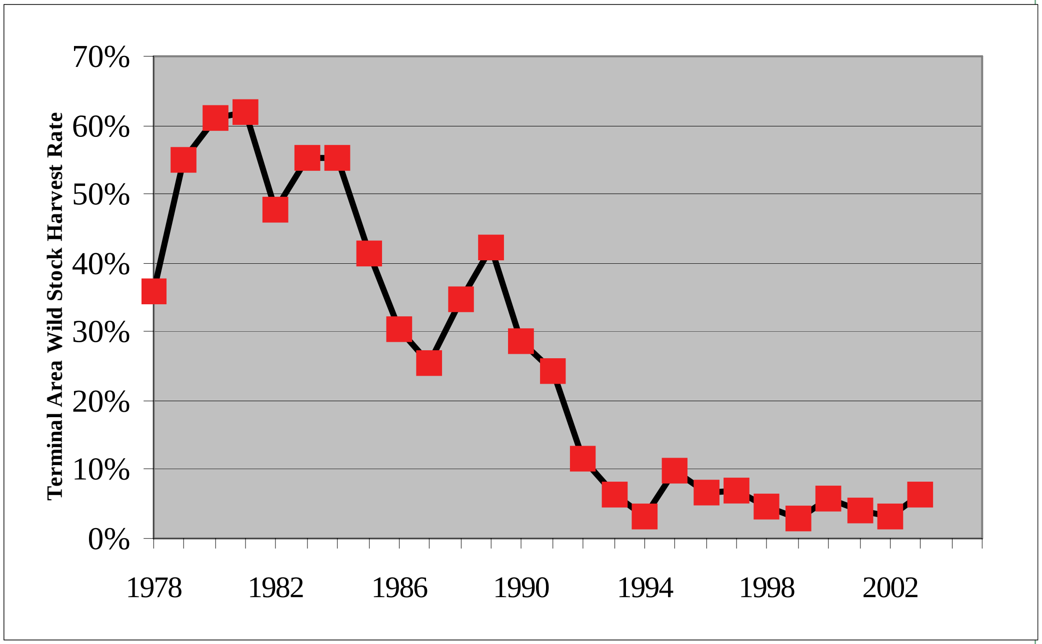
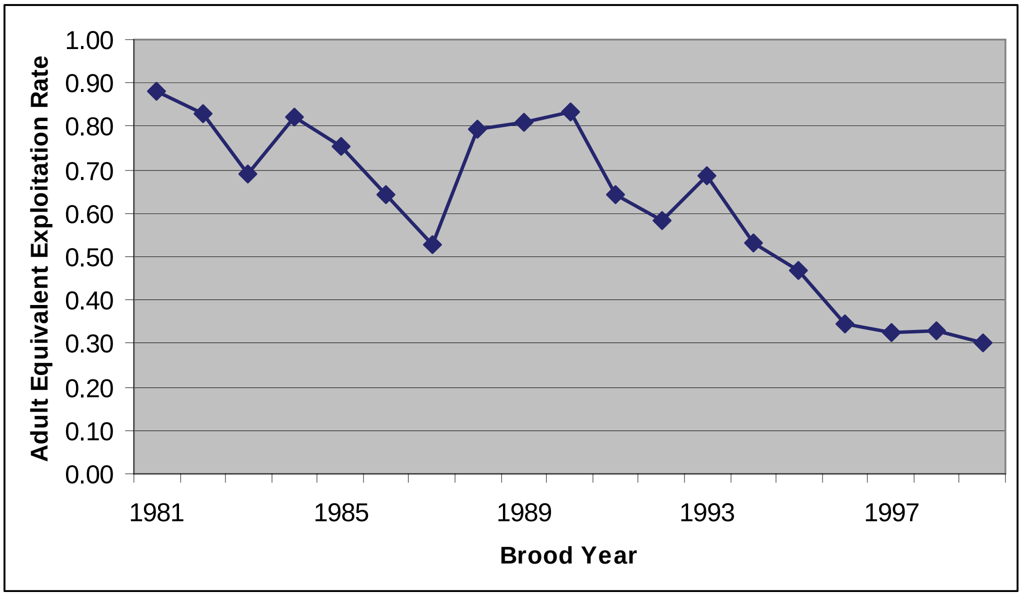
[13] ESC=escapement, SUS=United States below the 49th parallel, SBC=southern British Columbia, NCBC=northern British Columbia, AK=Alaska

Figure 10. Trend in terminal area wild stock harvest rate for Stillaguamish Chinook salmon, 1978-2003 (from Tulalip Tribes terminal area run reconstruction database).



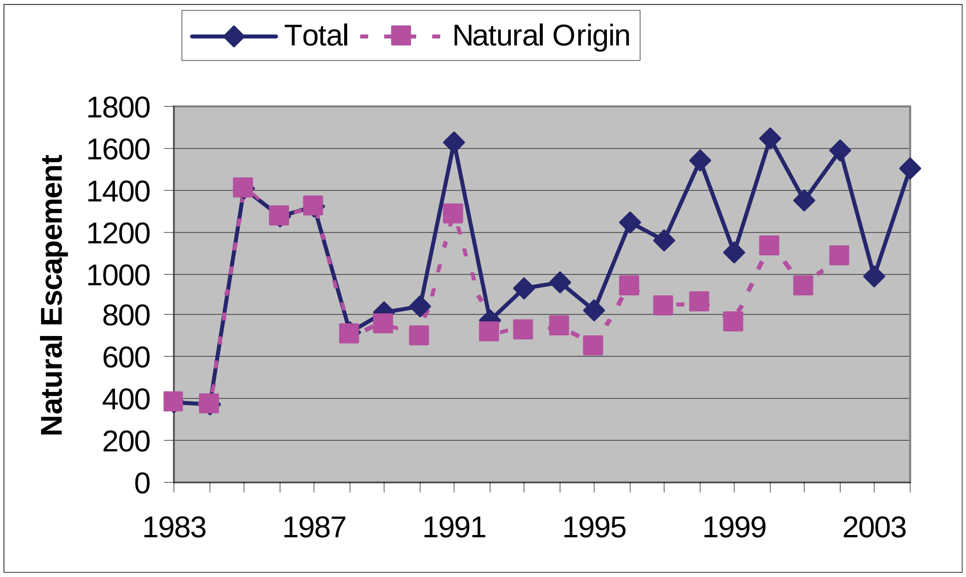
The decline in terminal area harvest rates has been accompanied by a reduction in pre-terminal fishery impacts on both sides of the US/Canada border. Under the 1999 annex of the Pacific Salmon Treaty, impacts to Stillaguamish and other Chinook salmon stocks are limited, and Canadian fisheries have not been fishing up to the maximum levels allowed under this agreement. The net result of changes in the management of harvest of Stillaguamish Chinook in all areas over the past two decades has been a reduction in overall exploitation rates from approximately 80% to 30% (Figure 11). Under the current harvest management plan, exploitation rates should be reduced further, to approximately 25%.

Figure 11. Adult equivalent exploitation rates on North Fork Stillaguamish Chinook salmon, brood years 1981-1999. (from Puget Sound Technical Recovery Team Abundance and Productivity Tables).



These greatly reduced exploitation rates have resulted in increasing escapements, although the proportional increase in spawning escapement has not been as large as the proportional decrease in exploitation rates (Figure 12). In recent years especially, the spawning escapement numbers have not responded to continually declining exploitation rates. This suggests that the system may have reached a limit in habitat capacity or productivity such that it will not respond to further harvest rate reductions.

Figure 12. Stillaguamish Chinook salmon spawning escapements 1983-2004. (Spawning escapement estimates from Washington Department of Fish and Wildlife; natural origin escapement fraction from Stillaguamish Tribe).



In addition to fishing mortality from all sources of incidental and directed harvest, there is known poaching of Chinook salmon in the Stillaguamish Watershed. Poaching refers to illegal harvest that is unreported. Determining total poaching impacts on Chinook salmon and its significance is difficult to quantify. Co-manager biological staff annually discover snagging gear (i.e., heavy hooks, weights, and line), nets, and/or other illegal fishing equipment in the Stillaguamish Watershed during field sampling activities, and annually encounter Chinook salmon bearing scars from unsuccessful poaching incidents. Although state and tribal enforcement efforts in the watershed have been increased in response to these observations, staffing and funding are still inadequate to reduce this problem to acceptably low levels.

Hatchery

Since 1952, hatchery programs have been developed in the watershed for the purpose of enhancing fishing opportunities and mitigating habitat loss with out-of-basin hatchery plants stopped in 1977 (STAG 2000). During 1986, concerns over high harvest rates and degrading freshwater habitat conditions resulted in the development of a natural stock restoration program by the Stillaguamish Tribe. By utilizing existing wild Chinook salmon from the North Fork Stillaguamish and providing a stable hatchery environment, additional Chinook salmon smolts could be released each spring to supplement the limited natural outmigration.

The current tribal natural stock restoration program contributes an estimated one-third of the returning adults to the spawning habitat of the North Fork

Stillaguamish River (Abundance & Productivity Tables; Appendix C). NOAA Fisheries (formerly NMFS) has determined that the Stillaguamish Chinook Salmon Natural Stock Restoration Program is one of the six essential hatchery programs within the Puget Sound necessary for Chinook salmon recovery. Based on NOAA Fisheries' assessment of population decline and habitat degradation, the North Fork Stillaguamish Chinook salmon would likely further decline and become extinct without the intervention of the natural stock restoration program (NMFS 1999).

The hatchery program uses both returning natural and hatchery Chinook salmon adults that are captured in the North Fork Stillaguamish using small mesh seines to provide the necessary brood stock for the natural stock restoration program. Adults are spawned during August and September. Chinook salmon spawning, incubation and early rearing occur at the Stillaguamish Tribe's Harvey Creek Hatchery while final rearing, coded wire tagging and release occur at the WDFW Whitehorse Springs Hatchery located in the area of the North Fork Stillaguamish where natural Chinook salmon spawn and rear. The Tribe's North Fork summer Chinook salmon restoration hatchery program is succeeding at maintaining genetic diversity. No legacy of Green River (hatchery) Chinook salmon introductions have been detected in tested samples (Eldridge and Killebrew, unpublished data; Appendix F).

The rearing and release of salmonids from hatcheries can have potential impacts to wild Chinook salmon populations. Hatchery-produced fish may lack genetic vigor (Busack and Currens 1995), transfer disease to wild fish (Busack and Currens 1995; ISAB 2002), and compete for food resources and space (Nickelson et al. 1986; Hawkins 1998). Genetic impacts to wild/natural spawning Chinook salmon populations from hatchery operations may include altering of the genetic population structure, decline in long-term fitness, and other impacts not reflected in population abundance (Busack and Currens 1995). Furthermore, increasing hatchery production theoretically makes more fish available for harvest, resulting in increased harvest pressure on wild salmon.

A number of actions have been implemented to reduce the risk of impacts to both wild and hatchery fish within the Stillaguamish Watershed. These include incorporating wild Chinook in the broodstock at a level that insures genetic integration of the two groups, marking all Chinook salmon released from the hatchery to minimize the masking effect, and ensuring an effective breeding population size by implementing 5 x 5 matrix spawning and final acclimation and release from a large gravel pond with controlled predation exposure (STAG 2000). Genetic analysis by Willy Eldridge of the Northwest Indian Fisheries Commission and preliminary risk/ benefit analysis by Michael Ford of NOAA Fisheries have indicated that the natural stock restoration program is minimizing impacts to natural spawning population of Chinook salmon.

In addition, Brannon et al. (2004) noted in the American Fisheries Society's journal *Fisheries* that "recent studies are quieting some of the concerns that have been raised about the fitness of hatchery fish and the risks associated with their use. These studies suggest that artificially propagated fish (of similar quality and genetic background) can perform comparable to their wild conspecifics and suggest that they can also contribute to the wild population (Brannon et al. 2004)."

Other Factors Affecting Chinook Salmon Populations

Estuarine/Ocean Productivity Conditions

A considerable amount of research has documented cyclical changes in ocean conditions, which have significant impacts on the marine survival of salmon (Mantua et al. 1997). Changes in marine currents and flows affect ocean temperatures, which in turn can affect productivity and salmon survival (Pearcy 1992). Although marine survival levels for Chinook salmon fluctuate widely, decadal shifts in marine conditions may have led to reductions in overall marine survival for Puget Sound Chinook salmon. Decadal changes in primary productivity may be connected to the decline of forage and bottom-dwelling fish species in Puget Sound over the last 20 years. In addition to productivity changes, the effects of estuarine and oceanic shifts in temperature, salinity, and current direction must be taken into consideration when developing and evaluating habitat, harvest, and hatchery recovery plans.

Predation on Chinook Salmon

Outmigrant predator/prey studies by Hawkins (1998) on the Lewis River found that both hatchery and wild salmonid smolts impact rearing juvenile fall Chinook salmon through predation. Wild steelhead, cutthroat, and coho smolts had higher predation rates than their hatchery counterparts. However, there was a greater impact on juvenile fall Chinook salmon by hatchery smolts as a result of their larger numbers at release.

There are three major mammalian predators of salmon in Puget Sound and coastal Washington: California sea lions, harbor seals, and Orca whales. Other non-marine mammalian predators include northern river otter, domestic dog, and black bear. Bird predation contributes to loss of salmon at all life stages. The Stillaguamish Tribe's North Fork Chinook salmon broodstock program has collected hundreds of adult Chinook salmon in the river since 1986. These fish show no significant scarring, which would be evidence of seal and sea lion predation (Pat Stevenson, personal communication, 2005). There is insufficient data to gauge the magnitude of bird and mammalian predation on Stillaguamish salmon populations; however, it is not likely worse than under historical conditions (NMFS website; Ruggerone and Goetz 2004).

Non-Native Species

Introduction of non-native aquatic nuisance species into the marine and freshwaters of Washington threatens the ecological integrity of the State's water resources, as well as economic, social, and public health conditions. Because they have few natural controls in their new habitat, these nuisance species spread rapidly, destroying native plant and animal habitat. *Spartina spp.* has demonstrated direct impacts to estuarine habitat (Dethier and Hacker 2004). The transition of inter-tidal acreage to *Spartina spp.*-dominated salt marsh at and above mean ordinary high water results in exclusion of species typically found in the inter-tidal region such as eelgrass, Dungeness crabs, clams, juvenile fish, shorebird, and waterfowl. The proliferation of *Spartina spp.* also results in the trapping of up to 6 inches of sediments annually. There are extensive populations of *Spartina spp.* in Port Susan and South Skagit Bay, which may pose a considerable threat to juvenile Chinook salmon populations.

Climatic Shifts

Climatologists have documented a number of cyclical changes that occur in surface temperatures and precipitation levels, which affect streamflows and water temperature in the Pacific Northwest (Climate Impacts Group 2004). Changes in climate and consequent shifts in weather and streamflow can have a dramatic effect on Chinook salmon survival during the freshwater phase of their life cycle. During warmer periods less snow pack develops, and what is available melts more quickly, increasing flooding potential. In summer, when air temperatures are higher, decreased snow pack and precipitation lead to lower streamflows with higher water temperatures. Flooding during the winter and spring impacts egg and fry survival, while lower flows in the summer impact the amount of water available for adult migration and spawning.