SALMON AND STEELHEAD HABITAT LIMITING FACTORS

WATER RESOURCE INVENTORY AREA 17
QUILCENE-SNOW BASIN

Photo provided by Hilton Turnbull

WASHINGTON STATE
CONSERVATION COMMMISSION

FINAL REPORT

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ABBREVIATIONS AND ACRONYMS

AIMT	Annual Instantaneous Maximum Temperature
7-DADMT	7-day Average of Daily Maximum Temperature
21-DADT	21-day Average Daily Temperature
BIBI	Benthic Invertebrate Biotic Index
CCCD	Clallam County Conservation District
CREP	Conservation Reserve Enhancement Program
Ecology	Washington State Department of Ecology
HCSEG	Hood Canal Salmon Enhancement Group
JCCD	Jefferson County Conservation District
JSKT	Jamestown S'Klallam Tribe
LWD	Large Woody Debris
Mg/L	Milligrams per Liter
NOSC	North Olympic Salmon Coalition
NTU	Nephelometric Turbidity Unit
NWIFC	Northwest Indian Fisheries Commission
PGST	Port Gamble S'Klallam Tribe
PNPTC	Point No Point Treaty Council
RM	River Mile
SaSI	Salmon and Steelhead Inventory
SASSI	Salmon and Steelhead Stock Inventory
SSHEAR	Salmon Screening, Habitat Enhancement and Restoration
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
TAG	Technical Advisory Group
TFW	Timber, Fish and Wildlife
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WCC	Washington Conservation Commission
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WOS	Wild Olympic Salmon
WRIA	Water Resource Inventory Area

EXECUTIVE SUMMARY

Water Resource Inventory Area (WRIA) 17 is located along the northeast corner of the Olympic Peninsula in western Washington State. The WRIA extends from the Marple/Jackson watershed in southeast Jefferson County northward and westward to, and including, the Johnson Creek watershed along the west side of Sequim Bay. It is bordered to the north by the Strait of Juan de Fuca, to the east by Admiralty Inlet, northern Puget Sound and Hood Canal, and to the south and west by the Olympic Mountains and associated foothills and floodplains. The majority of the WRIA 17 watersheds are small lowland drainages with headwaters in the low foothills of the Olympic Mountains. The WRIA lies within the Olympic "rainshadow", which indicates a moderate climate with rainfall limited to 15 to 20 inches in Port Townsend and increasing to 70 to 80 inches along the foothills of eastern Olympic mountain range. The WRIA area covers approximately 626 square miles (401,000 acres) and includes portions of Jefferson and Clallam counties. Over seventy percent of the WRIA is privately owned with a population exceeding 23,000 people (Parametrix, Inc. 2000).

The majority of WRIA 17 watersheds provide spawning and rearing habitats for four species of salmon: coho, chum, steelhead, and searun cutthroat. The estuarine and nearshore habitats provide a critical migration corridor for juvenile salmon of all species. Both Hood Canal summer chum and Puget Sound chinook are federally listed as threatened under the Endangered Species Act. Summer chum are documented in many WRIA 17 streams: Big Quilcene River, Little Quilcene River, Chimacum Creek, Snow Creek, Salmon Creek and Jimmycomelately Creek. It has not been determined if native chinook still exist in Hood Canal due to the interrelations with a mixed composition of hatchery introductions. Artificial supplementation programs have contributed to inconsistent adult chinook returns to the Big Quilcene River and more recently to Tarboo Creek. Fall chum returning to Quilcene Bay and Dabob Bay watersheds are considered healthy. Coho stocks range from critical in Discovery Bay to depressed in Quilcene, Dabob and Sequim Bay watersheds. Chimacum coho are healthy according to the proposed 2002 Salmon and Steelhead Inventory (SaSI) but that designation is subject to debate due to the index location in the best spawning habitat. Not much is known about winter steelhead populations with the exception of the Discovery Bay stocks, which have been designated depressed by proposed SaSI.

The species found in WRIA 17 utilize specialized habitats at different times and at different life stages. Different species stagger their upstream migration and each species has a unique rearing strategy. All species require adequate flow and water quality, ample spawning gravels, instream structure in the form of large woody debris and/or large boulders, pools, and a functional riparian zone while inhabiting the riverine system. While coho, chinook and steelhead remain in the freshwater for an extended period of time following fry emergence, pink and chum salmon tend to move directly out into the salt water. Estuarine, high salt marsh, eelgrass and shallow water nearshore habitats are critical to all species of juvenile salmonids as they enter the marine environment. Pink and chum salmon rely heavily on eelgrass beds for feeding and hiding and shallow water for prey avoidance. Studies also show that high salt marsh and estuarine tidal channels are critical habitats for chinook and coho as well.

Human alterations to salmonid habitat can be expected to have different consequences for different fish species and their life stages. While natural environmental conditions, such as fire, floods and mass wasting events create a disturbance/rebuilding cycle that tends to nourish the aquatic environment, human alterations to the landscape can impact the environment beyond it's natural ability to heal and sustain fish resources. Freshwater rearing is particularly critical for coho whose typical freshwater cycle extends through the summer months when many WRIA 17 streams are flow-limited. Freshwater rearing salmonids are therefore particularly vulnerable to habitat impacts such as elevated water temperatures and dewatering as a result of riparian removal and water extraction, and lack of instream structure such as pool-forming large woody debris. In the marine environment, shoreline alterations, such as bank armoring, overwater structures and intertidal fill, can interrupt important sediment input from eroding bluffs, alongshore sediment movement or drift, and continuous eelgrass beds that are critical to migrating juvenile salmon.

The Habitat Limiting Factors Analysis for WRIA 17 summarizes existing salmonid habitat data and represents the most current compilation and review of riverine and nearshore processes and human-induced impacts to salmon productivity. It does not cover salmonid productivity limited by hydroelectric dams, harvest or hatcheries. Data included or referenced in this report include watershed analysis, formal habitat inventories or studies specifically directed at evaluating fish habitat, salmon stock inventories and assessments, and other watershed data not specifically associated with fish habitat evaluation. Where data are lacking, the Technical Advisory Group (TAG) relied on its combined professional knowledge to assess the extent to which habitat conditions are affecting salmonid productivity. Where data and best professional knowledge are lacking, the habitat elements have been identified as data gaps and warrant additional specific watershed research or evaluation.

Land use activities associated with forest practices, agriculture, rural development and shoreline development have had negative impacts on salmon habitat in WRIA 17. Habitat conditions in the federally owned lands in the upper watershed, managed by the US Park Service (USPS) and the US Forest Service (USFS), are among the best in the WRIA. The USPS strives to maintain natural habitats through preservation, and even though very little land in WRIA 17 is managed by the USPS, their conservation measures protect downstream riverine function. The USFS has adopted a Riparian Reserve Program which provides for well functioning riparian habitat that ensures conifer canopy cover for temperature control, large woody debris recruitment, streambank stability to limit fine sediment input, and migratory corridors for numerous wildlife species. Their clearcuts rarely exceed 80 acres in size. This is in contrast to the large clearcuts and inadequate riparian zones on state-owned and private forest lands as evidenced in orthophoto analysis by TAG members. The riparian zone's ability to intercept fine sediments resulting from exposed soils diminishes as the riparian buffers decrease. In addition, mass wasting events and the subsequent above-normal delivery of sediments into the Snow Creek, Nordstrom Creek and Chimacum Creek watersheds have been directly linked to improper forest road construction, maintenance and/or abandonment on state-managed and/or private forest lands. Elevated water temperatures, lack of large woody debris, and limited large woody debris recruitment due to limited riparian areas are typical of many of the watersheds in the WRIA.

Agriculture activities within the floodplains of many WRIA 17 watersheds have channelized mainstems and tributaries, drained beaver ponds for livestock grazing and peat mining and eliminated forested riparian zones. These activities have eliminated valuable juvenile overwintering and rearing habitat associated with beaver ponds, decreased broad channel meanders, eliminated floodplain connectivity to side channel habitats, reduced channel complexity and instream structure, minimized pool/riffle ratios, decreased streambed and streambank stability, and eliminated healthy riparian zones. Salmon Creek, Chimacum Creek, Upper Ludlow Creek, and Tarboo Creek watersheds have experienced degradation from agriculture activities. Further agricultural impacts to estuarine and salt marsh habitats can be observed in the Big Quilcene, Little Quilcene and Snow Creek watersheds, where extensive diking and filling into the nearshore environment have decreased estuarine function and eliminated salt marsh habitats.

Jefferson County has designated Port Townsend as its urban growth area as defined by the Washington State Growth Management Act. This has not entirely eliminated rural development throughout the county where the total population growth is among the highest in the state. Rural development tends to remove riparian vegetation for views, increase stormwater runoff with impervious surfaces and threaten water quality through the use of herbicides, pesticides and chemical fertilizers. Shoreline development contributes further to impacts to salmonid habitats. Removal of riparian vegetation for views weakens bank stability which could threaten home sites and which often results in bank protection. Shoreline armoring prevents the movement of sediments from naturally occurring backshore feeder bluffs to the nearshore. Intertidal fill eliminates shallow water habitat utilized by migrating juvenile salmon to escape prey, fragments eelgrass beds, interrupts alongshore sediment drift, and can decrease valuable salt marsh and lagoon habitats.

In order to ensure that salmonid habitats can produce sustainable and harvestable populations into the future, the Technical Advisory Group consistently placed preservation of properly functioning habitats, particularly estuaries, actively eroding feeder bluffs and riverine riparian corridors, as priority action recommendations. Preservation of critical habitats is a cost effective tool to ensure that properly functioning habitats will remain as such into perpetuity. Protection of critical habitats is the top priority for Salmon Creek and the Big Quilcene River, and is an important action recommendation for Snow Creek and Chimacum Creek. The Chumsortium, a partnership between Jefferson Land Trust, Wild Olympic Salmon, Jefferson County Conservation District, North Olympic Salmon Coalition, Hood Canal Coordinating Council, Trout Unlimited, Jefferson County and the Washington Department of Fish and Wildlife, has been actively and strategically pursuing funding for the acquisition of critical salmon habitats in east Jefferson County.

When a watershed has been severely impacted and cannot heal itself within a reasonable time frame, habitat restoration may be necessary. Once the source of the problem has been identified, rehabilitation activities can be directed to restore properly functioning condition. Such activities in the riverine environment might include removal of artificial barriers to fish passage, reestablishment of a healthy riparian zone, restoration of sinuosity and/or complexity, installation of cattle exclusion fences, abatement of mass wasting events, and/or removal of streambank armoring. Restoration activities in the nearshore might include removal of intertidal fill, restoration of lagoon and/or salt marsh connectivity, removal of shoreline armoring and/or removal of estuary constrictions that impede natural function. In some cases, property acquisition may be necessary prior to initiating restoration activities. The Technical Advisory Group identified restoration activities for the majority of the watersheds in WRIA 17. Jefferson County Conservation District, Wild Olympic Salmon, North Olympic Salmon Coalition, Hood Canal Salmon Enhancement Group, Port Gamble S'Klallam Tribe, Jefferson County and Washington Department of Fish and Wildlife have all pursued funding and participated in habitat restoration projects. Continued efforts will be necessary to increase habitat productivity to ensure sustainable salmonid populations.

Protection and restoration activities are only a part of the salmonid habitat equation. Land use regulations and their enforcement must be redirected to protect the valuable fish and wildlife resources that WRIA 17 has to offer. Preventing habitat degradation is a very cost effective tool to ensure sustainable populations of fish and wildlife into the future. The Technical Advisory Group identified assessments and studies needed to fill data gaps. In some cases, assessments might be necessary prior to beginning preservation or restoration activities.

The following report is a detailed assessment of habitat limiting factors in WRIA 17. Each watershed assessment is complete with a prioritized list of action recommendations for that watershed. The nearshore discussion is followed by a prioritized list of nearshore projects for the entire WRIA. This report provides information that can be used in the development of salmonid habitat protection and restoration strategies. It is a snapshot in time that can be supplemented with additional data from habitat assessments and habitat restoration successes as information becomes available.

INTRODUCTION

Salmonid Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 *(later codified to RCW 77)* was a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- Directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- Directs the technical advisory group (TAG) to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- Defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- Defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydropower, and harvest limiting factors are being dealt with in other forums.

The Relative Role of Habitat in Healthy Populations of Natural Spawning Salmon (Chapter Author — Carol Smith, PhD, edited by the report Author)

During the last 10,000 years, Washington State Anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each species throughout the state. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during outmigration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as the pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which decrease spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base and woody debris for habitat and flow control. It also filters runoff prior and shades the stream to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their spawning grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can result in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water runoff into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during low flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and fall chinook salmon quickly migrate downstream to the estuary. Other species such as coho, steelhead, bull trout, and spring chinook will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed “seep” areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat. Woody debris and overhead cover provide protection from predators and habitat for forage species. Most juvenile salmonids use this type of habitat in the spring.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and spring chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce habitat; hence, the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and off-channel habitat again becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead cover are important habitat components during this time.

Except for bull trout and resident steelhead (rainbow/redband trout), juvenile parr convert to smolts as they migrate downstream toward the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population’s characteristics through adaptation over the last 10,000 years.

Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. In addition, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as a lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chinook Salmon Life History

Chinook salmon *(Oncorhynchus tshawytscha)* have three major run types in Washington State. Juvenile spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry in May or early June. Spring chinook spawn from July through September, typically in headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March. Outmigration downstream to the estuaries occurs over a broad period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks

(Snohomish summer chinook, Snohomish fall chinook, and upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall *et al.* 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

As they grow, juvenile salmonids move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Quality pool habitat includes deep pools with overhanging riparian cover, large woody debris, and large cobble/boulder substrate.

<u>Chum Salmon Life History</u>

Chum salmon (*Oncorhynchus keta*), also known as dog salmon and/or calico salmon, utilize the low gradient (0-8%) reaches of the stream for spawning, and typically spend less than 30 days in the freshwater after emergence. They remain in the estuary and nearshore environments, feeding primarily on copepods, tunicates and euphausiids, prior to migrating out to the ocean (Lichatowich, 1993a). Chum return to freshwater in three to five years to spawn and tend to be group spawners with each female accompanied by one or more males. The abundance of chum salmon in Puget Sound tends to fluctuate naturally during even/odd cycles, suggesting a possible competitive interaction with pink salmon in estuary or nearshore habitats (Salo 1991 in McHenry and Lichatowich 1996). Their carcasses provide high nutrient values for juvenile salmonids and numerous wildlife species. There are three distinct run times: summer, fall and winter. Summer and fall stocks are both found in WRIA 17.

<u>Coho Salmon Life History</u>

Coho (*Oncorhynchus kisutch*) penetrate deep into the upper watersheds, spawn from October to January and emerge in early March to late July. Most juvenile coho remain at least one year in freshwater, although recent studies have shown that some strains spend time in estuaries prior to smoltification. Those that remain in freshwater rear in shallow gravel areas near the streambank, pools and side channels. They school at first but later disperse and become aggressive and territorial. Coho go through physiological changes (osmoregulation or smoltification), preparing for life in salt water, and migrate to sea in spring (Lichatowich 1993). Coho are observed in most of the WRIA 17 watersheds.

<u>Steelhead/Rainbow Trout Life History</u>

Steelhead *(Oncorhynchus mykiss)* have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner *et al.* 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby *et al.* 2000). Because of this, steelhead rely heavily on freshwater habitat and are present in streams all year long.

<u>Bull Trout Life History</u>

Bull trout *(Salvelinus confluentus)* are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Bull trout exhibit a complex life history that includes three possible strategies. Resident fish stay in the natal stream their entire life. Fluvial fish migrate (as juveniles) from the natal stream to a larger river, and adfluvial juveniles migrate upstream or downstream to a lake or reservoir. These last two strategies are utilized to take advantage of increased food supplies, similar to anadromous salmonid maturation in the ocean. Adult bull trout return to the natal stream to spawn (Goetz 1989). Bull trout reproduce slowly because of a four to seven year sexual maturation period. They are a long-lived fish, with some known to live up to twelve years (Fish and Wildlife Service 1998). In the fall, they spawn in cold streams with clean gravel and cobble substrates on gentle gradients. Eggs hatch in late winter to early spring about four to five months after egg deposition. Fry hide in the substrate for several weeks prior to emergence (swimming up out of the gravel), at which time they continue to stay close to the bottom (Goetz 1989).

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, dolly varden, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples. Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review have indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

WATERSHED CHARACTERIZATION

Overview

Location: WRIA 17, with its aerial view bearing much resemblance to a dragon, lies in the northeast corner of the Olympic Peninsula and includes parts of the Straits of Juan de Fuca, Hood Canal and the northeast side of the Olympic Mountains. The watershed covers approximately 626.6 square miles (Parametrix, Inc. et al 2000) and includes portions of both Jefferson and Clallam Counties.

Geology: The retreat of the huge and heavy ice sheets of the cordilleran glaciations carved the inland waterways of Puget Sound, including those along east Jefferson County and Hood Canal. There is evidence that the termination of the latest glacial episode affecting WRIA 17, the Vashon, was rapid, with the ice sheet thinning, floating, and breaking up in the eastern Straits, as the temperature rose (Jamestown S'Klallam Tribe et al 1994). As the ice lobe retreated northwards and approached the Strait, there was an isolated drainage route connecting Dabob Bay with Discovery Bay via the Leland-Snow Creek valleys. This glacial history had important consequences for the evolution of stream drainages, headwater wetland formation, and fish colonization/movement among basins. Another such example in WRIA 17 with wetlands offering fish easy transit routs could be evidenced in a possible Ludlow-East Fork Chimacum link (Ted Labbe, personal communication, 2002). The sea-level rise was accordingly rapid and coastal lowlands freed from glacial ice were submerged under marine waters. The rebound of the earth's crust was more gradual, returning to equilibrium level about 5,000 years ago. At Port Townsend, the rise of the earth's surface has been estimated at nearly 500 feet since the Vashon ice disappeared. The coastal bluffs have formed in the time since the last glaciation, by gradual erosion of the coastline from a combination of wave action and wind erosion (Jamestown S'Klallam Tribe et al 1994).

Climate: WRIA 17 lies predominantly in the rainshadow of the Olympic Mountains, which intercept much of the precipitation from the Pacific Ocean. The majority of precipitation is in rainfall. Due to this rainshadow effect, precipitation ranges from 15 to 20 inches/year in Port Townsend and northern Miller Peninsula, which has been called the driest coastal region north of southern California (SCSWAT 1996). The southern part of the WRIA experiences increased precipitation to as much as 70 to 80 inches/year along the foothills of the eastern Olympic Mountains (Parametrix, Inc. et al 2000). Eighty-five percent of the rainfall occurs November through May.

Many WRIA 17 streams are naturally flow-limited and some dry during the summer months. This condition renders streams particularly vulnerable to habitat impacts such as elevated water temperatures or channel de-watering stemming from human removal of riparian vegetation and water extraction. Though many streams may naturally go dry, their importance to fish populations should not be assumed to be negligible. Seasonal flowing reaches of many streams provide important spawning habitat for coho and fall chum (Ted Labbe, personal communication, 2002).

Cultural Background: Prior to Euro-American contact, Native American tribes relied on a variety of flora and fauna, including fish and shellfish resources, along the Straits of Juan de Fuca, Admiralty Inlet and Hood Canal. Tribes were basically hunters and gatherers, moving seasonally to forage for a variety of food resources.

The Jamestown S'Klallam tribe, part of the coastal Salish family, numbered between 1500 to 2000, in 13 villages. The villages extended along the southern shores of the Straits of Juan de Fuca between the Dungeness River and Port Townsend. English and Spanish explorers visited this area in the late 1700s on their quest for the Northwest Passage, followed by fur traders, missionaries, gold miners and eventually, settlers. The occupation of the Sequim Prairie by white settlers destroyed premium native forage plants and game lands and negatively impacted native salmon runs through operation of irrigation systems. By the mid 1850s, the S'Klallam population had dwindled dramatically due to impacts that the Euro-Americans brought with them: disease, wars, alcoholism and devastation of their culture and resource base (Gorsline 1992). The Jamestown S'Klallam, their name meaning "strong people", are unique in that, upon failure of the US government to grant them their own reservation, they banded together to purchase 210 acres along Sequim Bay for $500. The Jamestown S'Klallam received federal recognition in 1981 and, in spite of a relatively low number of inhabitants, the community is alive and well today, maintaining a strong economic and political presence on the Olympic Peninsula (Gorsline 1992).

The Chimacum (or Ts-em-a-kum) Tribe originally occupied land from the mouth of Hood Canal to the mouth of Port Discovery Bay. It is believed that they originally came from the Quilleutes following a coastal high tide that drove some Quilleutes eastward to the vicinity of Port Townsend. Their connection is further supported by their similar number system and similar traditions (Castile 1985). Their main Chimacum village was located near Irondale/Port Hadlock and was a central capital for nearly all the tribes in Puget Sound where they occasionally gathered for various purposes. The Chimacum tribe was believed to be smaller in number, approximately 500 in the 1870s and dwindling down to 3 by 1910, possibly due to smallpox, alcoholism, and/or wars with other tribes. According to popular lore, they were brave and warlike and were reported to have suffered at the hands of their enemies. They are now virtually extinct as those that remain have married into other tribes (Simpson 1986). Modern legend has it that the name Chimacum means "heart of the dragon" with Anderson Lake being the heart.

The Quilceeds (or Kolsids or Quil-ceed-o-bish), meaning "salt water people", were one of the three bands of Twanas (along with the Skokomish and the Du-hlel-lips). They inhabited the shores of the west side of Hood Canal, typically at the mouth of salmon bearing streams in small groups bound together by a common language (Mayte et al 1994). The Twana had at least one permanent winter village near the present town of Quilcene with several campsites nearby. A retaliatory attack in the mid 1880s by the Quinaults reduced the Quilcene population to all but a handful (Mayte et al 1994). Most of the tribal members live on the Skokomish Reservation but a handful still live in the Quilcene area.

All the Point No Point Treaty Tribes (Lower Elwha S'Klallam, Jamestown S'Klallam, Port Gamble S'Klallam and the Skokomish) claim all or parts of WRIA 17 as their usual and accustomed hunting, fishing and shellfish harvesting area. They all overlap in Quilcene Bay.

Disturbance Regime: Disturbances, both human and naturally caused, affect the vegetation cover. Fire and timber harvesting are major disturbances that have affected the watershed (SCSCWAT 1996). Large forest fires are believed to recur at a 200 to 300 year frequency in the eastern Peninsula. There is evidence of wide-coverage fires in the early 1500s, and smaller fires in the 1700s and the 1890s (SCSCWAT 1996).

Demographics: Jefferson County is one of the fastest growing (per capita) counties in Washington (Ted Labbe, personal communication, 2002). The Jefferson County portion of WRIA 17 estimates the 1996 population at 24,792 and projects the 2016 population to be 38,392 for a net increase of 13,600. About 40 percent of the population increase is expected to be in the urban growth area of Port Townsend and another 20 percent of the increase is projected for the Port Ludlow Master Planned Resort. The remaining portions of east Jefferson County are expected to increase by a total of about 5,200 people between now and 2016 (Parametrix, Inc. et al 2000). Population pressure increases demand for water and developed residential properties, particularly with views, which can increase impacts to fish habitat through stormwater runoff, riparian degradation and surface and ground water withdrawal. Washington State's Growth Management Act is designed to minimize, but not eliminate, many of these impacts to fish habitat productivity.

Land Use: WRIA 17 includes a multitude of land use including forestry, agriculture, urban development, rural residential, light industry, and recreation. Much of Jefferson County is in public ownership given its position within the Olympic National Park, Olympic National Forest and state trust lands. Only 11% of the entire county is private, with a higher percentage of private lands in east Jefferson County. Most of the anadromous fish habitat is on private land with important consequences. Improper forestry and agriculture practices have contributed to habitat impacts throughout WRIA 17 through channelization, riparian loss and removal of instream structure. Rural residential development has added to these impacts. The City of Port Townsend has been designated the urban growth area under the Growth Management Act.

Marple/Jackson Creek – WRIA 17.0001

Marple Creek, sometimes called Jackson/Marple Creek, is 2.4 miles in length with an additional 2.2 miles contributed by its tributary, Jackson Creek (Ames and Bucknell 1981). The upper watershed is in federal forest with the lower mile privately owned. Anadromous fish use the lower mile although juvenile coho have been observed in the upper watershed.

Spencer Creek – WRIA 17.0004

Spencer Creek, approximately 3.8 miles in length with an additional 1.1 mile in tributary contribution (Ames and Bucknell 1981), flows into the northwest corner of Jackson Cove in Dabob Bay, about one mile south of the Big Quilcene River and drains an area of 3.29 square miles (Parametrix, Inc. 2000). The lower watershed supports spawning and rearing for chum, coho and coastal cutthroat. An impassable cascade prevents anadromous use of the upper watershed, although it supports resident cutthroat.

Indian George Creek – WRIA 17.0011

Indian George Creek, approximately 1.7 miles in length (Ames and Bucknell 1981), enters Quilcene Bay approximately 0.5 mile south of the Big Quilcene River. Indian George Creek is primarily forested with rural residential use near the mouth. Poor logging practices, including logging road maintenance, have created mass wasting events in the upper watershed that have seriously impacted habitat quality in the lower watershed.

Big Quilcene River – WRIA 17.0012

The Big Quilcene watershed, approximately 69.5 square miles, drains to Quilcene Bay in northwest Hood Canal, and is bounded by the Little Quilcene to the north, the Dungeness to the west and the Dosewallips to the south. The Big Quilcene has a total mainstem length of 19 miles and a combined tributary length of 80 miles (Ames et al 2000). The terrain is generally steep with roughly 7,800 feet of total vertical relief (GeoEngineers, Inc. et al 1998). One percent of the watershed is within the Olympic National Park and thirty percent of the Big Quilcene watershed (headwaters) is contained in the Buckhorn Wilderness Area. Below the Buckhorn, the Forest Service, state, and private forestland owners manage most of the remaining watershed for timber production. The primary water source for the City of Port Townsend (30 cfs water right) is diverted at river mile 9.4. This is a consumptive use and is diverted out of the basin (Ames et al. 2000).

The Big Quilcene watershed is underlain primarily by bedrock belonging to the Crescent formation, a unit of various glacial deposits and alluvial post-glacial deposits (GeoEngineers, Inc. et al. 1998). Above river mile 4.0, steep rugged slopes form a narrow corridor with numerous tributary streams. These steep slopes with their weak, easily eroded rock are prone to mass wasting (GeoEngineers, Inc. et al 1998). Below river mile 4.8, the channel gradient moderates and flows through an increasingly wide floodplain with small private land blocks that occupy about 5% of the watershed. The Quilcene National Fish Hatchery, located at river mile 2.8, utilizes water from both the Big Quilcene and from nearby Penny Creek (Ames et al 2000). Upstream passage is restricted on the Big Quilcene between September and December by an electric weir operated by the fish hatchery. A raised culvert and water intake structure permanently block access to Penny Creek, which has been identified as excellent refugia habitat by Frisell (Paula Mackrow, personal communication, February 2002). The channel below river mile 0.8 is diked, and portions of the channel between river mile 0.8 and 4.8 have been dredged, diked or the bank armored. The Big Quilcene flows through the town of Quilcene at approximately river mile 0.8.

Much of the watershed has been burned by at least three fires over the last four centuries. In spite of these fires, riparian vegetation has, for the most part, remained intact (Mayte 1994).

The watershed experiences a relatively mild marine climate with an average annual precipitation of 61 inches (51 inches in Quilcene and at the river mouth; 76 inches in the upper watershed). Above 4,000 feet, snow is the principal form of precipitation while rain and snow both contribute at the 2,000 to 4,000 foot elevation and rainfall is the principal precipitation below 2000 feet (GeoEngineers, Inc. et al 1998). The average low-flow is less than 60 cfs in September while maximum flows range from 1500 cfs to 3050 cfs (GeoEngineers, Inc. et al 1998). Most high flow events result from intense rainstorms, rain-on-snow events or sudden snow melt.

Jefferson county zoning indicates 93 percent of the watershed in forestry (86% of which is within the Olympic National Forest with multiple use placing some acreage in wilderness areas), 4 percent in rural residential categories, 0.2% in agriculture and 0.1% in commercial use.

Little Quilcene River – WRIA 17.0076

The Little Quilcene watershed, approximately 34.6 square miles in area, drains to Quilcene Bay in east Jefferson County. The Little Quilcene, with a mainstem length of 12.2 miles and a combined tributary length of 81.2 miles (Ames et al 2000), originates on the north side of Mount Townsend and in Bon Jon Pass in the Olympic Mountains (Ames and Bucknell 1981). The upper 1/3 of the watershed lies within the basalt-rich Crescent formation, and is primarily US Forest Service land. The upper portion, including the City of Port Townsend water diversion, is in Clallam County.

The City of Port Townsend diverts water (9.6 cfs water right, with a 6 cfs minimum instream flow requirement at the diversion) at river mile 7.1 to Lords Lake Reservoir on Howe Creek, which is removed from the watershed (Ames et al 2000). This water right is junior to a total of 5 cfs water rights held by landowners in Quilcene. Lords Lake, generally filled November through May, is used to supplement Port Townsend water diverted from the Big Quilcene when flows decline below the agreed flow level, or when the Big Quilcene contains excessive suspended sediment during floods (Ames et al 2000).

Precipitation in the Little Quilcene watershed averages 47.5 inches annually (Parametrix et al 2000). Jefferson County Conservation District data gathered in September/October of 1986 showed an average flow of 7.05 cfs (Gately G. 2001). The City of Port Townsend has continuous stream flow data available from 1994 to the present as well as USGS data from 1926-1927 and 1951-1958.

From approximately river mile 7.0, where a cascade/falls restricts anadromous passage, to the mouth, the watershed is composed of unconsolidated glacial sediment layers interbedded with siltstone and sandstone, and alluvium deposited by the river. This portion of the watershed contains extensive low-gradient anadromous habitat and associated development for agriculture, homes and the town of Quilcene. The Little Quilcene reaches the town of Quilcene at about river mile 1.0 (Ames et al 2000).

The Little Quilcene watershed is less protected than many other west side Hood Canal rivers. Protection as a municipal watershed should be considered (Ian Jablonski, personal communication 2002). No part of the watershed is located within Olympic National Park, although major portions of the watershed are located within the Olympic National Forest (Watson et al 2001). The upper watershed is managed for public and private commercial forestry. A total of 52 percent of the watershed is zoned forestry, 17 percent rural residential and 0.8 percent agriculture. Sixty percent of the riparian zone below river mile 3.0 is developed with agriculture, roads/dikes, rural residences and forestry. The lower 0.8 miles contains dikes and bank armoring for floodplain residences. Dikes, roads and ditches impact the tidal delta.

Donovan Creek – WRIA 17.0115

Donovan Creek, approximately 3 miles long with an additional 2.6 miles in tributaries (Ames and Bucknell 1981), flows into the north end of Quilcene Bay. The stream has been straightened and confined and is void of large woody debris and riparian vegetation in the lower reaches. An average of five flow measurements taken between July 11, 1996 and October 9, 1996 equated to 0.48 cfs (Gately 2001). The bulk of the watershed is in rural residential zoning (33.2%) and commercial forestry (43.7%). The remaining percentage is in agriculture (4.5%), rural forest (16.8%), water and tidelands (0.6%), and roads and right of ways (1.2%).

Lindsay Creek – WRIA 17.0123

Lindsay Creek initiates on the Bolton Peninsula and flows southeast to Dabob Bay. An impassable falls at river mile 1.0 limits anadromous fish access. Severe slides in the upper watershed due to improper land use activities have created sedimentation problems in the lower watershed.

Tarboo Creek – WRIA 17.0129

Tarboo Creek watershed initiates at about 600 feet elevation about four miles south of Discovery Bay in Jefferson County. The mainstem flows south about 6.8 miles along the west side of the Toandos Peninsula into Tarboo Bay at the head of Dabob Bay. The total stream length, including all tributaries, is nearly 13 miles (Ames and Bucknell 1981) draining 12.4 square miles of watershed (Parametrix 2000). The sediments exposed at Tarboo Bay are mapped as Vashon recessional outwash, suggesting that the cordilleran glacier-carved channel extended down to sedimentary bedrock where Tarboo Creek now flows (Jamestown S'Klallam Tribe et al 1994).

Flow measurements taken at the USGS staff gage in 1993, indicated 4.43 cfs on July 23 and 2.54 cfs on August 18 (Jamestown S'Klallam Tribe et al 1994). Jefferson County Conservation District measured low flows in August/September 1996 (average 1.45 cfs and in July/August 2000 (average2.5 cfs) (Gately 2001). Precipitation for the Dabob/Thorndyke area measures 39.3 inches annually (Parametrix, Inc. et al 2000).

The majority of the county zoning is within commercial forestry (66.9%), rural forestry (6.9%) and rural residential (20.5%). There are no forestlands under federal ownership. The primary residential land use is one dwelling unit per twenty acres. The remaining percentage is in agriculture (3.7%), water and tidelands (0.3%) and roads and right of ways (1.7%). Part of the lower watershed, with its intact riparian zone, is protected in public ownership by Washington Department of Fish and Wildlife.

Camp Discovery Creek – WRIA 17.0141

Camp Discovery Creek flows into the east side of Dabob Bay from the western side of Toandos Peninsula. The primary land use is in forestry and rural residential.

Fisherman Harbor Creek – WRIA 17.0153

Fisherman Harbor Creek flows into Hood Canal at the southern end of Toandos Peninsula. Land use is primarily rural residential and forestry.

NOTE: There are numerous other tributaries along the east and west side of Toandos Peninsula that have or may have cutthroat populations, but little is known about these systems.

Thorndyke Creek – WRIA 17.0170

Thorndyke Creek begins at Sandy Shore Lake in Jefferson County, flows mostly toward the south for 6.3 miles and drains a watershed area of 12.1 square miles (Parametrix 2000). Perennial and intermittent tributaries add an additional 7.7 miles to the total stream length (Ames and Bucknell 1981). A number of wetlands and seasonal lakes are mapped on the highland areas, but they have no apparent surface outlet (Jamestown S'Klallam Tribe et al 1994). A complex of beaver ponds occur downstream of South Point-Thorndyke Road, extending to the interface with tidal water. The majority of the watershed is managed by Olympic Resource Management and is in long-term forestry management with revegetation in various stages throughout the watershed. Jefferson County zoning places 1.8 percent of the watershed in rural residential, and 94.8 in commercial forest. The remaining percentage is in rural forest (0.4%), water and tidelands (2%) and roads and right of ways (0.5%).

Precipitation for the Dabob/Thorndyke area averages 39.3 inches per year (Parametrix, Inc. 2000). The flows measured at the USGS staff gage were 6.95 cfs on 7/22/93 and 4.9 cfs on 8/18/93 (Jamestown S'Klallam Tribe 1994).

Nordstrom Creek – WRIA 17.0180

Nordstrom Creek is a small stream flowing primarily through forestlands with rural residential area at the mouth, which is to the south of South Point. It has a stream length of approximately 1.4 miles (Ames and Bucknell 1981). Much of the watershed is owned by Pope Resources and managed by Olympic Resource Management for timber harvest. The watershed has experienced some mass wasting events above Thorndyke Road that have caused heavy siltation and channel changes in the lower reaches.

Shine Creek – WRIA 17.0181

Shine Creek, approximately two miles in length (Ames and Bucknell 1981) with a watershed area of 5.2 square miles (Parametrix 2000), initiates in a forested wetland near the Port Ludlow Golf Course at about 150 feet in elevation and about two miles south of Port Ludlow Village in east Jefferson County. The creek flows southward under Highway 104 about a mile south of its origin, eastward along the highway, and eventually through a large beaver pond to its estuary in Squamish Harbor. There are numerous fish bearing tributaries throughout the watershed (Ted Labbe, personal communication, January 2002). The estuary is a mudflat and marsh at the head of the bay, bisected by a county road connecting South Point to Highway 104 (Jamestown S'Klallam Tribe et al 1994).

Precipitation records indicate an average of 35 inches annually (Ludlow Watershed Management Committee 1991). Only sporadic flow measurements are available: 1.23 cfs on July 22,1993 and 0.64 cfs on August 18, 1993, measured at a USGS staff gage (Jamestown S'Klallam Tribe 1994).

Much of the watershed is owned by Pope Resources and managed by Olympic Resources for timber harvest, recreation and rural development. Jefferson County zoning regulations stipulate 40 percent of the watershed to be in rural residential, 5 percent in open space and rural forest and 49 percent in commercial forest. The remaining percentage is in water and tidelands (1.5%), master planned resort/recreation area (0.8%), and roads and right of ways (3.3%).

Bones – WRIA 17.181A

Bones Creek is a small stream flowing from north to south through forested/residential area and into its modified estuary in Squamish Harbor. The lower reach, below Shine Road, has been constricted with riprap. An erosion problem persists on the south embankment of Highway 104.

Ludlow Creek – WRIA 17.0192

Ludlow watershed, approximately 17.32 square miles in area, is located on the northeast portion of the Olympic Peninsula in east Jefferson County. The watershed is bordered by the Chimacum watershed to the north and west and the Shine watershed to the south. The mainstem, approximately 4.5 miles in length with an additional 8.25 miles in tributaries (Ames and Bucknell 1981), empties into a mudflat estuary at the narrow head of Ludlow Bay. The estuary is confined at this point by Paradise Bay Road. The watershed contains numerous small lakes, such as Ludlow, Horseshoe, and Teal, and many unnamed tributaries and wetlands. A falls/cascade at river mile 0.5 is impassable to anadromous migration during most flows. Resident cutthroat utilize habitat above the falls.

The Ludlow watershed is considered to be within the Olympic rainshadow with an annual precipitation ranging from about 35 inches in the southern part of the watershed to about 24 inches in the northern part.

County zoning stipulates 38.4 percent in residential, 50.6 percent forestry, one percent agriculture, 0.3 percent commercial, 1.8 percent resort complex, and 2.3 percent open space. Port Ludlow is a Master Planned Resort with a maximum of 2,250 dwellings currently platted. Four hundred fifty new residences are scheduled for construction within the next five to ten years, which will maximize the plan (Bert Loomis, personal communication, January 2002).

Piddling Creek – WRIA 17.0200

Piddling Creek, approximately 1.5 miles long with an additional mile in tributaries, flows into Mats Mats Bay just south of Bayshore Road (Ames and Bucknell 1981). The main land use in this watershed is rural residential and forestry. A culvert under Oak Bay Road at approximately river mile 0.2 is suspended over two feet above the creek at its outlet and is a barrier to fish migration.

Little Goose Creek – WRIA 17.0200A

Little Goose Creek flows into the northwest end of Oak Bay. The main land use in this watershed is residential and forestry. Little Goose originally drained into the estuary at Oak Bay but was separated from the estuary outlet by the county road. It now enters the bay directly onto the beach. This new outlet is closed by sand at low tide.

Chimacum Creek – WRIA 17.0203

Chimacum Creek originates in a number of spring fed tributaries and lakes in the forested hills of east Jefferson County on the northeast side of the Olympic Peninsula. The mouth of the stream enters Admiralty Inlet approximately five miles south of the City of Port Townsend. The mainstem divides into two forks at approximately river mile 2.9. The east fork continues southeast for 6.5 miles through Beaver Valley and the west fork continues southwest and then west at Eaglemount Road for 11.3 miles through Center Valley (Ames and Bucknell 1981). The Chimacum watershed is approximately 33 square miles in area, with a combined stream length of about 30 miles (Ames et al 2000).

Chimacum Creek flows into two glacially carved lowland valleys dominated by pastureland with peat and muck soils. The surrounding hills are used for rural residences and logging of second and third growth timber and the lowland valleys are dominated by agricultural use, primarily pastureland. Near the confluence of the east and west forks of Chimacum Creek at RM 2.9, are the towns of Chimacum, Port Hadlock, and Irondale with rapidly growing residential and commercial development. The mainstem enters a moderately confined and forested ravine below RM 1.3. At RM 0.2, the stream continues through a comparatively unimpacted estuarine lagoon, salt marsh and relatively deep inlet of Port Townsend Bay to the open saltwater of Admiralty Inlet. The creek empties into a short, partially forested tidal floodplain but has no distinct tidal delta (Ames et al 2000).

In the rain shadow of the Olympic Mountains, the watershed generally receives from 35 inches of rain in its headwaters to less than 22 inches at the mouth (Ames et al 2000). Jefferson County Conservation District measured high flows ranging from 210 to 250 cfs in January and February of 1998 and 1999; in 2000 the highest flow was 125 cfs measured in January. Low flows for the three years occurred in July and August. The lowest flows recorded for 1999 and 2000 were 4.22 cfs and 0.32 cfs respectively (Gately, G. 2001)

Land use in the upper Chimacum watershed is forestry, both public and private, while the middle section is characterized by agriculture, rural residences, commercial enterprise, industry and parks. Commercial zoned lands comprise 41.7 percent of the watershed while 39.9 percent is zoned rural residential, 14 percent agriculture, 3.6 percent parks and 0.7 percent commercial (Jeff Miller, unpublished data, 2002).

While much of the habitat in the lower mile is public ownership or protected by conservation easements through the Jefferson Land Trust, habitat in the upper Chimacum watershed has decreased dramatically both in quantity and quality over the past 145 years. Removal of beaver ponds, wetlands and channel meanders by extensive ditching to create farmland has eliminated over 90% of the coho juvenile rearing habitat from the watershed. Since European settlement in the 1850s, an estimated 6% of summer rearing habitat, 3% of winter rearing habitat and 88% of spawning habitat remains. Of this remaining habitat, most has been further degraded in terms of low oxygen and elevated stream temperatures associated with lack of forested riparian zones, heavy siltation of spawning and rearing areas and loss of channel complexity and structure, particularly the loss of large woody debris (Bahls and Rubin 1996). Approximately 1.5 to 1.75 miles of stream have been rehabilitated since 1998.

Snow Creek – WRIA 17.0219

The headwaters of Snow Creek originate at approximately 3,600-feet elevation on the northeast and east slopes of Mount Zion draining a watershed area of approximately 22 square miles. The stream flows east through a confined valley and then turns north into a wide valley before entering Discovery Bay. The mainstem is about 10 miles long and its tributaries contribute an additional 19.2 miles (Ames and Bucknell 1981).

Trappers Creek and Andrews Creek, including Crocker Lake, are the major tributaries. Andrews Creek initiates in the upper forested area above Snow Creek Road, flows through Crocker Lake and enters Snow Creek at river mile 3.5. Prior to development in the area, Andrews Creek apparently flowed south into Leland Lake; thus it’s 7.5 square mile subwatershed, about 1/3 of the Snow Creek watershed, was a tributary to the Little Quilcene River, and Crocker Lake had no natural outlet (Jamestown S'Klallam Tribe 1994).

Prior to development in the area, which resulted in the present channelized outlet at the east side of the valley, Snow Creek emptied into Salmon Creek near its estuary. During certain flood events, Snow Creek overflows into its original channel in the pasture, reestablishing some direct contact with Salmon Creek. Snow Creek still joins Salmon Creek in the intertidal area during low tides.

Over 90% of the watershed is forestland with coniferous forest in various stages of development. The most common species are Douglas-fir, western hemlock and some western red cedar, with various amounts of red alder inclusions. Most of the public forest is now in 50+ year age stands, but still in mid seral stages (SCSCWAT 1996).

The Snow Creek watershed lies predominately in the rainshadow of the Olympic Range, which moderates the amount of rainfall, resulting in average annual precipitation of 35.5 inches (Parametrix 2000). Average flows in 1988 taken monthly between August and October were 3.6 cfs. Average flows in 1998 taken monthly between August and October were 4.0 cfs (Gately 2001).

The Snow Creek Watershed contains a diverse array of land uses but is dominated by forest cover. Land use includes both public and private forest, hay and pasture lands and residential areas. Much of the commercial forestland is in public ownership and private industrial forestland. Ninety percent of the watershed is zoned forestry while one percent is in agriculture and 8% residential. The largest area of agricultural lands occurs in the lower Snow Creek Valley, through which both Snow and Salmon creeks flow. There is a small amount of commercial development along Highway 101 at the mouth.

Salmon Creek Watershed – WRIA 17.0245

Salmon Creek originates on the northern slopes of Mount Zion at an elevation of 3,400 feet, has a watershed area of 23.6 square miles, and flows 9 miles into Discovery Bay, which is located in the eastern portion of the Strait of Juan de Fuca (Ames et al 2000). There are approximately 15 additional river miles in tributaries that drain the watershed (Ames and Bucknell 1981). The lower mile of Salmon Creek flows through pastureland in a relatively flat valley. Gradient then becomes steeper up to the headwaters. The lower watershed is in Jefferson County while the upper watershed is in Clallam County.

The Salmon Creek watershed is underlain primarily by the Crescent basalt formation consisting of basalt flows and mudflow breccias. The basalts are generally harder and more erosion-resistant than the sedimentary rocks in this area. A fault, running approximately east-west, terminates the basalt exposure on the watershed's southern boundary (Tabor and Cady 1978 cited in SCSCWAT 1996). The lower watershed is characterized by sand, gravel and clay deposited during glaciation. Material transported from the upper watershed forms a broad alluvial fan (Bernthal et al 1999 in Parametrix 2000).

Salmon Creek watershed lies predominately in the rainshadow of the Olympic Range, which moderates the amount of rainfall, resulting in average annual precipitation of 35.5 inches (Parametrix 2000). Based on limited miscellaneous flow measurements, annual stream flow in Salmon Creek averages 8.4 cfs, with summer flows often measuring less than 2 cfs. Average flows in 1988 taken monthly between August and November were 5.7 cfs. Average flows in 2000 taken monthly between July and December were 2.32 cfs (Gately 2001).

Over 90% of the watershed is forestland with coniferous forest in various stages of development. The most common species are Douglas-fir, western hemlock and some western red cedar, with various amounts of red alder inclusions. Most of the public forest is now in 50+ year age stands, but still in mid seral stages (SCSCWAT 1996).

The Salmon Creek Watershed contains a diverse array of land uses but is dominated by forest cover. Land use includes both public and private forest, hay and pasture lands and residential areas. Much of the commercial forestland is in public ownership and private industrial forest. Ninety four percent of the watershed is zoned for forestry while 1 percent is in agriculture and 4 percent residential. The largest acreages of agricultural lands occur in the lower Snow Creek Valley, through which both Salmon and Snow Creeks flow. There is a small amount (3.0%) zoned commercial along Highway 101 near the mouth (Jeff Miller, unpublished data, 2002).

There has been heavy harvest in the private timberlands within the past 10 to 15 years, and many of those acres are in the early seral stages (SCSCWAT 1996). Overall timber harvest rate in the Salmon/Snow watershed has been 19 to 23 percent – higher than the generally accepted rate of 16 percent (Lichatowich 1993 cited in Parametrix, Inc. 2000). Road density of 3.7 miles per square mile in the Salmon Creek basin exceeds the threshold of 2.5 miles per square mile, which is recommended to maintain salmon habitat (Hall et al. 1992 cited in Parametrix, Inc. 2000). In addition, agricultural impacts from livestock grazing have degraded stream banks and water quality.

Houck Creek, a right bank tributary of Salmon Creek enters the mainstem at about river mile 1.0. Houck Creek was rerouted from its natural course in the 1960s and the new channel has cut back into the hillside, creating a 20-30 foot waterfall prior to entering Salmon Creek. The sediment eroded by the waterfall has been relocated downstream, contributing to aggradation/flooding cycles.

Salmon Creek joins with Snow Creek to form a common delta, although both have distinct distributary channels through the mudflats to the outer delta. The upper and mid-delta of both systems is heavily impacted by transportation, commercial and some residential development associated with the Highway 101 corridor that passes around the southern end of Discovery Bay. A railroad grade also parallels the highway in transecting the delta (Ames et al 2000).

Contractors Creek – WRIA 17.0270

Contractors Creek originates from springs and wetlands on the northeast slopes of Blyn Mountain and enters Discovery Bay on the west shore near Carr Point. The mainstem is approximately 3 miles in length with 5.9 miles in tributaries.

Much of the upper watershed has been logged. Where sections of the stream are designated type 3 or lower, most of the trees are left in the riparian management zones; however, most of the type 4 and 5 streams have had all the trees removed. The lower watershed has been severely impacted by flooding and subsequent failure of the streambanks between Highway 101 and Old Gardiner Road. Scot's broom is invading the existing denuded slopes and watercress is filling in the existing channel (Glen Gately, personal communication, January 7, 2002).

The streambed from Highway 101 downstream to the mouth is extremely unstable. Contractors Creek's channel was drastically changed both horizontally and vertically when, between December 26, 1996 and January 1, 1997, a rain-on-snow event washed out Old Gardiner Road at river mile 0.3. The culvert at Old Gardiner Road, which was 70 feet below the road surface, became obstructed and water backed up forming a 70 foot deep "lake", which extended upstream to Highway 101 at river mile 0.4 and beyond. As work crews tried to relieve the pressure on the remaining roadbed by opening up a channel, the entire lake flushed out, taking with it an enormous amount of material from the roadbed and from the valley walls. A waterfall about 10 feet tall is now present just downstream of the newly constructed bridge on Old Gardiner Road. In some places the channel may have moved to the side as much as 300 feet and aggraded as much as 200 feet. The aggraded channel has caused sediment to accumulate in the Highway 101 culvert, which could create another massive failure if not corrected.

An extended culvert at the mouth, where Contractors Creek meets Discovery Bay, could provide passage problems for chum, although coho have been observed above the culvert.

Eagle Creek – WRIA 17.0272

Eagle Creek flows into the northwest part of Discovery Bay between Diamond Point and Gardiner Bay. Land use is primarily commercial forestland with a small portion in agriculture/cattle grazing. Historically, Eagle Creek may have produced chum, coho, steelhead and searun cutthroat (PSCRBT 1992). A water diversion that feeds two ponds in the upper watershed has created a water flow problem that dewaters a portion of the stream about ½ mile below the pond. The stream immediately downstream of the ponds runs through a 500-foot long culvert under a pasture and then through a series of ditches. Below the ditches, the habitat becomes more natural yet degraded. The mouth is a spit-built estuary that is closed during part of the year (Hilton Turnbull, personal communication, 2002).

Chicken Coop Creek – WRIA 17.0278

Chicken Coop Creek enters the southeast corner of Sequim Bay to the northeast of Jimmycomelately Creek. The mainstem is 3.1 miles in length with an additional 3.1 miles in tributaries (Ames and Bucknell 1981). The mouth of Chicken Coop Creek shares a high intertidal zone with an adjacent unnamed system just a few meters to the west. (Hilton Turnbull, personal communication, 2002).

Jimmycomelately Creek- WRIA 17.0285

Jimmycomelately Creek is the largest tributary to Sequim Bay, initiating at an elevation of about 3,800 feet in the Olympic National Forest. It encompasses a watershed area of 19 square miles and has a total stream length of approximately 20 miles (Ames et all 2000). The mainstem, approximately 9 miles in length, runs from west to east with two major right bank tributaries entering the mainstem at about river mile 3.5 and river mile 2.5, where it turns north toward Sequim Bay. The lower watershed is low gradient with good spawning gravels. The gradient increases above the falls at river mile 1.9, then flattens out in the upper watershed into meadows and high elevation farmland of Palo Alto Valley.

Due to the extended foothills in the Olympic rainshadow, Jimmycomelately Creek is subjected to wide variations in flow. The average monthly flow is estimated at 9.7 cfs (McHenry et al 1996) with a record low summer flow recorded at 1 cfs. Typical summer flows stay around 2 cfs but winter/spring flows are in the 20-30 cfs range. Record highs have been recorded in June of 1988 at 42 cfs and June of 1990 at 49 cfs (Jamestown S'Klallam Tribe 1994).

Coniferous forest (Douglas fir and western hemlock) surrounds the upper meadows and dominates the downstream section, which is primarily managed for forestry resources. Logging activities and road failures have contributed sediments to the stream but timber harvest has occurred at a lower rate than adjacent watersheds (McHenry et al 1996). Below river mile 1.0, the rural settlement of Blyn consists mostly of single-family dwellings and hobby farms.

Early in the 1900s, the lower mile was moved and confined by dredge spoils, isolating the creek from its sub-estuary. Severe aggradation in the lower half mile has prompted landowners to build flood control structures, such as dikes, retaining walls and anchored logs, that concentrate flow and increase scour potential. Non-native vegetation has colonized the dikes, further constricting the channel. Cycles of aggradation, flooding and dredging have resulted. In 1997, the mouth of the stream was perched well above the estuary, creating a barrier to upstream migration (Ames et al 2000). The estuary and nearshore environment have recently been purchased by Washington State Department of Fish and Wildlife and the Jamestown S'Klallam Tribe as part of a restoration plan of the lower riverine and estuarine environment.

Dean Creek – WRIA 17.0293

Dean Creek drains the east side of Burnt Hill and the northwest side of Lookout Hill, flowing behind the Jamestown S'Klallam Tribal Casino into the southwest corner of Sequim Bay in Clallam County. The headwaters of Dean Creek begin at an elevation of 690 feet, approximately four miles from its mouth.

Johnson Creek – WRIA 17.0301

Johnson Creek flows in a northeast direction beginning in the foothills of the Olympic Mountains into the west side of Sequim Bay at Pitship Point near the John Wayne Marina in Clallam County. Approximately five river miles are attributed to the mainstem of Johnson Creek while two miles consist of tributaries, totaling seven miles of stream length. The east branch initiates near the top of Burnt Hill at an elevation of approximately 660 feet while the west branch drains an unnamed pond/lake at an elevation of about 240 feet (WRIA 17 Technical Assessment). Initially the creek flows through a substantial ravine while the lower two miles are low gradient rising 200 feet in two miles. Average flows range between 2.0 to 6.0 cubic feet per second.

The Highland Canal, part of the Sequim/Dungeness irrigation system which diverts water from the Dungeness River, spills tailwater into Johnson Creek which is then used for irrigation downstream of the spill (Parametrix 2000).

Nearshore

The Strait of Juan de Fuca is a wind-dominated system, with currents changing dramatically in response to both regional and larger scale oceanic winds (Strickland 1983 cited in Shaffer 2001). Due to deep oceanic water and strong wind and current mixing action, as well as seasonal strong contribution of riverine nutrients, the water of the Straits at large is well mixed, cold and nutrient-rich throughout the year (Mackas and Harrison 1997 cited in Shaffer 2001). The sill at Admiralty Inlet obstructs the continuous flow of deep water and diverts surface water back to the Sound, therefore producing one of the dominant areas of mixing in the entire Puget Sound (Nightingale 2000). These well-mixed waters of Port Townsend Bay contain higher dissolved oxygen levels than smaller inlets and bays that do not receive the mixing forces of Admiralty Inlet (Strickland 1983 in Nightingale 2000). In contrast, Discovery Bay lacks the mixing forces and flushing action and is stratified with colder, saltier and denser water near the bottom, resulting in lower nutrient levels at the surface and low oxygen near the bottom (Strickland 1993). A railroad grade along Discovery Bay results in the loss of estuary connections.

Shallow nearshore marine habitats provide important migration corridors for juvenile fish. Nearshore vegetated habitats are found along approximately 60% of the entire Strait shoreline and include kelp beds, eelgrass beds, drift algae, and rocky/cobble shorelines with Laminarian cover (Shaffer 2001).

Hood Canal, considered to be one of two fjords in the continental United States, is shallower than the Straits and seasonally stratified with limited flushing action. Nearshore vegetated habitats include bull kelp, eelgrass, drift algae and rock/cobble shorelines with *Fucus* sp. (Shaffer 2001). All these habitats are considered critical habitats for listed salmon stocks and have important functions in an ecosystem context (Shaffer 2001).

All salmonid species are known to use estuarine and nearshore environments at sometime during their life cycle. In addition, critical food fish for salmonids, such as surf smelt (*Hypomesus pretiosus*), sand lance (*Ammodytes hexapterus*) and herring (*Clupea harangus*) depend on quiet embayments, sandy, undisturbed, shaded beaches, and eelgrass beds for spawning (Penttila 1994 cited in Shaffer 2001).

Ecosystem links between upland and nearshore habitats are extremely important. While the area may appear rural and remote, habitat loss has been identified as the most serious threat to marine ecosystems of Puget Sound and the northeast Straits. A number of human activities along the Straits and Hood Canal, in a cumulative context, have significant ecosystem effects on their respective nearshore environments (Shaffer 2001). Dredging and diking the lower river systems, armoring of shorelines, non-point pollution, fill of intertidal areas, over and in water structures, roads and associated fill, and invasion of exotic vegetation are some of the impacting land alterations along the estuarine and nearshore environments associated with development pressures in WRIA 17.

DISTRIBUTION AND CONDITION OF STOCKS

Each species of salmon has a unique life history pattern, which allows each to partition the habitat in rivers where the species coexist. In addition to this diversity of life histories between species, there is a rich diversity of life histories within a species or stock, a strategy that contributes to sustainability through changing environmental conditions (Lichatowich 1993a).

Chinook *(Oncorhynchus tshawytscha)*

Chinook salmon spawning grounds begin just above tidal influence and can extend up to 1,200 miles upriver, as in Alaska. They prefer deeper water and larger gravels for spawning than the other salmonids. There appear to be two general patterns: the stream type and the ocean type. The stream type remains in freshwater for an entire year prior to migrating to the salt water the following spring. The ocean type tends to remain in freshwater for a shorter duration, heading to the sea within a few months of emergence from the redd. Smolts of both varieties spend some time close to shore prior to moving to the open ocean (Lichatowich 1993a). They tend to mature at four or five years, but that can vary from two to nine years. There are typically three run timings when adults return to the freshwater to spawn: spring, summer and fall. The fry emerge from the gravels the following spring. Chinook prefer water temperatures of 12-14 degrees C (Lichatowich 1993a).

Chinook salmon in Hood Canal are managed as a single stock of mixed origin with composite production (WDFW and WWTribes 1994). They are the summer/fall variety and typically spawn mid-September to late October. They are listed with Puget Sound chinook as threatened under the Endangered Species Act.

Chinook salmon, also known as king salmon, are not found in WRIA 17 in abundant numbers as spawners and, when found, are either the result of hatchery production or straying. The US Fish and Wildlife Service hatchery on the Big Quilcene River has been in existence since 1911. In 1980, they began a spring chinook program that continued until 1994. That run has not sustained itself over time, as recent spawner surveys indicate no adult returns to the river. Old records maintained by hatchery personnel document sporadic numbers of naturally spawning chinook, probably fall chinook due to the low summer flows, but again, those have not sustained a natural population (Larry Telles, personal communication, March 2002).

A small local volunteer chinook rearing project on Tarboo Creek released 100,000 fry/smolts (100/lb) from George Adams stock at river mile 2.5 in 1994, 1995 and 1996. Small numbers of returning adults and/or their associated redds have been observed in the lower river since 1997. Time will tell if the run is sustainable.

Estuarine and nearshore habitats are critical habitats for juvenile chinook as migration corridors and feeding and refuge. Chinook juveniles have recently been documented in

Camp Discovery Creek and Shine Creek estuaries. (Ron Hirschi and Tom Doty, unpublished data, 2002).

Chum (*Oncorhynchus keta*)

Chum salmon, also known as dog salmon and/or calico salmon, utilize the low gradient (0-8%) reaches of the stream for spawning, and typically spend less than 30 days in the freshwater after emergence. They remain in the estuary and nearshore environments, feeding primarily on copepods, tunicates and euphausiids, prior to migrating out to the ocean (Lichatowich, 1993a). Chum return to freshwater in three to five years to spawn and tend to be group spawners with each female accompanied by one or more males. The abundance of chum salmon in Puget Sound tends to fluctuate naturally during even/odd cycles, suggesting a possible competitive interaction with pink salmon in estuary or nearshore habitats (Salo 1991 in McHenry and Lichatowich 1996). Their carcasses provide high nutrient values for juvenile salmonids and numerous wildlife species. There are three distinct run times: summer, fall and winter. Summer and fall stocks are both found in WRIA 17.

Summer Chum

Summer chum, federally listed as threatened under the Endangered Species Act, are found in several WRIA 17 watersheds. They begin their upstream migration between mid to late August through mid-October with fry emergence toward the end of March through the end of April, depending on water temperatures. They are of native stock origin and managed for wild production (WDFW and WWTribes 1994; Ames et al 2000).

Figure 1. Summer Chum Spawning in Chimacum Creek. Photo provided by Al Latham, JCCD

While low summer flows and habitat degradation in some of the systems have contributed to the decline of summer chum, an additional factor in the decline could also result from the marginalization of the stock through designation as a secondary management unit in the Hood Canal Salmon Management Plan (Lichatowich 1993a). The early chum populations in all streams entering Hood Canal were combined into one stock, with the exception of Union River (Lichatowich 1993a). Examination of the standard of substantial reproductive isolation, indicated by distributional and genetic differences, nine distinct summer chum stocks have been identified: three in the Strait of Juan de Fuca streams and six in Hood Canal

Streams. An additional seven streams in Hood Canal have been identified as once having summer chum that have been extirpated (Ames et al 2000).

Quilcene Bay Summer Chum

Summer chum populations in Quilcene Bay are managed as a single native stock of composite production. In 1992 this stock was a component of the Hood Canal summer chum stock and did not receive a separate status rating (WDFW and WWTribes 1994). Large escapements of Big/Little Quilcene summer chum have occurred since 1995, but these returns have been a direct result of a hatchery supplementation program designed to rebuild this stock. Since escapements had been chronically low, and the current level of natural production is not known, and because habitat conditions are poor and may constrain natural production in both rivers, the status of the stock is judged to be depressed (Ames et al 2000; Thom Johnson, unpublished data 2002).

Summer chum populations have been monitored since 1968 in the Big Quilcene River with escapement calculated using the curve model or area under the curve model, with some years relying on live+dead counts. The population began declining in 1979 and reached a low of one fish in 1989.

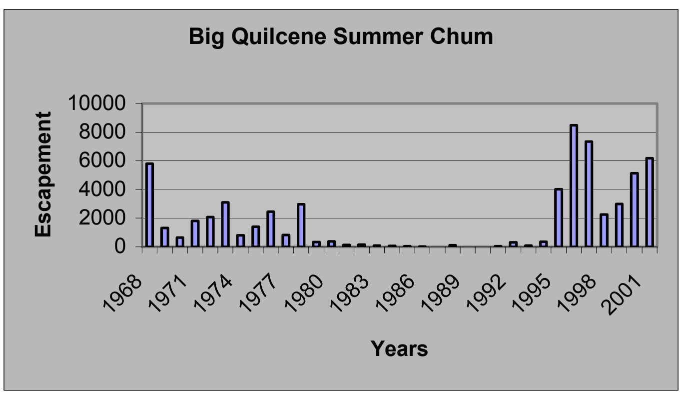

Figure 2. Big Quilcene Summer Chum Escapement, 1968 to 2001. Data provided by Thom Johnson, WDFW

In 1992, the Quilcene National Fish Hatchery, operated by the US Fish and Wildlife Service, began a stock recovery that has increased the run dramatically, beginning with 1995 returns. The annual releases from the hatchery to the Big Quilcene River have varied over the first eight years of the program. See Table 1.

Table 1. Quilcene National Fish Hatchery Summer Chum Releases. Data provided by Larry Telles, USFWS

Year	1993	1994	1995	1996	1997	1998	1999	2000
Number	216,441	24,784	344,000	441,167	612,598	340,744	343,530	181,711

Little Quilcene Summer Chum

The Little Quilcene River has also experienced a decline in summer chum populations. Adult returns were particularly low between 1989 and 1994. No fish returned in 1990 and 1994. A possible contributor to the decline is over harvest in mixed species fisheries (Lichatowich 1993a; Ames et al 2000). Strays from the hatchery stock-rebuilding program in the Big Quilcene River are finding their way into the Little Quilcene River, which is acceptable since they are considered the same stock. In addition, otolith recovery analysis indicates straying from the Salmon Creek stock.

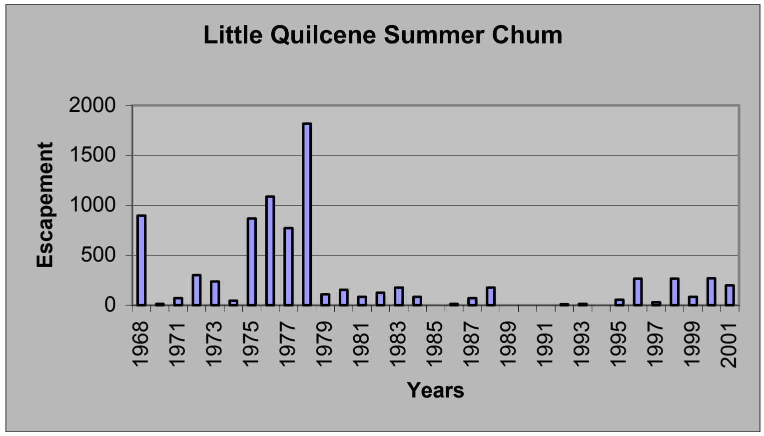

Figure 3. Little Quilcene Summer Chum Escapement, 1968 to 2001. Data provided by Thom Johnson, WDFW

Chimacum Creek Summer Chum

Chimacum Creek summer chum probably collapsed sometime in the mid 1980s. To compound the situation, a catastrophic culvert failure occurred in 1985-1986 and deposited a large amount of fill into the lower watershed. In the years following the event, gravels in the lower mile were cemented together with fine sediments, eliminating spawning gravels for redd construction and securing the extirpation of the stock.

A local salmon restoration organization, Wild Olympic Salmon, with financial help from the North Olympic Salmon Coalition and technical help from the Washington Department of Fish and Wildlife, began a stock restoration program to reestablish a summer chum run in Chimacum Creek. To accomplish this task, they first began to rebuild the summer chum run in Salmon Creek to use as a donor stock. Volunteer incubation and rearing facilities were built on both Salmon Creek and Chimacum Creek and, in brood year 1996, eggs were transferred from Salmon Creek to a small facility at Chimacum High

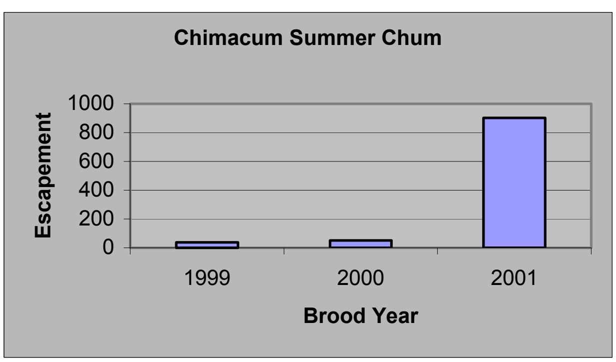

Figure 4. Chimacum Creek Summer Chum Escapement, 1999 to 2001. Data provided by Randy Cooper, WDFW

School. In the early spring of 1997, 28,788 fry were released into the lower watershed and estuary. The small facility has been moved to the upper watershed where eggs are incubated and fry are reared to one-gram size. A net pen at Kala Point provides additional rearing capacity and in the spring of 2001, a total of 73,300 fish were released. At the same time the stock recovery program has been in operation, efforts to protect and improve the spawning habitat in the lower watershed have also been underway.

The first returning adult summer chum were observed in 1999 when a total of 38 fish returned. In 2000, 52 adults returned and, in 2001, 903 adults returned. It is likely that the majority of the returning adults are from the Chimacum Creek project with some straying from Salmon Creek. Otolith analysis will help determine adult origin beginning in brood year 2002. Until otolith examination determines adult origin, it cannot be assumed that a naturally producing population is established in the stream (Thom Johnson, personal communication 2002). Rather, they are considered a range extension of the Discovery Bay summer chum stock. Consequently, Chimacum Creek summer chum status is still considered Extinct (Ames et al 2000; Thom Johnson, SaSI contribution in review 2002).

Discovery Bay Summer Chum

Because of the close proximity of Salmon and Snow Creek (Snow Creek flowed into Salmon Creek until the early 1900s) and the absence of an indicated difference from the genetic sampling results, the Snow Creek and Salmon Creek populations are a single native stock with composite production (Ames et al 2000). They enter freshwater and spawn from the beginning of September to mid-October (WDFW and WWTribes 1994). Snow/Salmon Creek summer chum have experienced increased escapements since 1995, in part because of a successful cooperative hatchery supplementation program. This improvement has moved the stock out of Critical status, but the stock is rated Depressed in 2002 because of continuing chronically low escapements (Thom Johnson, SaSI contribution in review, 2002)

Escapement data for Snow Creek indicates, in general, a population decline for the past twenty years (McHenry and Lichatowich 1996) that has been in serious condition since 1989 (Ames et al 2000). See Figure 5. Interception of Snow Creek summer chum salmon in other fisheries appears to be less significant than in Hood Canal. There are no net fisheries in Discovery Bay or terminal fisheries in Snow Creek. Some fish may be intercepted in the sockeye fishery in the Straits of Juan de Fuca and in

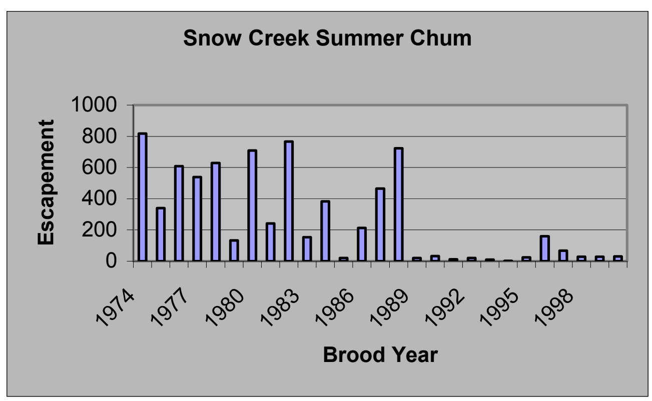

Figure 5. Snow Creek Summer Chum Escapement, 1974 to 2001. Data provided by Thom Johnson, WDFW

Canada (McHenry and Lichatowich 1996). Attempts to remedy habitat degradation have been successful between State Route 20 and the Washington Department of Fish and Wildlife Snow Creek Research Station at approximately river mile 0.4. Strays from the Salmon Creek stock restoration program are found in Snow Creek, which is acceptable since they are considered a single stock

Salmon Creek summer chum have been in critical condition since 1989 (see Figure 6), although Discovery Bay summer chum are not targeted in any fishery. In addition, there have been no non-native stock introductions in the watershed (McHenry and Lichatowich 1996). Stock restoration efforts, initiated and implemented by a local volunteer salmon restoration group, Wild Olympic Salmon, began in 1992 using local broodstock and have successfully increased the number of adult spawners returning to Salmon Creek. In brood year 2001, over 2500 adults returned to spawn. Otolith recovery records indicate the local facility contributes significantly to escapement.

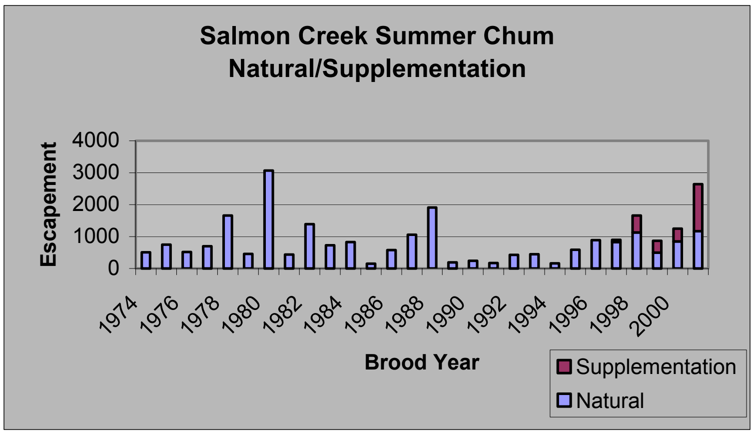

Figure 6. Salmon Creek Summer Chum Escapement, 1974 to 2001. Data provided by Thom Johnson, WDFW

Washington Department of Fish and Wildlife and the Jefferson Land Trust have received funding to purchase and protect much of the lower river and estuarine habitats of Salmon and Snow Creeks. The Jefferson County Conservation District has received funding from the Salmon Recovery Funding Board, North Olympic Salmon Coalition and Jefferson County to conduct substantial habitat restoration in the lower 0.5 miles of Salmon Creek. The creek, which had been channelized for agricultural use, will be returned to its historic channel with meanders and structure (large woody debris) to provide bed stability. This should provide the habitat improvements necessary to ensure sustainable stock recovery.

Jimmycomelately Summer Chum

Jimmycomelately Creek, a tributary to Sequim Bay in Clallam County, had experienced sporadic but steady summer chum returns until its serious decline in the 1990s. Good escapement data is available since 1982 and illustrates this downward trend (see figure 7). Summer chum utilize the lower two miles of spawning gravels. Status under the Salmon and Steelhead Stock Inventory (SASSI) was rated Critical (WDFW and WWTribes 1994). Status remains Critical in 2002 because of short-term severe decline in escapements in 1999 and 2000 and because of their continuing chronically low escapements (Thom Johnson, SaSI contribution in review 2002). Summer chum in this system is a native stock with wild production. Allozyme analysis has shown that Jimmycomelately Creek summer chum are genetically distinct from all other Washington chum stocks examined (Thom Johnson, SaSI contribution in review 2002).

Estuarine and riverine modifications have created unstable spawning substrate in the lower ½ mile, which may have contributed to stock decline. Stock restoration efforts by WDFW, Wild Olympic Salmon, and local volunteers, with funding from North Olympic Salmon Coalition, began in 1999 and will continue for a maximum of three brood cycles, or 12 years, during which time habitat restoration will have taken place. Jamestown S'Klallam Tribe and Washington Department of Fish and Wildlife have purchased much of the estuary, lower river and nearshore habitats to ensure that proper habitat restoration will provide habitat to sustain a healthy population of summer chum.

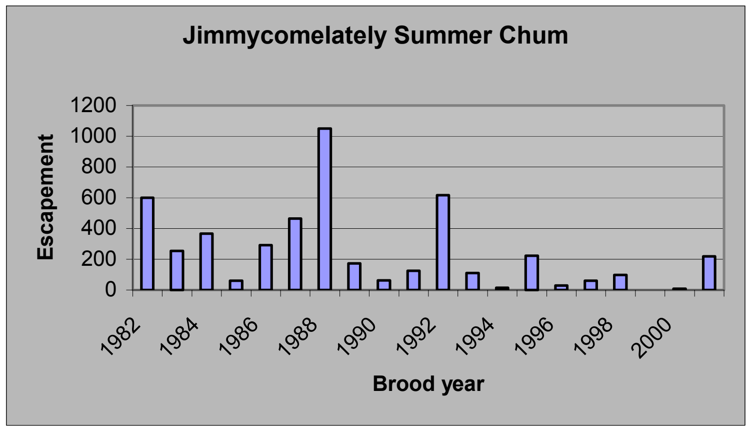

Figure 7. Jimmycomelately Summer Chum Escapement, 1982 to 2001. Data provided by Thom Johnson, WDFW

Fall Chum

Fall chum fisheries are managed to harvest hatchery stock throughout Hood Canal. Ten separate stocks are all listed as healthy in WRIA 17 (WDFW and WWTribes 1994).

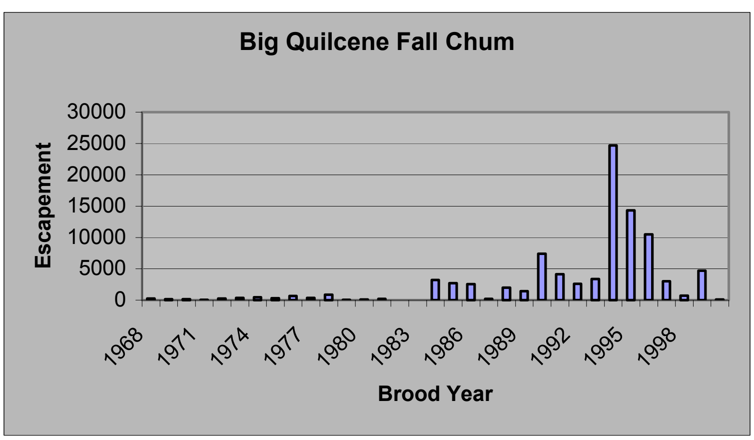

Figure 8. Big Quilcene Fall Chum Escapement, 1968 to 2001. Data provided by Thom Johnson, WDFW.

Quilcene/Dabob Bay

Fall chum in the Big Quilcene River is a mixed stock of composite production supported by releases from the Quilcene National Fish Hatchery located at river mile 2.3 (Lichatowich 1993). They spawn between late October and early January (WDFW and WWTribes 1994). The1992 Salmon and Steelhead Stock Inventory rated the stock healthy (WDFW and WWTribes 1994).

Data are total escapement estimates based on live spawner counts in index areas on the Big Quilcene and Little Quilcene rivers and Spencer and Jackson creeks. The status of the stock is healthy since several thousand fall chum spawn in these streams each year. A low return of 88 fish in brood year 2000 may be cause for concern, however (Thom Johnson, SaSI contribution in review, 2002).

Escapement records for the Big Quilcene River are available since 1968 (see Figure 8), and show an increase in production after implementation of the stock recovery program at the Quilcene National Fish Hatchery with fry releases beginning in 1992 (see Figure 10).

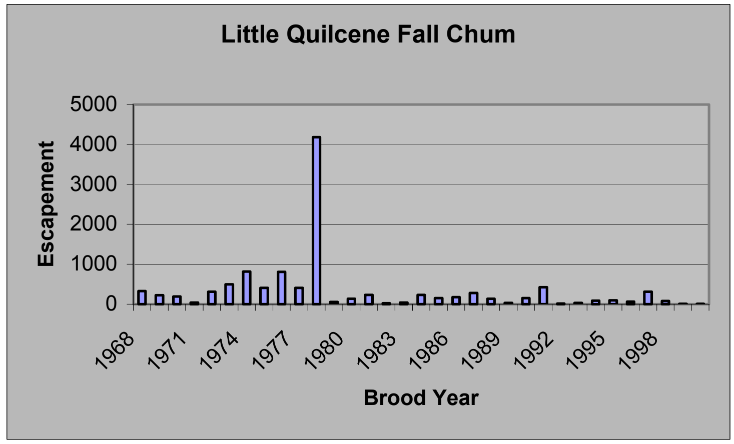

Figure 9. Little Quilcene Fall Chum Escapement 1968 to 2001. Data provided by Thom Johnson, WDFW.

The Little Quilcene fall chum have been monitored since 1968 (see Figure 9) and has been steadily low with the exception of a sudden peak of over 4,000 fish in 1978. In 1999, only seven adults were counted. The Quilcene National Fish Hatchery at river mile 2.3 has released fall chum into the Big Quilcene River since 1992, which probably influenced the increase in returning adults to that system.

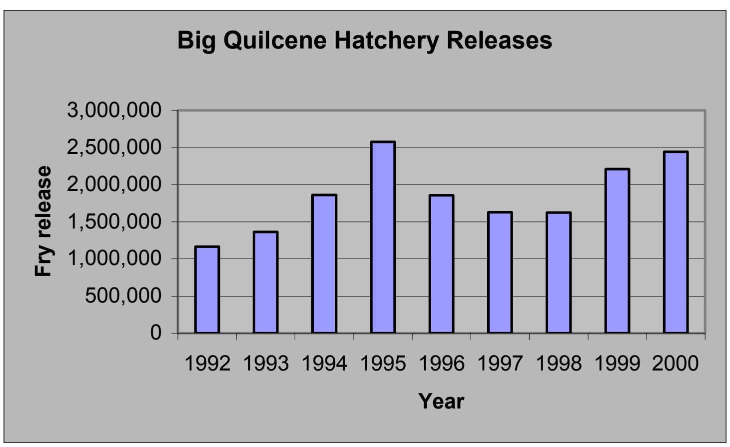

Figure 10. Big Quilcene Fall Chum Hatchery Releases, 1992 to 2000. Data provided by Larry Telles, USFWS

Discovery Bay

Spawning ground records suggest the former existence of a fall chum run in Snow Creek but Washington Department of Fish and Wildlife personnel at the Snow Creek Research Station report that no fall chum have been captured at their weir since 1974 (Thom Johnson, personal communication 2002). Williams et al. (1975) reported Snow Creek fall chum as depressed and were probably extirpated in the early 1970s before the Snow Creek research program was initiated (McHenry and Lichatowich 1996).

Other Tributaries

Port Gamble S'Klallam tribal biologists and Wild Olympic Salmon volunteers monitor Tarboo, Thorndyke and Shine Creeks. Fall chum have been observed in Tarboo and Thorndyke Creeks. Wild Olympic Salmon operated a fall chum RSI on Thorndyke Creek with 125,000 eggs annually from George Adams Hatchery between 1992 and 1999.

Coho *(Oncorhynchus kisutch)*

Coho spawn from October to January and emerge in early March to late July. Most juvenile coho remain at least one year in freshwater, although recent studies have shown that some strains spend time in estuaries prior to smoltification. Those that remain in freshwater rear in shallow gravel areas near the streambank. They school at first but later disperse and become aggressive and territorial. Coho go through physiological changes (osmoregulation or smoltification), preparing for life in salt water, and migrate to sea in spring (Lichatowich 1993b). Coho salmon in Hood Canal are managed on a wild stock basis.

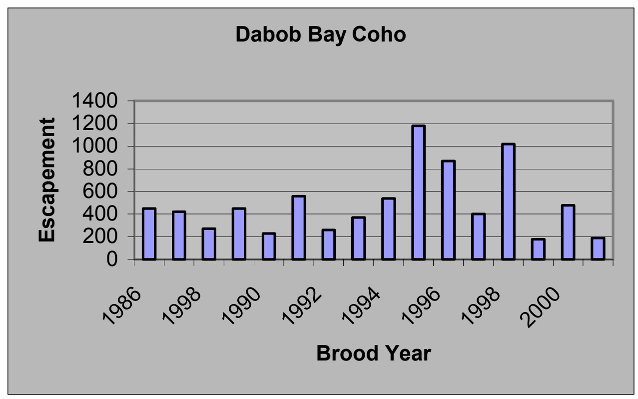

Figure 11. Dabob Bay Coho Escapement 1968 to 2001. Data provided by Thom Johnson, WDFW.

Quilcene/Dabob Bay Coho

The coho populations from streams entering Quilcene and Dabob Bays are combined into a single stock that were rated depressed in SASSI (WDFW and WWTribes 1994) and are still considered depressed in the updated Salmon and Steelhead Inventory (SaSI) (Thom Johnson, contribution to SaSI in review, 2002). See Figure 11. However, the Quilcene National Fish Hatchery on the Big Quilcene River produces enough coho to sustain a very popular instream fishery (see Figure 12).

Rearing habitat for natural production within the Big Quilcene River is very limited as there are few side channels and very little structure for juvenile feeding and cover (Larry Telles, personal communication, 2002). The natural spawning coho in the Big Quilcene River have been strongly influenced by the early spawning hatchery stock (Lichatowich 1993a). The observed coho salmon/mile in the Little Quilcene peaks about six weeks later than the observed coho salmon/mile in the Quilcene River. These data suggest there is little effective straying and the interbreeding between the populations in the two Quilcene Rivers and that coho salmon in the Little Quilcene River have retained at least some of the life history traits of the native stock (Lichatowich 1993a). Lichatowich further suggests that the coho returning to the two Quilcene Rivers should be treated as separate stocks.

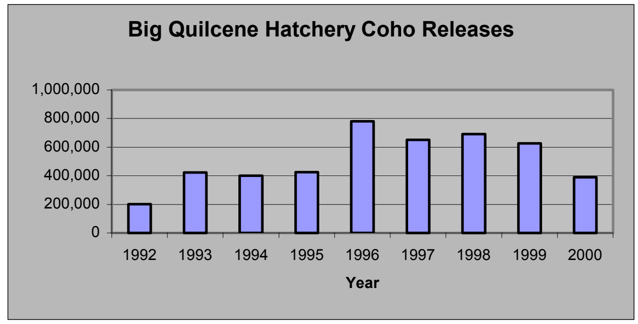

Figure 12. Big Quilcene Hatchery Coho Releases, 1992 to 2000. Data provided by Larry Telles, USFWS.

Chimacum Creek

SASSI lists Chimacum Creek coho as a separate stock of mixed origin and composite production with a status rating of Healthy (WDFW and WWTribes 1994). The index season-cumulative redd count experienced an increasing trend in the mid to late 1990s time period, so the stock has again been healthy. This is a provisional rating, as there are concerns regarding the overall health of the coho population in the basin that the index data may not adequately represent, given the survey index is likely representative of only the better quality coho spawning habitat in the stream basin (Thom Johnson, SaSI contribution in review, 2002). McHenry and Lichatowich (1996) provide a compelling argument that Chimacum coho are not healthy but are actually depressed. Escapement has remained steady throughout the past twenty-five years (see Figure 13). WDFW monitors cumulative redd counts at two index sites, river mile 8.3 to 9.2 and river mile 9.4 to 10.2. Beginning in the year 2000, the lower index area was shortened to river mile 8.9 to 9.2. An additional population statistic available for this stock is stratified random sampling based estimates of total adult coho escapement for the Chimacum Creek for the 1998 to 2000 return years

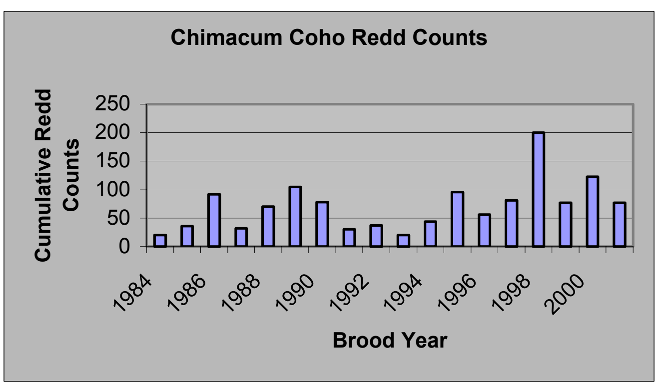

Figure 13. Chimacum Coho Cumulative Redd Counts, 1984 to 2001. Data provided by Randy Cooper, WDFW

(1998 = 550 coho, 1999= 711 and 2000= 1,054). These estimates are based on a selection of survey areas stratified by geographic region and habitat type (Randy Cooper, personal communication, 2002).

Chimacum High School initiated a small hatchery on Chimacum Creek in 1971 and began incubating a rearing coho using Quilcene stock. The project ended in the late 1980s, the last three years of which used Dungeness stock (Ray Lowry, personal communication 2002). Wild Olympic Salmon collected eggs from local broodstock for two years in the early 1990s and observed an extended run time possibly due to the infiltration of the early Quilcene stock and the later run Dungeness stock. McHenry and Lichatowich (1996) speculate that the early returning fish probably could not survive the low flow conditions in Chimacum Creek during most years. All fish captured at the Wild Olympic Salmon weir were wild in origin (Wild Olympic Salmon, unpublished data 1994).

Discovery Bay

Discovery Bay coho are described as a mixed stock with composite production and were classified as critical in SASSI (WDFW and WWTribes 1994). Recommended status in 2002 SaSI remains critical due to chronically low escapements (Thom Johnson, contribution to SaSI in review, 2002).

Snow Creek Research Station, owned and operated by Washington Department of Fish and Wildlife, has monitored upstream and downstream migration of coho, steelhead and chum salmon since 1977. Coho escapement has ranged from 1,357 fish in 1977 to 4 fish in 1992, indicating a severe decline during the past twenty years (see Figure 14). Snow Creek research biologists have initiated and implemented a stock restoration program that has boosted the population to over 400 returning adults in the year 2001, which looks encouraging.

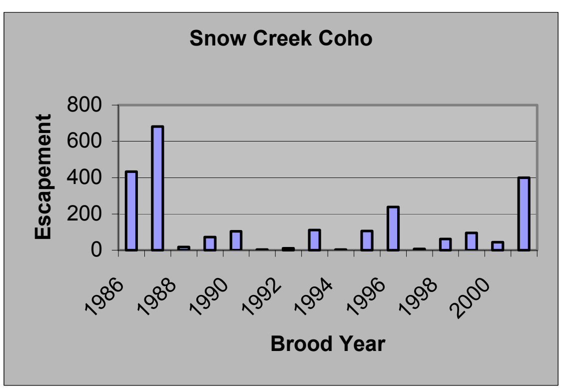

Figure 14. Snow Creek Coho Escapement. 1968 to 2001. Data provided by Thom Johnson, WDFW

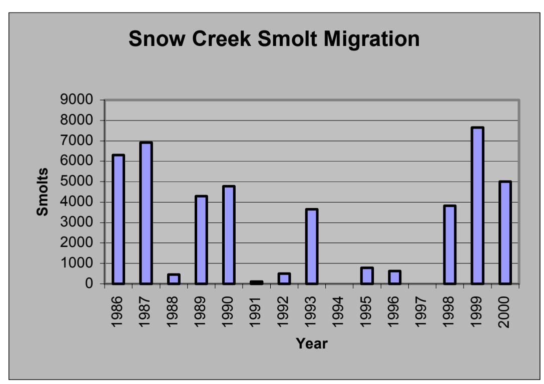

Figure 15. Snow Creek Coho Smolt Migration, 1986 to 2001. Data provided by Thom Johnson, WDFW

Smolt production has also been well below the estimated carrying capacity of 9,700 fish (Lestelle et al 1993b in McHenry and Lichatowich 1996) (see Figure 15).

Biologists have observed coho on Salmon Creek but consistent monitoring has not been conducted. There are no directed fisheries in Discovery Bay (McHenry and Lichatowich 1996).

Sequim Bay

SASSI combines all the independent drainages in Sequim Bay into a single stock, of which the Jimmycomelately population is the dominant component (WDFW and WWTribes 1994)). WDFW monitors Jimmycomelately index area at river mile 0.0 to 1.5. An additional population statistic available for this stock as adopted by the comanagers is a stratified random sampling based estimate of total adult coho escapement for the Sequim Bay Stock (which includes Jimmycomelately, Johnson and Dean Creeks) for the 1998 to 2000 returns years (1998 = 269 coho, 1999 = 358 and 2000= 358) (R. Cooper, personal communication, 2002). There have been infusions of non-native stocks into Jimmycomelately Creek (McHenry and Lichatowich 1996) and the fall coho are considered a mixed stock with wild production (Randy Cooper, SaSI contribution in review, 2002). This stock was rated depressed in 1992 due to short-term severe decline in escapement estimates. Index redd counts have been relatively stable since that period. Since there has been no significant increase in redd counts since that time period, the stock status rating remains depressed due to chronically low escapement indicator values (Randy Cooper, SaSI contribution in review, 2002). Spawning in Jimmycomelately Creek peaks in the last two weeks of November. Coho have recently been observed spawning intertidally (Randy Johnson, personal communication 2002).

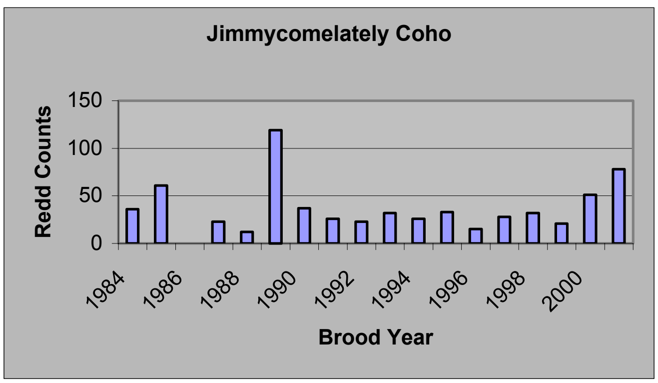

Figure 16. Jimmycomelately Coho Redd Counts, 1984 to 2001. Data provided by Randy Cooper, WDFW

Other Tributaries

Port Gamble S'Klallam tribal biologists and Wild Olympic Salmon volunteers monitor Tarboo, Thorndyke and Shine Creeks. Coho have been observed in all three streams. Tarboo is included in the Dabob Bay stock while Thorndyke and Shine are considered part of the northeast Hood Canal stock (Lichatowich 1993b). Ludlow Creek and Little Goose Creek also have coho in their lower watersheds.

Pink Salmon *(Oncorhynchus gorbuscha)*

Pink salmon spawn from mid July to late October and emerge late February to early May. Fry move downstream at night, immediately after emergence. The juveniles stay in the nearshore waters for several months, then move offshore as they migrate out to the Pacific Ocean. Preferred foods include euphausiids, amphipods, fishes, squid, copepods and pteropods. Pink salmon remain at sea for two years before returning to freshwater to spawn (Lichatowich 1993b).

Pink salmon are not found in WRIA 17 in large numbers. The Big Quilcene River has spawning pinks in some years but the runs have not been enumerated (Thom Johnson, personal communication 2002). Several (less than ten) were observed in Chimacum Creek during summer chum spawner surveys in 2001 (Wild Olympic Salmon, unpublished data 2001). Pinks have also been observed in Salmon Creek, but in very low numbers (less than ten in a given year) and in both even and odd years (Wild Olympic Salmon, unpublished data, multiple years).

Winter Steelhead *(Oncorhynchus mykiss)*

Steelhead spawn winter through spring and, unlike the five species of Pacific salmon, may return to sea and return again to spawn another year. Fry emerge April through June in WRIA 17 and spend one to two years, and rarely three years, in fresh water (Thom Johnson, personal communication 2002). They migrate to sea in the spring. They spend one to two summers in the open ocean and feed on crustaceans, squid, herring and other fish (Lichatowich 1993b).

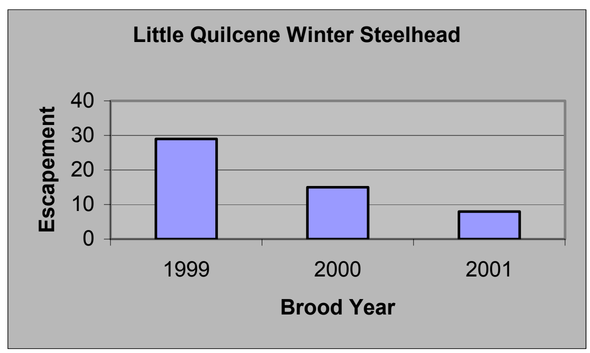

Figure 17. Little Quilcene Winter Steelhead. Data provided by Thom Johnson

Quilcene/Dabob Bay

The populations of winter steelhead from all the streams entering Quilcene and Dabob Bays are combined into one stock. They spawn between mid-February and the beginning of June (WDFW and WWTribes 1994). Washington Department of Fish and Wildlife has been monitoring winter steelhead in the Little Quilcene River since 1999. An escapement goal has not been set. The status is Unknown, both in SASSI and SaSI. The origin of this stock is unresolved (Thom Johnson, contribution to SaSI in review, 2002).

Discovery Bay

Washington Department of Fish and Wildlife combines all the winter steelhead populations from streams entering Discovery Bay into one stock described as native with wild production (WDFW and WWTribes 1994). Short-term declines in spawning escapements (see Figure 18), indexed by counts at the Snow Creek Research Station, can be attributed, in part, to factors outside the freshwater basins because the decline is a coast wide phenomenon (Cooper and Johnson 1992).

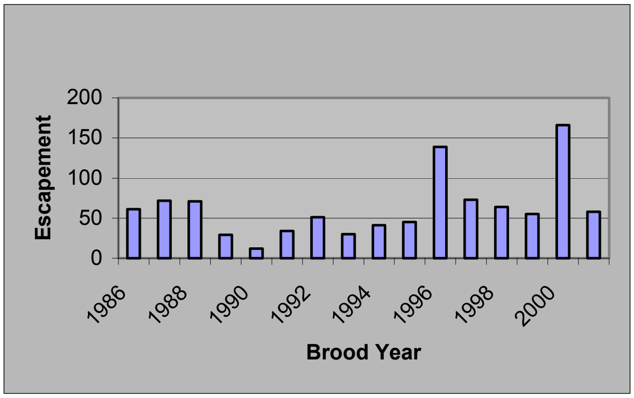

Figure 18. Discovery Bay Winter Steelhead Escapement, 1986 to 2001. Data provided by Thom Johnson.

Because of the research conducted at the Snow Creek station, the life history of this population is well understood and may be broadly applicable to other winter steelhead populations on the Olympic Peninsula (WDFW and WWTribes 1994; McHenry and Lichatowich 1996). WDFW and WWTribes (1994) further report:

- The number of days from freshwater entry to downstream migration has averaged 60±6 days (adults).
- The number of days from egg deposition to first emergence of fry from the gravel has averaged 62 days, with 50 percent emergence by 71 days.
- During August, age 0+ steelhead average 58 mm in length and 2.5 g in weight, average density is 43±17 fish/100m^2. By October, average length is 70 mm and weight is 4.6 g, with average densities of 32±13 fish/100 m^2.
- During August, age 1+ steelhead average 116 mm in length and 18g in weight, average density is 13±1 fish/100 m^2. By October, average length is 121 mm and weight is 20 grams, with average densities of 11±0.05 fish/100 m^2.
- Smolt outmigration begins in the first week of April and ends by the second week of June.
- Age composition of winter steelhead smolts for 1978-1992 was 9.8 percent age 1, 84.5 percent age 2, and 6.7 percent age 3.
- Survival rates have been: 0.67 to 3.64 percent from egg to smolt; 21.5 to 69.9 percent from fry to smolt; 4.6 to 14.3 percent from fall fry to smolt; and 12.5 to 49.9 percent from parr to smolt.
- Production in Snow Creek has ranged from 22 to 112 steelhead smolts per female spawner. Wild winter steelhead smolt to adult survival rate averaged 6.3 percent ± 1.8 percent and ranged from 2.2 to 10.7 percent excluding repeat spawners.

Other Tribs.

Escapement is not monitored for steelhead on many of the small tributaries in WRIA 17.

Rainbow Trout *(Oncorhynchus mykiss)*

WDFW stocks various lakes in WRIA 17 with rainbow trout: Crocker Lake, Leland Lake, Tarboo Lake, Anderson Lake, Gibbs Lake, Charlea Lake, Goat Lake and Sandy Shores (Thom Johnson, personal communication, 2002). Escapees from a trout farm on Jimmycomelately Creek account for the rainbow trout found in the lower reaches (Donald 1990).

Status Summary

Species/Stock Status	**1992 SASSI**	**2002 SaSI** (proposed)
Chinook	NA	NA
Summer Chum		
Quilcene/Dabob	Not Rated	Depressed
Chimacum	Not Rated	Extinct
Discovery Bay	Critical	Depressed
Sequim Bay	Depressed	Critical
Fall Chum		
Quilcene Dabob	Healthy	Healthy
Coho		
Quilcene/Dabob	Depressed	Depressed
Chimacum	Healthy	Healthy
Discovery Bay	Critical	Critical
Sequim Bay	Depressed	Depressed
Pink	NA	NA
Winter Steelhead		
Quilcene/Dabob	Unknown	Unknown
Discovery Bay	Depressed	Depressed

Fish Distribution

The Habitat Limiting Factors Analysis for WRIA 17 included mapping the distribution of chinook, chum, coho, pinks, steelhead/rainbow trout, and cutthroat 7 at a 1:24,000 scale. Maps for each species were generated based on existing information from SASSI (WDFW and Tribes 1994), Streamnet, and WDFW and tribal spawner and juvenile surveys. In addition, members of the Technical Advisory Group added considerable professional knowledge to this effort. Mapping included known presence, presumed presence, and potential/historic presence. Following is a tabular representation of the fish distribution information:

Table 2. WRIA 17 Fish Distribution.

Stream Segment	Species Present*					Miles of Use**			
	Chin	*Chum*	*Pink*	*Coho*	*Sthd*	*Known*	*Presumed*	*Potential*	*Total*
Big Quilcene Subbasin									
Big Quilcene River-Mouth to Rogers St	x	x	x	x	x	0.7	0.0	0.0	0.7
Big Quilcene River-Rogers St to Hiddendale	x	x	x	x	x	3.2	0.0	0.0	3.2
Big Quilcene River-Hiddendale to Falls at RM 7.8	x	x		x	x	3.2	0.0	0.0	3.2
Big Quilcene River-Above falls at RM 7.8						0.0	0.0	0.0	0.0
Penny Creek						0.0	0.0	3.3	3.3
Indian George Creek		x		x	x	0.2	0.0	0.0	0.2
Marple/Jackson Creek		x		x		1.7	0.0	0.0	1.7
Spencer Creek		x		x		1.4	0.0	0.0	1.4
Miscellaneous Streams						0.0	0.3	0.0	0.3
Big Quilcene Subbasin Total	*x*	*x*	*x*	*x*	*x*	10.4	0.3	3.3	14.0
Little Quilcene Subbasin									
Lower Little Quilcene River		x		x	x	2.7	0.0	0.0	2.7
Middle Little Quilcene River		x		x	x	2.7	0.0	0.0	2.7
Upper Little Quilcene River						0.0	0.0	0.0	0.0
Leland Creek		x		x	x	4.5	2.4	0.4	7.3
Ripley Creek				x		1.3	0.0	0.0	1.3
Howe Creek				x		0.2	0.0	0.0	0.2
Donovan Creek				x		2.1	0.9	0.0	3.0
Jakeway Creek				x		0.2	0.0	0.0	0.2
Little Quilcene Subbasin Total		x		x	x	13.7	3.3	0.4	17.4
Tarboo/Thorndyke Subbasin									
Lindsay Creek				x		0.1	1.0	0.0	1.1
Lower Tarboo Creek	x	x		x	x	1.1	1.3	0.0	2.4
Middle Tarboo Creek	x	x		x	x	4.3	0.7	0.0	5.0
Upper Tarboo Creek				x	x	0.4	0.0	2.6	3.0
East Fork Tarboo				x		2.0	1.1	2.7	5.8
Camp Discovery Creek		x		x		0.8	0.5	0.0	1.3
Fisherman's Harbor Creek		x		x		0.1	0.9	0.0	1.0
Thorndyke Creek		x		x	x	5.2	4.4	0.0	9.6
Miscellaneous Streams		x		x	x	1.0	1.7	0.0	2.7
Tarboo/Thorndyke Subbasin Total	x	x		x	x	15.0	11.6	5.3	31.9
Shine/Ludlow Subbasin									
Nordstrom Creek				x	x	0.6	2.1	0.0	2.7
Lower Shine Creek		x		x		1.1	0.0	0.0	1.1
Upper Shine Creek				x		0.9	0.2	0.0	1.1
Bones Creek						0.0	0.2	0.0	0.2
Lower Ludlow Creek		x		x	x	0.5	0.0	0.0	0.5
Upper Ludlow Creek						0.0	0.0	0.0	0.0
Piddling Creek				x		0.2	0.0	0.4	0.6
Little Goose Creek				x		0.2	0.0	0.0	0.2

Stream Segment	Species Present*					Miles of Use**			
	Chin	*Chum*	*Pink*	*Coho*	*Sthd*	*Known*	*Presumed*	*Potential*	*Total*
Miscellaneous Streams		x		x		0.2	0.3	0.4	0.9
Shine/Ludlow Subbasin Total	x	x		x	x	3.7	2.8	0.8	7.3
Chimacum Subbasin									
Lower Chimacum Creek		x	x	x	x	3.3	0.0	0.0	3.3
Middle Chimacum Creek		x	x	x	x	7.0	0.0	0.0	7.0
Upper Chimacum Creek				x	x	5.5	0.2	0.0	5.7
East Fork Chimacum Creek				x	x	6.8	0.3	1.4	8.5
Putaansuu Creek				x		1.1	0.0	0.0	1.1
Naylor Creek			x	x	x	3.5	0.2	0.0	3.7
Barnhouse Creek				x		1.0	0.0	0.4	1.4
Chimacum Subbasin Total		x	x	x	x	28.2	0.7	1.8	30.7
Discovery Bay Subbasin									
Lower Snow Creek		x		x	x	3.6	0.0	0.0	3.6
Upper Snow Creek		x		x	x	3.8	0.0	0.0	3.8
Lower Andrews Creek				x	x	2.2	0.0	0.0	2.2
Upper Andrews Creek				x	x	0.5	0.0	0.0	0.5
Lower Salmon Creek		x		x	x	0.9	0.0	0.0	0.9
Upper Salmon Creek		x		x	x	5.2	0.0	0.0	5.2
Contractors Creek				x	x	0.4	0.0	1.2	1.6
Eagle Creek						0.0	0.0	0.0	0.0
Miscellaneous Streams		x				0.1	0.0	0.0	0.1
Discovery Bay Subbasin Total		x		x	x	16.7	0.0	1.2	17.9
Sequim Bay Subbasin									
Chicken Coop Creek				x		0.3	0.0	2.7	3.0
Lower Jimmycomelately		x		x	x	1.1	0.0	0.0	1.1
Middle Jimmycomelately		x		x	x	0.9	0.0	0.0	0.9
Upper Jimmycomelately						0.0	0.0	0.0	0.0
East Fork Jimmycomelately						0.0	0.0	0.0	0.0
Dean Creek				x		0.5	0.0	0.0	0.5
Johnson Creek		x		x		0.7	0.6	0.0	1.3
Miscellaneous Streams						0.0	0.1	0.0	0.1
Sequim Bay Subbasin Total		x		x	x	3.5	0.7	2.7	6.9
WRIA 17 Total	**x**	**x**	**x**	**x**	**x**	**91.2**	**19.4**	**15.5**	**126.1**

*Species Present indicates Known use in the Subbasin or stream as of August 2002. Lack of presence in this table does not indicate that a particular species is absent from the subbasin or stream. Chin = chinook, Sthd = steelhead

**Miles of use is the stream length with chinook, chum, pink, coho or steelhead use identified as of August 2002. Use categories are defined in the associated LFA report.

HABITAT LIMITING FACTORS BY SUB-BASIN

For the purpose of the limiting factors analysis, Water Resource Inventory Area (WRIA) 17 was divided into subbasins delineated as follows:

- Big Quilcene (Big Quilcene, Indian George, Spencer, Marple/Jackson
- Little Quilcene (Little Quilcene, Donovan)
- Dabob/Thorndyke (Lindsay, Tarboo, Camp Discovery, Thorndyke)
- Ludlow (Nordstrom, Shine, Bones, Ludlow)
- Chimacum (Chimacum, Piddling, Little Goose)
- Discovery Bay (Snow, Salmon, Contractors, Eagle)
- Sequim Bay (Chicken Coop, Jimmycomelately, Dean, Johnson)

The habitat elements considered by the Technical Advisory Group (TAG) for the WRIA 17 habitat limiting factors analysis include:

- Fish Access (artificial physical fish passage barriers)
- Floodplain Modifications (constrictions, loss of floodplain connectivity, loss of side channel habitat)
- Channel Condition (fine sediment, large woody debris, pool quantity/quality, streambank stability)
- Sediment Input (sediment supply, mass wasting, road density)
- Riparian Condition (canopy closure/shade, bank stability, LWD recruitment)
- Water Quality (temperature, dissolved oxygen, total suspended solids)
- Hydrology (flows, hydrologic maturity, impervious surface)
- Biological Processes (fish carcass nutrients)
- Estuarine Condition
- Nearshore Condition

A list of data needs and action recommendations follows the discussion. A table with the TAG ratings for designated stream reaches can be found in Table 22.

BIG QUILCENE SUB-BASIN

The Big Quilcene sub-basin includes Marple/Jackson Creek (WRIA 17.0001), Spencer Creek (WRIA 17.0004), Indian George Creek (WRIA 17.0011, and the Big Quilcene River (WRIA 17.0012). The following reaches were evaluated by the TAG:

1. Marple/Jackson Creek, entire watershed
2. Spencer Creek, entire watershed
3. Indian George Creek, entire watershed
4. Big Quilcene River, mouth to Rogers Street Bridge, river mile 0.0 to 1.0
5. Big Quilcene River, Rogers Street Bridge to Hiddendale, river mile 1.0 to 3.2
6. Big Quilcene River, Hiddendale to the natural falls, river mile 3.2 to 7.8
7. Big Quilcene River, above the falls, including Tunnel Creek, SF Tunnel Creek, NF Tunnel Creek, mainstem Big Quilcene River, and Townsend Creek
8. Penny Creek, tributary to the Big Quilcene River at river mile 2.8

Marple/Jackson Creek

Marple Creek, sometimes called Jackson/Marple Creek, is 2.4 miles in length with an additional 2.2 miles contributed by its tributary, Jackson Creek (Ames and Bucknell 1981). The upper watershed is in federal forest with the lower mile privately owned. Anadromous fish use the lower mile although juvenile coho have been observed in the upper watershed.

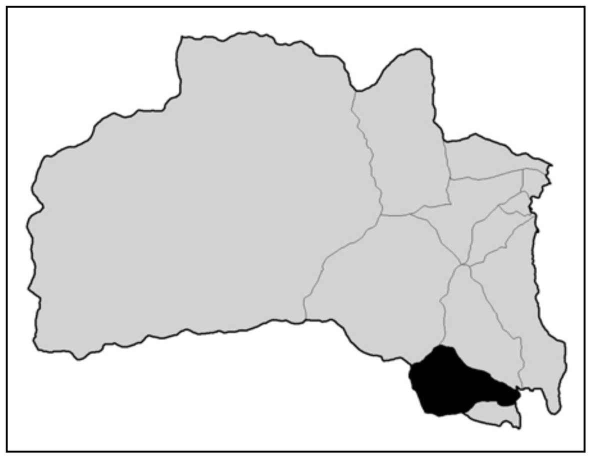

Figure 19. Marple/Jackson Watershed. Map provided by Jennifer Cutler, NWIFC

Marple Creek, with its main tributary called Jackson Creek, is considered one reach for this analysis. Little data were available. US Forest Service (USFS) watershed analysis provided hydrologic maturity data. Steve Todd, Point No Point Treaty Council biologist, provided floodplain hydromodification data and calculated road density. The SSHIAP database provided information on fish access. The TAG was able to provide limited evaluation based on best professional knowledge. The remaining parameters were considered data gaps.

Access and Passage

Access

A culvert on Bee Mill Road, below Highway 101, is a juvenile migration barrier. At Highway 101, the culvert on Marple Creek is a partial barrier. The TAG rated this parameter poor as more than 20 percent of the watershed is inaccessible.

Water diversion structures in upper Jackson Creek may block migration of resident trout (Parametrix, Inc. 2000).

Floodplains

Floodplain Connectivity

The creek has been moved to the southern portion of the floodplain to accommodate a housing development in the floodplain. The restricted connectivity with the floodplain resulted in a poor rating by the TAG.

Loss of Floodplain Habitat

Due to a housing development in the floodplain, modifications have been made to the lower watershed, such as left bank armoring between Highway 101 and Bee Mill Road. The TAG gave this a poor rating.

Channel Conditions

Fine Sediment

This element was not rated, as there are no data available.

Large Woody Debris

Large woody debris has been removed from the lower reaches for flood control and the riparian zone has been partially cleared and developed (Parametrix, Inc. 2000). The TAG rated this element as poor due to the lack of large woody debris (LWD) in the developed section of the watershed. Future LWD recruitment in the lower reach of Marple Creek is poor due to the high deciduous content of the riparian zone.

Percent Pools

The rating for percent pools is poor for the lower 1.3 miles but fair between river mile 1.3 and 1.5 (Matye et al.1994).

Pool Frequency

This element was not rated, as there are no data available.

Pool Quality

This element was not rated, as there are no data available for this parameter.

Streambank Stability

This element was not rated, as there are no data available.

Sediment Input

Sediment Supply

This is a high gradient system in which the channel constrictions have altered the rate that sediments are transported. High rates of coarse sediment input leading to substrate scour are an issue but the TAG did not rate this parameter.

Mass Wasting

Habitat for anadromous species in the lower reaches is influenced by the naturally high frequency of mass wasting and high sediment loading (Parametrix, Inc. 2000). Watershed Analysis indicates a 1.6 to 2.6-fold increase over the natural rate, which leads to a poor rating. It is estimated that 90% of the mass wasting is road related.

Road Density

Road density in Marple Creek is 4.61 miles of road per square mile of watershed. Road density in Jackson Creek is 3.35 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zone

Riparian Condition

Based on best professional knowledge, the TAG rated this parameter poor.

Water Quality

Temperature

Water temperatures were recorded in the lower river just above Bee Mill Road during the summer months of 2001 (Labbe 2002). The annual instantaneous maximum temperature was 17.8^{o}C, which results in a fair rating for both spawning and migration/rearing.

Dissolved Oxygen

This element was not rated, as there are no data available.

Hydrology

Flow – Hydrologic Maturity

Greater than sixty five percent of the watershed is older than 25 years (TAG 2002), resulting in a good rating for hydrologic maturity.

Flow – Percent Impervious Surface

This parameter is not applicable.

Biological Processes

Nutrients

There were no consistent escapement data for this watershed so it is not practical to assign a rating for this attribute.

Estuary

Development in the Marple Creek estuary restricts estuary function, tidally influenced surface area and channel migration. There is no sediment storage within the floodplain and consequently all the sediment is deposited in the channel or delta leading to a progradation problem. Shorelines have steepened and tidal channels and sloughs have been lost.

Data Needs

- Fine sediment data
- Large woody debris
- Assess pool quality and pool frequency
- Assess streambank stability
- Determine sediment supply
- Assess riparian condition
- Determine dissolved oxygen levels
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

- Reestablish riparian buffer
- Increase channel complexity in the lower channel
- Evaluate options for and proceed with moving dikes further away from the channel

Spencer Creek

Spencer Creek, approximately 3.8 miles in length with an additional 1.1 mile in tributary contribution (Ames and Bucknell 1981), flows into the northwest corner of Jackson Cove in Dabob Bay, about one mile south of the Big Quilcene River and drains an area of 3.29 square miles (Parametrix, Inc. 2000). The lower watershed supports spawning and rearing for chum, coho and coastal cutthroat. An impassable cascade prevents anadromous use of the upper watershed, although it supports resident cutthroat.

Spencer Creek was treated as a single reach. Little data were available. US Forest Service (USFS) watershed analysis provided hydrologic maturity data. Steve Todd, Point No Point Treaty Council biologist, calculated road density. Washington Department of Fish and Wildlife (WDFW) provided passage evaluation at culverts. The TAG was able to provide limited evaluation based on best professional knowledge. The remaining parameters were considered data gaps.

Access and Passage

Artificial Barriers

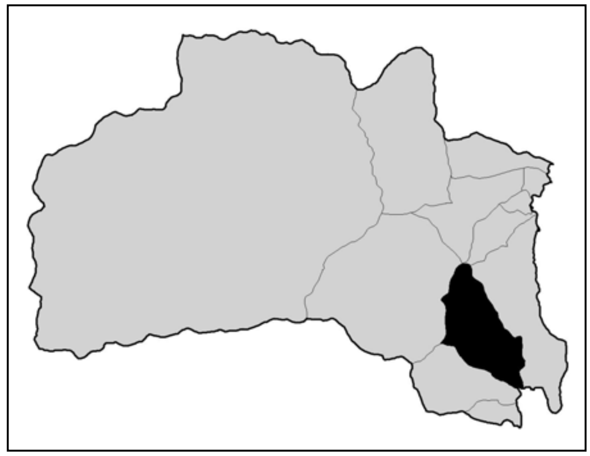

Figure 20. Spencer Creek Watershed. Map provided by Jennifer Cutler, NWIFC

A problematic culvert at the mouth of Spencer creek is a partial barrier to adult migration and in conjunction with the road fill, forms an impairment to estuary function. A culvert on tributary 17.0004 is a partial barrier and if corrected would provide better access to 790 meters of watershed upstream (975 square meter of spawning habitat and 33,644 square meters of rearing habitat) (Till et al. 2000). A culvert on the first left bank tributary, stream number 17.0005, on Bee Mill Road is a barrier. A logging road crossing on the mainstem is not a barrier at this time but could become a problem as it is filled halfway with gravels. This could be fixed or removed altogether as a potential project. There are multiple natural falls approximately fifty feet tall at river mile 0.7.

Floodplain

Floodplain Connectivity

Due to gradient, this parameter is not applicable.

Loss of Floodplain Habitat

Due to gradient, this parameter is not applicable.

Channel Condition

Fine Sediment

The TAG rated this parameter fair based on recent cursory habitat observations of moderate fines in the gravels. Mass wasting events have increased the sediment recruitment beyond natural rates (Matye et al.1994). Some streambanks in the lower reach are exposed which could lead to sloughing and additional sediment input (TAG 2002).

Large Woody Debris

Data were not available but the TAG gave it a poor rating based on personal observation. Past efforts at LWD restoration and streambed stabilization with log weirs have failed due to chronic coarse sediment deposition from mass wasting and slide events and are consequently now buried. Wood recruitment is important for channel integrity in the lower reach below the falls. Very little wood is transported over the falls to the downstream reach and must come from the riparian zone. Consequently, the riparian zone along the lower 0.7 miles is the primary source of large wood.

Percent Pool

Based on professional observation by TAG members, the percentage of pools is low for this watershed.

Pool Frequency

Based on professional observation, the TAG estimated a low pool frequency.

Pool Quality

Based on professional observations during cursory habitat surveys, the TAG did not observe deep pools with adequate cover. Therefore, pool quality was rated poor.

Streambank Stability

Based on professional observation, the TAG determined the streambanks to be greater than 80 percent unstable, resulting in a poor rating.

Sediment Input

Sediment Supply

This element was not rated, as there are no data available.

Mass Wasting

There is a 2.6 to 13-fold increase of sediment delivery from mass wasting above natural levels in the Spencer Creek watershed (Matye et al.1994). There are little data regarding the transport of these sediments to the stream.

Road Density

Road density was calculated at 3.44 miles of road per square mile of watershed, which puts it in the poor category (PNPTC, unpublished data, 2002). In addition, there are three stream crossings that contribute to fragmentation of the riparian zone and increase sediment input. Existing cross drains and relief pipes can undermine fill and adjacent unvegetated slopes.

Riparian Zones

Riparian Condition

The riparian zone is poor over the entire watershed due to clear cuts in the upper watershed that left an inadequate riparian zone. A mixed coniferous and deciduous forest below the falls is well established (TAG 2002)

Water Quality

Temperature

Temperatures in this watershed, below the falls are good. However, above the falls temperatures ranged from 15.6^{o}C to 16.1^{o}C between 1992 and 1994 which makes it fair for spawning and poor for migration and rearing (Labbe 2002).

Table 3. Spencer Creek Water Temperatures. Data provided by Ted Labbe, PGST

Stream/Location	1992 AIMT	1993 AIMT	1994 AIMT	2001 AIMT	2001 7-DADMT	2001 21-DADT
Spencer Crk-lower	13.3°C	14.4 °C	13.3 °C	13.2 °C	12.9 °C	12.2 °C
Spencer Crk-upper	15.6 °C	15.0 °C	16.1 °C			

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

This element was not rated, as there are no data available.

Hydrology

Flow – Hydrologic Maturity

Greater than 65 percent of the watershed is older than 25 years (Matye et al.1994). This translates to a good rating for hydrologic maturity.

Flow – Percent Impervious Surface

Though there are no data regarding percent impervious surfaces for the Spencer Creek watershed, best professional knowledge suggests it is less than 3 per cent, resulting in a good rating. However, Highway 101 parallels the stream and likely produces hydrologic and sediments to the creek.

Biological Processes

Nutrients (carcasses)

There are no formalized spawner surveys on Spencer Creek nor are there escapement goals so this parameter was not rated.

Estuary

The undersized county culvert at the mouth of Spencer Creek restricts tidal influence and wood and sediment movement throughout the lower stream reach and floodplain as well as the delta/estuary. At low tide the culvert is a fish passage barrier.

Data Needs

- Collect fine sediment data
- Determine sediment supply
- Large woody debris
- Evaluate the frequency and quality of pool habitat
- Determine dissolved oxygen levels
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Identify, abate and monitor sediment sources
2. Remove culvert on logging road in upper watershed that could soon fail
3. Evaluate options for ameliorating channel/floodplain constriction and improving fish passage at the Bee Mill Road crossing.

Indian George Creek

Indian George Creek was analyzed as a single reach. Data were sparse; therefore the TAG made the following assessment based on their best professional knowledge.

Access and Passage

Artificial Barriers

The culvert under Linger Longer Road has been replaced and is no longer a barrier to fish migration. However, extreme headcutting, as a result of the culvert placement and bed instability, has become a barrier upstream.

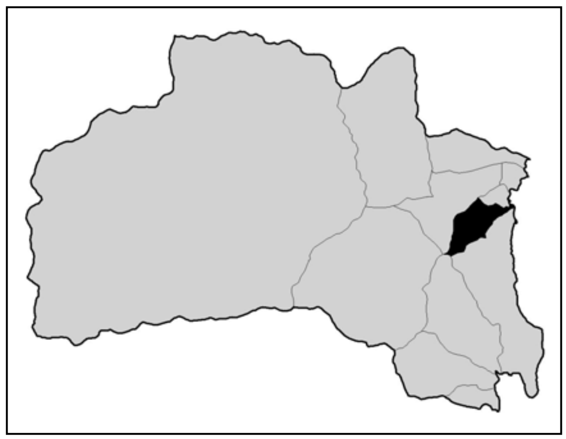

Figure 21. Indian George Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The TAG rated floodplain connectivity as poor due to disconnection of a slough from the estuary. There is some creek water flowing into the slough but delta connectivity no longer exists.

Loss of Floodplain Habitat

The TAG rated flood plain habitat as poor due to recent massive gravel inputs to the lower system from the headcutting and upstream streambank instability. A large part of the upper watershed has been clearcut, which has contributed to the sedimentation.

Channel Conditions

Fine Sediment

There are no data available to evaluate this parameter although mass wasting is a problem in this watershed (Matye et al.1994) that might deliver substantial quantities of fine sediment to the stream channel.

Large Woody Debris

There are no data available to evaluate this parameter for the entire watershed. Large wood was added to the channel in the lower watershed downstream of Linger Longer Road as part of a habitat restoration project by Wild Olympic Salmon, Quilcene Snow Restoration Team and Jefferson County Conservation District.

Percent Pool

Based on best professional knowledge, TAG members have observed few pools in the stream channel.

Pool Frequency

Based on best professional knowledge, the TAG considers pool frequency to be low.

Pool Quality

Based on best professional knowledge, TAG members have observed no deep pools with adequate cover.

Streambank Stability

Based on best professional knowledge, TAG members have observed streambed and streambank instability throughout the watershed.

Sediment Input

Sediment Supply

This was identified as a data gap. However, the TAG concluded that due to the large clearcuts in the upper watershed coupled with the headcutting above Linger Longer Road and the subsequent downstream gravel deposition, sediment supply exceeds a natural rate.

Mass Wasting

There is a 13-fold increase in mass wasting above natural levels, due to forest practices and the associated road network in this watershed, particularly in the steep walled slopes of the canyon above Linger Longer Road. This mass wasting contributes to sediment problems downstream (Matye et al. 1994). Habitat for anadromous species in the lower reaches is influenced by the naturally high frequency of this mass wasting and high sediment loading in the upper watershed. The lower reaches of the riverine section had been restored with the addition of large woody debris and the replacement of an undersized culvert. However, recent slide events filled in the newly established pools.

Road Density

There are 3.41 miles of road per square mile of watershed (PNPTC, unpublished data, (2002). Seventy five percent of the landslide activity is related to roads (Matye et al 1994). There remains the potential for more mass wasting in the future unless the road problems are addressed.

Riparian Zones

Riparian Condition

The TAG designated a poor rating based on recent timber harvest activities in the watershed. Little riparian buffer remains in the upper watershed, which has significantly contributed to mass wasting events and subsequent sedimentation (TAG 2002).

Water Quality

Temperature

April 20, 2001, water temperature downstream of Linger Longer culvert was 9^{o}C (Gately 2001. Additional summer temperature data collected between June 28 and September 14, 2001, indicate a fair rating (Glenn Gately, personal communication, 2002).

Dissolved Oxygen

Based on Glenn Gately's data, all fifteen dissolved oxygen readings taken weekly at the Linger Longer Road culvert between June 28 and September 14, 2001, were above 8.0 mg/L, except for one reading at 7.9mg/L. Using these data, dissolved oxygen was rated as good.

Hydrology

Flow/Hydrologic Maturity

Due to recent timber harvest in the watershed, the percentage of immature forest exceeds 60 percent, which translates to a poor hydrologic maturity. Nearly the entire headwaters were clearcut over a short period of time resulting in highly degraded hydrologic conditions (Ted Labbe, personal communication, 2002).

Impervious Surface

Data do not exist for this watershed, though the TAG determined that the percent impervious surface is likely less than 3 percent, resulting in a good rating.

Biological Processes

Nutrients (carcasses)

Consistent and systematic spawner surveys have not been conducted on this stream so the TAG was unable to provide a rating for this parameter.

Estuary

Indian George Creek estuary had been highly modified for aquaculture activities about forty years ago. A large amount of fill had been placed across the estuary and the mouth of the stream was moved to the south to enter directly into Quilcene Bay. A large old barge, along with two smaller barges, further diminished tidal flow and estuary function. The site is owned by Washington Department of Fish and Wildlife and is a popular public shellfish harvest area. Previous restoration efforts rerouted the channel to its historic estuary. Recent restoration efforts have removed much of the fill and all the barges to restore estuary function.

Figure 22. Indian George Creek Estuary, Pre-restoration. Graphic provided by Randy Johnson, WDFW

Figure 23. Indian George Creek Estuary, Post-restoration. Photo provided by Randy Johnson, WDFW

Data Needs

- Fine sediment data collection
- Channel condition data, particularly LWD
- Sediment supply analysis
- Determine escapement numbers
- Evaluate road and road crossing impacts to aquatic resources

Action Recommendations

1. Identify, abate and monitor sediment sources
2. Revegetate riparian zone throughout the watershed

Big Quilcene River, mouth to Rogers Street, river mile 1.0

Data used for analysis of the Big Quilcene watershed came from the US Forest Service (USFS) watershed analysis, Timber Fish and Wildlife (TFW) ambient monitoring, Port Gamble S'Klallam Tribe temperature data, and professional knowledge by TAG members. Some parameters, where data and/or knowledge are lacking, have been identified as data needs.

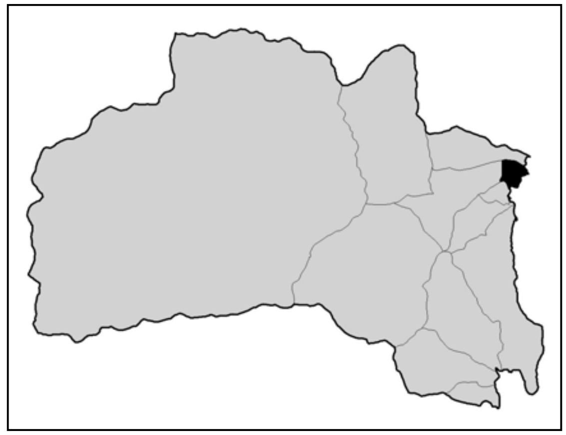

Figure 24. Big Quilcene Watershed, river mile 0.0 to 1.0. Map provided by Jennifer Cutler, NWIFC

Access and Passage

Artificial Barriers

The lower reach of the mainstem is barrier-free up to the Quilcene National Fish Hatchery at river mile 2.8.

Floodplains

Floodplain Connectivity

Much of the lower reach, river mile 0.0 to 1.1, has been disconnected from its floodplain by rip-rap armor, diking and dredging that has occurred on both sides of the river as flood protection measures for residents living within the historic floodplain. Extensive channel aggradation has increased the streambed elevation in this reach by two to seven feet between 1971 and 1993 and has extended the river mouth 1700 feet into the historic estuary/delta (TAG 2002).

Loss of Floodplain Habitat

The floodplain associated with this lower reach has been modified for residential use and for agriculture (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment sampling, according to Timber Fish and Wildlife (TFW) ambient monitoring protocols, has not been conducted in this watershed and has been identified as a data gap. Total suspended solids, measured in December of 1996 at Linger Longer Bridge, were 90 mg/liter, which is below lethal limits (Gately 2002). Turbidity measurements taken the same day at the same location were 103 ntu (Gately 2002). Turbidity is naturally high during periodic storm events. Additional turbidity monitoring at additional locations and time intervals could point to reach specific erosion problems.

Large Woody Debris

Large woody debris is poor in the lower reach of the Big Quilcene River and future recruitment is also poor (TAG 2002).

Percent Pool

The lower reach, river mile 0.0 to 1.1, has no pool habitat. The reach is essentially one large riffle (TAG 2002).

Pool Frequency

The lower reach, river mile 0.0 to 1.1, has no pool habitat. The reach is essentially one large riffle (TAG 2002).

Pool Quality

The lower reach has no deep pools with adequate cover. The reach is essentially one large riffle (TAG 2002).

Streambank Stability

The lower reach is considered artificially stable due to the amount of riprap protecting the dikes and banks. Riprap can be a sign of instability or a sign of a flashy system in transitional condition.

Sediment Supply

Sediment Supply

Sediment sources can result from channel incision as well as from bank instability, mass wasting and sheet erosion. As a whole, the watershed received a poor rating because the sediment supply exceeds the natural rate. On a reach-by-reach level, the rates vary due to geology and land use. In a natural condition, there would be little sediment coming from the downstream reach, as it is a depositional zone. However, the lower reach is not a natural condition and the TAG therefore gave it a poor rating. There is some notable incision occurring in the reach below Highway 101.

Mass Wasting

Mass Wasting in the lower reach is not a limiting factor as there are no significant mass wasting opportunities due to the low gradient and topographic relief in the lower reach.

Road Density

A very high density of roads (7.2 miles/square mile of watershed) occurs in the lower watershed downstream of Rogers Street (PNPTC, unpublished data 2002). Approximately two road crossings per mile of stream can have serious impacts from stormwater runoff as well as fragmentation of the riparian corridor. There are 0.83 crossings in the lower 3.2 miles. The mainstem crossings include the power line crossing, Linger Longer Road, Rogers Street and Highway 101 upstream at river mile 2.6.

Riparian Zones

Riparian Condition

The riparian zone in the lower watershed has been altered from historic conditions. Evidence of large cedar stumps indicate a once conifer-dominated landscape that has been cleared for agricultural and residential purposes (TAG 2002).

Water Quality

Temperature

Water temperatures were recorded at the Rogers Street Bridge in 2001, which is indicative of the segment between Rogers Street and US101 (see Table 4). The TAG expressed concern for coho rearing during summer months and summer chum spawning at the elevated temperatures recorded at this site but felt the condition for coho and fall chum spawning is acceptable. It has not yet been determined what impact that elevated water temperatures and low flows during their adult migration/spawning time have had on summer chum.

Dissolved Oxygen

While dissolved oxygen readings are limited in number, they indicate a good condition throughout the watershed. Where data was lacking, the TAG based their rating on temperature and morphology.

Hydrology

Flow – Hydrologic Maturity

Overall, hydrologic maturity is good throughout the watershed in spite of past logging activities. The lower reach, however, has been converted to agriculture, eliminating forested habitats.

The TAG discussed how water withdrawals in the Big Quilcene watershed might impact fish migration, spawning and rearing. From a biological standpoint and in general, water withdrawal can impact fish during low flow periods by creating hydraulic barriers and limiting access to specific stream reaches and/or habitats during critical migration and spawning periods. Further research should be conducted in this area before drawing conclusions.

Flow – Percent Impervious Surface

This parameter was not evaluated.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not practical. However, the general consensus of the TAG is that the escapement levels to the hatchery weir have been good, especially with the federal summer chum stock restoration program. The USFWS is now passing coho above the hatchery weir.

Estuary

By 1883 diking of the lower Big Quilcene River had begun, eliminating valuable salt marsh habitat and tidal channels. Over 21 percent of the historic delta area of 125 acres has been obstructed by dikes/levees with three percent of the historic delta filled for residential and commercial use (TAG 2002). The river has breached the dike more than once in the lower watershed, but has always been rebuilt. Some dikes on the left bank on Washington Department of Fish and Wildlife and Jefferson County properties have been removed to provide a channel migration zone. Additional dike removal is necessary to provide properly functioning riverine and estuarine habitats. The river has been aggrading as much as four feet per year. When the dikes along the left bank were removed, accretion stopped and, in fact, the river did some downcutting (TAG 2002). With the remaining dikes in place, there is no place for the river to deposit sediments so the river aggrades and the delta progrades. Removal of the delta cone, which is the result of floodplain disconnection, will be necessary at the same time the dikes are removed. At one time, boats used to access the river all the way to Linger Longer Road during high tides, but due to river aggradation and delta progradation, this is not possible today (TAG 2002).

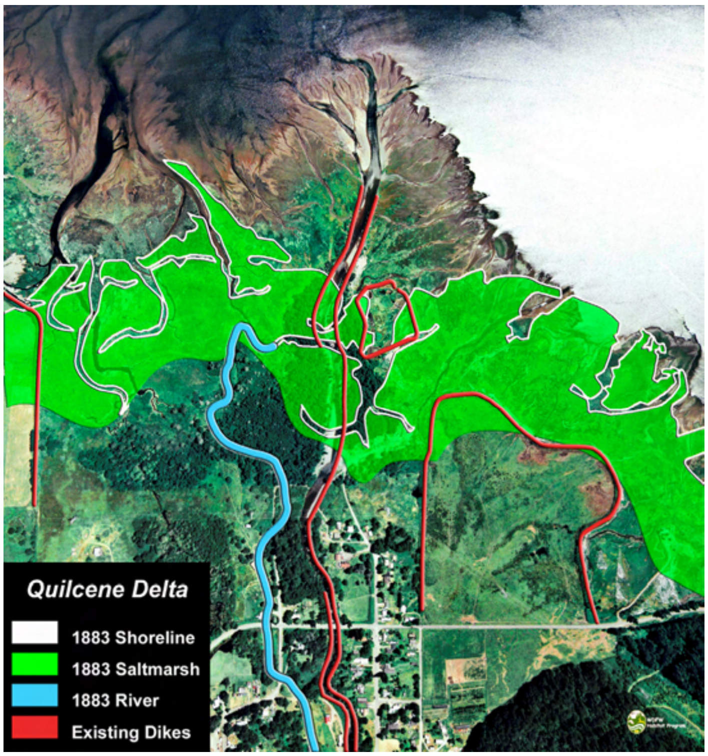

Figure 25. Big Quilcene River Estuary. Graphics provided by Randy Johnson, WDFW

Data Needs

- Total suspended solids monitoring
- Fine sediment data collection
- Sediment supply
- Dissolved oxygen
- Intergravel dissolved oxygen
- Total suspended solids impact on fish and redds
- Individual river escapement goals
- Low flow impacts on fish

- Groundwater/surface water interaction that affect flows
- Investigate temperature/stream flow interactions
- Evaluate road and road crossing impacts on aquatic resources

Big Quilcene River, Rogers Street Bridge to Hiddendale, river mile 1.0-3.2

Access and Passage

Artificial Barriers

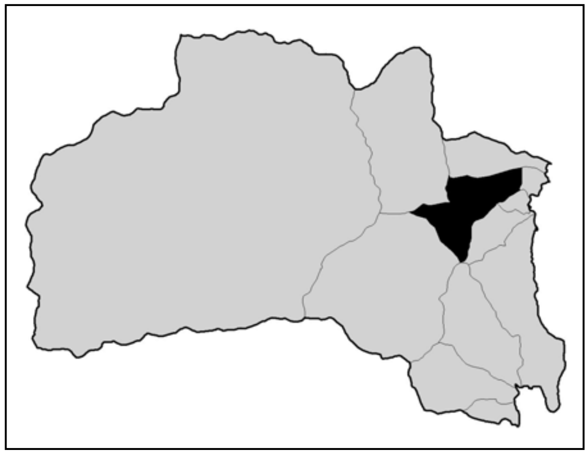

Figure 26. Big Quilcene Watershed, river mile 1.0 to 3.2. Map provided by Jennifer Cutler, NWIFC

The lower reach of the mainstem is barrier-free up to the Quilcene National Fish Hatchery at river mile 2.8. As part of the hatchery facility, the US Fish and Wildlife Service (USFWS) operates an electric weir from approximately the end of October (unless high flows dictate an earlier start) through the end of December each year. During low flow conditions the weir is always a barrier to fish migration, but from January through May, when the weir is not in operation and when the flows are substantial enough, fish, particularly steelhead and coho, can navigate upstream. There is a fish ladder at this site but it is not currently functioning properly due to gravel aggradation. In addition, the hatchery operates two water-intake diversions to provide water for their facility. A diversion upstream of the hatchery on the mainstem diverts water at river mile 3.2 and returns it to the system downstream at river mile 2.8 and could be a passage barrier for juveniles and residents, but not for adult salmon. A second intake system is at the confluence of Penny Creek with the mainstem and eliminates anadromous access to Penny Creek, which has been identified as some of the best refugia in east Jefferson County (Paula Mackrow, personal communication 2002).

In addition to the physical barriers, a hydrologic barrier exists in this segment on a right bank unnamed tributary, 17.0013, which enters the Big Quilcene River at approximately river mile 2.4. Hydromodification (diking) and incision restrict access to this tributary.

Floodplains

Floodplain Connectivity

Moving upstream from the Rogers Street Bridge at river mile 1.1 to US 101 at river mile 2.6, the habitat has been improving for the past 10-15 years (TAG 2002). The upstream and downstream sections of this river segment, however, continue to degrade due to historic hydromodifications. The middle section with LWD jams and side channels allows high flows to extend over the banks into the riparian zone to deposit both fine and coarse sediments onto the floodplain. Due to its relatively good floodplain habitat and connectivity, this section received a fair rating by the TAG.

The river channel between the USFWS hatchery at river mile 2.8 and the residential development of Hiddendale at river mile 3.2 migrates south to north with signs of beaver activity on the east valley wall. Some armoring and diking has occurred in this area. The remainder of the stream channel habitat in the watershed is greater than one percent gradient where this parameter is not applicable.

Loss of Floodplain Habitat

The habitat in the vicinity of the federal fish hatchery has been modified to accommodate the facility. This section of river, downstream of the fish hatchery, has good instream structure, side channel development in some reaches and a recovering riparian zone. There is some beaver activity upstream of the fish hatchery and residential development in the floodplain at Hiddendale.

Channel Conditions

Fine Sediment

Fine sediment sampling, applying TFW ambient monitoring protocols, has not been conducted in this watershed and has been identified as a data gap.

Large Woody Debris

The entire mainstem below Hiddendale at river mile 3.2, with the exception of one short section, is devoid of large woody debris due to removal for bank protection and or firewood. The section of the river between Rogers Street Bridge and Highway 101 has been recruiting LWD and will likely continue recruiting LWD if the local citizenry leaves it there. Overall, this section rates poor.

Percent Pool

Percent pools are rated fair with approximately 35 percent of habitat area in this reach comprised of pools (Bernthal and Rot 2001).

Pool Frequency

Pool frequency is greater than four channel widths per pool for this reach (Bernthal and Rot 2001).

Pool Quality

Twenty percent of the pools have a depth greater than one meter with the vegetation in the riparian zone at the pole/sapling stage (Bernthal and Rot 2001).

Streambank Stability

This parameter is a data gap.

Sediment Supply

Sediment Supply

There is some notable incision occurring in the reach below Highway 101. It is not known if sediment supply exceeds the natural rate in the section between Rogers Street and Hiddendale. However, there are several bluff locations along the reach that are actively delivering sediments. Erosion of at least one of these bluffs may be greatly exacerbated by illegal dredge spoils and an old dike that occur along the left bank and are forcing the active channel away from the historic floodplain and into the bluffs on the south side of the channel (Steve Todd, personal communication, 2002).

Mass Wasting

The section between Rogers Street and Hiddendale is showing signs of improvement but may have some residual effects that will take time to recover. Three bluffs in this section actively input sediments to various degrees. Currently, only the uppermost bluff in this section is introducing large amounts of fine sediment along with some LWD.

Road Density

There are 4.37 miles of road per square mile of watershed in this section (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

On the reach between Highway 101 and Rogers Street there are small conifers scattered throughout a deciduous dominated riparian zone at the pole/sapling stage (Bernthal and Rot 2001). From Highway 101 upstream to Hiddendale the riparian condition is degraded by rural development.

Water Quality

Temperature

At the USFWS hatchery, the August seven day average temperatures in the pre-settling pond were 14^{o}C (Larry Telles, personal communication, 2002). Port Gamble S'Klallam Tribe recorded water temperatures at Rogers Street Bridge in 2001 which are indicative of conditions between Rogers Street and the hatchery, and at Highway 101 (Labbe 2002). The temperatures, as follows, rate poor for both spawning and rearing at Rogers Street and poor for spawning and fair for rearing at Highway 101.

Table 4. Lower Big Quilcene Water Temperatures. Data provided by Ted Labbe, PGST

Stream/Location	2001 AIMT	2001 7-DADMT	2001 21-DADT
Big Quilcene – Rogers Street	18°C	17.7°C	13.4°C
Big Quilcene – Highway 101	16.4 °C	16.2 °C	12.6 °C

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

Dissolved oxygen is a data gap for this segment.

Hydrology

Flow – Hydrologic Maturity

The habitat limiting factors uses two parameters to assess flow: hydrologic maturity and percent impervious surface. Overall, hydrologic maturity is good throughout the watershed in spite of past logging activities. Immediately upstream of Rogers Street the riparian zone will continue to mature at a natural rate, providing that the local citizenry finds other sources of firewood and development remains low. The shoreline above the hatchery has been subplatted for development.

Flow – Percent Impervious Surface

Percent impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Data Needs

- Fine sediment data collection
- Stability of badly destabilized reaches vs. rip-rap
- Evaluate road and road crossing impacts on aquatic resources
- Establish escapement goals
- Determine percent impervious surface
- Monitor bank stability and causes for instability
- Continue temperature and flow monitoring

Big Quilcene River, river mile 3.2 to the falls at river mile 7.8

Access and Passage

Artificial Barriers

There are no known artificial barriers through this canyon reach, prior to the impassable falls at river mile 7.8.

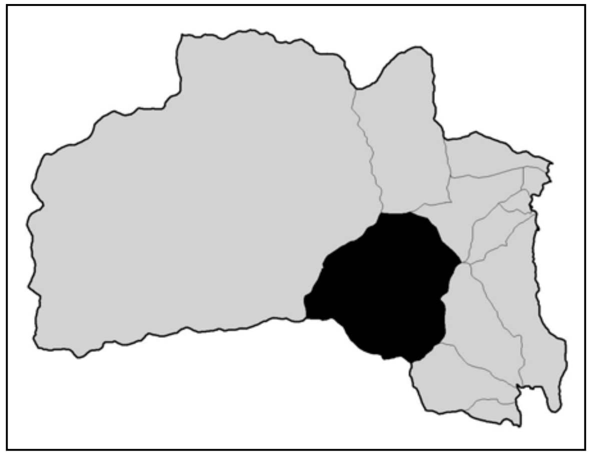

Figure 27. Big Quilcene, Hiddendale to Falls. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

This parameter is not applicable due to gradient.

Loss of Floodplain Habitat

This parameter is not applicable due to gradient.

Channel Conditions

Fine Sediment

Fine sediment sampling, applying TFW ambient monitoring protocols, has not been conducted in this watershed and has been identified as a data gap.

Large Woody Debris

Large boulders between Hiddendale and the falls provide some fish habitat. There is one small logjam within the canyon but other than this, there is no significant LWD (Ted Labbe, personal communication, 2002)

Percent Pool

The percent pools for the section between Hiddendale and the falls is rated poor based on LFA criteria. However, based on the USFS Watershed Analysis data, much of the reach is a confined transport reach so percent pools would naturally be small.

Pool Frequency

The pool frequency is good at 0.24 channel widths per pool for this reach (Matye et al.1994).

Pool Quality

Pool quality is unknown.

Streambank Stability

Above Hiddendale at river mile 3.2, streambanks are stable since the canyon is primarily composed of bedrock.

Sediment Input

Sediment Supply
Above Hiddendale, the sediment supply does not exceed the natural rate in this reach.

Mass Wasting
In the anadromous section above Hiddendale mass wasting is absent due to the bedrock canyon walls.

Road Density
Road density is 4.48 miles of road per square mile of watershed. In addition, there are 2.61 road crossings per mile of stream in this section, including all tributaries (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
Riparian condition is unknown through the canyon reach.

Water Quality

Temperature
Temperature readings for the remaining mainstem above Falls Creek Campground are good. Annual instantaneous maximum temperature in 2001 was 13.1^{o}C (Labbe 2002).

Dissolved Oxygen
This parameter is a data gap.

Hydrology

Flow – Hydrologic Maturity
From US101 to the Port Townsend water supply diversion is 67 percent of the watershed is older than 25 years (Matye et al.1994).

Flow – Percent Impervious Surface
Though data does not exist for percent impervious surface in this section, the rural and remote character of the landscape gives us sound reason to suspect it does not exceed three percent (Steve Todd, personal communication, 2002).

Biological Processes

Nutrients (Carcasses)
This parameter is a data gap.

Data Needs

- Large woody debris

- Percent pools
- Pool quality
- Riparian condition
- Evaluate current and potential impacts of forested roads and road crossings on aquatic resources

Big Quilcene River, above the falls at river mile 7.8, including Tunnel Creek and Townsend Creek

Access and Passage

Artificial Barriers

A natural falls on the mainstem at river mile 7.8 limits anadromous migration upstream. The City of Port Townsend has their water supply diversion dam at river mile 9.2, just downstream of the confluence with Tunnel Creek, which serves as an artificial barrier to resident fish migration. There are also culvert barriers for resident trout on Townsend Creek at milepost 0.45 on the US Forest Service 2750 Road, as well as a total barrier at the Penny Creek crossing of the Big Quilcene River Road (USFS Road 2027) at milepost 1 and a partial barrier where Penny Creek Road crosses Penny Creek.

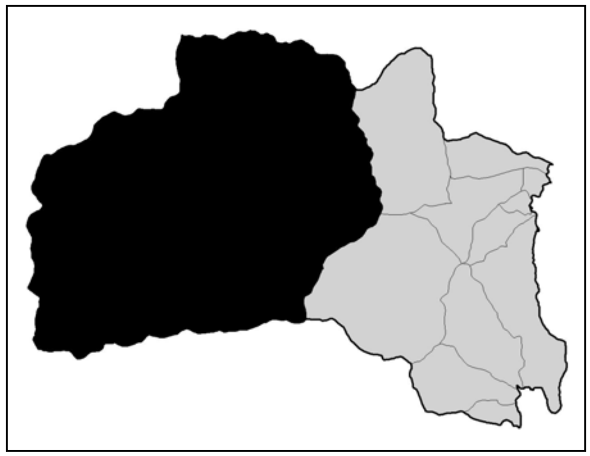

Figure 28. Upper Big Quilcene Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

This parameter is not applicable due to gradient.

Loss of Floodplain Habitat

This parameter is not applicable due to gradient.

Channel Conditions

Fine Sediment

Fine sediment sampling, according to TFW ambient monitoring protocols, has not been conducted in this watershed and has been identified as a data gap.

Large Woody Debris

Above the falls the amount of large woody debris is variable. It is generally poor in the mainstem but good in Tunnel Creek. These wood values are good for resident cutthroat and are important for routing sediment but the impact to downstream processes is unknown.

Percent Pool

The percent pools and pool quality above the falls is unknown.

Pool Frequency

Pool frequency is a data gap.

Pool Quality

The percent pools and pool quality above the falls is unknown.

Streambank Stability

Above the falls the streambank stability is variable with a low erosion potential. USFS Watershed Analysis (1994) gives it a high stability ranking but it is not quantified.

Sediment Supply

Sediment Supply

The sediment supply in the upper watershed exceeds the natural rate (Matye et al.1994).

Mass Wasting

According to the USFS Watershed Analysis, there is a 13-fold increase in landslide frequency in the upper watershed, including Penny Creek, with no understanding of how much enters the stream.

Road Density

The road density in the upper watershed is variable according to the USFS Watershed Analysis. It is good in the mainstem above the City of Port Townsend diversion and in both the south and north forks of Tunnel Creek. Townsend Creek and the mainstem Tunnel Creek watersheds have greater road densities. Over all, there are 2.04 miles of road per square mile of watershed (PNPTC, unpublished data, 2002), which rates fair.

Riparian Zones

Riparian Condition

The upper watershed is recovering from past timber harvest activities and several devastating fires and has a strong conifer component with good canopy closure and future large woody debris recruitment (TAG 2002). The USFS has initiated a riparian reserve program along the stream corridors under their ownership using two site potential tree heights as a guide adjacent to fish bearing streams and one site potential tree height along non-fish bearing streams. Riparian reserves are also in effect within geological hazard areas of steep, unstable slopes (Mark McHenry, personal communication, 2002).

Water Quality

Temperature

Temperature readings for the remaining mainstem above Falls View Campground are good. Annual instantaneous maximum temperature in 2001 was 13.1°C measured at Falls View Campground below the falls (Labbe 2002). Data are not available for the upper watershed.

Dissolved Oxygen

Dissolved oxygen is a data gap for this segment.

Hydrology

Flow – Hydrologic Maturity

From the City of Port Townsend's water supply diversion and extending into the upper watershed the hydrologic maturity varies among the different tributaries. South Fork Tunnel Creek has 70 percent of the watershed in forests older than 25 years (good rating), North Fork Tunnel Creek is slightly greater than 48 percent (poor rating), and mainstem Tunnel Creek is at 65 percent (good rating). The mainstem Big Quilcene River has greater than 48 percent (poor rating) of the watershed in forests older than 25 years (Matye et al.1994).

Flow – Percent Impervious Surface

Though data does not exist for percent impervious surface in this section, the rural and remote character of the landscape gives us sound reason to suspect it does not exceed three percent (Steve Todd, personal communication, 2002).

Biological Processes

Nutrients (Carcasses)

This section of the Big Quilcene does not receive anadromous fish, and it is currently difficult to assess historic vs. current carcass contributions from residential salmonids.

Data Needs

- Fine sediment data collection
- Percent pool habitat
- Pool quality
- Evaluate road impacts to aquatic resources

Penny Creek, tributary to the Big Quilcene River at river mile 2.8

Access and Passage

Artificial Barriers

The Quilcene National Fish Hatchery intake system is at the confluence of Penny Creek with the mainstem and eliminates anadromous access to Penny Creek, which has been identified as some of the best refugia in east Jefferson County (Paula Mackrow, personal communication 2002.

Floodplains

Floodplain Connectivity

This parameter is not applicable due to gradient.

Loss of Floodplain Habitat

This parameter is not applicable due to gradient.

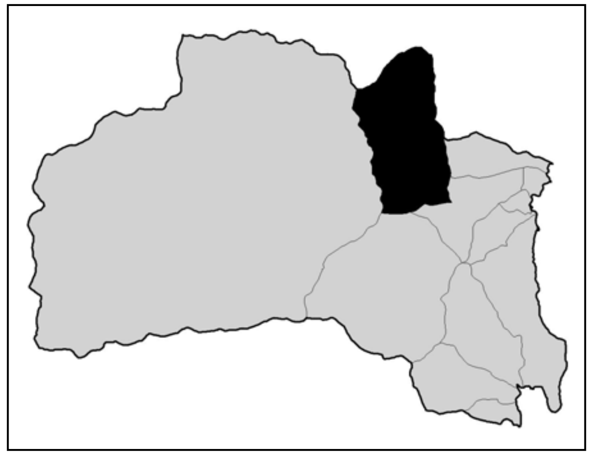

Figure 29. Penny Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Channel Conditions

Fine Sediment

Fine sediment sampling, applying TFW ambient monitoring protocols, has not been conducted in this watershed and has been identified as a data gap.

Large Woody Debris

Large woody debris surveys are lacking in Penny Creek but professional knowledge of TAG members indicate a poor to fair rating due to the low conifer recruitment potential, especially large key pieces.

Percent Pool

Penny Creek pool habitat information is a data gap but there are known beaver ponds in the headwaters.

Pool Frequency

Penny Creek pool habitat information is a data gap but there are known beaver ponds in the headwaters.

Pool Quality

Penny Creek pool habitat information is a data gap.

Streambank Stability

Streambank stability in Penny Creek is unknown.

Sediment Supply

Sediment Supply

Sediment supply is a data gap for Penny Creek.

Mass Wasting

According to the USFS Watershed Analysis (1994), there is a 13-fold increase in landslide frequency in the upper watershed, including Penny Creek, with no understanding of how much enters the stream.

Road Density

Penny Creek has a road density at 2.73 miles of road per square mile of watershed. Perhaps of equal importance, the road crossing frequency in the Penny Creek watershed is 1.85 crossings/mile of stream (PNPTC, unpublished data, 2002). As a point of interest, there are more county roads than forest service roads in this section (TAG 2002).

Riparian Zones

Riparian Condition

The Penny Creek watershed lacks a conifer component in the riparian zone (TAG 2002).

Water Quality

Temperature

Penny Creek water temperature data were collected by Port Gamble S'Klallam Tribe in 1992, 1993, 1994 (using Taylor maximum-minimum thermometers) and 2001 (using continuous temperature data loggers) at Big Quilcene River Road (Labbe 2002).

Location	1992 AIMT	1993 AIMT	1994 AIMT	2001 AIMT	2001 7-DADMT	2001 21-DADT
Penny Creek	13.3°C	13.3 °C	13.9 °C	12.7 °C	12.5 °C	11.2 °C

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

Dissolved oxygen is a data gap for this segment.

Hydrology

Flow – Hydrologic Maturity

This parameter is a data gap.

Flow – Percent Impervious Surface
Though data do not exist for percent impervious surface in this section, the rural and remote character of the landscape gives us sound reason to suspect it does not exceed three percent (Steve Todd, personal communication, 2002).

Biological Processes

Nutrients (Carcasses)
There is currently uncertainty as to whether the Penny Creek system was used by salmonids, and the extent of that use, in historic times. Gradient and other habitat factors, including extensive beaver ponds, suggest it may have been used by species such as coho salmon before operation of the Quilcene National Fish Hatchery (Steve Todd, personal communication, 2002).

Data Needs

- Fine sediment data collection
- Channel condition, including LWD, pools, bank stability
- Sediment supply and mass wasting
- Dissolved oxygen
- Evaluate the impact of roads and road crossings on aquatic resources
- Determine historic salmonid use of Penny Creek watershed

Action Recommendations
The following sequenced salmon habitat restoration actions are recommended for the Big Quilcene River watershed:

1. Protect and restore natural processes in the lower river and estuary
   NOTE: Acquisition or conservation easements may be needed to accomplish the following restoration activities:
    a. Address dike and road impacts in the lower reach
    b. Restore sinuosity
    c. Reestablish functional estuary/freshwater link
    d. Address artificially aggraded delta cone sediments
2. Protect and restore riverine function above river mile 1.1
    a. Restore channel complexity (LWD) and sinuosity
    b. Protect intact riparian forest
    c. Restore fish passage above hatchery weir
3. Monitor and address mass wasting, as per watershed analysis
    a. Identify, abate and monitor sediment sources
    b. Maintain or abandon roads in the upstream forest areas
    c. Quantify severity of scour problem
4. Hydrologic and flow studies (WRIA 17 Planning Unit)
    a. Assess hydrologic continuity between groundwater and surface water
    b. Build watershed hydrologic model
    c. Assess minimum necessary summer low flow
    d. Address summer low flow

LITTLE QUILCENE SUB-BASIN

For the purpose of this discussion, the Little Quilcene River subbasin includes the Little Quilcene River (WRIA 17.0076) and its major tributaries (Leland Creek (WRIA 17.0077), Ripley Creek (WRIA 17.0089) and Howe Creek (WRIA 17.0090)) as well as Donovan Creek (WRIA 17.0015) and its major tributary, Jakeway Creek (WRIA 17.0016). The TAG divided the Little Quilcene sub-basin into the following reaches for their analysis

1. Little Quilcene mouth to river mile 2.7
2. Little Quilcene river mile 2.7 to 6.8
3. Little Quilcene above river mile 6.8
4. Leland Creek, tributary to Little Quilcene at river mile 1.7
5. Ripley Creek, tributary to Little Quilcene at river mile 4.35
6. Howe Creek, tributary to Little Quilcene at river mile 5.2
7. Donovan Creek
8. Jakeway Creek, tributary to Donovan Creek at river mile 0.1

US Forest Service watershed analysis was not used for this report because the sample size for channel condition data was too small to be statistically valid. The Point No Point Treaty Council collected TFW ambient monitoring data for channel conditions and riparian condition and provided road density estimates. The Port Gamble S'Klallam Tribe provided temperature data. The TAG had some professional knowledge of the watershed and provided input where possible. The remaining parameters are identified as data needs. The following is the habitat evaluation for these watersheds as completed by the TAG:

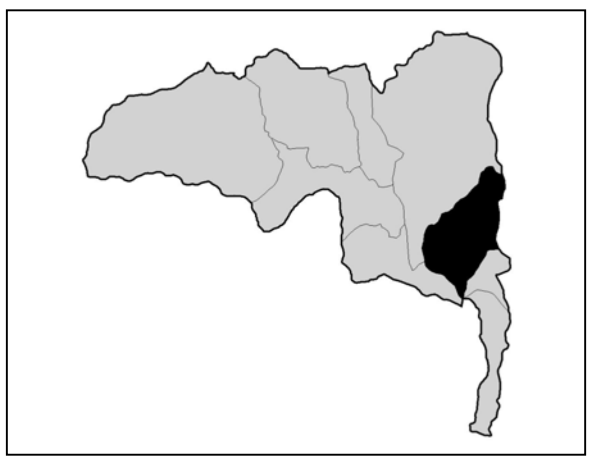

Figure 30. Little Quilcene Watershed, river mile 0.0 to 2.7. Map provided by Jennifer Cutler, NWIFC

Little Quilcene River – mouth to river mile 2.7

Access and Passage

Artificial Barriers

There are no physical artificial barriers in the downstream reach of the Little Quilcene River between the mouth and the natural barrier (falls) at river mile 6.8.

Floodplains

Floodplain Connectivity

Floodplain connectivity has been reduced throughout the lower reach by ditching, diking and dredging. The channel is incised and over 70% has been disconnected from its floodplain. The streambanks have been armored and stream cleanout is continuing, actions that help perpetuate the disconnection between the channel and floodplain habitat (Ted Labbe, personal communication, 2002).

Loss of Floodplain Habitat

Floodplain habitat has been lost through conversion to agriculture as well as the associated ditching/diking activities (TAG 29 March 2002). Due to accumulation of sediment in the lower reach, mid channel bars have formed with the river alternating flows between the left and right banks. Due to the ditching and diking activities, these sediments are no longer distributed to the floodplain.

Channel Conditions

Fine Sediment

The TAG has identified this parameter as a data gap throughout the watershed.

Large Woody Debris

Large woody debris has been removed from the lower reach. The riparian zone lacks conifer trees and thus limits future recruitment (Ted Labbe, personal communication, 2002). There is less than one piece of wood per channel width throughout this segment (Bernthal and Rot 2001).

Percent Pools

The lower 0.2-mile of Little Quilcene River rates good with 50 percent pools but becomes fair/poor between river mile 0.2 and river mile 2.7 (Bernthal and Rot 2001).

Pool Frequency

Pool frequency is greater than four channel widths per pool (Bernthal and Rot 2001). The situation becomes better above highway 101 but it still rates poor all the way to the falls. TAG member Chris May has observed small pocket pools in the lower reach with very little protection.

Pool Quality

The lower reach has five percent pools deeper than one meter (Bernthal and Rot 2001). Lack of cover reduces quality.

Streambank Stability

Data has not been collected for the lower mainstem reach but observations indicate a poor condition below highway 101 as evidenced by armored ditches (Ted Labbe, personal communication, 2002) and an improved condition above 101 (Chris May, personal communication, 2002).

Sediment Input

Sediment Supply

The low gradient reach of the mainstem is a deposition reach with an accumulation of sediments that have created mid-channel bars with the river alternating its course on either side of the bars. These sediments are no longer distributed to the floodplain due to the dredging/diking activities associated with agriculture and residential development. However, specific data is lacking throughout the mainstem and this parameter was not rated.

Mass Wasting

The lower reach from the mouth to river mile 2.7 has low banks and there appears to be no increase over natural levels for mass wasting. Data is lacking regarding mass wasting along the remainder of the mainstem.

Road Density

The lower reach of the mainstem between the mouth and river mile 2.7 has 5.24 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Riparian condition in the lower watershed is poor as it is alder dominated (Chris May, personal communication, 2002) with numerous exotic species such as ivy, holly, blackberry and reed canary grass (Richard Brocksmith, personal communication, 2002). There are 1.19 road crossings per mile of stream (0.74 per kilometer) in this section, which tends to fragment the canopy cover (PNPTC, unpublished data, 2002).

Water Quality

Temperature

Port Gamble S'Klallam Tribe collected temperature data in 1992, 1993, 1994 and 2001 in the lower Little Quilcene at Highway 101. The average instantaneous maximum temperature was 16.6^{o}C (Labbe 2002). In addition, Jefferson County Conservation District provided 1986 grab sample data of 16.1^{o}C at river mile 0.8 and 16.1^{o}C at river mile 1.5.

Table 5. Lower Little Quilcene River Water Temperatures. Data provided by Port Gamble S'Klallam Tribe.

Stream/Location	1992 AIMT °C	1993 AIMT °C	1994 AIMT °C	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C
Little Quilcene – RM 0.0-2.7	17.2	15.6	17.8	16.0	15.7	13.2

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

Glenn Gately of the Jefferson County Conservation District collected dissolved oxygen grab-sample data in 1993 at river mile 0.8 (Center Valley Road). The lowest reading was in July at 9.4 mg/L.

Hydrology

Flow: Hydrologic Maturity

The TAG agreed that, while hydrology in the entire watershed appears to be good, flow data is needed between the mouth and river mile 6.8 for better analysis.

Flow: Percent Impervious Surface

Percent impervious surface is unknown. There are localized stormwater issues in the lower sections due to road crossings.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Estuary

Beginning in the late 1800s, extensive diking has occurred in the Little Quilcene River estuary, eliminating good quality salt marsh habitat and estuary function. The delta has prograded due to loss of floodplain connectivity and deposition area for the excessive sediment load from the upper watershed.

Restoration activities necessary to restore estuary function involve dike removal, restoration of sinuosity in the lower river and estuary, and removal of some of the delta cone that has prograded.

Data Needs

- Fine sediment data

- Determine relationship between number of logjams and TFW LWD pieces
- Assess sediment supply
- Determine hydrologic maturity
- Determine percent impervious surface
- Evaluate nutrients
- Evaluate road and road crossing impacts on aquatic resources

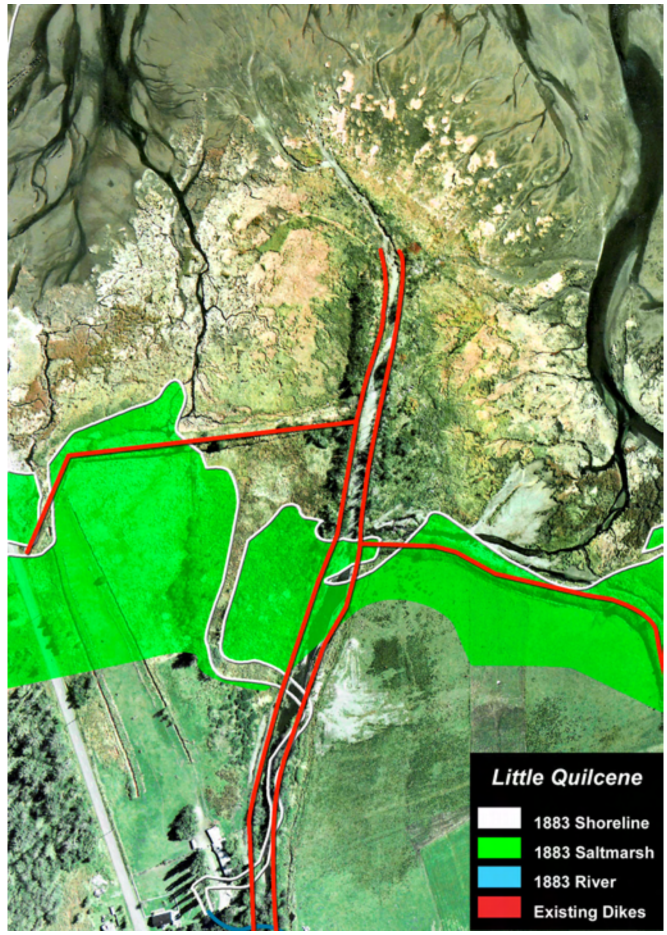

Figure 31. Little Quilcene River Estuary. Graphics provided by Randy Johnson, WDFW

Little Quilcene River – river mile 2.7 to 6.8

Access and Passage

Artificial Barriers

There are no physical artificial barriers in the downstream reach of the Little Quilcene River between the mouth and the natural barrier (falls) at river mile 6.8.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable in this segment due to gradient.

Channel Conditions

Fine Sediment

The TAG has identified this parameter as a data gap throughout the watershed.

Large Woody Debris

Large woody debris is rare in this segment with less than one piece of wood per channel width (Bernthal and Rot 2001) but has some potential to improve if adequate buffers are retained (TAG 2002).

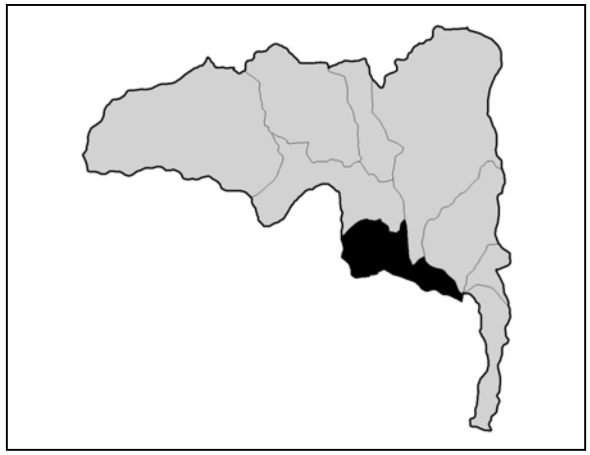

Figure 32. Little Quilcene Watershed, river mile 2.7 to 6.8. Map provided by Jennifer Cutler, NWIFC

Percent Pools

Between river mile 2.7 and 5.2, percent pools is poor at 23 to 25 percent (Bernthal and Rot 2001). The TAG suspects that the condition is similar from river mile 5.2 to the falls.

Pool Frequency

Pool frequency is poor at 4.5 and 4.8 channel widths per pool in the two reaches evaluated by Point No Point Treaty Council (Bernthal and Rot 2001). The TAG assigned a poor rating all the way to the falls.

Pool Quality

Bernthal and Rot (2001) report ten percent pools deeper than one meter with some riparian cover.

Streambank Stability

There is not enough information to evaluate this parameter above river mile 2.7.

Sediment Input

Sediment Supply

This parameter is a data gap.

Mass Wasting

Data is lacking regarding mass wasting for this section of the mainstem.

Road Density

Road density in this segment is 3.33 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Between river mile 2.7 and 6.8 there is a narrow riparian zone, which has been harvested but is growing back as a conifer dominated forest. Actual data is lacking in general throughout this section.

Water Quality

Temperature/Dissolved Oxygen

There is no water quality data for this segment.

Hydrology

Flow: Hydrologic Maturity

The TAG agreed that, while hydrology in the entire watershed appears to be good, flow data is needed between the mouth and river mile 6.8 for better analysis.

Flow: Percent Impervious Surface

Percent impervious surface is unknown. There are localized stormwater issues in the lower sections due to road crossings.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Data Needs

- Gather fine sediment data
- Determine relationship between number of logjams and TFW LWD pieces
- Assess streambank stability
- Determine sediment supply and mass wasting
- Assess riparian condition
- Collect water quality data
- Determine hydrologic maturity and percent impervious surface
- Evaluate nutrients
- Evaluate road and road crossing impacts on aquatic resources

Little Quilcene River – above river mile 6.8

Access and Passage

Artificial Barriers

Although the barriers upstream of the falls have not been systematically evaluated, the US Forest Service has identified a resident fish blockage at milepost 0.9 on the 2700 330 road.

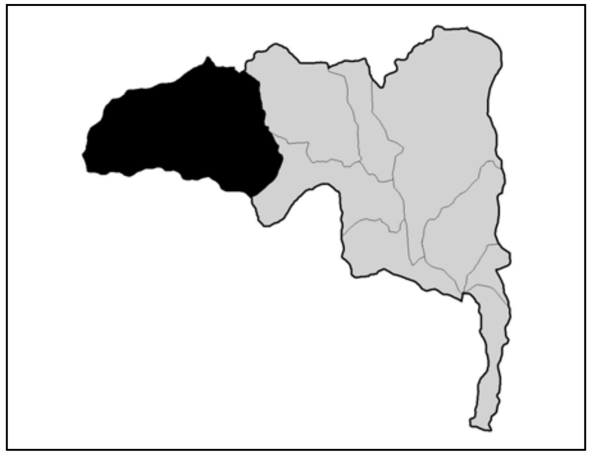

Figure 33. Upper Little Quilcene Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplains were not evaluated due to gradient.

Channel Conditions

Channel information collected above the falls by the US Forest Service does not have an adequate sample size from which to draw conclusions (TAG 2002).

Sediment Input

Sediment Supply

Specific data are lacking throughout the upper watershed and this parameter was not rated.

Mass Wasting

Data is lacking regarding mass wasting for this section of the mainstem.

Road Density

Road density in the upper watershed is poor at 3.26 miles of road per square mile of watershed, which includes all tributaries to this section (PNPTC, unpublished data, 2002). The US Forest Service is decommissioning roads in the upper Little Quilcene River, Deadfall Creek, and the lower Little Quilcene River.

Riparian Zones

Riparian Condition

Riparian reserves, which leave two site-potential tree heights (380 feet) on fish bearing streams and one site-potential tree height (190 feet) on non-fish bearing streams with steep and unstable slopes, are in place on USFS lands in the upper watershed.

Water Quality

Temperature

One year of temperature readings taken at the forest Service Road 3039 crossing in 2001 indicate a fair rating for temperature, although it was noted that 2001 was a low water year (Labbe pers. comm. 29 March 2002).

Table 6. Upper Little Quilcene River Water Temperature. Data provided by Port Gamble S'Klallam Tribe

Stream/Location	2001 AIMT ^{o}C	2001 7-DADMT ^{o}C	2001 21-DADT ^{o}C
Upper Little Quilcene River	14.6	14.4	12

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

No dissolved oxygen data have been collected for this segment of the mainstem, although the TAG assumes conditions to be good based on gradient and water temperatures.

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity, as measured by the proportion of watershed composed of mature native vegetation, is unknown. Above the falls at river mile 7.1, the City of Port Townsend diverts water (9.6 cfs water right with 6 cfs minimum instream flow requirement at the diversion) to Lords Lake Reservoir on Howe Creek, which is removed from the watershed. This water right is junior to a total of 5 cfs of water rights held by landowners in Quilcene (Ames et al 2000). Lords Lake Reservoir, which is usually filled in April/May, is used to supplement Port Townsend water diverted from the Big Quilcene when flows decline below the Big Quilcene minimum instream flow level, or when the Big Quilcene contains excessive suspended sediment during floods (Ames et al 2000).

Flow: Percent Impervious Surface

Percent impervious surface is unknown.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Data Needs

- Gather fine sediment data
- Assess LWD
- Evaluate pool quantity, frequency and quality
- Assess streambank stability
- Determine sediment supply
- Assess riparian condition
- Collect water temperature data
- Evaluate road and road crossing impacts on aquatic resources

Leland Creek

Access and Passage

Artificial Barriers

A total barrier exists on an unnamed tributary (17.0078) to Leland Creek at West Leland Valley Road. There is a railroad grade along the foot of the valley wall that presents migratory problems. There is no information on private culverts. Dense reed canary grass encroachment presents a very serious problem ½ mile downstream of Lake Leland and up to its outlet and can restrict fish migration through this reach during certain flows. In addition, there are problematic patches of reed canary grass all the way downstream to river mile 1.0. An unnamed fish-bearing tributary (17.0081) has been rerouted to enter Lake Leland and there are many ditches that could strand fish in this area. Fish are known to extend up to river mile 4.5 and are presumed an additional 2.4 miles. Therefore, the TAG rated this parameter fair.

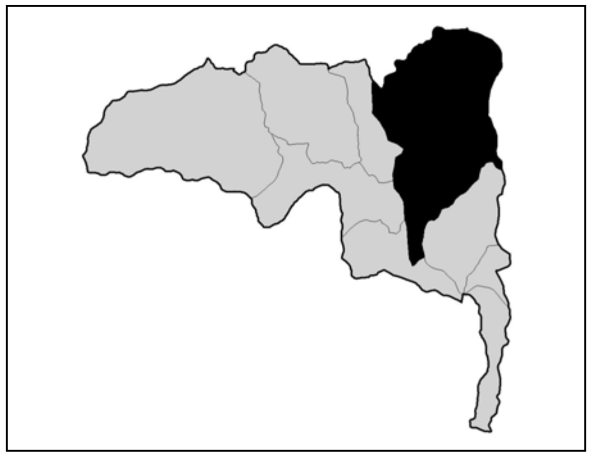

Figure 34. Leland Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

A railroad bed confines the channel as it crosses back and forth across the stream within the floodplain. Highway 101 and West Leland Valley Road confine the stream, which has also been channelized. Where the stream has not been confined by roads, it has incised.

Loss of Floodplain Habitat

At one time, Leland Creek Valley was dominated by cedar swamp habitat and numerous beaver dams created habitat diversity and floodplain connection (Labbe, pers. comm. 29

March 2002). Land conversion to agricultural and residential uses has altered the natural floodplain habitat.

Channel Conditions

Fine Sediment

The TAG has identified this parameter as a data gap throughout the watershed.

Large Woody Debris

Leland Creek lacks large woody debris although TAG members acknowledged there is some downstream of the reed canary grass section.

Percent Pools

Pool habitat data on Leland Creek have not been collected, but the observations of the TAG indicate that pools comprise a relatively small portion of stream surface area.

Pool Frequency

Data for pool frequency in Leland Creek does not exist but the consensus among the TAG is that there are beaver dams above highway 101. Below highway 101 pools are uncommon.

Pool Quality

Data for pool quality in Leland Creek do not exist but there are beaver dams above highway 101, which provide quality pool habitat. Little quality pool habitat is present downstream from highway 101 (TAG 2002).

Streambank Stability

There are bedrock outcroppings along Leland Creek that serve as local grade controls and prevent streambank erosion. However, where alluvial and glacial sediments are found along this stream and where there has been vegetation and LWD removal, there is some very significant streambank erosion problems (Ted Labbe, personal communication (2002). The agriculturally developed areas have been ditched and dredged without the addition of habitat structure and these areas have streambank stability problems (TAG 2002).

Sediment Input

Sediment Supply

Leland Creek has sediment problems but nothing has been quantified (TAG 2002).

Mass Wasting

There are no data available for Leland Creek but there are no known conditions that would contribute to mass wasting in this tributary due to its low gradient (TAG 2002).

Road Density
Road density for Leland Creek is poor at 3.87 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
Exotic and invasive plant species are common in the riparian zone along Leland Creek. There are 1.55 road crossings per mile of stream, or 0.96 per kilometer (PNPTC, unpublished data, 2002).

Water Quality

Temperature
Leland Creek water temperatures, taken at Rice Lake Road between highway 101 and the confluence with the Little Quilcene River were high. The annual instantaneous maximum temperatures for 1992, 1993 and 1994 were 16.7°C, 18.3°C and 17.2°C respectively and 18.1°C in 2001 (Labbe 2002) (see Table 3). The seven-day average daily maximum temperature in 2001 at this location was 17.7°C. These readings are substantiated by Jefferson County Conservation District grab sample data taken between noon and 2 pm in 1998 near Lake Leland, which averaged 18.4°C between June and September.

Table 7. Leland Creek Water Temperatures. Data provided by Port Gamble S'Klallam Tribe.

Stream/Location	1992 AIMT °C	1993 AIMT °C	1994 AIMT °C	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C
Leland Creek	16.7	18.3	17.2	18.1	17.7	15.4

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen
Dissolved oxygen readings taken in 1998 at the outlet of Lake Leland (surface release estimated to be 2 to 4 cubic feet per second) were good until March (see Table 4).

Table 8. Leland Creek Dissolved Oxygen Concentrations. Data provided by Glenn Gately, JCCD

Location	Mar	Apr	May	June	July	Aug	Sept
Leland Creek – lake outlet	6.7mL	3.1mL	1.4mL	1.4mL	0.0mL	0.0mL	0.0mL

Readings were consistently poor throughout the reed canary grass section. The exotic Brazilian elodea creates problems for dissolved oxygen in Lake Leland itself. Water quality downstream to the confluence is unknown.

Hydrology

Flow: Hydrologic Maturity
Hydrologic maturity is a data gap.

Flow: Percent Impervious Surface
Percent impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)
Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Data Needs
- Conduct culvert/barrier assessment on private roads
- Evaluate road and road crossing impacts on aquatic resources
- Gather fine sediment data
- Assess streambank stability
- Determine sediment supply
- Evaluate nutrients
- Assess riparian condition

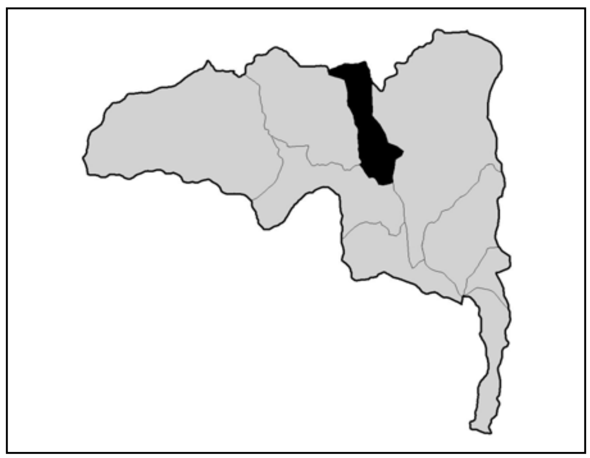

Figure 35. Ripley Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Ripley Creek

Access and Passage

Artificial Barriers
There are no culvert issues on Ripley Creek but the stream goes subsurface above Little Quilcene Road, which could be a natural occurrence. There are numerous wetlands and beaver dams in the upper watershed.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
This parameter is not applicable in this segment due to gradient.

Channel Conditions

Fine Sediment
The TAG has identified this parameter as a data gap throughout the watershed.

Large Woody Debris

Ripley Creek lacks LWD but the recruitment potential is good as there is a fully forested mixed riparian zone (TAG 2002).

Percent Pools

Ripley Creek has 50 percent pools by surface area (Bernthal and Rot 2001)

Pool Frequency

Pool frequency is 3.6 channel widths per pool (Bernthal and Rot 2001), which rates fair.

Pool Quality

Bernthal and Rot (2001) reports two percent pools with a depth greater than one meter. Timber/Fish/Wildlife protocols that were used do not take into account pools associated with beaver dams and wetlands, which could provide additional quality pools (TAG 2002).

Streambank Stability

Streambank stability for Ripley Creek is a data gap but the TAG does not suspect a big problem.

Sediment Input

Sediment Supply

Data is lacking for this parameter for Ripley Creek.

Mass Wasting

There is no data available for Ripley Creek but there are no known conditions that would contribute to mass wasting in this tributary due to its low gradient (TAG 2002).

Road Density

Road density calculations for Ripley Creek are 4.51 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Ripley Creek's riparian zone is fully forested but narrow in spots with mixed composition and mature age class (TAG 2002).

Water Quality

Temperature

Ripley Creek annual maximum temperatures taken in 1992, 1993, and 1994 by Port Gamble S'Klallam Tribe were 16.7, 18.9 and 19.4 respectively (Labbe 2002). A small amount of water originates from beaver ponds and wetlands (TAG 2002). It is difficult to measure water temperatures in a stream that regularly dries and leaves flows spatially discontinuous (Ted Labbe, personal communication, 2002).

Table 9. Ripley Creek Water Temperature. Data collected by Port Gamble S'Klallam Tribe

Stream/Location	1992 AIMT °C	1993 AIMT °C	1994 AIMT °C	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C
Ripley Creek	16.7	18.9	16.1	19.1	18.3	13.5

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen

There is no dissolved oxygen data for Ripley Creek.

Hydrology

Flow: Hydrologic Maturity

Ripley Creek regularly dries during summer months and it is not clear if this phenomenon was common historically or if it has been exacerbated by land use practices (Ted Labbe, personal communication, 2002). Hydrologic maturity is a data gap.

Flow: Percent Impervious Surface

Percent impervious surface is a data gap. However, due to its remote location away from rural development, it is likely that impervious surface does not exceed 3 percent (Steve Todd, personal communication, 2002).

Biological Processes

Nutrients (Carcasses

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Data Needs

- Gather fine sediment data
- Evaluate streambank stability
- Determine sediment supply
- Gather dissolved oxygen data
- Evaluate road and road crossing impacts on aquatic resources

Howe Creek

Access and Passage

Artificial Barriers

A natural falls at river mile 0.4 on Howe Creek prevents anadromous migration upstream. Upstream of the falls are four barriers to resident migration but the significance is unknown. There are two partial resident fish barriers on Lords Lake Loop Road, one at milepost 2.9 and one at milepost 4.43. The Lords Lake outlet to Howe Creek is incised and of steep gradient and a debate continues as to the existence of native fish in the lake outlet prior to becoming the City of Port Townsend's water supply.

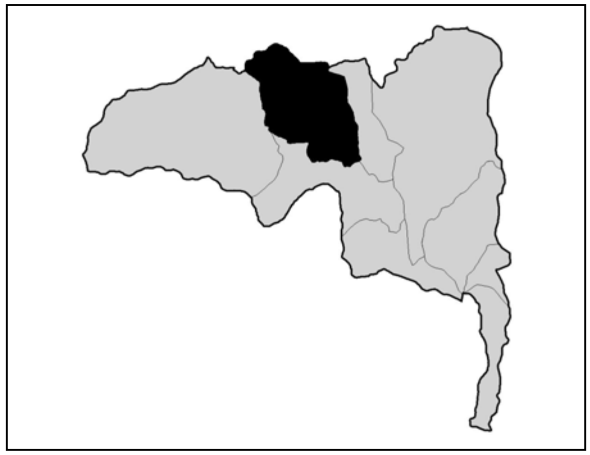

Figure 36. Howe Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity/Loss of Floodplain Connectivity

This parameter is not applicable in this segment due to gradient.

Channel Conditions

Fine Sediment

The TAG has identified this parameter as a data gap throughout the watershed.

Large Woody Debris

Howe Creek is lacking large woody debris (TAG 2002).

Percent Pools

Percent pools for Howe Creek ranges between five and thirty-one percent for pools 0.5 to one meter in depth, with no pools greater than one meter deep (Bernthal and Rot 2001). The data do not account for the beaver influenced reaches, which provide good overwintering/pool habitat (TAG 2002).

Pool Frequency

Pool frequency for Howe Creek averages two to four channel widths per pool (Bernthal and Rot 2001).

Pool Quality

Bernthal and Rot (2001) gives Howe Creek a poor rating, as there are no pools greater than one meter deep. Timber/Fish/Wildlife protocols that were used do not take into account pools associated with beaver dams and wetlands, which could elevate the rating (TAG 2002).

Streambank Stability
Data for this parameter is lacking for Howe Creek.

Sediment Input

Sediment Supply
This parameter is a data gap for this segment.

Mass Wasting
Even though the headwaters of Howe Creek are in the foothills of the Olympic Mountains, the gradient is low enough to not suspect mass wasting problems (TAG 2002).

Road Density
Road density for Howe Creek is 1.70 miles of road per square mile of watershed. Most of the roads are in the lower reach of this tributary (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
The TAG considers riparian condition in Howe Creek fair. There are large conifers in the lower reach near the falls but density decreases upstream. Road crossings for Howe Creek are 0.8 per mile (PNPTC, unpublished data, 2002), which does not seriously impact riparian connectivity (Chris May, personal communication, 2002).

Water Quality

Temperature
Temperatures for Howe Creek below the beaver dams in 2001 were high (Labbe 2002).

Table 10. Howe Creek Water Temperature. Data provided by Port Gamble S'Klallam Tribe

Stream/Location	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C
Howe Creek	19.9	19.4	15.8

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen
There are no dissolved oxygen readings for Howe Creek.

Hydrology

Flow: Hydrologic Maturity

Hydrologic maturity is a data gap.

Flow: Percent Impervious Surface

Percent impervious surface is a data gap. However, due to the remote location of the watershed, it is conceivable that impervious surface does not exceed 3 percent.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable.

Data Needs

- Gather fine sediment data
- Assess streambank stability
- Determine sediment supply
- Collect dissolved oxygen data
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

The following sequenced salmon habitat restoration actions are recommended for the Little Quilcene River watershed:

1. Restore estuary function/reestablish functional estuary-freshwater link
   NOTE: Acquisition and/or conservation easements might be needed to accomplish the following activities:
    a. Restore north Little Quilcene salt marsh/tidal prism
    b. Restore south Little Quilcene salt marsh/tidal prism
    c. Restore estuarine diked areas
    d. Evaluate relative effect of road fill causeways on the creation and maintenance of tidal sloughs
2. Protect and restore natural riverine functions
    a. Acquire property or easements
    b. Remove dikes
    c. Restore channel sinuosity
    d. Update floodplain and channel migration maps
    e. Add complexity such as LWD
3. Assess, stabilize, monitor sediment sources
4. Hydrologic and flow studies (WRIA 17 planning unit)
    a. Assess hydrologic continuity between groundwater and surface water
    b. Build watershed hydrologic model
    c. Assess minimum necessary summer low flow

Donovan/Jakeway - WRIA 17.0115/17.0116

Data are lacking for Donovan/Jakeway Creeks but the TAG has some professional knowledge of the watershed and was able to contribute some information. Port Gamble S'Klallam Tribe provided temperature data. Steve Todd at the PNPTC calculated road densities. The remaining parameters are identified as data needs.

Access and Passage

Artificial Barriers

A natural falls at river mile 2.1 defines the extent of anadromy on mainstem Donovan Creek. One artificial partial barrier on a farm road that crosses an unnamed tributary, WRIA 17.0118, is within the anadromous reach and two additional barriers, one on an unnamed tributary, WRIA 17.0119, and one on the mainstem are both above the falls and both occur at Center Road (TAG 2002).

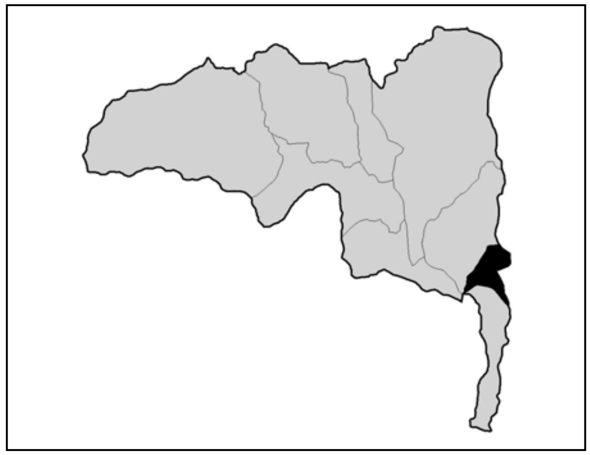

Figure 37. Donovan/Jakeway Watershed. Map provided by Jennifer Cutler, NWIFC

A natural barrier on Jakeway Creek at river mile 1.0 restricts anadromous fish migration above this point. All artificial barriers downstream of this point have been corrected due to efforts of Jefferson County Conservation District, Wild Olympic Salmon and the Quilcene/Snow Jobs for the Environment Crew.

Floodplains

Floodplain Connectivity

The low gradient downstream sections in both Donovan Creek and Jakeway Creek have been channelized and have become incised (TAG 2002).

Loss of Floodplain Habitat

Channelization, incision, and conversion to agriculture have disconnected the floodplains of Donovan and Jakeway Creeks (TAG 2002).

Channel Conditions

Fine Sediment

There are no data available to determine the status of this parameter.

Large Woody Debris

There are no data available on LWD, but local observations by TAG members suggest there is no LWD in the agriculture section of Donovan Creek between river mile 0.0 and

0.4. Conditions improve within the wooded section between river mile 0.4 and the falls, but they are not ideal (TAG 2002).

The lower section of Jakeway Creek between river mile 0.0 and 0.4 has also been cleared for agriculture and contains little large woody debris, according to personal observation of TAG members. Past restoration efforts (Jefferson Conservation District, Wild Olympic Salmon and Quilcene/Snow Jobs for the Environment Crew) in this section included the addition of some large woody debris, along with streambed stabilization utilizing log weirs and cattle exclusion fencing.

Percent Pools

No data exist for this parameter, but based on local observation the TAG estimates that there are greater than forty percent pools.

Pool Frequency

No data exists for this parameter.

Pool Quality

No data exists for this parameter.

Streambank Stability

Based on professional observation, streambanks on Donovan Creek within the channelized section are unstable due channelization. The streambank stability outside of the channelized section is good (TAG 2002).

On Jakeway Creek above river mile 0.4, the steep slopes were logged just prior to the 1997 rain-on-snow event causing unnatural amounts of gravel to inundate the channel. However, the bank stability is unquantified (TAG 2002).

Sediment Input

Sediment Supply

Monthly total suspended solids measurements in Donovan Creek were consistently higher downstream at river mile 0.4 than upstream at river mile 1.9, alluding to streambank erosion in this reach (Gately 2001). However, the TAG determined that data is lacking to evaluate this element at this time.

Mass Wasting

No data exist to evaluate this element.

Road Density

Road density for Donovan Creek is poor at 3.09 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Road density for Jakeway Creek is considered fair at 2.58 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

TAG member Chris May has determined the forested area between river mile 0.8 and the falls on Donovan Creek has dense riparian coverage. The area between river mile 0.4 to 0.8 has been cleared for agriculture with only pockets of riparian vegetation. Existing cedar stumps provide evidence of an historic cedar forest in this reach.

Land use conversion to agriculture and recent clearcutting activity in the upper watershed has damaged/removed riparian vegetation along Jakeway Creek (TAG 2002).

Water Quality

Temperature

TAG member Ted Labbe, Port Gamble S'Klallam tribal biologist, provided temperature data for Donovan Creek, collected from 1992 through 1994 and again in the summer of 2001 and measured in the agriculturally developed section (see Table 11). The annual maximum temperatures ranged from 18.9°C to a high of 22.8°C. TAG member Glenn Gately, Jefferson County Conservation District water quality specialist, corroborates these data with two grab samples taken in July and August of 1986 at the Quilcene Road Bridge where temperatures ranged from 18.2°C to 19.5°C.

Table 11. Donovan Creek Watershed Water Temperatures. Data provided by Port Gamble S'Klallam Tribe

STREAM NAME	1992 AIMT °C	1993 AIMT °C	1994 AIMT °C	2001 AIMT °C	2001 7-DADMT °C	2001 21-DADT °C
Donovan Creek	18.9	22.8	22.8	20.1	19.3	16.3

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Glenn Gately also collected temperature data at two sites on Jakeway Creek, river mile 0.0 and river mile 0.4, once the beginning of a forest. In 1993, the upper site approached 16°C. In 1996, the temperature reading was 17.2°C. At the mouth in 1993, two August temperature readings reached 18.6°C and 17.6°C. At this same site on July 26, 1996, the temperature was elevated to 25.4°C, possibly and partly due to landowner's diversion of the creek to a pond. On this same day, the water temperature immediately above the pond was 21.8°C but reached a higher reading of 26.0°C immediately downstream of the pond. Two readings in August of 1996 at river mile 0.0 were 20.0°C and 18.2°C.

Dissolved Oxygen

Glenn Gately provided dissolved oxygen data taken from two sites on Donovan Creek, approximately river mile 0.1 during the summer of 1993 and 1996 and river mile 0.4

during August of 1996. At the lower location at river mile 0.1,l and in 1993, two data points dropped below 8 ml/L, July at 7.6 ml/L and August at 7.6 ml/L. In 1996 all data points were above 8 milligrams per liter. At river mile 0.4 in August of 1996, the dissolved oxygen reading dropped to 7.3 ml/L.

Hydrology

Flow - Hydrologic Maturity

The TAG rated this element poor for both Donovan and Jakeway Creeks due to the lack of riparian vegetation in the lower floodplain.

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

TAG member Ted Labbe, Port Gamble S'Klallam tribal biologist, noted that there were more coho observed returning to Donovan Creek this year than in previous years. However, without escapement goals for individual watersheds, this parameter is difficult to rate.

Estuary

The East Quilcene Road crossing over Donovan Creek is a filled causeway that restricts tidal action into the historic estuary (TAG 2002).

Data Needs

- Gather fine sediment data
- Assess LWD
- Evaluate pool quantity, frequency and quality
- Determine sediment supply
- Assess mass wasting
- Assess riparian condition
- Evaluate road and road crossing impacts to aquatic resources

Action Recommendations

The following sequenced salmon habitat restoration actions are recommended for the Donovan Creek watershed:

1. Restore tidal flux
2. Remeander stream
3. Add LWD
4. Plant riparian area
5. Convert fill roadways to pile causeways

TARBOO/THORNDYKE SUB-BASIN

The Tarboo/Thorndyke sub-basin includes Lindsay Creek (WRIA 17.0123), Tarboo Creek (WRIA 17.0129), East Fork Tarboo Creek (WRIA 17.0130), Camp Discovery Creek (WRIA 17.0141), Fisherman Harbor Creek, (17.0153), and Thorndyke Creek (WRIA 17.0170). The TAG further divided the Tarboo/Thorndyke sub-basin into the following reaches for their discussion:

1. Lindsay Creek, mouth to river mile 1.2, and including all tributaries
2. Tarboo Creek, mainstem, mouth to river mile 0.9, including all tributaries
3. Tarboo Creek, mainstem, river mile 0.9 to 4.0, including all tributaries
4. Tarboo Creek, mainstem, above river mile 4.0, including all tributaries
5. East Fork Tarboo, tributary to Tarboo Creek at river mile 0.9, including all tributaries
6. Camp Discovery Creek, mouth to river mile 2, including all tributaries
7. Fisherman Harbor Creek, including all tributaries
8. Thorndyke Creek, mouth to river mile 6.2, including all tributaries

Timber fish and wildlife ambient monitoring data is scarce for this sub-basin but many members of the TAG have walked many of the segments of the streams and, based on personal observations, were able to describe habitat conditions. Peter Bahls of Northwest Watershed Institute has received funding to conduct habitat surveys in the Tarboo watershed and its adjacent nearshore area, which will provide additional data for this watershed. Glenn Gately of the Jefferson County Conservation District (JCCD) has collected, and will continue to collect, water quality data for Tarboo Creek. Port Gamble S'Klallam Tribal (PGST) biologists have collected and will continue to collect temperature data for Tarboo Creek and Thorndyke Creek. In the early 1980s, Point No Point Treaty Council (PNPTC) collected pool data for Thorndyke Creek, which we are using in this report. Steve Todd of PNPTC provided road density calculations.

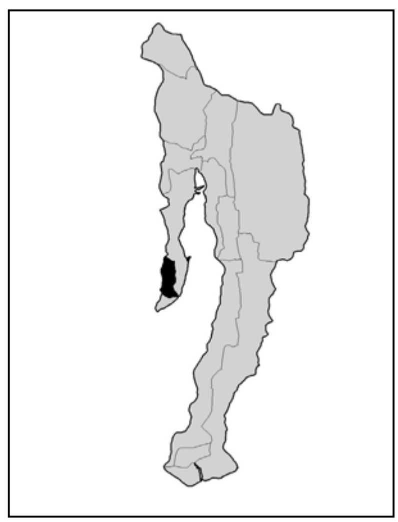

Figure 38. Lindsay Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Lindsay Creek

Data is lacking for Lindsay Creek. However, some TAG members had professional knowledge about the watershed conditions. The rest are considered data needs.

Access and Passage

Artificial Barriers

An impassable falls inhibits anadromous migration at approximately river mile 1.0. Landslides in the upper watershed have created passage problems in terms of sediment buildup that have caused the stream to flow subsurface in the lower quarter mile. This is considered a human induced migratory problem (Ted Labbe, personal communication, 2002). Further observations at all times of the year are among the recommended data needs.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable on Lindsay Creek due to gradient.

Channel Conditions

Fine Sediment

The TAG assumes that fine sediment is a problem in Lindsay Creek due to the amount of mass wasting occurring in the upper watershed. Mass wasting should be further researched. The TAG identified this as a data gap.

Large Woody Debris

The system lacks large woody debris (Ted Labbe, personal communication, 2002).

Percent Pools

Pool habitat is lacking (Ted Labbe, personal communication, 2002).

Pool Frequency

Pool habitat is minimal (Ted Labbe, personal communication, 2002).

Pool Quality

Deep pools are not found in this watershed (Ted Labbe, personal communication, 2002).

Streambank Stability

Incision through clay banks in the lower watershed has destabilized the banks (Ted Labbe, personal communication, 2002). Further assessments of bank stability are needed (TAG 2002).

Sediment Input

Sediment Supply

Severe slides in the upper watershed and the subsequent sediment deposition to the creek have destabilized the bed and banks (Ted Labbe, personal communication, 2002).

Mass Wasting

There have been severe slides in the upper watershed due to land use activities that have deposited large amounts of sediment into the creek (Ted Labbe, personal communication, 2002).

Road Density

Road density is 2.04 miles of road per square mile of watershed (PNPTC, unpublished data, 2002). There are no road crossings of the creek below the impassable falls at about river mile 1.0.

Riparian Zones

Riparian Condition

The isolated cedar bottom remnants are outnumbered by hardwoods with less than 30 percent in conifer. The riparian zone is of variable width and has been cut in a few places (Ted Labbe, personal communication, 2002).

Water Quality

Temperature

This parameter has been identified as a data gap.

Dissolved Oxygen

No dissolved oxygen data exist for Lindsay Creek.

Hydrology

This parameter has been identified as a data gap.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently practicable and has been identified as a data need.

Estuary

Lindsay Creek estuary is a small estuary with intense disturbance. Sixty percent of the shoreline has been modified with riprap/bulkheads and two low impact boat ramps (DNR 2001). An aquaculture facility is adjacent to the estuary (Ecology 2001).

Data Needs

- Check flow levels monthly to determine hydrologic barriers
- Assess fine sediment
- Determine streambank stability
- Collect temperature data
- Collect dissolved oxygen data
- Determine hydrologic maturity
- Evaluate road and road crossing impacts to aquatic resources

Action Recommendations
1. Restore natural riverine function
    a. Identify and abate sediment and mass wasting sources
    b. Add structure to create bed stability, pool habitat and cover
2. Establish a riparian zone for bank stability and future LWD recruitment

Tarboo Creek, mouth to river mile 0.9

Access and Passage

Artificial Barriers
Based on the WDFW/Jefferson County culvert assessment and personal observations, there are no known barriers on Tarboo Creek mainstem within this segment. There is a small right bank tributary with a culvert barrier at Carl Johnson Road but there is only a small amount (318 meters stream length) of available habitat upstream (Till et al 2000).

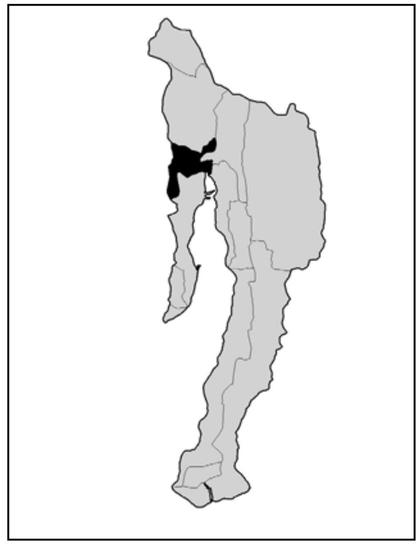

Figure 39. Tarboo Creek, river mile 0.0 to 0.9. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity
There is good flood distribution of sediments throughout the floodplain in this section, most of which is in public ownership (Washington Department of Fish and Wildlife). There has been insignificant channelization or diking within this reach and access to side channel habitat is not obstructed (TAG 2002).

Loss of Floodplain Habitat
The riparian zone is intact to provide shade and leaf litter and there has been no significant channelization or major instream alteration (TAG 2002).

Channel Conditions

Fine Sediment
The TAG does not believe that either specific data, written information or sufficient personal observation presently exists to adequately rate this particular habitat attribute in the watersheds of the Tarboo/Thorndyke subbasin. TAG (2002) observations are that, because fine sediments are distributed throughout the floodplain, there is not a fine sediment problem in this reach. However, further investigation is necessary to give this parameter a rating.

Large Woody Debris

According to TAG observation, large woody debris is relatively plentiful and, due to the intact multi-species riparian zone, recruitment potential is good. Peter Bahls, Northwest Watershed Institute, maintains that large wood is plentiful in this reach, particularly wood that forms large pools, and his 2002-2003 assessment will quantify this parameter.

Percent Pool

There are no pool data for Tarboo Creek but the TAG assumes this parameter to rate fair based on personal observations. Peter Bahls, Northwest Watershed Institute, maintains that there is a high frequency of large pools and his 2002-2003 assessment will quantify this parameter.

Pool Frequency

Pools are relatively common. Peter Bahls, Northwest Watershed Institute, maintains that there is a high frequency of large pools and his 2002-2003 assessment will further quantify this parameter.

Pool Quality

Pools are relatively large a deep, particularly associated with large woody debris (TAG 2002). Peter Bahls, Northwest Watershed Institute, maintains that there is a high frequency of deep, large pools with good cover, and his 2002-2003 assessment will further quantify this parameter.

Streambank Stability

Streambanks are stable in this reach (TAG 2002).

Sediment Input

Sediment Supply

Sediment supply does not exceed the natural rate (TAG 2002).

Mass Wasting

There is no mass wasting, based on personal observation and low gradient throughout the floodplain (TAG 2002).

Road Density

Road density is 4.39 miles of road per square mile of watershed (PNPTC, unpublished data, 2002). There are 1.32 road crossings per mile of stream (0.82 crossings per kilometer).

Riparian Zones

Riparian Condition

Riparian condition is good. The lower watershed is in public ownership (Washington Department of Fish and Wildlife) and has good canopy closure with conifer and deciduous mixed forest extending throughout the floodplain. Future large woody debris recruitment potential is good.

Water Quality

Temperature

Glenn Gately of Jefferson County Conservation District collected temperature data at the upper end of this segment at river mile 0.9. There were two days in the year 2000 in which the temperature exceeded 16^{o}C. The upper mainstem and the East Fork influence the temperature in the upper part of this section. Temperatures likely improve downstream since the riparian corridor throughout this section is intact (TAG 2002). Temperature monitoring downstream and just above the tidal influence is necessary to rate this parameter for this reach.

Dissolved Oxygen

Dissolved oxygen concentrations at river mile 0.9 were consistently greater than 8.0 mg/L in 2000 (Gately 2002).

Hydrology

Flow: Hydrologic Maturity

This reach has a functional riparian zone and floodplain connectivity. However, there has been extensive logging on Carl Johnson Road and the upstream watershed has low hydrologic maturity (TAG 2002). Further investigation is warranted to determine the extent of the clearcut activities in relation to the lower watershed (Steve Todd, personal communication, 2002).

Flow: Percent Impervious Surface

This parameter is a data gap for this section.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently practicable and has been identified as a data need.

Estuary

Tarboo Creek connects with the marine environment by way of an undisturbed, high quality estuary. Tarboo Bay is a mudflat that is filling in with sediment supplied by Tarboo Creek (Johannessen 1992). The estuary is bordered by Long Spit to the southwest and an acre of drift logs to the east of the creek mouth. Long Spit is one of Tarboo Bay's most important features and efforts to protect the spit are underway by the Nature Conservancy and the Department of Natural Resources Natural Area Preserve Program.

Data Needs

- Collect channel condition data to verify TAG descriptions and note changes over time
- Evaluate road and road crossing impacts on aquatic resources, especially in the upper watershed of this section
- Set escapement goals for the entire watershed, or conduct benthic invertebrate study to assess nutrients

Tarboo Creek, river mile 0.9 to 4.0

Access and Passage

Artificial Barriers

While there are many culvert issues within the watershed as a whole, there are no WDFW/Jefferson County identified barriers in this section. Private culverts on the tributaries have not been assessed. Their status for fish migration is an unknown and has been identified as a data need. Reed canary grass has sometimes been a barrier under certain flows and at certain times of the year. There is a small right bank tributary, which is unnamed and unnumbered, just to the south of unnamed tributary number 17.0133 that is a velocity barrier during certain flows.

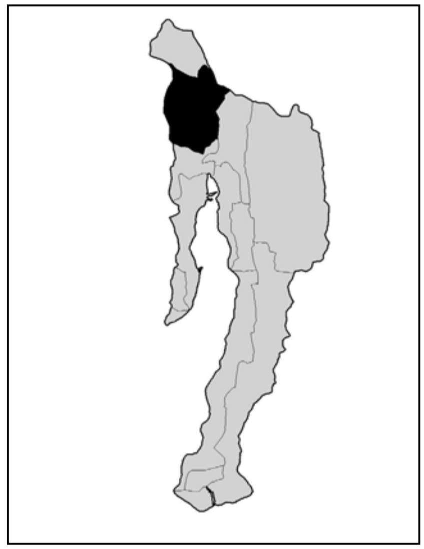

Figure 40. Tarboo Creek, river mile 0.9 to 4.0. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The majority of this section is low gradient. Less than 20 percent has been channelized, according to Point No Point Treaty Council mapping efforts (SSHIAP, unpublished data, 2002).

Loss of Floodplain Habitat

General Land Office maps of the mid 1800s indicate spruce bottom and hardhack bottom along much of the valley. There was a cedar mill near Old Tarboo Road that hauled cedar from the valley bottom (Peter Bahls, personal communication, 2002). Much of this section has been converted to agriculture (river mile 0.9 to 2.5) resulting in loss of riparian habitat, including future large woody debris recruitment. Much of this lower valley has been drained by ditches that divert tributaries along the base of the side hills and drain wetlands by underground tiling (Peter Bahls, personal communication, 2002). Between river mile 2.5 and 4.0 rural residential use dominates the landscape where the floodplain condition is variable. Jefferson County Conservation District has recently placed one mile of the mainstem into the Conservation Reserve Enhancement Program which will protect 180 feet on either side of the stream (Al Latham, personal communication, 2002). This should improve the habitat condition in this section.

Channel Conditions

Fine Sediment

There is no data or personal observation for this section.

Large Woody Debris

Amounts of large woody debris are low. The riparian area is sparse so future recruitment potential is low (TAG 2002).

Percent Pool

This section is mostly a low gradient glide with few pools. Instream structure, such as large woody debris, is needed to form pools (TAG 2002).

Pool Frequency

Due to the lack of large woody debris, pool formation is minimal (TAG 2002).

Pool Quality

This reach is a continuous glide (TAG 2002).

Streambank Stability

Low gradient and a relatively natural channel yield generally stable banks. In addition, cattle exclusion fencing has minimized their impact on streambanks and reed canary grass, an undesirable invasive species, tends to hold them in place (TAG 2002).

Sediment Input

Sediment Supply

Sediment supply has been identified as a data need for this section. A slide on tributary 17.0134 sent a large amount of fine sediment into the mainstem about two years ago during an extremely wet season (Al Latham, personal communication, 2002).

Mass Wasting

This section is low gradient with no steep hills so mass wasting is not expected to be a problem (TAG 2002).

Road Density

Road density is 3.98 mile of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Much of this section has been converted to agriculture and cattle grazing. Jefferson County Conservation District has recently placed one mile of the mainstem into the Conservation Reserve Enhancement Program, which will protect 180 feet on either side of the stream (Al Latham, personal communication, 2002). Once this is fenced and planted, the riparian condition should improve in this section. Road crossings occur at 1.85 crossings per mile (1.15 per kilometer), including tributaries (PNPTC, unpublished data, 2002).

Water Quality

Temperature

Glenn Gately, Jefferson County Conservation District, collected temperature data at both ends of this segment in the year 2000 and the Port Gamble S'Klallam Tribe collected temperature data in the middle of this segment at Old Tarboo Road during the years 1992, 1993 and 1994. At river mile 0.9 the temperature exceeded 16°C on two days in 2000. The upper section, measured at river mile 4.0, reached a high of up to 14°C on two occasions in 2000. The middle section, which is low gradient with little or no riparian vegetation, had elevated annual instantaneous maximum temperatures of 18.9°C in 1992 and 1993 and 19.4°C in 1994 (Labbe et al 2002).

Dissolved Oxygen

The lowest dissolved oxygen concentration reading on August 1, 2000 at river mile 0.9 was 8.7 ml/L (Glenn Gately, personal communication, 2002). Readings at the upper site, river mile 4.0 were all above 8.7 ml/L.

Hydrology

Flow – Hydrologic Maturity

Much of this section has been heavily logged for conversion to agricultural and rural residential development as well as timber harvest. The replanting that has taken place on forestry lands is less than 25 years old. The Jefferson County Conservation District's efforts with the CREP program will begin to improve the riparian zone along one mile of this section over the next 15 years (DNR orthophoto 2000; TAG 2002).

Flow – Percent Impervious Surface

This parameter has been identified as a data need.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently practicable and has been identified as a data need.

Data Needs

- Conduct culvert assessment on private road crossings
- Conduct historical assessment of habitat condition
- Assess fine sediment
- Determine sediment supply

- Determine percent impervious surface
- Evaluate road and road crossing impacts on aquatic resources

Tarboo Creek, above river mile 4.0

Access and Passage

Artificial Barriers

Two major barriers occur in this reach at Dabob Road and at Center Road and have been given high priority index ratings by WDFW. They rank number 3 and number 1 respectively on the prioritized list of county road culverts to be fixed. Hood Canal Salmon Enhancement Group received Salmon Recovery Funding Board money to replace the culverts during the summer of 2003. Access to Browns Lake is a complete barrier and no salmonids have been trapped in the lake in recent years (Chris May, personal communication, 2002). However, they were historically present. There is an additional barrier on a tributary downstream, which is under Pope ownership. The reach adjacent to Highway 104 is typically dry during the summer months as is the section at the music farm. There is also a culvert barrier at the music farm.

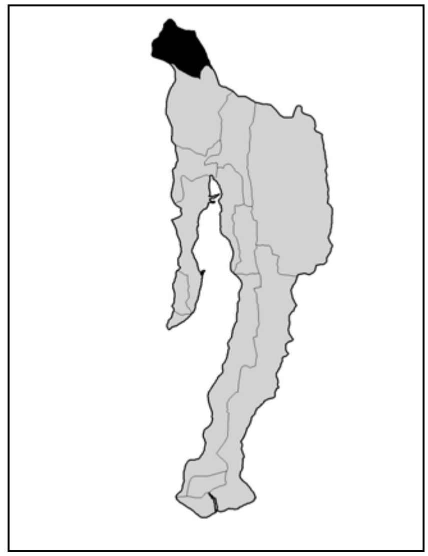

Figure 41. Tarboo Creek, above river mile 4.0. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

This parameter is not applicable to this segment. The majority of this reach is greater than 1-2 percent gradient and therefore this parameter cannot be assessed. However, there are some reaches where floodplain development is possible, particularly near Center Road and the Olympic Music Festival where much of the reach is armored and channelized. Floodplain connectivity is poor through this reach.

Loss of Floodplain Habitat

This parameter is not applicable to this segment due to gradient. However, where the gradient is moderate, floodplain habitat loss if poor/fair. There are some areas of former floodplains that could still be useful habitat (Steve Todd, personal communication, 2002).

Channel Conditions

Fine Sediment

This parameter has been identified as a data need. However, TAG member Chris May has observed good spawning gravel/cobble that is totally dewatered during part of the year.

Large Woody Debris

Some large woody debris exists in this section. It was logged in recent years and future recruitment is fair/poor (TAG 2002).

Percent Pool

This parameter has been identified as a data need for this section.

Pool Frequency

This parameter has been identified as a data need for this section

Pool Quality

This parameter has been identified as a data need for this section.

Streambank Stability

Streambanks are generally stable (TAG 2002).

Sediment Input

Sediment Supply

Part of this segment flows in a fairly confined channel between Highway 104 and a logging road managed by Pope Resources. There are no curbs along the highway and stormwater has created numerous large slide events. As a result of the sediment accumulation, the stream goes subsurface through this stretch. Sediment supply appears to exceed the natural rate but this should be verified with field assessments.

Mass Wasting

Mass wasting occurs in this section along Highway 104 as a result of stormwater runoff (TAG 2002).

Road Density

Road density is high due to the number of logging roads in this segment. There are 5.78 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

A narrow band of deciduous trees dominates the riparian vegetation and a road limits buffer width. The number of road crossings is 2.55 per mile of stream or 1.58 per kilometer (PNPTC, unpublished data, 2002), which fragments the canopy cover.

Water Quality

Temperature

Temperature readings at river mile 4.0 were below 14^{o}C in the year 2000 (Glenn Gately, personal communication, 2002).

Dissolved Oxygen
Dissolved oxygen readings at river mile 4.0 did not fall below 9.3 ml/L in the year 2000 (Glenn Gately, personal communication, 2002).

Hydrology

Flow – Hydrologic Maturity
Extensive logging has occurred in the watershed. Greater than 60 percent of the replanted forest is less than 25 years old.

Flow – Percent Impervious Surface
This parameter has been identified as a data gap.

Biological Processes

Nutrients (Carcasses)
Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently applicable and has been identified as a data need.

Data Needs
- Assess fine sediment
- Collect pool data
- Determine percent impervious surface
- Determine sediment supply
- Evaluate mass wasting
- Evaluate road and road crossing impacts on aquatic resources

East Fork Tarboo Creek

Access and Passage

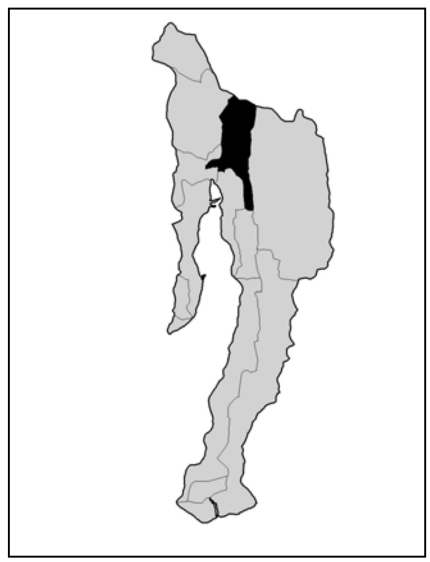

Figure 42. East Fork Tarboo Creek. Map provided by Jennifer Cutler, NWIFC

Artificial Barriers
There is a partial barrier at river mile 1.0 and a total barrier on the East Branch near the confluence. With high priority index values of 26.82 and 17.68 respectively (Till et al 2000). The quality of habitat upstream of these barriers is good. Fixing these barriers would open up 2.15 (3,453 meters) and 0.74 miles (1,198 meters) of stream respectively.

Floodplains

Floodplain Connectivity

There are road constrictions and armoring through parts of this section, which eliminate floodplain connectivity to off channel habitats. Sediment deposition along the margins of the creek could further illustrate the lack of deposition throughout the floodplain. Where floodplain connectivity is probably most relevant, Coyle Road dissects the floodplain. The numerous road crossings along this reach, including the tributaries, also impair channel processes (Steve Todd, personal communication, 2002).

Loss of Floodplain Habitat

There is a large wetland complex worth noting to the north of the stream between the mouth and river mile 0.5. Due to the location of Coyle Road, floodplain habitat functions are at risk (Steve Todd, personal communication, 2002). However, information is lacking to provide a rating and thus the TAG determined this to be a data need.

Channel Conditions

Fine Sediment

The TAG identified this parameter as a data need for this segment.

Large Woody Debris

Whereas the general consensus is that there is little or no wood in this segment, the TAG wanted more information before assigning a rating.

Percent Pool

This parameter has been identified as a data gap, although the TAG suspects it to be poor based on personal observations that pools are low in number and quality.

Pool Frequency

This parameter has been identified as a data need, although the TAG suspects it to be poor based on personal observations that pools are uncommon.

Pool Quality

This parameter has been identified as a data need, although the TAG suspects it to be poor based on personal observations that deep pools with adequate cover are limited.

Streambank Stability

The TAG identified this parameter as a data need although they agreed that the streambank stability is poor along the sections of Coyle road that have been armored and were built on fill. Coyle Road has artificially confined the stream channel against the south valley wall, contributing to streambank erosion problems and introducing large amounts of sediment to the channel (Ted Labbe, personal communication, 2002).

Sediment Input

Sediment Supply
The TAG identified this parameter in this section to be a data need.

Mass Wasting
The TAG acknowledged that the main channel along Coyle Road has suffered from slide events due to the road construction and associated fill. The rest of the reach is unknown and is identified as a data gap.

Road Density
Road density estimates are 3.95 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
The lower East Fork and the entire East Branch have poor riparian condition due to the dominance of deciduous trees and the presence of Coyle Road. The TAG has identified the upper mainstem and the north branch as data needs. Road crossings that fragment the riparian corridor are 0.98 crossings per kilometer of stream (PNPTC, unpublished data, 2002).

Water Quality

Temperatures
Port Gamble S'Klallam Tribe provided the following temperature (Labbe et al, 2002).

Table 12. East Tarboo Creek Stream Temperatures. Data provided by Ted Labbe, PGST

Stream/Location	AIMT 1992 °C	AIMT 1993 °C	AIMT 1994 °C	AIMT 2001 °C	7DADMT 2001 °C	21DADMT 2001 °C
East Fork Tarboo Coyle Road	17.2	15.6	16.1	16.8	15.8	13.4

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen
Dissolved oxygen data for this segment do not exist and are therefore a data need.

Hydrology

The TAG has identified this parameter for this section as a data need.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable and have been identified as a data need.

Data Needs

- Determine floodplain connectivity
- Assess fine sediment
- Survey large woody debris
- Collect pool data
- Determine streambank stability
- Determine sediment supply
- Evaluate mass wasting
- Evaluate riparian condition
- Collect dissolved oxygen data
- Determine hydrologic maturity
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Address culvert barriers
2. Restore natural riverine function
    a. Add channel sinuosity
    c. Restore complexity, such as large woody debris
    d. Plant riparian area between river mile 0.9 and 4.0
3. Create access to pond on a left bank tributary at about river mile 1.0 and two ponds on the right bank at about river mile 2.7 in the vicinity of unnamed tributary 17.0135.

Camp Discovery Creek

Access and Passage

Artificial Barriers

The TAG has identified access issues as a data gap for this watershed.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable to this watershed.

Channel Conditions

The TAG has identified all channel condition parameters as a data need for Camp Discovery Creek watershed.

Sediment Input

Sediment Supply

The TAG has identified this parameter as a data need for Camp Discovery Creek watershed.

Mass Wasting

Road related slides at about river mile 0.7 have contributed sediment to the system. However, the TAG felt that more information was needed regarding the remainder of the watershed before a rating could be given.

Road Density

Road densities in the Camp Discovery Creek watershed are very high at 6.36 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

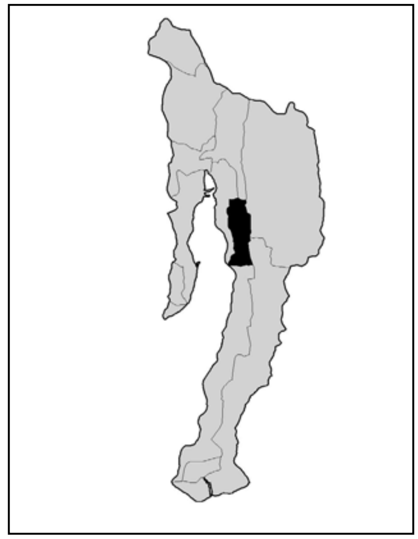

Figure 43. Camp Discovery Watershed. Map provided by Jennifer Cutler, NWIFC

Riparian Zones

Riparian Condition

The TAG has identified riparian condition as a data need. Examination of orthophotos from year 2000 suggests an alder dominated riparian zone but the TAG would like more information prior to giving this parameter a rating. There are 2.43 road crossings per mile of stream (1.51 per kilometer) that fragment the riparian corridor (PNPTC, unpublished data 2002).

Water Quality

Temperature

The TAG has identified water temperature as a data need in this watershed. Port Gamble Tribal biologists monitored water temperatures during the summer of 2002 and concluded that temperature conditions appear to be quite good (Ted Labbe, personal communication, 2002). Further monitoring is necessary to rate this parameter.

Dissolved Oxygen

The TAG has identified dissolved oxygen as a data need for this watershed.

Hydrology

Flow – Hydrologic Maturity

The TAG has identified hydrologic maturity as a data need. From the year-2000 orthophotos the watershed looks immature from extensive timber harvest.

Flow – Percent Impervious Surface
This parameter has been identified as a data need.

Biological Processes

Nutrients (Carcasses)
Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently practicable and has been identified as a data need.

Estuary
Camp Discovery Creek enters Dabob Bay through a narrow channel cut into a spit that is migrating rapidly from south to north. As the spit moves, it encloses an ever longer, though narrow lagoon. This tidal lagoon is very small and contains one deep scour pool that is used year round by estuary rearing coho. Smaller pockets of habitat suitable for juvenile salmonids occur where small logs have been cabled into the streambank and where overhanging banks create side scour pools. There is essentially no saltmarsh present (Ron Hirschi, personal communication, 2002). A few streambank plantings of willow and some conifers are evident. Coho, cutthroat and juvenile chum reside in the estuary from December through the middle of June. One juvenile chinook was found in the estuary in the spring of 2002 (Ron Hirschi, unpublished data, 2002).

Data Needs
- Assess culvert situation
- Assess fine sediment
- Survey large woody debris
- Collect pool data
- Determine streambank stability
- Determine sediment supply
- Evaluate riparian condition
- Collect water quality data
- Determine hydrologic maturity
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations
1. Conduct surveys and assessments as identified as data needs.

Fisherman Harbor Creek

Access and Passage

Artificial Barriers
A partial barrier for salmon migration exists on Coyle Road. Four tributaries each have total barriers for a total stream length loss of 1.23 miles or approximately 2.0 meters (Till et al 2000).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
This parameter is not applicable in this watershed due to gradient.

Channel Conditions

The TAG has identified all channel condition parameters as a data need for Fisherman Harbor Creek watershed.

Sediment Input

Sediment Supply
The TAG has identified this parameter as a data gap for Fisherman Harbor Creek watershed.

Mass Wasting
The TAG has identified this parameter as a data gap for Fisherman Harbor Creek watershed.

Road Density
Road density is 5.36 miles of road per square mile (PNPTC, unpublished data). There are 1.94 road crossings per kilometer of stream.

Riparian Zones

Riparian Condition
The TAG has identified this parameter as a data need for the Fisherman Harbor Creek watershed.

Water Quality

Water Temperature/Dissolved Oxygen
The TAG has identified water quality as a data need for Fisherman Harbor Creek watershed.

Hydrology

The TAG has identified this parameter as a data need for Fisherman Harbor Creek watershed.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes are not currently practicable and have been identified as a data need.

Estuary

Fisherman's Harbor is long and narrow inlet that provides the marine connection to Fisherman's Harbor Creek. Within Fisherman's Harbor is a marina with 32 boat slips and other private docks, a total of five in all (TAG 2002 viewing Ecology 2001).

Data Needs

- Assess fine sediment
- Survey large woody debris
- Collect pool data
- Determine streambank stability
- Determine sediment supply
- Evaluate riparian condition
- Collect water quality data
- Determine hydrologic maturity
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Conduct surveys and assessments as identified as data needs.

Thorndyke Creek

Access and Passage

Artificial Barriers

Two culverts, both on Thorndyke Road, have been identified by WDFW and Jefferson County that partially block fish migration. One barrier is a double culvert on the mainstem and the other barrier culvert occurs on an unnamed tributary. Migration through these culverts is possible during certain flows (TAG 2002). Down-cutting on the downstream side of the mainstem culvert is exacerbating the passage. The bottom of the larger pipe is rotting and water seeps through. If fixed, this barrier would allow 15 miles (24,464 meters) of stream to be fully accessible to anadromous fish. The priority index value is 39.04 and placed number two on the prioritized list of culvert projects (Till et al 2000).

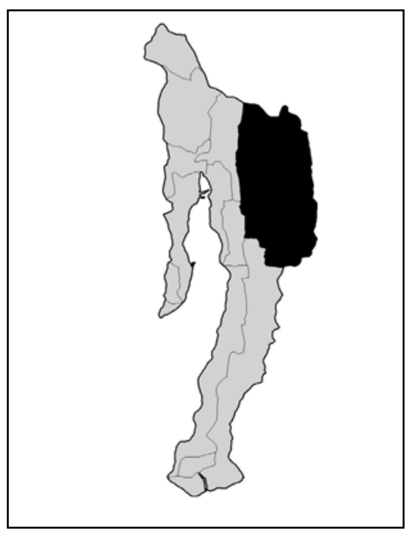

Figure 44. Thorndyke Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The stream has not been channelized and flood flows distribute sediments throughout the floodplain in the low gradient reaches.

Loss of Floodplain Habitat

There is good off channel habitat immediately above the road with active beaver throughout the system. Wetlands are a large component of the watershed. The stream goes dry during certain conditions between river mile 3.5 and 4.2 and has become incised with unstable banks.

Channel Conditions

Fine Sediment

The TAG does not believe that either specific data, written information or sufficient personal observation presently exist to adequately rate this habitat attribute in the Tarboo/Thorndyke subbasin. Therefore, fine sediment is identified as a data gap.

Large Woody Debris

Thorndyke Creek has not recovered from the stream "clean-out" activities conducted by Washington Department of Fisheries in the late 1960s. Future prospects for recruitment of large woody debris are also not good due to the mixed composition of the riparian zone (TAG 2002).

Percent Pool

Downstream of Thorndyke Road (river mile 0.9) percent pool is 61 percent (PNPTC, unpublished data, 1988). Between river mile 0.9 and 4.4, percent pool is between 35.4 and 36.8 percent. In addition, two of the three tributaries that were surveyed, stream number 17.0171 and 17.0174 were approximately 35 percent pools. The small portion of stream number 17.0179 that was sampled provided 51 percent pools.

Pool Frequency

Pool frequency is between 3.0 and 3.8 channel widths per pool on the mainstem. The tributaries exceed 5.6 channel widths per pool (PNPTC, unpublished data, 1988).

Pool Quality

The data that was collected by Point No Point Treaty Council for pool depth does not fit the parameters as determined by criteria for this report. The TAG therefore identified this parameter as a data need.

Streambank Stability

The TAG has identified this parameter as a data need although their professional observations indicate that streambank stability is not a problem with the exception of two areas: river mile 3.5 to 4.0 on the mainstem and river mile 0.0 to 0.2 on tributary 17.0175.

Sediment Input

Sediment Supply
The TAG has identified this parameter as a data gap.

Mass Wasting
The TAG is not aware of mass wasting problems in this watershed but further investigation would be warranted.

Road Density
Road density in this watershed is 3.45 miles of road per square mile of habitat (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
Canopy closure data from Point No Point Treaty Council indicates 92 percent closure above Thorndyke Road. Their study did not look at riparian composition but the observations of TAG members determined it is mixed, the majority of which is alder and other deciduous species. Large stumps indicate the watershed was largely conifer historically. The lack of a conifer component limits contribution to present and future instream structure. Road crossings occur at 1.13 per mile (0.7 per kilometer (PNPTC, unpublished data, 2002).

Water Quality

Temperature
Water temperatures have remained fairly constant in the past decade (see Table 2).

Table 13. Thorndyke Water Temperatures. Data provided by Ted Labbe, PGST

Stream/ Location	AIMT 1992 ^{o}C	AIMT 1993 ^{o}C	AIMT 1994 ^{o}C	AIMT 2001 ^{o}C	7DADMT 2001 ^{o}C	21DADMT 2001 ^{o}C
Thorndyke Mainstem Thorndyke Road	15.0	14.4	15.0	14.3	13.6	12.2
West Trib. Thorndyke Near stream mouth	16.1	16.1	15.6			

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature.

Dissolved Oxygen
The TAG has identified this parameter as a data gap.

Hydrology

Flow - Hydrologic Maturity

Recent timber harvest activities have reduced hydrologic maturity. The TAG assumes poor for this parameter until other data becomes available.

Percent Impervious Surface

This parameter has been identified as a data gap. However, due to the remote location and lack of rural development, it is likely that impervious surface does not exceed 3 percent.

Biological Processes

Nutrients (Carcasses)

Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not currently practicable and has been identified as a data need.

Lakes

Tarboo Lake is in the watershed but is not connected to the river. Washington Department of Fish and Wildlife plants cutthroat fry for a popular resident fishery.

Estuary

Thorndyke Bay may serve as a model estuary of its size, with undisturbed high salt marsh and extensive tidal channels. There are beaver in the lower watershed and no known major impairments, with the exception of the Thorndyke Road crossing.

Data Needs

- Assess fine sediment
- Determine pool quality/depth
- Determine streambank stability
- Determine sediment supply
- Identify mass wasting
- Collect dissolved oxygen data
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Protect high quality riverine and estuarine habitats
2. Replace mainstem culvert at Thorndyke Road
3. Underplant riparian with native conifer species

LUDLOW SUB-BASIN

The Ludlow sub-basin includes Nordstrom Creek (WRIA 17.0180), Shine Creek (WRIA 17.0181), Bones Creek (WRIA 17.0185), Ludlow Creek (WRIA 17.0192), Piddling Creek (WRIA 17.0200) and Little Goose Creek (WRIA 17.0200A). The TAG further divided the watershed as follows:

1. Nordstrom Creek, entire watershed
2. Shine Creek, mouth to river mile 1.0 at SR 104
3. Shine Creek, above SR 104
4. Bones Creek, entire watershed
5. Ludlow Creek, mouth to river mile 0.5
6. Ludlow Creek, above river mile 0.5
7. Piddling Creek, mouth to river mile 1.4
8. Little Goose Creek, entire watershed

Timber fish and wildlife ambient monitoring data was limited to pool data for Shine Creek. Temperature data were available from Port Gamble S'Klallam Tribe (PGST) for Nordstrom, Shine and upper Ludlow Creeks. Barrier assessment was available through the Washington Department of Fish and Wildlife (WDFW) but was limited to county and state roads. Point No Point Treaty Council (PNPTC) provided conservative road density estimates for this report. The TAG applied some professional knowledge and observations of some parameters for some of the streams. The remaining parameters have been identified as data gaps.

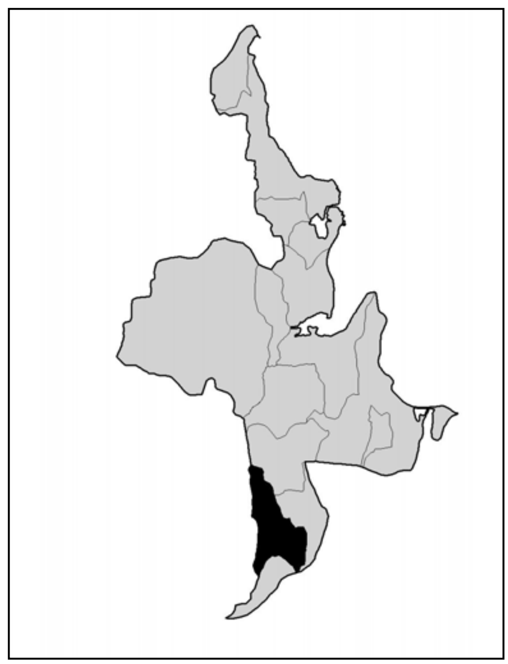

Figure 45. Nordstrom Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Nordstrom Creek

Access and Passage

Artificial Barriers

A perched and undersized culvert at Thorndyke Road creates a velocity barrier during certain flows. A culvert on a right bank tributary in the upper watershed is a complete barrier and could be fixed to provide access to a wetland complex upstream.

Floodplains

Floodplain Connectivity

The lower watershed, above the estuary, has not been modified and allows for the distribution of sediments and the migration of the stream throughout the floodplain.

Loss of Floodplain Habitat

The vegetation has not been altered and provides the shade and structure of properly functioning floodplain habitat.

Channel Conditions

Fine Sediment

There has been no data collection for fine sediment analysis in this watershed so this parameter has been identified as a data gap. The TAG did, however, recognize sediment problems resulting from previous mass wasting events in the upper watershed.

Large Woody Debris

The TAG identified this parameter as a data gap. The riparian composition is predominantly deciduous and there has been no research as to the historical content of the riparian corridor. Future recruitment potential of coniferous large woody debris is not good.

Pools

No information was available to describe pool conditions.

Streambank Stability

The TAG identified this parameter as a data gap.

Sediment Input

Sediment Supply

Due to mass wasting events observed by TAG members, sediment supply exceeds the natural rate. Extensive logging in the upper watershed has destabilized slopes and introduced excessive amounts of sediments to enter the stream.

Mass Wasting

Mass wasting events have occurred above Thorndyke Road contributing to above normal sediment loads in the lower watershed. The TAG rated this parameter poor.

Road Density

Steve Todd, Point No Point Treaty Council biologist, estimated 4.62 miles of roads per square mile of watershed. Road crossings are 1.1 per kilometer of stream.

Riparian Zones

Riparian Condition

The TAG acknowledged that the riparian zone is alder dominated with few conifers throughout the system but did not have enough confidence in their collective knowledge to give this parameter a rating.

Water Quality

Temperature

Port Gamble S'Klallam Tribe collected the following temperature data in Nordstrom Creek at Thorndyke Road (Labbe et al 2002).

Table 14. Nordstrom Creek Water Temperatures. Data provided by Ted Labbe, PGST

Stream/Location	AIMT 1992 ^oC	AIMT 1993 ^oC	AIMT 1994 ^oC	AIMT 2001 ^oC	7DADMT 2001 ^oC	21DADT 2001 ^oC
Nordstrom Creek	15.0	13.9	14.4	14.0	13.5	12.1

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature

Dissolved Oxygen

There are no dissolved oxygen data for this watershed. This parameter is a data gap.

Hydrology/Flow

The TAG identified both hydrologic maturity and percent impervious surface as a data gap.

Biological Processes

Nutrients (Carcasses)

Because there are no escapement goals for independent watersheds, this parameter cannot be evaluated and is therefore a data need.

Estuaries

The small estuary at Nordstrom Creek has been modified with an access road and culvert system. Fish access has not been inhibited, however.

Data Needs

- Collect TFW ambient monitoring data to assess large woody debris, pool habitat, and fine sediments.
- Determine streambank stability

- Assess riparian condition
- Monitor water quality
- Determine hydrologic maturity
- Determine percent impervious surface
- Establish escapement goals
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

Following is a sequenced project list for Nordstrom Creek:

1. Assess and abate mass wasting potential
2. Replace culvert at Thorndyke Road
3. Replace culvert on right bank tributary in the upper watershed

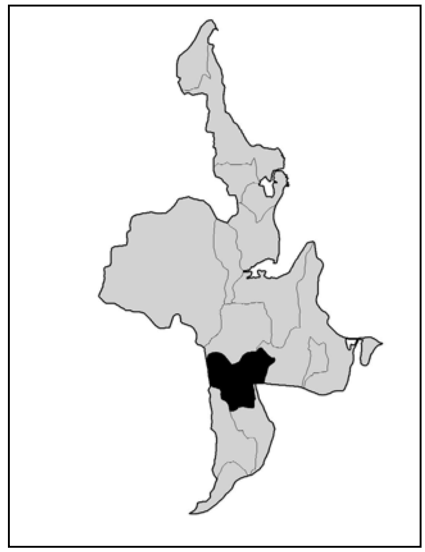

Figure 46. Lower Shine Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Shine Creek, mouth to SR 104

Access and Passage

Artificial Barriers

A triple culvert system at the mouth of Shine Creek at Thorndyke Road inhibits estuary function and is a velocity barrier for adult and juvenile migration at certain flows. During most flows, however, fish have access to the upper watershed. The TAG rated this parameter good.

Floodplains

Floodplain Connectivity

The stream immediately above the culverts at Thorndyke Road has been channelized but access to the floodplain has not been inhibited. There is historic evidence of channelization through the large wetland complex upstream but the stream has since reestablished a meander pattern through this section. A right bank tributary of Shine Creek downstream of Highway 104 has incised more than five feet due to relocation for highway construction (Peter Bahls, personal communication, 2002).

Loss of Floodplain Habitat

Beaver have been instrumental in maintaining the large wetland complex in this reach which provides significant rearing habitat. Most of the spawning takes place in the upper watershed.

Channel Conditions

Fine Sediment

The TAG identified this parameter as a data gap but noted many sediment problems associated with the stormwater runoff along SR 104, particularly where a right bank tributary is constricted between the highway and a logging road.

Large Woody Debris

Lower Shine Creek has quite a bit of large wood, though some of it may not qualify under strict TFW criteria since much of it is alive and growing. There are numerous places where old-growth LWD is still present and abundant in the channel. Much of this organic debris contributes to substantial channel complexity that provides resting and hiding places for juvenile coho which are often abundant here (Ted Labbe, personal communication, 2002).

Percent Pool

A large wetland complex throughout the watershed, partially influenced by beaver activity, contributes to pool habitat (PNPTC, unpublished data, 1988).

Pool Frequency

Pool frequency is greater than 4 (PNPTC, unpublished data, 1988). However, because the beaver have created a large wetland complex in the lower reach, the TAG gave this parameter a fair rating rather than a poor rating.

Pool Quality

The residual average depth did not exceed one meter (PNPTC, unpublished data, 1988). In spite of the low depth, the vast wetland complex provides quality off-channel habitat (TAG 2002).

Streambank Stability

Streambanks are stable in the lower watershed (PNPTC, unpublished data, 1988).

Sediment Input

Sediment Supply

A right bank tributary to the south of SR 104 receives stormwater runoff and subsequent sediment input above natural rates. Other sediment sources in this watershed are unknown and the TAG therefore did not give this parameter a rating.

Mass Wasting

The watershed does not have steep slopes and consequently the TAG suspects that mass wasting is not a problem in this watershed. However, the TAG was not able to give this parameter a rating and identified it as a data need.

Road Density

Road density for lower Shine Creek watershed is 4.79 miles of roads per square mile of watershed. The number of road crossings is 0.91 per kilometer (1.46 per mile) of stream (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Canopy closure was 76-100 percent, predominately deciduous/mixed forest PNPTC, unpublished data 1988). Composition of historical riparian zone is unknown. The lower watershed has been recently logged leaving minimum buffers along the harvested area with minimal large woody debris recruitment potential. Reed canary grass and blackberry are present in the lower watershed and should be monitored and/or extirpated (TAG 2002).

Water Quality

Temperature

The following temperature measurements were taken at SR104 by Port Gamble S'Klallam Tribe. Taylor maximum-minimum thermometers were used in 1992-1994 during summer/early fall months. Thermometers were placed at the bottom of a pool and checked every 7-14 days. In 2001, continuous temperature data loggers (Hobo Temps and StowAway Tidbit Temps were placed at the bottom of large well-mixed pools and calibrated using TFW ambient monitoring protocols (Labbe et al 2002). An additional temperature reading taken at Thorndyke Road in August 1991 was 16.0^{o}C (Glenn Gately, personal communication, 2002).

Table 15. Shine Creek Water Temperature. Data provided by Ted Labbe, PGST

Stream/Location	AIMT 1992 ^{o}C	AIMT 1993 ^{o}C	AIMT 1994 ^{o}C	AIMT 2001 ^{o}C	7DADMT 2001 ^{o}C	21DADMT 2001 ^{o}C
Shine Creek, SR104	15.0	16.7	14.4	14.5	13.5	12.6

Note: AIMT = annual instantaneous maximum temperature; 7-DADMT = 7-day average of the daily maximum temperature; 21-DADT – 21-day average of the daily average temperature

Dissolved Oxygen

The TAG identified this parameter as a data gap. Measurements were taken in1991 but the instruments were faulty. Low dissolved oxygen readings were recorded, but the readings are suspected to be inaccurate. Information was not adequate in quality or quantity to describe dissolved oxygen levels (TAG 2002).

Hydrology/Flow

Hydrologic Maturity
The TAG identified this parameter as a data gap.

Percent Impervious Surface
The TAG estimated less than 5 percent of the lower watershed is impervious surface.

Biological Processes

Nutrients (Carcasses)
Escapement goals have not been set for individual watersheds in this WRIA so the criteria for establishing a rating for biological processes is not applicable and has been identified as a data need.

Estuary
Shine estuary was historically a considerable salt marsh of approximately 85 acres and 5.3 acres of intertidal habitat. The salt marsh has been truncated by South Point Road and its associated fill with three culverts, each 36 inches in diameter, allowing Shine Creek to enter Squamish Harbor with somewhat limited salt water flow into the historic estuary. Total estuary function is lacking, as is the movement of logs and debris from the fluvial into the estuarine environment. Riverine and estuarine function can be restored with a bridge replacing the three culverts (TAG 2002).

Data Needs
- Identify historic and current location of tributaries
- Assess fine sediment
- Assess sediment supply
- Determine mass wasting
- Monitor dissolved oxygen
- Assess hydrologic maturity
- Establish escapement goals
- Evaluate road and road crossing impacts on aquatic resources

Shine Creek – Above SR 104

Access and Passage

Artificial Barriers
There are no known human induced physical barriers throughout most of the watershed. The culvert at Highway 104 may be a partial barrier due to slope but adult coho have been observed upstream (Peter Bahls, personal communication, 2002). There are several 100+km long culverts running beneath the Port Ludlow golf course that obstruct fish passage in upper Shine Creek. Resident cutthroat trout are found upstream of these culverts and coho fry are regularly observed immediately downstream (Washington Trout, unpublished data (2002).

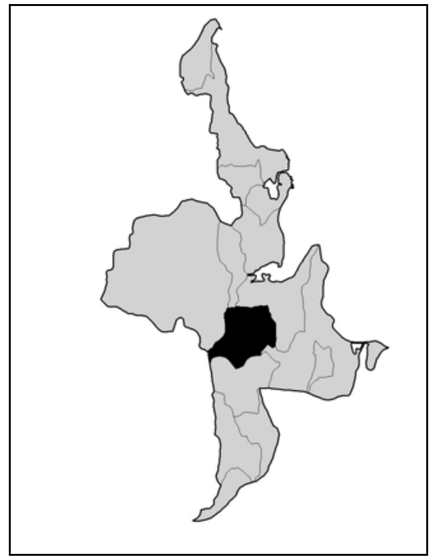

Figure 47. Upper Shine Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

This parameter is not applicable to this part of the watershed although the loss of headwater wetlands and floodplain habitat due to the golf course was acknowledged.

Channel Conditions

Fine Sediment

Golf course maintenance activities are likely to affect fine sediment in this reach but since data is lacking the TAG identified this parameter as a data gap.

Large Woody Debris

A diffuse channel/wetland complex in the lower part of the segment and the approximately forty-year-old riparian forest provide moderate potential for future LWD recruitment (TAG 2002).

Percent Pool

Point No Point Treaty Council's 1991 surveys indicate 54.6% pool habitat, which gives this parameter a good rating for the upper watershed.

Pool Frequency

Pool frequency is 6.4 channel widths per pool (PNPTC, unpublished data, 1988).

Pool Quality

Beaver dams create 99 percent of the pools in this watershed (PNPTC, unpublished data, 1991).

Streambank Stability

According to 1991 Point No Point data, the streambanks lose their stability in the upper watershed where the stream has been dredged and otherwise altered for golf course activities. Downstream of the golf course the streambanks are stable. The TAG did not rate this parameter for this section.

Sediment Input

Sediment Supply/Mass Wasting

This parameter has been identified as a data gap.

Road Density

Road density is 4.48 miles of road per square mile of watershed. The number of road crossings is 0.72 per mile (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

The TAG did not rate this parameter. However, golf course maintenance and expansion activities have degraded riparian functions at the headwaters (Ted Labbe, personal communication, 2002).

Water Quality

Temperature

Port Gamble S'Klallam Tribal biologists monitored temperatures at SR 104 (see Table 5). The Ludlow Watershed Action Plan discusses a July 2, 1991, golf course pond water release that caused high turbidity and a temperature increase from 13.3^{o}C to 15.5^{o}C within one minute.

Dissolved Oxygen

The TAG identified this parameter as a data gap.

Hydrology/Flow

Hydrologic Maturity

The TAG identified this parameter as a data gap.

Percent Impervious Surface

The TAG identified this parameter as a data gap but acknowledged that the percent impervious surface is greater in the upper watershed than the lower watershed due to the golf course, housing development and associated roads. During the 1997/1998 spawning season, Shine Creek had high turbidity due to surface runoff from the Shine quarry pit on the north side of Highway 104. The runoff flowed into a wetland tributary between the quarry road and Highway 104, and then into Shine Creek. After this problem was brought to the quarry manager's attention, he agreed to dig a trench to divert runoff away from the stream into a clearcut. Monitoring the stormwater runoff from the pit is essential to ensure the problem is solved (Peter Bahls, personal communication, 2002).

Biological Processes

Nutrients (Carcasses)

The TAG identified this parameter as a data gap.

Data Needs

- Assess fine sediment
- Evaluate streambank stability
- Calculate sediment supply
- Identify mass wasting potential
- Collect dissolved oxygen data
- Determine hydrologic maturity

- Determine escapement goals for nutrient analysis
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Restore tidal flows and estuary function by widening crossing span on South Point/Thorndyke Road
2. Address stormwater runoff and associated siltation of right bank tributary running along the south side of SR 104
3. Monitor/extirpate exotic species (i.e. reed canary grass and Himalayan blackberry)
4. Work with golf course maintenance regarding best management practices

Bones Creek

With the exception of access, the TAG has little knowledge of this watershed. A partial barrier at Shine Road limits fish migration during most flows and five upstream barriers are total barriers (TAG 2002).

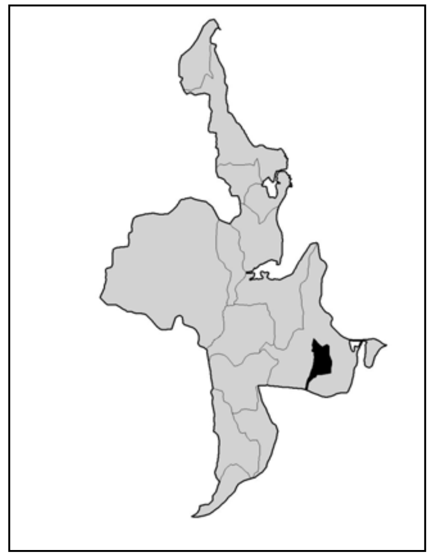

Figure 48. Bones Creek Watershed. Map provided by Jennifer Cutler, NWIFC

The creek has constant spring fed flows with good water quality and cutthroat trout in the headwaters (Peter Bahls, personal communication, 2002). Floodplain connectivity and loss of floodplain habitat are not applicable due to gradient. The status of a development with individual wells upstream of Highway 104 is unknown. There are stormwater runoff and associated erosion problems on the south embankment of SR 104. The remaining parameters are data gaps.

A small stream, adjacent to and east of Shine Creek, has a private fish-rearing pond. A standpipe blocks passage half way between Highway 104 and the mouth. Shine Road is being undermined at this point. All northern Squamish Harbor tributaries are blocked at Highway 104.

Estuaries

The lower watershed that is tidally influenced has been channelized and armored. Estuary function has been eliminated.

Data Needs

- Assess fine sediments
- Conduct ambient monitoring surveys for streambank stability, pools, large woody debris and riparian condition information
- Assess sediment supply and mass wasting potential
- Monitor water quality

- Determine hydrologic maturity, road density and percent impervious surface
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Address access problems
2. Address erosion problem on south embankment of SR 104
3. Collect additional habitat information

Ludlow Creek – Mouth to River Mile 0.5 (Cascade)

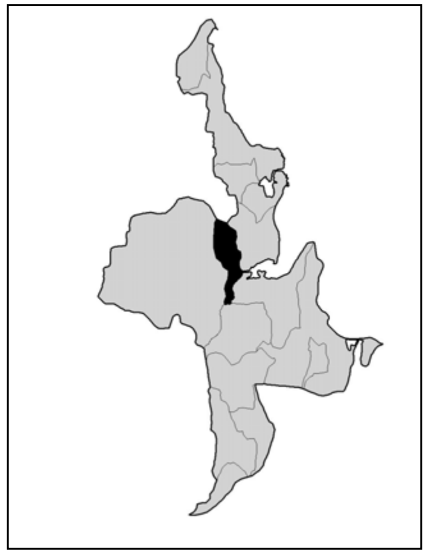

Figure 49. Lower Ludlow Watershed. Map provided by Jennifer Cutler, NWIFC

Access and Passage

Artificial Barriers

No man-made barriers are known to be present on the lower mainstem. A cascade at river mile 0.5 limits salmon migration. A right bank tributary and a left bank tributary in this lower watershed have partial barriers near their mouths. The culvert under Paradise Bay Road inhibits estuary function although tidal influence penetrates upstream.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The mainstem floodplain is intact. A maintenance road runs along the left bank but is away from the stream for most of the length. Flood flows are allowed to distribute sediments throughout the floodplain.

Channel Conditions

Fine Sediment

The TAG identified this parameter as a data gap.

Large Woody Debris

Large wood is present in moderate amounts (TAG 2002).

Pools

Information regarding pools is a data gap.

Streambank Stability

Streambanks are stable in the lower watershed (TAG 2002).

Sediment Input

Sediment Supply

A natural right bank slope failure below the cascade provides sediment to the lower system. A right bank tributary carries stormwater and associated sediment and debris from an upstream development and is a chronic erosion/slope failure problem. The TAG determined that the latter exceeds the natural sediment supply.

Mass Wasting

The TAG identified this parameter as a data gap.

Road Density

Road density is relatively low at 1.17 miles of road per square mile of watershed, though a valley bottom road exists. Road crossings are 1.23 crossings per mile of stream (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

There is an access road along the left bank but there is adequate cover with a substantial conifer component within the mixed forest/shrub habitat.

Water Quality

Temperature/Dissolved Oxygen

The TAG identified this parameter as a data gap.

Hydrology/Flow

Hydrologic Maturity

The TAG identified this parameter as a data gap. The TAG acknowledged that an intermittent left bank tributary is dry during the summer months.

Percent Impervious Surface

The TAG identified this parameter as a data gap.

Biological Processes

Nutrients (Carcasses)

The TAG identified this parameter as a data gap but acknowledged good spawning numbers within the half mile of habitat.

Estuaries

Ludlow Creek estuary is truncated by a culvert at Paradise Bay Road and some members of the TAG feel it should be replaced with a bridge to restore the tidal prism. Juvenile coho and cutthroat are found in the existing wetland with deep tidal channels that have formed by the road fill (Ron Hirschi, personal communication, 2002). Photographs taken in the 1800s of the head of the bay indicate less diverse tidal channel on mudflat without the marsh boundary (Ron Hirschi, personal communication, 2002).

Data Needs

- Assess fine sediments
- Collect pool information
- Determine mass wasting potential
- Collect water quality data
- Determine hydrologic maturity
- Determine percent impervious surface
- Evaluate road and road crossing impacts on aquatic resources

Ludlow Creek – above river mile 0.5

Access and Passage

Artificial Barriers

According to the barrier inventory conducted by WDFW for Jefferson County, a complete barrier for resident fish exists on each of two tributaries at Oak Bay Road, eliminating a total of 2.71 miles of stream. Two partial barriers on Larson Lake Road block approximately 3.83 miles of habitat to during certain flows. A partial barrier on Embody Road blocks approximately 1.96 miles of habitat during certain flows and a partial barrier on Thoren Road inhibits passage to 0.65 miles of habitat (Till et al.2000). These culverts provide total and partial barriers to resident fish. Additional barrier inventories on private roads are lacking (TAG 2002).

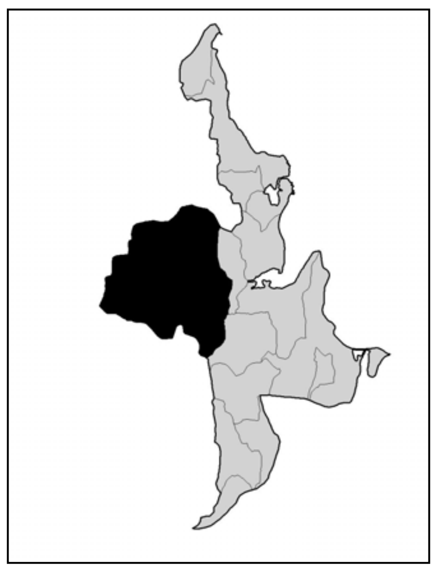

Figure 50. Upper Ludlow Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

According to the TAG's personal experience in the upper watershed, floodplain connectivity/habitat is fair. Flood flows have some access to the floodplain but there is some road constriction throughout parts of the upper watershed. The section around Larson Lake Road and Beaver Valley Road (SR 19) has been channelized at the confluence of three tributaries with the mainstem (TAG 2002).

Channel Conditions

Fine Sediment/ Large Woody Debris
The TAG identified these parameters as a data gap.

Pools
The TAG identified this parameter as a data gap but acknowledged the depth of beaver pond associated pools often exceeds the length of one's hipwaders.

Streambank Stability
Streambanks are stable in the upper Ludlow watershed (TAG 2002).

Sediment Input

Sediment Supply
The TAG determined that this parameter does not apply to the upper watershed as there are no steep areas that would affect the stream.

Mass Wasting
Again, the TAG determined that this parameter is not applicable due to the lack of steep slopes that would affect the upper watershed.

Road Density
Road density for the upper Ludlow watershed is 3.21 miles of road per square mile of watershed. The number of road crossings is 1.22 crossings per mile or 0.76 per kilometer (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
The riparian zone consists of a mixed forest but the historical component is unknown. The forestry buffers are minimal. Agricultural practices north of Larson Lake Road have limited riparian buffers as well (TAG 2002).

Water Quality

Temperature
The average instantaneous maximum temperature for 2001 was 15.4^{o}C near Phillips Road (Labbe 2002). Future temperature data will better define the status of water quality.

Dissolved Oxygen
The TAG identified this parameter as a data gap.

Hydrology/Flow

Hydrologic Maturity/Percent Impervious Surface
The TAG identified this parameter as a data gap.

Biological Processes

Nutrients (Carcasses)
The TAG identified this parameter as a data gap.

Data Needs
- Assess fine sediments
- Assess large woody debris
- Collect pool data
- Collect dissolved oxygen data
- Determine hydrologic maturity
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations
1. Increase span on Paradise Bay Road to increase tidal flow and estuary function
2. Assess and abate sediment input on right bank tributary in the lower watershed
3. Establish functioning riparian zone in the upper watershed
4. Assess and abate passage problems in the upper watershed
5. Conduct ambient monitoring surveys
6. Conduct benthic invertebrate studies

Piddling Creek

Access and Passage

Artificial Barriers
A perched culvert at Oak Bay Road prevents fish access to the upper watershed. WDFW determined it to be a partial barrier and placed it at number 36 of 84 on their Jefferson County barrier assessment with a priority index value of 9.53. There are two additional barriers upstream. If fixed, 0.80 miles of habitat would be available to anadromous fish (Till et al. 2000). One of the two is plugged with a wetland developing behind it. The potential for failure is high and could devastate the habitat downstream (Ted Labbe, personal communication, 2002).

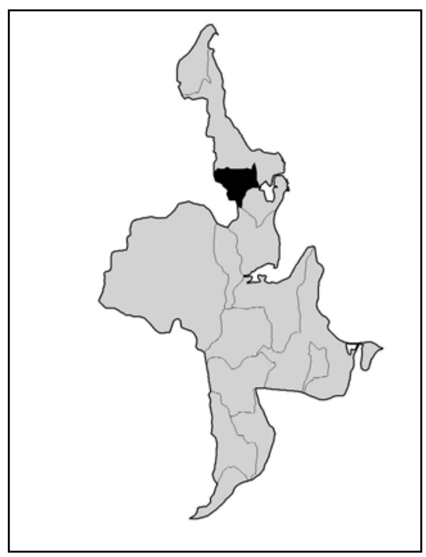

Figure 51. Piddling Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

Floodplain function is altered by channelization, armoring and constriction on both streambanks by driveways (TAG 2002).

Loss of Floodplain Habitat

Floodplain habitat is poor due to the constriction between two driveways, lack of coniferous in the riparian zone and development within the floodplain.

Channel Conditions

No information was available to characterize channel conditions.

Sediment Input

Sediment Supply/ Mass Wasting

The TAG identified this parameter as a data gap.

Road Density

Road density is 4.5 miles of road per square mile of watershed. The number of road crossings are 2.75 per mile of stream or 1.7 per kilometer (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Although it was acknowledged that the riparian zone is conifer dominated mixed forest with logging activities in the upper watershed, the TAG did not have enough collective experience with this watershed to give this parameter a rating and therefore identified it as a data need. There is no riparian buffer on the upper tributaries due to aggressive forestry in the upper watershed (Ted Labbe, personal communication, 2002).

Water Quality

There are no water quality data for this watershed.

Hydrology/Flow

The TAG identified this parameter as a data gap.

Biological Processes

Nutrients (Carcasses)

The TAG identified this parameter as a data need.

Estuaries
Piddling Creek estuary has been highly modified. Originally a wetland complex in conjunction with an adjacent stream to the south, the mouth has been channelized and armored. The creek empties to a very low gradient mudflat (TAG 2002).

Data Needs
Nearly all the parameters evaluated for this report need data and/or additional information prior to assessing limiting factors in this watershed.

Action Recommendations
1. Provide fish passage at Oak Bay Road
2. Gather habitat information/data to better understand production potential of this watershed.

NOTE: Other tributaries to Mats Mats Bay have been highly modified, with passage and development issues.

Little Goose Creek

The TAG had little collective knowledge about Little Goose Creek and identified all the parameters to be data needs. Some discussion took place, but not enough data or information were available to provide ratings.

Due to the placement of weirs, fish have access through culverts in the lower watershed, although the one under Oak Bay Road is listed as a partial barrier according to WDFW's barrier assessment. Fish do not have access to the pond which is regulated by a center standpipe. Coho spawn up to this barrier and trout are observed above the barrier. The headwaters from a wetland complex are seasonal and three seasonal tributaries, two of them good size with a width varying from four to six feet, are dry by June (TAG 2002). Road density is estimated at 2.81 road miles per square mile of watershed, and road crossings occur at 1.66 crossings per mile of stream (1.03 per kilometer)(PNPTC, unpublished data, 2002).

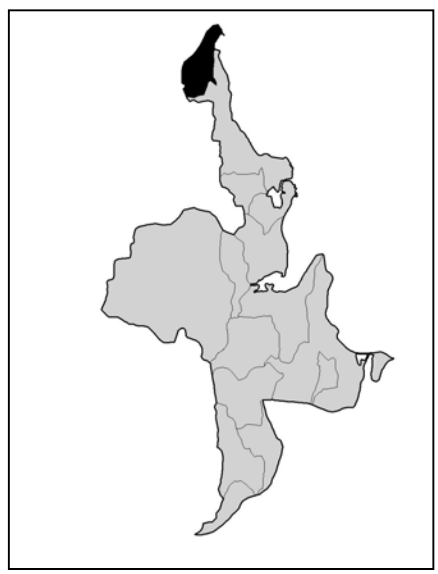

Figure 52. Little Goose Creek Watershed. Map provided by Jennifer Cutler, NWIFC

The lower watershed has been channelized, armored and developed for residential use. Access of flood flows to the floodplain has been eliminated although some habitat restoration has occurred in some parts of the lower watershed. There is local interest in reconnecting Little Goose Creek with its historic estuary. Historical accounts route the creek through the lagoon to the north of the existing outlet (Ray Lowry, personal communication, 2002). A bulkhead constricting the mouth of the creek and infringing on shoreline habitat has been removed. Some underplanting within the deciduous riparian corridor has taken place by local landowners. The TAG did not have enough collective knowledge of this watershed and identified the remaining parameters as a data gaps.

Estuaries

Historically, Little Goose Creek entered Little Oak Bay Lagoon which emptied into Port Townsend Bay. Currently, Little Goose Creek enters directly into Oak Bay to the east of the lagoon. There is no estuary and fish can enter the creek during high tide only.

Data Needs

- Basic information on Little Goose Creek

Action Recommendations

1. Restore historical connection with its estuary
2. Conduct habitat surveys, i.e. large woody debris, pools, streambank stability, water quality, and riparian condition
3. Provide passage to the manmade pond and upper watershed

CHIMACUM SUBBASIN

The Chimacum watershed is a low gradient system originating in forested headwaters and flowing through two valleys that have been converted from beaver complex/forested wetlands to agriculture and rural development. The East Fork flows through the aptly named Beaver Valley and the mainstem (sometimes referred to as the West Fork) flows through Chimacum Valley. The confluence of the two is at approximately river mile 2.8. Below the confluence the mainstem flows through rural residential developments of Port Hadlock and Irondale with the lower mile in a forested ravine that is largely protected from development by public and preservation organization ownership. There is little spawning habitat along the mainstem, which serves primarily as rearing habitat, both presently and historically. The numerous spring-fed tributaries are and were important spawning areas but less important for rearing (Ted Labbe, personal communication, 2002).

The Chimacum sub-basin includes Chimacum Creek (WRIA 17.0203) and its tributaries: East Fork Chimacum Creek (WRIA 17.0205), Putaansuu Creek (WRIA 17.0206), Naylor Creek (WRIA 17.0208) and South Fork Chimacum Creek (aka Barnhouse Creek) (WRIA 17.0213). The TAG further divided the mainstem as follows: lower Chimacum Creek (river mile 0.0-3.0), middle Chimacum Creek (river mile 3.0-9.4) and upper Chimacum Creek (above river mile 9.4).

Timber Fish and Wildlife (TFW) ambient monitoring data were collected by Wild Olympic Salmon (WOS) in 1999-2000 but effort was limited to the lower mile. Temperature data were available from Port Gamble S'Klallam Tribe (PGST) and Jefferson County Conservation District (JCCD). Barrier assessment was available through the WDFW but was limited to county and state roads. Point No Point Treaty Council (PNPTC) provided road density estimates for each section. At the riverine workshop session for this subbasin, the TAG reviewed Washington Department of Natural Resources (WDNR) aerial orthophotographs from the year 2000 to evaluate hydrologic maturity, riparian buffer width, stand age and composition and evidence of mass wasting events. Peter Bahls and Jude Rubin collected summer season data on water quality, fish distribution and abundance, and habitat condition in 1995. Western Washington University students working with Dr. Chris May provided additional data, collected spring of 2001. The TAG had further professional knowledge and observations of some parameters for some of the streams. The remaining parameters have been identified as data gaps.

Chimacum Creek, mouth to river mile 3.0

Access and Passage

Artificial Barriers
Fish have access throughout this reach, although the TAG noted that the culvert at Ness's Corner is undersized and potentially blocks anadromous migration during certain flows.

Floodplains

Floodplain Connectivity
Chimacum Creek has fill access to the floodplain throughout most of this reach, although the creek has been ditched and simplified through Ness's Corner, near river mile 2.0. The area between Hunt Road and the confluence with the East Fork is a wetland complex that was historically a beaver pond and maintains its wetland characteristics. The lower mile is a forested ravine with good access to side channels (TAG 2002).

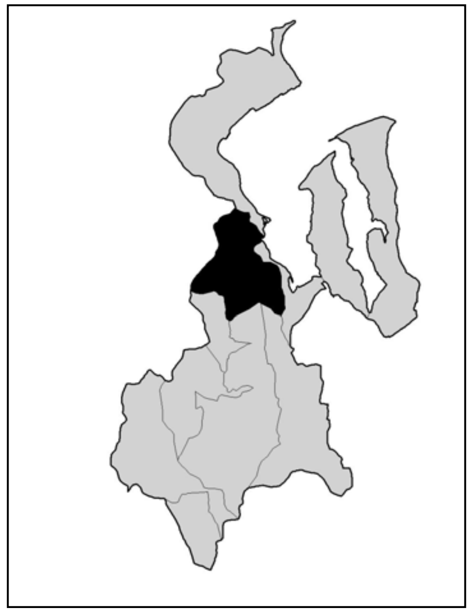

Figure 53. Lower Chimacum Watershed, river mile 0.0 to 3.0. Map provided by Jennifer Cutler, NWIFC

Loss of Floodplain Habitat
Floodplain habitat is mixed. The lower mile is a ravine with mixed forest cover that provides good fall and summer chum spawning habitat as well as spawning and rearing for coho, cutthroat and steelhead. The majority of the ravine and the associated estuary/nearshore habitats are largely protected through public ownership and/or conservation easements maintained by the Jefferson Land Trust. The upstream part of the reach, particularly above Ness's Corner, had been degraded through previous land use activities but is now healing (TAG 2002).

Channel Conditions

Fine Sediment
In 1985-1986 the culvert at Irondale Road (river mile 1.0) failed, depositing a large amount of fill into the stream. Over the next few years, gravels in the lower mile were cemented together with fine sediments and the entire summer chum population was extirpated. This event was not the only cause of extirpation, but it probably contributed significantly to spawning and incubation failure. Wild Olympic Salmon and The Quilcene Snow Restoration Team attempted to clean gravels several times. In recent years the cementing effects of the culvert failure have diminished. Recent summer chum escapement (900 in 2001) helps improve the gravels further by digging redds and moving sediment further downstream. Sediment has been a noticeable problem in Chimacum

Creek since the soils adjacent to the creek have a high fine content (Al Latham, personal communication 2002).

Large Woody Debris

The ravine has a fair amount of large woody debris with good recruitment potential from a mixed forest riparian zone. Very little large woody debris is observed between the ravine and Hunt Road but good recruitment potential exists in this reach. The wetland between Hunt Road and the confluence with the East Fork also houses very little wood (TAG 2002).

Percent Pool

Downstream of Irondale Road pool habitat is approximately 17 percent, with 50 percent riffle and 33 percent glide (Ball et al 2001). Upstream of Irondale Road pool habitat increases to approximately 20 percent with 40 percent riffle and 40 percent glide (Ball et al 2001).

Pool Frequency

This parameter has been identified as a data gap.

Pool Quality

Pool quality is poor. Few deep pools exist where there is adequate cover (TAG 2002). Mean pool depth downstream of Irondale Road is 0.3 meters (Bahls and Rubin 1996). Riparian cover is good in this ravine section. Mean pool depth increases to 0.95 meters upstream of Irondale Road (Bahls and Rubin 1996) but riparian cover decreases (TAG 2002).

Streambank Stability

Streambank stability is good for most of this segment, although the TAG noted a channelized section near Hunt Road with raw banks. The ravine reach has experienced two small slope failures in the past five years that contributed sediments to the lower watershed. These types of failures that are naturally occurring are important for sediment recruitment within this reach.

Sediment Input

Sediment Supply

A culvert/fill failure at Irondale Road in the mid 1980s contributed a large amount of sediment to the lower watershed. In addition to the additional, naturally occurring slope failures, sediment supply is compounded by the number of roads and the amount of development in the vicinity of Irondale and Hadlock. The amount of sediment resulting from human activities in the watershed increases the sediment supply above the natural. Considerable amounts of sediment enter the creek when Jefferson County Public Works cleans the road ditches and will continue to be a problem until the county alters the timing and methodology of their ditch cleaning efforts (TAG 2002).

Mass Wasting

With the exception of the culvert/fill failure at Irondale Road in the mid 1980s, mass wasting is not a problem in this lower segment. Two small slope failures within the ravine reach were natural occurrences (TAG 2002).

Road Density

Road density is high at 6.56 miles of roads per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

The riparian corridor within the ravine reach below Irondale Road consists of mixed forest of various age classes extending to the top of the ravine and has a canopy cover of approximately 60 percent. The riparian corridor above Irondale Road is dominated by alder and shrubs, with a canopy closure of approximately 30 percent (Ball et al 2001). Human activities have diminished the riparian quality in the vicinity of Ness's Corner.

Water Quality

Temperature

Jefferson County Conservation District places data loggers (Optic StowAway) programmed to record temperature data every hour at three temperature stations in this segment of Chimacum Creek: river miles 0.1, 1.1 and 2.3.

Table 16. Lower Chimacum Creek Annual Instantaneous Maximum Temperatures, ^{o}C.

Location	1992	1993	1994	1995***	1996	1998	1999	2000	2001
RM 0.1*				~16.5		19.0	17.0	18.0	
RM 1.**	18.3	18.9	18.3	~18.9	18.3			18.7	16.3
RM 1.1*								19.0	
RM 2.3*								18.0	

*Data collected by Jefferson County Conservation District
**Data collected by Port Gamble S'Klallam Tribe
***Data collected by Bahls and Rubin

Water temperature data has also been collected by Port Gamble S'Klallam tribal biologists in 1992, 1993, and1994 using Taylor maximum-minimum thermometers and in 2001 using continuous temperature data loggers (Hobo Temps and StowAway TidBit Temps) at the Irondale Road culvert. In 1995, Bahls and Rubin used computerized continuous monitoring thermometers in the deepest pools available. With good canopy cover in the lower reach, the elevated temperatures are coming from upstream (Glenn Gately, personal communication 2002).

Dissolved Oxygen

Between river mile 0.0 and 1.1, the dissolved oxygen concentrations are well above 8.0 mg/L (Bahls and Rubin 1996; Gately 2001). Between river mile 1.1 and 3.4, dissolved oxygen concentrations remain above 8.0 mg/L (Bahls and Rubin 1996). At river mile 3.4, the dissolved oxygen concentrations drop well below 8.0 mg/L (Bahls and Rubin 1996; Gately 2001). Water quality is significantly impacted by upstream activities. In addition, Glenn Gately has recorded intergravel dissolved oxygen concentrations and has found them to be variable but overall poor. The concentrations are particularly low prior to summer chum emergence from the gravels (Glenn Gately, personal communication, 2002).

Hydrology

Flow – Hydrologic Maturity

The TAG identified this parameter as a data gap.

Flow – Percent Impervious Surface

Percent impervious surface for this reach is 5.8 (Jeff Miller, personal communication, 2002).

Biological Processes

Nutrients (Carcasses)

Two benthic invertebrate samples were analyzed in the lower river/estuary and were found to contain predominantly stoneflies, true flies and mayflies, all indicators of healthy habitats (Ball et al 2001). Recent returns of summer chum to the lower reach boost the nutrient level, but nothing has been quantified. Bahls and Rubin (1996) detail the loss of about 95 percent of coho rearing habitat in the watershed and coho spawning and related nutrient levels are probably much depleted from historic conditions.

Estuary

Chimacum Creek enters its narrow estuary near the southwest corner of Port Townsend Bay. The estuary begins in a highly degraded nearshore habitat but develops more pristine qualities as it flows 3,500 feet landward toward a forested ravine. The lower estuary and adjacent nearshore environment had been filled for use as a log storage site but has recently been purchased by Washington Department of Fish and Wildlife and restoration funds have been awarded for fill removal. Non-native fill will be removed from the site and clean native fill (sandy marine sediment) will be relocated against the bluff for future marine recruitment to nourish nearshore features, such as the historic estuary spit that has been altered. Continuing efforts by the Chumsortium, a cooperative consortium of public agencies and local non-profit organizations, have preserved much of the lower watershed, including the estuary, through acquisition and/or conservation easements.

Data Needs

- Determine pool frequency

- Determine hydrologic maturity
- Establish escapement goals for Chimacum Creek

Chimacum Creek, river mile 3.0-9.4

Access and Passage

Access

Two partial barriers exist in this segment: a double culvert under Center Road at approximately river mile 6.6 and a culvert under Eaglemount Road at approximately river mile 8.8. These two culverts are passable during most flows. The two culverts are ranked for replacement priority as number 12 and number 26, respectively, on WDFW's Jefferson County culvert inventory (Till et al 2000).

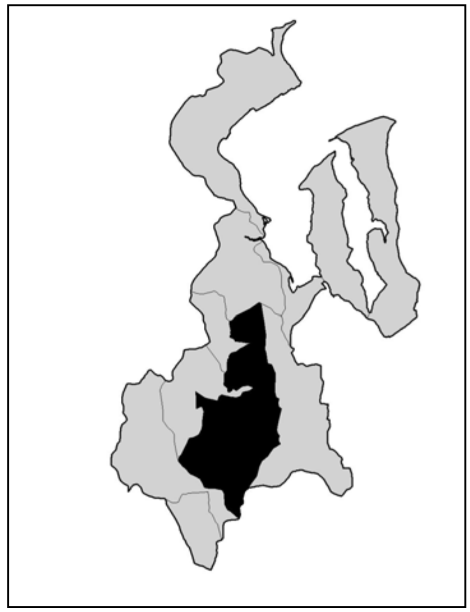

Figure 54. Middle Chimacum Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The creek has been channelized through 90 percent of this segment with maintenance dredging associated with reed canary grass removal on an as needed basis. Flooding does occur but the channel is not allowed to meander throughout the valley as it did historically. The creek is incised through peat (muck soils) through much of this reach (Al Latham 2002).

Loss of Floodplain Habitat

General Land Office surveys, conducted between 1858 and 1873, reported both branches of Chimacum Creek to be dominated by beaver marshes, cedar and spruce swamps, and shallow lakes (Bahls and Rubin 1996). These historic beaver ponds/wetlands have been converted to agriculture and rural residential use and are now predominantly ditches without structure, complexity or riparian zones (TAG 2002).

Jefferson County Conservation District, Port Gamble S'Klallam Tribe, Wild Olympic Salmon, the Quilcene/Snow Restoration Team and the North Olympic Salmon Coalition have been working in the watershed for the past two decades to reestablish structure, complexity of stream channels, and riparian zones where landowners are willing.

Channel Conditions

Fine Sediment

Soil composition is predominantly muck types and is without the presence of spawning gravels. Fine sediments are a problem throughout the watershed (Al Latham, personal communication 2002) but have not been quantified in this reach. The TAG determined this to be a data gap.

Large Woody Debris

Large woody debris is lacking in this segment and future recruitment potential is limited due to lack of a forested riparian zone (Bahls and Rubin 1996). Ongoing restoration efforts in this reach include large woody debris placement. Efforts to reestablish a forested riparian zone are also ongoing, but it will be a long time until the trees reach maturity (TAG 2002).

Percent Pool

The mainstem through Center Valley has been channelized and dredged. The majority is one long glide without structure to create pools (TAG 2002).

Pool Frequency

Pool frequency is low due to the extensive glide habitat in this reach (TAG 2002).

Pool Quality

The majority of this segment is one extensive glide with few deep pockets and with little or no cover (TAG 2002).

Figure 55. Chimacum Creek Habitat Restoration. Photo provided by Al Latham, JCCD

Streambank Stability

The stream has been channelized and is now an incised ditch with little water movement during low flows in summer. Reed canary grass, an undesirable invasive species, is found along the banks and its massive root system protects the soil/banks from erosion. The reach along the Christian property has shown some instability (Al Latham, personal communication 2002) and has become a focused effort for habitat restoration.

Sediment Input

Sediment Supply

The TAG determined this parameter to be a data gap.

Mass Wasting

The TAG determined this parameter to be not applicable as there are no steep hills in this segment.

Road Density
Road density is poor at 3.82 miles of road per square mile of watershed. The number of road crossings is 1.98 per mile (1.23 per kilometer) of stream (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
Three small sections of the creek at river mile 3.5 (school), river mile 3.7 and river mile 4.2 have trees and shrubs on both banks. Between river mile 6.5 and 7.0 and again between river mile 8.6 and 8.8, the banks are forested but the remaining 5.7 miles is open and exposed (TAG 2002).

Water Quality

Temperature
Jefferson County Conservation District maintains water quality stations at river mile 3.9, 5.3 6.7, 7.0, 9.0 and 9.4. The station at river mile 9.4 is indicative of the watershed condition above this segment. Annual instantaneous maximum temperatures in this segment were measured in the summer months.

Table 17. Middle Chimacum Creek Water Temperatures. Data provided by Glenn Gately, JCCD

Year	RM 3.9 °C	RM 5.3 °C	RM 6.7 °C	RM 7.0 °C	RM 9.0 °C	RM 9.4 °C
1998	23	19.5			18.5	15
1999	22.5	17			16.3	16
2000	24		16	17	15.5	14

Bahls and Rubin (1996) monitored water temperature at 22 stations throughout the watershed in 1995 and their findings substantiate the JCCD temperature data.

Dissolved Oxygen
Jefferson County Conservation District measured dissolved oxygen at three stations in this segment. At river mile 3.9 and 5.3, the concentrations dropped below 6 mg/L. At river mile 6.7 concentrations improved but still fell below 8 mg/L (Gately 2001). Bahls and Rubin (1996) found that summer dissolved oxygen levels reached daily lows below salmonid tolerance levels in the lower part of this reach.

Hydrology

Flow – Hydrologic Maturity
Orthophoto analysis indicates the majority of this segment of watershed has been cleared for agriculture and rural development (TAG 2002).

Flow – Percent Impervious Surface
This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

Macroinvertebrate surveys at river mile 6.8, 8.3 and 9.4 were 80 percent caddisfly, mayfly and stonefly, indicating a healthy system (Costello et al 2001). The results are interesting but since the number of samples taken is not statistically enough to rate this parameter, the TAG considers it a data gap.

Data Needs

- Determine fine sediments
- Evaluate sediment supply
- Evaluate nutrients
- Evaluate road and road crossing impacts on aquatic resources

Chimacum Creek, above river mile 9.4

Access and Passage

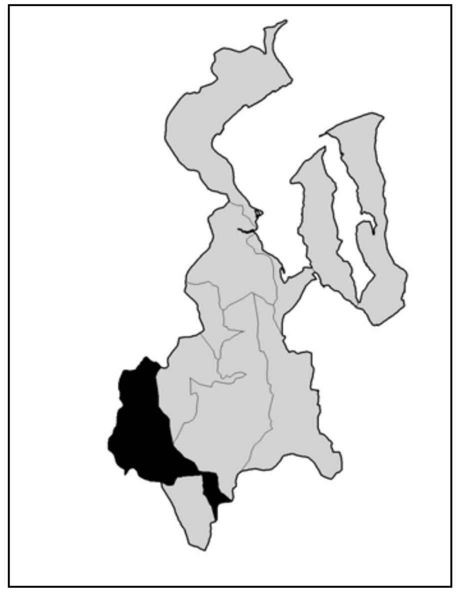

Figure 56. Upper Chimacum Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Access

The culvert at river mile 12.6 under Eaglemount Road just below Delaney Lake is marginally passable during certain flows. Juvenile coho have not been observed above the culvert (Jefferson County Conservation District, unpublished data 2002). Washington Department of Fish and Wildlife found the habitat to be of good quality above the culvert, estimating 16,247 meters of stream length, 7,633 square meters of spawning habitat and 139,977 square meters of rearing habitat. The priority index for this culvert is 32.32, placing it number 5 out of 84 on the list of county culverts to be replaced (Till et al 2000). Fish use in this part of the upper watershed is flow dependent and during low flow years, particularly summer months, there is no fish utilization. The creek is dry upstream of river mile 12 to the Eaglemount Road culvert beginning in late June (Glenn Gately, personal communication, 2002).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

The TAG determined this parameter to be not applicable to most of this segment due to gradient.

Channel Conditions

Fine Sediment
The TAG determined this parameter to be a data gap.

Large Woody Debris
The WDFW coho index area in the downstream end of this segment between river mile 9.4 and 10.2 has a moderate amount of large wood and substantial recruitment potential. The upstream part of this segment has been converted to agriculture with no large woody debris and poor recruitment potential.

Percent Pool
The headwaters contained very few pools and riffles (Costello et al 2001) but the percentage has not been quantified. The TAG did not rate this parameter and considered it a data gap.

Pool Frequency
The TAG determined this parameter to be a data gap.

Pool Quality
The TAG determined this parameter to be a data gap but noted that quality of any existing pools is diminished by effects of mass wasting in this segment.

Streambank Stability
Based on best professional knowledge, the TAG determined that, overall, streambanks in this segment are moderately stable.

Sediment Input

Sediment Supply
This parameter is poor as the sediment supply exceeds the natural rate due to mass wasting events in this segment. As a result, a sediment basin at the lower end of this segment requires periodic maintenance/sediment removal.

Mass Wasting
Two adjacent right bank slope failures, nearly an acre in area, dramatically increased the sediment load to this segment. A perched landing with subsurface water gave way to a massive failure in the mid 1990s. Wild Olympic Salmon, the Quilcene/Snow Restoration Team and the landowner, Pope Resources, have modified the drainage in the area to abate the failure and to prevent future failures.

Road Density
Road density is poor at 4.74 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

The TAG gave this parameter an overall fair rating. The Washington Department of Fish and Wildlife coho spawning index area is forested with good cover and good future large woody debris recruitment. The upper watershed has been converted to agriculture and has little or no riparian zone (TAG 2002).

Water Quality

Temperature

Water temperatures are affected by the agriculture activities in the upper watershed (Table 17).

Dissolved Oxygen

Dissolved oxygen concentrations in the lower part of this segment occasionally drop below 8 mg/L (Gately 2001). There is little or no flow with no aeration and no water in the channel in the agriculture section after the end of June (Glenn Gately, personal communication 2002).

Hydrology

Flow – Hydrologic Maturity

Upon viewing/analyzing aerial orthophotos from the year 2000, the TAG determined that less than sixty percent of the watershed is older than 25 years.

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Data Needs

- Determine fine sediments
- Collect pool data: percent, frequency and quality
- Determine nutrients
- Evaluate road and road crossing impacts on aquatic resources

Chimacum Creek, East Fork

Access and Passage

Access

An undersized culvert under the Egg and I Road is 67% passable for salmonids, according to WDFW estimate based on physical characteristics. Approximately 6,725 meters of stream length are above the culvert with 2,994 square meters of spawning habitat and 6,104 square meters in rearing habitat. The priority index value is 11.21 and it ranked number 30 out of 84 on the prioritized culvert project list for Jefferson County (Till et al 2000). A perched culvert on a Swansonville tributary under SR 19 totally blocks anadromous migration. In addition, private culverts on ditches are often undersized but an extensive inventory has not been undertaken and is considered a data gap. However, fish are observed in the most of the headwaters and tributaries, except Swansonville (Bahls and Rubin 1996; TAG 2002).

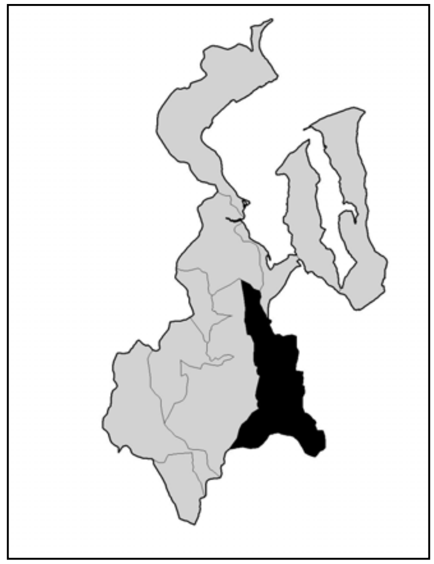

Figure 57. East Fork Chimacum Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

Historic beaver habitat and associated wetlands have been converted to agriculture and consequently 90 percent of the stream is channelized. Much of the East Fork flows through peat and sand and has incised. The valley floods during wet winters, but the channel is not allowed to meander and there are no side channels other than ditches.

Loss of Floodplain Habitat

Historically, beaver dams and associated wetlands defined the landscape of the East Fork, hence the name Beaver Valley, and provided good rearing habitat, particularly for coho. As the valley was converted to agriculture, spruce and cedar disappeared, as did instream structure and sinuosity. The Jefferson County Conservation District is actively promoting their CREP incentive program, which includes cattle exclusion fencing and riparian planting within a maximum buffer width of 180 feet. Port Gamble S'Klallam Tribe partnered with Wild Olympic Salmon and the Quilcene/Snow Restoration Team to remove a farm road culvert barrier, develop ponds, remeander the stream and stabilize a downcut channelized section with log weirs. Cattle exclusion fencing and replanting the riparian area were also components of this project in the upper watershed. Seasonal monitoring with minnow traps has documented that coho juveniles now use this reach for summer and winter rearing (Peter Bahls, personal communication, 2002). Port Gamble S'Klallam Tribe, the North Olympic Salmon Coalition and Wild Olympic Salmon have also actively pursued grants to provide additional instream structure, sinuosity and riparian plantings. As these efforts continue, the habitat quality should improve (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap, although the TAG noted that the majority of the valley bottom is very sandy and does not provide spawning substrate except in the upper watershed.

Large Woody Debris

Large woody debris is present only in the upper watershed where the landscape has not been altered and remaining forests provide recruitment. Very little large woody debris exists in the agriculturally developed valley and riparian recruitment is negligible. However, as restoration efforts continue to add structure and riparian plantings to the system, this parameter will likely improve over time (TAG 2002).

Percent Pool

The agricultural section of the East Fork is one long glide with no instream structure to create pools and riffles. Data collected in a 100-meter section in the headwaters determined the pool/riffle/glide ratio to be 10.4/46.2/43.4 (Stumbaugh et al 2001). The upper watershed does provide spawning habitat for coho, cutthroat and steelhead.

Pool Frequency

The majority of the agricultural section is one long riffle/glide without significant pools and riffles. Data do not exist to quantify pool frequency (TAG 2002).

Pool Quality

Parts of the headwaters of the East Fork and its tributaries are forested. However, the majority of the East Fork is agricultural without riparian cover to contribute to pool quality (TAG 2002).

Streambank Stability

The majority of the agricultural section is an incised ditch without rapidly flowing water. Reed canary grass, an undesirable invasive non-native ground cover, dominates the riparian zone and its dense root system, along with the lack of rapidly flowing water, prevents streambank erosion. The TAG noted some erosion in some areas where dredging has eliminated the streambank vegetation cover and/or where livestock has access to the creek. Recent restoration efforts by the Jefferson County Conservation District and Jamestown S'Klallam Tribe upstream of Beaver Valley Road involved cleaning out the reed canary grass and replanting with native shrubs and trees to shade future reed canary grass growth and at the same time provide stream bank stability. These efforts include long term monitoring and maintenance to ensure success of the project. Past restoration efforts by Wild Olympic Salmon, Quilcene/Snow Restoration Team and Jefferson County Conservation District have included the installation of livestock exclusion fencing and riparian plantings.

Sediment Input

Sediment Supply

The sediment supply in the East Fork exceeds the natural rate due to the ditch maintenance within the agricultural section (TAG 2002).

Mass Wasting

This parameter is not applicable to this section as only 0.7 percent of the watershed is greater than 30 percent slope (TAG 2002).

Road Density

Road density is 3.39 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

About 79.5 percent of the East Fork is non-forested lands/agriculture while 20.5 is forested. Of the forest cover, 4.7 percent is greater than 70 percent conifer and 11.3 percent is less than 10 percent conifer. The remaining 4.5 percent is 10-70 percent conifer. (Stumbaugh et al 2001). The majority of the watershed, however, has been converted to agriculture with little or no riparian habitat. The majority of the riparian zone throughout the watershed lacks overstory vegetation. There are 0.894 road crossings per kilometer of stream, which fragments the canopy (PNPTC, unpublished data 2002). Fragmentation of riparian canopy occurs mainly in the upper watershed due to roads, homes and barns (Stumbaugh 2002). Jefferson County Conservation District is promoting the Conservation Reserve Enhancement Program, a 15-year lease program that establishes a 180-foot maximum buffer on either side of the creek and provides livestock exclusion fencing and riparian planting. Past restoration efforts by Wild Olympic Salmon, Quilcene/Snow Restoration Team, Port Gamble S'Klallam Tribe, North Olympic Salmon Coalition and Jefferson County Conservation District have included the installation of livestock exclusion fencing and riparian plantings.

Water Quality

Temperature

Jefferson County Conservation District monitors water quality at four sites on East Fork Chimacum Creek: river miles 0.1, 1.0, 3.3 and 5.4 (Table 18). Temperature data loggers (Optic StowAway) were installed during the summer months at the bottom of low areas of the stream (Gately 2001). Port Gamble S'Klallam tribal biologists have monitored water temperature at Beaver Valley Road, river mile 1.0, since 1992. Taylor maximum-minimum thermometers were used between 1992 and 1994 but were replaced with continuous temperature data loggers (Hobo Temps and StowAway TidBit Temps) in 1996. Thermometers were placed on the bottom of a pool at the monitoring site (Labbe et al 2002).

Table 18. East Fork Chimacum Creek Water Temperatures. Data provided by Ted Labbe, PGST and Glenn Gately, JCCD

Location	1992 °C	1993 °C	1994 °C	1996 °C	1998 °C	1999 °C	2000 °C	2001 °C
RM 0.1*							18-19	
RM 1.0*					17.5	17	19.5	
RM1.0**	17.2	16.7	17.2	16.2	17.9	17.1	19.7	19.2
RM 3.3*					16.5	15	15	
RM 5.4					13	12	11.5	

* data from Jefferson County Conservation District
** data from Port Gamble S'Klallam Tribe

The headwaters at river mile 5.4 are forested and water temperatures are consequently good. Moving downstream, water temperatures begin to increase as forest cover decreases. The lower 3.3 miles flows through open agricultural lands, which increases water temperatures (see Table 7).

Dissolved Oxygen

Jefferson County Conservation District monitors dissolved oxygen at the same sites as water temperature and the data follows the same pattern. The forested headwaters have good dissolved oxygen concentrations. Above river mile 1.8 the data shows dissolved oxygen concentrations between 1999 and 2001 falling between 6-8 milligrams per liter. At Beaver Valley Road (river mile 1.0) dissolved oxygen concentration deteriorates, often falling below 6 mg/L in 1995 (Bahls and Rubin 1996) and between 1997 and 2001 (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

Conversion from forested wetland and beaver habitat to agriculture and rural development throughout the majority of the segment has eliminated much of the forest cover (TAG 2002).

Flow – Percent Impervious Surface

This parameter is a data gap. Some impervious surfaces exist, including state, county and private roads. A qualitative judgment would be that implications are fairly negligible (Stumbaugh et al 2001). The drainage density (miles of stream/watershed) is quite high at 0.80. Because the majority of the creek is within agricultural usage, any impervious surface will undoubtedly affect the system (Stumbaugh et al 2001).

Biological Processes

Nutrients (Carcasses)

Western Washington University students collected three samples of macroinvertebrates at each of two major sites: the forested headwaters and the agricultural reach near Peat Plank Road. In the forested headwaters, stonefly dominated at 34.3 percent, with mayfly at 11.7 percent and caddisfly at 9.5 percent (Stumbaugh et al 2001). The dominance of these species indicates a healthy watershed as they are intolerant of pollutants (Paulsen 1995). The agriculture reach had oligochaetes at 28.7 percent and caddisfly at 21 percent with stonefly low at 0.33 percent and no mayflies recorded (Stumbaugh et al 2001). The high percentage of oligochaete (worms) along with low percent of stonefly and absence of mayfly suggests a high tolerance of pollutants (Paulsen 1995). However, because of the low number of sites sampled, this parameter is still considered a data gap.

Data Needs

- Determine fine sediments
- Determine pool frequency
- Assess nutrients
- Evaluate road and road crossing impacts on aquatic resources

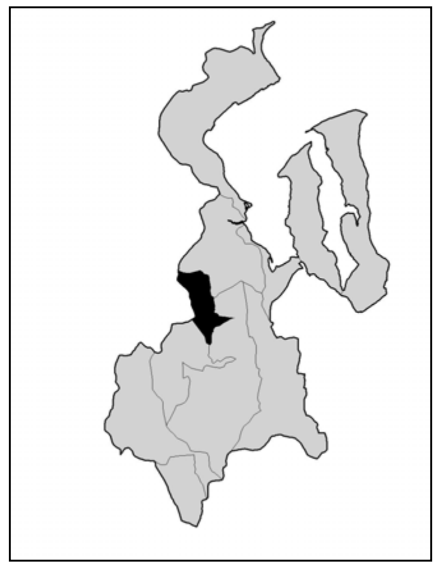

Figure 58. Putaansuu Watershed. Map provided by Jennifer Cutler, NWIFC.

Putaansuu Creek

Putaansuu Creek is a left bank tributary to Chimacum Creek at approximately river mile 4.0. Putaansuu Creek flows out of Anderson Lake through a wetland complex without a definitive channel. The upper watershed is managed for forest practices and the lower reach is an incised channel through agriculture lands.

Access and Passage

Access

There are no known artificial barriers in Putaansuu Creek although habitat above the pond is limited by gradient (TAG 2002).

Floodplains

Floodplain Connectivity

The lower reach of Putaansuu Creek has been channelized and is now an incised ditch with poor connectivity with the floodplain. The upper reach increases in gradient above the pond that is just upstream of West Valley Road (TAG 2002).

Loss of Floodplain Habitat

Putaansuu Creek flows out of Anderson Lake through a wetland complex without a definitive channel. The lower reach, also of lower gradient, has been channelized and is now an incised ditch through agriculture lands with a narrow riparian zone, the result of riparian restoration efforts by Chimacum students, Boy Scouts and the Quilcene/Snow Restoration Team. The trees were planted between 1990 and 1995 and will take time to mature (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap although the substrate is sandy (Al Latham, personal communication 2002).

Large Woody Debris

Large woody debris is lacking and future recruitment potential in the lower watershed is also poor. The upper watershed is managed for timber harvest with minimum riparian buffers (TAG 2002).

Percent Pool

Personal knowledge by TAG participants indicates that percent pool is small.

Pool Frequency

Personal knowledge by TAG participants indicates that pools are uncommon.

Pool Quality

Lack of deep pools and canopy closure limits pool quality (TAG 2002).

Streambank Stability

Streambank stability is a data gap.

Sediment Input

Sediment Supply

Sediment supply is a data gap, although the TAG noted that there are possible logging impacts in the upper watershed but nothing has been quantified.

Mass Wasting

Mass wasting is a data gap.

Road Density

Road density is poor at 5.15 miles of road per square mile of habitat (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Riparian cover is minimal throughout the agricultural portion of this segment. Between 1990 and 1995, Chimacum students, Boy Scouts and the Quilcene/Snow Restoration Team fenced and planted a narrow riparian zone in the lower reach (Al Latham, personal communication 2002). As the trees and shrubs mature, the riparian condition will improve through this reach. The riparian condition in the upper watershed is also limited due to the minimum buffer size remaining after timber harvest (TAG 2002).

Water Quality

Temperature

Annual instantaneous maximum temperature at this site was 21^{o}C in 1998 and 21.5^{o}C in 1999. Temperatures did not exceed 16^{o}C at river mile 0.5 above the pond and were recorded at 12.5^{o}C in 2000 (Gately 2001). Water temperatures should improve as a canopy is established when riparian plantings reach a more mature size (TAG 2002).

Dissolved Oxygen

Dissolved oxygen concentrations did not fall below the state standard of 9.5 mg/L in the year 2000 (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

Due to conversion to agriculture in the lower watershed and recent clear-cutting in the upper watershed, more than sixty percent of the watershed is in forest less than 25 years old (TAG 2002).

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap for this segment.

Data Needs

- Determine fine sediments
- Assess sediment supply, mass wasting potential and streambank stability
- Determine percent impervious surface
- Evaluate nutrients
- Evaluate road and road crossing impacts on aquatic resources

Naylor Creek

Naylor Creek is a left bank tributary meeting Chimacum Creek at approximately river mile 5.4. The headwaters flow through Gibbs Lake through poorly managed forestlands, a small amount of rural development, and agricultural lands in the lower reach.

Access and Passage

Access

A partial barrier exists at a deteriorating culvert under West Valley Road that limits fish access to the upper watershed under certain flows. Approximately 6,146 meters of stream are above west valley road with 2,847 square meters of spawning habitat and 203,011 square meters of rearing habitat. This barrier received a priority index value of 26.91 and is prioritized for restoration as number 9 out of 84 on the Jefferson County culvert/barrier inventory. There are five additional upstream barriers on tributaries under private roads and driveways (Till et al 2000). A hydrologic barrier exists above West Valley Road as the stream is dewatered during the summer months (TAG 2002).

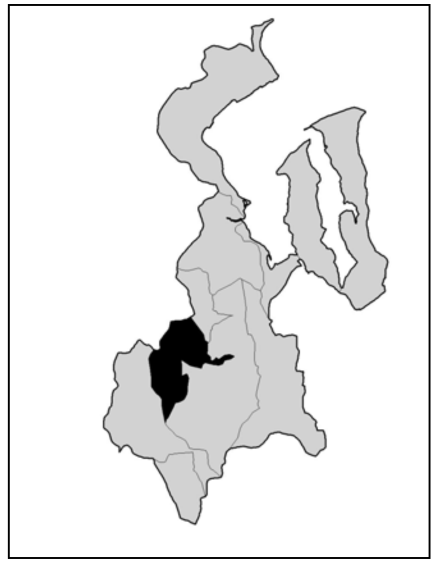

Figure 59. Naylor Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The low gradient reach is in the lower 0.8 mile and has been channelized and deeply dredged (TAG 2002).

Loss of Floodplain Habitat

The low gradient reach is in the lower 0.8 mile and has been channelized and deeply dredged. Ditching has also occurred in the headwaters along the mainstem and in a left bank tributary that is managed for agriculture/cattle grazing. Another tributary, Sheister Creek, has been extensively modified at its headwaters with a series of ditches that drain a wetland. Artificial spawning pads below Gibbs Lake could use more gravel. The mid-section of Naylor Creek provides good habitat and remains in a natural condition.

Channel Conditions

Fine Sediment

Fine sediment is a data gap. The TAG noted sandy substrate in the vicinity of West Valley Road and a very soft bottom at the mouth.

Large Woody Debris

Large woody debris is a data gap although the TAG noted a distinct lack of large woody debris in the lower section.

Pools
Information about pools does not exist for this segment.

Streambank Stability
TAG participants with knowledge of this creek consider streambank stability to be moderately stable (Al Latham, personal communication 2002; Glenn Gately, personal communication 2002).

Sediment Input

Sediment Supply
Sediment supply is a data gap, but the TAG noted that past logging practices could have created some problems.

Mass Wasting
Mass wasting is not a problem (TAG 2002).

Road Density
Road density is poor at 4.05 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
The upper watershed was extensively logged in the 1980s with little or no riparian buffer. The lower reach has been converted to agriculture and is devoid of riparian cover (TAG 2002).

Water Quality

Temperature
Annual instantaneous maximum temperatures are high near the mouth of Naylor Creek and improve upstream at river mile 0.7 (see Table 19).

Table 19. Naylor Creek Water Temperatures. Data provided by Glenn Gately, JCCD

Location	1998	1999	2000
Naylor Creek, RM 0.2	16.3^{o}C	14.5^{o}C	15^{o}C
Naylor Creek, RM 0.7			12.2^{o}C

Dissolved Oxygen
Data from the year 2000 indicates that the concentrations near the mouth approach 8 mg/L in the summer months. Concentrations at river mile 0.7 remain above the state standard of 9.5 mg/L (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

The upper watershed was harvested less than 20 years ago and little buffer remains along the mainstem and tributaries. Agriculture practices in the lower watershed have eliminated trees and shrubs (TAG 2002).

Flow – Percent Impervious Surface

Percent impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Data Needs

- Assess fine sediments
- Assess large woody debris and future recruitment
- Conduct pool quantity/quality surveys
- Determine sediment supply
- Determine percent impervious surface
- Evaluate nutrients
- Evaluate road and road crossing impacts on aquatic resources

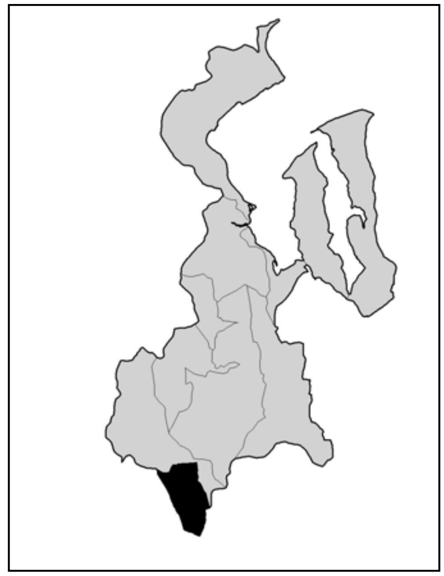

Figure 60. South Fork Chimacum (aka Barnhouse) Watershed. Map provided by Jennifer Cutler, NWIFC

South Fork Chimacum Creek (Barnhouse Creek)

South Fork Chimacum Creek has been known by different names over the years. It was at one time considered to be the mainstem, but this report acknowledges the mainstem flowing to the north as depicted in the stream catalogue (Ames and Bucknell 1986). The creek assumed the name Barnhouse Creek when habitat restoration and preservation activities occurred on the Barnhouse property. The creek originates from springs in the upper watershed and flows through a recently restored section downstream of Center Road and through beaver dams downstream. The lower part of the creek has been channelized through agriculture lands.

Access and Passage

Artificial Barriers

Access is good throughout most of this stream and its tributaries. A culvert under Center Valley Road is a velocity and gradient barrier during certain flows. Approximately 756 meters of stream are above the barrier with 533 square meters of spawning habitat and 797 square meters of rearing habitat. WDFW assigned this culvert a priority index value of 6.74 and it ranks 52 out of 84 on Jefferson County's culvert/barrier restoration list (Till et al 2000). A culvert on a tributary to Barnhouse Creek has a total barrier under Center Road with 481 meters of stream above the culvert, 256 square meters of spawning habitat and 369 square meters of rearing habitat. This culvert ranks 82 out of 84 on the replacement priority list (Till et al 2000).

Floodplains

Floodplain Connectivity

The lower reach of Barnhouse Creek has been channelized and is incised with no off channel habitat, but does flood during certain flows. Beaver habitat and associated wetlands in the midreach are the only beaver ponds remaining on the creek and provide good floodplain connectivity. A major protection and restoration effort has been completed by Jefferson Land Trust, Northwest Watershed Institute and cooperators on the upper portion of this creek. Approximately ten acres of riparian mature forest are protected by conservation easement upstream of Center Road. Downstream of Center Road, approximately 600 feet of previous ditch was remeandered and fenced and a total of about one-half mile and thirty acres of adjacent beaver pond and bottomland wetland is fenced and protected under a conservation easement (Peter Bahls, personal communication, 2002). The restoration improved floodplain connectivity in this section (TAG 2002).

Loss of Floodplain Habitat

The TAG determined this parameter to be a data gap.

Channel Conditions

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris is lacking, except through the restored reach below Center Valley Road where large woody debris placement augments existing wood. As the excavation to return the channelized stream into its historic meanders was occurring, spruce and cedar logs and stumps were uncovered, indicating previously forested habitat (Peter Bahls, personal communication 1999).

Percent Pool

The lower part of this tributary is one long glide. Beaver ponds and the newly restored section downstream of Center Road vastly provide good pool habitat for juvenile rearing (TAG 2002).

Pool Frequency

Pool frequency is a data gap.

Pool Quality
Pool quality is a data gap.

Streambank Stability
Streambanks are relatively stable, except where livestock has access to the creek in the lower reach, particularly the horses near the mouth (TAG 2002).

Sediment Input

Sediment Supply
Sediment supply is slightly elevated from natural levels. Livestock access in the lower reach creates some sediment problems (TAG 2002).

Mass Wasting
Mass wasting is not an issue due to the lack of steep slopes within this segment (TAG 2002).

Road Density
Road density is poor at 4.34 miles of road per square miles of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
The majority of the creek downstream of Center Valley Road lacks a riparian zone. The condition will improve through the restored reach as trees grow and mature. Riparian condition upstream of Center Valley Road is immature in age due to timber harvest (TAG 2002).

Water Quality

Temperature
Jefferson County Conservation District began collecting water quality data on Barnhouse Creek in the year 2000 at the mouth and at river mile 1.0. Annual instantaneous maximum water temperature at the mouth in the year 2000 was 15.8^{o}C. Water temperature at river mile 1.0 that same year was 11.5^{o}C (Glenn Gately, personal communication, 2002). Bahls and Rubin (1996) report that water temperatures remained less than 12^{o}C immediately upstream of Center Road.

Dissolved Oxygen
Dissolved oxygen is a data gap for most of the watershed. Bahls and Rubin (1996) report dissolved oxygen concentrations remain above 9.5 g/L upstream of Center Road.

Hydrology

Flow – Hydrologic Maturity

The majority of the watershed has been converted to agriculture/grazing and the upper watershed has been harvested (TAG 2002).

Flow – Percent Impervious Surface

Impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Data Needs

- Assess fine sediments
- Determine loss of floodplain habitat
- Assess pool quantity/quality
- Monitor dissolved oxygen concentration
- Determine percent impervious surface
- Assess nutrients
- Evaluate road and road crossing impacts on aquatic resources

Action Recommendations

1. Restore natural riverine function (Note: acquisition or conservation easements may be needed to accomplish the following activities)
   a. Restore sinuosity
   b. Re-establish riparian plantings
   c. Restore complexity
   d. Restore wetlands and beaver ponds
   e. Control reed canary grass
   f. Long-term maintenance of planting and fencing
   g. Correct fish passage barriers
3. Restore estuary/nearshore function (Note: acquisition or conservation easements of tidelands, estuary and nearshore habitats may be needed to accomplish the following activities)
   a. Restore tidal delta, estuary and nearshore habitats, i.e. remove fill
   b. Assess estuary rearing habitat conditions
4. Provide protection of high quality habitat through acquisition or conservation easement
5. Assess/monitor water quality and habitat conditions
   a. Work with Jefferson County Public Works to alter their ditch cleaning methods to incorporate fish and wildlife needs.
   b. Assess, stabilize, monitor fine sediment sources
   c. Assess coliform and dissolved oxygen
   d. Monitor water temperature

   e. Monitor water quality impacts of urbanization
   f. Continue TFW ambient monitoring and mapping

6. Flow
   a. Assess surface/ground water withdrawals for impact on summer low flow
   b. Stream gauge below Chimacum to monitor effects of urbanization
      i. Locate, monitor runoff sources
      ii. Monitor potential impacts from peak flows with scour chains, i.e. redd

DISCOVERY BAY SUBBASIN

The Discovery Bay sub-basin includes Snow Creek (WRIA 17.0219), Salmon Creek (WRIA 17.0245), Contractor's Creek (WRIA 17.0270), and Eagle Creek (WRIA 17.0272). The TAG further divided the watershed as follows:

1. Snow Creek, mouth to river mile 3.5
2. Snow Creek, above river mile 3.5, including Trapper Creek
3. Andrews Creek (trib. to Snow Creek at river mile 3.5), mouth to Bolton Road at river mile 2.2
4. Andrews Creek, above river mile 2.2
5. Salmon Creek, mouth to Uncas Road at river mile 0.7
6. Salmon Creek, above river mile 0.7
7. Contractor's Creek, entire watershed
8. Eagle Creek, entire watershed

Timber fish and wildlife ambient monitoring data were limited to channel characteristics data for Salmon Creek and large wood debris data for Snow Creek. Temperature data were available from Jefferson County Conservation District for Snow, Andrews, Salmon and Contractor's Creeks. Barrier assessment was available through the Washington Department of Fish and Wildlife but was limited to county and state roads. Point No Point Treaty Council provided conservative road density estimates for this report. Jamestown S'Klallam Tribal Biologists provided a Power Point presentation of their reconnaissance of contractor's Creek and Eagle Creek. At the riverine workshop session, the TAG reviewed Washington Department of Natural Resources aerial orthophotographs from the year 2000 to evaluate hydrologic maturity, riparian buffer width, stand age and composition and evidence of mass wasting events. The TAG had further professional knowledge and observations of some parameters for some of the streams. The remaining parameters have been identified as data gaps.

Snow Creek, mouth to river mile 3.5

Access

Artificial Barriers

Washington Department of Fish and Wildlife operates a salmonid population monitoring weir at approximately river mile 0.8. Officially known as the Snow Creek Research Station, fisheries biologists have been enumerating upstream migrating salmonids at this site since 1977 and downstream migrants since 1978. Summer chum, coho, steelhead and cutthroat are counted and passed over the weir. Since brood year 2000, a portion of the upstream coho migrants have been artificially spawned, incubated and reared as part of a stock rebuilding supplementation program. Young fish are released as fry, juveniles and presmolts into Andrews Creek, Crocker Lake and Snow Creek itself. The weir restricts gravel, sediment and large woody debris movement downstream. Gravel and sediments are removed periodically and disposed of at an upland site. Large woody debris is passed downstream and contributes to habitat structure. All fish are passed over the weir and resulting mortalities are extremely rare.

Floodplains

Floodplain Connectivity

Snow Creek originally meandered through the valley as a right bank tributary to Salmon Creek. The lower part of Snow Creek has been channelized to run along the east side of the valley and now enters directly into Discovery Bay to the east of Salmon Creek. During flooding flows, however, the channel in this lower reach has been observed to jump its banks and reconnect with Salmon Creek in the lower valley (TAG 2002).

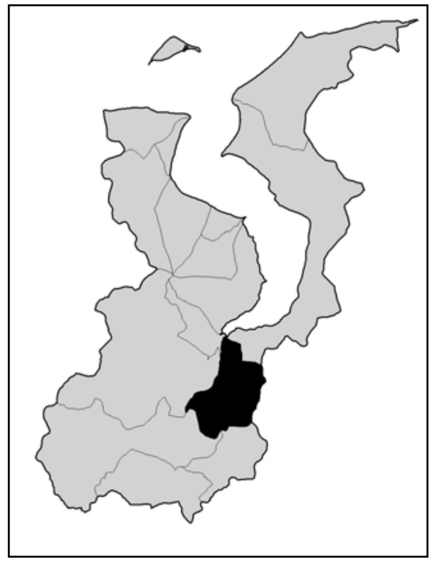

Figure 61. Lower Snow Creek Watershed, mouth to river mile 3.5. Map provided by Jennifer Cutler, NWIFC

The channel is incised between Uncas Road and Snow Creek Ranch, which limits access of flooding flows to the floodplain in this reach. This downcutting is possibly due to forest conversion, loss of large woody debris to provide structure to trap gravels, and direct ditching along Highway 101 (TAG 2002).

Loss of Floodplain Habitat

Land use has been converted to agriculture and cattle grazing downstream of Uncas Road. Habitat restoration activities between the mouth and the WDFW weir removed two to three feet of sediment and added large woody debris for structure and bed stability. Natural habitat improves in a small area between Uncas Road and Snow Creek Ranch. A low flow right bank tributary that runs through the Highway 104 interchange has been altered and the wetlands at the interchange have been filled (TAG 2002).

Channel Conditions

Fine Sediment

Sediment samples were collected by Wild Olympic Salmon/Quilcene Snow Restoration Team in 1996 and evaluated using McNeil sampling techniques. Collective recollection by the TAG of this effort determined the fines to be high. The actual data has not been recovered.

Large Woody Debris

Point No Point data, collected in 1993-1994, indicated 0.07 pieces of wood per meter channel width. There were no large logs observed or recorded. Riparian vegetation is largely deciduous with very few conifers for future recruitment (TAG 2002). The

Summer Chum Salmon Conservation Initiative considers the lack of wood to have a high impact on summer chum production.

Percent Pool

Point No Point (unpublished data, 1993-1994) enumerated 47 percent pools. However, it was also noted that a lack of wood, lack of cover, and lack of depth reduces the quality of these pools.

Pool Frequency

Point No Point (unpublished data, 1993-1994) indicated 5.7 channel widths per pool.

Pool Quality

Point No Point (unpublished data, 1993-1994) measured a range of pool depth between 0.3 and 1.4 meters. Lack of cover and lack of wood in the stream diminishes pool quality.

Streambank Stability

Some of this section of Snow Creek has been armored with riprap, which can be a sign of unstable banks. The majority, however, is intact.

Sediment Input

Sediment Supply

The lower deposition reach is filled with sediment from the upper watershed and is now stable. The sediment is removed at the WDFW weir on an average of every three years depending on the flow regime (Thom Johnson, personal communication, 2002).

Mass Wasting

The TAG determined this parameter not applicable as it is a response reach.

Road Density

Road densities were calculated at 3.47 miles of road per square mile of watershed within this segment (PNPTC, unpublished data 2002), including all tributaries. This compares with USFS data that calculated 3.1 miles of road per square mile for the entire watershed (Ricketts et al 1996). Road crossings are 0.88 per kilometer of stream (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

The existing riparian zone is deciduous dominant where historical evidence indicates conifer presence. The buffer is also narrow, whereby 76 percent of the riparian zone is less than 66 feet (Ames et al. 2000).

Water Quality

Temperature

WDFW Snow Creek Research Station has been recording average daily stream temperatures since 1977. A summary of monthly stream temperatures based on those records, 1977 to 1989, showed maximum temperatures of 12.8 ^{o}C in April, 16.4 ^{o}C in May, 19.5 ^{o}C in June, 20.5 ^{o}C in July, 20.5 ^{o}C in August, 18.3 ^{o}C in September and 14.7 ^{o}C in October (Jones and Stokes 1991 cited in Lichatowich 1993). Jefferson County Conservation District collected water quality data for 1999 and 2000 at Uncas Road Bridge and at the SR 20 Bridge. Water temperatures at the SR 20 Bridge regularly exceeded 16^{o}C with peaks approaching 20^{o}C during July and August. There is a narrow riparian buffer with less shading effects, which would indicate higher ambient temperatures. The area at the power station is exposed with no vegetation at all, which increases the water temperature. Water temperatures at the West Uncas Road Bridge regularly exceeded 16^{o}C but rarely exceeded 18^{o}C (Gately 2001).

Dissolved Oxygen

In the year 2000, the lowest dissolved oxygen concentration reading was 9.5 mg/L (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

Land use alteration, minimum buffer width, and lack of conifer have reduced hydrologic maturity. Less than sixty percent of the watershed in this segment is forested (TAG 2002).

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients

Escapements are low into Snow Creek. Summer chum are federally listed as threatened, and steelhead and coho are listed as critical in SaSI (Thom Johnson, personal communication, 2002).

Estuary

Snow Creek estuary is an accretional beach of abundant alongshore and fluvial sediment alternating between mudflat and sand/gravel composition (WDNR 2001). The existing Snow Creek estuary is not a properly functioning estuary due to its artificial channel, dike/fill system and dissection by a railroad grade (TAG 2002). Funding has been secured by Jefferson Land Trust and WDFW to acquire critical habitats in the lower watershed and estuary. Additional funding will be necessary to accomplish restoration activities in the Snow/Salmon estuaries (see nearshore discussion).

Data Needs

- Study re-integration of the estuary with Snow Creek
- Study re-establishing the historic link with Salmon Creek
- Assess estuary rearing habitat conditions
- Assess scour and deposition
- Evaluate road and road crossing impacts on aquatic resources
- Assess flows (WRIA 17 Planning Unit)
    - Peak – assess channel ability to accommodate peak flood flows
    - Low flows –
        - Assess surface/groundwater withdrawals for impact on low flows
        - Assess instream flow; consider ways to increase instream flows

Snow Creek, above river mile 3.5

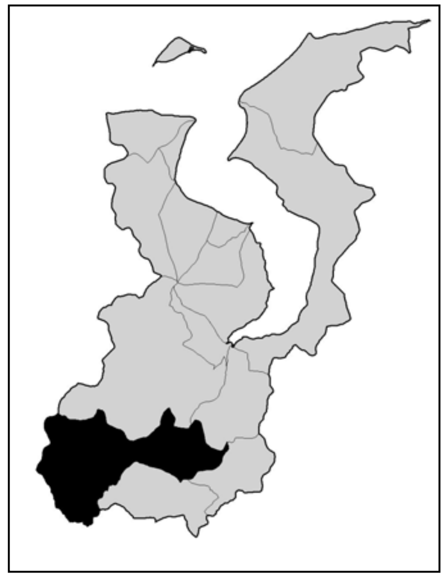

Figure 62. Upper Snow Creek, above river mile 3.5. Map provided by Jennifer Cutler, NWIFC

Access and Passage

Artificial Barriers

A natural falls at river mile 7.5 restricts anadromous migration to this point. No artificial barriers are known to be present below the falls (TAG 2002).

Floodplains

Floodplain Connectivity/ Loss of Floodplain Habitat

This parameter is not applicable to this reach due to gradient.

Channel Conditions

Fine Sediment

This parameter is a data gap.

Large Woody Debris

LWD is lacking in this segment (TAG 2002).

Percent Pool

The percentage of pools in the lower section (1-2 percent gradient) of this segment is low at 19 percent. The upper reaches are higher gradient (4-6 percent) and pools comprised 37 percent of the stream surface area (Bernthal and Rot 2001).

Pool Frequency

No data exist for this parameter.

Pool Quality

The TAG was not able to reach a consensus decision on this parameter based on the data available. The lower section lacks large woody debris and pool depth does not reach one meter. There is more large wood in the upper reach which could increase pool depth. The upper reach is dominated by cascades with boulders in a steep gradient and most of the pools are pocket pools. Pool quality in this section is a data gap.

Streambank Stability

The streambanks are stable with the exception of mass wasting events. There is not a high incidence of streambank instability along US Forest Service Roads.

Sediment Supply

Sediment supply exceeds the natural rate in the upper watershed due to mass wasting events (TAG 2002).

Mass Wasting

Mass wasting has occurred in the upper watershed, some of which are results of improper road maintenance on WDNR lands. In the mid 1990s, Wild Olympic Salmon and the Quilcene/Snow Restoration Team located and abated several slope failures. Roads were properly abandoned and the associated steep unstable slopes were stabilized and revegetated (Al Latham, personal communication 2002). The result of the work has stabilized the steep slopes that were failing.

Road Density

Road density is 3.14 miles of road per square mile of watershed. The number of road crossings is 0.7 per kilometer of stream (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

The riparian condition is good, particularly above the falls, which is under federal ownership. The US Forest Service has adopted their riparian reserve program, which leaves a riparian buffer of two potential tree heights on fish bearing streams and unstable geohazard areas and one potential tree height on non-fish bearing streams. Point No Point Treaty Council data determined a 70-80 percent canopy cover which is conifer dominant (Bernthal and Rot 2001). Below the falls, the riparian zone narrows. The upper half of the section below the falls has been extensively logged and is in poor condition, as determined by viewing 2001 aerial orthophotos. The lower half is in better condition (TAG 2002).

Water Quality

Temperature

Jefferson County Conservation District monitored temperatures at the Snow Creek Ranch. There were spikes above 16^{o}C during the summer of 2000 and some above 14^{o}C during the summer of 1999 (Gately 2001). .

Dissolved Oxygen

Jefferson County Conservation District data at Snow Creek Ranch indicate that dissolved oxygen concentrations did not fall below 10 mg/L (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

Forest maturity poor below the falls is reduced by a large clearcut in the mid to late 1980s. Above the falls and under federal ownership, the over sixty percent of the forest is older than 25 years (TAG 2002).

Flow – Percent Impervious Surface

According to Jefferson County data, a negligible amount of the watershed is impervious (Jeff Miller 2002).

Biological Processes

Nutrients

Escapements of coho, steelhead and summer and fall chum are low below the falls. Above the falls, cutthroat are in good shape (Thom Johnson, personal communication 2002).

Data Needs

- Assess fine sediments
- Determine pool frequency and pool quality
- Evaluate road impacts on aquatic resources

Andrews Creek, mouth to Bolton Road

Access and Passage

Artificial Barriers

Access is good throughout the lower segment of Andrews Creek. There are two small high gradient right bank tributaries to Crocker Lake with a storm drain at the junction of Highway 101 and Highway 104 that prevents fish passage to this tributary. Concrete remnants of an old Washington Game Department fish wheel remain at the outlet of Crocker Lake but the drum is gone and access has been restored (TAG 2002).

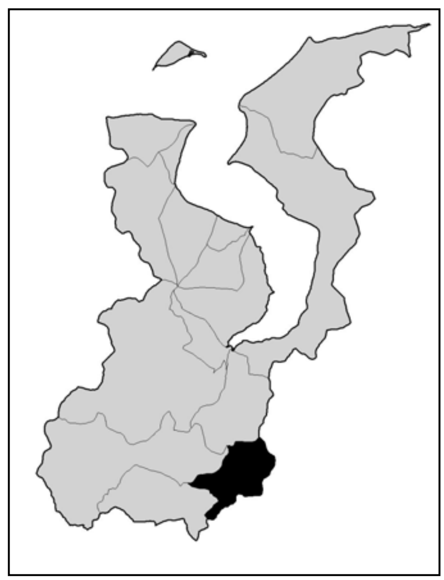

Figure 63. Lower Andrews Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The lower section has been channelized throughout the lower watershed. Wetlands have been converted to ditches and reed canary grass has become a large problem (TAG 2002).

Loss of Floodplain Habitat

Due to conversion of wetland habitat to agriculture, habitat has been lost throughout this section. A small habitat restoration project created some modest meanders with some large woody debris when the creek was relocated from the east side of Highway 101 to the west side. Washington Department of Transportation, Wild Olympic Salmon and the Quilcene/Snow Restoration Team partnered on the project (Al Latham, personal communication 2002).

Channel Conditions

Fine Sediment

No data have been collected for this parameter for this segment.

Large Woody Debris

LWD is lacking in this section of Andrews Creek, except in the restored channel adjacent to Highway 101 (TAG 2002).

Percent Pool

The TAG determined this parameter to be a data gap but did note that below Crocker Lake there are few pools, between Crocker Lake and Highway 101 is a long slough and between Highway 101 and Bolton Road are few pools.

Pool Frequency

The TAG identified this parameter as a data gap.

Pool Quality

The TAG identified this parameter as a data gap but noted that this section is extensively channelized.

Streambank Stability

The TAG determined this parameter to be a data gap but noted that the channelized ditch appears stable.

Sediment Input

Sediment Supply

Sediment supply does not exceed the natural rate (TAG 2002).

Mass Wasting

There are no known mass wasting events in this section (TAG 2002).

Road Density

Road densities were calculated to be 5.16 miles of road per square mile of watershed. There are 1.16 road crossings per kilometer of stream (PNPTC, unpublished data 2002).

Riparian Zone

Riparian Condition

After viewing aerial orthophotos, the TAG noted that the majority of this section lacks adequate buffers with a conifer component. Trees have been planted in a restoration site between Crocker Lake and Highway 101 and are growing well (Al Latham, personal communication 2002).

Water Quality

Temperature

Temperatures collected at Bolton Road and at Highway 101 rarely exceeded 16^{o}C during the summer months. Temperatures collected at the mouth of Andrews Creek often exceeded 20^{o}C and spiked to 24^{o}C in the summer of 2000 (Gately 2001).

Dissolved Oxygen

No data has been collected for this segment.

Hydrology

Flow – Hydrologic Maturity

Based on orthophoto analysis, the TAG noted that less than 60 percent of the forest was older than 25 years.

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients

Due to low escapement of coho, chum and steelhead (Thom Johnson, personal communication 2002), nutrients in Andrews creek are low (TAG 2002).

Data Needs

- Assess fine sediments
- Collect percent pool, pool frequency and pool quality data
- Determine streambank stability
- Collect dissolved oxygen data

- Evaluate road impacts on aquatic resources

Andrews Creek, above Bolton Road

Access and Passage

Artificial Barriers

WDFW SSHEAR program has identified a total barrier on Snow Creek Road at milepost 3.83. If fixed, an additional 5,955 meters of stream length would be accessible, which includes 4,433 square meters of spawning habitat and 8,897 square meters of rearing habitat (Till et al 2000). Additional barriers are a data gap.

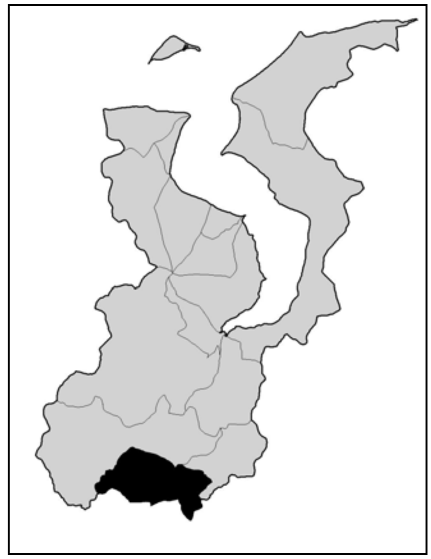

Figure 64. Andrews Creek above Bolton Road. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity/ Loss of Floodplain Habitat

This parameter is not applicable to this segment due to gradient.

Channel Conditions

No information is available to describe channel conditions.

Sediment Input

Sediment Supply/Mass Wasting

This parameter is a data gap for this segment.

Road Density

Road density for this segment is 2.2 miles of road per square mile of watershed. There are approximately 0.52 road crossings per kilometer of stream (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

Riparian condition is a data gap.

Water Quality

Temperature

There are no known temperature data for this segment.

Dissolved Oxygen
This parameter is a data gap for this segment.

Hydrology

Flow – Hydrologic Maturity
Analysis of year 2000 orthophotos revealed that recent clearcuts have created a large expanse of immature forest (TAG 2002).

Flow – Percent Impervious Surface
This parameter is a data gap.

Biological Processes

Nutrients
Escapements have been low in recent years (Thom Johnson, personal communication 2002).

Data Needs
- Determine fine sediment composition
- Determine large woody debris abundance
- Collect percent pool, pool frequency and pool quality data
- Determine streambank stability
- Assess riparian habitat
- Determine sediment supply and mass wasting
- Collect water quality data
- Evaluate road impacts on aquatic resources

Snow Creek Action Recommendations
- Restore estuary function/re-establish functional estuary-freshwater link (Note: acquisition or conservation easements may be needed to accomplish the following activities)
    - Provide protection by acquisition or easements of tidelands
    - Remove railroad grade
    - Evaluate/abate the impacts of the Highway 101 bridge
    - Remove dikes and fill
- Restore natural riparian/riverine functions (Note: acquisition or conservation easements may be needed to accomplish the following activities)
    - Remove channel constrictions
    - Restore sinuosity
    - Add large woody debris/create stable, long-term log jams
    - Increase and plant riparian with conifer
    - Install cattle exclusion fencing where necessary
    - Construct over-wintering habitat off channel or within the floodplain
    - Maintain/modify WDFW weir

    - Allow establishment of a riparian zone below the falls for future large woody debris recruitment and subsequent pool formation
- Provide protection by acquisition or conservation easement of high quality habitat
- Assess, stabilize, monitor fine sediment sources
    - Reduce excess sediment input or increase movement of sediment through the system
    - Evaluate/address impacts of Highway 101/104 junction storm drain
    - Evaluate and control impacts of road maintenance in the watershed
    - Assess and restore the debris jam and slide areas

Andrews Creek Action Recommendations

- Restore riverine function
    - Restore sinuosity
    - Add large woody debris
    - Reestablish riparian zone to provide shade and recruitment for future large woody debris and help eliminate reed canary grass
- Establish riparian zone for shade and future large woody debris recruitment
- Collect data as recommended in Data Needs

    - Remove railroad grade
- Assess, stabilize, monitor fine sediment sources
    - Maintain roads in upstream forest areas
- Assess scour and deposition
- Assess flows (WRIA 17 Planning Unit)
    - Peak – assess channel ability to accommodate peak flood flows
    - Low
        - Assess surface/groundwater withdrawals for impact on low flows
        - Assess instream flow; consider ways to increase instream flows

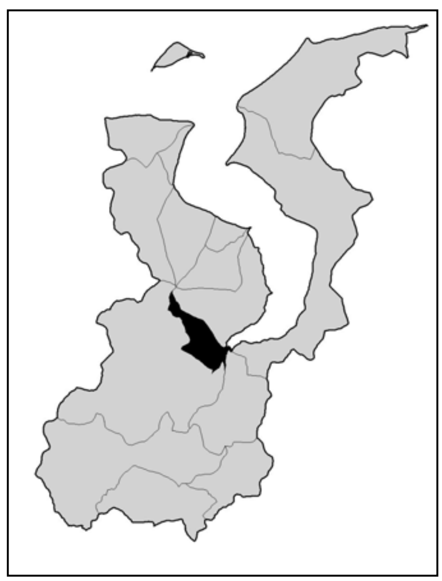

Figure 65. Lower Salmon Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Salmon Creek, mouth to Uncas Road

Access and Passage

Artificial Barriers

Access is good in the lower Salmon Creek watershed. A Washington Department of Fish and Wildlife weir operates during August, September and October at river mile 0.3 to enumerate adult migrating summer chum. All fish are passed upstream and mortalities at the site are extremely rare. The weir has been in operation since 1994 and is part of the summer chum stock recovery program. Although fish are allowed to migrate upstream, the weir constricts the stream and traps gravel and woody debris that would otherwise be routed downstream. Activities at the weir are scheduled to terminate in the year 2004 (TAG 2002).

Floodplains

Floodplain Connectivity

Over 50 percent of this segment has been channelized, with a small portion maintained in riprap to prevent erosion. The creek does not have access to its floodplain except in very high flows. WDFW and Jefferson Land Trust have received funding to purchase the lower watershed and estuarine environments. Jefferson County Conservation District has received Salmon Recovery Funding as well as a donation from North Olympic Salmon Coalition to restore floodplain connectivity, sinuosity and complexity (TAG 2002).

Loss of Floodplain Habitat

Habitat in the lower watershed has been converted to agriculture and grazing. Sinuosity and habitat complexity have been severely altered. Cattle exclusion fencing limits cattle access to the creek except for a well-established ford at about river mile 0.4 but the riparian buffer is minimal where it exists at all (TAG 2002).

Channel Conditions

Fine Sediment

Point No Point sediment samples taken in 1993-1994 indicated an average of 16 percent fines in the spawning gravel (Bernthal and Rot 2001).

Large Woody Debris

Point No Point data, collected in 1993-1994, showed an average of 0.32 pieces of large woody debris per channel width with 0.03 key pieces for this segment (Bernthal and Rot 2001).

Percent Pool

This low gradient reach was comprised of 39 percent pools (Bernthal and Rot 2001).

Pool Frequency

Pools occurred at a frequency of 4.6 channel widths per pool (Bernthal and Rot 2001).

Pool Quality

There were two deep pools between river mile 0.2 and 1.3 (Bernthal and Rot 2001). Best professional knowledge of the lower watershed confirmed the data.

Streambank Stability

The TAG did not rate this parameter due to lack of data, but noted that dredging has forced the channel into place and the existing riprap could be an indicator of unstable banks.

Sediment Input

Sediment Supply

The channel in the lower watershed is a response reach and is aggrading, indicating a more than normal sediment supply from the upper watershed.

Mass Wasting

The TAG determined that this parameter is not applicable.

Road Density

Road density, including Houck Creek, is 5.4 miles of road per square mile of watershed. There are 1.63 road crossings per kilometer of stream (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

Cattle exclusion fencing does exist throughout this part of the watershed with the exception of the historical ford at approximately river mile 0.4. The fencing leaves a very shallow buffer that is predominantly alder, where trees exist at all, with Himalayan blackberry as the predominant understory (TAG 2002).

Water Quality

Temperature

Jefferson County Conservation District has two temperature stations in this reach. The readings at Highway 101 often exceeded 18^{o}C during the summer months, 2000 (Gately 2001). Readings at West Uncas Road seldom exceeded 16^{o}C of 2000 but are more indicative of conditions in the upper watershed (Gately 2001).

Dissolved Oxygen

Dissolved oxygen readings in lower Salmon Creek did not drop below 10 mg/L during the year 2000 (Gately 2001).

Hydrology

Flow – Hydrologic Maturity

Analysis of 2001 orthophotos determined that conversion to agriculture and home sites has reduced hydrologic maturity (TAG 2002).

Flow – Percent Impervious Surface

Impervious surface is 0.38 percent (Jeff Miller 2002).

Biological Processes

Nutrients

Discovery Bay coho and steelhead are in critical condition and summer chum are federally listed as threatened. Recent summer chum stock restoration efforts by Wild Olympic Salmon volunteers have been successful and the returning adults have consistently numbered over 800 for the past 5 years. The 2001 return was estimated to be in excess of 2500, a good number for this watershed (Thom Johnson, personal communication 2002).

Estuary

Salmon Creek estuary is an accretional beach of abundant alongshore and fluvial sediment sources alternating between mudflat and sand/gravel composition (WDNR 2001). Upstream modifications to Salmon Creek, as well as the truncation of tidal channels by the railroad grade, limit its ability to perform as a properly functioning estuary. Funding has been secured to acquire critical habitats in the lower watershed and estuary for protection. Additional funding will be necessary to complete appropriate restoration activities (see nearshore discussion).

Data Needs

- Assess estuary rearing habitat condition
- Evaluate effects of Highway 101 bridge and other roads on aquatic resources
- Conduct spawning gravel composition study

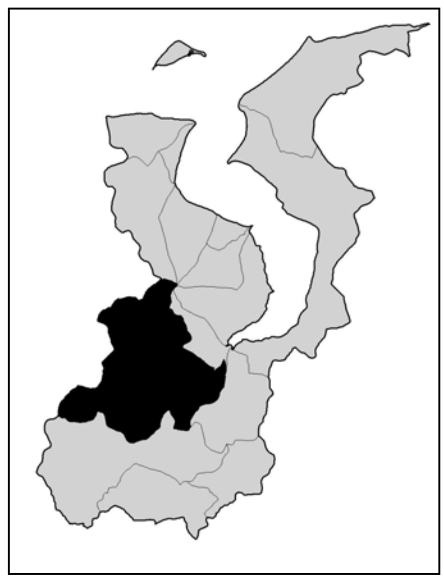

Figure 66. Upper Salmon Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Salmon Creek, above Uncas Road

Access and Passage

Artificial Barriers

Access is good to the natural impassable falls at approximately river mile 2.2 (TAG 2002).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable due to gradient.

Channel Conditions

Fine Sediment

There are no data for this parameter.

Large Woody Debris

Point No Point data, collected in 1993-1994, showed moderate levels of large woody debris below the falls with 1.02 pieces per channel width between river mile 1.3 and 1.5 (Bernthal and Rot 2001). Clearcutting activity above the falls has limited the amount of large woody debris as well as future recruitment in the upper watershed (TAG 2002).

Percent Pool

Pools occupy 36 to 39 percent of the stream area (Bernthal and Rot 2001).

Pool Frequency

The TAG determined pool frequency to be a data gap but observations note good frequency above the falls.

Pool Quality

The TAG determined pool quality to be a data gap but observations note that pool quality is good above the falls.

Streambank Stability

Professional observations by TAG members indicate the streambanks are stable in the upper watershed.

Sediment Input

Sediment Supply

Sediment supply from the upper watershed exceeds the natural rate due to slope failures/mass wasting events, particularly associated with Houck Creek, a right bank tributary entering Salmon Creek at approximately river mile 1.3 (TAG 2002).

Mass Wasting

Houck Creek, a right bank tributary at river mile 1.3, has experienced mass wasting events as a result of a stream diversion over 40 years ago. The original channel historically flowed into Salmon Creek below Uncas Road but was rerouted to avoid flooding of pastureland. The soils in the newly created channel were loose till over clay, which resulted in mass wasting events. To compound the situation a sediment pond was created near the top of the "cliff" which has saturated the ground and has created a potentially unstable situation. Jefferson County Conservation District has received funding from the North Olympic Salmon Coalition to provide short-term stability to the area. The TAG recognizes that this is not a long-term solution to the problem and recommends putting the creek back into its historic channel.

Road Density

Below the falls the road density is 4.2 miles of road per square mile of watershed. Above the falls the density is 3.7 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

By viewing 2001 aerial orthophotos, the TAG observed a new clearcut in the upper watershed that has numerous roads with numerous drainages that potentially carry sediments to Salmon Creek. However, the TAG was not willing to rate this parameter without further data and determined it to be a data gap.

Water Quality

Temperature

Jefferson County Conservation District collected temperature data at West Uncas Road and rarely did the temperature exceed 16^{o}C during the summer months of the year 2000 (Gately 2001). Temperature data have not been collected for the upper watershed.

Dissolved Oxygen

There are no dissolved oxygen data for the upper watershed.

Hydrology

Flow – Hydrologic Maturity

The hydrologic maturity on US Forest Service lands is 69 percent of the forest in the mature age class (Ricketts et al 1996). The downstream portion of this segment is immature due to recent clearcutting activity, as evidenced on 2001 aerial orthophotos (TAG 2002).

Flow – Percent Impervious Surface

The percent impervious surface is low (Jeff Miller 2002).

Biological Processes

Nutrients

The TAG determined this parameter to be a data gap.

Data Needs

- Assess fine sediment
- Collect pool frequency and pool quality data
- Assess riparian condition
- Collect water quality data
- Evaluate nutrients
- Evaluate road impacts on aquatic resources

Action Recommendations

- Provide protection through acquisition or conservation easements of high quality habitats

- Restore riverine function (Note: acquisition or conservation easements may be needed to accomplish the following restoration activities)
    - Abate Houck Creek sedimentation
        - Short term – stabilize banks
        - Long term - put the creek into its original channel Remove WDFW weir
    - Remove riprap
    - Restore sinuosity
    - Add large woody debris/stable log jams
    - Increase and plant the riparian zone
- Reestablish functional estuary-freshwater link (Note: acquisition or conservation easements may be needed to accomplish the following restoration activities)
    - Assess estuary rearing habitat condition

Contractor's Creek

Access and Passage

Artificial Barriers

A long box culvert, estimated to be greater than 100 feet, is within 50 feet of the mouth of Contractor's Creek and is a barrier at certain flows. A new falls has developed about ¼ mile upstream as a result of headcutting due to a large slide/culvert failure event in 1996. The slide event eliminated wood controls from the system. The falls have become an artificial barrier, eliminating access to the majority of the watershed. A new bridge has now replaced the failed culvert. The old culvert is still exposed at its upper end and some water enters it. The lower end is buried under the fill. Further upstream, the box culvert under Highway 101 has aggraded at the downstream end but is still passable, if fish could get to it. Maintenance of this culvert is critical to reduce the risk of a catastrophic failure (Tim Rymer, personal communication 2001).

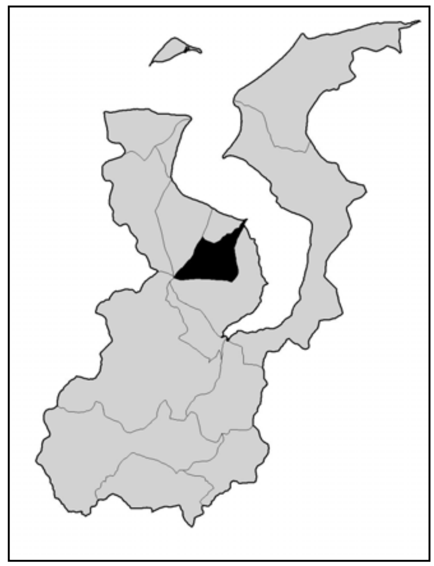

Figure 67. Contractor's Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

Floodplain connectivity has been reduced by channel modifications and residential development. The original delta fan has been eliminated due to moving of the stream mouth and associated culvert (TAG 2002).

Loss of Floodplain Habitat

Habitat in the lower watershed has been altered. The mouth of the creek has been moved to the south and runs through a long (estimated greater than 100 feet) culvert. Remnant cedar stumps are all that remains of historic forested wetlands. An attempt has been made at restoration upstream of the culvert with large woody debris placement to create pools and riffles. The riparian zone consists mainly of Scot's broom and infestations of reed canary grass have also been observed (Hilton Turnbull, personal communication 2002).

Channel Conditions

Fine Sediment

No data have been collected but TAG observations note a high occurrence of fines where hardpan clay is absent.

Large Woody Debris

A Power Point presentation by Jamestown S'Klallam tribal biologists indicates that the amount of large woody debris is insufficient (Hilton Turnbull, presentation, 2002).

Percent Pool

No data have been collected for this parameter but TAG members have not observed a high percentage of pools below Highway 101. Percent pool above Highway 101 is a data gap.

Pool Frequency

No data has been collected for this parameter but TAG members have observed low pool frequency below Highway 101 (Hilton Turnbull, personal communication 2002) and therefore rated this parameter poor. Pool frequency is a data gap above Highway 101.

Pool Quality

Pools are less than one meter deep with no good cover downstream of Highway 202 (Hilton Turnbull, personal communication 2002). Pool quality upstream of Highway 101 is a data gap.

Streambank Stability

Streambanks are unstable downstream of Highway 101 (TAG 2002). The TAG determined streambank stability above Highway 101 to be a data gap.

Sediment Input

Sediment Supply

Due to the culvert/fill failure of 1996, sediment supply exceeds the natural rate below Highway 101. Sediment supply above Highway 101 is a data gap.

Mass Wasting

The culvert/fill failure of 1996 devastated the lower watershed as catastrophic amounts of sediments were released into the stream. Maintenance of the box culvert and associated fill under Highway 101 is critical to avoid another catastrophic mass wasting event (Tim Rymer, personal communication 2001).

Road Density

Road density for the entire watershed has been calculated to be 4.1 miles of road per square mile of watershed. There are 1.01 road crossings per kilometer of stream (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

Downstream of Highway 101, forested wetlands have been eliminated and coniferous trees have been replaced with Scot's broom and reed canary grass. Cedar stumps remain as remnants of a forested wetland (Hilton Turnbull, personal communication 2002). Riparian condition upstream of Highway 101 is unknown.

Water Quality

Temperature

There are no temperature data for Carpenter's Creek.

Dissolved Oxygen

The TAG identified this parameter as a data gap.

Hydrology

Flow – Hydrologic Maturity

Downstream Highway 101, forests are immature or have been converted to home sites. Hydrologic maturity is a data gap upstream of Highway 101 (TAG 2002).

Flow – Percent Impervious Surface

Percent impervious surface is 1.6 percent (Jeff Miller 2002).

Biological Processes

Nutrients

Escapements to Carpenter Creek are very low (TAG 2002).

Estuary

Contractor's Point is a deposition zone that has been significantly modified for residential and commercial shellfish use. A 15-acre salt marsh on the spit is no longer there due to shoreline armoring and a service road adjacent to the beach. The mouth of Contractor's creek has been moved to the south, forced through a series of undersized culverts, and no longer exits through the historic estuary/salt marsh area (TAG 2002). The TAG recommends active restoration at this site to eliminate large impacts to fish. See nearshore discussion.

Data Needs

- Assess channel conditions above Highway 101
- Assess fine sediment and water quality for the entire watershed
- Evaluate road impacts on aquatic resources

Action Recommendations

- Maintain culvert at Highway 101
- Restore a free flowing stream where there is now a 100 foot culvert at the mouth
- Add large woody debris to establish bed stability, pools and riffles and eliminate man-made falls/barrier
- Establish a riparian zone with conifer trees

Eagle Creek

Access and Passage

Artificial Barriers

Eagle Creek is a naturally occurring bar bound estuary with seepage to Discovery Bay. A salt marsh upstream of the bar is inhabited with cedar stumps, remnants of a forested wetland. During high flows, the bar is breached and adult salmon are able to migrate upstream. Water flows in the stream above Highway 101 but is dammed below Highway 101 to form two man-made ponds. This is a managed system that dries up the stream at about river mile 1.0, creating a hydrologic and physical barrier. The outlet of the pond is a five hundred foot culvert that runs under a field and into a ditch along side a railroad grade. A series of ditches, often dry, eventually connects with the stream, where flow is restored from seeps and small tributaries (Hilton Turnbull, personal communication 2002).

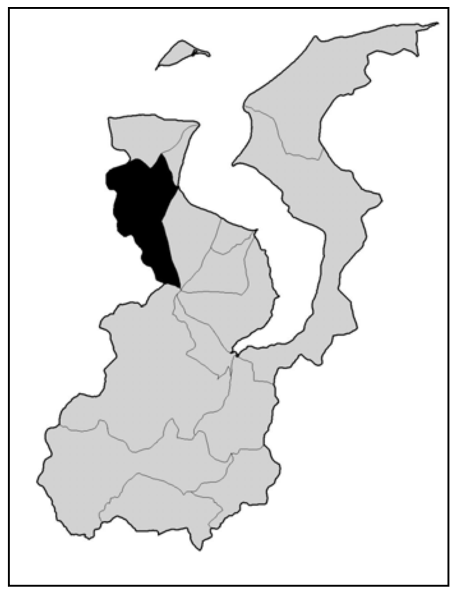

Figure 68. Eagle Creek Watershed. Map provided by Jennifer Cutler, NWIFC.

Floodplains

Floodplain Connectivity

Flood flows have access to the lower watershed, although many of the side channels and tributaries are often dry (TAG 2002).

Loss of Floodplain Habitat

Where flows exist in the lower watershed to maintain a forested wetland, the floodplain habitat is marginal. Upstream, where the culvert, ditches, water diversion and development pressures have severely altered the habitat, the condition is poor. Upstream of Highway 101, the habitat condition is unknown (TAG 2002).

Channel Conditions

Fine Sediment

Downstream of Highway 101, high levels of fines are present (Hilton Turnbull, personal communication 2002). The condition upstream of Highway 101 is a data gap.

Large Woody Debris

Large woody debris is lacking in quantity/quality downstream of Highway 101 (Hilton Turnbull, personal communication 2002). Upstream of Highway 101 the large woody debris condition is unknown.

Percent Pool

Pools are minimal in the lower watershed (TAG 2002). Percent pool upstream of Highway 101 is a data gap.

Pool Frequency

Pool frequency is a data gap throughout the system.

Pool Quality

Pool quality is a data gap throughout the system.

Streambank Stability

The TAG was not able to rate this parameter. The lower reach has stable banks whereas the upper section has been severely altered through ditching where there is instability. Some headcutting is occurring in the lower watershed, which could indicate future problems, especially with increasing development pressures and lack of large woody debris to provide stability (Hilton Turnbull, personal communication 2002). Upstream of Highway 101 is a data gap.

Sediment Input

Sediment Supply

The TAG was unable to rate this parameter.

Mass Wasting

A right bank slope failure at approximately river mile 0.25 in 1998-1999 contributed above normal sediments to the system, including a lot of fines. This has promoted vegetation growth and the area is healing (Hilton Turnbull, personal communication 2002). The TAG did not rate this parameter.

Road Density
Road density is poor at 4.07 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition
Riparian condition varies throughout the watershed. The lower mile of the watershed is comprised of mixed forest. Less than 70 percent is conifer, although large cedar stumps remain as indicators of historic forested wetland. The riparian condition is degraded through the developed areas, including the fields and ponds. The riparian condition above Highway 101 is unknown.

Water Quality

Temperature/Dissolved Oxygen
There are no known water quality data for this watershed.

Hydrology

Flow – Hydrologic Maturity
Based on aerial orthophoto analysis, the majority of the watershed is less than 25 years old (TAG 2002).

Flow – Percent Impervious Surface
This parameter is a data gap.

Biological Processes

Nutrients
Escapement has not been quantified in this watershed so this parameter is a data gap.

Estuary
Eagle Creek is a bar bound estuary with a salt marsh and well-developed channel with a high potential for fish use (TAG 2002).

Figure 69. Eagle Creek Estuary. Photo provided by Hilton Turnbull, JSKT

Data Needs
- Assess channel conditions above Highway 101
- Determine pool quantity and quality throughout the watershed
- Collect water quality data throughout the watershed
- Evaluate road impacts on aquatic resources

Action Recommendations

1. Restore sinuosity and complexity between Highway 101 and the free flowing forested stream
2. Restore flows from managed pond system

SEQUIM BAY SUBBASIN

The Sequim Bay subbasin includes Chicken Coop Creek (WRIA 17.0278), Jimmycomelately Creek (WRIA 17.0285), Dean Creek (WRIA 17.0293) and Johnson Creek (WRIA 17.0301). The TAG further divided the subbasin as follows:

1. Chicken Coop Creek, entire watershed
2. Jimmycomelately Creek, river mile 0.0-1.0
3. Jimmycomelately Creek, river mile 1.0-3.5
4. Jimmycomelately Creek, above river mile 3.5
5. East Fork Jimmycomelately, entire watershed
6. Dean Creek, entire watershed
7. Johnson Creek, entire watershed

Data are limited in this subbasin. Mike Donald of the US Forest Service completed a good survey in 1990. Some data from Resources Northwest were applicable and some data was excluded at the request of TAG members, as they did not feel that the data adequately represented what was on the ground. Streamkeepers of Clallam County made their water quality data available, although it was sporadic and not always in the summer months. Steve Todd of Point No Point Treaty Council calculated road densities and road crossing frequencies. Aerial orthophotos were analyzed at the TAG meeting for hydrologic maturity and riparian condition. Byron Rot and Hilton Turnbull, biologists with Jamestown S'Klallam Tribe, led Power Point presentations on Chicken Coop Creek and Jimmycomelately. Randy Johnson, Washington Department of Fish and Wildlife, gave a presentation to the nearshore workgroup regarding the status and restoration plans for Jimmycomelately estuary.

Chicken Coop Creek

Access and Passage

Access

Two water diversions are near East Sequim Bay Road: one downstream and one upstream of the road. The culvert at Old Blyn Highway is a total barrier. The culvert is five feet in diameter while the bank full width is ten feet. The stream has a four-foot drop at this culvert. In addition, the culvert is not parallel with the stream and the stream is headcutting (Hilton Turnbull, personal communication 2002).

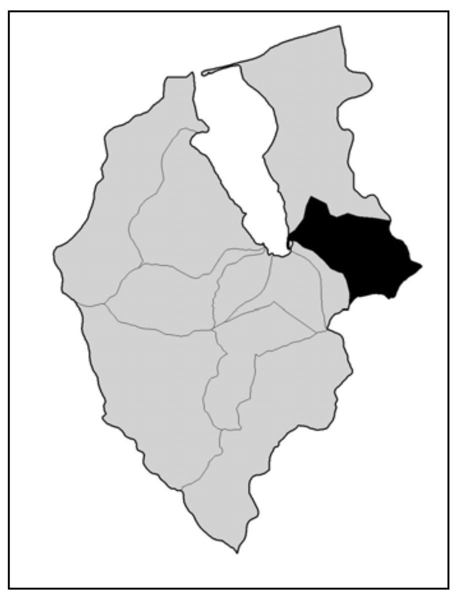

Figure 70. Chicken Coop Creek Watershed. Map provided by Jennifer Cutler, NWIFC

A complete barrier exists at Highway 101 and is scheduled for repair. When replaced, 3,336 square meters of habitat will be available to fish upstream, provided that remedial actions are also taken with the Chicken Coop Road barrier upstream (Johnson 2001). The culvert at Chicken Coop Road is a total barrier. The culvert is also leaking through holes in the bottom and is eroding away road fill (Hilton Turnbull, personal communication 2002).

Floodplains

Floodplain Connectivity

The habitat below East Sequim Bay Road is a forested wetland/wet meadow complex. The low gradient habitat above East Sequim Bay Road is dominated by invasive reed canary grass (Hilton Turnbull, personal communication 2002).

Loss of Floodplain Habitat

Floodplain habitat below East Sequim Bay Road is a forested wetland/wet meadow complex that provides some good habitat for fish. The habitat above East Sequim Bay Road deteriorates into reed canary grass dominated riparian cover (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

The TAG has observed no wood from the mouth to Chicken Coop Road, nor is there a forest to provide future large woody debris recruitment.

Percent Pools

There are no pool-forming structures in the stream (TAG 2002).

Pool Frequency

Pool frequency is low because there is no large woody debris in the stream to create pools (TAG 2002).

Pool Quality

There are no pools with depth or cover, with the exception of the forested wetland downstream of East Sequim Bay Road (TAG 2002).

Streambank Stability

The streambanks are well vegetated below Chicken Coop Road. The dense root system of reed canary grass, an undesirable non-native invasive species, keeps the streambanks from eroding. There is no riprap as an indicator of bank instability (TAG 2002).

Sediment Input

Sediment Supply/Mass Wasting

Sediment input is a data gap.

Road Density
Road density for Chicken Coop Creek is 5.04 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition
The riparian zone is dominated by shrubs and non-native invasive species (TAG 2002). In addition, there are 1.95 road crossings per mile of stream (or 1.21 crossings per kilometer of stream), which further fragment the riparian zone (PNPTC, unpublished data 2002).

Water Quality

Temperature
No temperature data are available for Chicken Coop Creek.

Dissolved Oxygen
This parameter is a data gap.

Hydrology

Flow – Hydrologic Maturity
The watershed has been harvested and the forest is immature (TAG 2002).

Flow – Percent Impervious Surface
This parameter is a data gap, but the TAG noted that impervious surface is not a problem in this watershed.

Biological Processes

Nutrients (Carcasses)
Barriers prevent escapement to Chicken Coop Creek (TAG 2002).

Estuary
Chicken Coop Creek enters onto a sand flat along the southeast shoreline of Sequim Bay (Hilton Turnbull, personal communication, 2002).

Data Needs
- Collect fine sediment data
- Determine sediment supply
- Determine mass wasting
- Collect water quality data
- Evaluate road impacts on aquatic resources

Action Recommendations

1. Replace the culverts under East Sequim Bay Road, Old Blyn Highway, US 101 and Chicken Coop Road
2. Add large woody debris
3. Plant a riparian zone with native species to provide cover and future large woody debris recruitment

Jimmycomelately Creek, mouth to river mile 1.0

Access and Passage

Access

The lower reach of Jimmycomelately Creek is generally accessible, although aggradation can be, and has been in the past, a physical barrier during low flows, particularly for summer chum. As a result of channelization, the creek is downcutting upstream and depositing the gravels in the lower reach (Byron Rot, personal communication 2002).

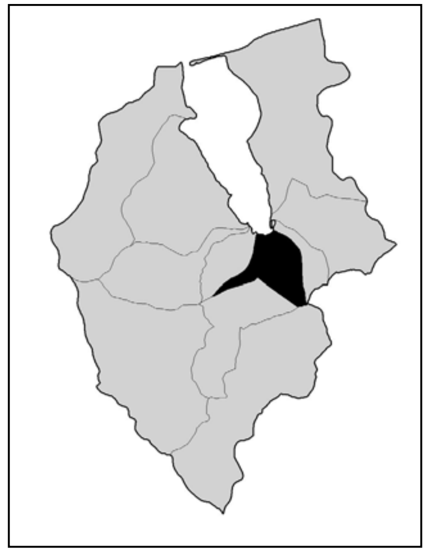

Figure 71. Lower Jimmycomelately Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The creek has been channelized and moved to the east side of the valley. The reach between US 101 and Correia Road has been diked, straightened and armored. The channel is incised, has no access to the floodplain and is without side channels. Downstream of US 101, the floodplain is lower than the channel, due to the aggradation of gravels, and frequently floods and distributes sediments throughout this part of the floodplain (TAG 2002).

Loss of Floodplain Habitat

A century of logging, road development, commercial development, railroad construction, dredging, wetland filling, diking, native vegetation removal, agriculture and residential development have resulted in direct loss of wetlands and other historic riverine and estuarine habitats and have contributed to reduced floodplain function (Shreffler 2001). Above US101, the channelized creek has no side channels and is incised. The lower section has better habitat, although the streambed has aggraded and the channel is disconnected from its estuary (TAG 2002

Clallam County Conservation District (CCCD), Jamestown S'Klallam Tribe (JSKT), and WDFW have received funding to restore floodplain function by putting the creek back into its historic meanders with a 100-foot floodplain. Part of the funding provides for acquisition of the lower river/estuary for permanent protection (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris is lacking in the lower reach. US Forest Service biologist, Mike Donald reports 0.07 small pieces (12”-24”diameter), 0.02 medium size pieces (24”-36” diameter) and 0.01 large pieces (> 36” diameter) per meter of stream length in 1990. A 1998 survey reports 0.09 pieces of wood per meter of stream length (Resources Northwest 1999).

Percent Pools

The pool/riffle/glide ratio is 30:64:3 (Mike Donald, unpublished data 1990; Ames et al 2000). Channelization and associated bank armoring, along with the lack of large woody debris or other pool forming structure, has created predominantly glide habitat (Byron Rot, personal communication 2002).

Pool Frequency

Pool frequency is 9.0 channel widths per pool (Ames et al 2000). There are 34.6 pools per mile of stream length (Mike Donald, unpublished data 1990).

Pool Quality

The one major pool with depth and cover is associated with a wall of creosoted timbers and green painted marine plywood (Byron Rot, personal communication 2002).

Streambank Stability

The channelized section is armored with riprap and wood, a sign of instability (TAG 2002).

Sediment Input

Sediment Supply

Sediment supply is a data gap. The TAG notes that this is a response reach, with sediment coming from above and from the bed as well, as can be observed by downcutting and aggradation.

Mass Wasting

Mass wasting is not applicable to this reach.

Road Density

Road density for the lower reach is 5.23 miles of road per square mile of habitat (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

The riparian buffer is narrow and is dominated by deciduous species above US 101 and willow below US 101 (TAG 2002). There are 3.36 stream crossings per mile of stream (2.09 per kilometer), which fragments the riparian corridor (PNPTCd, unpublished data 2002).

Water Quality

Temperature

Streamkeepers of Clallam County have been collecting water temperature data at river mile 0.1 using grab sample methodology beginning in 2000. Existing data prior to 2000 were collected by Clallam County in 1991 and 1992. In 1991, temperatures reached 16°C in both August and September. In 1992, temperatures reached 19°C in June, 16°C in July and 18°C in August. Temperatures reached 14.8°C in July and 14.1°C in August 2000. Water temperatures improved in 2001 as they reached a high of 12.5°C in August.

Water Quality

Streamkeepers of Clallam County have been collecting dissolved oxygen data since 2000. Clallam County collected water quality data in 1991 and 1992. The concentrations have all been above 8 mg/L with the exception of September of 2001 when the concentration was 7.4 mg/L (Streamkeepers, unpublished data, 1991-2001).

Hydrology

Flow – Hydrologic Maturity

The lower two miles have been logged both historically and recently. The first mile of stream, which is primarily private land, has homes built along the banks, which have affected the flow due to bank protection and water withdrawals. In 1990, seventy-one percent of the riparian zone vegetation of the lower two miles consisted of small trees (8-21 inch diameter), primarily red alder with big leaf maple and willow intermixed. Douglas fir and western hemlock became more abundant near the upper end of this section (Donald 1990). Upon viewing 2001 aerial orthophotos (WDNR 2001), the east side of the creek consists of a second growth forest that is nearing maturity. Younger stands are found on the west side of the creek. The TAG found this parameter difficult to quantify and called it variable.

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

Escapement has been poor. Coho are depressed and summer chum are federally listed as threatened. Streamkeepers of Clallam County conducted a Benthic Invertebrate Biotic

Index (BIBI) in September and October 2000. The rating was 22, which is poor by BIBI standard. A summer chum stock restoration effort is underway, which looks promising for increased adult returns.

Estuary

Jimmycomelately Creek has been totally disconnected from its estuary due to channelization, road construction, and log yard activities. Currently there are two mouths, which divides the flow and allows accretion of a tidal cone into the intertidal area. An abandoned log yard filled the intertidal zone with a pier and rafted logs that disconnected eelgrass beds. A log access road, a railroad trestle, Blyn Road and Highway 101 have further constricted and impacted estuary function (TAG 2002).

Data Needs

- Determine fine sediment
- Evaluate road impacts on aquatic resources

Jimmycomelately Creek, river mile 1.0-3.5

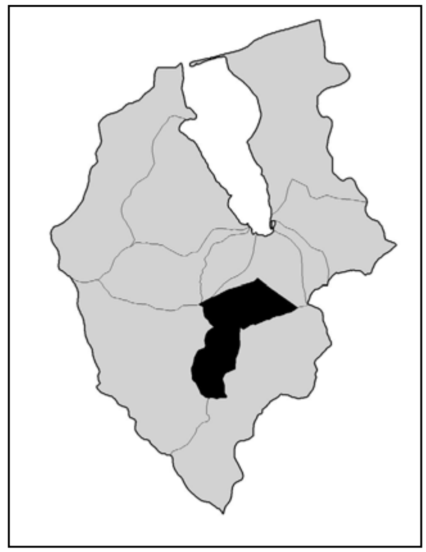

Figure 72. Jimmycomelately Watershed, river mile 1.0 to 3.5. Map provided by Jennifer Cutler, NWIFC

Access and Passage

Artificial Barriers

Access to the upper watershed is under debate around an anecdotal falls at approximately river mile 2.0. WDFW biologists are setting minnow traps to determine presence/absence of anadromous fish in the upper watershed. Access is good to the possible natural barrier.

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat

This parameter is not applicable to this section due to gradient.

Channel Conditions

Fine Sediment

Fine sediment is a data gap, although Pacific Northwest Resources (1999) determined fines were variable, with some in the lower gradient areas.

Large Woody Debris

It is difficult to assess the existing data due to the lumping of gradients. There is considerably less wood per meter between river mile 1.8 and 2.3 than in the lower 1.8 miles and moderately less between river mile 2.3 and 2.9 (Donald 1990). Added together, the rating is still below 0.15 pieces of wood per meter of stream. Personal observation of TAG members indicates moderate LWF levels in lower gradient portions but low LWD levels in the higher gradient segments. The majority of this reach is higher gradient (TAG 2002).

Percent Pools

In 1990, there were less than 30 percent pools (Donald 1990).

Pool Frequency

Pool frequency is a data gap.

Pool Quality

Some deep pools are present but they are not common (TAG 2002).

Streambank Stability

Streambank stability is a data gap.

Sediment Input

Sediment Supply

Sediment supply does not exceed normal levels for the watershed (TAG 2002). A 1996 culvert failure from a county road contributed excess sediments to the watershed but that was a one-time event that has been corrected (TAG 2002).

Mass Wasting

Mass wasting is a data gap.

Road Density

Road density in this segment is 3.3 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

The majority of the riparian vegetation in this segment is shrub/sapling with red alder, big leaf maple and salmonberry dominating due to clearcut logging of the riparian area on both sides of the creek. There are some areas with residual western hemlock and cedar that exceed 32 inches in diameter left from logging operations (Donald 1990). Much of the riparian zone is now in recovery with some coniferous trees maturing into old growth. The rest is second growth with a good coniferous/deciduous mix (TAG 2002). In addition, there are 1.74 road crossings per mile (1.08 per kilometer) of stream (PNPTC, unpublished data, 2002), which tends to fragment the canopy.

Water Quality

Temperature/Dissolved Oxygen

No water quality data were available.

Hydrology

Flow – Hydrologic Maturity
The watershed has been clearcut but is beginning to grow back. Upon viewing 2001 aerial orthophotos (WDNR), the east and south sides of the creek consist of a second growth forest that is nearing maturity. Younger stands are found on the west and north sides of the creek. The TAG found this parameter difficult to quantify and called it variable.

Flow – Percent Impervious Surface
This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)
Escapement has been poor and therefore the TAG rated this parameter poor.

Data Needs

- Determine if cascade/falls is passable to anadromous fish
- Assess fine sediment
- Determine pool frequency
- Evaluate streambank stability
- Determine percent impervious surface and evaluate road impacts on aquatic resources

Jimmycomelately Creek, above river mile 3.5

Access and Passage

Access
There are no known culvert barrier problems (TAG 2002).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
This parameter is not applicable.

Channel Conditions

Fine Sediment
Fine sediment is a data gap.

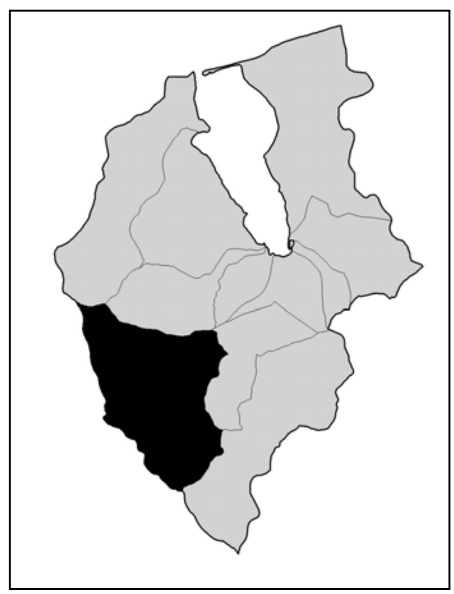

Figure 73. Upper Jimmycomelately Watershed. Map provided by Jennifer Cutler. NWIFC.

Large Woody Debris

This parameter is a data gap.

Percent Pools

Pools in the high gradient reach (5 percent gradient) are minimal. The upper lower gradient (3 percent) section has some pools (7 percent) but is primarily riffle habitat (Donald 1990).

Pool Frequency

Pool frequency is a data gap.

Pool Quality

There are few deep pools with adequate cover (TAG 2002).

Streambank Stability

Streambank stability is a data gap, although Donald (1990) noted evidence of cattle grazing along the banks and much of the reach was characterized by heavily embedded substrate.

Sediment Input

Sediment Supply

Sediment supply is a data gap.

Mass Wasting

Mass wasting is a data gap.

Road Density

Road density is 3.62 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Selective and clearcut logging has adversely affected the riparian area. Salmonberry, devil's club, gooseberry, willow and cottonwood dominate the streambanks, with a small tree cover of western red cedar, western hemlock and red alder. There are 1.59 road crossings per mile of stream (0.99 per kilometer), which fragment the canopy (PNPTC, unpublished data, 2002).

Water Quality

Temperature

Water temperature for this segment is a data gap.

Dissolved Oxygen
Dissolved oxygen concentrations for this segment are a data gap.

Hydrology

Flow – Hydrologic Maturity
Much of the upper watershed has been converted to agriculture and the rest is in immature second growth (TAG 2002).

Flow – Percent Impervious Surface
Percent impervious surface is a data gap.

Biological Processes

Nutrients (Carcasses)
This parameter is not applicable as it is assumed to be above anadromous migration. However, rainbow escapees from the trout farm are found throughout the watershed, as are cutthroat trout.

Data Needs

- Assess fine sediments
- Determine pool frequency
- Evaluate streambank stability
- Assess sediment supply and mass wasting
- Collect water quality data
- Determine percent impervious surface
- Evaluate road impacts on aquatic resources

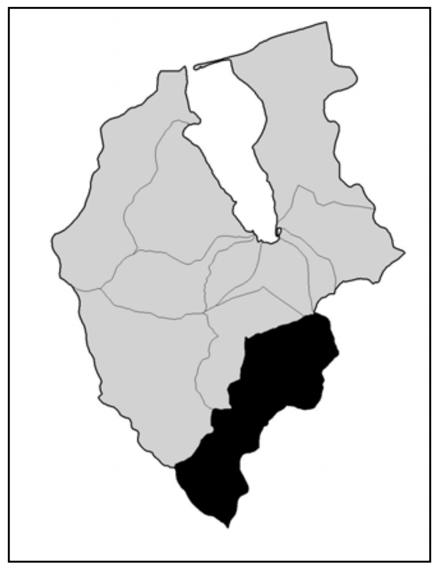

Figure 74. East Fork Jimmycomelately Watershed. Map provided by Jennifer Cutler, NWIFC

East Fork Jimmycomelately Creek

Access and Passage

Artificial Barriers
Culverts are not a limiting factor in the East Fork of Jimmycomelately Creek. A ten-foot high waterfall with a 60 percent gradient serves as an upstream migratory barrier. However, there are fish, probably resident cutthroat, present upstream of the obstruction (Donald 1990).

Floodplains

Floodplain Connectivity/Loss of Floodplain Habitat
This parameter is not applicable due to gradient.

Channel Conditions

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Donald (1990) reported 98 small pieces (12"-24"dbh) of wood per mile, 36 medium pieces (24"-36"dbh) and 15 large pieces (>36"dbh). This equates to less than 0.1 pieces of wood per meter of stream. A 1998 stream survey conducted by Resources Northwest Consultants confirmed these results (Resources NW 1998). A recent clearcut along the left bank limits future large woody debris recruitment (Donald 1990).

Percent Pools

Donald (1990) reported 26 percent pools and 71 percent riffles within a four percent gradient.

Pool Frequency

There were 41.86 pools in the 1.4 miles of stream length and a wetted width of 11.5 feet (Donald 1990). Pool frequency was 3.64 channel widths per pool.

Pool Quality

There are no deep pools with adequate cover (Resources NW 1998).

Streambank Stability

Streambanks are stable in this segment with one small slide noted in 1998 (Resources NW 1998).

Sediment Input

Sediment Supply

Sediment supply is a data gap.

Mass Wasting

No mass wasting events have occurred and the watershed is fairly stable (Resources NW 1998).

Road Density

Road density is 3.41 miles of road per square mile of watershed (PNPTC, unpublished data 2002).

Riparian Zones

Riparian Condition

A US Forest Service Road is in close proximity of the stream. There is some conifer with shrub understory but a recent clearcut along the left bank comes within 30 feet of the stream in some places (Donald 1990).

Water Quality

Temperature
There are no temperature data for this segment of stream.

Dissolved Oxygen
There are no dissolved oxygen data for this segment of stream.

Hydrology

Flow – Hydrologic Maturity/Percent Impervious Surface
The TAG did not rate this parameter and considered it a data gap.

Biological Processes

Nutrients (Carcasses)
This parameter is a data gap.

Data Needs
- Assess fine sediments
- Determine sediment supply
- Collect water quality data
- Determine hydrologic maturity
- Determine percent impervious surface
- Evaluate nutrients
- Evaluate road impacts on aquatic resources

Action Recommendations
- Remove pilings and contaminated sediment from the estuary
- Remove log yard fill
- Remove log yard road
- Turn the abandoned trailer park and infrastructure into a salt marsh
- Use Washington Department of Transportation mitigation dollars to construct tidal channels
- Remove the county road
- Move the creek channel to the west to its historic location, put in a new three-span bridge and plant a riparian zone
- Remove the delta cone accretion of the old channel to regain intertidal habitat
- Remove trestle over the tributary that carries casino stormwater and replace with a walking bridge (the trestle still leaks creosote)
- Underplant riparian zone with conifer below the cascade
- Conduct culvert assessment
- Install cattle exclusion fencing with riparian planting in the upper watershed

Dean Creek

Access and Passage

Access

The culvert at Highway 101 could limit migration during low flows. A forty-foot impassable falls downstream of the power line at approximately river mile 1.2 is a migration barrier. A culvert at the powerline right of way is a possible barrier and should be investigated. There are resident fish between the falls the powerline culvert (Hilton Turnbull, personal communication, 2002).

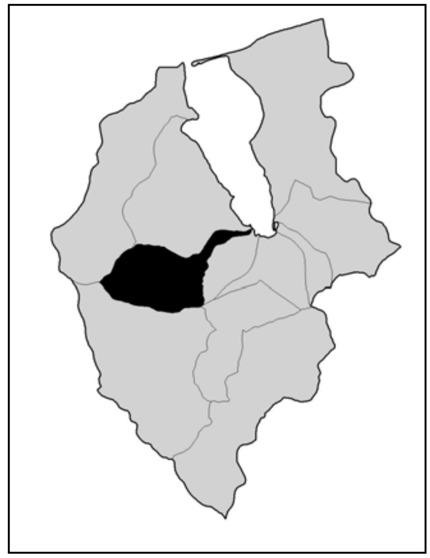

Figure 75. Dean Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

Below river mile 0.5, the stream has been channelized and the streambanks have been armored. The flows have no access to the floodplain (TAG 2002).

Loss of Floodplain Habitat

The lower watershed has been developed with parking lots and logging operations, which have eliminated historic wetlands, riparian areas, and instream sinuosity and complexity (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap. The TAG noted that after slide events, fines are noticeable as turbidity.

Large Woody Debris

Large woody debris is absent in the lower 0.5 miles of the stream and the opportunity for future recruitment is lacking, as the little riparian areas that exist are predominantly willow. The situation improves upstream (TAG 2002). In between areas of steep gradient in the upper watershed, the habitat is quite good with the presence of large woody debris and pools. The coniferous trees that were taken down for power line maintenance were unfortunately dropped away from the stream (Hilton Turnbull, personal communication, 2002).

Pools

Pool information is a data gap. Pools are present between gradient areas and fish are present in all pools (Hilton Turnbull, personal communication, 2002).

Streambank Stability

Streambank stability is a data gap as there is not enough information or data to quantify. The lower 0.5-mile has bank scour with no pools. The upper reaches have stable banks except for a few places. One such site is a left bank slide at approximately river mile 1.0 that is within a geologically steep and unstable area, compounded by a road that was not abandoned properly nor was it maintained. There is also a small diversion here with evidence of recent maintenance and no fish screen. A valve is connected to the downstream pipe allowing flow control (Hilton Turnbull, personal communication, 2002).

Sediment Input

Sediment Supply/Mass Wasting

Sediment input is a data gap.

Road Density

Road density is 4.3 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Riparian buffers in the lower 0.5-mile consist primarily of willow. Above river mile 0.5, the riparian condition improves but is mixed deciduous/coniferous of different age classes to form a multistoried canopy. In addition, there are 3.16 road crossings per mile of stream (1.96 per kilometer), which fragment the riparian corridor (PNPTC, unpublished data, 2002). These crossings are concentrated in the lower watershed.

Water Quality

Temperature

Water temperature data are very sparse and therefore a data gap.

Dissolved Oxygen

Dissolved oxygen is a data gap.

Hydrology

Flow – Hydrologic Maturity

Hydrologic maturity is good in this watershed. However, potential harvest will reduce this quality (TAG 2002).

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

Escapement has been poor. The fish population consists mainly of resident trout (TAG 2002).

Estuary

The lower watershed and associated estuary have been filled for log yard activities. The lower 0.5 miles of stream have been channelized and armored, with willow as the primary vegetation in the riparian zone. All historic wetland/salt marsh habitat has been lost, as has estuary function (TAG 2002).

Data Needs

- Investigate the culvert at the power line right of way road for access
- Assess fine sediment
- Collect pool data
- Assess streambank stability
- Determine sediment supply
- Determine mass wasting
- Collect water quality data
- Determine percent impervious surface
- Evaluate road impacts on aquatic resources

Action Recommendations

- Add sinuosity to Dean Creek below Highway 101
- Remove log yard to restore estuary function of Dean Creek
- Submit stream-type upgrade with appropriate agencies to reflect fish presence to at least the powerlines

Johnson Creek

Access and Passage

Access

There are no known barriers on Johnson Creek. The culvert at Highway 101 is not a barrier as there are fish present on both sides of the culvert. Some instream work in the form of log weirs has occurred downstream of the culvert (Hilton Turnbull, personal communication 2002).

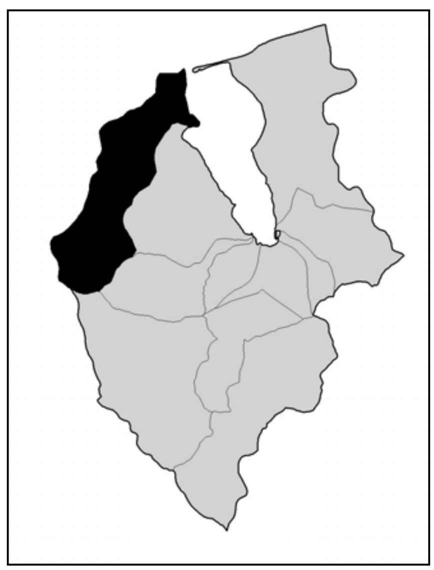

Figure 76. Johnson Creek Watershed. Map provided by Jennifer Cutler, NWIFC

Floodplains

Floodplain Connectivity

The lower gradient section below Highway 101 has been channelized and heavily armored. Due to incision in the lower reaches associated with the trailer park and marina, flows do not have access to the floodplain (TAG 2002).

Loss of Floodplain Habitat

Downstream of Highway 101, the watershed has been developed with a marina and trailer court, eliminating sinuosity and instream structure (TAG 2002).

Channel Conditions

Fine Sediment

Fine sediment is a data gap.

Large Woody Debris

Large woody debris is a data gap. TAG members have observed some fallen trees in the channel downstream of Highway 101. The condition above Highway 101 is unknown.

Percent Pools

Percent pools is a data gap because nothing has been quantified. The restored area immediately downstream of Highway 101 is functioning well with pools. Downstream of the restored area is very little pool habitat except some associated with undercut banks (Hilton Turnbull, personal communication, 2002).

Pool Frequency

Pool frequency is a data gap.

Pool Quality

Downstream of Highway 101 there are few deep pools with adequate cover, but the condition is unknown upstream of Highway 101 (TAG 2002).

Streambank Stability

The lower segment of the stream that is associated with the marina and the trailer park is incised with bank exposure. Recent dirt moving/grading activities associated with the construction of a footbridge in the lower watershed have the potential to increase sediments to the stream. Active erosion has not been observed along the remaining streambanks, however. Good root strength within the riparian zone has been observed.

Sediment Input

Sediment Supply/Mass Wasting

Sediment input is a data gap.

Road Density

Road density is very high with 6.11 miles of road per square mile of watershed (PNPTC, unpublished data, 2002).

Riparian Zones

Riparian Condition

Riparian condition is good above Highway 101 and between Highway 101 and the trailer court. However, aerial orthophotos indicate no vegetation around farm ponds on a tributary to Johnson Creek above Highway 101. Riparian buffers in vicinity of the trailer court and continuing down to the mouth are non-existent (TAG 2002).

Water Quality

Temperature

Eight Streams Project monitored water temperature between 1997 and 1999. Clallam County monitored water temperature in 1991 and 1992. All took grab samples throughout the year, but this analysis primarily involves the summer/fall months.

Table 20. Johnson Creek Water Temperatures Recorded Annual High. Data provided by Ed Chadd, Streamkeepers of Clallam County

Location	1991 °C	1992 °C	1997 °C	1998 °C	1999 °C
Johnson Creek, RM 0.0	15	18	15	14	13.3
Johnson Creek, RM 0.6			13.5	12	13.3

Dissolved Oxygen

Eight Streams Project (1997-1999) and Clallam County (1991-1992) collected water quality data and only one reading (July 17, 1998) was greater than 8 mg/L.

Hydrology

Flow – Hydrologic Maturity

The west tributary and headwaters have less than fifty percent in mature forest (TAG 2002).

Flow – Percent Impervious Surface

This parameter is a data gap.

Biological Processes

Nutrients (Carcasses)

This parameter is a data gap.

Estuary

The tidally influenced area of Johnson Creek has been channelized and heavily armored as it flows along a retaining wall by the John Wayne marina, and has therefore lost all estuary function (TAG 2002).

Data Needs

- Assess fine sediment
- Collect pool data
- Determine sediment supply and mass wasting
- Collect nutrient data
- Evaluate road impacts on aquatic resources

Action Recommendations

- Establish a riparian zone in the lower watershed adjacent to the trailer court

HABITAT CONDITION RATING STANDARDS AND WRIA 17 HABITAT RATINGS

Under the Salmon Recovery Act, passed by the legislature as House Bill 2496 and later revised by Senate Bill 5595, the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state and federal documents that use some type of habitat rating system were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed by WCC, with the expectation that it will be modified or replaced as better data become available. In addition to these ratings, the WRIA 17 TAG also noted Data Gaps, Not Applicable, and Variable.

Following are the WCC habitat condition standards used in this report. Following the standards are the habitat ratings for WRIA 17.

Table 21. Salmonid Habitat Condition Rating Standards.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA / NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minumim size to qualify as a key piece:	BFW (m) 0-5 6-10 11-15 16-20	Diameter (m) 0.4 0.55 0.65 0.7	Length (m) 8 10 18 24		

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50' 26 4.1 75' 23 3.1 100' 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	• <75' or <50% of site potential tree height (whichever is greater) OR • Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC

Table 22. WRIA 17 Habitat Ratings.

HABITAT LIMITING FACTORS BY SUBBASIN																			
Stream Name	WRIA	Acc-ess	Fldplain Connect	Hab Loss	Fine Sed	LWD	% Pool	Pool Freq	Pool Quality	Bank Stability	Sed Supply	Mass Wastng	Road Dens	Riparian Cond	Temp	D/O	Hydro Mat	Imp Surf	Nutrnts
Big Quilcene																			
Marple/Jackson	17.0001	P	P	P	DG	P	P/F	DG	DG	DG	DG	P	P	P	F	DG	G	DG	DG
Spencer Creek	17.0004	P	NA	NA	F	P	P	P	P	P	DG	P	P	P	G/F	DG	G	DG	DG
Indian George	17.0011	P	P	P	DG	DG	P	P	P	P	P	P	P	P	F	G	P	DG	DG
Big Quilcene River																			
RM 0.0-1.0	17.0012	G	P	P	DG	P	P	P	P	P	P	G	P	P	P	G	G/P	DG	G
RM 1.0-3.2	17.0012	P	P/F	F	DG	P	F	P	F	DG	P	P	P	P	P	DG	G	DG	DG
RM 3.2-7.8	17.0012	G	NA	NA	DG	DG	NA	NA	NA	G	G	G	P	DG	G	DG	G	G	DG
Above RM 7.8	Various	P	NA	NA	DG	V	DG	DG	DG	DG	P	P	F	F/G	DG	DG	V	G	NA
Penny Creek	17.0014	P	NA	NA	DG	P/F	DG	DG	DG	DG	DG	P	F	P	G	DG	DG	G	DG
Little Quilcene																			
Little Quilcene River																			
RM 0.0-2.7	17.0076	G	P	P	DG	P	F/P	P	P	P/F	DG	G	P	P	F	G	DG	DG	DG
RM 2.7-6.8	17.0076	G	NA	NA	DG	P	P	P	P/F	DG	DG	DG	P	DG	DG	DG	DG	DG	DG
Above RM 6.8	17.0076	DG	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	P	G	F	G	DG	G	DG
Leland Creek	17.0077	F	P/F	P	DG	P	P/F	P/G	P/G	P/G	DG	DG	P	P	P	P/DG	DG	DG	DG
Ripley Creek	17.0089	G	NA	NA	DG	P	F	F	P/DG	DG	DG	DG	G	F	P	DG	DG	G	DG
Howe Creek	17.0090	G	NA	NA	DG	P	F	F	P	DG	DG	DG	G	F	P	DG	DG	G	DG
Donovan Creek	17.0015	F	F	P	DG	P/F	DG	DG	DG	P/G	DG	DG	P	P/G	P	F	P	DG	DG
Jakeway Creek	17.0016	G	F	P	DG	P	DG	DG	DG	DG	DG	DG	F	P	P	F	P	G	DG
Tarboo/Thorndyke																			
Lindsay Creek	17.0123	P	NA	NA	DG	P	P	P	P	P/DG	P	P	F	P	DG	DG	DG	G	DG
Tarboo Creek																			
RM 0.0-0.9	17.0129	G	G	G/F	DG	F	F	F	F	G	G	G	P	G	DG	G	DG	G	DG
RM 0.9-4.0	17.0129	G	F	P	DG	P	P	P	P	F	DG	G	P	P	P	G	P	DG	DG

HABITAT LIMITING FACTORS BY SUBBASIN																			
Stream Name	WRIA	Acc-ess	Fldplain Connect	Hab Loss	Fine Sed	LWD	% Pool	Pool Freq	Pool Quality	Bank Stability	Sed Supply	Mass Wastng	Road Dens	Riparian Cond	Temp	D/O	Hydro Mat	Imp Surf	Nutrnts
Above RM 4.0	17.0129	P	NA	NA	DG	F	DG	DG	DG	G	P/DG	P/DG	P	P	G	G	P	G	DG
EastFork	17.0130	P	P/F	DG	DG	DG	DG	DG	DG	P/DG	DG	P/DG	P	P	F	DG	DG	G	DG
Camp Discovery	17.0141	DG	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	P	DG	DG	DG	DG	DG	DG
Fisherman Harbor	17.0153	P	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	P	DG	DG	DG	DG	DG	DG
Thorndyke Creek	17.0179	F	G	G	DG	P	V	G	DG	DG	DG	DG	P	F	F	DG	P/DG	G	DG
Shine/Ludlow																			
Nordstrom Creek	17.0180	P	G	G/F	DG	DG	DG	DG	DG	DG	P	P	P	DG	F/G	DG	DG	DG	DG
Shine Creek																			
RM 0.0-1.0	17.0181	G	G	G	DG	F/P	G/P	F	F	G	DG	DG	P	P	F	DG	DG	F	DG
Above RM 1.0	17.0181	G	NA	NA	DG	DG	G	P	F	DG	DG	DG	P	DG	F	DG	DG	DG	DG
Bones	17.0185	P	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Ludlow Creek																			
RM 0.0-0.5	17.0192	G	G	G	DG	F/G	DG	DG	DG	G	P	DG	F/G	G	DG	DG	DG	DG	DG
Above RM 0.5	17.0192	F/P	F	F	DG	DG	DG	DG	DG	G	NA	NA	P	F	F	DG	DG	DG	DG
Piddling Creek	17.0200	P	P	P	DG	DG	DG	DG	DG	DG	DG	DG	P	DG	DG	DG	DG	DG	DG
Little Goose Creek	17.0100A	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	F	DG	DG	DG	DG	DG	DG
Chimacum																			
Chimacum Creek																			
RM 0.0-3.0	17.0203	G	G	G/F	P	P	P	DG	P	G	P	G	P	G	P	G/F/P	DG	F	DG
RM 3.0-9.4	17.0203	G	P	P	DG	P	P	P	P	G	DG	NA	P	P	P	P/F	P	DG	DG
Above RM 9.4	17.0203	F	NA	NA	DG	F/P	DG	DG	DG	F	P	P	P	F	F	G/P	P	DG	DG
East Fork	17.0205	G	P	P	DG	P	P	DG	P	G	P	NA	P	P	P/F/G	P/F/G	P	DG	DG
Puutansuu	17.0206	G	P	P	DG	P	P	P	P	DG	DG	DG	P	P	P	G	P	DG	DG
Naylor	17.0208	G	P	P/G	DG	DG	DG	DG	DG	F	DG	G	P	P	F/G	G	P	DG	DG
Barnhouse	17.0213	G	P/F/G	DG	DG	P	P	DG	DG	G/F	G/F	G	P	P	F/G	DG	P	DG	DG
Discovery Bay																			
Snow Creek																			

HABITAT LIMITING FACTORS BY SUBBASIN																			
Stream Name	WRIA	Acc-ess	Fldplain Connect	Hab Loss	Fine Sed	LWD	% Pool	Pool Freq	Pool Quality	Bank Stability	Sed Supply	Mass Wastng	Road Dens	Riparian Cond	Temp	D/O	Hydro Mat	Imp Surf	Nutrnts
RM 0.0-3.5	17.0219	G	P	P	P/F	P	F	P	P/F	F/G	G	NA	P	P	P	G	P	DG	P
Above RM 4.1	17.0219	G	NA	NA	DG	P	P/G	DG	DG	G	P	P	P	G/P/F	F	F	G	G	P
Andrews 0.0-Bltn	17.0221	G	P	P	DG	P	DG	DG	DG	DG	G	G	P	P	F/P	DG	P	DG	P
Andrews abv Bltn	17.0221	DG	NA	NA	DG	DG	DG	DG	DG	DG	DG	DG	F	DG	DG	DG	P	DG	P
Salmon Creek																			
RM 0.0-0.7	17.0245	G	P	P	F	P	P	P	F	DG	G	NA	P	P	P	G	P	G	P
Above RM 0.7	17.0245	G	NA	NA	DG	F/G	F	DG	DG	G	P	P	P	F	DG	DG	P	G	P
Contractor's Creek	17.0270	P	P	P	DG	P	P/DG	P/DG	P/DG	P/DG	P/DG	P	P	P/DG	DG	DG	P/DG	G	P
Eagle Creek	17.0272	P	F/P	F/P	P/DG	P/DG	P/DG	DG	DG	DG	DG	DG	P	F/P/DG	DG	DG	P	DG	DG
Sequim Bay																			
Chicken Coop Creek	17.0278	P	P	P	DG	P	P	P	P	F	DG	DG	P	P	DG	DG	P	DG	P
Jimmycomelately Creek																			
RM 0.0-1.0	17.0285	G	P	P	DG	P	P	P	P	P	DG	NA	P	P	F	G	V	DG	P
RM 1.0-3.5	17.0285	G	NA	NA	DG	P	P/F	DG	F/G	DG	G	DG	P	F	DG	DG	V	DG	P
Above RM 3.5	17.0285	G	NA	NA	DG	DG	P	DG	P	DG	DG	DG	P	P	DG	DG	P	DG	NA
East Fork	17.0286	G	NA	NA	DG	P	P	F	P	G	DG	G	P	F	DG	DG	DG	DG	DG
Dean Creek	17.0293	G	P	P	DG	F	DG	DG	DG	DG	DG	DG	P	F	DG	DG	G	DG	P
Johnson Creek	17.0301	G	P	P	DG	DG	DG	DG	F/DG	F	DG	DG	P	G/P	G/P	G	P	DG	DG

Key:
- G = Good (Properly functioning)
- F = Fair (At risk)
- P = Poor (Not properly functioning)
- V = Various (More than one rating applies)
- DG = Data Gap (No information or professional knowledge available)
- NA = Not Applicable (Does not apply)

NEARSHORE INTRODUCTION

Salmonid use of the nearshore environment is well documented. Chinook, coho, steelhead and chum spawn in streams that empty into estuaries along the shorelines of WRIA 17. They are known to use the nearshore for protection from predators, feeding and migration. Chinook are particularly fond of tidal channels and sloughs while chum feed on copepods found on eelgrass. Chinook and coho eventually feed on smaller fish, such as sand lance, herring and surf smelt. Protection of estuaries, tidal channels, eelgrass and forage fish spawning grounds is critical for salmon recovery.

The Nearshore Technical Advisory Group (TAG) developed a Stressor-Effects Table as a guide to base their discussions and analysis (See Table 23). The Stressor-Effects Table identifies five stressors that impact nearshore environments: shoreline armoring, overwater structures, ramps, stormwater/wastewater, landfill and riparian loss. The Table identifies the physical processes that are altered by these stressors and how the effects are manifested in the nearshore environment. Each geographic section also describes physical attributes of each drift cell (location, drift direction, and sediment abundance) as well as biotic background to present a picture of the landscape. Following the nearshore discussion is a prioritized list of nearshore action recommendations for use in prioritizing projects in the nearshore.

For their analysis of historic habitat change, the TAG used US Coast and Geodetic Survey charts from the 1800s both in their original form and in a digitized form prepared by Robert Huxford and interpreted by Steve Todd, PNPTC. The TAG compared these historic maps with current 2000 aerial orthophotos from Washington Department of Natural Resources (WDNR) and current oblique shoreline photos from Washington Department of Ecology (Ecology) to determine habitat change over time. WDNR's Shorezone Inventory and Ecology's net shore drift maps provided additional information as did the WDFW's forage fish habitat surveys with supplemental forage fish surveys by North Olympic Salmon Coalition (NOSC). The TAG decided not to rate the elements within the Stressor-Effects Table but rather to identify and quantify their impacts where possible.

The shoreline/nearshore has been divided into geographic units for ease of discussion. They include all estuaries within their boundaries. Estuary discussions are also associated with their corresponding watershed. The nearshore units are:

Jackson Cove through Quilcene Bay
Dabob Bay through Thorndyke Bay
Thorndyke Bay to Portage Canal
Portage Canal to McCurdy Point
Discovery Bay
Sequim Bay

Much of the discussion focuses on drift cell units as determined by Washington State Department of Ecology and the US Geologic Survey, although habitat information from DNR's shorezone segments were incorporated.

JACKSON COVE THROUGH QUILCENE BAY

Right Smart Cove

Drift Cell and Biota Background
The southern end of nearshore habitat in WRIA 17 begins with Smart cove to the west of Wawa Point. A small lagoon is located at the head of this cove. Although the size of the lagoon appears to be unaltered when compared with the 1883 USGS Coastal Survey maps, the extent of the surrounding salt marsh has been reduced by landfilling for building sites. It also appears that the riparian zone on the north edge of the lagoon has been eliminated. The marsh supports native high marsh vegetation, such as pickleweed (*Salcornia virginica*) and sea arrow grass *(Triglochin spp.)*. The sediment source is alongshore in moderate abundance. The backshore is classified in the 2001 Coastal Shorezone Inventory as low inclined cliff with live trees and dune grasses. The beach face is a veneer of pebbles over sand. Patches of pickleweed (*Salcornia virginica*), barnacles (*B. glandula*), oysters, brown seaweeds (*Laminaria spp. and Sargassum spp.*), and eelgrass (*Zostera marina*) inhabit the intertidal zone (WDNR 2001).

A natural beach separating the lagoon from marine waters has some natural wood but lacks riparian canopy (Richard Brocksmith, personal communication, 2002). A flood delta exists to the west of the lagoon with a deep tidal prism. As the tide fluctuates the surface area doesn't change but the depth to surface area decreases. The delta imports marine sediments that encourage the formation of the salt marsh. This is not a stable configuration in this case (Randy Johnson, personal communication, 26 April 2002).

No appreciable net shore-drift occurs in this section. The major substrates of this cove are sand and mud. Cove sediments are abundant with the sediment source being alongshore (WDNR 2001). Continuous eelgrass beds line the bay with herring spawning all along the cove. Oysters also line the shoreline and a small geoduck tract is found south of the cove (WDFW 2002).

Shoreline Armoring
WDFW (2001) identifies the cove as sixty percent armored. The armoring is in the form of riprap and a concrete bulkhead to protect building sites.

Stormwater/Wastewater
Several sources of stormwater (sheet flow and storm flow) to Highway 101 are collected in three or four culverts and enter the property at the northwest corner of the cove (Richard Brocksmith, personal communication, 2002). The location and condition of the septic systems associated with the residences are unknown.

Landfill
Approximately two acres of salt marsh habitat originally associated with the lagoon have been filled and the filling activity appears to be continuing (John Cambalik, personal communication, 7 May 2002). The lagoon itself appears to not have been altered, with the exception of elimination of the forest that originally surrounded the lagoon. Another historic salt marsh to the east of the lagoon has been filled to accommodate a house.

Riparian Loss
The forest that originally surrounded the lagoon has been eliminated and invasive blackberries have taken its place in many places. There is no overhanging vegetation along the north shore of the cove but a good riparian area exits along the east side of the cove and around the point (Steve Todd, 2000 orthophoto coverage, 2002).

Action Recommendations
- Remove approximately two acres of fill
- Revegetate the lagoon riparian zone to restore historical estuarine habitat functions

Wawa Point

Drift Cell and Biotic Background
The eastern side of Right Smart Cove to Wawa Point is a partly enclosed sand and gravel beach. Sediment abundance is moderate and sediment source is alongshore (WDNR 2001). The biology of this shoreline includes barnacles, oysters, sargassum, eelgrass and kelp. Herring spawn on the eelgrass along this shoreline. A healthy shoreline riparian area still exists with a few clearings for home sites. The backshore, above mean high water, is classified as low inclined cliff with live trees and dune grasses. The intertidal beach face is a veneer of pebbles, cobbles and boulders overlying sand (WDNR 2001).

The Wawa Point shoreline is an open rocky shore of basalt with rocky outcroppings and a substrate of bedrock and gravel. Sediment abundance is scarce with no appreciable net shore drift. The shoreline is stable with no signs of measurable change over a one-two year period. The backshore profile consists of a low inclined cliff and bedrock. The intertidal consists of sand, pebble and cobble over bedrock. The biology of this shoreline includes barnacles, oysters, kelp, sargassum and eelgrass with herring spawning on the eelgrass (Penttila 2000, WDNR 2001). A healthy shoreline riparian area still exists with a few clearings for residential sites (TAG 2002). An eagle nest is located at the center of Wawa Point (Barb Nightingale, personal communication, 2002)

Shoreline Armoring
Wawa Point itself is not armored but consist of basalt outcroppings along the shoreline.

Overwater Structures
The shoreline contains one dock and associated riprap midway between Right Smart Cove and Wawa Point.

Ramps
A well-used boat ramp, concrete covered with a new layer of asphalt, is in the northwest corner of the cove (Richard Brocksmith, personal communication, 2002). Two marine rails are associated with the southern and eastern part of Wawa Point.

Jackson Cove/Pulali Point

Drift Cell and Biota Background

Jackson Cove is the home of Camp Parsons, a Boy Scout camp located at the head of the bay. The west side of the cove contains a net shore drift cell originating approximately 0.6 km north of Wawa Point across the Marple Creek delta and northward for 0.9 km to the southern side of the Spencer Creek Delta. The northward net shore drift is observed by an increase in northward beach width, a decrease in sediment size, sediment accumulations on the south side of rock outcrops that partially interrupt drift near the cell origin, and a northward offset of the Marple Creek delta. At this point, the beach is sixty meters wide (Johannessen 1992). The Spencer Creek delta is home to an eagles nest (Barb Nightingale, personal communication, 2002).

The remainder of Jackson Cove has no appreciable net shore drift and is semi-protected. The sediment source is alongshore in moderate abundance (WDNR 2001). The east and west shores of Pulali Point are semiprotected with backshore sediment source. The tip of Pulali point is protected with alongshore sediment source of moderate abundance (WDNR 2001). The shore in this area is comprised of basalt with a wave-cut terrace of varying width. It is devoid of a continuous beach. Within Jackson Cove, several large pocket beaches are present between basalt promontories. The westernmost pocket beach receives sediment from Spencer Creek (Johannessen 1992). An undersized county culvert at the mouth of Spencer Creek restricts tidal influence and wood and sediment movement. At low tide this creates a fish passage barrier.

Salt marsh habitat is found in the northwest corner of Jackson Cove and patches of barnacles, oysters, sargassum and eelgrass are found along the western and northern intertidal area. The eastern beach of Pulali Point has continuous barnacle and oyster beds with patches of sargassum, fucus, and ulva (WDNR 2001). Herring spawn in the eelgrass and a geoduck tract is found in the subtidal along the shorelines of Jackson Cove and Pulali Point (Penttila 2000). Three eagle nests line the eastern shorelines of Pulali Point (Barb Nightingale, personal communication, 2002).

Shoreline Armoring

The shoreline along the northward drift cell between Marple and Spencer estuaries is 20% armored, although the bulkheads are segmented and not continuous. A bulkhead extending to the east of Spencer Creek does not intrude into the intertidal area but sediment is accumulating in this reach. An existing wharf could be interrupting sediment transport, bathymetry, and/or tidal forces as well as altering the form of accumulated sediments. There is a gain in intertidal beach. This is not problematic and could possibly be a beach feature. The east side of Jackson Cove is 50 percent bulkheaded, which could be restricting sediment input. The beach has retreated a small amount, possibly due to a small, unnamed creek with a small delta and little tidal influence (TAG 2002).

Overwater Structures

One large pier, associated with Camp Parsons, and one large marine rail system (PNPTC, unpublished data, 2002) are found in Jackson Cove.

An undersized county culvert at the mouth of Spencer Creek restricts tidal influence and wood and sediment movement. At low tide, this creates a fish passage barrier.

Ramps
Eight ramps exist along the western and northern shores of Jackson Cove.

Stormwater/Wastewater
There is no information regarding stormwater/wastewater issues in this section.

Landfill
The bulkhead and associated fill south of Marple Creek have negative impacts to juvenile salmon migration, changes in substrate size, loss of riparian habitat, loss of space for primary and secondary productivity and increase in water temperature in the immediate vicinity of the bulkhead.

Development in the Marple Creek estuary restricts estuary function, tidally influenced surface area and channel migration. The stream has been channelized to the south and is aggrading. There is no sediment storage within the floodplain and consequently all the sediment is deposited out in the nearshore environment leading to a progradation problem. The net result is a steeper shoreline and a loss of tidal channels and sloughs.

Riparian Loss
Riparian loss is most noticed in the vicinity of Camp Parsons.

Data Needs
- Determine extent, if any, of progradation resulting from bulkheads

Dabob Bay/Point Whitney/Dabob Bay

Drift Cell and Biotic Background
Point Whitney is the location of the Washington Department of Fish and Wildlife Shellfish Laboratory. The associated drift cell originates 1.0 km north of Pulali Point within Dabob Bay and has a northward then northwestward net shore drift for 2.5 km, depositing at Bees Mill. Northward and northwestward net shore drift is indicated by northward beach width increase and sediment size decrease, and northwestward spit progradation at Bees Mill. After rounding Whitney Point, net shore drift continues for several hundred meters in front of a small estuary before terminating at a zone of drift convergence located at Bees Mill. The beach is greater than 100 meters wide at the drift cell terminus (Johannessen 1992).

The drift cell to the north of Point Whitney represents a short (1.5 km) section of shoreline that is more exposed to northerly and northeasterly fetch than the adjacent shorelines. As a result, the net shore-drift is to the southeast. The cell originates approximately 1.0 km south of Frenchman's Point at an erosional area and ends at Bees Mill. The southeastward net shore-drift is reflected in the southeastward bluff vegetation, an increase in beach width and sediment size south of Frenchman's Point (Johannessen 1992). Two small drainages with small deltas are within this section (TAG 2002).

The exposure varies between protected and semiprotected with backshore sediment source along the sand flats/sand beaches of Dabob Bay between Pulali Point and Point Whitney, shifting to alongshore sediment source at Point Whitney and continuing north to Frenchman's Point. The substrate is sand with a veneer of pebble in some places. Oysters continuously line this shoreline. Eelgrass is patchy in some places but continuous around the point with herring spawning on the eelgrass beds (Penttila 2000; WDNR 2001). A saltmarsh/grass land appears in photos along Dabob Bay (TAG 2002). The above species continue in patches north to Frenchman's Point, with the addition of patches of focus. Sand lance spawn in the sandy beach just to the north of Point Whitney. A lagoon along the northern side of Point Whitney was originally about 8 acres in size but has decreased due to human activities. Historically a small salt marsh existed in the area, which was formerly a sand-spit deposition area. Surf smelt spawn just north of the lagoon (Penttila 2000). A geoduck tract runs from just north of the lagoon to just south of Frenchman's Point (Barb Nightingale, personal communication, 2002).

Shoreline Armoring

There are no shoreline modifications along the southern Dabob Bay portion of this shoreline. However, a riprap bulkhead extends along approximately 50 percent of the shoreline of Point Whitney (WDNR 2001) and the lagoon to the north of Point Whitney has been diked and bulkheaded. Between one third to one half of the lagoon area was cut off by diking for the state shellfish facility. A small bulkhead, approximately 38m in length to the north of Point Whitney, is less than five percent of its associated drift cell and is not an impact (TAG 2002).

Overwater Structures

A pier with two boat slips accommodates the Shellfish Lab at the Point.

Ramps

There are no ramps in this section of the shoreline

Stormwater/Wastewater

There are no known stormwater/wastewater issues in this section of the shoreline.

Landfill

There is no known fill in this section of the shoreline

Riparian Loss

Riparian coverage is approximately 24 percent along Dabob Bay with no coverage at Point Whitney. Approximately 75 to 80 percent of the shoreline to the between Point Whitney and Frenchman's Point has an intact riparian zone.

Data Needs

- Determine influence of the bulkheading, which is a minor amount considering the length of shoreline, on sediment transport.
- Determine change in intertidal area due to the two small drainages through time series assessment of aerial photos.

Quilcene Bay

Drift Cell and Biota Background

Quilcene bay begins to the south of Frenchman's Point on the west side and ends southeast of Fisherman's Point on the east side. A drift cell originating 0.8 km south of Frenchman's Point has a northward movement to the Quilcene Boat Haven marina that is indicated by northward bluff vegetation, an increase in beach width and a decrease in sediment size. The cell origin is located at a bluff composed of glacial drift over basalt and fronted by a steep narrow beach. Recent bluff failures, demonstrate its erosional nature. A small stream, Frenchman's Creek, drains Devils Lake and provides a fluvial sediment source to the nearshore. Sediment accumulates on the south side of several rock outcrops and south of the riprapped marina. The shallow depths of the bay prohibit the formation of waves large enough to cause significant sediment transport (Johannessen 1992). Northern Quilcene Bay is gradually filling in with sediment transported by the Big Quilcene River, Little Quilcene River and Donovan Creek (Johannessen 1992; TAG 2002).

Between Quilcene Boat Haven marina and the shoreline approximately 1.3 km south of East Quilcene there is no appreciable net shore drift. The deltas of the Big Quilcene River, the Little Quilcene River and Donovan Creek lie within this section. To the south, on the eastern side of the bay a northward net shore-drift originates southeast of Fisherman's Point and extends northward along the eastern shoreline of Quilcene Bay for approximately 4.2 km. A poorly vegetated bluff cut into glacial drift is located at the cell origin. The northwestward net shore drift is indicated by a northwestward bluff vegetation increase, northward and northeastward spit progradation from Fisherman's Point and northward sediment size decrease. Nearshore bars are oriented northwest to southeast, moving to the north between 2 and 4 km north of Fisherman's Point. Sediment accumulation is evident on the south side of the base of a short causeway terminus.

Quilcene Bay shoreline consists largely of protected and semi-protected sand flat and sand beaches. Sediment sources are moderate and alongshore, except where rivers and/or streams enter the bay where they become more abundant and fluvial. Sediment is scarce at the marina. Quilcene Bay is famous for its shellfish, particularly oysters, which are found in continuous and patchy sections throughout the bay. Salt marsh habitat is found along the southwest shoreline. Sargassum, barnacles, ulva and fucus are found in patchy segments (Shorezone Inventory 2001). Eelgrass is continuous throughout the northern end of the bay and the eastern shoreline. Herring are also know to spawn throughout the northern bay area and surf smelt spawn along the beaches on the (Penttila et al 2000).

Shoreline Armoring
A 425-foot concrete bulkhead just south of the Boat Haven marina is setback and provides minimal impact to the shoreline processes (TAG 2002). Over 2550 feet of the shoreline, beginning with the marina and moving northward, consist of concrete bulkhead or riprap and associated fill to protect a park, business and home sites along Linger Longer Road. This bulkhead impacts juvenile fish through its disruption and area decrease to the shallow migratory corridor. This loss of shallow migratory corridor poses the risk of increasing predation of juveniles. Through comparison of early (1880's) coastal surveys and current aerial orthophotos, a high salt marsh with a grassland margin and intertidal channel and a riparian corridor were eliminated through this reach.

A saltwater marsh is developing in front of a concrete bulkhead south of the Donovan Creek estuary, which is known to happen in protected, low tidal action areas. This is a good candidate for time sequencing aerial photos (TAG 2002). An additional concrete bulkhead further to the south has been removed but the fill and riprap remain for future residential development. This fill removes valuable intertidal habitat as well as the shallow water corridor for juvenile migration during high tide (TAG 2002).

The shoreline from about 1.3 km south of East Quilcene and south along the eastern shoreline of Quilcene Bay on the Bolton Peninsula and out to Fisherman's Point is approximately fourteen percent armored (Steve Todd, unpublished data, 2002).

Overwater Structures
The Boat Haven marina consists of a main pier with 36 boat slips and a fuel dock. There are no additional private docks or piers. However, three stairways for single-family dwellings are found along the eastern shoreline of Quilcene Bay on the Bolton Peninsula (Steve Todd, unpublished data, 2002).

Ramps
There is a major boat ramp and associated parking lot to the north of the Quilcene Boat Haven marina.

Stormwater/Wastewater
Old railroad trestle pilings south of the marina may have water quality impacts due to creosote coating. Gas and oil spills within the marina pose major water quality problems. Agriculture stormwater and associated water quality impacts are an issue in lower Donovan Creek and associated estuary. The residents to the north of the marina as well as commercial harvesters along the east side of the bay are diligent in the monitoring of stormwater and other water quality impacts in an effort to keep the shellfish beds open for harvest.

Landfill
Over 2550 feet of the shoreline beginning with the Boat Haven marina and moving northward, consists of concrete and/or riprap bulkheads with associated fill. The resulting elimination of shallow water habitat has been identified as a major impact to juvenile fish known to use the shallow migratory corridor for predator avoidance. In the

1970s, fill was placed in the Indian George Creek estuary for aquaculture purposes. Much of that fill has been removed to reestablish estuary function within that watershed. Monitoring that site will determine if salt marsh habitat reestablishes as a result of the estuary restoration project.

By 1883, diking of the lower Big Quilcene River had begun, eliminating valuable salt marsh habitat and tidal channels. Over 21 percent of the historic delta area of 125 acres has been obstructed by dikes/levees with 3 percent of the historic delta filled for residential and commercial use (TAG 2002). The river has breached the dike more than once in the lower watershed, but has always been rebuilt. Some dikes on the left bank on Washington Department of Fish and Wildlife lands and Jefferson County lands have been removed to provide a channel migration zone. Additional dike removal is necessary to provide properly functioning riverine and estuarine habitats. The river has been aggrading as much as four feet per year. When the dikes were removed, accretion stopped and, in fact, the river did some downcutting (TAG 2002). With dikes in place, there is no place for the river to deposit sediments so the river aggrades and the delta progrades. Boats used to access the river all the way to Linger Longer Road during high tides. However, due to river aggradation and delta progradation, this is not possible today (TAG 2002).

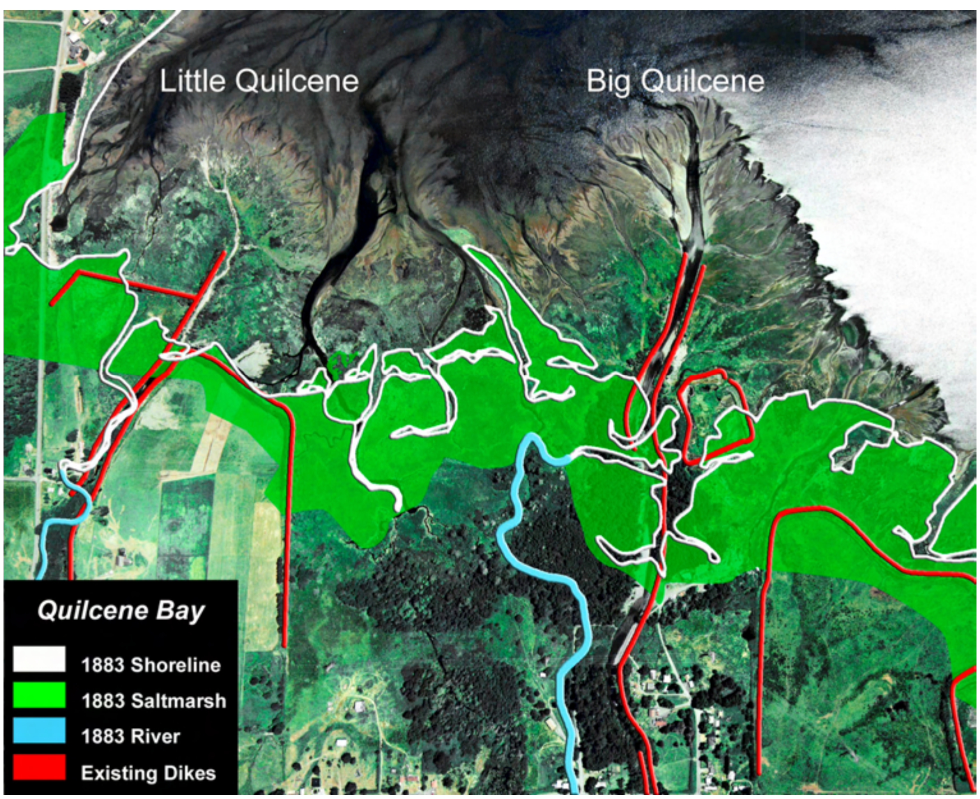

Figure 77. Big Quilcene and Little Quilcene Estuary Modification. Graphics provided by Randy Johnson, WDFW

Extensive diking has also occurred in the Little Quilcene River estuary, eliminating good quality salt marsh habitat and estuary function. The delta has prograded due to loss of floodplain connectivity and deposition area for the excessive sediment load from the upper watershed.

The East Quilcene Road crossing over Donovan Creek is a filled causeway and inhibits tidal action into the historic estuary (TAG 2002). A concrete bulkhead further to the south has been removed but the fill and riprap remain for future residential development. This fill removes valuable intertidal habitat as well as the shallow water corridor for juvenile migration during high tide (TAG 2002). Pilings adjacent to this site should also be removed. Further south, the East Quilcene Road blocks backshore sediment transport (TAG 2002).

According to early coastal survey maps, Fisherman's Point was originally a salt marsh adjacent to and south of an intertidal lagoon surrounded by a grass and sand spit. This area was a little more than four acres historically but is less than ½ acre now that a picnic area has been developed for recreational use (Todd unpublished data 2002). A small salt marsh near the inlet/outlet of the lagoon has developed but is very small and does not replace the value of the historic salt marsh (TAG 2002).

Riparian Loss

The shoreline between the Boat Haven marina and Indian George Creek estuary has been developed for business, parks and housing, eliminating the naturally occurring riparian zone and high salt marsh. Much of the land adjacent to the lower Big Quilcene River, the lower Little Quilcene River, lower Donovan Creek and their respective estuaries has been converted to agriculture and/or residences, which has eliminated riparian habitat.

Steve Todd, Point No Point habitat biologist, calculated a salt marsh loss of about 5 acres in the vicinity of the Indian George Creek estuary. Much of the fill within the Indian George Creek estuary has been removed to reestablish estuary function in that watershed. Monitoring that site will determine if salt marsh habitat re-establishes as a result of the estuary restoration project.

By 1883, diking of the lower Big Quilcene River had begun, eliminating valuable salt marsh habitat and tidal channels. It is possible we have gained salt marsh habitat along the margins of the prograded delta area, but this progradation is not necessarily a desired quality. Tidal channels radiate away from the river but are not connected. The same is true for the Little Quilcene River.

The nearly continuous riparian zone along the eastern shoreline of Quilcene Bay provides overhanging vegetation necessary for shade, cover, and detritus for the nutritive cycle.

Data Needs

- Time sequence aerial photos of the salt marsh developing in front of a concrete bulkhead to the south of Donovan Creek

Action Recommendations

- Restore lower floodplain of Marple Creek
- Remove intertidal fill on Marple estuary
- Remove pilings north of Marple Creek
- Replace culvert on Spenser Creek with appropriate alternative
- Remove dike in the lagoon at Point Whitney
- Remove additional dikes on WDFW property on the Big Quilcene River
- Acquire properties on the south side of the Big Quilcene River to restore salt marsh habitat
- Restore sinuosity in the Big Quilcene River and connect river with tidal channels
- Remove the left bank dike along the Little Quilcene River and nearshore (currently owned by Jefferson County) to restore salt marsh habitat.
- Acquire conservation easement and set back right bank dike along the nearshore associated with the Little Quilcene River to restore salt marsh habitat
- Remove some delta cone that has prograded
- Restore sinuosity in the Little Quilcene River and associated nearshore
- Acquire fill area, slated for development, along the east side of Quilcene Bay to the south of Donovan Creek and remove pilings
- Restore shoreline between Boat Haven Marina and Indian George Creek with more natural soft armoring techniques
- Restore natural backshore sediment transport process blocked by Little Quilcene Road.

DABOB BAY THROUGH THORNDYKE BAY

The Dabob Bay through Thorndyke Bay discussion is divided into three sections: Dabob Bay, South and West Toandos Peninsula, and Thorndyke Bay. Action recommendations are summarized at the end. Washington Department of Ecology's (Ecology) net shore-drift delineation by Johannessen (1992) was used to describe drift cell background. Washington Department of Natural Resources Shorezone Inventory (2001) offered biotic and sediment source and abundance information. The TAG reviewed Ecology's 2001 oblique shoreline photographs to further the analysis.

Dabob Bay

Drift Cell and Biota Background

The eastern portion of Dabob Bay begins at the southern tip of the Bolton Peninsula and extends north, then bends briefly to the east and then south to the tip of Toandos Peninsula. One single 9.5 km long drift cell extends northward along the eastern Bolton shoreline to Tarboo Bay. The western shoreline of Toandos Peninsula also has one single drift cell, extending northward 21 km from the southern tip of the peninsula and terminating in at the northern end of Long Spit in Tarboo Bay. Tarboo Bay, a mud flat north of the terminus of two drift cells, is filling in with sediment supplied by Tarboo Creek (Johannessen 1992).

Figure 78. Tarboo Bay. 2001 Ecology Nearshore Oblique Photo

The southern shore of the Bolton Peninsula, beginning to the west of Red Bluff and moving eastward, consists of a bluff cut into red, coarse-grained sandstone and conglomerate and overlain by sandy glacial drift and fronted by a poorly sorted beach. The bluff is poorly vegetated and steep, with indication of a recent slope failure, reflecting its erosional nature (Johannessen 1992; Ecology 2001). Washington State Department of Ecology 2001 shoreline oblique photos show a house precariously perched above this sloughing bluff. The shoreline in this section is still natural. Sediment sources fluctuate between backshore and alongshore in moderate abundance. Barnacles are continuous along the beach with patches of oysters, sargassum and eelgrass extending north to Tarboo Bay (WDNR 2001). Eelgrass is predominately continuous along the shorelines of Dabob Bay. Herring are known to spawn in the eelgrass between Red Bluff Point and Broad Spit (Penttila 2000).

The net shore drift, moving first toward the northeast and then toward the north along the eastern shore of Bolton Peninsula, is indicated by several features: an increase in northeastward bluff vegetation, the presence of red sand northeast of the red sandstone outcrop at the cell origin, a decrease in sediment size moving toward the north and northeast, northward progradation of Broad Spit, and the northeastward progradation of several bayhead bars located directly west of the town of Dabob (Johannessen 1992). Within the drift cell, 46 percent of the backshore is sloping and 15 percent of the beaches are accretion spits or barrier beaches (PNPTC, unpublished data 2002). Along the eastern side of the entire Bolton peninsula, numerous natural slope failures, which provide valuable sediment recruitment to the marine environment, are found. Every effort should be made to protect these features. Areas of disturbance are found along the shoreline adjacent to Lindsay Creek. These are: an aquaculture facility at Broad Spit (although Broad Spit itself is an intact spit with subaerial wetlands) and associated staging area further to the north, a small development in the center of this eastern shoreline, and individual home sites are found scattered throughout. The drift cell ends at Tarboo Bay. Tarboo Bay is essentially a mudflat area bordered by Long Spit to the southwest and an acre of drift logs to the east of creek mouth. Long Spit is one of Tarboo Bay's most important features and efforts to protect the spit are currently underway to expand the current protections afforded by a conservation easement and acquisition by the Nature Conservancy and Department of Natural Resources Natural Area Preserve Program (Barb Nightingale, personal communication, 2002).

Figure 79. Naturally Eroding Bluff. 2001 Ecology Nearshore Oblique Photo

Surf smelt spawn along small beach segments just north of Broad Spit at the central part of eastern Bolton Peninsula, located along the east side of Tarboo Bay and immediately south of Camp Discovery. Sand lance spawn on the beaches from the center of eastern Bolton Peninsula to Long spit with a smaller spawning reach near Camp Discovery and another further south toward the western side of Toandos Peninsula (Penttila 2000). Sand dollars are found throughout Dabob Bay. Ulva is present, particularly in front of development and/or stream mouths. Geoduck tracts also line the bay (WDNR 2001).

The drift cell along the eastern shoreline of Dabob Bay originates at the southern end of Toandos Peninsula at a broad drift divergence zone located about 1.0 km northwest of

Oak Head and terminates at Tarboo Bay. Johannessen (1992) describes the drift cell as generally moving northward with the net shore-drift direction indicated by a northeastward stream mouth located 0.7 km northeast of Zelatched Point, a northward stream mouth 2.6 km south of Tabook Point, a northward progradation of two spits, and a northward stream mouth immediately north of Camp Harmony. It is further indicated by sediment accumulation on the south side of a rock groin approximately 2.0 km north of Camp Harmony. The northward stream mouth at Camp Discovery and the erosional nature of the bluff approximately 2.0 km north of Camp Discovery, combined with an increase in northward bluff vegetation, the northward progradation of the 1.5-km-long spit (Long Spit) and a northward stream mouth in northern Dabob Bay also indicate a drift cell of northward direction. The sediment sources are mainly alongshore with some moderate level backshore contribution. Patches of barnacles, oysters, sand dollars and predominantly continuous eelgrass beds are found along the western shores of Toandos Peninsula.

The northeast part of Dabob Bay includes both rural residential development and a shellfish facility, both with associated fill and stormwater/wastewater issues. Houses to the south of the aquaculture facility are precariously placed on top of feeder bluffs, which could be contributing to their instability and should be further investigated. It is important to avoid bank hardening in these instances since these sediments are important for the marine ecosystem (TAG 2002). Ulva, an indicator of nutrient loading, is typically present in front of many of the developed areas (TAG 2002). Undeveloped areas include intact riparian areas interspersed with feeder bluffs, both important features for a healthy shoreline. Natural spit formations create inside tidal channels that are particularly favored habitats for juvenile chinook. The area northeast of Zelatched Point includes houses located around a creek mouth and an intertidal open water lagoon. Along the US Navy property, historic salt marshes are mostly intact, although some marsh area has been filled to accommodate a helicopter pad. The shoreline between Zelatched Point and Tskutsko Point is pristine and includes a known osprey nest. The shoreline along the eastern side of the Bolton Peninsula host many bald eagle nests and the shoreline from Oak Head to north of Camp Harmony hose eagle and osprey nests (Barb Nightingale, personal communication, 2002).

Shoreline Armoring

The section of shoreline bordering Lindsay Creek is a dense area of disturbance with a total of 60 percent modification through bulkheading (WDNR 2001). Riprap serves to protect an aquaculture facility from erosion at Broad Spit (Ecology 2001). Additional shoreline armoring is found associated with a small development in the central part of the shoreline along the eastside of Bolton Peninsula. Riprap protects a house and an associated groin blocks sediment drift, which tends to create an erosion problem further down the drift cell with the depletion of fine beach sediment. This in turn encourages additional shoreline armoring to minimize further erosion of beach property.

Modifications to the northwest section of Toandos Peninsula on the eastside of Dabob Bay includes residential development with associated bulkheads and fill which are impacting juvenile fish migration. Erosion along the county road indicates a failed attempt at bank protection of a filled area. South of Camp Discovery, a house protected by a wood bulkhead and extensive terracing along the bank slope is surrounded by feeder bluffs. The bulkhead is blocking feeder bluff sediment recruitment. This intrusion extends into the intertidal area. Bulkheading protects the US Navy's weather communication system to the northeast of Zelatched Point. Within Fisherman Harbor is a log/rock bulkhead that protects a boathouse.

Overwater Structures
A small beach house with a deck extending over the water is in the vicinity of Long Spit. A shellfish facility along the northwest shore of Toandos Peninsula includes a large dock with a float. These modifications present juvenile migratory issues and a potential loss of primary productivity. A nearby beach house is built over the intertidal area with an adjoining dock.

Ramps
One low-impact ramp exists along the southern shore of the Bolton Peninsula. Two low-impact boat ramps are found in the vicinity of Lindsay Beach. A ramp associated with a small development in the central part of the eastern Bolton Peninsula shoreline is connected to a rock groin that blocks shoreline sediment drift. An access ramp at a shellfish facility in the northeast corner of Dabob Bay presents intertidal disturbances. Low impact ramps are associated with Camp Discovery along western Toandos Peninsula.

Stormwater/Wastewater
Stormwater from a paved parking lot and rooftops of an aquaculture facility at Broad Spit could present water quality problems. A small development in the central part of the shoreline along the eastside of Bolton Peninsula could have some stormwater impacts due to drainage from large parking areas, roofs, roads and lawns. To the north a house, precariously perched on a bluff, could pose potential stormwater/wastewater issues that may be evidenced by the ulva (indicative of nutrient loading) along the associated nearshore. There are several instances of ulva presence in front of residential development throughout this section. Potential stormwater impacts and hydrologic alterations from a large clearing and structure in the vicinity of Long Spit should be monitored.

Creosoted pilings in the vicinity of a shellfish facility at the northeast corner of Dabob Bay potentially create water quality problems and should be removed. Poston (2001) reports continued creosote leaching as long as it is in the water with resulting bioaccumulation in barnacles and sediments. Rural residential development and associated septic systems in the vicinity of the shellfish facility may be encouraging the growth of ulva along the shoreline. Ulva is present along the intertidal area in front of Camp Discovery potentially indicating water quality impacts and/or riverine nutrients. The relationship between failing septic systems and the presence of ulva should be investigated in this area. South of Camp Discovery, a house with a wood bulkhead extends into the intertidal area and it is unknown if the wood contains creosote.

Landfill
A deteriorating bulkhead intrudes into the intertidal area at an aquaculture staging area to the north of the center of the shoreline along eastern Bolton Peninsula. Some TAG members note that aquaculture activities throughout Dabob Bay involve some beach alteration, the impacts of which are unknown.

The northwest section of the Toandos Peninsula on the eastside of Dabob Bay includes residential development with associated bulkheads and fill, which impact juvenile fish migration. Erosion along the county road indicates a failed attempt at bank protection of a filled area. Houses constructed on the beach could have filled emergent marsh habitat and should be investigated through map analysis. South of Camp Discovery, a house protected a wood bulkhead is surrounded by feeder bluffs with extensive terracing along the bank slope in an attempt to protect the house. The bulkhead is blocking feeder bluff sediment recruitment and extends into the intertidal area. Moving south to the end of the Toandos Peninsula, a minimum of five additional houses and/or housing developments encroach onto the intertidal zone. One in particular is associated with five rock groins for additional road protection. The beach is headcutting in the vicinity of a culvert in this area. More bulkheads with fill and groins are found immediately to the south. The groins interrupt sediment transport and can create beach erosion down the drift cell. Further south, houses are located right on the beach as well as behind a continuous concrete, wood and rock bulkhead that extends into the intertidal zone. Some salt marsh habitat to the northeast of Zelatched Point has been replaced by a US Navy helicopter pad.

Riparian Loss
Rural housing development tends to remove vegetation for a view, which has proven to be a legitimate risk to property and human life when in the vicinity of unstable slopes and or bluffs.

Southern and Eastern Toandos Peninsula

Drift Cell and Biota Background
The next drift cell is located along the southern shore of the Toandos Peninsula, originating from a broad zone of drift divergence between Tskutsko Point and Oak Head, where a bluff is cut into sandy glacial drift. Net shore-drift is to the southeast around Oak Head and northeastward to Hazel Point for a total length of 4.2 km. Southeastward net shore-drift to Oak Head is indicated by southeastward bluff vegetation, an increase in beach width, and a decrease in sediment size. Northeastward net shore-drift from Oak Head to Hazel Point is indicated by an increase in northeastward beach width and a decrease in sediment size. It is further indicated by northeastward progradation of a baymouth spit most of the way across the very shallow entrance to Fisherman Harbor (which does not prohibit most drift sediment from crossing it), and progradation of the small spit known as Hazel Point, where the drift cell ends (Johannessen 1992). The majority of this southern shore is semiprotected. Sediment sources are primarily backshore in moderate abundance. Patches of barnacles, oysters, geoduck tracts, kelp and eelgrass are found along this shoreline (WDNR 2001). Fisherman Harbor, located

along this south shore, extends into a narrow, relatively deep, protected bay at the mouth of Fisherman Harbor Creek.

Approximately 3.6 km north of Hazel Point on the southeast corner of Toandos Peninsula, southward and southeastward net shore-drift extends to Hazel Point where two drift cells converge. The northeast-facing nature of this segment exposes it to northerly fetch of up to 27 km, causing southward and southeastward net shore-drift. Southward net shore-drift is evidenced by southward bluff vegetation and an increase in beach width, and sediment accumulations on the north side of boat ramps located northwest of Hazel Point. The southward stream mouth, 1.8 km northwest of Hazel Point, and the progradation of Hazel point, a small spit that contains ponded water and abundant drift logs are also indications of this southward net shore-drift. It is believed that much of the net shore-drift sediment reaching Hazel Point may be lost to deep water off the point, where water is in excess of 70 m deep 90 m seaward of the tip of Hazel Point (Johannessen 1992). The majority of the shoreline is semi protected with an abundant sediment source fluctuating between backshore and alongshore. Patches of barnacles, sargassum and eelgrass are found along this shoreline with nearly continuous ulva (WDNR 2001). Sand lance spawn on two beaches in this drift cell (Penttila 2000). Much of this area is still pristine with a minimal residential impact. Sediment recruitment is naturally occurring from feeder bluffs along this shoreline. Additional sediment is delivered to the shore via a slide resulting from a logging road system failure in this area. Approximately 0.75 mile north of Hazel Point is a two-acre beach pond with salt marsh habitat along the eastern edge.

The next drift cell originates from a zone of drift divergence located 3.5 km north of Hazel Point. This cell has a generally northeastward net shore-drift along the eastern shore of the Toandos Peninsula for approximately 17 km to the northern end of the spit that originates near South Point (Johannessen 1992). The shoreline is semi protected with an abundant source of sediments fluctuating between fluvial (derived from two stream deltas near the cell origin), alongshore and backshore. Patches of ulva and eelgrass are present along with some fucus, sargassum and barnacles (WDNR 2001). Much of this coastline is pristine. A lighthouse is located at Brown Point within the US Naval Reserve. South of Thorndyke Bay is a small residential development along the shoreline with cement and wood bulkhead intrusions and associated stairways onto the intertidal area. Mud has accumulated on the beach in this area, perhaps due to a structure directly on top of a small creek that empties into the marine environment at this point. Thorndyke Bay, which is very shallow, and the spits fronting the marsh in the bay are a sink for a portion of northeastward-moving net shore-drift sediment in this cell (Johannessen 1992). Thorndyke Bay may serve as a model estuary of its size, with undisturbed high salt marsh and extensive tidal channels. There are beaver ponds in the lower river and no known major impairments.

Shoreline Armoring

Within Fisherman Harbor is a log/rock bulkhead that protects a boathouse. Along Hazel Point on the southeast corner of the Toandos Peninsula, approximately 100 feet is bulkheaded with a new house and deck extending over the intertidal area. Another house in this vicinity is fronted by riprap that also extends into the intertidal area.

Overwater Structure
Within Fisherman Harbor is a marina with 32 boat slips and other private docks, totaling five in all. Some of the docks are old and could be removed.

Ramps
A boat launch in Fisherman Harbor is associated with a small marina. About 0.75 mile north of Hazel Point, a boat ramp is located at the northern side of a two-acre beach pond.

Stormwater/Wastewater
Wastewater issues associated with marinas, including toxic materials used in boat maintenance, could present problems. Gas and oil leakage/spillage are also issues of concern.

Landfill
Along Hazel Point on the southeast corner of the Toandos Peninsula, approximately 100 feet is bulkheaded and filled with a new house and deck extending over the intertidal area. Another house in this vicinity is fronted by riprap that also extends into the intertidal area.

Riparian Loss
Rural housing development tends to remove vegetation for a view, which has proven to be a legitimate risk to property and human life when in the vicinity of unstable slopes and or bluffs. Removing vegetation also depletes future large woody debris recruitment into the nearshore.

Thorndyke Bay

Drift Cell and Biota Background
East of the Thorndyke Creek outlet sand-rich glacial drift deposits are exposed in south-facing bluffs. These bluffs are subjected to southerly waves that develop over a 17 km fetch. These bluffs are a major source of drift sediment for the northern portion of this cell. There is good sediment recruitment in this area immediately to the east of

Figure 80. Thorndyke Estuary. 2001 Ecology Nearshore Oblique Photos

Thorndyke Bay where there is no shoreline development. The shoreline is semiprotected with an abundant sediment source fluctuating between backshore and alongshore (WDNR 2001).

Overwater Structures
South of Thorndyke Bay, a residential development with docks and stairways is found. One dock has a floating platform for boat storage.

Stormwater/Wastewater
It is unknown if the pilings to the south of Thorndyke Bay contain creosote, but they should be removed regardless (TAG 2002).

Landfill
South of Thorndyke Bay is a small residential development along the shoreline with cement and wood bulkhead intrusions onto the intertidal area.

Riparian Loss
Rural housing development tends to remove vegetation for a view, which has proven to be a risk to property and human life when in the vicinity of unstable slopes and or bluffs.

Data Needs
- Investigate the spatial relationship between the presence of ulva mats, water quality and rural development
- Determine salt marsh habitat loss due to residential and commercial development
- Determine through time sequence photo analysis whether developments on feeder bluffs are contributing to their instability
- Investigate creosote content of wooden bulkhead south of Camp Discovery

Action Recommendations
- Protect naturally eroding bluffs as valuable sources of sediments for the marine environment
- Remove creosote pilings in the vicinity of the shellfish facility in the northeast corner of Dabob Bay
- Investigate and remove old docks within Fisherman's Harbor
- Remove pilings to the south of Thorndyke Bay

NORDSTROM CREEK TO PORTAGE BAY

The Nordstrom Creek to Portage Bay segment is divided into seven sections: Nordstrom Creek/Bridgehaven, Squamish Harbor, Termination Point to Point Hannon, Point Hannon to Tala Point, Ludlow Bay to Basalt Point, Mats Mats to Olele Point and Olele Point to Portage Canal. Data needs and actions are summarized at the end of the discussion.

Nordstrom Creek to Bridgehaven

Drift Cell and Biota Background

East of the Thorndyke Creek outlet, sand-rich glacial deposits are exposed in south-facing bluffs. From this origin, net shore-drift is to the northeast, terminating at a northern, recurved end of a spit, seaward of the Bridgehaven Marina. The increase in northeastward bluff vegetation and the increase in beach width are indicators of a generally northeastward net shore drift. Other indicators are: accumulation of sediment on the southwest side of the riprap revetment at South Point and northward progradation a 1.0 km-long spit from South Point. Continued northward net shore-drift in this cell is interrupted by a riprap jetty located approximately 40 m north of the spit (Johannessen 1992). Patches of ulva, kelp and eelgrass with some barnacles are found along the shoreline (WDNR 2001). Sand lance spawn along the beaches between Thorndyke Bay and Bridgehaven (Penttila 2000) and a geoduck tract lies offshore in the subtidal area.

Figure 81. South Point Ferry and Salt Marsh. 2001 Ecology Nearshore Oblique Photo

A currently non-operating ferry terminal at South Point and adjacent housing development have impacted the shoreline and salt marsh habitat. Upon cursory inspection of the ferry terminal, Richard Brocksmith (2002) reports that riprap, a bulkhead and a groin, in addition to the massive creosote piling/pier system are impacting the juvenile salmon nearshore migration corridor. A large lagoon and associated salt marsh behind the terminal are impacted by the housing development and associated fill. Disconnection of the upper saltwater marsh from its tidal channels has limited both the tidal prism and the ability of freshwater to course downhill toward the saltmarsh. Riparian clearing and subsequent infestation of exotic flora has allowed large amounts of fine sediments to enter the freshwater marsh west and east of the access road, and limited access by juvenile fish to the lagoon through an undersized culvert on Bridghaven's access road have impacted this habitat. Bridgehaven, a residential development built upon a sandspit, associated salt marsh and intertidal area, is 100% riprapped with numerous stair and ramps accessing the beach on both sides of the spit.

Shoreline Armoring
There is a wood bulkhead with riprap at the mouth of Nordstrom Creek. Bulkheads and associated fill are found along the shoreline at an old ferry terminal at Southpoint, to protect the shoreline from wave action from the ferry service. The ferry terminal is currently not in service. Bridgehaven, a residential development built upon a sandspit, salt marsh and intertidal area, is 100% riprapped with numerous stair and ramps accessing the beach on both sides of the spit.

Overwater Structures
A ferry terminal at South Point includes a large pier for car and pedestrian access but is not in use at this time. Twenty docks with a total of 30 boat slips are along the inside shoreline of the Bridgehaven spit, a significant impact to juvenile salmon in terms of predation and primary productivity. Dredging inside the southern spit at Bridgehaven has deepened valuable intertidal and eliminated salt marsh habitat. (Ron Hirschi, personal communication, 2002). Sampling by minnow trap, seine, and visual observation during the past year has failed to find any use of this area by juvenile salmonids. In contrast, tidal sloughs behind the eroding spit to the north (the remnant spit once a part of the Bridgehaven spit complex) are used by numerous chum and pink outmigrants (Hirschi and Doty, unpublished data, 2002).

Figure 82. Bridgehaven. 2001 Ecology Nearshore Oblique Photo

Ramps
A launch ramp serving the Bridgehaven community is located just south of the marina.

Stormwater/Wastewater
Creosoted pilings are associated with the ferry terminal at South Point. The Bridgehaven residential development could have water quality issues if failing septic tanks are present. Wastewater associated with boats, including toxic materials used in boat maintenance could also be an issue of concern.

Landfill
Bridgehaven, a residential development built onto a sandspit, salt marsh and intertidal area, is 100% riprapped with numerous stair and ramps accessing the beach on both sides of the spit. Dredge spoils from the Bridgehaven spit have filled much saltmarsh habitat for home construction, including the widening of the southern spit so that homes could be constructed (Ron Hirschi, personal communication, 2002).

Riparian Loss
Trees are often cleared for views, which depletes future wood recruitment into the nearshore environment.

Squamish Harbor

Drift Cell and Biota Background
Squamish Harbor begins with a northward net shore drift for 3.0 kilometers along the southwestern shore. The drift originates immediately north of a riprap jetty located between the two spits that are found north of South Point. The jetty was installed during development of the small harbor, which is known as Bridgehaven Marina. The jetty has interrupted northward net shore drift along this shoreline. The spit immediately north of the drift cell origin prograded northward in the past, but is now becoming detached from the mainland due to a reduction in the volume of sediment reaching it. A consequence of the sediment reduction is the potential loss of forage fish spawning habitat (TAG 2002). Sand lance are know to spawn along the beach at the drift origin (Penttila 2000). Sediment volume may have been reduced because of the progradation of the spit near South Point, located up-drift of it, by the proliferation of seawalls near South Point and along the spit north of South Point, or by the installation of the riprap jetty between the two spits (Johannessen 1992).

The northward net shore drift along this western shore of Squamish Harbor is indicated by northward beach width increase north of the spit, sediment accumulations on the south side of several large trees lying across the beach 3.0 km north of South Point, and a northward progradation of a small spit located south of the northwest corner of Squamish Harbor. Net shore drift terminates at the shallow delta in northwest Squamish Harbor (Johannessen 1992). The exposure along this shoreline varies from semiprotected to protected. The backshore, consisting of moderate cliffs of till, provides abundant sediments. The sediment source changes to alongshore of abundant quantity in the middle of this southern shoreline. Shine Creek, at the head of the bay, provides abundant fluvial sediments (WDNR 2001).

A continuous stretch of barnacles are found along the middle section with patches of ulva and eelgrass. Beach grasses are found along the backshore. Juvenile coho and chum have been documented in the tidal channels on the Shine Creek delta inside the spit that forms at the head of Squamish Harbor (Ron Hirschi, unpublished data, 2002).

Shine estuary historically had a considerable salt marsh of approximately 85 acres and 5.3 acres of intertidal habitat. The salt marsh has been truncated by South Point Road and its associated fill with three culverts, each 36 inches in diameter, allowing Shine Creek to enter Squamish Harbor with somewhat limited salt water flow back into the estuary. Total estuary function is lacking, as is the movement of logs and debris from the fluvial into the estuarine environment. During high flows, the culverts act as a velocity barrier to upstream salmon migration. The ecosystem functions provided by this estuary for salmonids, including important life history strategies such as foraging, physiological transition, and refuge from predators are severely limited by the culverts under the county road (Simenstad et al 1982). The tidal influence, if not impeded, would allow for frequent mixing between the saltwater of Squamish Harbor and fresh water of Shine Creek, creating the unique vegetation types, water chemistry, depth and temperature important for salmonids and other organisms (Thom 1987). Despite this habitat modification, chum, chinook and coho juveniles, in large numbers and large sizes, have been found in the dammed pool just above South Point Road (Ron Hirschi, unpublished data, 2002). Riverine and estuarine function can be restored with a bridge replacing the three culverts (TAG 2002).

The northern shoreline of Squamish Harbor has a westward net shore drift originating at an erosional bluff composed of stratified, sandy glacial drift at the eastern end of the shoreline. Westward net shore drift is evidenced by an increase in westward bluff vegetation, an increase in beach width, and a decrease in sediment size. Sediment accumulations on the east side of a boat ramp located 0.8 km west of the drift origin, and at a concrete jetty and a riprap revetment in front of the town of Shine are also indicators of this westward drift. Shore-drift is again evidenced by westward progradation of a wide, sandy spit in front of a marsh that has caused westward stream mouth offset (Shine Creek) at the drift terminus in northwestern Squamish Harbor (Johannessen 1992).

The wind wave exposure is semiprotected with abundant sediments from alongshore and backshore sediment sources. The high cliffs, composed of glacial till, at the eastern end of northern Squamish Harbor provide good sediment recruitment. Continuous barnacles with patchy to continuous ulva and eelgrass are found along this northern shoreline. Penttila (2000) reports that herring spawn in the eelgrass beds and sand lance spawn along the central and westward part of this shoreline.

Shoreline Armoring

The proliferation of seawalls along the shoreline north of South Point may be contributing to sediment reduction in this segment (Johannessen 1992). There are bulkheads along both the western and northern shoreline that extend into the intertidal area. These could be moved back and replaced with soft armoring.

Overwater Structures

There are numerous overwater structures in Squamish Harbor in some formerly valuable estuarine habitat (Ron Hirschi, personal communication, 2002).

Ramps
There is a large public boat ramp at the Jefferson County Park along the north shore of Squamish Harbor and its associated retaining wall could be impacting sand/gravel size within sand lance spawning habitat (TAG 2002).

Stormwater/Wastewater
Stormwater runoff from Shine Road and South Point Road could be an issue and should be investigated (TAG 2002). An exposed septic tank is just west of Termination Point. This steep area needs investigation for eroded drain fields and similar potential problems (Ron Hirschi, personal communication, 2002).

Landfill
Road fill has buried a number of small streams, some of which still support cutthroat. Most of these come down from forestlands along the southwestern shore of Squamish Harbor. Small culverts beneath several feet of fill dissect these valuable streams, eliminating estuarine functions. An excellent example is Oyster Creek, just south of Thorndyke Road. South Point Road construction has isolated its watershed from Squamish Harbor with all flow pinched through too small a culvert. Other unnamed creeks to the north still have some spawning habitat below the South Point Road crossing, but little estuary function remains and upstream migration appears blocked (Ron Hirschi, personal communication, 2002). A riprap jetty between two spits north of South Point may be contributing to sediment reduction in this segment (Johannessen 1992). The salt marsh along the northeast corner of this northern shoreline has been filled and a tide gate under Shine Road restricts freshwater input and tidal flux, thereby reducing channel robustness (TAG 2002). A bulkhead and fill at the end of Shine Road encroaches onto the salt marsh habitat. Westward drift feeds a spit feature. A house on the spit includes associated fill (Ecology 2001).

Riparian Loss
The riparian zone at the southeastern end of this shoreline is still intact, although it is decreasing as development is increasing toward the northwest.

Termination Point to Point Hannon

Drift Cell and Biota Background
One drift cell extends from Termination Point to the north end of Bywater Bay and two more extend around Hood Head to Point Hannon. Moving north from the mouth of Squamish Harbor, northward drift begins approximately 1.0 km southwest of the base of the Hood Canal floating bridge near Termination Point moving northward for 3.5 km to northern Bywater Bay. Substantial erosion/sediment recruitment is occurring at the drift cell origin at a moderately high bluff composed of stratified sandy, glacial till. A near-vertical, poorly vegetated bluff face is found here, fronted by a narrow, coarse gravel beach that contains abundant boulders. Net shore drift sediment has accumulated on the southwest side of fill at the base of the bridge with progradation seaward until drift sediment could pass around the base of the bridge (Johannessen 1992).

Continuous barnacles and patches of ulva are found to the south of the bridge, with some oysters and soft brown algae (WDNR 2001). A large herring holding area is offshore and extends north to Tala Point (Penttila 2000).

Net shore drift continues northward beyond the bridge and Shine Tidelands State Park adjacent to the north side of the bridge (Johannessen 1992). Immediately north of the park is a series of northeast-southwest trending nearshore bars, moving northward, indicating continued northward net shore drift. Beach width increases over the length of the cell, from approximately 30 meters at the cell origin to 100 meters in northern Bywater Bay, also indicating northward net shore drift. Other indicators of northward net shore drift include northward increase in bluff vegetation, decrease in sediment size and the progradation of a 0.5 km-long sandy spit in northern Bywater Bay, the end of which constitutes the cell terminus. This spit, which is approximately 50 meters wide, is a major sediment sink. It contains four prominent beach ridges and remnants of older beach ridges. Some sand continues beyond the distal end of this spit and across a shallow tidal channel to be deposited on the beach along the connection to Hood Head (Johannessen 1992).

Surf smelt and sand lance spawn along the western beach in Bywater Bay (Penttila 2000). Patchy stands of eelgrass and ulva with some soft brown kelp dominate the nearshore vegetation (DNR 2001). Chum salmon are found in the tidal pond at the beginning of this drift cell at the northern end of Bywater Bay, a model for unique features that have not been impacted. There is very little habitat loss along this bay. Bywater Bay is a popular public shellfish harvest site.

Two drift cells and the terminus of a third surround Hood Head. Net shore drift originates from the southern end of Hood Head and moves northward along eastern Bywater Bay for 1.5 km to the head of the bay. The erosional headland of southern Hood Head provides abundant drift sediment to this short drift cell. This is causing Bywater Bay to gradually fill with sediment. Northward net shore drift is evidenced by an increase in northward beach and bluff vegetation, a decrease in sediment size, and accretion of a broad, vegetated base to the south and east portion of the berm connecting Hood Head to the mainland. This has resulted in a plan view shape similar to that of a cuspate spit. Net shore drift terminates at the northern end of Bywater Bay at a broad low tide beach (Johannessen 1992). Patches of fucus and ulva dominate this shoreline and barnacles are found throughout (WDNR 2001).

The next drift cell originates in a zone of divergence at the southern Hood Head and has a net shore drift to the northeast for 1.6 km to Point Hannon (Whiskey Spit). Southern Hood Head is an erosional headland comprised of glacial drift that contains abundant sand and gravel. It consists of a thirty-meter high, poorly vegetated, steep bluff face. Indicators of the northeastward net shore-drift are an increase in northeastward bluff vegetation and beach width, a decrease in sediment size, and progradation of the cuspate spit at Point Hannon (Johannessen 1992).

An open water lagoon, surrounded by salt marsh, is found at the base of the land and on the spit. The spit is covered with beach grass and an abandoned cabin is the only disturbance, making this cuspate spit a good reference point for unique habitat types (TAG 2002). Patches of eelgrass and ulva are found along the southern and eastern nearshore of Hood Head (WDNR 2001). Sand lance spawn along the southern shore of Whiskey Spit (Penttila 2000). Juvenile chinook have been observed along this high-energy cuspate spit, feeding on the sand lance (Ron Hirschi, personal communication 2002).

Shoreline Armoring
The bulkhead protecting the western end of the Hood Canal floating bridge has become a major problem. The rock used in the bulkhead is a weak composite from Mats Mats quarry and is beginning to break apart (TAG 2002).

Another long riprap bulkhead protects the road/parking lot at Shine Tidelands State Park and eliminates shallow water habitat for migrating juvenile salmon. Moving the parking lot southward and eliminating the road/riprap would open up the freshwater marsh and allow sediment exchange as well as provide additional rearing habitat for juvenile salmon.

Shoreline armoring occurs along the west side of Hood Head but does not encroach onto the intertidal zone.

Overwater Structures
The Hood Canal floating bridge is the major overwater structures in this segment. An elevated wooden walkway extends over the beach into the intertidal zone along the eastern shore of Bywater Bay. Several stairways are also found along this stretch of beach.

Ramps
A large boat ramp immediately to the north of the Hood Canal floating bridge provides public access for fishing and boating.

Stormwater/Wastewater
Stormwater runoff from the Hood Canal floating bridge and its western approach is an issue that needs to be addressed as part of the scheduled repair work in 2006 (TAG 2002).

Landfill
The western abutment of the Hood Canal floating bridge extends well into the intertidal area and has backed up sediments on the south side. Johannessen (1992) maintains that sediments have accreted enough to allow sediments to continue their northern migration. However, the TAG questions the movement of sediment northward around the bridge abutment. The landfill has caused a loss of shallow water habitat that is critical for juvenile salmonids, including summer chum and chinook.

An open, isolated freshwater marsh, with occasional input from the marine environment during high tide storm events, is landward of the beach. A bulkhead that protects the road to the public beach/access area prevents slump material from the bank to enter the marine environment. Although there is no evidence of historic access for salmon, moving the road/parking lot back toward the Hood Canal floating bridge would provide a connection for sediment recruitment and would be good for the ecosystem as a whole (TAG 2002).

Riparian Loss
The riparian zone is healthy along the east and west sides of Bywater Bay with good wood and overhanging vegetation.

Point Hannon to Tala Point

Drift Cell and Biota Background
The drift cell between Ludlow Bay and Hood Head begins at Tala Point, has a southeastward net shore drift for 7.8 km, and ends at Point Hannon. The sediment source in this cell comes from eroding bluffs composed of sandy glacial drift found in the northern and central parts of the cell. Beach characteristics and sediment composition vary as several points alter the beach exposure levels (Johannessen 1992). Changes in topography and sediment sources are not characteristic of a single drift cell (TAG 2002). Sandy drift material is abundant in the bluffs close to Tala Point but are relatively scarce further south where the bluffs are composed of silt and clay-rich glacial till, with little sand or gravel to replenish the beach (Johannessen 1992).

The tombolo to Hood Head has a narrow, low berm that is overtopped at high storm tides. This forms a washover fan (also called a flood tidal delta) on the southern side of the berm and a thin sand lobe on the beach on the northern side of the berm. Sand on the northern side of the berm has been drifted beyond the end of the spit and over the top of the berm at the beginning of ebb tidal cycles. The sand lobe is offset to the east further than to the west, also indicating eastward net shore drift in this cell. The cell terminates at Point Hannon, a narrow cuspate spit that extends more than 300 meters from the uplands and is a zone of drift convergence in common with the previously discussed drift cell (Johannessen 1992). Patches of ulva and continuous eelgrass dominate the nearshore vegetation (WDNR 2001).

The abundant sediment source at White Rock Cove is alongshore. Patches of fucus, barnacles, ulva, and soft brown kelp, with continuous eelgrass beds, vegetate the nearshore. A bedrock point approaching Paradise Bay is a natural feature. The remaining shoreline from Paradise Bay to Tala Point is semiprotected with the majority of the abundant sediment coming from backshore sources. Patches of barnacles, eelgrass and ulva, with some soft brown kelp toward the center section, are found along the nearshore. A brackish marsh is south of the unnamed broad point that is south of Tala Point (DNR 2001).

Surf smelt spawn in two segments along the shoreline to the north of Paradise Bay and again to the south of a broad point to the south of Tala Point. Sand lance spawn along this beach (Penttila 2000). Recent forage fish surveys have documented new surf smelt spawning along the beach immediately to the south of Tala Point. An additional surf smelt site has been documented along the northern shore of Paradise Bay (NOSC, unpublished data, 2002).

Shoreline armoring
The shoreline along White Rock Cove is 20% armored with riprap (WDNR 2001). To the north of Paradise Bay, a large house is situated close to the edge of a slumping bluff. Riprap has been placed at the toe of the bluff to halt the erosion/slumping process and to protect the elaborate stairway system and eventually the house (Ecology 2001; TAG 2002). A high bluff at the head of the drift cell at Tala Point is armored at the toe, which prevents sediment input into the marine environment at this point (Ecology 2001; TAG 2002)

Overwater Structures
There are no overwater structures within this segment.

Ramps
A steep boat launch ramp extends into the intertidal zone at Paradise Bay.

Stormwater/Wastewater
There are stormwater runoff issues associated with the rural community of Paradise Bay.

Landfill
Riprap/fill encroaches onto the intertidal zone in Paradise Bay but may not be needed for bank protection due to the location in the drift cell (TAG 2002). To the north of Paradise Bay, a riprap bulkhead with associated fill and road leading to it encroaches on the intertidal zone and interrupts drift.

Riparian Loss
Much of the riparian zone in White Rock Cove has been cleared for views. The riparian zone between White Rock Cove and Paradise Bay is denser with overhanging vegetation and downed trees forming drift logs. Houses in the vicinity of Paradise bay are a good example of houses set back from the shoreline/bluff with the overhanging riparian zone in tact. To the north of Paradise Bay riparian zones have again been eliminated for views. View clearing eliminates large wood recruitment on eroding bluffs and allows seepage through sandy soils.

Ludlow Bay to Basalt Point

Drift Cell and Biota Background
Two drift cells and one area of no appreciable net shore drift constitute this segment. The first net shore drift originates on the west side of Tala Point and goes southwestward for 3.4 km into Port Ludlow harbor, terminating in southern Port Ludlow. Tala Point is a

mostly non-vegetated, erosional headland that is composed of sandy glacial drift and shows evidence of a recent slide. The TAG (2002) notes that Tala Point itself is a good feeder bluff. The point is fronted by a narrow, coarse-graveled beach with large boulders in the nearshore area. Southwestward net shore drift is indicated by an increase in southwestward beach width and bluff vegetation and a decrease in sediment size. The beach sediment grades into mud at the broad intertidal zone in southern Port Ludlow harbor. The cell terminates at the eastern side of the small-unnamed peninsula south of the marina (Johannessen 1992).

No appreciable net shore drift occurs within Port Ludlow harbor, the southern shore of which is composed of basalt. Although sand beach occurs over parts of the harbor, low wave energy and substantial human modification preclude net shore drift from occurring (Johannessen 1992). The outlet of Ludlow Lagoon Creek and Ludlow Creek provide abundant fluvial sediments. Patches of eelgrass and ulva are found at this southern end of the bay (WDNR 2001). The southern shoreline was filled by mill spoils from the late 1800s (TAG 2002).

Ludlow Lagoon is a historic open water lagoon that has aggraded and become a salt marsh behind a spit that has been developed along the shoreline (TAG 2002). The salt marsh itself has been partially filled but not developed. A culvert near the mouth of Ludlow Lagoon Creek draining the golf course restricts tidal action and should be replaced with a larger culvert to restore estuary function. A second undersized culvert just upstream should also be replaced to pass all flows and debris (TAG 2002). Tidal channels and a plunge pool at the outlet of the downstream culvert provide juvenile fish habitat. Coho, cutthroat, chum and pinks have been observed utilizing this lagoon and adjacent habitats (Ron Hirschi, personal communication, 2002).

Ludlow Creek estuary is truncated by a culvert at Paradise Bay Road and some members of the TAG feel it should be replaced with a bridge to restore the tidal prism. Juvenile coho and cutthroat are found in the existing wetland with deep tidal channels that have formed by the road fill. Photographs taken in the 1800s of the head of the bay indicate less diverse tidal channel on mudflat without the marsh boundary (Ron Hirschi, personal communication, 2002).

The second cell originates immediately south of the Mats Mats quarry barge harbor, immediately south of Basalt Point, and has net shore drift to the south for 4.2 km to the marina in Port Ludlow. An erosional bluff at the origin of the cell serves as the sediment source. Southward net shore drift is indicated by sediment accumulations on the north side of rock outcrops located west of Colvos Rocks, an increase in beach width toward the south, and a decrease in sediment size. Net shore drift continues to an accretionary, sandy beach at the southern end of an artificially enlarged point that defends the marina, located south of the village of Port Ludlow. Net shore drift terminates at a concrete structure on the southwest corner of this point (Johannessen 1992). Both sand lance and surf smelt spawn along the nearshore beach immediately north of the harbor mouth (Penttila 2000). Recent forage fish surveys have documented positive surf smelt and sand lance spawning along the north shore of Port Ludlow Bay as well as along the beaches south of Basalt Rock (NOSC, unpublished data, 2002).

Shoreline Armoring
There is significant shoreline armoring above the ordinary high water mark between Tala Point and Ludlow Lagoon. Trees have been removed for views in moderately high bank areas and the toe has been protected with various forms of armoring. There are sporadic but numerous bulkheads at the toe of medium high bluffs between Ludlow Bay and Basalt Point (Ecology 2001).

Overwater Structures
There are eight private piers and docks along the southeastern and southern shore of Ludlow Bay. Port Ludlow Marina is a large marina with nine piers and over two hundred slips (DNR 2001).

Stormwater/Wastewater
Stormwater is an issue in Ludlow Bay. A pond associated with the Ludlow Bay development appears to be part of a stormwater treatment facility but the certainty of its purpose is in question. Associated wastewater problems, such as low dissolved oxygen, has become an issue for the marina. Creosoted pilings are found in Ludlow Bay and should be removed, along with the associated sediments that contain creosote contaminants (TAG 2002).

Landfill
Between Tala Point and Ludlow Lagoon, two separate houses are built on fill that extends over the intertidal zone. Ludlow Lagoon has been partially filled and should be restored to historic configuration. Fill associated with the Paradise Bay Road truncates estuary function of Ludlow Creek. 1855 photographs depicting the Pope and Talbot mill site indicate that a large amount of fill has been placed in the intertidal zone in comparison with the original sawmill. This filled area serves as protection for the marina

Riparian Loss
Trees have been removed for views between Tala Point and Ludlow Lagoon in moderately high bank areas. Very little riparian vegetation exists along the shoreline between Ludlow Bay and Basalt Point. However, there is some active sediment recruitment with fallen trees in one segment north of the Ludlow development (Ecology 2001)

Mats Mats to Olele Point

Drift Cell and Biota Background
No appreciable net shore drift occurs between the Mats Mats quarry barge harbor and Olele Point where the coast is comprised of basalt. The only sediment present along this reach is found in small, isolated beaches enclosed by rocky points. No appreciable net

shore drift occurs within Mats Mats Bay, as there is little wave energy (Johannessen 1992).

Mats Mats Bay is a popular cutthroat fishing site. A small stream entering the bay from the south has an unstable lower watershed. A perched culvert at the mouth limits estuary function. The stream is incised below the culvert and aggraded above the culvert (Ted Labbe, personal communication, 2002). An unnamed tributary to the south of Piddling Creek has been highly modified at the mouth. The original distribution of tidal channels is unknown. This stream, along with Piddling Creek to the north, once formed a wetland complex in the lower watershed (Ted Labbe, personal communication, 2002).

The area north of Mats Mats Bay has experienced very little impact from human development (TAG 2002). Colvos Rocks is a seal haul out/pupping area (WDFW 2002).

Shoreline Armoring
Extensive armoring throughout Mats Mats Bay is evident from viewing Ecology's 2001 oblique shoreline photos (TAG 2002).

Overwater Structures
There are three docks to the north of Piddling Creek (WDNR 2001).

Ramps
There is one public boat launch along the southern shore of Mats Mats Bay that filled a historic salt marsh (TAG 2002). Two private boat ramps are between Mats Mats Bay and Olele Point (WDNR 2001).

Stormwater/Wastewater
Water quality issues are unknown.

Landfill
The historic configuration of the Mats Mats quarry shipping harbor is unknown. It would be good to determine if the site involved fill to create sides to protect the harbor. Shallow water habitat for juvenile migration has been eliminated (TAG 2002). A bulkhead and associated fill along the south shore of Mats Mats Bay encroaches onto the intertidal zone (WDNR 2001).

Riparian Loss
Riparian habitat is lacking in Mats Mats Bay. A small buffer extending approximately 275 feet along the southwest shore is still intact. Another small buffer, approximately 700 feet in length is to the north of Piddling Creek (DNR 2001).

Olele Point to Portage Canal

Drift Cell and Biota Background
Four drift cells extend from Olele Point to Portage Canal. The first, an eastward net shore drift originating immediately east of the erosional headland located 1.0 km west of

Olele Point, continues for 0.8 km to the west side of rocky Olele Point. The headland at the cell origin is a zone of drift divergence. The next drift cell is fronted by a narrow gravel beach. A relatively wide, sandy beach is located at the terminus of the cell. Eastward net shore drift is indicated by an increase in eastward beach width and bluff vegetation as well as a decrease in sediment size (Johannessen 1992). Sand lance spawn on this beach where this drift cell meets the next drift cell (Penttila 2000). Continuous eelgrass beds and patches of ulva are found along the nearshore (WDNR 2001).

The next very short 300-meter drift cell originates at the small, poorly vegetated headland comprised of glacial drift that is located 1.0 km west of Olele Point. The scarcity of vegetation and steep slope of the headland suggest that it is eroding and providing sediment to the shore drift system. A narrow beach consisting of boulders and cobbles fronts the small headland. Southwestward net shore drift is evidenced by an increase in southwestward bluff vegetation and beach width as well as a decrease in sediment size (Johannessen 1992).

The next cell originates at the southern end of the zone of drift divergence in common with the above described drift cell and has southeastward net shore drift, terminating 1.3 km west of Olele Point. This cell represents a 1.1 km-long, local drift direction reversal, in contrast to generally northward net shore drift within Oak Bay. Local drift reversal results from the protection that Olele Point offers from the southerly winds that cause northward net shore drift in most sectors of the Hood Canal. Southeastward net shore drift is evidenced by southeastward bluff vegetation and beach width increase, and southeastward sediment size decrease. Net shore drift sediment is deposited at the cell terminus, an accretionary sandy beach with multiple pebble and cobble beach ridges located along the concave shore reach west of Olele Point (Johannessen 1992).

The final drift cell in this segment originates in a broad zone of drift divergence in southern Oak Bay and has northward net shore drift terminating at the northern end of Oak Bay. A small volume of sediment is transported in this cell. Northward net shore drift is indicated by an increase in northward bluff vegetation and beach width and a decrease in sediment size from coarse gravel to fine gravel and sand. Northward net shore drift is also indicated by the northeastward progradation of a 0.8 km-long bayhead spit in northern Oak Bay, which has been anchored with riprap. The cell terminus is located against the western side of two riprap jetties stabilizing the Portage Canal (Johannessen 1992).

Sand lance spawn at the head of Oak Bay in front of Oak Bay County Park (Penttila 2001). A new surf smelt spawning site has been documented midway along the western shore of Oak Bay (NOSC, unpublished data, 2002). Continuous eelgrass beds and ulva with patches of fucus and red algae line the nearshore (WDNR 2001).

The head of Oak Bay has been modified intensively. Historically, the sand beach connected the mainland with Indian Island. Behind the sand beach was a salt marsh and extensive mud flat extending northward into Port Townsend Bay. There was a possible small portage site somewhere in the middle of this beach. In 1908, the US Army Corps of Engineers dredged a deep-water channel and placed extensive armoring through the mudflat to connect Oak Bay with Port Townsend Bay. This filled much of the salt marsh and resulted in the extension of two jetties into Oak Bay. Little Goose Creek historically entered the mudflat, but has been rerouted to enter directly into Oak Bay. The original salt marsh behind the beach berm is gone, as is the extensive mud flat. In its place is a new salcornia salt marsh with open salt water. The outlet to this lagoon runs along the jetty into Oak Bay, with some seepage through the jetty. Moving Little Goose Creek back to its historic channel would help keep this channel open along the jetty and provide consistently available high quality habitat for juvenile salmonid use. The jetty should also be sealed to eliminate seepage and fish entrainment and five acres of fill removed to increase bypass stability (TAG 2002).

Shoreline Armoring
A concrete bulkhead is to the west of Olele Point. There is a lot of armoring in Oak Bay but most is above the ordinary high water line without encroachment into the intertidal zone (Todd, unpublished data 2002). The shoreline in front of Oak Bay Park has been 100 percent modified (TAG 2002).

Overwater Structures
There are docks and stairs in the short drift cell to the west of Olele Point. An elaborate stairway with a platform is further up Oak Bay (Ecology 2001).

Ramps
There are four ramps to the West of Olele Point (DNR 2001) and one to the northwest that is accessible during high tides only (Ecology 2001).

Stormwater/Wastewater
Creosoted pilings and their associated contaminated substrate in the northern half of western Oak Bay should be removed.

Landfill
A 4.5 acre salt marsh has been lost to fill by two culverted roads that interrupt tidal flow. The culverts should be replaced with bridges to connect tidal channels to allow more tidal flow for more fish use (Ecology 2001). (See the above discussion regarding the development of the Portage Canal at the head of Oak Bay.)

Riparian Loss
Approximately 70 percent of the riparian area has been removed to the west of Olele Point (WDNR 2001). The riparian zone along the west shore of Oak Bay has been fragmented with development and the removal of trees for views (Ecology 2001).

Data Needs

- Quantify riparian loss along the southern shore of Squamish Harbor
- Monitor the county park and its boat ramp with riprap groin. The beach is coarsening and sand lance spawned here historically.
- Determine stormwater effects from Shine Road and Southpoint Road

- Determine effectiveness of pond at Port Ludlow Resort for treating stormwater.
- Determine historic configuration of Mats Mats quarry shipping harbor.

Action Recommendations

- Identify bulkheads along the southern shore of Squamish Harbor imposing onto the intertidal zone and replace with soft armoring above the high water line.
- Replace three culverts along South Point Road with a bridge to restore natural estuary function associated with Shine Creek. An increase in tidal exchange will eventually restore the historic salt marsh habitat and allow the free exchange of large woody debris.
- Remove jetty along the northern shoreline of Squamish Harbor
- Protect freshwater input into Squamish Harbor along the northern shoreline.
- Reconstruct the western bridge abutment (Hood Canal floating bridge) to mitigate for the loss of shallow water habitat and loss of sediment along shore drift.
- Move the parking lot and road at the county park immediately to the north of the Hood Canal floating bridge to allow saltwater access to the marsh behind the berm.
- Restore Ludlow Lagoon to its historic configuration by reestablishing some open water features and restoring lost salt marsh.

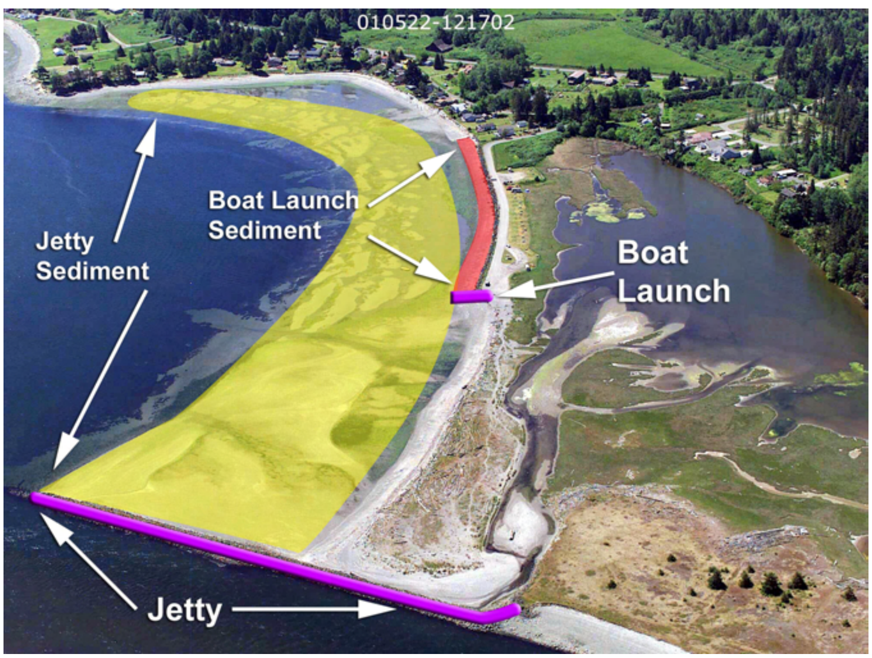

Figure 83. Oak Bay. Graphics provided by Randy Johnson, WDFW

- Replace two culverts on Ludlow Lagoon Creek to pass all flows, including tidal exchange.
- Replace Ludlow Creek/estuary culvert at Paradise Bay Road with a bridge.
- Remove creosote pilings in Ludlow Bay.
- Revegetate the segment between Ludlow Bay and Basalt Point.

- Replace culverts in small stream/historic salt marsh to the west of Olele Point with bridges to increase marine connection to tide channels, restore ecosystem function and reestablish salt marsh habitat.
- Remove creosoted pilings in Oak Bay
- Improve fish habitat in the lagoon at the head of Oak Bay
    - Put Little Goose Creek back into its historic channel to provide bypass stability and access to high quality rearing habitat for juvenile salmonids
    - Seal the jetty to eliminate seepage
    - Improve the tidal prism to keep the bypass open
    - Remove five acres of fill along the channel to get increased tidal action and increase bypass stability

PORTAGE CANAL TO MCCURDY POINT

This nearshore segment covers Indian Island, Marrowstone Island, Port Townsend Bay, and north Quimper Peninsula to McCurdy Point. Complete drift cell descriptions from Washington Department of Ecology (Ecology) are not available for this segment. Instead, drift cell direction and minimal descriptions are available from US Geologic Survey (USGS) mapping compiled between 1979 and 1982 and published in 1988. Washington Department of Natural Resources' Shorezone Inventory (WDNR 2001) provided biota background. The TAG observed Ecology's oblique photos from the year 2001 to further understand habitat impacts to nearshore processes and their effects on salmon migration, feeding and rearing.

Portage Canal to Kinney Point

Drift Cell and Biota Background

A single drift cell for this segment originates at Kinney Point from a point of divergence with a northwestward direction along the southwest shore of Marrowstone Island, extends along the south side of the spit that defines the southern tip of Scow Bay and continues along the southwest side of Indian Island, terminating at a point of convergence at Oak Bay (USGS 1988). The abundant sediment source is alongshore and is considered semi-protected (WDNR 2001). The drift cell begins with a zone of relatively slow wave erosion where relatively frequent but small landslides are common and, moving toward the northwest, fluctuates between a depositional beach and an approximately neutral coastal segment with little or no net erosion or deposition (USGS 1988). The terminus at Oak Bay is a depositional beach.

Along the shoreline of northeastern Oak Bay is an intact salt marsh with beach grass and an open water lagoon. Scow Bay, historically connected to Oak Bay through two southwestward channels, has been altered by a road/causeway with an undersized culvert that eliminates tidal action and creates a stagnant situation at the southern end of Scow Bay. Removing the fill and replacing the culvert with a bridge would improve fish passage and water quality. This would benefit both Puget Sound and Hood Canal stocks (TAG 2002).

Shoreline Armoring

The Jefferson County park along the southeast shore of Indian Island has a bulkhead that protects the parking lot fill. A bulkhead and associated fill at the Ecologic Center along the southwestern shore of Marrowstone Island intrudes onto the intertidal zone and should be removed.

Overwater Structures

No overwater structures were noted in this segment.

Stormwater/Wastewater

A state/road causeway connecting Indian Island with Marrowstone Island has filled two historic channels that historically connected Scow Bay with Oak Bay. This fill has eliminated tidal exchange to and from Scow Bay and has created a stagnant water quality problem.

Landfill
The parking lot of the Jefferson County park to the southeast of Portage Canal on Indian Island extends into the intertidal zone. A state road/causeway connecting Indian Island with Marrowstone Island has filled two historic channels that historically connected Scow Bay with Oak Bay. A bulkhead and associated fill at the Ecologic Center along the southwestern shore intrudes onto the intertidal zone and should be removed.

East and North Marrowstone Island

Drift Cell and Biota Background
Southeast Marrowstone Island drift is a divergent zone between Kinney Point and Liplip Point. Frequent but small landslides along the high steep cliff are common due to the low wave impact along this shoreline with the area at each point becoming more active (USGS 1988). Along the nearshore patches of ulva, soft brown kelp, sargassum and eelgrass with continuous barnacles are found. Approximately five percent of the shoreline is forested (DNR 2001).

From Liplip Point to Marrowstone Point, the sediment drift direction is northward in a single drift cell. Feeder bluffs vary from areas of slow wave erosion where frequent but small landslides are common to areas of little or no erosion or deposition. Liplip Point itself is a low inclined cliff moving into a high steep cliff at Nodule Point. The abundant sediment sources are from the backshore between Liplip Point and Nordland. A small segment of the shoreline north of Nordland is a depositional beach with a storm ridge. Dune grass is the predominant vegetation. The sediment sources are characterized as abundant from alongshore processes. Moving northward, the backshore steepens with littoral sediment sources characterized as abundant and from the backshore. At the southern boundary of Fort Flagler, two depositional beaches with storm ridges and dune grasses are separated by a steep cliff of moderate height (USGS 1988; WDNR 2001). Patches of ulva, red algae, soft brown kelp, and sargassum are found along the shoreline with continuous to patchy areas of barnacles and eelgrass (WDNR 2001). Along the northern shore of Marrowstone Point a salt marsh with an open water brackish pond is found. This marsh apparently was not historically connected to the nearshore (TAG 2002). Sand lance spawn are known to spawn along the eastern shore of Marrowstone Point (Penttila 2001).

Two drift cells, originating from a divergent zone in the center of the northern shore of Marrowstone Island, move in opposite directions to form depositional beaches. One cell moves toward the east to form Marrowstone Point, and one moves to the west to form Long Spit. A man-made cut through Long Spit created Rat Island to the north of Indian Island. The northeast midsection is a zone of substantial wave erosion with active feeder bluffs and more neutral coastal processes to the west (USGS 1988). Patchy-to-continuous red algae, soft brown kelp, sargassum, barnacles, eelgrass and ulva are found along the shoreline (WDNR 2001). Sand lance spawn along Long Spit (Penttila 2000).

Shoreline Armoring
Along the county park, a bulkhead intrudes into the intertidal to provide for a parking lot. Moving the parking lot upland would allow removal of the bulkhead and associated fill that currently interrupts shoreline drift and eliminates shallow water habitat for juvenile salmonids. Marrowstone Point is heavily riprapped to protect the active automated lighthouse, parking lot and USGS research station. A large amount of funding has recently upgraded the facility, which is currently conducting studies on smoltification (Glenn Gately, personal communication, 2002). Moving the research facility to an upland site and removing the riprap would restore alongshore sediment drift, salt marsh habitats along the north shore, and the shallow water juvenile salmonid migration corridor. Fort Flagler State Park has taken steps to restore the marsh at Marrowstone Point as a potential refugia site (Ron Hirschi, personal communication, 2002).

Overwater Structures
A large pier within Fort Flagler and south of Marrowstone Point that is no longer in use should be removed to eliminate creosote seepage, predator perches and shoreline drift interruption (TAG 2002).

Ramps
The TAG did not note boat launch ramps within this reach.

Stormwater/Wastewater
A forested wetland to the south of Marrowstone Island drains into two sewage ponds within Fort Flagler State Park. These ponds seep out over the berm into the ponds adjacent to the beach and then empty into the open water (Ecology 2001; TAG 2002). Between forty and fifty creosoted pilings along the north and west shoreline of Fort Flagler should be removed.

Landfill
Along the county park within this eastern shoreline, a bulkhead intrudes into the intertidal to make space for a parking lot. Moving the parking lot upland would allow removal of the bulkhead and associated full that currently interrupts shoreline drift and eliminates shallow water habitat for juvenile salmonids. A large parking lot and camping area associated with Fort Flagler fills approximately 282 acres of historic salt marsh.

Riparian Loss
Houses along the southern and midshore section have removed much of the riparian zone for views, eliminating riparian connectivity, large woody debris recruitment and wildlife corridors. The northern part of this shoreline is more pristine without development and with an intact forested wetland (Ecology 2001; TAG 2002).

Kilisut Harbor

Drift Cell and Biota Background

Along the eastern shoreline of Kilisut Harbor and the western shore of Marrowstone Island, between Long Spit and Scow Bay, and including Mystery Bay, four drift cells are found. The northernmost drift cell originates in a zone of divergence approximately 3.5 kilometers south of Long Spit, moving in a northern direction and contributing to the formation of Long Spit. The majority of the drift cell is within a zone of low wave erosion with two depositional beaches, one in the middle of the drift cell and the other at the terminus at Long Spit (USGS 1988). The abundant sediment source alternates between alongshore and steep eroding bluffs along the backshore (DNR 2001). The zone of divergence at the cell origin, locally known as Sand Point, is a brackish marsh indicated by the presence of pickleweed (*salcorinia*). Alongshore, patches of ulva, soft brown kelp and continuous eelgrass are found (WDNR 2001). Continuous eelgrass beds provide the necessary substrate for herring spawn (Penttila 2000). Clams are found throughout Kilisut Harbor and geoduck tracts are found both inside and outside of the mouth of the harbor (WDNR 2001). Juvenile and adult salmon have been observed in Kilisut Harbor and cutthroat fishing has been known to be very good at Griffiths Point (Ray Lowry, personal communication, 2002).

Two drift cells terminate at the end of Mystery Bay. One originates at the zone of divergence near Sand Point and moves southward to the tip of Mystery Bay. The second originates at a zone of divergence along the steep, moderately high cliff along the southern shore at the mouth and continuing along the western shore of the bay to the terminus (USGS 1988), which is a mudflat (WDNR 2001). The sediment sources are primarily alongshore and are characterized as abundant with some fluvial influence at the end of the bay (WDNR 2001). A saltwater lagoon associated with a high salt marsh along the northern shore of the mouth of Mystery Bay is similar in configuration and size to the historic mapping of 1883 (TAG 2002). An intact salt marsh associated with Mystery Bay State Park has become inundated with exotic species (TAG 2002). Sand lance spawn along this northern shore and continuous eelgrass beds are found throughout Mystery Bay and Killisut Harbor which provide the necessary substrate for spawning (Penttila 2000). Patches of oysters, barnacles, ulva and red algae are found along the shore (WDNR 2001).

The fourth drift cell associated with east Kilisut Harbor originates at the point of divergence to the west of the mouth of Mystery Bay and terminates at a tide flat with tidal channels and tide pools at the end of Scow Bay (USGS 1988; WDNR 2001). The shoreline is predominantly a zone of relatively slow wave erosion with a depositional beach in the center of the cell and also at the terminus (USGS 1988). The sediment sources are predominantly backshore and characterized as moderate-to-abundant with the alongshore drift terminating at the end of Scow Bay (WDNR 2001). Surf smelt and sand lance spawn along this shoreline (Penttila 2000). Oysters are found in Scow Bay, as is evidenced by a small aquaculture operation (TAG 2002).

Two drift cells are found along the western shore of Kilisut Harbor. They both originate at a point of divergence along the central shoreline. One moves southward, terminating in Scow Bay and the other moves northward terminating at a depositional point at the northeast corner of Indian Island. The shoreline varies between a zone of relatively slow wave erosion to neutral zones of little erosion/deposition. Five depositional beaches are found in this segment (USGS 1988). A high marsh with an open lagoon at Bishop Point has not been altered and the two salt marshes to the north are also still intact (TAG 2002). The sediment sources are predominately alongshore and characterized as moderate-to-abundant. Patches of oysters, red algae, ulva, fucus and continuous barnacles are also found along the shoreline (WDNR 2001). Sand lance spawn along the entire shoreline with surf smelt spawning along the southern shoreline and in pockets along the northern shoreline of East Indian Island (Penttila 2000; NOSC 2002).

Shoreline Armoring
Approximately fifty percent of the shoreline in Mystery Bay has been altered with riprap (WDNR 2001). A bulkhead immediately to the north of the bay protects houses above a feeder bluff where the riparian area has been removed for views. A rock and log bulkhead along the northwestern shore of Indian Island protects a toxic capped and vented landfill.

Overwater Structures
A pier with six boat slips is associated with Fort Flagler (WDNR 2001). One large pier with 16 small slips and two docks with 10 small slips are located in Mystery Bay. The dock associated with an oyster farm is within a historic salt marsh. One large dock with a float is along the southeast shoreline of Kilisut harbor. In addition, a house extends over the beach on creosoted pilings.

Ramps
There are two boat launches associated with Fort Flagler (WDNR 2001; TAG 2002). There are eleven boat launches within Mystery Bay (TAG 2002). A long boat ramp is found along the southeastern shore of Kilisut Harbor (TAG 2002).

Stormwater/Wastewater
Over one hundred creosoted pilings associated with Mystery Bay State Park should be removed. A toxic capped and vented landfill is found along the northwestern side of Indian Island. This is protected by rock and anchored log bulkheading.

Landfill
Approximately thirty to forty percent of the historic salt marsh along a small cove to the south of Fort Flagler has been filled. The historic saltmarsh was approximately 5.2 acres in size but has been reduced to approximately 2.7 acres (TAG 2002). A structure sits on the beach. The TAG recommends purchase of this property in order to remove the fill and restore the salt marsh and tidal channel. An access road at the southwest end of Mystery Bay blocks tidal exchange to that salt marsh south of the road. This should be removed. A concrete boat bulkhead and associated fill along the southeastern shore of Kilisut Harbor intrudes into the intertidal zone (TAG 2002).

Riparian Loss
Riparian connectivity is good within the majority of Fort Flagler State Park but a large clearcut to the south and gradual removal of trees for views have reduced riparian habitat along this shoreline. The riparian zone along the east side of Indian Island is still in tact.

East Port Townsend Bay/North and West Indian Island

Drift Cell and Biota Background
Two drift cells originate in the zone of divergence in the center of the northwestern coastline of Indian Island with one terminus at a depositional beach at the northeastern point of the island and the other terminus at the depositional beach toward the southwest at Walan Point. The cell origin is backed by a high feeder bluff with substantial wave erosion (USGS 1988) and abundant alongshore drift (DNR 2001). A high salt marsh with an open lagoon along the northeast shoreline is still intact with pickleweed (*salcornia*), dune grasses and oysters. Patches of red algae, soft brown kelp and continuous barnacles and eelgrass are also found along the shoreline. A high salt marsh along the northern shore of Walan Point, along with the tidal flat associate with the tidal channel is also still intact (WDNR 2001). Surf smelt and sand lance are known to spawn along Walan Point (Penttila 2000).

Two drift cells along the western shoreline of Indian Island originate in a zone of divergence approximately one kilometer to the south of Walan Point. One short drift cell moves northwestward along a zone of relatively slow wave erosion (USGS 1988) with abundant alongshore drift (DNR 2001). The other extends southward along the remaining shoreline of Eastern Indian Island to Portage Canal (USGS 1988). Sand lance spawn in patches along this segment (Penttila 2000). Continuous barnacles, ulva and eelgrass are found along the shoreline along with patches of oysters (DNR 2001).

Shoreline Armoring
Bulkheading extends along the parking lot and storage area to the north of Crane Point.

Overwater Structures
A pier with three large slips at Walan Point is part of the Indian Island military facility (WDNR 2001). Two piers with two large slips are to the north of Crane Point and are also part of the naval operations.

Ramps
Two boat launches are north of Crane Point.

Landfill
Approximately 3.1 acres of salt marsh and 2.5 acres of intertidal lagoon have been entirely eliminated by the parking lot and storage area at Crane Point (PNPTC 2002; TAG 2002).

Riparian Loss
Riparian areas are, for the most part, still intact along this reach.

Portage Canal to Kala Point

Drift Cell and Biota Background
One drift cells runs from northeast to southwest along the southern shore of Port Townsend Bay. The cell origin at Portage Canal begins with a zone of slow wave erosion and ends at a depositional beach (USGS 1988). Sediments at the mouth of Portage Canal are scarce but alongshore sediments become abundant moving toward the west (WDNR 2001). A small seasonal stream enters into a large tidally accessible lagoon inside a spit with patches of dune grasses, ulva, red algae, eelgrass and clams. This historically complex area sits behind Skunk Island to the west of the Port Hadlock Inn and Marina (TAG 2002).

Two drift cells are between Skunk Island and Chimacum Creek, originating in a zone of divergence with relatively slow wave erosion approximately one kilometer south of the mouth of Chimacum Creek. One cell moves toward the southeast, terminating along the depositional spit behind Skunk Island. The other terminates within the depositional beach of Chimacum estuary (USGS 1988). Sediment sources vary between backshore, alongshore and fluvial sources at Chimacum Creek. The sediment sources are characterized as abundant. Ulva and eelgrass are found along the shoreline (DNR 2001). Surf smelt are known to spawn in a small segment to the north of Port Hadlock and sand lance spawn from the spit behind Skunk Island to north of Port Hadlock and again along the marine shoreline south of Chimacum Creek (Penttila 2000).

Two drift cells are found between Chimacum Creek and Kala Point, originating from a zone of relatively slow wave erosion approximately 0.5 kilometers to the north of the mouth of Chimacum Creek. One cell moves southwesterly toward Chimacum Creek estuary and the second cell moves northeasterly terminating at the depositional beach (Kuhn Spit), salt marsh and lagoon at Kala Point (USGS 1988). The abundant sediment source is predominantly alongshore with ulva and eelgrass found along the nearshore (WDNR 2001). Sand lance are known to spawn along the southern and northern shoreline of Kala Point (Penttila 2000).

Shoreline Armoring
Approximately seventy percent of the shoreline along Port Hadlock has been armored (WDNR 2001). Riprap, combined with a cement bulkhead and associated fill, intrude onto the intertidal as protection for a house and picnic area located to the north of Port Hadlock (TAG 2002). The shoreline along the nearshore to the south of Chimacum Creek has been armored and filled, but a restoration plan has been funded by the Salmon Recovery Funding Board to remove the riprap and fill to restore the nearshore.

Overwater Structures
A large marina with over 100 boat slips at the Port Hadlock Inn and Marina is fronted to the north by a large breakwater consisting of a metal waveboard for protection from

northerly winds. Four docks with ten small slips are also found along the Port Hadlock shoreline (WDNR 2001).

Figure 84. Chimacum Creek Nearshore, Existing. Photo provided by Randy Johnson, WDFW

Figure 85. Chimacum Creek Nearshore, After Proposed Restoration. Graphic provided by Randy Johnson, WDFW

Ramps

The county ramp at Port Hadlock collects sand, which has been a maintenance problem for the Port of Port Townsend. The ramp intercepts sand and accumulates sediments that could reduce forage fish spawning habitat by blocking the deposition of sand to the adjacent forage fish spawning beach (TAG 2002).

Stormwater/Wastewater

The Port Hadlock Inn and Marina allows for live-aboard vessels which could pose associated wastewater risks to water quality. Creosoted pilings in front of Port Hadlock should be removed (TAG 2002).

Landfill

A narrow salt marsh, approximately 0.6 acres in area, extended landward adjacent to the shoreline on the other side of the spit behind Skunk Island, but has been filled/replaced by lower Port Hadlock. A large amount of fill has been placed into the intertidal for a home site north of Port Hadlock (TAG 2002). The shoreline along the nearshore to the south of Chimacum Creek has been armored and filled as part of a log storage operation, but a restoration plan has been funded by the Salmon Recovery Funding Board to remove the riprap and fill to restore the nearshore. The property is now in public ownership. A county park is planned immediately south of the proposed fill removal.

Riparian Loss

The riparian zone is intact throughout the undeveloped areas. However, much of lower Port Hadlock has been converted to light industrial land use. In addition, trees have been removed to enhance home site water views.

Kala Point to Point Hudson

Drift Cell and Biota Background

Two drift cells define the shoreline between Kala Point and Point Hudson. Originating within a zone of divergence and relatively slow wave erosion approximately two kilometers north of Kala Point at Old Fort Townsend, one drift cell moves southeast to the depositional beach at Kala Point. The second cell moves toward the northwest and then turns toward the northeast at Glen Cove terminating at a depositional beach at Point Hudson (USGS 1988). Sediment sources vary between backshore along the high steep cliffs from Kala Point to Glen Cove and alongshore. The shoreline adjacent to the Larry Scott Trail, now on the abandoned railroad bed between the paper mill and the Boat Haven, is completely riprapped with the bluffs isolated from the intertidal by the trail and riprap (WDNR 2001). Sediment abundance is characterized as high. Ulva and eelgrass dominate the nearshore (WDNR 2001). Surf smelt and sand lance spawn to the south of Old Fort Townsend State Park. Sand lance are known to spawn on either side of Boat Haven Marina (Penttila 2000). Herring spawn between Kala Point and Glen Cove and geoduck are found along the same shoreline (WDNR 2001).

The shoreline between Glen Cove and Point Hudson is heavily modified by the paper mill site and associated structures, an abandoned railroad grade that has been converted to a public trail, two marinas, and various bulkheads and overwater structures located intermittently along the City of Port Townsend waterfront. Kah Tai Lagoon is shown on historic maps as a freshwater marsh with a grass lined beach berm on the south side. It is difficult to determine or affirm, if any, the level of historic connection between the marsh and the nearshore. A major portion of the historic marsh has been filled to make space for the Boat Haven shipyard and businesses along that stretch of Sims Way. A tide gate now connects the lagoon with marine waters in the Boat Haven. This connection maintains a brackish salinity level in the lagoon. Efforts to protect Kah Tai Lagoon from development are ongoing. Three short beaches, the Tyler Street beach, the Adams Street Park and Pope Marine Park are the only areas along the south shore of Port Townsend that are not completely armored. Boats anchoring close to the downtown shoreline tend to disrupt the substrate and negatively impact the eelgrass beds. Properly designed and installed mooring buoys outside the eelgrass zone and the establishment of a "no-anchorage" zone in the eelgrass zone could eliminate these effects (TAG 2002). Point Hudson was historically a lagoon but the historic connection to the nearshore has not been determined. It has been partially filled as part of the Point Hudson complex and is dredged for the marina.

Shoreline Armoring
Riprap and fill associated with an abandoned railroad grade eliminates backshore sediment input to the nearshore environment. Almost the entire southern shoreline of Port Townsend is armored, with most structures intruding into the intertidal zone. Only three small beaches, one at the end of Tyler Street, one adjacent to the Adams Street Park, and one adjacent to the Pope Marine Park allow full tidal access to the natural high water line. A concrete art sculpture, the Tidal Clock, between Quincy Street and the City Dock limit tidal movement and block fish passage into what could have been a protected embayment. A concrete seawall is still in place at the Old Thomas Oil site and adjacent to the salmon club boat launch. The entire shoreline associated with Point Hudson marina is armored.

Overwater Structures
Twenty-seven creosoted pilings in the vicinity of Old Fort Townsend State Park should be removed. The Port Townsend paper mill, built on pilings and fill, extends over the intertidal area and eliminates shallow water habitat for juvenile summer chum migration. An abandoned railroad trestle built on creosoted pilings should be removed. Boat Haven marina blocks sediment transport due to the jetty and also eliminates shallow water habitat for juvenile salmon migration. There are additional creosoted pilings along the shoreline of the City shoreline that should also be removed. Not only is the creosote a water quality problem of unknown consequences to salmonids, but the pilings serve as man-made perches for predators, such as cormorants and osprey. The Surf restaurant is built on fill and pilings, eliminating shallow water habitat for juvenile salmon migration. The old ferry terminal is no longer in use and the wave gallery has limited use. These structures consist of creosoted pilings, are associated with breakwaters that limit the intertidal and shallow migration area of juvenile salmon and should be removed.

Ramps
A large boat ramp is associated with the Boat Haven marina and is located in the marina. The salmon club launch is gravel-covered and is located along the south shore of Port Townsend to the west of Point Hudson. These ramps have little effect on the juvenile salmon migration corridor.

Stormwater/Wastewater
Twenty-seven creosoted pilings in the vicinity of Old Fort Townsend State Park should be removed. Boat Haven marina allows for live aboard vessels and has a gas dock which can pose water quality problems during tourist seasons due to discharges and fuel spills. Fecal coliform levels have been found to be high in the Port Townsend Boat Haven and

the Point Hudson Marina during levels of high tourist traffic (Barb Nightingale, personal communication, 2002). Numerous unused creosoted pilings along the shoreline of the City of Port Townsend should be removed. Although the extent of risk is unknown, the creosote poses potential water quality risks to salmonids and the pilings serve as perches for predators, such as cormorants and osprey.

Two existing ponds of unknown water quality associated with Port Townsend paper mill are used for wastewater treatment and discharged offshore. There could be a dioxin problem associated with the paper mill due to the hog fuel burner used in the papermaking process (TAG 2002). An abandoned railroad trestle built on creosoted pilings should be removed. Recent restoration of the shoreline along the abandoned oil storage facility to the west of Point Hudson has removed toxic marine sediments as part of the future Northwest Maritime Heritage Center. All stormwater outfalls along the south shore of Port Townsend should be treated. When repairing the jetty at Point Hudson, creosoted pilings within the jetty should be replaced with non-creosoted pilings.

Landfill

A picnic area at Old Fort Townsend State Park, which intrudes into the intertidal and eliminates shallow water habitat for juvenile summer chum migration should be moved upland. Glen Cove, an area zoned for industrial and commercial development, has experienced a major loss of salt marsh and nearshore habitat due to fill associated with Port Townsend paper mill. The boat yard associated with Boat Haven marina is entirely on fill, as is the City of Port Townsend, which eliminates sediment recruitment from the steep bluffs (TAG 2002). The ferry dock fill is used as a parking lot, which reduces sediment transport and eliminates shallow water habitat for juvenile fish migration. The fill at Indian Point serves as a picnic area and could be removed. Port Townsend Plaza is built on dredge spoils removed from the adjacent nearshore. This dredging has left a large, deep hole in the eelgrass beds. Point Hudson was historically a lagoon but the historic connection to the nearshore has not been determined. It has been partially filled as part of the Point Hudson complex and is dredged for the marina. The submarine net anchor offshore is no longer in service and should be removed.

Riparian Loss

Riparian cover is intact between the Kala Point development and Glen Cove. The riparian zone between Glen Cove and Point Hudson has been converted to commercial and residential development. The shoreline is basically landfill which took place through power washing the bluffs down to fill in the intertidal at the turn of the 20th century. This landfill provided what is now downtown. It also isolated the bluffs from the intertidal and eliminated further input from a marine riparian zone.

Point Hudson to Point Wilson

Drift Cell and Biota Background

Net shore drift originates along a depositional beach at Point Hudson and continues in a northeasterly direction to a depositional beach at Point Wilson. The Fort Worden Boat Basin now effectively terminates that drift cell at the western end of the goat basin. The steep almost 200-foot bluffs along this shoreline are characterized as relatively unstable with areas of recent landslides. There is relatively slow wave erosion from the high bluffs along this shoreline (USGS 1988). The fetch along this shoreline ranges from seven to thirteen miles predominately from the east. The substrates along this shoreline are a mix of cobble and sands and gravel (WDNR 2001). Surf smelt and sand lance spawn along the northern end of this beach (Penttila 2000). A geoduck tract lies offshore of this shoreline. Most of this shoreline has been designated as priority habitat by WDFW due to the presence of purple marten, pigeon guillemots, proximity to bald eagle nests and harlequin duck and brant feeding areas. Eelgrass beds and floating kelps are the predominant vegetation along this shoreline with dunegrass found along the backshore of the Point Wilson area (WDNR 2001). Houses are built along the top of the bluffs and trees have been removed for view (Ecology 2001).

Shoreline Armoring
The shoreline in front of Chetzemoka Park has been armored with riprap and chunks of concrete aggregate. An aesthetic, unnatural creek flows over the bank of Chetzemoka Park. The area between Chetzemoka Park and Fort Worden is unarmored. Riprap and wooden pilings protect the US Coast Guard station and lighthouse at Point Wilson.

Overwater Structures
The wharf at Fort Worden is built on densely lined piles to block sediment transport in order to maintain boat basin depth. Historically, the boat basin has been periodically dredged as sediment continues to fill in the basin. The wharf should be modified to allow greater sediment transport from the drift cell to the west and provide for juvenile fish passage and continuity of the nearshore migratory corridor (TAG 2002).

Figure 86. Pier at Fort Worden. Ecology 2001 Oblique Photo

Ramps
Two concrete ramps are associated with Chetzemoka Park along this shoreline. One boat launch is adjacent to the wharf at Fort Worden and extends out into the intertidal and subtidal for 132 feet to protect the boat ramp from wind wave exposure.

Stormwater/Wastewater
An artificial creek for aesthetic purposes at Chetzemoka Park discharges chlorinated city water into the intertidal zone with unknown water impacts. There is no sewer or stormwater outfall to marine waters associated with Fort Worden. Stormwater is infiltrated into the ground, or in the case of some structures, diverted to the Chinese Garden lagoon system.

Riparian Loss
Houses are built along the top of the bluffs and trees have been removed for views, eliminating future large woody debris recruitment.

Point Wilson to McCurdy Point

Drift Cell and Biota Background
One drift cell along this north shore originates approximately three kilometers to the southwest of McCurdy Point, terminating to the northeast at a depositional beach at Point Wilson. A zone of relatively slow wave erosion dominates the shoreline with a high bluff zone of substantial erosion and landslides to the east of McCurdy Point (USGS 1988). The fetch along this shoreline ranges from 32 to 69 miles from the north and northwest. This high level of wind and wave energy causes significant erosion at Point Wilson depending on seasonal and annual conditions. The high bluffs along this shoreline reach heights close to 300 feet. These bluffs are receding at a rate of six centimeters per year and contribute 2.5 cubic yards (five cubic meters) net drift to Point Wilson per year. Point Wilson tends to migrate to the south due to the sediment transport and erosion mechanisms along this reach (TAG 2002). Surf smelt are known to spawn along the beach between Point Wilson and North Beach (Penttila 2000). Canopy-forming bull kelp *(Nereocystis)*, a WDFW priority habitat, is found along the northern shoreline (WDNR 2001). This habitat has been found to be important to migrating juvenile salmon and a wide variety of other marine animals (Anne Shaffer, personal communication, 2002).

Shoreline Armoring
Riprap is placed around the Coast Guard facility at Point Wilson in an attempt to protect it from erosion but this has been basically ineffective. In the event that the lighthouse is abandoned and no longer needed as a navigation aid, all riprap and the associated parking lots for both the lighthouse and the north side of the point should be removed to allow the spit to naturally migrate. Removal of this shoreline armoring could have a positive effect on the high erosion level observed along this shoreline. Efforts to protect this shoreline have not been successful. The shoreline armoring also includes remnants of sills once built to protect the parking lot and northern shoreline of the spit from erosion. This was not successful and remnants of the sills still exist and should be removed (TAG 2002).

Ramps
A derelict boat launch at North Beach should be removed.

Stormwater/Wastewater
A treated sewer/stormwater outfall is offshore at North Beach.

Landfill

The remains of three rock groins/sills intrude on the intertidal zone along the north side of Point Wilson and should be removed. Historically, an open water lagoon was at the beginning of Point Wilson spit but is not present today.

Riparian Loss

The riparian zone along Fort Worden State Park is intact. Residential development and pasture areas just west of North Beach on both the low and high bank areas have eliminated trees for views. McCurdy Point has an intact riparian zone with some clearing for home sites just east of the point.

Action Recommendations

- Remove the bulkhead and fill at the Jefferson County park located southeast of the Portage Canal on southeast Indian Island and move the parking lot back from the ordinary high water mark.
- Remove the causeway fill connecting Indian Island and Marrowstone Island and replace the culvert with a bridge to improve fish passage and water quality to benefit Hood Canal and Puget Sound stocks.
- Remove the bulkhead at the Ecologic Center on the southern end of Marrowstone Island that intrudes into the intertidal zone.
- Remove the bulkhead that intrudes onto the intertidal zone at the county park along east Marrowstone Island and move the parking lot inland.
- Remove the dilapidated pier associated with Fort Flagler along the eastern shore of Marrowstone Island.
- Purchase property associated with a salt marsh along a cove in northeastern Kilisut Harbor, remove the fill and restore salt marsh and tidal channel.
- Over one hundred creosoted pilings associated with Mystery Bay State Park should be removed.
- Remove the access road at the southwestern end of Mystery Bay to provide for tidal exchange to the salt marsh, which is now blocked.
- Remove creosoted pilings in front of Port Hadlock.
- Move a picnic area at Old Fort Townsend State Park, which intrudes into the intertidal, upland to provide shallow water habitat for juvenile summer chum migration.
- Remove twenty-seven creosoted pilings in the vicinity of Old Fort Townsend State Park.
- Relocate paper mill landward of ordinary high water mark if/when major renovation becomes necessary.
- Remove abandoned railroad trestle between Port Townsend paper mill and Boat Haven marina.
- Remove fill at Indian Point picnic area within the City of Port Townsend.
- Remove all unused creosoted pilings along the south shore of the City of Port Townsend

- Fill in the hole in front of Port Townsend Plaza and restore eelgrass to the location.
- Remove the old ferry terminal and associated creosoted pilings, the Tidal Clock art sculpture and the wave gallery and associated creosoted pilings, all along the south shore of the City of Port Townsend.
- Treat stormwater outfalls along the south shore of the City of Port Townsend
- Establish a “no-anchor zone” over the downtown Port Townsend shoreline eelgrass beds and place mooring buoys beyond the eelgrass beds to protect the eelgrass beds and other important aquatic vegetation from anchor damage.
- Remove submarine net anchors (one offshore in Port Townsend and one offshore of Rat Island)
- Exchange creosoted pilings in the jetty at Point Hudson with non-creosoted pilings.
- Modify wharf at Fort Worden to allow sediment transport and fish passage.
- Remove remains of three derelict sills along the north side of Point Wilson.
- Remove riprap along Point Wilson if/when the lighthouse is abandoned.
- Remove derelict boat launch at North Beach

DISCOVERY BAY

The Discovery Bay nearshore discussion begins at McCurdy Point at the north end of the Quimper Peninsula and ends at Rocky Point on the north side of Miller Peninsula and includes all of Discovery Bay and Protection Island. Complete drift cell descriptions from Washington Department of Ecology (Ecology) are not available for this segment. Instead, drift cell direction and minimal descriptions are available from US Geologic Survey (USGS) mapping compiled between 1979 and 1982 and published in 1988. Washington Department of Natural Resources' Shorezone Inventory (WDNR 2001) provided biota background. The TAG observed Ecology's oblique shoreline photos from the year 2000 to further understand habitat impacts to nearshore processes and their effects on salmon migration, feeding and rearing. Digitized historical coastal maps are not yet available for this section of WRIA 17.

Cape George

Drift Cell and Biota Background

A long drift cell originates from a zone of divergence midway between McCurdy Point and Cape George and terminates at a depositional beach at Beckett Point. Between McCurdy Point and Cape George the shoreline alternates between a zone of substantial wave erosion/erosion induced landslides and a zone of relatively slow wave erosion/frequent but small landslides (USGS 1988). The abundant sediment supply is from backshore processes (DNR 2001) that provide valuable sediments to the marine environment (TAG 2002). Some of this segment (approximately 30 acres along Middlepoint) is protected by conservation easements held by the Jefferson Land Trust that protect the feeder bluffs and the subsequent future sediment recruitment. It is unknown where these enormous sediment inputs are deposited (TAG 2002). Patches of barnacles, ulva, red algae, surf grass and canopy-forming bull kelp (*nereocystis*) are found along the shoreline (DNR 2001). A depositional area is along the south shore of Cape George at the site of a marina (USGS 1988). Patches of dune grass, ulva red algae, soft brown kelp and eelgrass are found along this shoreline (WDNR 2001).

The shoreline between Cape George and Beckett Point alternates between a zone of relatively slow wave erosion and a zone that is deposition/erosion neutral (USGS 1988). The abundant sediment source alternates between backshore and alongshore processes. Eelgrass is continuous along this shoreline, with patches of ulva and barnacles as well (WDNR 2001). Geoducks are found along the entire shoreline with the exception of the vicinity of Cape George marina (WDFW 2002).

Shoreline Armoring

Over 30 percent of the shoreline along the south shore of Cape George is armored (WDNR 2001).

Overwater Structures

A marina along the southwestern shore of Cape George has seven piers with 50 slips (WDNR 2001). The entrance is to the marina is protected along the north side by a jetty and is dredged during an extreme low tide each summer, and sometimes more often as necessary to maintain the opening. The jetty has been reduced in length from its original size (David Sullivan, personal communication, 2002). This will continue to be an issue since this section of shoreline is a depositional beach. The TAG recommends setting back the armoring and replacing existing riprap with softbank technology.

Figure 87. Cape George Marina. Ecology 2001 Oblique Photo

Ramps

There is one boat ramp within the Cape George marina that is heavily used. There is also one to the south of the marina entrance.

Stormwater/Wastewater

Stormwater runoff is an issue with the large amount of impervious surface within the development at Cape George (TAG 2002). There are a number of small storm drains along the private roads that ender directly onto the beach. There is one large stormwater conveyance down a ravine to the bay, which lacks treatment (David Sullivan, personal communication, 2002). Stormwater likely carries herbicides, pesticides and fertilizers, but the quantity is unknown (TAG 2002). The lots were platted in the early 1960s and are too small to allow for both a septic and an alternate. New construction must have new systems of better technology (David Sullivan, personal communication, 2002). Water quality issues associated with marinas, such as waste disposal for boats, gas and oil leakage, and materials used to maintain boats and motors, could also be a problem.

Landfill

The jetty protecting the entrance to the Cape George marina interrupts sediment drift, eelgrass continuity and a shallow water migration corridor for juvenile salmonids. The beach down drift of the jetty consists of a coarser beach composition with no sand or fine sediments (TAG 2002). The TAG recommends removal of the jetty. If dredging of the mouth is allowed to continue, dredge spoils should be placed down-drift of the marina to rebuild the beach (TAG 2002).

Riparian Loss
The entire riparian zone has been removed throughout the Cape George developments. Houses are precariously close to the edge of eroding bluffs along this segment (TAG 2002).

Becket Point

Drift Cell and Biota Background
Beckett Point is a depositional beach at the convergence of two drift cells. The above-mentioned drift cell originates midway between Cape George and McCurdy Point and terminates at Beckett Point. The southern drift cell originates within Adelma Beach and moves northwesterly to terminate at Beckett Point (USGS 1988). Both the northern and southern sides of Beckett Point are narrow sand and gravel beaches with abundant alongshore drift. A closed lagoon with high salt marsh is bordered on both sides by a beach with a storm ridge (WDNR 2001). This lagoon was historically open to tidal influence along the south shore (TAG 2002) but may have closed off naturally. High storm tides overtop the beach on the north side and western point as well as the south side (David Sullivan, personal communication, 2002). The salinity in the lagoon is the same as the salinity in the bay (Glenn Gately, personal communication 2002). The TAG recommends purchase of property along the south shore, enough to reestablish tidal connection.

Figure 88. Beckett Point. 2001 Ecology Nearshore Oblique Photo

South of Beckett Point the shoreline alternates between substantial wave action with highly erosional bluffs, zones of slow wave action with small landslides, and depositional beaches (USGS 1988). The abundant sediment source alternates between alongshore and backshore (WDNR 2001). A brackish lagoon to the north of Tukey cuspate foreland receives marine influence during high tides (TAG 2002). Patches of eelgrass, ulva, fucus and barnacles are found along the shoreline (WDNR 2001). Sand lance spawn between the two points of Chevy Chase and Tukey Spit (TAG 2002).

Shoreline Armoring
The northern shoreline of Beckett Point is armored with some intrusion into the intertidal to protect houses and a road. This armoring prevents backshore sediments from

contributing to the marine environment. The southern shoreline has a seawall that is placed landward of the ordinary high water mark.

Ramps
There is one boat launch ramp along the north shore of Beckett Point (DNR 2001).

Stormwater/Wastewater
Septics associated with the numerous small cabins built along the shoreline could be a problem if they start to fail (TAG 2002). At this time, the fecal coliform monitoring in shellfish from the area produced low results (Glenn Gately, personal communication, 2002).

Landfill
The northern shoreline of Beckett Point is 20 percent armored and intrudes into the intertidal.

Riparian Loss
A house to the south of Beckett Point is perched on top of an active bluff where trees have been removed for views (TAG 2002).

Adelma Beach to Salmon/Snow Creeks

Drift Cell and Biota Background
In the center of Adelma Beach is a zone of divergence with one drift cell moving toward the northwest to Beckett Point and the other moving south and then southwest to the mudflats at the head of Discovery Bay (USGS 1988). The alongshore sediment sources provide abundant sediments along Adelma Beach which has a backshore of inclined cliffs (WDNR 2001). The abundant sediments are from fluvial source at Woodman's Delta, a depositional zone to the south of Adelma Beach (USGS 1988; WDNR 2001). Abundant alongshore sediment sources continue south to the Fairmont area. Continuous eelgrass beds are found along the shoreline with patches of ulva and barnacles. Ulva becomes continuous at Fairmont with patches of dune grass, eelgrass and a salt marsh (WDNR 2001). The salt marsh at Fairmont has been impacted by human activities and a small structure along the beach which could be a tide gate (TAG 2002). The TAG recommends analyzing historic maps to determine the extent and configuration of the historic salt marsh and follow-up with restoration activity to include removing part of the railroad grade to open up the salt marsh to tidal influence and subsequently better access for fish. Sand lance and surf smelt spawn in the vicinity of north of Fairmont (Penttila 2000).

Shoreline Armoring
There is a highly armored section of Adelma Beach that potentially affects backshore sediment recruitment (TAG 2002). To the south of Adelma Beach a bulkhead protects an old railroad grade that is 7500 feet long. The TAG recommends removal of this bulkhead where it is in front of feeder bluffs and blocks sediment recruitment and where it interrupts tidal connection with historic and/or existing salt marsh habitat. The Fairmont area is 80 percent armored with approximately 20 percent fill (WDNR 2001).

Overwater Structures
Two docks with two boat slips are at Adelma Beach. There is one dock with two slips at Fairmont.

Ramps
Boat launches are unknown for this segment.

Stormwater/Wastewater
Water quality has been a problem in the past along Adelma Beach due to drainfields, particularly those associated with houses along the beach (TAG 2002). Dissolved oxygen concentrations have been low, below 3 mg/L, which might be a natural occurrence due to the stratified nature of the bay. There are also high ammonium concentrations with a tendency toward eutrophication (Glenn Gately, personal communication, 2002).

Landfill
A house constructed on the beach of Adelma Beach impacts shallow water migration, littoral drift and potential forage fish spawning (TAG 2002). An aquaculture facility to the south of Woodman's Delta extends into the intertidal area with armoring and fill. A house at Fairmont also intrudes onto the intertidal zone and has been identified in the Snow/Salmon Creek estuary acquisition for potential purchase and removal (TAG 2002). A substation has been constructed on the spit that could impact the salt marsh at that site (TAG 2002). The TAG recommends taking a vegetation core on the spit.

Riparian Loss
Only five to ten percent of the riparian zone is remaining at Adelma Beach (WDNR 2001) as many of the trees have been removed for views.

Snow/Salmon Creek Estuaries

Drift Cell and Biota Background
Snow and Salmon Creek estuaries are accretional beaches of abundant alongshore and fluvial sediment sources alternating between mudflat and sand/gravel composition (WDNR 2001). Two drift cells meet at the estuary. One originates at Adelma Beach and flows to the south and southeast along the eastern side of Discovery Bay. The other originates at a point of divergence to the north of Mill Point Spit, a deposition beach, and flows south and southwest along the western shore of Discovery Bay. The majority of the shoreline along the west side is a zone of neutral activity with no appreciable deposition or erosion (USGS 1988).

Historically, Snow Creek entered Salmon Creek above US 101 and was considered a tidal slough. The existing Snow Creek estuary is not a properly functioning estuary due to its artificial channel, dike/fill system and dissection by a railroad grade (TAG 2002). Upstream modifications to Salmon Creek, as well as the truncation of tidal channels by the railroad grade, limit its ability to perform as a properly functioning estuary. A pond at an abandoned mill site has been truncated by access road fill. This fill should be removed to provide tidal exchange to the millponds. The historic configuration is unknown. The TAG recognizes the value of the historic mapping to assess nearshore habitat loss and supports the continuation of the mapping efforts originally initiated by Port Gamble S'Klallam Tribe. This methodology was used throughout the Hood Canal portion of WRIA 17 limiting factors analysis. Surf smelt and sand lance spawn along the shoreline to the north of the abandoned mill site and herring spawn in the eelgrass beds throughout lower Discovery Bay (Penttila 2000).

Shoreline Armoring
The banks along lower Snow Creek are armored to protect dikes/levees. A concrete, riprap and wood bulkhead extends along the west side of Discovery Bay at the ordinary high water mark but protects a moderate/low bluff that could provide sediments to the marine environment if the bulkhead were not there (TAG 2002). The entire shoreline in front of Trend West, a time-share condominium to the north of the abandoned mill site, is armored.

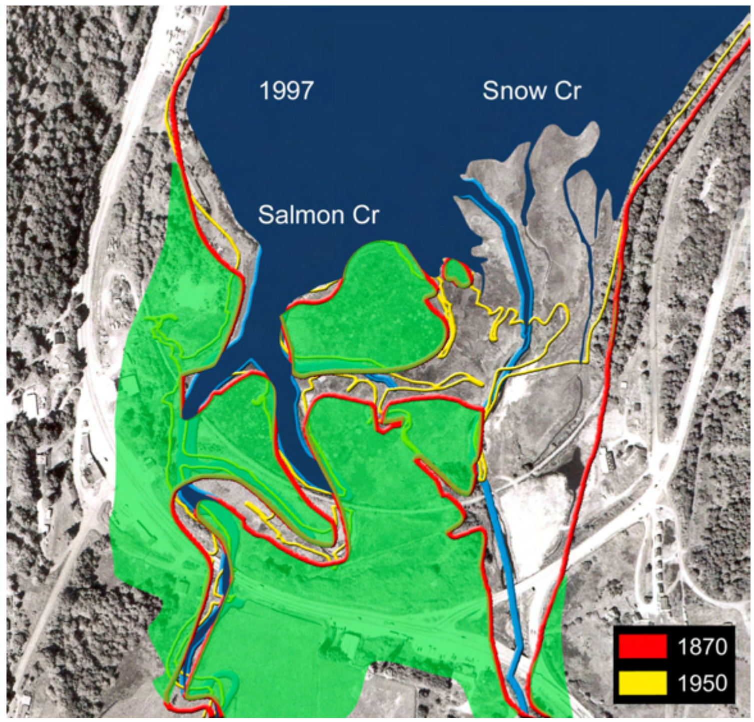

Figure 89. Salmon and Snow Estuaries with Historic Overlay. Graphic by Randy Johnson, WDFW

Overwater Structures
Existing railroad trestles crossing both Snow and Salmon Creek estuaries constrict tidal exchange and should be removed. Two large piers associated with Trend West condominiums are permanent fixtures for guests.

Ramps
There are no known boat launch ramps in this segment.

Stormwater/Wastewater
Water quality issues, particularly stormwater, have been a problem at Trend West. As mitigation, there is public access at the site but it is not advertised (TAG 2002). Creosoted pilings interrupt eelgrass continuity in this area as well (TAG 2002).

Landfill
A railroad grade crosses both estuaries which limits water circulation, displaces salt marsh habitat and disrupts the flow of nutrients. The TAG recommends removal of this

railroad grade all the way to Mill Point spit. An old pig farm to the east of the Salmon Creek estuary is placed entirely on fill and should be removed to restore salt marsh habitat. An artesian well of approximately 0.1 cfs is currently culverted to a pond and could be part of the salt marsh restoration. Dikes along Salmon Creek estuary should also be pulled back to reestablish salt marsh habitat. A pond at an abandoned mill site to the west of Salmon Creek has been truncated by access road fill. The road is no longer in use and should be removed to allow tidal exchange into the millpond. A house with a wood bulkhead intrudes into the intertidal area to the north of this site. The entire shoreline in front of Trend West, a time-share condominium to the north of the abandoned mill site, is armored and extends below the ordinary high water mark, eliminating shallow water habitat for summer chum juveniles migrating along the shoreline from Salmon and Snow Creeks.

Riparian Loss

Exotic vegetation has invaded much of the shoreline and should be removed.

Mill Point Spit to Diamond Point

Drift Cell and Biota Background

The drift cell origin is at a zone of divergence to the north of Mill Point Spit, with one moving to the south and southwest along the west side of Discovery Bay and the other moving north and northwest, terminating at Contractor's Spit (USGS 1988). The abundant sediment source alternates between backshore and alongshore (WDNR 2001), the majority of which is a zone of relatively slow wave erosion (USGS 1988). Deposition zones are at Kalset Point and Contractors Point. Eelgrass is continuous along most of the shoreline with patches of soft brown kelp, ulva and a salt marsh at Kalset Point. Oysters are found to the south of Contractor's spit and there is an aquaculture facility at Kalset Point (DNR 2001). The area between Kalset Point and Contractor's spit is pristine (TAG 2002).

Two drift cells converge at Contractors Point: one originating south of Kalset Point and terminating at Contractor's Point, and one originating to the west of Rocky Point on the Straits of Juan de Fuca and moving to the east and south around Diamond Point and terminating at Contractor's Point (USGS 1988). Contractor's Spit is a deposition zone that has been significantly modified for residential and commercial shellfish use. A 15-acre salt marsh on the spit is no longer there due to shoreline armoring and a service road adjacent to the beach. The mouth of Contractor's Creek has been moved to the south, forced through a series of undersized culverts, and no longer exits through the historic estuary/salt marsh area (TAG 2002). The TAG recommends active restoration at this site to eliminate large impacts to fish. Actions recommended include: removing the bulkheads, moving the access roads along the beach, restoring the salt marsh to its historic template and moving Contractor's Creek to its historic channel.

The area between Contractor's Point and Diamond Point is predominantly a zone of relatively slow wave erosion with a depositional beach north of the rural community of Gardiner (USGS 1988). Indicators of drift direction are object interruption of sediment, changing bluff morphology from south to north, diminishing grain size, and a northerly increase in beach width and primary dune development (Schwartz 1992) Eelgrass beds and ulva are continuous along the shoreline with patches of red algae, barnacles and soft brown kelp (WDNR 2001). Surf smelt spawn along the shoreline throughout the Gardiner area (Penttila 2000). Herring continue to spawn throughout this reach as well. A lagoon between Contractor's Point and Gardiner has been altered, possibly dredged as is evidenced by the straight line defining the upland border. The salt marsh south of the lagoon has been filled and there is a road to the north of the lagoon. A small creek feeds into the north end of the lagoon which still has tidal channels but may flow through an undersized culvert (TAG 2002). Eagle Creek to the north of Gardiner is a bar bound estuary with a salt marsh and good channel and a good potential for fish use (TAG 2002).

Figure 90. Eagle Creek Estuary. Photo provided by Hilton Turnbull

Diamond Point is a depositional zone that is entirely armored, some of which extends into the intertidal zone. The eastward moving drift cell, originating in a divergent zone between Thompson spit and Diamond Point, is indicated by accumulation of sediment on the west side of obstacles and a decrease in bluff slope and sediment size to the east. In addition, beach slope and width increase toward the terminus at Diamond Point (Schwartz 1992). An isolated, brackish lagoon has no open connection to the marine environment. Historical connection is unknown (TAG 2002).

Shoreline Armoring

The shoreline along Contractor's Spit is armored to protect a service road and no longer provides tidal influence to a historic salt marsh area. A boat launch between Contractor's Point and Gardiner exits a parking lot that is protected by riprap. There is some bulkheading southwest of Troll Haven at Gardiner. Diamond Point is entirely bulkheaded, primarily with old wood pilings, some of which extends into the intertidal zone. The TAG recommends removal of the old riprap bulkheads and replacement with softbank technology. Shoreline homeowners have started to replace the old wood pilings with riprap (John Cambalik, personal communication, 2002).

Overwater Structures
A pier/dock with two associated rail launches are at Mill Point. Pilings on the beach of the point provide man-made perches for predatory birds and could come out. There is a dock at Kalset Point associated with aquaculture activities. There is a dock/pier with holding tanks at Contractor's Point. The contents of the holding tanks are unknown (TAG 2002).

Ramps
There is one boat launch ramp at Contractor's Point and one along the shoreline to the north.

Stormwater/Wastewater
There are stormwater issues associated with residential/commercial development at Contractor's Point. Septic system and stormwater runoff from the residential area are issues at Diamond Point as evidenced by algal blooms in the isolated lagoon during the summer months (TAG 2002).

Landfill
A service road and associated armoring extends through a salt marsh at Kalset Point although the road is overtopped during extreme high tides (TAG 2002). A 15-acre salt marsh on the spit at Contractor's Point is no longer there due to shoreline armoring and a service road adjacent to the beach. The salt marsh south of the lagoon between Contractor's Point and Gardiner has been filled and there is an access road fill to the north of the lagoon (TAG 2002).

Riparian Loss
The riparian zone to the north of Mill Point Spit is intact.

Diamond Point to Rocky Point

Drift Cell and Biota Background
The eastward moving drift cell, originating in a divergent zone between Thompson Spit and Diamond Point, is indicated by accumulation of sediment on the west side of obstacles and a decrease in bluff slope and sediment size to the east. In addition, beach slope and width increase toward the terminus at Diamond Point (Schwartz 1992).

A short drift cell originates in a zone of divergence between Diamond Point and Thompson Spit, moving westward with the terminus at Thompson Spit. This westwardly net shore-drift is evidenced by a decrease in grain size and bluff slope toward the west and a westerly increase in beach slope and width (Schwartz 1992). A drift cell originating at Rocky Point moves eastward, also terminating at Thompson Spit. Increases in beach width, beach slope and bluff vegetation indicate the easterly net shore-drift. Grain size diminishes from the origin to the terminus (Schwartz 1992).

The north side of Miller Peninsula is owned by Washington State Parks. An unaltered lagoon along this shoreline could be an example of model lagoon features (TAG 2002). Canopy forming bull kelp extends throughout this shoreline (WDNR 2001).

Shoreline Armoring
Shoreline armoring to the west of Diamond Point is not an issue.

Overwater Structures
There are no known overwater structures in this segment.

Ramps
A poorly maintained access road and boat ramp, owned by Clallam County, exist west of Diamond Point.

Stormwater/Wastewater
Stormwater coming from the western portion of the Diamond Point residential area might be an issue at this location.

Landfill
There are no known landfill issues to the west of Diamond Point.

Riparian Loss
Riparian condition is good along the northern Miller Peninsula.

Protection Island

Drift Cell and Biota Background
Protection Island guards the entrance to Discovery Bay. It was once platted for development but has since been recognized for its importance to numerous sensitive bird species, such as tufted puffin and rhinoceros auklets, and has since been protected as a wildlife refuge. Much of the original infrastructure and development have been removed.

Four short drift cells surround Protection Island. The southern side is a zone of divergence of relatively slow wave action and little erosion with two drift cells moving in opposite directions along the shoreline. One terminates along a depositional spit to the southwest while the other terminates to the east at Violet Point, a long depositional spit. Continuous soft brown kelp with patches of focus, barnacles and eelgrass are found along this shoreline (DNR 2001). A harbor has been dredged and developed into a marina along this south shore at the base of Violet Spit for past development purposes. It is unknown if this harbor was at one time a lagoon or salt marsh, but the opening was not there historically (TAG 2002).

The other two drift cells originate within a zone of divergence along the northwest side. One terminates at the spit along the southwest side and the other terminates at Violet Point. The north and northwest shoreline is a steep high cliff within a zone of substantial wave erosion and landslides (USGS 1988). There is enough backshore sediment supply to support both spits (TAG 2002). Continuous eelgrass and patches of soft brown kelp are found along the nearshore. Dune grass is found along both sides of Violet Spit (DNR 2001). The north side of the Violet Spit is a harbor seal haul out site.

Overwater Structures
The marina along the south side at the base of Violet Spit has two large jetties on either side of the entrance. Residents once used the harbor as a ferry terminal; the existing use or need is unknown. The TAG recommends removal of the harbor infrastructure and the jetties at the entrance.

Figure 91. Protection Island Marina. 2001 Ecology Nearshore Oblique Photo

Ramps
There are no known boat launches on the island.

Stormwater/Wastewater
Water quality issues are unknown.

Landfill
Two jetties bordering the entrance to the harbor at the base of Violet Spit interrupt shallow water habitat and should be removed (TAG 2002).

Riparian Loss
Riparian loss is unknown.

Action Recommendations
- Continue efforts to digitize historic coastal maps for use in analyzing habitat loss along the shoreline.
- Set back existing armoring along the south shore of Cape George and replace existing riprap with softbank technology.
- Remove jetty along the north side of the entrance to Cape George marina to regain shallow migration corridor and allow reestablishment of eelgrass on both sides
- Acquire property along the south shore of Beckett Point, enough to reestablish a tidal connection to the lagoon.
- Remove sections bulkhead protecting an old railroad grade to the south of Adelma Beach that are in front of feeder bluffs and/or in front of historic and/or existing salt marsh habitats.
- Analyze historic maps of the Fairmont area to determine the extent and configuration of the historic salt marsh followed by active restoration by removing part of the railroad grade to open up the salt marsh to tidal influence and subsequently better access for fish.

- Acquire house in Fairmont that is constructed within the intertidal zone and remove the house and associated fill.
- Remove the railroad grade that runs across the Snow/Salmon Creek deltas all the way to Mill Point Spit to reestablish historic circulation, salt marsh habitat and the flow of nutrients.
- Remove the fill, including the dikes, along Snow Creek estuary at the old pig farm. Remove existing pond at pig farm to reestablish salt marsh habitat
- Pull back the dikes along Salmon Creek to reestablish historic salt marsh habitat
- Control exotic vegetation along Snow/Salmon Creek estuaries.
- Restore complexity of tidal channels within the Snow/Salmon Creek estuaries
- Remove fill between the ponds at the old mill site to reestablish tidal influence.
- Remove the access road that possibly truncates the historic pond at the abandoned mill site access to salt water.
- Remove the bulkheads along Contractor's Point, move the access roads off the beach, restore the salt marsh to its historic template and moving Contractor's Creek to its historic channel.
- Remove the old riprap bulkheads at Diamond Point and replace with softbank technology.
- Remove harbor infrastructure and jetties on Protection Island

SEQUIM BAY

The Sequim Bay nearshore discussion begins at Rocky Point at the north end of the Miller Peninsula and ends at Pitship Point along the west side of Sequim Bay. Drift cell descriptions are derived from Washington Department of Ecology (Ecology). Washington Department of Natural Resources' Shorezone Inventory (WDNR 2001) provided biota background. The TAG observed Ecology's oblique shoreline photos from the year 2001 to further understand habitat impacts to nearshore processes and their effects on salmon migration, feeding and rearing. Digitized historical coastal maps are not yet available for this section of WRIA 17.

Rocky Point to Hardwick Point

Drift Cell and Biota Background

A drift cell originating at Rocky Point moves westward terminating at the tip of Travis Spit. Active bluff erosion on the western end of the northern shoreline of Miller Peninsula with sediment deposition on the eastern side of drift logs indicates a westerly net shore-drift. As part of the feeder system to Travis Spit, this segment originates at a zone of divergence near Rocky Point. A decrease of course sediment becomes evident only near the western end of this segment. Westerly increases in beach width and the growth of Travis spit also indicate of westerly sediment movement (Schwartz 1992).

The southern side of Travis Spit is formed by westerly drift originating in Paradise Cove. A decrease in westward grain size and an interruption of sediment on the east side of drift logs indicate the net shore drift direction (Schwartz 1992). Abundant along shore-drift feeds the spit. Continuous dune grass and patches of eelgrass, soft brown kelp, red algae and fucus are found on both sides of the pristine spit. Salt marsh habitat is on the south side only (WDNR 2001).

A third drift cell in this segment originates in a zone of divergence about 1.5 km north of Hardwick Point and terminates at the tip of a spit that projects northward across the mouth of Paradise Cove. The northerly spit growth, decreasing grain size and deposition of material on the south side of drift logs indicates the northerly net shore drift direction (Schwartz 1992). The sediment source is characterized as abundant and from backshore sources, such as eroding bluffs. Continuous eelgrass and ulva are found along the nearshore (WDNR 2001). A lagoon to the south of the spit is open to tidal influence (TAG 2002).

Shoreline Armoring

There are some small bulkheads along the northwestern coast of Miller Peninsula but their location in relation to the ordinary high line is unknown (TAG 2002). Ten percent of the shoreline between Paradise Cove and Hardwick Point is armored (WDNR 2001).

Overwater Structures
Paradise Cove has three piers with three slips (WDNR 2001). There are five docks with ten slips between Paradise Cove and Hardwick Point (WDNR 2001).

Ramps
The presence of boat launch ramps is unknown for this segment.

Stormwater/Wastewater
Stormwater/wastewater issues are unknown for this segment.

Landfill
There are bulkheads along the shoreline between Paradise Cove and Hardwick Point that extend below the ordinary high waterline (TAG 2002).

Riparian Loss
Riparian areas have been removed for views wherever there are houses.

Hardwick Point to Chicken Coop Creek

Drift Cell and Biota Background
This segment contains the origin and major portion of a drift cell that originates approximately 1.5 km north of Hardwick Point and terminates in the southeast corner of Sequim Bay. Mid-sector bluff erosion in the areas south of Hardwick and Goose Points temporarily obscures the southeasterly decrease of grain size. Hardwick and Goose Points are looped bars with progradation to the southeast in both cases. Upon nearing each point, the beach widens and the bluff vegetation increases. The net shore drift of this segment is southeasterly (Schwartz 1992). Continuous eelgrass is found along the shoreline with patches of red algae, ulva and sargassum (WDNR 2001).

Shoreline Armoring
Shoreline armoring to the south of Hardwick Point is at the ordinary high waterline (TAG 2002).

Overwater Structures
One dock with two slips is at Hardwick Point and four docks are south of the point associated with residential development (WDNR 2001).

Ramps
One boat launch ramp is at Hardwick Point (WDNR 2001).

Stormwater/Wastewater
Stormwater/wastewater issues are unknown in this segment.

Landfill
There is shoreline armoring between Hardwick Point and the southeast corner of Sequim Bay but the extent of intertidal fill is unknown.

Riparian Loss
Trees have been removed for views.

Chicken Coop, Jimmycomelately and Dean Creek Estuaries

Drift Cell and Biota Background
The southern end of Sequim Bay is largely a sand flat with abundant fluvial sediment influence (WDNR 2001). Chicken Coop Creek shares a high intertidal zone with an adjacent unnamed system just a few meters to the west and enters onto a sand flat along the southeast shoreline of Sequim Bay. Jimmycomelately Creek enters into an altered estuary at the head of the bay. Dean Creek inters onto a sandflat along the southwestern shoreline.

Jimmycomelately Creek has historic significance for the Jamestown S'Klallam Tribe. The tribal center is located at the head of Sequim Bay. The creek, including the mouth, was moved and straightened resulting in accretion in the intertidal area. The creek channel has two mouths in the delta and is not successful in moving all the sediments out of lower Jimmycomelately Creek. Aggradation is a serious problem. Coho have been observed spawning intertidally (Randy Johnson, personal communication, 2002). In broody year 2002, more than 20 summer chum died in the estuary prior to spawning as the progradation and aggradation of the delta cone impeded their migration (Cheri Scalf, personal communication, 2002). A log yard has filled the intertidal area of both Jimmycomelately Creek and Dean Creek and a pier with rafted logs has interrupted the continuity of the eelgrass beds. Three roads further impact the estuarine system. These are: the log yard access road, Blyn Road and Highway 101.

Jamestown S'Klallam Tribe, Washington Department of Fish and Wildlife, Washington Department of Transportation, and the Clallam County Conservation District have received funding for habitat acquisition and/or restoration of the lower watershed and estuary. Work has begun to acquire properties necessary for habitat restoration. Work has begun with reconfiguring the lower watershed to its historic location.

Shoreline Armoring
Shoreline armoring has not been determined.

Overwater Structures
The pier and pilings associated with the abandoned log yard should be removed (TAG 2002).

Ramps
Existing launch ramps have not been determined.

Stormwater/Wastewater
Contaminated sediments from creosoted pilings and barge work that has been associated with the log yard operations are problems that need to be addressed (TAG 2002).

Landfill

Fill associated with the old log yard, including the log yard road, should be removed (TAG 2002). Tidal channels have been disrupted due to removal of the mouth of Jimmycomelately Creek from its estuary.

Figure 92. Jimmycomelately Estuary with Proposed Restoration Actions. Graphic by Randy Johnson, WDFW

Riparian Loss

A significant riparian with a conifer component has been removed along the south shore of Sequim Bay. Willow dominates the lower watersheds of both Jimmycomelately Creek and Dean Creek.

Dean Creek to Pitship Point

Drift Cell and Biota Background

This single drift cell originates at a zone of divergence near Pitship Point and terminates to the south of Schoolhouse Point. Sediment sources are characterized as both backshore and alongshore and being in abundance (WDNR 2001). Southeasterly net shore drift is indicated by the accumulation of sediment on the northwest side of the groins, boat ramps, and bulkheads and a southeasterly trend toward a decrease in sediment size (Schwartz 1992). Patches of ulva and soft brown kelp are found along the entire shoreline of west Sequim Bay. Eelgrass is continuous until the John Wayne Marina, where it becomes fragmented. Sediment is also scarce at the marina (WDNR 2001). A saltmarsh, replete with tidal channels on the southwest side of Pitship Point, is fronted by two opposing spits that historically almost met. A road now fills the connection with an undersized culvert allowing very little tidal access. A spring creek feeds into the marsh, which is approximately 3.2 miles from the mouth of Jimmycomelately Creek and is most likely right on the migration corridor of Jimmycomelately summer chum (Randy

Johnson, personal communication, 2002). The TAG recommends replacing the culvert with a bridge to restore the outlet to historic conditions.

Shoreline Armoring
Much of the shoreline between Dean Creek and Pitship Point is armored. The cove south of Pitship Point is armored along all of its shoreline, as is John Wayne Marina (WDNR 2001).

Overwater Structures
Two docks are to the south of a well-developed point north of Dean Creek. Eight docks with sixteen slips are to the north of the same point. John Wayne Marina consists of seven piers that provide 250 slips (WDNR 2001).

Ramps
One boat ramp is associated with the development along a small point to the north of Dean Creek. Another boat launch ramp is associated with John Wayne Marina (WDNR 2001).

Stormwater/Wastewater
Treated stormwater from the casino enters a tributary to Jimmycomelately Creek. Timbers from the railroad trestle are leaking creosote into Jimmycomelately and should be removed. Wastewater associated with marinas is an issue, as is the improper application and/or disposal of boat maintenance materials. Gas and oil spillage from boats and motors can also be an issue.

Landfill
Approximately twenty percent of the shoreline armoring south of Pitship Point extends into the intertidal zone (WDNR 2001). A road connecting two spits has filled the estuary of a small creek that feeds a salt marsh in this location. The undersized culvert allows very little tidal exchange and should be replaced with a bridge (TAG 2002)

Riparian Loss
Trees have been removed for views in residentially developed areas. The removal of trees has destabilized banks and has eliminated future wood recruitment along the nearshore.

Data Needs
Determine historic habitats through digital interpretation of mid 1800's coastal survey maps.

Action Recommendations
- Remove creosoted pilings and contaminated sediments from barge work
- Remove abandoned log yard fill to restore estuary function of both Dean and Jimmycomelately Creeks
- Remove log yard road

- Reclaimed trailer park could become salt marsh habitat, although there is no evidence of an historic salt marsh
- Reconnect tidal channels of Jimmycomelately Creek
- Remove the county road
- Move Jimmycomelately Creek channel to the west to its historic location
- Remove the delta cone accretion of the old channel (Jimmycomelately) just low enough to be intertidal.
- Put in a new bridge with three spans over the newly configured Jimmycomelately Creek
- Remove the railroad trestle over the tributary to Jimmycomelately that carries stormwater from the casino and replace the trestle with a walking bridge.
- Add sinuosity to Dean Creek below highway 101
- Replace a culvert between two spits that truncates a valuable salt marsh south of Pitship Point with a bridge

PRIORITIZED NEARSHORE ACTION RECOMMENDATIONS

Numerous nearshore action recommendations have been suggested throughout this document. These actions are from a fish perspective. The TAG accepted the task of prioritizing action recommendations for the nearshore. To do so, they developed criteria to guide the assignment of values to certain parameters. The parameters include proximity to priority watersheds, special scale, temporal scale, and ecological scale. The following criteria were used to rank the potential projects:

Proximity to priority watersheds, maximum 5 points
The proximity to priority watersheds, as determined by the Hood Canal Coordinating Council strategy for salmon habitat recovery (Watson 2001), was evaluated as follows:

- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 1 estuary, the action received the maximum of 5 points.
- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 2 estuary, the action received 4 points.
- If the nearshore project action was within 0.0 to 1.0 miles from a Tier 3 estuary, the action received 3 points.
- The value was reduced by one point if the action was between 1.0 and 7.0 miles from a Tier 1, 2, or 3 estuary.
- The value was reduced by two points if the action was greater than 7.0 miles from a Tier 1, 2, or 3 estuary.

Spatial Scale, maximum 5 points
The size of the benefit was evaluated as follows:

- The action received the maximum of 5 points if the project protected and/or restored greater than 10 acres of habitat.
- The action received 4 points if the action protected and/or restored 5 to 10 acres of habitat.
- The action received 3 points if the action protected and/or restored 2 to 5 acres of habitat.
- The action received 2 points if the project protected and/or restored ½ to 2 acres of habitat.
- The action received one point if the project protected and/or restored less than ½ acre of habitat.

Ecological Scale, maximum 5 points
Ecological scale was designed to evaluate impacts to nearshore processes. If the action addressed multiple processes, species and life histories, it received a higher value. For example, if an action recommendation involved estuary restoration that would affect both nearshore and riverine processes, such as dike removal in the lower floodplain, it received a higher score than one that involved a single process, such as the removal of individual creosoted pilings, which systematically received one point.

Temporal Scale, maximum 3 points
Time scale was designed to evaluate the benefit over time. If the action recommendation restored a nearshore process which is long term by nature, it received a higher score than a project that is more short term and requires a lot of maintenance

General, Basin-wide Recommendations
In addition to the site-specific recommendations, there are some general basin-wide recommendations that should be considered when determining nearshore restoration actions to pursue or when making policy and/or regulatory decisions. These include:

- protection of naturally eroding bluffs
- removal of intertidal fill
- protection of estuaries
- proper treatment of stormwater and wastewater
- protection and/or restoration of salt marsh habitat
- removal of unused creosoted pilings

Following is the Stressor-Effects table developed by the nearshore TAG workgroup for description of nearshore impacts and the prioritized list of action recommendations.

Table 23. Nearshore Stressors - Effects Table.

Causal Factors/ Stressors	Physical Processes Altered	Physical/Chemical Effects	Habitat Effects	Juvenile Salmon Effects
Shoreline Armoring (riprap, bulkheads)	a. erosion/sediment transport (backshore, intertidal and alongshore)	a. altered beach sediment size/type b. decreased sediment abundance c. increased wave energy d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages (loss of eelgrass/copepods) b. beach scouring and/or lowering c. loss of shallow nearshore d. loss of connectivity e. altered shoreline hydrodynamics/drift (groins, etc..)	a. reduced prey b. increased predation c. altered migration
Overwater Structures (stairs, docks, marinas)	a. erosion/sediment transport	a. altered beach sediment size/type b. decreased sediment abundance c. light limitation/alteration d. water quality declines from flow alteration, accumulation of drift material (including macroalgae blooms)	a. altered plant/animal assemblages b. altered access to shallow nearshore corridor	a. reduced prey b. increased predation c. altered migration
Ramps	a. erosion/sediment transport	a. altered beach sediment type/size b. altered sediment distribution	a. altered plant/animal assemblages	a. reduced prey
Stormwater Wastewater	a. nutrient input b. freshwater input	a. low dissolved oxygen b. contaminant loading c. nutrient loading d. physical scouring from increased runoff e. increased shoreline erosion from poor stormwater conveyance/maintenance f. alteration of beach hydrodynamics	a. altered plant/animal assemblages (including macroalgae blooms) b. lost habitat due to eelgrass declines from smothering, anoxia, shading, etc. c. forcing of habitat shifts due to blooms (slowing of water, accumulation of nutrients,etc)	a. increased injury risk (lesions, tumors) b. reduced prey c.reduced habitat
Landfill (below the high high water line)	a. tidal exchange b. erosion/sediment transport	a. delta and lagoon loss b. altered beach sediment size/type c. decreased sediment abundance d. increased wave energy	a. altered plant/animal assemblages b. loss of shallow nearshore corridor c. loss of riparian d. beach scouring and/or lowering e. loss of connectivity	a. reduced prey b. osmoregulation (due to delta/lagoon loss) c. increased predation
Riparian Loss	a. nutrient input b. erosion/sediment transport c. large wood function in spit formation	a. increased temperature b. organic input (food web)	a. shade b. erosion c. lwd function	a. reduced prey b. increased predation

Table 24. Nearshore Action Recommendations (Prioritized)

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Quilcene Bay	Remove additional dikes on WDFW property on the Big Quilcene River	5	5	4	3	17
Quilcene Bay	Acquire properties and remove dikes on the south side of the Big Quilcene River to restore salt marsh habitat	5	5	4	3	17
Quilcene Bay	Restore sinuosity in the Big Quilcene River in the historical tidally influenced area	5	5	4	3	17
Quilcene Bay	Remove the left bank dike along the Little Quilcene River and nearshore	5	5	4	3	17
Quilcene Bay	Acquire conservation easement and set back right bank dike along the nearshore associated with the Little Quilcene River to restore salt marsh habitat	5	5	4	3	17
Quilcene Bay	Restore sinuosity in the Little Quilcene River in the historical tidally influenced area	5	5	4	3	17

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Snow/Salmon Creeks	Remove railroad grade, fill, and levees along estuary to restore salt marsh and tide flats	5	5	4	3	17
Quilcene Bay	Remove aggraded delta cone at mouth of Big Quilcene River	4	5	4	3	16
Quilcene Bay	Remove delta cone that has prograded on Little Quilcene River	4	5	4	3	16
Quilcene Bay	Replace Donovan Ck. Culvert at mouth with an appropriate alternative to restore estuary function	5	5	4	2	16
Quilcene Bay	Remove landfill and bulkhead to restore historic saltmarsh and intertidal habitat between Boat Haven Marina and Indian George Creek.	5	4	4	3	16
Chimacum	Remove non-native fill along nearshore to the south of Chimacum estuary from the site and move the native fill back to the bluff for future recruitment	5	4	4	3	16

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Glen Cove	Remove fill and overwater structures to reestablish shallow water habitat and improve salmon juvenile migration	5	5	3	3	16
Oak Bay	Remove Portage Canal jetties to restore littoral drift	4	5	3	3	15
Oak Bay	Reconnect Little Oak Bay Lagoon to ocean	5	4	3	3	15
Scow Bay	Remove fill, bridge both channels, and reestablish connection to restore fish passage	5	5	3	2	15
Squamish	Replace Shine Creek culverts under South Point Road with bridge to restore natural processes by increasing tidal exchange and encouraging reestablishment of salt marsh vegetation	5	4	3	2	14
Oak Bay	Improve tidal prism by removing fill in Little Oak Bay Lagoon	4	4	3	3	14
Fairmont	Remove part of the railroad grade to open up a salt marsh to tidal action for better access for fish	3	4	4	3	14
Jimmycomelately	Remove log yard fill	3	4	4	3	14

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Jimmycomelately	Reestablish tidal channels	3	4	4	3	14
Jimmycomelately	Move the county road	3	4	4	3	14
Dean Creek	Remove log yard fill to restore estuary function	3	4	4	3	14
Smart Cove	Remove Fill in Western Lobe (<2 acres)	2	4	4	3	13
Point Whitney	Remove dike from within the lagoon at Point Whitney	3	4	3	3	13
Quilcene Bay	Acquire and remove fill area, slated for development, along the east side of Quilcene Bay	3	3	4	3	13
Dabob/Toandos	Remove fill and reconnect salt marshes at Zelatched Point	3	4	3	3	13
Bridgehaven	Protect and restore salt marsh parcels above Bridgehaven RD	3	4	3	3	13
Oak Bay	Reconnect Little Goose Creek with estuary	3	4	3	3	13
Marrowstone	Remove bulkhead at Marrowstone Point to allow saltmarsh restoration, littoral drift, and spit formation	4	4	2	3	13

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Port Townsend	Allow more water flow, sediment flow, and fish through the wharf at Fort Worden	4	4	2	3	13
Beckett Point	Purchase property/houses along south side and reestablish the connection of a tidal lagoon with the marine environment	4	4	2	3	13
Adelma Beach	Remove bulkhead, riprap and associated fill along old railroad grade where it is in front of feeder bluffs	4	3	3	3	13
Maynard Mill Site	Remove railroad grade and road fill between ponds to open up tidal flow	3	3	4	3	13
Jimmycomelately	Establish salt marsh at abandoned trailer park	2	4	4	3	13
Jimmycomelately	Move creek channel/mouth to its historic location	2	4	4	3	13
Jimmycomelately	Remove delta cone accretion at old channel	2	4	4	3	13
Quilcene Bay	Remove abandoned creosoted RR pilings in Quilcene Bay, particularly south of Quilcene along W side of Bay	2	3	4	3	12

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Bridgehaven	Replace undersized culvert under Bridgehaven Road with bridge to increase tidal action to salt marsh to decrease need for dredging	3	4	3	2	12
Ludlow Bay	Restore existing stormwater pond to accessible nearshore habitat	3	3	3	3	12
Oak Bay	Remove 1000 feet of riprap and boat launch along Little Oak Bay Park RD	3	3	3	3	12
Glen Cove	Remove railroad trestle, fill, and creosoted pilings	3	3	3	3	12
Port Townsend	Minimize and treat stormwater discharge along Port Townsend south shore	3	3	3	3	12
Port Townsend	Move lighthouse and associated coast guard buildings away from nearshore and remove groins and riprap to allow spit feature to continue to develop	4	3	2	3	12
Snow/Salmon Creeks	Control exotic vegetation	4	2	4	2	12
Contractor's Point	Restore salt marsh to historic template	3	3	3	3	12
Jimmycomelately	Install new bridge (3 spans) over new creek channel	2	4	4	2	12

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Jimmycomelately	Remove trestle over left bank tributary and install pedestrian bridge	2	3	4	3	12
Dean Creek	Add sinuosity below Highway 101 to mouth	2	3	4	3	12
Pitship Point	Replace culvert with a bridge to restore salt marsh connection	3	4	3	2	12
Smart Cove	Revegetate Lagoon Riparian Zone	2	2	4	3	11
Jackson Cove	Restore lower floodplain	2	2	4	3	11
Jackson Cove	Remove pilings north of Marple	1	3	4	3	11
Jackson Cove	Replace culvert on Spencer with appropriate alternative	2	3	4	2	11
Dabob/Toandos	Investigate and remove old docks within Fisherman's Harbor	2	3	3	3	11
Thorndyke	Remove pilings to the south of Thorndyke Bay	2	3	3	3	11
Bridgehaven	Remove wing walls, piles, and fill associated with parking lot at Southpoint Ferry Terminal	2	3	3	3	11

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Bridgehaven	Investigate opportunities to restore natural processes at Bridgehaven Spit	2	3	3	3	11
Termination	Reconstruct west side of the Hood Canal floating bridge approach to restore shallow water habitat and littoral drift	3	4	2	2	11
Ludlow Bay	Remove creosoted pilings within the bay	2	3	3	3	11
Olele Point	Restore salt marsh connectivity along northshore of Olele Point	3	3	2	3	11
Port Townsend	Remove Indian Point fill and creosoted pilings	2	3	3	3	11
Port Townsend	Remove shopping mall fill (Swains, etc.) off of intertidal zone	2	3	3	3	11
Port Townsend	Remove old cannery building	2	3	3	3	11
Port Townsend	Remove old ferry terminal and creosoted pilings	2	3	3	3	11
Port Townsend	Remove tide bowl (art project), wave gallery and creosoted pilings	2	3	3	3	11

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Port Townsend	When repairing jetty at Point Hudson, remove creosoted pilings	2	3	3	3	11
Cape George	Restore littoral drift and shallow water migration corridor at the marina	3	3	2	3	11
Contractor's Point	Remove bulkheads and adjacent road	2	3	3	3	11
Contractor's Point	Remove culvert and restore Contractors Creek to historic channel	2	3	3	3	11
Jimmycomelately	Remove pilings and contaminated sediments	2	2	4	3	11
Pitship Point	Modify marina fill along north side of Johnson Creek to alleviate sediment transport problem	2	3	3	3	11
Jackson Cove	Remove Intertidal Fill on Marple Estuary	1	2	4	3	10
Dabob/Toandos	Remove creosote pilings in the vicinity of the shellfish facility in the northeast corner of Dabob Bay	1	3	3	3	10
Dabob/Toandos	Remove groins on beach between Camps Discovery and Harmony	2	2	3	3	10

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Squamish	Remove tide gate under Shine Road to increase channel robustness and tidal flux	2	3	3	2	10
Termination	Move parking lot, road, and riprap to allow natural beach berm development at Shine Tidelands State Park	2	3	2	3	10
Ludlow Bay	Remove fill from Ludlow Lagoon to reestablish historic open water	1	3	3	3	10
Ludlow Bay	Enlarge two culverts at upstream end of Ludlow Lagoon to allow tidal influence and reestablishment of salt marsh and access to the creek	2	3	3	2	10
Ludlow Bay	Replace Ludlow Creek culvert at Paradise Bay Road with bridge to restore tidal prism.	2	3	3	2	10
Mats Mats	Revegetate shoreline (multiple landowners) between Ludlow and Mats Mats Bays	2	2	3	3	10
Mats Mats	Eliminate sediment impacts from quarry in loading bay	2	2	3	3	10

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Mats Mats	Restore salt marsh at Port of Port Townsend boat launch	1	3	3	3	10
Mats Mats	Restore salt marsh at mouth of Piddling Creek	1	3	3	3	10
Marrowstone	Remove pier at Fort Flagler that is no longer in use	2	3	2	3	10
Marrowstone	Restore connection to Rat Island	2	2	3	3	10
Marrowstone	Remove 40-50 creosote pilings in vicinity of Fort Flagler	2	3	2	3	10
Old Fort Townsend	Remove 27 creosoted pilings	1	3	3	3	10
Port Townsend	Fill hole in eelgrass bed in front of Port Townsend Plaza	1	3	3	3	10
Gardiner	Increase tidal prism of Gardiner Lagoon associated with road crossing and fill	2	3	3	2	10
Squamish	Identify bulkheads that extend into intertidal, remove fill and replace with soft shore revetment above the ordinary high water line	2	2	3	2	9
Squamish	Remove jetty near county park	1	2	3	3	9

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Ludlow Bay	Remove nearshore fill just northeast of Ludlow Creek	1	2	3	3	9
Mats Mats	Restore South Mats Mats creek connectivity and function with Bay through culvert removal and restoration	1	2	3	3	9
Indian Island	Reconfigure parking lot and remove bulkhead in South Indian Island County Park while maintaining public access	1	2	3	3	9
Indian Island	Address beach erosion near south end of Portage Canal terminus	2	3	3	1	9
Marrowstone	Remove bulkheads that intrude onto intertidal at Ecologic Place	1	2	3	3	9
Marrowstone	Protect and restore Mumby Road salt marsh through fill removal and tidal channel reconnection	2	3	2	2	9
Marrowstone	Remove creosoted pilings in Mystery Bay	1	3	2	3	9
Marrowstone	Remove access road at the end of Mystery Bay for more tidal exchange and reestablish salt marsh south of the road	1	3	2	3	9

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Old Fort Townsend	Remove riprap/fill from the picnic area to reestablish shallow water habitat and improve summer chum juvenile migration	1	2	3	3	9
Port Townsend	Install mooring buoys to discourage anchoring	2	2	3	2	9
Beckett Point	Purchase property/homes with bulkhead and intertidal fill along the north side of the point and remove bulkhead/fill	2	2	2	3	9
Protection Island	Remove structures and jetties associated with the marina	2	3	1	3	9
Hardwick Point	Remove bulkheads when intruding on intertidal	1	2	3	3	9
Pitship Point	Replace culvert with bridge over Johnson Creek	1	3	3	2	9
Thorndyke	Monitor and remove spartina in Thorndyke Bay as necessary	1	2	3	2	8
Termination	Beach nourishment for ~0.5 km east of bridge	3	2	2	1	8
Marrowstone	Remove unused launch ramp on north end of Marrowstone	1	2	2	3	8

Location	Action Item	Spatial Scale	Ecological Scale	Proximity to Priority Stocks	Time Scale	Sum
Port Townsend	Remove submarine net anchor near Point Hudson	1	1	3	3	8
Diamond Point	Remove wood pilings and riprap bulkheads and use soft bank technology	2	2	2	2	8
North Beach	Remove launch ramp	1	1	2	3	7

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APPENDIX A: MAPS