SALMON AND STEELHEAD

HABITAT LIMITING FACTORS

WATER RESOURCE INVENTORY AREA 18

WASHINGTON STATE
CONSERVATION COMMISSION

FINAL REPORT

Donald Haring
12/27/99

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ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

The following list provides a guide to acronyms or abbreviations used in this report:

BMP	Best Management Practices
cfs	cubic feet per second (a measure of water flow)
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DAWACT	Dungeness Area Watershed Analysis Cooperative Team
DQ Plan	Dungeness-Quilcene Water Management Plan
ESA	ENDANGERED SPECIES ACT
IFIM	Instream Flow Incremental Methodology
LWD	Large Woody Debris
mg/L	milligrams/Liter
mi	mile
mi^2	square miles
NRCS	Natural Resource Conservation Service
NWIFC	Northwest Indian Fisheries Commission
ONP	Olympic National Park
PSCRBT	Puget Sound Cooperative River Basin Team
RM	River Mile
SASSI	Salmon and Steelhead Stock Inventory
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
SSI	Salmonid Stock Inventory
TAG	Technical Advisory Group
USFS	U.S. Forest Service
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WWTIT	Western Washington Treaty Indian Tribes
yd^3	cubic yards
yr	year

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Several maps have been included with this report for your reference. The maps are appended to the report, either as a separate electronic file (for the electronic copy of this report) or separate printed section (for hard copy). The maps are included as a separate electronic file to enable the reader to utilize computer multi-tasking capabilities to simultaneously bring up the map and associated text. Below is a list of maps that are included in the WRIA 18 Map appendix/file:

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EXECUTIVE SUMMARY

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." It is important to note that the charge to the Conservation Commission in ESHB 2496 does not constitute a full limiting factors analysis. A full habitat limiting factors analysis would require extensive additional scientific studies for each of the subwatersheds in Water Resource Inventory Area (WRIA) 18. Analysis of hatchery, hydro, and harvest impacts would also be part of a comprehensive limiting factors analysis, but these elements will be considered in other forums.

WRIA 18 is located on the north Olympic Peninsula, with streams and rivers draining to the Strait of Juan de Fuca. WRIA 18 includes two large river systems (Dungeness and Elwha rivers); one medium sized river system (Morse Creek); and 14 smaller independent drainages to salt water (Bell, Gierin, Cassalery, Cooper, Meadowbrook, McDonald, Siebert, Bagley, Lees, Ennis, Peabody, Valley, Tumwater, and Dry creeks). Topography of the subwatersheds ranges from small lowland drainages with headwaters in the low foothills of the Olympic Mountains, to the larger drainages with headwaters in the high elevation peaks of the Olympic Mountains. Stream channels range from low gradient unconfined channels in the lower Dungeness valley to deep confined canyons on the Elwha River and other drainages. Measured precipitation ranges from 240 inches annually in the headwaters of the Elwha River, to only 15 inches in the lower Dungeness Valley, where rainfall is limited by the "rainshadow" effect of the Olympic Mountains.

This report addresses habitat conditions that support anadromous salmonids, based on the stock designations identified in the Salmon and Steelhead Stock Inventory (SASSI, Washington Department of Fish and Wildlife (WDFW) and Western Washington Treaty Indian Tribes (WWTIT) 1992). This report attempts to compile the best available information on the current distribution and condition of salmonid stocks, for use in determining potential benefits of salmonid habitat protection and restoration efforts. Table 1 provides a summary of identified salmon stocks, initial SASSI status, status update recommendations based on Technical Advisory Group (TAG) input, and ESA listing status (Char and Coastal Cutthroat distribution and status are not specifically included in this report, and will be incorporated in a future update). Distributions of individual salmon and steelhead species are shown on the maps in the separate Maps appendix (hard copy) or file (electronic version) included with this report.

Table 1: WRIA 18 Salmon and Steelhead Stock Designations and Associated Status

Stock	**SASSI Status**	**Updated Status Recommendation**	**ESA Listing Status**
Dungeness Spring/Summer Chinook	Critical	Critical	Threatened
Elwha/Morse Creek Summer/Fall Chinook	Healthy	Depressed/Critical	Threatened
Elwha Spring Chinook	Not Identified as Distinct Stock	Critical/Extinct	Threatened
Dungeness Summer Chum	Not Identified as Distinct Stock	Depressed/Critical	Threatened
Dungeness River/East Strait tribs Fall Chum	Unknown	Critical	Not Warranted
Elwha Fall Chum	Unknown	Critical	Not Warranted
Dungeness Coho	Depressed	Depressed	Candidate
Morse Creek Coho	Depressed	Depressed	Candidate
Dry Creek Coho	Not Identified as Distinct Stock	Unknown (very low numbers)	Candidate
Elwha Coho	Healthy	Healthy	Candidate
Upper Dungeness Pink	Depressed	Depressed	Not Warranted
Lower Dungeness Pink	Critical	Critical	Not Warranted
Morse Creek Pink	Not Identified as Distinct Stock	Depressed/Critical	Not Warranted
Elwha Pink	Critical	Critical	Not Warranted
Dungeness Summer Steelhead	Depressed	Critical	Not Warranted
Morse Creek Summer Steelhead	Not Identified as Distinct Stock	Unknown	Not Warranted
Elwha Summer Steelhead	Depressed	Critical	Not Warranted
Dungeness Winter Steelhead	Depressed	Critical	Not Warranted
Morse Creek/Independents Winter Steelhead	Depressed	Depressed	Not Warranted
Port Angeles Area Winter Steelhead	Not Identified as Distinct Stock	Unknown	Not Warranted
Elwha Winter Steelhead	Depressed	Depressed	Not Warranted

Data included in this report include formal habitat inventories or studies specifically directed at evaluating fish habitat, other watershed data not specifically associated with fish habitat evaluation, and personal experience and observations of the watershed experts involved in the TAG. These data provide an analysis of the salmonid habitat limiting factors in the Elwha-Dungeness watershed, also known as WRIA 18 (see location on Figure 1). Although many of the habitat data/observations in this report may not meet the highest scientific standard of peer reviewed literature, they should nevertheless be considered as valid, as they are based on the collective experience of the watershed experts that are actively working in these streams. Although there are a significant number of past studies and reports on these watersheds, a large number of salmonid habitat "data gaps" remain, which will require additional specific watershed research or evaluation. The available data indicate several common habitat themes across watersheds within WRIA 18, including:

- natural stream ecological processes have been significantly altered due to adjacent land management practices and direct actions within the stream corridor,

- substrate sediment transport processes have been altered to the extent that has resulted in stream morphology changes, either due to excess sediment contribution from land use practices in the watersheds, or preclusion of sediment transport due to dams
- fine sediment (<.85 mm) levels in the gravels of several streams are identified as likely being high enough to adversely affect spawning success and benthic invertebrate production,
- lack of adequate large woody debris in streams, particularly larger key pieces that are critical to developing pools, log jams, and other habitat diversity important to salmonids,
- lack of adequate pool frequency, or large deep pools that are important to rearing juvenile salmonids and adult salmonids on their upstream migration,
- loss of natural floodplain processes, due to confinement of channels by dikes, levees, bank armoring, and channelization, including the loss of functional off-channel habitat
- loss of riparian function due to removal/alteration of natural riparian vegetation, which affects water quality, lateral erosion, streambank stability, instream habitat conditions, etc.,
- the presence of a significant number of culverts/screens/dams/etc. that preclude unrestricted upstream or downstream access to juvenile and adult salmonids,
- significant increase in peak flow frequency and magnitude due to channelization, routing of stormwater through the irrigation delivery system, and increased stormwater runoff from lands that have been converted to non-forest status; many of the less developed streams are facing similar threats from further development and growth,
- alteration and reduction of the normal streamflow regime due to irrigation and other water withdrawals (the Dungeness River valley has the most intensively developed irrigation use of any river system in western Washington), and
- estuarine/marine function is significantly impacted by physical alteration of natural estuaries, by significant alteration of nearshore ecological function due to shoreline armoring, and by poor water quality in Port Angeles harbor.

There is stark contrast between watershed types and impacts across WRIA 18, mainly associated with topography and land use. Much of the Elwha River is located within the boundaries of the Olympic National Park (ONP), where habitat conditions are excellent. However, anadromous salmonids have been precluded from approximately 70 miles of mainstem habitat and all of the tributary habitat since the construction of Elwha Dam in 1910, and subsequent construction of Glines Canyon Dam upstream. The floodplain and channel downstream of the Elwha Dam has been altered by construction of dikes, water diversion pipelines, and development, although the impacts are less significant than in other watersheds in WRIA 18. The Elwha estuary and marine nearshore area has been significantly altered by the loss of sediment transport from the Elwha River and marine feeder bluffs, and by diking that has precluded flow through historic distributaries.

Most of the Dungeness River Watershed lies outside the ONP and salmonid habitat in the anadromous accessible zone has been heavily impacted by land use practices dating back to the mid-1800s. Dungeness River is the river system most affected by irrigation withdrawals in western Washington, and impacts to salmonids were identified in the early 1900s. Other major land use impacts to the Dungeness River and tributaries include logging impacts in headwater tributaries, agricultural and development impacts in the lower watershed, alteration of natural channel characteristics with heavy equipment, and floodplain constriction due to dikes, levies, and transportation corridors. Tributaries to the Dungeness River and independent drainages in the lower Dungeness valley are primarily low gradient streams flowing through agricultural areas and the City of Sequim. The flows in these streams are influenced by increased groundwater flows from irrigation runoff, and will likely be adversely affected by water conservation actions in the Dungeness River. However, the benefits to fish resulting from water conservation efforts that restore instream flow in the Dungeness River are expected to greatly overshadow the habitat losses in the smaller streams. The tributaries and independent drainages are also heavily influenced by a history of channelization, riparian vegetation removal, and open access to livestock. The Dungeness estuary has been completely modified from historic condition by extensive diking and conversion of historic estuary to agriculture and development lots. The marine nearshore habitat in Dungeness Bay has been affected by the alteration of sediment transport from the Dungeness River, by shoreline armoring, and by loss of eelgrass habitat. Morse Creek, a smaller watershed between the Dungeness and Elwha rivers, was also a significant producer of anadromous salmonids, particularly in relation to its size. The channel has been altered by channelization, forest practices, and development. Floodplain function has been severely altered by floodplain constrictions resulting from diking, development encroachment, and transportation corridors. Historic estuary conditions, thought to be in large part responsible for Morse Creek's productivity, have been basically eliminated by development. The marine nearshore habitat at the mouth of Morse Creek has been altered by historic railroad construction and armoring within the intertidal area, which has eliminated the shallow nearshore habitat to the west of Morse Creek.

McDonald, Siebert, Bagley, and Lees creeks, located between the Dungeness River and Port Angeles, flow through incised ravines and drain directly to the Strait of Juan de Fuca. The lower portions of these streams are generally intact, but habitat in the upper portions are adversely affected by recent forest practices, agricultural practices, and rural development. Habitat in these streams would benefit from restoration actions. The streams in the Port Angeles urban area (Ennis, Peabody, Valley, Tumwater, and Dry creeks) have been highly modified to accommodate urban and commercial development in Port Angeles. Ennis Creek has restoration potential, particularly with the closure and removal of the old Rayonier mill. The other streams have a number of severe habitat problems that will require significant effort and cost to effectively address. The marine shoreline is armored from the mouth of Morse Creek, west through Port Angeles to the end of Ediz Hook. This armoring effectively eliminates most, if not all, natural nearshore habitat function.

The streams in WRIA 18 have been ranked on the basis of salmonid productivity potential resulting from habitat restoration:

- Highest – Dungeness River (including tributaries), Elwha River, Morse Creek,
- Moderate – Ennis, Siebert, Gierin, and Meadowbrook, Bell, Cassalery, and McDonald creeks
- Lower –Cooper, Bagley, Lees, Valley, and Tumwater creeks
- Little potential – Peabody Creek, Dry, and White (tributary to Ennis) creeks

However, this ranking should not preclude projects in lower priority streams that will effectively address identified habitat limiting factors, particularly where willing landowners and partnerships can increase the effectiveness/efficiency of the restoration project. Habitat conditions also vary between different reaches of a stream; restoration proposals should consider the potential benefits of the proposal in relation to habitat conditions likely to be encountered by salmonids elsewhere in the stream. This ranking represents a snapshot in time; ranking and benefits may change as a result of habitat restoration successes.

In addition, restoration of the marine nearshore should be considered a high priority, based on benefits to all salmonid stocks including stocks originating outside WRIA 18.

Protection/restoration of salmonid resources can not be accomplished by watershed restoration projects alone. It is unlikely that we will be able to resolve the salmon predicament using the same land management approaches that got us into it. We will need to look at the watershed with a clear new vision. Salmonid recovery will require a combination of efforts, including:

- revision, implementation, and enforcement of land use ordinances that provide protection for natural ecological processes in the marine, instream, and riparian corridors, including measures to maintain impervious surfaces to levels, and in a manner, that will maintain natural hydrology,
- protection of marine, instream, and riparian habitat that is currently functioning, particularly key habitat areas, and
- restoration of natural marine, instream, and riparian ecological processes where they have been impaired.

This report provides information that can and should be used in the development of salmonid habitat protection and restoration strategies. It should be considered a living document, with additional habitat assessment data and habitat restoration successes incorporated as information becomes available.

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 is 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 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. In waters shared by salmon, steelhead trout and bull trout we will include all three. Later, we will add bull trout only waters as well as cutthroat trout.

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)

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 shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon 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, thus 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 out-migration 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 they 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 result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade 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 natal 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 results 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 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 lower 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 some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bulltrout, and 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. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

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, bulltrout, and certain 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 that amount of 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 again, off-channel habitat becomes important. During the winter, coho, steelhead, bulltrout, 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 are important habitat components during this time.

Except for bulltrout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards 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. Also, 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 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.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the 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. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile 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 River, 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, but not until August in Puget Sound. 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, and outmigration downstream to the estuaries occurs over a broad time 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.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles 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. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Steelhead 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. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

Bulltrout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bulltrout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

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 char, 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 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.

INTRODUCTION

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and large woody debris (LWD). These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors. Provided first though, is a general description of the current and historic habitat including salmon populations.

Discussion of Habitat Limiting Factor Elements

Fish Passage Barriers

Salmon are limited to certain spawning and rearing locations by natural features of the landscape. These features include channel gradient and the presence of physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some falls may be impassable at low flows, but then become passable at higher flows. In some cases flows themselves can present a barrier, such as when extreme low flows occur in some channels; at higher flows fish are not blocked. Flow conditions may also allow accessibility to some anadromous salmonid species, while precluding access to others.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and diversions with no passage facilities that prevent adult salmon from accessing historically used spawning grounds. However, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, in estuarine areas, dikes and levees have blocked off historically accessible estuarine areas such as tidal marshes, and poorly designed culverts in streams have impacted the ability of coho juveniles to move upstream into rearing areas. This chapter highlights known human-caused barriers to salmon and steelhead trout.

Functions of Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. In general, most floodplain areas are located in lowland areas of river basins and are associated with higher order streams. Floodplains are typically structurally complex, and are characterized by a great deal of lateral, aquatic connectivity by way of distributaries, sloughs, backwaters, sidechannels, oxbows, and lakes. Often, floodplain channels can be highly braided (multiple parallel channels).

One of the functions of floodplains is to provide aquatic habitat. Aquatic habitats in floodplain areas can be very important for some species and life stages such as coho salmon juveniles that often use the sloughs and backwaters of floodplains to overwinter since this provides a refuge from high flows. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape, lessening the impact of floods on incubating salmon eggs. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes. This acts as a filter of nutrients and other chemicals to maintain high water quality. Floodplains also provide an area for sediment deposition and storage, particularly for fine sediment, outside of the river channel, reducing the effects of sediment deposition and instability in the river channel.

Impairment of Floodplains by Human Activities

Large portions of the floodplains of many Washington rivers, especially those in the western part of the state, have been converted to urban and agricultural land uses. Much of the urban areas of the state are located in lowland floodplains, while land used for agricultural purposes is often located in floodplains because of the flat topography and rich soils deposited by the flooding rivers.

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain. This occurs both laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. This has: 1) eliminated off-channel habitats such as sloughs and side channels, 2) increased flow velocity during flood events due to the constriction of the channel, 3) reduced subsurface flows and groundwater contribution to the stream, and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed. Channels can also become disconnected from their floodplains as a result of downcutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. The natural riparian and terrestrial vegetation in floodplain areas was historically coniferous forest. Conversion of these forested areas to impervious surfaces, deciduous forests, meadows, grasslands, and farmed fields has occurred as floodplains have been converted to urban and agricultural uses. Loss of vegetation on the floodplain reduces shading of water in floodplain channels, eliminates LWD contribution, reduces filtering of sediments, nutrients and toxics, and results in increased water energy during flood flows.

Elimination of off-channel habitats results in the loss of important habitats for juvenile salmonids such as sloughs and backwaters that function as prime spawning habitat for chum, pink, and coho that is protected from flood flow impacts, and rearing and overwintering habitat for coho juveniles. The loss of LWD from channels reduces the amount of rearing habitat available for chinook juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

Streambed Sediment

The sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes which input, store, and transport the materials. Processes naturally vary spatially and temporally and depend upon a number of features of the landscape such as stream order, gradient, stream size, basin size, geomorphic context, and hydrological regime. In forested mountain basins, sediment enters stream channels from natural mass wasting events (e.g. landslides and debris flows), channel bank erosion (particularly in glacial deposits), surface erosion, and soil creep. Inputs of sediment to a stream channel in these types of basins naturally occurs periodically during extreme events such as floods (increasing erosion) and mass wasting which are the result of climatic events (e.g., rainstorms, rain on snow). In lowland, or higher order streams, erosion is the major natural sediment source. Inputs of sediment in these basins tend to be steadier in geologic time.

Once sediment enters a stream channel it can be stored or transported depending upon particle size, stream gradient, hydrological conditions, availability of storage sites, and channel type or morphology. Finer sediments tend to be transported through the system as wash load or suspended load, and have relatively little effect on channel morphology. Coarser sediments (>2 mm diameter) tend to travel as bedload, and can have larger effects on channel morphology as they move downstream, depositing through the channel network.

Some parts of the channel network are more effective at storing sediment, while other parts of the network are more effective at transporting material. There are also strong temporal components to sediment storage and transport, such as seasonally occurring floods, which tend to transport more material. One channel segment may function as a storage site during one time of year and a transport reach at other times. In general, the coarsest sediments are found in upper watersheds while the finest materials are found in the lower reaches of a watershed. Storage sites include various types of channel bars, floodplain areas, and behind LWD.

Effects of Human Actions on Sediment Processes

Changes in the supply, transport, and storage of sediments can occur as the direct result of human activities. Human actions can result in increases or decreases in the supply of sediments to a stream. Increases in sediment deposition in the channel result from increased erosion due to land use practices, or isolation of the channel from the floodplain (diking and roading), which eliminates important off-channel storage areas for sediment and increases the sediment load beyond the transport capacity of the stream. In addition, actions that destabilize the landscape in high slope areas such as logging or road construction increase the frequency and severity of mass wasting events. Finally, increases in the frequency and magnitude of flood flows, and/or loss of floodplain vegetation, increase erosion. These increases in coarse materials fill pools and aggrade the channel, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids. Increase in total sediment supply to a channel increases the proportion of fine sediments in the bed, which can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Decreases in sediment supply occur in some streams. This occurs primarily as a result of disconnecting the channel from the floodplain. A dam can block the supply of sediment from upper watershed areas while a levee can cut off upland sources of sediment. In addition, gravels are removed from streambeds to increase flow capacity (dredging) or for mineral extraction purposes. Reduction in sediment supply can alter the streambed composition, which can coarsen the substrate and reduce the amount of material suitable for spawning.

In addition to affecting sediment supply, human activities can also affect the storage and movement of sediment in a stream. An understanding of how sediment moves through a system is important for determining where sediment will have the greatest effect on salmonid habitat and for determining which areas will have the greatest likelihood of altering habitats. In general, transport of sediment changes as a result of gradient, hydrology changes (water removal, increased peak flows, or altered timing and magnitude of peak flows), and isolation of the channel from its floodplain. This increases in the magnitude and frequency of flood flows. Larger and more frequent flood flows move larger and greater amounts of material more frequently. This can increase bed scour, bank erosions, and alter channel morphology, and ultimately degrade the quality of spawning and rearing habitat. Unstable channels become very dynamic and unpredictable compared to the relatively stable channels characteristic of undeveloped areas. Additional reductions in the levels of instream LWD can greatly alter sediment storage and processing patterns, resulting in increased levels of fines in gravels and reduced organic material storage and nutrient cycling.

Riparian Zone Functions

Stream riparian zones include the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the average high water mark of the wetted channel toward the uplands to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the drainage network. Large-scale natural disturbances (fires, severe windstorms, and debris flows) can dramatically alter riparian characteristics. These natural events are typically infrequent, with recovery to healthy riparian conditions for extended periods of time following the disturbance event. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin unimpacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Functions of riparian zones include providing hydraulic diversity, adding structural complexity, buffering the energy of runoff events and erosive forces, moderating temperatures, and providing a source of nutrients. They are especially important as the source of LWD in streams which directly influences several habitat attributes important to anadromous species. In particular, LWD helps form and maintain the pool structure in streams, and provides a mechanism for sediment and organics sorting and storage upstream and adjacent to LWD formations. Pools provide a refuge from predators and high-flow events for juvenile salmon, especially coho that rear for extended periods in streams.

Effects of Human Activities on Riparian Zones

Riparian zones are impacted by all types of land use practices. In general, riparian forests can be completely removed, broken longitudinally by roads and laterally by bridges and culverts, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when native, coniferous trees are replaced by exotic species, shrubs, and deciduous species. Deciduous trees are typically of smaller diameter than coniferous forests and decompose faster than conifers, so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover regrows, and coniferous species colonize.

Changes to riparian zones affect many attributes of stream ecosystems. For example, stream temperatures can increase due to the loss of shade, while streambanks become more prone to erosion due to elimination of the trees and their associated roots. Perhaps the most important impact of riparian changes is a decline in the frequency, volume, and quantity of LWD due to altered recruitment from forested areas. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces the number of rearing salmonids. Loss of LWD affects the amount of both overwintering and low flow rearing habitat, as well as providing a variety of other ecological functions in the channel.

Water Quantity

The hydrologic regime of a drainage basin refers to how water is collected, moved and stored. The frequency and magnitude of floods in streams are especially important since floods are the primary source of disturbance in streams and thus play a key role in how channels are structured and function. In ecologically healthy systems, the physical and biotic changes caused by natural disturbances are not usually sustained, and recovery is rapid to pre-disturbance levels. If the magnitude of change is sufficiently large, however, permanent impacts can occur.

Alterations in basin hydrology are caused by changes in soils, decreases in the amount of forest cover, increases in impervious surfaces, elimination of riparian and headwater wetlands, and changes in landscape context. Hydrologic impacts to stream channels occur even at low levels of development (<2% impervious surfaces) and generally increase in severity as more of the landscape is converted to urban or open uses.

Salmonid production is profoundly affected by water withdrawals for irrigation, industrial, and domestic use, including water transfers between basins. Removal of water either directly from the stream channel or from wells that are in hydraulic continuity with stream flows reduces the amount of instream flow and wetted useable area remaining for support of adult salmonid spawning and juvenile rearing. The relationship between the wetted useable area of a stream and stream flow varies between species and life stages. For example, juvenile coho prefer quiet water in pools for rearing, whereas juvenile steelhead prefer areas of faster water (Hiss and Lichatowich 1990). Impacts are typically greatest during the dry summer and early fall months when stream flows are lowest. In other instances stream flows may actually increase due to direct or indirect (irrigation ground water return flows) water transfers from other basins. In some instances peak flood flows may be transferred to basins that would otherwise not be affected by flood flows. These situations may increase the stream flow and wetted useable area for fish use, but the increased hydrology may cause channel bedload movement, bank erosion, loss of LWD, and other adverse habitat impacts that would not be experienced under the natural hydrology regime to which the channel is adapted.

The presence of the extensive irrigation system within the Dungeness Area Watershed is unique in western Washington. Historically, the routing of irrigation ditches across the very coarse and well-drained soils of the lower valley resulted in a great deal of water loss from the ditches and an increased contribution of water to the shallow groundwater aquifer. Irrigation practices themselves, primarily the widespread use of flood irrigation also contributed to an elevated water table in the valley. These elevated groundwater levels, and direct surface connections to the irrigation system, resulted in increased stream flows and an increase in stream length in the independent streams of the lower Dungeness valley, such as Bell, Gierin, Cassalery, Cooper, Hurd, and Matriotti creeks. Conservation of irrigation water has resulted in localized lowering of the water table, loss of stream length (especially for Gierin, Cassalery, and Hurd creeks), and/or a lengthened period of dewatering in the summer relative to conditions in the mid-1980s. This phenomenon was discussed at length in the Dungeness-Quilcene Water Resources Plan (DQ Plan), which was completed in 1994. The participants in the plan made a conscious decision that the negative effects on the independent tributaries, resulting from irrigation conservation, were outweighed by the beneficial effects that conservation has on fish habitat and water quality in the mainstem Dungeness River.

The Dungeness River mainstem loses a significant amount of water to the water table, and water conservation to retain flow within the Dungeness does not result in a total loss of water to the tributaries and independent drainages of the lower valley. This is because the majority of flow in all of these drainages comes from springs, which are connected to the same water table. The flow in these streams mirrors the seasonal height of the water table, which is largely controlled by the amount of recharge the Dungeness River provides to the water table. Accordingly, these flows mirror flows in the Dungeness River – more flow during the winter, lower flows during late-February, March, and April; and higher flows during the smowmelt to May, June, and July**.**

These watershed-unique factors are critical to evaluation of some of the water-quantity information presented later in this report in the Habitat Limiting Factors by Sub-Basin section. The hydrologic models used in the "toe-width methodology" for determining recommended flows (used for the independent drainages of the Dungeness Area Watershed), as well as the models in the Instream Flow Incremental Methodology (IFIM) study on the Dungeness, may not match local conditions (Joel Freudenthal). The flow curves, on which these models are generated, are based on the hydrology of streams draining the Cascades of western Washington and Oregon, which typically have rain or rain-on-snow winter peak flows, as opposed to the bi-modal (December-January and May-June) average annual peak flows that occur in the streams which drain the northeastern Olympic Peninsula (Joel Freudenthal). Consequently, many of the recommended flows (especially the March-April flows) based on toe-width measurements, as referenced in the Habitat Limiting Factors by Sub-Basin chapter of this report, may be physically impossible to achieve. There is also concern that the Cascades life-history effect modeling may not be representative of conditions observed on the north Olympic Peninsula (Joel Freudenthal). However, this does not necessarily invalidate the conclusions of the Dungeness IFIM. For instance, marginal increases in summer flows in the Dungeness will result in a relatively large increase in habitat for chinook, as the IFIM model demonstrates.

Secondly, channel width measurements used as input values in the "toe-width methodology" used for tributary and independent stream in the Dungeness Area Watershed may reflect artificially elevated average flows and peak flows, due to past influences of irrigation diversions that resulted in higher groundwater and stormwater inputs to these streams. Flows in these streams have decreased as a result of water conservation from the Dungeness itself. As these streams return to a more natural channel configuration (which may take several decades), it is anticipated that channel widths will decrease (in the absence of other hydrologic modifications), and the recommended flows generated by the toe-width model will also decrease. This should not be interpreted to mean that maintenance of sufficient flows in these streams is unimportant, rather that we currently lack the tools and historic information regarding channel conditions to accurately describe the flows in these streams under pre-settlement conditions, or the optimal flows for sustaining their ecological integrity.

Estuarine Habitat

Worldwide, few other habitats are so valuable for fish production and yet are so imperiled as estuaries. Estuaries include the area from the uppermost extent of tidal influence within the stream to the upper intertidal line on the delta face. Their abundant food supply, wide salinity gradients, and diverse habitats make these areas particularly valuable to anadromous fish for rearing, feeding, and osmoregulatory acclimatization during transition between fresh water and marine habitats (Macdonald et al 1987). The vital role estuaries play in chum salmon ecology (Walters et al. 1978; Healy 1980A, Levy and Northcote 1982) is a basic tenant of salmon biology. Other species of salmonids are also known to inhabit estuaries, sometimes in high densities, include coho (Tschaplinski 1982, Mason 1974, Miller and Simenstad 1997, Nielsen 1994, Hiss 1994), sockeye (Healy 1980A), pinks (Hiss 1994), and chinook (Levy and Northcote 1982, Healy 1980A, Healy 1980B, Congleton et al 1981, Shreffler et al 1992). According to Levy and Northcote (1982), significant estuary rearing by chum and chinook fry on the Fraser River Delta extends even into tidal channels that are dewatered during normal low tides. In the Skagit River Estuary, Beamer and LaRock (1998) found high densities of chinook, chum, and smelt (Hypomesus pretiosus pretiosus) inhabiting a salt marsh tidal channel (Browns Slough) that was not associated with any freshwater stream. Also found in Browns Slough were coho smolts and adult cutthroat trout engorged on smelt. Juvenile chinook have been documented in at least two Puget Sound estuarine salt marshes not associated with chinook spawning streams - Shine Creek on the Olympic Peninsula (Lichatowich 1993) and Seabeck Creek on the Kitsap Peninsula (Hirschi, personal communication). The spawning of Pacific herring, an important forage fish for salmonids, has been documented in Willapa Bay and Grays Harbor estuarine salt marshes, but the presence or importance of Pacific herring has not been assessed in Strait of Juan de Fuca estuaries.

Extensive loss and impairment of estuarine habitat has occurred within WRIA 18. These impacts are described in the Habitat Limiting Factors by Sub-Basin and Marine Habitat Limiting Factors sections of this report.

WATERSHED DESCRIPTION

WRIA 18 General Watershed Description

General

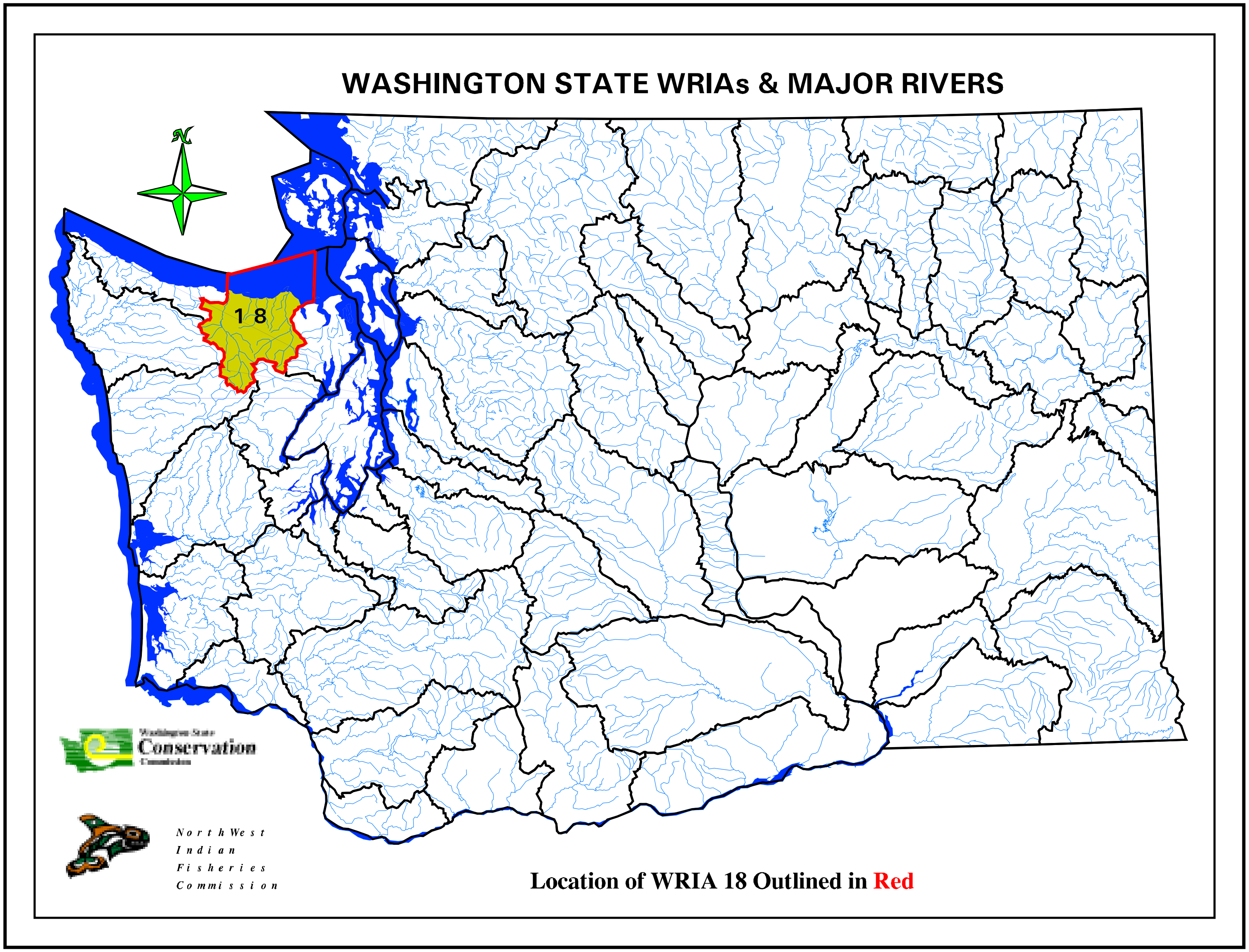
Water Resource Inventory Area (WRIA) 18 is located on the north end of the Olympic Peninsula (Figure 1). It includes two major river drainages, the Dungeness and Elwha, and a number of smaller watersheds that drain independently to the Strait of Juan de Fuca. The upper end of several of the drainages is located within the boundaries of the Olympic National Park (ONP), which covers much of the interior of the northern portion of the Olympic Peninsula. Rainfall is variable with 240 inches/year of precipitation in the headwater mountains of the Elwha (Amerman and Orsborn 1987), to only 15 inches/year in the low elevation lands of the Dungeness River Watershed that are affected by the Olympic rainshadow.

Watershed description information has been compiled from previous reports on the watersheds in WRIA 18. Generally, in this document the watershed descriptions in WRIA 18 progress from east to west, and for drainages where tributaries are discussed, they generally progress from lower to upper tributaries in each watershed. Because these descriptions are an artifact of organization of previous reports, there are two areas where several drainages are consolidated within a larger watershed context; the Dungeness Area Watershed discussion (includes drainages from Gierin Creek to the east to Bagley Creek to the west, including the Dungeness River and tributaries), and the Port Angeles Urban Watersheds (including Ennis, Peabody, Valley, Tumwater, and Dry creeks). Bell Creek is discussed separately, although it could also be considered as part of the Dungeness Area Watershed. However, Bell Creek was not included in land use summary calculations in the Puget Sound Cooperative River Basin Team (PSCRBT 1991) report on the Dungeness Area Watershed that is referenced below.

Bell Creek

Bell Creek lies at the extreme eastern end of WRIA 18, flowing into Washington Harbor at the entrance to Sequim Bay. It is identified separately from other Dungeness Area Watershed streams, because it was not included in the Dungeness River Area watershed description or land use analysis conducted by the PSCRBT (1991). Similar to the Dungeness River, Bell Creek is located in the rain shadow of the Olympic Mountains, with an average rainfall of approximately 15 inches. Bell Creek is approximately 3.8 miles long and drains 8.9 $mi.^2$ of low elevation watershed. The creek flows from the uplands of Happy Valley and the north flank of Burnt Hill, through the eastern portion of the City of Sequim, and into Washington Harbor (De Lorm 1999). Historically, the creek was probably an ephemeral stream fed by rain run-off, but similar to other independent streams included in the Dungeness Area Watershed description, it has been heavily influenced by irrigation runoff since the initiation of irrigation from the Dungeness River and the channeling of stormwater from the base of Bell Hill. The headwaters of Bell Creek are heavily influenced by the growing community development of Sequim, and much of the rest of the watershed is in rural agriculture.

Figure 1: Location of WRIA 18 in Washington State



Dungeness Area Watershed (modified from PSCRBT 1991)

The following description of the Dungeness Area Watershed includes the Dungeness River, as well as the independent drainages (from east to west) of Gierin , Cassalery, Cooper, McDonald, Bagley, and Siebert creeks. Although these drainages drain independently to the Strait of Juan de Fuca, they are jointly discussed in this watershed description, in large part due to the connectivity of these systems through the irrigation distribution network and influences from the Dungeness River. However, habitat limiting factors will be discussed separately for each of these drainages in following sections.

The Dungeness River Area Watershed is located in the northeastern corner of the Olympic Peninsula. The watershed drains 172,517 acres. Mount Constance is the highest point in the watershed (7,743 feet) and forms the southern boundary. Adjacent watersheds are Maiden Creek and the Elwha River on the west, Sequim Bay on the east, and the Dosewallips River on the south. The western portion of the City of Sequim is the only incorporated area in the watershed, however unincorporated areas are located at Carlsborg, Oldtown, Agnew, Sequim Valley and Dungeness. The population of the watershed is over 13,600. Figure 2 provides an aerial view of the lower portion of the Dungeness Area Watershed (1993 photo), including the entry of the river into Dungeness Bay.

Figure 2: Aerial View of the Lower Dungeness Area Watershed (1993 photo, courtesy of Randy Johnson)

The watershed topography includes three distinct areas: mountains; foothills; and the alluvial fan adjoining the Strait of Juan de Fuca. The mountainous area includes lands within Olympic National Park and Olympic National Forest. Slopes in these areas range from 20% in the foothills to 100% in the rocky peaks. The agricultural and residential areas in the northern portion are gently rolling to nearly flat. The foothill areas range from flat valley bottom to moderate 40% slopes. Very steep bluffs dominate the marine shoreline west of the Dungeness River.

There are 546 miles of streams and tributaries in the watershed. The major subdrainages are the Dungeness River (including the Meadowbrook, Matriotti, Hurd, Bear, Canyon, and Gray Wolf subbasins), McDonald, Siebert, Bagley, Cassalery and Gierin Creeks. These streams flow into the Strait of Juan de Fuca, which includes 33 miles of shoreline on the northern edges of the watershed. The Dungeness River irrigation system was mapped in 1998 as part of the Comprehensive Water Conservation Plan (Montgomery, 1999) and contains approximately 62 miles of main ditch canal and another 111 miles of secondary ditches and laterals, carrying water from the Dungeness River to agricultural and residential lands. Irrigation ditches play an important role in groundwater recharge in the lower watershed. Although the City of Sequim has historically diverted flow from the Dungeness River for its municipal supply, they are changing to reliance on ground water (surface water right is retained for emergencies).

The climate is mild, reflecting the moderating influence of winds from the Pacific Ocean. Portions of the Dungeness Area Watershed lie in the "rain shadow" of the Olympic Mountains, with substantially reduced rainfall compared to other watersheds in western Washington. Precipitation varies from 15 inches adjacent to Sequim to 140 inches in the upper headwater peaks (Amerman and Orsborn 1987) of the Dungeness River. Prevailing winds blow from the Pacific Ocean along the Strait of Juan de Fuca. Infrequent high-pressure cells over southern British Columbia produce strong northeasterly wind patterns. These events in September or October produce high temperatures, which combined with low relative humidity, make an extreme fire hazard and have a strong influence on the vegetative cover. In late December or January, they produce extreme cold temperatures and heavy snowfall. The majority of the precipitation in the upper Dungeness drainage occurs from November through March.

The natural fire disturbance history is infrequent, on the order of several hundred years between major catastrophic fires. In 1890-1891, a large fire started in the foothills near Sequim, burning approximately 30,000 acres mostly in the Dungeness watershed. In 1902, there was a smaller fire near Tubal Cain Mine in the Silver Creek basin (Henderson et al 1989, as referenced in Orsborn and Ralph 1992).). The USFS Watershed Analysis also indicates that large-scale windthrow is not a major disturbance factor in the Dungeness Watershed, and that wildfire is also not a major factor, with periodicity of approximately 200 years.

In the Dungeness Area Watershed, there are 353 regulated wetlands totaling 4,525 acres, and 174 artificially created ponds totaling 156 acres. Nineteen of the wetlands make up 57% (2,579 acres) of the wetland acreage (Joel Freudenthal). Hydric soils cover an additional 4711 acres (2.7% of the watershed). The largest wetland systems are in the lower watershed. The predominant wetland type is palustrine emergent, occupying 2142 acres (47% of identified wetland acreage). Sixteen percent of watershed wetlands are intersected by streams, affecting 69% of the mapped wetlands; 10% of watershed wetlands are intersected by irrigation ditches, affecting 56% of mapped wetlands – some are intersected by both. Most wetlands are disturbed. Wetlands lack adequate protection and are under the most serious threat from increasing residential development. Wetlands that occur along salt or fresh water shorelines are especially threatened. The majority of wetlands visited in the field had >60-80% vegetation cover, with forested wetlands with dense understory commonly adjacent to major streams (PSCRBT 1991). Loss rate of wetlands is presumed to be similar to the statewide estimate of 33-50% (Canning and Stevens 1989, as referenced in PSCRBT 1991).

During the Vashon stade (approximately 10,000 years ago), glaciers extended across the Strait of Juan de Fuca and up the Dungeness valley approximately 11 miles to the 2,500 foot elevation , and up the Gray Wolf to the 1,600 foot elevation. Large lakes formed behind the ice dams, accumulating thick beds of sediments in the Gold Cr., Dungeness, and Gray Wolf drainages (Henderson et al., 1989 as referenced in Osborn and Ralph, 1992). Kohler et al (1989, as referenced in Orsborn and Ralph, 1992) concludes that the primarily sedimentary geology, with an overlay of lake deposits on top of glacial and alluvial morrains, is responsible for the inherent instability of the upper watershed.

The instability of the upper watershed has provided the upper Dungeness River with a huge load of coarse and fine sediments. As these sediments were transported out of the upper watershed they were deposited in a large alluvial fan. This alluvial fan gives the "Dungeness Valley" a unique topography and contributes to stream instability. As the river deposited sediments in the lower valley, channel migration occurred across the alluvial fan. The Dungeness River once flowed down the present courses of Bell, Gieren, Cassalery, Hurd, and Meadowbrook Creeks to the east of the current location of the river. To the west, the river once flowed throughout lower Matriotti Creek, almost as far west as McDonald Creek. As a result, all of the above mentioned creeks have a floodplain which is larger than what would be expected for the streams in the lower valley, especially spring-fed streams such as Gieren, Cassalery and Meadowbrook. The unique situation of the oversized floodplains for these streams means that floodplain modifications have different effects on these streams than other streams in WRIA 18. Many of these streams have been affected by channelization in these fertile former floodplains of the Dungeness, and this type of activity has had a great effect on these streams.

Streams that have their headwaters in the foothills, such a Bell, Matriotti, McDonald, Siebert and Bagley Creeks, (and other streams in the Port Angeles Area) are subject to hydrologic/stormwater effects as a result of forestry activities and permanent loss of forest cover due to conversion to residential development. These effects are especially severe in low elevation rainstorms or rain-on-snow events such as the January 1997 and January 1999 rain storms. These storms did not produce significant flood events in the larger river systems of the Dungeness and Morse Creek, but did cause substantial flooding and flood-related damage in Sequim (from Bell Creek), and on Kitchen-Dick and Atterberry Roads (from Matriotti Creek and drainages to McDonald Creek). The effect of these impacts is to increase erosion in the small headwaters streams as well as increased stream power to transport sediment and erode streambanks lower in the system. These effects are visible on Bell, Matriotti, McDonald, Siebert, Bagley, and other streams that drain from the foothills.

The Dungeness River Area Watershed contains a diverse array of land uses and cover types. Land uses includes pasture, hayland and cropland on both commercial and small farms, residential development scattered throughout the lower watershed, private and public forestland in the upper watershed, as well as a large portion of the Olympic National Park.

Table 2 indicates public and private forestlands total 74,624 acres (43% of the watershed). Of this, 28,058 acres are available for timber production, and 46,566 acres are assigned as wilderness or in habitat conservation areas (PSCRBT 1991). Of the 58,272 acres in the watershed that are in Olympic National Forest ownership, 18,616 acres (32%) are in riparian reserve (Dungeness Area Watershed Analysis Cooperative Team (DAWACT) 1995).

Table 2: Land Use in the Dungeness Area Watershed (modified from PSCRBT 1991)

Land Use	Acres	Percent of Area Watershed
Commercial Forestland	74,624	43.26
Residential High Density	1,364	0.79
Residential Low Density	5,940	3.44
Cropland	420	0.24
Pasture/Hayland	9,899	5.74
Grass/Scrub/Shrub	7,103	4.12
Private Woodlots	8,735	9.07
Conversions	2,377	1.38
Urban Lands	410	0.24
Ponds/River Channels	808	0.47
Quarries	167	0.10
Olympic National Park	51,308	29.74
Unclassified	9,362	5.43
Grand Total	172,517	100.00

Rural/Agricultural land occupies 35,838 acres (21% of the watershed) including residential, pasture and hayland, cropland, and private woodlots. The number of irrigated acres used for commercial farms decreased from 11,970 in 1954 to 4,748 in 1987; the number of dairy farms decreased from 679 in 1954 to 27 in 1987 (DAWACT 1995). The Rural/Agricultural area is generally defined as the area between forestlands and incorporated urban areas. Over 10,000 acres of land are used for crop, hay and pastureland. Seventy to eighty percent of the agricultural land is irrigated from water diverted from the Dungeness River and area streams through an extensive network of irrigation ditches. The agricultural survey identified 604 small farms (non-commercial) in the watershed. Most are located north of Highway 101 with the remainder scattered throughout the watershed. Thirty-four commercial farm operations were found in the watershed. The largest contributor of nonpoint pollution in the Dungeness watershed was identified as agricultural activities, including irrigation diversions and laterals, direct animal access to waterways, and chemical application (Tetra Tech 1988). Rural residential areas include 3,960 housing units broken down into two densities, high (less than1.5 acres per housing unit) and low (1.5 to 5 acres per housing unit). The entire rural/agricultural area accounts for over 90% of the watershed's population. More than 7,100 acres are not intensively used, and are in either a grass or shrub cover. In the past, most of this land was probably farmed but now is being held either for recreational or investment purposes. Private woodlots, which are not intensively managed for timber production, make up another five percent of the watershed. Land under conversion, predominately from forest or agricultural to residential use, covered nearly 2,400 acres in 1990.

Urban areas (410 acres)(PSCRBT 1991, significant urban/suburban development has occurred since these 1991 estimates, but revised estimates are unavailable) within the watershed include portions of the City of Sequim and the Sunland development. In this watershed the Sunland development, even though not an incorporated city, is included under the urban category since it has a small lot housing density and contains its own water and sanitary sewer facilities. Most of the urban area included in the watershed is used for residential purposes; however, some business establishments exist along the west and northern boundaries of Sequim. Other business establishments are scattered along Highway 101 and in the vicinity of the communities of Carlsborg and Dungeness. Much of the rural residential development that is occurring in the watershed is not supported by sanitary sewers. Approximately 82% of the soils within the watershed have severe limitations for on-site septic use (PSCRBT 1991).

The other category (61,645 acres or 36 percent) includes lands covered by ponds and the Dungeness River channel; sand and gravel quarries; and unclassified lands (beaches, subalpine, rock outcrop areas). The largest area under one management entity is Olympic National Park, covering 51,300 acres or 30% of the entire watershed.

Please refer to the Introduction and Habitat Limiting Factors by Sub-Basin chapters of this report for discussions of the effects of the extensive irrigation diversion network in the lower Dungeness Area Watershed.

<u>McDonald Creek</u>

McDonald Creek is located between Siebert Creek to the west and the Dungeness River to the east. The McDonald Creek drainage is included as part of the previous discussion of the Dungeness Area Watershed. The following information provides additional information specific to McDonald Creek. Stream length is 13.6 miles, draining a watershed area of 23.0 mi^2 (14,600 acres). The headwaters originate at 4,700 feet and the high gradient headwaters flow through a deeply incised coastal upland and marine bluff before entering the Strait of Juan de Fuca. Topography and land uses are similar to those described for Siebert Creek, however, agricultural impacts, including water withdrawals, are considered more significant (McHenry et al. 1996).

<u>Siebert Creek</u>

The Siebert Creek drainage is included as part of the previous discussion of the Dungeness Area Watershed. The following information provides additional information specific to Siebert Creek. Siebert Creek is located approximately midway between Port Angeles and Sequim, draining an area of 19.5 mi^2 (17,200 acres). The creek is 12.4 miles long, draining directly to the Strait of Juan de Fuca (Williams et al. 1975). Siebert Creek drains the low hills paralleling the Strait of Jan de Fuca, and the upper reaches of the watershed are typically steep and incised at elevations up to 3,800 feet. Land in the upper watershed is managed for commercial forestry, with the extreme headwaters located in the Olympic National Park. The lower reaches contain both moderate and low-gradient habitat, with land uses including commercial forestry, agriculture, and increasing levels of real estate development (McHenry et al. 1996).

<u>Morse Creek</u>

Morse Creek is the largest of the independent drainages to salt water between the Dungeness and Elwha rivers, entering the Strait of Juan de Fuca approximately 2 miles east of Port Angeles.

Morse Creek is a moderate sized watershed that drains steep headwaters of Olympic National Park including Hurricane Ridge, Mt. Angeles, and Deer Park. Within the Morse Creek watershed, 28,800 out of the total 36,600 acres, or approximately 10% are in the Olympic National Park (Tetra Tech 1988). Like other watersheds on the North Olympic Peninsula that accumulate significant snowpack, Morse Creek exhibits two peaks in annual discharge (one associated with winter rainstorms and the other resulting from spring snowmelt). Morse Creek is known to have produced a high diversity of salmon species in greater numbers than would be expected for a stream of its size.

Lees Creek

Lees Creek currently supports very low numbers of anadromous salmon, limited to a few returning coho and steelhead. The mouth of Lees Creek is a "closed channel" through the summer, isolated from the Strait of Juan de Fuca by a natural sand spit during low flow periods. Ingress or egress access for anadromous salmon is only provided when flows and tides increase to the extent that the sand spit is overtopped. Historically, closed streams may have had fewer anadromous fish as compared to streams with fully developed estuaries. However, it is difficult to assess the historic populations of salmon in Lees Creek because the watershed was already largely degraded 80–90 years ago**.** There is a perched culvert (installed by Bruch) close to the mouth, with a significant drop at the outlet, that is a total barrier to anadromous fish (Walt Blenderman). In 1998. a fishway was installed in the culvert beneath Highway 101 (Carl Ward), which has been a barrier since approximately 1940 (Dick Goin). The fishway is not functioning properly, requiring further modification. Other upstream culverts (e.g., Marsden Road) remain as total fish passage barriers. In addition, fish passage may be limited by logjams north of Highway 101. Cutthroat populations occur in the upper portions of both the East and West forks.

Port Angeles Urban Watersheds

The streams within the Port Angeles urban area include Ennis Creek, Peabody Creek, Valley Creek, Tumwater Creek, and Dry Creek. Approximately 10% of the Tumwater, Peabody, and Valley creeks sub-basin, and 1% of the Ennis Creek sub-basin is located within the Olympic National Park (Tetra Tech 1988). Until the early 1900s, much of what is now downtown Port Angeles existed as low lying marine waterfront (shoreline) and shallow subtidal areas. To increase dry land for commerce and industry, this area was gradually filled with upland soils and nearshore dredge materials over a 40-year period, ending in the early 1950s (Economic and Engineering services, Inc. 1996). The Port Angeles urban streams have been viewed as "impediments to development" of the urban Port Angeles area. Drainage patterns have been changed, channels have been straightened, numerous road fills and culverts have been placed, etc.. Later, these streams were actively used for sewage disposal and as stormwater conduits (Mike McHenry, Pat Crain).

There are no major lakes within the anadromous zone of streams in the Port Angeles area watershed. Lake Angeles, a small alpine lake is located in the western portion of the Morse Creek sub-basin. Dawn Lake is located in the upper Ennis Creek basin. Neither of these lakes are considered to contribute to habitat limiting factors.

Ennis Creek is the smallest snow fed stream on the North Olympic Peninsula. The watershed is approximately 10.5 mi^2 (12,300 acres) in size, with the headwaters located at the 6,000-ft. elevation in Olympic National Park near Klahane Ridge. Ennis Creek is generally considered the healthiest of the Port Angeles urban streams. Steelhead, coho, cutthroat and char have been observed in the basin in recent years. Smolt trapping conducted in 1998 showed that steelhead are currently the most abundant species in Ennis Creek (Unpublished Data, WDFW). The gradient of Ennis Creek is generally steep and confined within much of its length by valley side slopes. Upstream of the old dam diversion site at RM 3.0, the channel bed is dominated by cobble and large gravel substrate with intermittent outcrops of bedrock. The lower portion of the creek is channelized and constrained between the former Rayonier mill and the Port Angeles wastewater treatment plant. The mill is currently being dismantled and a cleanup of the site will be conducted in the next several years. The mill is known to have contaminated soils, groundwater, Ennis Creek and Port Angeles Harbor with various toxic substances including dioxin, heavy metals and PCB's (EPA 1999). White Creek, a major tributary that enters Ennis Creek at RM 0.3, is heavily degraded from urbanization (including construction of a motel over the watercourse, which is now encased in a bottomless culvert) and has little production potential due to extensive culverting and impassible culverts.

A Klallam village site (Y'inis) was historically located at the mouth of Ennis Creek. In the late nineteenth century the first cooperative colony in Washington was constructed at this location. A large pulp mill followed in the 1930's.

Peabody Creek is a rain dominated watershed that drains off the low foothills paralleling the Strait of Juan de Fuca. The 4.8 mile long stream drains through heavily urbanized areas of Port Angeles. The watershed is 2.6 mi^2 in size, with headwaters in the lower foothills at the northern boundary of ONP (Economic and Engineering Services, Inc. 1996). Sewage was historically discharged directly to Peabody Creek. The creek still serves as a Combined Sewer Overflow (CSO) for a small portion of the City of Port Angeles. Improvements to the stormwater/sanitary sewer system in 1996 eliminated the major source of raw sewage to the creek. The remainder of the upgrade to eliminate the CSO will occur in the near future (Joel Freudenthal). Vast quantities of stormwater are currently routed into the creek. Historic logging has occurred throughout the watershed. A portion of the upper stream corridor was included in recent additions to Olympic National Park associated with the Hurricane Ridge Road. Coho and possibly chum salmon have been historically observed, but are thought to be extirpated. Currently only cutthroat trout are known to utilize this creek.

The Valley Creek watershed is 2.4 mi^2 in size, with headwaters in the lower foothills at the northern boundary of Olympic National Park (Economic and Engineering Services, Inc. 1996). Sixty percent of the watershed is in urban land use, with 50% of that land in impervious surface (TetraTech 1988). Valley Creek has been significantly altered to accommodate urban and industrial development in Port Angeles, and is heavily impacted by stormwater runoff from the urban and industrial development. The level of habitat degradation has been great enough to extirpate all salmonid species except for cutthroat trout. Ironically, with the construction of an engineered 1.5 acre estuary in 1998, Valley Creek is now the primary focus of restoration efforts within the urban streams of Port Angeles. A conceptual restoration plan for the watershed has been developed (McHenry and Odenweller 1998).

The Tumwater Creek watershed is approximately 5.6 mi^2 in size, with headwaters in the lower foothills at the northern boundary of Olympic National Park. The upper portion of the watershed has been modified by past and ongoing forest harvest, with a mosaic of timber age and altered hydrologic character. The central and lower portions of the stream have been modified by residential, agricultural, road, and commercial/industrial development (Economic and

Engineering Services, Inc. 1996). Tumwater Creek is another stream in Port Angeles that is heavily impacted by urban and industrial development in the lower reaches. Rural development and impacts of stormwater runoff have created serious habitat problems throughout the watershed. Sediment yield from a stormwater related massive gully head-cutting off Black Diamond Road is so great that Tumwater Creek remains highly turbid throughout the winter. Although this has been a long-standing problem, the extent of impact worsened as a result of increased slide and erosion activity in 1997. Tumwater Creek historically supported populations of coho, chum and steelhead. Chum salmon have been extirpated and coho and steelhead productivity is currently limited. Smolt trapping conducted in 1998 yielded only 119 and 320 coho and steelhead smolts, respectively (Unpublished Data, WDFW).

Dry Creek

Dry Creek is a small watershed (6.5 mi^2, 4,600 acres) on the west side of Port Angeles that drains the north side of the foothills of the Elwha River immediately south of Highway 101. Downstream of Highway 101, Dry Creek flows across a broad glacial out-wash plain. This area was historically forested with very large cedars. This vegetative community is indicative of a perched water table, which reflects the presence of an impermeable glacial till layer just below the soil surface. Much of this area has been filled to accommodate industrial development east of Dry Creek, and modified by the Port of Port Angeles for airport upgrades. After flowing over this glacial out-wash plain, Dry Creek flows over an impassable 20-foot bedrock falls/cascade and enters a ravine flowing another mile north before entering the Strait of Juan de Fuca near Angeles Point.

Elwha River

The Elwha River is certainly the largest and historically the most productive river within WRIA 18, and possibly the Olympic Peninsula. It originates on the south and east sides of Mt. Olympus, deep in the Olympic National Park, and flows first south, then making a 180^o turn to flow northward to the Strait of Juan de Fuca. Most of the tributary headwaters originate at about the 4,000-foot elevation. The Elwha drains 321 square miles (208,000 acres), 83% (183,000 acres) of which is located within the Olympic National Park. Despite the rugged headwater terrain, the river maintains mostly moderate gradient throughout much of its length, with excellent pool-riffle areas and occasional cascades and rapids. The mainstem is approximately 45 miles in length, with 100 miles of tributary streams (Williams et al. 1975). Precipitation in the drainage is influenced by the rainshadow created by the Olympic Mountains. Annual precipitation in the upper watershed averages 200+ inches, while that of the lower drainages averages 56 inches (Dept. Interior et al. 1994). Because the Elwha River is snow-field-fed, streamflows have a bimodal discharge pattern; peaks occur during winter freshets and, at a lower level, in late spring or early summer from snowmelt (Munn et al. 1998). Average monthly flows are highest in June; average daily flows are highest in November/December (Pat Crain/Mike McHenry; Munn et al. 1996, as referenced in Munn et al. 1998).

The Elwha supported legendary runs of salmon including at least ten species of anadromous salmonids (summer/fall chinook, spring chinook, coho, winter steelhead, summer steelhead, pink, chum, sockeye, sea-run cutthroat, native char). Hydroelectric dams were constructed in the early part of the century at RM 4.9 and 13.2 without fish passage facilities, preventing salmon from reaching their historic spawning and rearing areas. This immediately eliminated up-river production of coho, spring and summer chinook, winter and summer run steelhead, and char.

Some lower river stocks such as pinks, chums remained at relatively high abundance into the mid 1960's. However, ecological changes associated with the dams, including the truncation of gravel recruitment in combination with channelization, ultimately led to the collapse of these stocks by the 1970's. Today, natural production of salmon is limited to just a few areas in the lower river. Hatchery supplementation is necessary to maintain production of summer/fall chinook, fall coho, and winter steelhead.

DISTRIBUTION AND CONDITION OF SALMON AND STEELHEAD STOCKS

General

> ***The wild stocks were tougher than anything nature threw at them, they were hard to kill. So you ask yourself, "Why are they gone now?" The answer is it took us all this time to kill them, they were tough!***
> (from Lichatowich interview with Dick Goin)

Lichatowich (1992) estimates that the population size of salmon stocks in the Dungeness River were substantially larger for several thousand years before Euro-American settlement than those today. Estimates of historic fish numbers based only on consumption by S'Klallam Indians range from 12,470 to 63,667. Estimates of run size based on harvest rate by S'Klallam Indians range from 17,814 to 106,111. Estimates of run size, based on production of pink and chinook in pristine spawning habitat expanded by harvest rate, range from 19,502 to 26,003 chinook salmon and 449,350 to 599,133 pink salmon. Although the accuracy of these estimates is open to some debate, they contrast starkly with recent average spawning escapements of less than 15,000 fish for all species combined, most of which are coho supported by the hatchery production (see graphs of individual species spawning escapements below). The actual pink salmon spawning escapement to the Dungeness River in 1963 of >400,000 fish is a verification that the historic abundance estimates may be realistic. In addition, estimates of historic salmon and steelhead numbers to the Elwha River indicate runs of approximately 400,000 fish (ONP 1995).

WRIA 18 salmon and steelhead distribution (all species combined) and major public lands are identified on Map 1 (in the separate Maps file included with this report) and in Table 4 (at end of this chapter). Adult and juvenile distribution is limited by natural and human-caused migration barriers, but may also be significantly influenced by total number of fish in the stream (the extent of stream area utilized may decrease as adult or juvenile fish abundance declines). Most current distribution knowledge is based on contemporary stock assessment work (since 1965-1970), and may represent a more confined distribution than occurred historically, when habitat and fish abundance were healthier.

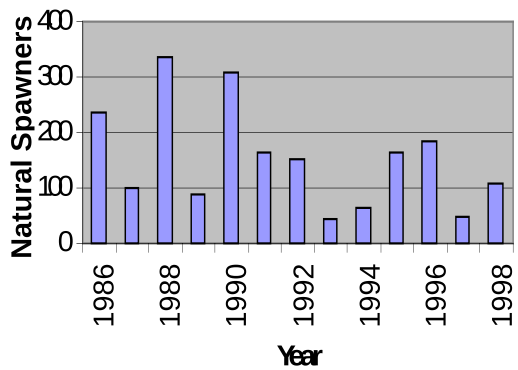
Stream gradient breaks have been estimated by the Salmon and Steelhead Habitat Inventory and Assessment (SSHIAP) project being conducted by the Northwest Indian Fisheries Commission. Chum distribution is presumed to occur upstream to a sustained 8% gradient (where there are no known natural barriers downstream), or to a sustained 12% gradient where an 8% gradient is not noted downstream. Other salmon and steelhead are presumed to occur upstream to a sustained 12% gradient (SSHIAP 1999).

Known instream timing of various life stages of salmonid species in the Dungeness River is shown in Figure 14 in the Habitat Limiting Factors by Subbasin section of this report.

Spring Chinook

The Dungeness River spring/summer chinook stock is the only spring chinook stock in WRIA 18 identified in the Salmon and Steelhead Stock Inventory (SASSI,WDFW and WWTIT, 1994). It is classified as a distinct stock based upon geographic distribution and spawn timing. This stock has been documented to the impassable falls at River Mile (RM) 18.7, and in the lower 2.5 miles of the Gray Wolf River (although the river is accessible to RM 8.0). Most chinook are thought to migrate to saltwater as 0-age, although some may migrate as yearlings (Lichatowich 1992). The hatchery rack at RM 10.8 precluded unrestricted upstream access and spawning in the upper Dungeness for many years, although some chinook were known to have regularly gotten past the rack. In addition, chinook are known to have spawned in the Dungeness River downstream of the rack. Chinook have also been observed spawning in Canyon Creek below the dam (RM 0.08). Adult chinook returns to the Dungeness hatchery are available back to 1938 (WDFW hatchery escapement records). The peak hatchery spawning escapements for the period of record are 880 chinook in 1938, and 1,305 chinook in 1959. Reliable estimates of numbers of natural spawners in the mainstem Dungeness River are only available for recent years. Estimates of spring chinook natural spawning escapement to the Dungeness River ranged from <100 to >300 for the years 1986-1998 (Figure 3). The stock has shown a precipitous drop since 1973, and the stock status is currently identified as critical.

Figure 3: Dungeness River Natural Chinook Spawner Escapements (courtesy of Randy Cooper)



No other spring chinook stocks are identified in SASSI for any other streams or rivers in WRIA 18. However, Dick Goin (long-time local resident and sport fisher) reports historic runs in Morse Cr., Ennis Cr. (report actually from Les Sandison through Dick Goin), and the Elwha R.. These observations were generally supported by other TAG participants. These runs may be extinct, but are difficult to assess as they enter the streams during peak spring flows, with associated high turbidity. The peak entry timing of Morse Cr. spring chinook was thought to be from April 15-20, with spawning occurring from approximately RM 3.0 to the impassable falls at RM 4.9.

The remnant run of Elwha spring chinook was still quite strong 35-40 years ago (Dick Goin). In the early 1990s, test fishing conducted by the Elwha Klallam Tribe captured chinook in the river in early June (this is near the spring chinook timing recalled by Dick Goin, who fished spring chinook off the mouth of the Elwha near Memorial Day). The test fishing captures were made at RM 1.7, and data indicates these chinook may have entered the river in mid-late May (Pat Crain). Most of the remaining spring chinook habitat is located above the dams; habitat below the dams has been impacted over time by the loss of gravel and LWD from the system. Before the dams were built on the Elwha, it is believed that chinook entering the river in the spring swam upriver and spawned upstream of Carlson Canyon Falls at RM 34. Fish entering in the late summer or fall spawned downstream of RM 34 (ONP 1995).

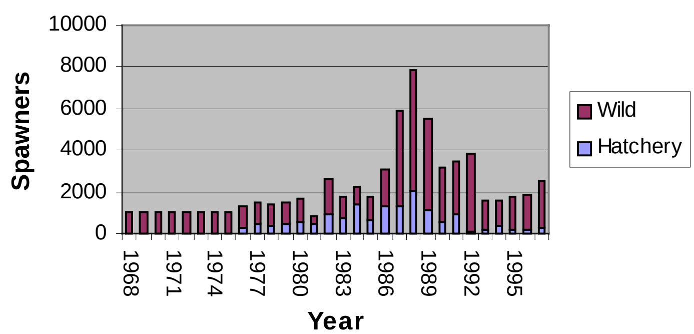
Distribution of chinook (spring and summer/fall stocks combined) in WRIA 18 streams is shown on the chinook species map (see Map 2–WRIA 18 Chinook Salmon Presence in the separate Maps file included with this report) and in Table 4.

Summer/Fall Chinook

Elwha/Morse Cr. summer/fall chinook are the only WRIA 18 summer/fall chinook stock identified in SASSI, and are identified as a distinct stock based upon their geographic distribution and run timing. Genetic analysis has been done for Elwha hatchery fall chinook, and the resulting genetic profile is significantly different from that of all other Puget Sound chinook stocks (SASSI), and appears to be intermediate between the coastal and Puget Sound stock genetic profiles (WDF et al. 1993). Dick Goin recalls that there never has been a summer/fall chinook run in Morse Creek. The native chinook were thought to be springs (see above), with later returning chinook thought to be due only to hatchery strays.

The summer/fall chinook run in the Elwha R. is of native origin, with natural spawning limited to only the lower 4.9 miles of the river due to the presence of impassable dams. The run is heavily supported by contribution from state hatchery facilities. Historic pre-dam natural spawning extended much further into the watershed. SASSI identified the status of this stock as healthy, but general TAG consensus is that the status should be reviewed as depressed or critical due to low spawning returns in recent years. Adult summer/fall chinook spawner escapement to the Elwha is identified in Figure 4. The life history and characteristics of the once abundant summer/fall chinook have been altered. It has been speculated that, historically, the substrate size in the lower Elwha River may have selected for fish that had been in the marine environment longer and were consequently much larger than stocks in other rivers (Brannon and Hershberger 1984, as referenced in Munn et al. 1998). In contrast, the current hatchery-produced chinook grow faster and mature earlier than wild fish and are smaller when they return to spawn. Smaller size may also be influenced by size selectivity of net fishery harvests, which tend to disproportionately remove larger fish (Mike McHenry). The substrate in the lower river has coarsened over time as a result of loss of sediment transport past Elwha Dam, which in combination with smaller fish, significantly reduces the potential of effective chinook spawning in the lower mainstem Elwha River.

Figure 4: Adult summer/fall chinook spawner escapement to the Elwha River



Distribution of chinook (spring and summer/fall stocks combined) in WRIA 18 streams is shown on the chinook species map (see Map 2–WRIA 18 Chinook Salmon Presence in the separate Maps file included with this report) and in Table 4.

Summer Chum

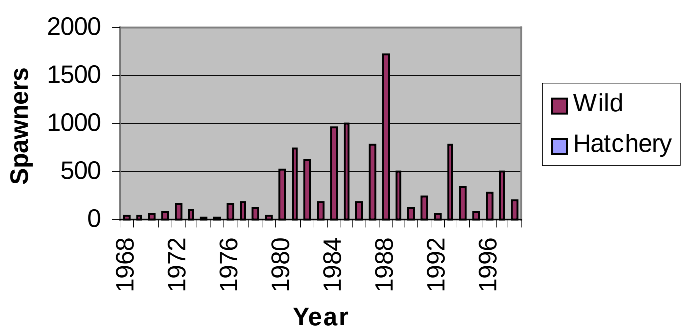
Although not specifically identified in SASSI, the Dungeness River is the westernmost drainage with summer chum in Puget Sound/Strait of Juan de Fuca. The number of summer chum in the Dungeness is very low, but it is thought that the run has likely always been very low (Goin, TAG). Most spawning occurs below Ward Bridge (Ray Johnson), although juvenile summer chum are reported to have been caught by Ken Gilliam as high as RM 9.0. Adult summer chum have been reported at the Dungeness Hatchery (RM 10.8, Kevin Bauersfeld). Summer chum are also reported to spawn in the lower 0.5 miles of Matriotti Creek, and to the hatchery rack in Hurd Creek (RM 0.5). The status of this stock should be considered depressed or critical, consistent with the status for Sequim Bay summer chum. This stock is listed as threatened under the Endangered Species Act. Although it is unlikely that any restoration projects will likely be proposed specifically to benefit summer chum, most projects in the lower mainstem Dungeness River designed to benefit lower river pinks will also benefit remaining summer chum.

Distribution of chum (summer and fall stocks combined) in WRIA 18 streams is shown on the chum species map (see Map 3-WRIA 18 Chum Salmon Presence in the separate Maps file included with this report) and in Table 4.

Fall Chum

SASSI designates two stocks of fall chum in WRIA 18: Dungeness R./East Strait Tribs. fall chum and Elwha fall chum. The Dungeness/East Strait Tribs. fall chum stock is designated based on its isolation from other Puget Sound stocks by geographic separation and temporal differences. Spawning for this stock occurs in the Dungeness River (to upstream of RM 11.8), Bear Creek (below Taylor Cut-off Road, Matriotti Creek (possible spawning upstream to Highway 101, but documented only to RM 0.9), Beebe Creek (to upper end), McDonald Creek (thought to be Dungeness strays only), Siebert and Bagley creeks (few chum historically to below Highway 101), Lees Creek (1940s observations to Highway 101, RM 0.8), and in Morse Cr. (to RM 3.5, although most spawning below Harlow's at ~RM 3.0). Dick also recalls the mouth of Mining Creek (tributary to Morse Creek) being full of chum. The presence of chum in Cassalery, Bell, and Gierin Creeks is unknown. These streams were heavily impacted by the conversion of the lower sections to duck clubs. There were possibly historic chum runs prior to this conversion. There were also small historic runs of fall chum that returned to Ennis, Valley, and Tumwater creeks, all thought to be extinct. Spawner escapements for Dungeness River chum are represented in Figure 5.

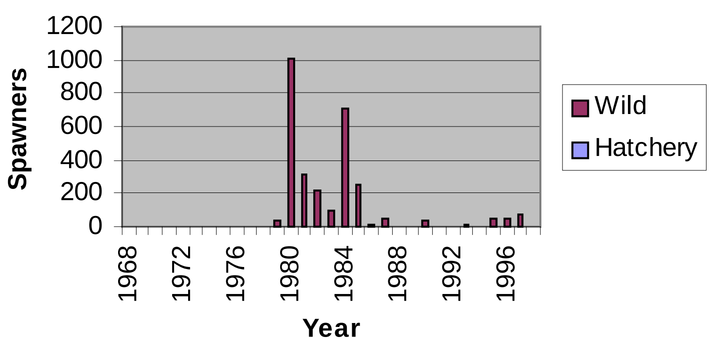
Figure 5: Fall chum spawner escapement to the Dungeness River Watershed (WDFW Run Reconstruction Database 1999)



Historically, chum were the second most numerous salmon species in WRIA 18 streams, and are reported to have been incredibly numerous in most streams (Dick Goin). SASSI indicates the stock status as unknown, but the TAG consensus is that the stock status should be reconsidered as critical, as there are only "a handful" of fish returning on an annual basis.

The Elwha fall chum salmon stock was identified as a separate stock because it is isolated from other Puget Sound stocks by geographic separation (WDF et al. 1993). The stock status is identified as unknown in SASSI, but the consensus of the TAG is the stock should be reconsidered as critical, with recent annual returns of less than 500 spawners (Mike McHenry, based on good spawner survey efforts since the mid-1990s). Spawning occurs from the mouth upstream to the Highway 112 crossing. Hiss (1994 and 1995) identified spawning distribution to RM 2.6, with most chum observed in side channels downstream of RM 2.1. Dick Goin states there were two distinct entry timings for Elwha chum. One group would enter the river in early October, usually entering the river ripe and ready to spawn (there may still be some of this group remaining). The other group entered the river in November-early December, and this group represents most/all of the remaining run. Genetic work indicates there may be two components of this later stream entry timing, possibly influenced by the past introduction of Wolcott Slough chum (Pat Crain). The native chum run to Bosco Cr., a tributary entering the Elwha near the mouth, was not specifically identified in SASSI, probably due to mapping resolution constraints. Chum spawn in Bosco Cr. from the mouth to approximately RM 1.0. Chum also spawn in Boston Creek, a left bank side channel just upstream of the mouth of the Elwha. Fall chum spawner escapement to the Elwha river watershed is represented in Figure 6.

Figure 6: Fall chum spawner escapement to the Elwha River Watershed (WDFW Run Reconstruction Database 1999)



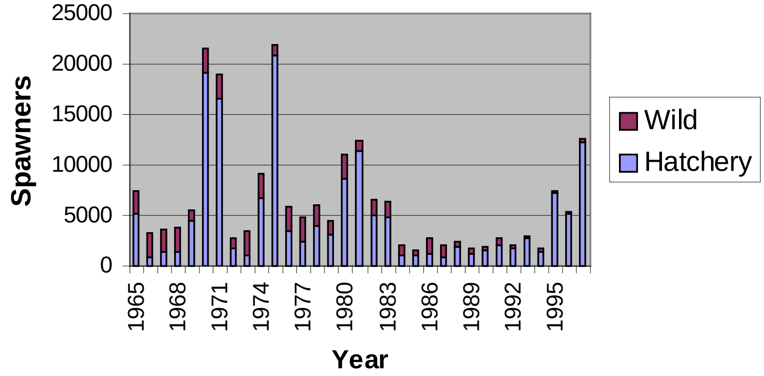
Distribution of chum (summer and fall stocks combined) in WRIA 18 streams is shown on the chum species map (see Map 3-WRIA 18 Chum Salmon Presence in the separate Maps file included with this report) and in Table 4.

Coho

SASSI designates three stocks of coho in WRIA 18: Dungeness, Morse Cr., and Elwha coho. The stocks are distinguished on the basis of geographic segregation, with no distinct biological characteristics identified at this time.

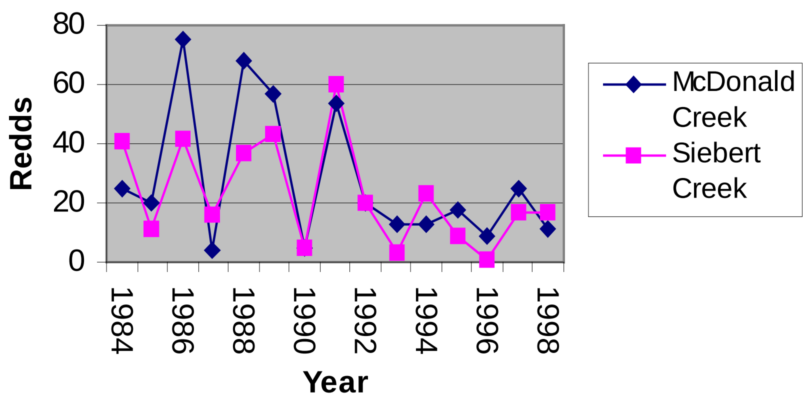
Dungeness River coho production is dominated by hatchery production from the Dungeness Hatchery. However, natural coho spawning is documented in Bell Creek (to RM 3.0), Unnamed trib. to Bell Cr. entering at RM 0.8 (juvenile presence only to RM 0.3), Gierin Creek (to RM 2.7 and spawning to headwaters of tributaries), Cassalery Creek (to headwaters just below RM 2.9), Cooper Creek (juveniles shocked in headwaters in March/April after tide gate at mouth modified), Meadowbrook Creek (to headwaters, RM 2.4), Dungeness River (to impassable falls at RM 18.7) Meadow Creek (right bank side channel entering Dungeness at RM 7.0, to headwaters), Duncan Slough (left bank side channel to Dungeness at RM 9.3, coho throughout), Matriotti Creek (to Agnew Ditch syphon at RM 6.8), Beebe Creek (to headwaters at RM 0.6), and Unnamed right bank trib. to Matriotti entering at RM 6.0 (to Hooker Road, RM 0.4), Lotsgazell Creek (to RM 1.8) and Woodcock Creek (to RM 0.6), Mud Creek (to RM 1.6), Bear Creek (trib. to Matriotti, to impassable barrier at RM 1.0), Hurd Creek (to hatchery rack at RM 0.5, potential to Old Olympic Highway), Bear Creek (18.0030, to impassable barrier at RM 1.0), Canyon Creek (to dam at RM 0.08), Gray Wolf River (to ~1 mile below 3-forks), and Gold Creek (to RM 0.1, with potential to RM 1.5). Streamnet also indicates coho presence in Cameron and Grand creeks, but TAG participants were unable to verify this presence. The status of this stock is designated as depressed. Estimated coho spawning escapements for the Dungeness River are included in Figure 7.

Figure 7: Coho spawner escapements for the Dungeness River Watershed



Morse Creek coho include those coho spawning in McDonald, Siebert, Bagley, Morse, Lees, Ennis, Valley, and Tumwater creeks. The Morse Creek coho salmon stock does not demonstrate unique temporal or biological characteristics. Streams in this area have been heavily planted with hatchery coho. Spawning is known to occur in McDonald Creek (known to RM 5.1, presumed to RM 9.0), Pederson Creek (to RM 3.6), Unnamed 18.0164 (left bank tributary to McDonald at RM 7.4, to Geller Road at RM 1.2), Siebert Creek (to RM 8.5), Unnamed 18.0175 (left bank tributary to EF Siebert at RM 6.4, to RM 1.4), WF Siebert Creek (to RM 2.0), Bagley Creek (to RM 4.7), Morse Creek (to RM 4.7), Mining Creek (to RM 0.2), Lees Creek (to RM 3.8), EF Lees Creek (to RM 3.2), Ennis Creek (to RM 5.0), Valley Creek (to RM 1.2), and Tumwater Creek (to RM 2.5). In addition, the historic run of coho to Peabody Creek has been extirpated. Coho redd count estimates for McDonald and Siebert creeks are shown in Figure 8. Electroshocking data are also available from WDFW for McDonald and Siebert creeks for the years 1978-1984, indicating the presence and densities of juvenile coho, steelhead,and cutthroat. The stock status of Morse Creek coho is designated in SASSI as depressed.

Figure 8: Coho cumulative redd counts for McDonald and Siebert creeks (courtesy of Randy Cooper)

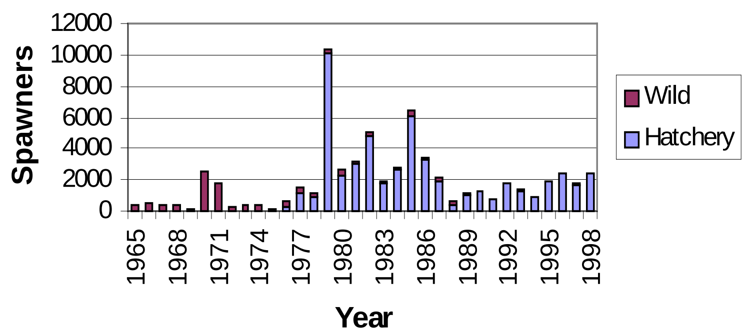


There are low numbers of coho in Dry Creek (to RM 1.0). These were not designated as a distinct stock in SASSI, or included in either of the neighboring (Morse Creek or Elwha) coho stocks.

The Elwha coho stock is defined

on the basis of geographic segregation, assuming limited straying from other regions of Puget Sound. There are no distinct biological characteristics associated with this stock at this time. The Elwha R. has been heavily planted with hatchery coho, and most coho are caught due to emphasis on hatchery harvest rate. Elwha Hatchery coho are primarily of Elwha River origin. Some swapping occurred between Elwha and Dungeness stocks, and Satsop (Chehalis river basin) fish were used in one year only. Coho spawn from approximately RM 0.5 upstream to Elwha dam. Coho spawning also occurs from the mouth to the upstream end of Boston Cr., and from the mouth to approximately RM 1.0 in Bosco Cr., both tributaries to the Elwha R.. Dick Goin indicates there was a historic run of summer coho (entry in August) to the Elwha R. that is now thought to be extinct. There also remains a return of "late" coho (Nov.-early Feb. return) that appear to have different characteristics from the hatchery return (large aggressive fish, Dick Goin). Elwha coho stock status is identified in SASSI as healthy. Upstream of Elwha Dam, there are nearly 65 miles of tributary and main channel coho habitat, with coho not expected to pass Carlson Canyon Falls at RM 34. (FERC, as referenced in ONP 1995). Estimated coho spawning escapements for the Elwha River are included in Figure 9.

Figure 9: Estimated coho salmon spawner escapements for the Elwha River



Distribution of coho in WRIA 18 streams is shown on the coho species map (see Map 4-WRIA 18 Coho Salmon Presence in the separate Maps file included with this report) and in Table 4.

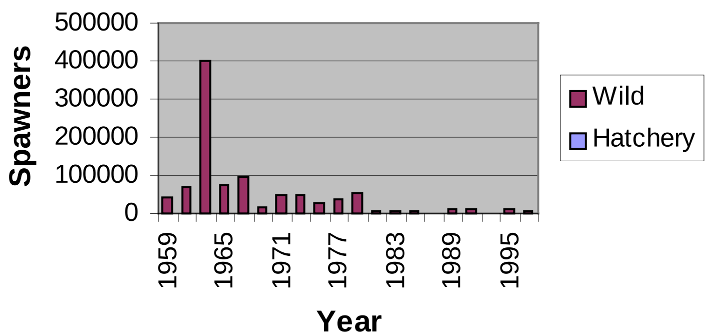
Pink

SASSI identifies three pink stocks in WRIA 18, Upper Dungeness River pinks, Lower Dungeness River pinks, and Elwha pinks. Each of these stocks is identified as a separate stock based on their isolation from other Puget Sound pink stocks. In addition, the two Dungeness River pink stocks have distinct spawning distribution and run-timing differences, as well as being genetically distinct. The TAG indicates there is also a natural run of pink salmon to Morse Cr., which should be considered for designation as a separate stock, based on geographic separation criteria similar to the other pink stocks and other species in this area. The Upper Dungeness River pink stock status is identified as depressed, and the status for both Lower Dungeness River pink and Elwha River pink is identified as critical. The Morse Creek pink run appears to be building in numbers of fish, but are also considered depressed or critical (Mike McHenry).

Upper Dungeness River pinks spawn primarily in the Dungeness River (from approximately 1.0 mile below the hatchery rack (RM 9.8) upstream to the impassable falls at RM 18.7), Grey Wolf River (to approximately 1-1.5 miles below 3-forks (RM 7.8)), the very lower portion of Gold Creek (to RM 0.3), and in Canyon Creek to the dam (RM 0.08). This stock enters the Dungeness River from mid-July to mid-August, with spawning through August until mid-September.

Lower Dungeness River pink spawning occurs primarily in the Dungeness River (to RM 6.0, with most of the spawning downstream of RM 3.0), Matriotti Creek (to RM 0.2), Beebe Creek (to RM 0.6), and in Hurd Creek (to the hatchery rack at RM 0.5). Studies in 1959, 1961, and 1963 (adult tagging and carcass recovery) indicate that lower Dungeness pinks enter the river from August through early October, with spawning from mid-September through late October. The earlier returns remain in pools in the lower river until they are ready to spawn (Ray Johnson). Because both stocks spawn during the low flow period of late summer, they will generally be found in whichever streams or side channels are accessible, given the flow conditions. Pink spawner estimates are for combined Upper and Lower Dungeness stocks and are shown in Figure 10.

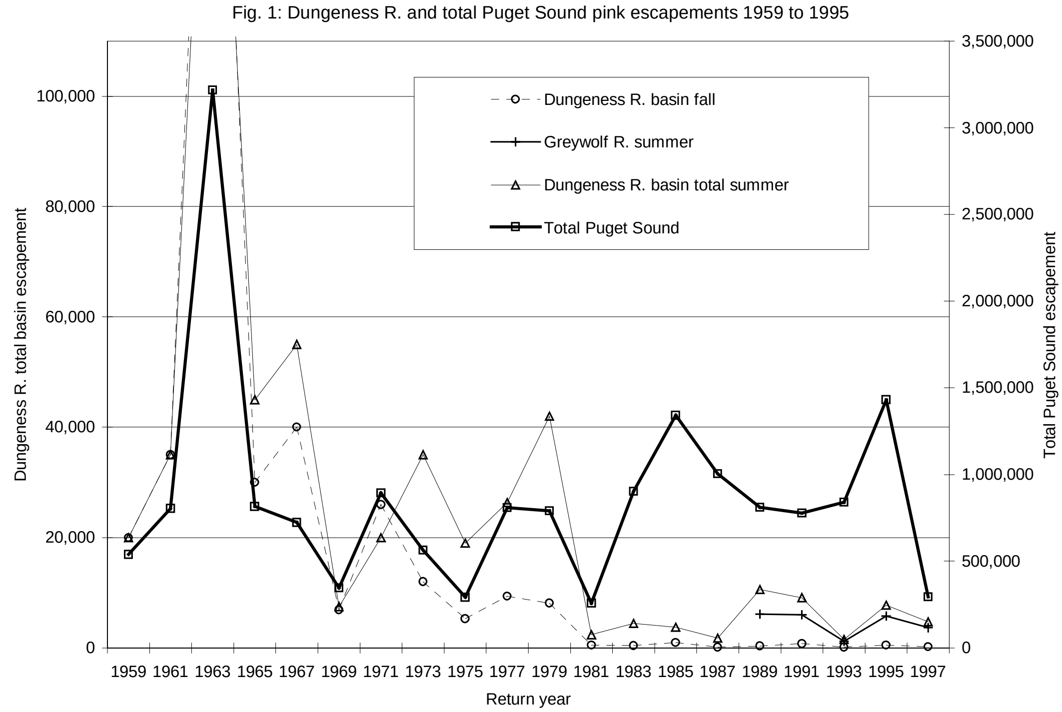
Figure 10: Pink spawner estimates for the Dungeness River (odd-year runs only) (WDFW Run Reconstruction Database 1999)



Trends in abundance of pink salmon from the Dungeness River tracked closely with total Puget Sound production until 1981 (Figure 11). After 1981, the two production trends appear to diverge, with the Dungeness going into decline. This suggests that the cause of the decline is within the Dungeness basin. Lichatowich (1992) indicates potential causes as including: 1) the large slide in Gold Creek in 1968-1969, 2) streambed aggradation through braided channels that could create barriers to migrating adults, and shifting bedload that could kill incubating eggs, and 3) artificial propagation of coho, which could result in increased predation on pinks. Recent scour chain studies conducted by the Jamestown S'Klallam Tribe, in mainstem areas typically occupied by pinks, indicate that severe bed scour and aggradation may contribute significantly to the decline. Hiss (1995) examined the return to escapement of Dungeness River summer-run and fall-run pink salmon in relation to annual measures of nine environmental factors for the period 1959-1983 using multiple regression analysis. Of the nine environmental factors, sea-surface temperature had the greatest influence on return to escapement for the summer-run population. Peak instream flows and low winter air temperatures were equally important as secondary influences; low flow between the time of adult return to the river and spawning was third in importance. For the fall-run population, low winter air temperature had the greatest influence on return to escapement; sea surface temperature was next in importance, followed by marine upwelling. Four other factors not amenable to regression analysis were also examined. Annual acres clearcut over the study period did not coincide with trends in escapement. The immediate effect of slope failures appeared to temporarily depress escapement. The largest increases in streambank protection (armoring, diking) coincided with the current period's depressed escapement.

Pink salmon, which return during the traditional low flow period, will typically enter whatever spawning areas are accessible. Although there is general separation of the majority of spawners

Figure 11: Total Production of Pink Salmon from the Dungeness River and Puget Sound (1959-1997)(data from WDFW run reconstruction, courtesy of Jeffrey Hames)

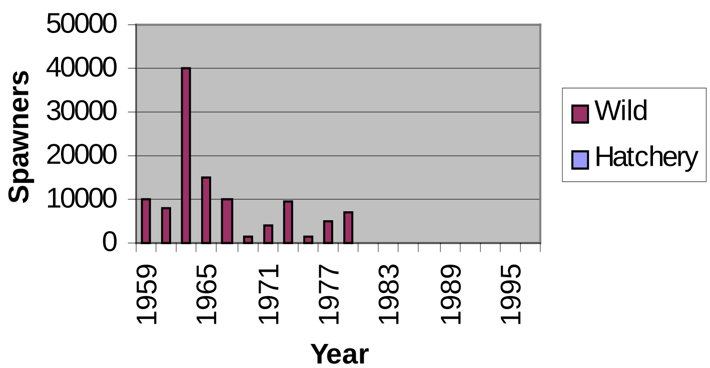


of the two Dungeness River pink stocks, there is overlap in the central portion of the river (RM 3.0-9.0), where there is a mixture of lower and upper pink stock spawning. Fish in this area also have an intermediate spawning timing (Ray Johnson). The difference in timing is not surprising, and is actually to be expected, since the water temperature differences in the upper and lower Dungeness are substantial. Hydraulic sampling of pre-emergent fry in both the upper Dungeness/Gray Wolf area and the lower mainstem, conducted in the 1960s, found the fry development virtually identical. Historically, there were proportionately fewer pinks in the central portion of the river, however, there has been a greater proportion of pink spawners in the central portion of the river in recent years (Ray Johnson). This increased presence in the central portion of the river could be due to various factors: higher flow conditions and irrigation withdrawals could provide improved access to side channel habitats in this portion of the river; higher flow conditions could generally tend to attract fish higher in the watershed; pinks may be attracted to groundwater return flow areas that have changed with the increase in river flows; and/or the disproportionate increase could be due to poor survival in the lower diked portion of the river. Meadow Creek in the vicinity of the Sequim Prairie irrigation intake and bypass, and other accessible stable side channels, tend to be very productive areas for pink salmon. The timing of downstream juvenile pink outmigration in the Dungeness appears to coincide with that of all other streams in Puget Sound, with early marine residence in April and early May during spring blooms and increasing food abundance.

Pink spawning in Morse Cr. occurs from approximately 0.2 miles below the impassable falls (Humpy Hole at ~RM 4.5) downstream for approximately 1.5 miles (~RM 3.0). The peak entry timing of the stock is reported as around August 1 (Dick Goin). Pink salmon have actually been doing better than most other species in Morse Cr., but the consensus of the TAG is to designate the status as depressed or critical based on the recent average spawning escapement of approximately 100 fish. Spawner estimates for Morse Creek are combined with other Strait of Juan de Fuca Independent streams and are not reported separately.

The Elwha pink stock is defined on the basis of geographic segregation. Elwha River pink salmon are September to October spawners (WDFW & WWTIT, 1994). The stock status is defined as critical, with recent spawner escapements of <100 fish. Pink spawner estimates for the Elwha River are represented in Figure 12. Spawning occurs from the mouth to the dam at RM 4.9. The pink run to Bosco Cr., a tributary entering the Elwha near the mouth, was not specifically identified in SASSI, probably due to mapping resolution constraints. Pink historically spawned in Bosco Cr. from the mouth to approximately RM 1.0, but haven't been observed in several decades. It is hoped that restoration efforts will result in their return. Pink declines in the Elwha River may, in part, be related to the proportionately large increase in fall chinook production at the Elwha Channel hatchery facility (Ray Johnson). Pink surveys during the years with larger spawner escapements (1959 through mid-1960s) showed heavy utilization of spawning gravel that was followed be equally heavy usage by chinook salmon in later years following the increase in hatchery releases. Escapement data show the pink decline coinciding with chinook increases.

Figure 12: Pink spawner estimates for the Elwha River (odd-years only) (WDFW Run Reconstruction Database 1999)



Distribution of pink salmon in WRIA 18 streams is shown on the pink salmon species map (see Map 5-WRIA 18 Pink Salmon Presence in the separate Maps file included with this report) and in Table 4.

Sockeye

A historic run of sockeye existed in the Elwha River, returning to Lake Sutherland. They require access to Lake Sutherland to complete their reproductive cycle. Removing the Elwha dams would allow unobstructed access to Lake Sutherland, but stock availability may limit restoration success (ONP 1995). Lake Sutherland has little tributary spawning habitat available. Lakeshore spawning habitat, though possibly degraded due to development of the lakeshore, has not been assessed. It is likely that Elwha sockeye used both Indian Creek and lakeshore spawning areas historically. Currently, kokanee use the lake and are effective spawners (Mike McHenry, Pat Crain).

Summer Steelhead

SASSI identifies two stocks of summer steelhead in WRIA 18, Dungeness summer steelhead and Elwha summer steelhead. The TAG, however, indicates there is also a summer steelhead run in Morse Cr., which may be stray hatchery fish from the Elwha or Dungeness (Randy Cooper), or may be true Morse Creek returns that should be considered for designation as a separate stock based on geographic separation criteria similar to other species in this area.

Dungeness summer steelhead have been designated as a distinct stock based on the geographic isolation of the spawning population. Little is known regarding Dungeness summer steelhead (SASSI, Dick Goin). Adult steelhead presence is known to the impassable falls on the mainstem (RM 18.7), and to at least 3-Forks on the Gray Wolf (RM 9.6, Dick Goin). The lowermost extent of spawning is unknown as summer and winter steelhead can not be distinguished at spawning time, but they are thought to spawn in the upper reaches of the river. The stock status was listed as depressed, but the TAG consensus is to review the status for potential redesignation to critical.

The summer steelhead in the Elwha River have been classified as a distinct stock based on the geographic isolation of the spawning population. The stock status is designated as depressed based on the difference between the abundance at the time SASSI was published and that at historic levels. The consensus of the TAG is to reconsider the status as critical (Dick Goin has seen 1 in 3 years of sampling; Mike has seen 1 in 9 years of stream surveys). Summer steelhead have been observed annually in the "upper" pool below the dam in virtually all recent years (perhaps a dozen fish present in latest survey in mid-October, 1999) of chinook surveys conducted by WDFW (Ray Johnson/Ken Gilliam). Spawning occurs upstream as far as the dam, with the lowermost extent of spawning unknown. The Elwha has been regularly planted by WDFW with 10,000 Skamania origin summer steelhead, with past plantings as high as 25,000 (Mike McHenry).

The most recent observation of Morse Cr. summer steelhead by TAG members was approximately four years ago by Dick Goin; based on the location and size of the observed fish in Morse Creek, the steelhead observed four years ago were thought to be native. These may be stray hatchery fish from the Elwha or Dungeness (Randy Cooper), or may be true Morse Creek returns that should be considered for designation as a separate stock, The current status is unknown, but the consensus of the TAG is to consider the stock status as critical. They spawn upstream to the falls at RM 4.7, but the lower extent of spawning is unknown.

Distribution of summer steelhead in WRIA 18 streams is shown on the summer steelhead species map (see Map 6-WRIA 18 Summer Steelhead Presence in the separate Maps file included with this report) and in Table 4.

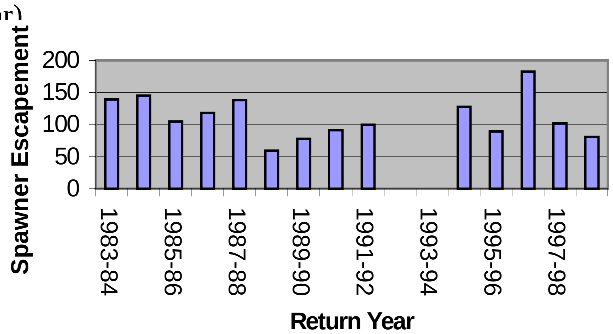
Winter Steelhead

Three separate stocks of winter steelhead are identified in WRIA 18, Dungeness winter steelhead, Morse Cr./Independents winter steelhead, and Elwha winter steelhead. Each of these stocks is designated based on the geographic isolation of the spawning population.

Dungeness winter steelhead spawning distribution is thought to be similar to the coho spawning distribution (to RM 18.7), extending downstream to the upper extent of tidewater. Winter steelhead distribution is also presumed to be the same as for coho in Bell, Gierin and tributaries, Cassalery, Cooper, Meadowbrook, Matriotti, Beebe, Lotsgazell, Woodcock, Mud, Bear (trib. to Matriotti), Unnamed trib to Matriotti at RM 6.0, Hurd, Bear (18.0030), Canyon, and Gold creeks, and the Gray Wolf River. The stock status is identified as depressed, but the TAG consensus is to review the status for potential redesignation to critical.

The Morse Cr./Independents winter steelhead stock specifically includes steelhead in Morse, Siebert, and McDonald creeks. The Morse Cr./Independents stock status is designated as depressed. The TAG identifies Morse Creek spawning to the impassable falls at RM 4.7. Dick Goin indicates there is still a remnant segment of November returns. He also recalls "spectacular" numbers of winter steelhead in Morse Cr. (in comparison to other Strait streams), but generally small fish compared to those in other streams. Although designated as depressed, there is some optimism in response to escapements in recent years (Bill Freymond). Spawner count data for wild steelhead in Morse Creek for recent years are shown in Figure 13. Electroshocking data are available (WDFW) for McDonald and Siebert creeks for the years 1978-1984, indicating the presence and densities of juvenile coho, steelhead,and cutthroat. Regular plantings of 5,000 Bogacheil origin winter steelhead have been made in Morse Creek.

Figure 13: Wild winter steelhead spawner counts for Morse Creek (courtesy of Randy Cooper)(Note: 1998-99 counts represent only 1 survey, river unsurveyable most of year)



Additional winter steelhead streams not specifically noted in SASSI include Lees, Ennis, Valley, Tumwater, and Dry creeks. The status of winter steelhead in these streams is generally unknown, with little current or historic data available on steelhead production. Limited smolt trapping data are available for Valley Creek. Spawning distribution in Lees Cr. extends from the mouth to approximately RM 3.8 in the mainstem, and to approximately RM 3.2 in the East Fork. Spawning distribution in Ennis Cr. is from approximately RM 0.2 upstream to the impassable cascade at RM 5.0 (approximately 36 redds were counted in one season in the 1980s, Dick Goin). The spawning distribution in Valley Cr. is thought to be the same as for coho, up to Highway 101 at RM 1.2 (4 redds were observed by Dick Goin approximately 4 years ago). Spawning distribution in Tumwater Creek is thought to be the same as for coho, extending from the mouth to at least the power line crossing at RM 2.3 (Dick Goin observed a bright female approximately 8 years ago, Randy Johnson observed several winter steelhead redds in the early 1990s). Steelhead spawning has been observed in Dry Creek to approximately 100 yards below the road at the falls (RM 1.0). Dry Creek has limited over-summer habitat, steelhead presence may be influenced by attraction of Elwha River water which leaks from pipeline into Dry Creek (Mike McHenry).

Elwha winter steelhead spawning occurs from just above the mouth upstream to the dam. In addition, spawning occurs in Bosco Creek from the mouth to approximately RM 1.0. The status of the stock is designated as depressed based on the differences between the abundance at the time SASSI was published and historic levels.

Distribution of winter steelhead in WRIA 18 streams is shown on the winter steelhead species map (see Map 7-WRIA 18 Winter Steelhead Presence in the separate Maps file included with this report) and in Table 4.

Char (Bull Trout/DollyVarden)

Four stocks of char are tentatively identified in WRIA 18, upper Dungeness River, Dungeness/Grey Wolf, lower Elwha River, and upper Elwha River. The stocks are considered separate based on the geographic distribution of their spawning populations. There is no genetic information for these stocks at this time (Salmonid Stock Inventory (SSI)).

Dungeness/Grey Wolf char are native and are maintained by wild production. Anglers report that historically char were very common and widespread from the lower to the upper watershed. They report that they are still widespread, but greatly reduced in numbers (Mongillo 1992, as reported in SSI). This observation is supported by the TAG, which also indicates presence of char in tributaries and nearby independent tributaries during salmon spawning periods. Successful spawning is probably confined to the colder waters of the upper watershed, but the extent of spawning utilization is unknown. They are known to be excellent “climbers” and it is unknown whether the cascades near the three forks on the Gray Wolf River are a migration barrier to char (Dick Goin). Dick Goin reports catching char in the lower Dungeness system with sea lice on them, clearly indicating anadromy. The stock status is unknown.

Char in the Dungeness River upstream of the falls at RM 18.7 have been identified as a distinct stock based on their geographic distribution. Resident and fluvial life history forms are present. Spawn timing and locations are unknown. The stock status is tentatively considered healthy based upon the number, distribution, and age composition of char seen in a survey conducted by WDFW in the upper mainstem Dungeness in 1996 (Salmonid Stock Inventory (SSI)). Dennis Ward (employee fo local irrigation ditch company and active sport fisher) reports having observed and handled an adult char in Canyon Cr. near the Agnew Ditch in October, 1998 (Dick Goin). Bull trout /dolly varden have also been observed in upper Bell Creek (Joel Freudenthal). Although this is a low elevation area, the spring-fed deep holes provide excellent habitat for char, and presence may also be influenced by the presence of Dungeness River water in Bell Creek. Due to the observed presence in Bell Creek, Cassalery, and Gierin creeks are also thought to have potential as char habitat.

Char in the lower Elwha River (below the hydropower dams) have been identified as a distinct stock based on their geographic distribution. This population is thought to be anadromous. Spawn timing and locations are unknown. The stock status is unknown, based on insufficient information to assign stock status with confidence (SSI).

Char in the upper Elwha River (above the hydropower dams) have been identified as a distinct stock based on their geographic distribution. Anglers have reported hooking char in both reservoirs, in the river between the reservoirs, and in the river above the upper reservoir. ONP has captured bull trout upstream of Carlson Canyon falls (Brian Winter). The ONP maintains a database of documented char observations in the Elwha Basin (Table 3). These data reflect uppermost sampling locations, but are not necessarily the uppermost distribution since limited sampling has occurred in many rivers. There are also likely other tributaries in the upper Elwha watershed in which char are present, but that have yet to be sampled. Fluvial, adfluvial, and resident life history forms of char are believed to be present in the upper Elwha. Spawn timing and locations are unknown. The stock status is unknown, based on insufficient information to assign stock status with confidence (SSI).

Table 3: Char (Bull Trout/Dolly Varden) observations in the Elwha watershed (courtesy of Sam Brenkman, ONP)

Stream Name	WRIA #	Uppermost Observation (RM)	Source
Elwha River	18.0272	43.9	ONP, USGS
Hughes Creek	18.0339	0.25	Morrill and McHenry 1995
Griff Creek	18.0357	0.05	Morrill and McHenry 1995
Boulder Creek	18.0376	0.1	Morrill and McHenry 1995
Cat Creek	18.0422	1.5	Adams et al. 1996
Prescott Creek	18.0519	Present	Hagen 1961
Stony Creek	18.0529	0.1	ONP
Hayes Creek	18.0561	0.4	Adams et al. 1996
Godkin Creek	18.0589	3.5	Adams et al. 1996
Buckinghorse Cr.	18.0620	0.9	Adams et al. 1996
Delabarre Creek	18.0634	1.0	Adams et al. 1996

Other Species

This evaluation has not fully considered the presence and distribution of sea-run cutthroat or resident trout species. These species are present throughout these same watersheds and should also be considered whenever habitat or fish production modifications are considered.

Sturgeon have been captured at the site of the Dungeness pink salmon weir (RM 0.5), and have been observed in pools immediately upstream of the mouth (Kevin Bauersfeld). Dick Goin reports the presence of sturgeon in the Elwha River. An acquaintance of Dick's, Charles Barker, observed a very large sturgeon beached below the lower dam. There is also a history of 3-5 foot sturgeon being netted in the lower Elwha through the early 1980s (Pat Crain). It isn't known whether sturgeon were in the river for spawning or just present.

Table 4: Distribution of salmon and steelhead in WRIA 18 streams

The following streams have been identified as having anadromous salmon and steelhead presence. Data sources used to identify fish distribution include: A catalog of Washington Streams and Salmon Utilization (WDFW Stream Catalog (Williams et al. 1975); Salmon and Steelhead Stock Identification (SASSI 1992); Streamnet (SN)(WDFW 1999); Technical Advisory Group (TAG) observations; Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP); and others as noted. Note that the identified distribution represents the current knowledge of fish use in these streams, which may be significantly different than historic distribution, with current distribution likely being more limited. Reasons for more restricted current distribution include habitat conditions that no longer support salmonid production, reduced spawner escapements that minimize use of fringe habitats, and presence of barriers that preclude salmonid access to productive habitats. Marine distribution is also not included in this summary; salmonid distribution should be considered as ubiquitous in all marine waters.

Presumed uppermost stream distribution (SSHIAP) may extend to 8% (chum, or all species where a 12% gradient break is not otherwise indicated downstream) or to 12% (species other than chum). Chum are presumed to 12% gradient when there is no 8% gradient indicated downstream. These gradient breaks are noted only where there is no known natural anadromous barrier downstream.

Text abbreviations: LB (left bank, looking downstream); RB (right bank, looking downstream); GIS Ref (reference numbers for species distribution maps; species distribution maps are included as a separate Maps file with this report); RM (river mile, measured upstream from the mouth)

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
29	Bell Creek	18.0001	Coho	3.50	SN	Randy Johnson documented coho to RM 3.0.
NA			Chum			TAG reports potential, but unknown. None seen in 1998 spawner surveys.
230			WSH	3.50	TAG	Assumed same as coho
491			8%	4.10	SSHIAP	
112	Unnamed		Coho	0.30	Rymer, Perkins, Johnson	LB trib enters Bell at RM 0.8. Juv. Coho documented, no adults seen.
487	Unnamed		8%	1.80	SSHIAP	LB enters Bell at RM 3.0
489	Unnamed		8%	1.00	SSHIAP	LB enters Bell at RM 3.1

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
488	Unnamed		12%	1.60	SSHIAP	LB enter Bell at RM 3.1 (same as above)
490	Unnamed		12%	0.30	SSHIAP	RB enters unnamed trib at RM 1.1
494	Unnamed		12%	0.60	SSHIAP	RB enters Bell at RM 3.4
493	Unnamed		8%	0.20	SSHIAP	RB enters Bell at RM 3.5 (east)
492	Unnamed		8%	0.20	SSHIAP	RB enters Bell at RM 3.5 (southeast)
485	Unnamed		12%	0.20	SSHIAP	Unnamed trib to Washington Harbor, enters N of Bell Creek
21	Gierin Creek	18.0004	Coho	2.70	SN	
NA			Chum			TAG reports potential, but unknown.
222			WSH	2.70	TAG	Assumed same as coho
482			8%	0.40	SSHIAP	
484	Unnamed		8%	0.40	SSHIAP	RB trib enters Gierin at RM 2.7
483	Unnamed		8%	0.20	SSHIAP	LB enters unnamed trib above at RM 0.1
23	Unnamed A		Coho	0.30	TAG	LB trib. to Gierin entering at N end of wetlands
224			WSH	0.30	TAG	LB trib. to Gierin entering at N end of wetlands, presumed same as coho
25	Unnamed B		Coho	0.20	TAG	LB trib. To Gierin entering at S end of wetlands
226			WSH	0.20	TAG	LB trib. to Gierin entering at S end of wetlands, presumed same as coho
27	Cassalery Creek	18.0015	Coho	2.90	Randy Johnson/ Hansen	SN reports coho to RM 1.8. Juveniles sampled in headwaters just below Old Olympic HW. Adults observed upstream of Jamestown Rd.
NA			Chum			TAG reports potential, but unknown.
115			WSH	0.60	Hansen	Known distribution to Taylor Ranch Rd.
228			WSH	2.90	TAG	Presumed uppermost extent same as coho
477			8%	4.20	SSHIAP	
479	Unnamed		8%	1.10	SSHIAP	RB enters Cassalery at RM 2.4
480	Unnamed		8%	0.30	SSHIAP	RB enters Cassalery at RM 2.5
481	Unnamed		8%	0.20	SSHIAP	LB enters unnamed trib at RM 0.1
478	Unnamed		8%	0.20	SSHIAP	RB enters Cassalery at RM 2.7

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
31	Cooper Creek	18.0017	Coho	0.80	Randy Johnson	Juveniles shocked in upper end.
232			WSH	0.80		Presumed same as coho
9	Dungeness River	18.0018	SP/SU chinook	18.70	SN, SSD	Lichatowich (1992) indicates lower extent of spawning at RM 3.0, TAG indicates limited spawning above RM 8.0
13			Coho	18.70	SN	LB side channel to Dungeness at RM 9.3 reported by TAG to be good coho producer.
L-01, U-02			Upriver pink (summer)	9.7-18.7	Hiss, 1995	Lichatowich (1992) indicates spawning from RM 10.0 to just upstream of Gold Cr. Ray Johnson reports most spawning upstream from 1 mile below hatchery.
6			Lower River pink (fall)	6.50	TAG	Hiss (1995) indicates spawning to RM 6.0, Lichatowich (1992) indicates spawning from mouth of Matriotti Cr. To HW 101 (RM 6.5).
61			Summer chum	10.80	SN	Ray Johnson reports Ken Gilliam has trapped juveniles as high as RM 9.0, and that most summer chum spawning occurs below Woodcock. Randy Johnson reports observations of adult summer chum in gravel traps below HW 101.
63			Fall chum	11.80	TAG	SSD verifies presence to RM 10.8. Dick Goin has observed adult chum to at least 1 mile above hatchery (RM 11.8).
69			SSH	18.70	SASSI	Lower extent of spawning unknown
14			WSH	18.70	SN	
33	Meadowbrook Cr.	18.0020	Coho	2.40	Rymer	
234			WSH	2.40	TAG	Assumed same as coho
41	Matriotti Creek	18.0021	Coho	6.80	SN	
62			Summer chum	0.50	Rymer	Dick Goin reports mouth to falls at RM 1.5
66			Fall chum	0.90	SSD	Rymer indicates could go to 101, but unknown.
266			Fall chum	5.40	Rymer	Presumed presence to HW 101.

GIS Ref	Stream				WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
8						Lower river pink	0.20	Ray Johnson	SN reports pinks to RM 5.5, but TAG indicates lower river pink use in lower portion only
42						WSH	6.80	SN	
462						8%	8.10	SSHIAP	
117			Beebe Creek			Coho	0.60	Goin, Johnson, Hansen	Highly productive constructed channel through Olympic Game Farm
116						Chum	0.60	Goin, Johnson, Hansen	Highly productive constructed channel through Olympic Game Farm
118						Pink	0.60	Goin, Johnson, Hansen	Highly productive constructed channel through Olympic Game Farm
119						WSH	0.60	Goin, Johnson, Hansen	Highly productive constructed channel through Olympic Game Farm
35			Lotsgazell Cr.		18.0022	Coho	1.80	Hansen, Rymer	
236						WSH	1.80	TAG	Presumed same as coho
473						8%	2.10	SSHIAP	
201				Woodcock Cr.	18.0023	Coho	0.60	TAG	Presumed presence
202						WSH	0.60	TAG	Presumed same as coho
37			Mud Creek		18.0024	Coho	1.60	Hansen, Rymer	
38						WSH	1.60	TAG	Presumed same as coho
113			Bear Creek			Coho	1.00	Hansen	Spawning to Spath Road
114						WSH	1.00	Hansen	Spawning to Spath Road
466			Unnamed		18.0026	8%	1.10	SSHIAP	
464				Unnamed		8%	0.40	SSHIAP	LB enters 0026 at RM 0.7
43			Unnamed			Coho	0.40	TAG	RB trib. To Matriotti at RM 6.0

GIS Ref	Stream				WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
244						WSH	0.40	TAG	RB trib. To Matriotti at RM 6.0 presumed same as coho
471						8%	1.20	SSHIAP	RB trib. To Matriotti at RM 6.0
469				Unnamed		8%	0.30	SSHIAP	LB to unnamed trib above at RM 0.1
470				Unnamed		8%	0.20	SSHIAP	LB to unnamed trib above at RM 0.7
472				Unnamed		8%	0.20	SSHIAP	RB to unnamed trib above at RM 0.9
465			Unnamed		18.0027	8%	0.30	SSHIAP	
39		Hurd Creek			18.0028	Coho	0.50	TAG	SSD indicates presence to RM 1.0, but blocked at hatchery rack at RM 0.5.
339						Coho	1.40	TAG	Potential use to Old Olympic HW
65						Summer chum	0.50	Beebe, Rymer	
7						Lower river pink	0.50	Ray Johnson	Upstream to hatchery rack during 1999 spawning surveys
40						WSH	0.50	TAG	Assumed same as coho, blocked at hatchery rack at RM 0.5
340						WSH	1.40	TAG	Assumed same as coho, potential use to Old Olympic HW
476						8%	2.90	SSHIAP	
474			Unnamed			8%	0.20	SSHIAP	LB to Hurd RM 1.0
475			Unnamed			8%	0.20	SSHIAP	LB to Hurd RM 1.3
120		Unnamed				Pink	0.20	Rot	Dawley side channel (LB) just upstream of HW 101
45		Bear Creek			18.0030	Coho	1.00	TAG	SN indicates spawning to RM 2.0, which was based on previous stream entry point to Dungeness
64						Fall chum	0.20	Goin	To Taylor Cutoff Rd., unknown above.
246						WSH	1.00	TAG	Presumed same as coho
467						8%	3.50	SSHIAP	
96		Meadow Creek				Coho	0.60	TAG	RB side channel to Dungeness upstream of island upstream of HW 101
NA		Canyon Creek			18.0038	SP/SU chin			SN reports chinook to RM 1.65, but TAG reports Canyon does not have sufficient flows for chinook access

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
19			Coho	0.08	TAG	SN reports to RM 1.65, but dam blocks passage at RM 0.08
4			Upper river pink	0.08	TAG	Dam blocks passage at RM 0.08
220			WSH	0.08	TAG	Presumed same as coho
495			8%	1.50	SSHIAP	
NA	Unnamed	18.0045			TAG	Probably no salmon use due to gradient
NA	Caraco Cr.	18.0046			TAG	Unknown whether any use in lower creek
NA	Unnamed	18.0047			TAG	Probably no salmon use due to gradient
496	Unnamed		8%	0.10	SSHIAP	RB to Dungeness at RM 11.7
497	Unnamed		8%	0.20	SSHIAP	LB to Dungeness at RM 13.0
498	Unnamed		8%	0.90	SSHIAP	RB to Dungeness at RM 14.8
97	Gray Wolf River	18.0048	SP/SU chin	2.50	TAG	Lichatowich (1992) reports chinook to RM 5.1. SN reports spring/summer chinook to RM 9.6. SN also reports fall chinook but TAG reports no fall chinook in Dungeness. TAG reports spring chinook documented to RM 2.5, potential to RM 8.0
394			SP/SU chin	8.00	Ray Johnson	Potential distribution to RM 8.0
98			Coho	8.60	Ray Johnson	SN reports coho to RM 9.6, but Ray indicates coho unlikely to pass cascades ~1 mile below 3-forks.
5			Upriver pink (summer)	8.60	Ray Johnson	SN and Hiss (1995) show spawning to RM 9.6. Ray indicates uppermost extent ~1-1.5 miles below 3-forks. Pink presence did not extend to 3-forks in 1963 run, the largest escapement of record.
121			SSH	8.00	Ray Johnson	Known presence to Slab Camp trail
203			SSH	9.60	Goin	Presence to 3-forks based on Lewis bros. pictures. Distribution may extend into tributaries upstream.
106			WSH	9.60	Goin	Presumed similar distribution to summer steelhead

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
11	Gold Creek	18.0121	Coho	0.10	TAG	Access limited by slide
			Coho	1.50	TAG	SN reports preslide spawning to RM 1.5
3			Upriver pink (summer)	0.30	R. Cooper	Access limited by slide. Spawner observations to RM 0.3 in 1999
303			Upriver pink (summer)	1.50	TAG	SN reports preslide spawning to RM 1.5
12			WSH	0.10	TAG	Presumed same as coho
312			WSH	1.50	TAG	Presumed same as coho
51	McDonald Creek	18.0160	Coho	9.00	TAG	SN reports distribution to RM 5.1. SSD verifies presence to RM 5.0. TAG indicates presumed presence to RM 9.0
NA			pink			SN reports pinks to RM 4.9, but TAG indicates no known pink presence.
NA			Fall chum			Ray Johnson reports no chum seen in spawner surveys above Old Olympic HW. Goin reports some past presence of chums in lower creek, but believed to be Dungeness chums from attraction water.
52			WSH	9.00	TAG	SN reports distribution to RM 7.5. Cooper verified presence to 1.0 mile above power line
459			8%	0.90	SSHIAP	
463	Unnamed	18.0161	8%	2.80	SSHIAP	
47	Pederson Creek	18.0163	Coho	3.60	SN	
248			WSH	3.60	TAG	Presumed same as coho
448	Unnamed		8%	0.30	SSHIAP	LB to Pederson at RM 1.0
449	Unnamed		8%	1.80	SSHIAP	LB to Pederson at RM 1.8
450	Unnamed		8%	0.20	SSHIAP	LB to Pederson at RM 3.0
451	Unnamed		8%	0.10	SSHIAP	LB to Pederson at RM 3.2
49	Unnamed	18.0164	Coho	1.20	Rymer	Coho verified to Geller Rd.

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
250			WSH	1.20	TAG	Presumed same as coho
456	Unnamed	18.0166	8%	2.00	SSHIAP	
458	Unnamed		8%	0.30	SSHIAP	LB to 0166 at RM 1.0
457	Unnamed		8%	0.10	SSHIAP	RB to 0166 at RM 1.9
	Unnamed	18.0165			TAG	No salmon use due to natural barrier at mouth.
452	Unnamed		8%	0.30	SSHIAP	RB to McDonald at RM 10.2
53	Seibert Creek	18.0173	Coho	8.50	SN	
67			Fall chum	1.40	Goin	Few chum historically to Old Olympic HW. Ray Johnson has seen no chum in coho spawner surveys from RM 4.5-0.9. TAG reports little habitat below RM 0.9
54			WSH	8.50	TAG	SN reports distribution to RM 8.0
443			8%	8.10	SSHIAP	
444	E Fk Seibert Cr.	18.0173	8%	9.80	SSHIAP	
442	Emery Cr.	18.0174	8%	0.30	SSHIAP	
57	Unnamed	18.0175	Coho	1.40	SN	
258			WSH	1.40	TAG	Presumed same as coho
445			8%	5.00	SSHIAP	
446	Unnamed		8%	1.10	SSHIAP	RB trib enters 0175 at RM 3.9
55	WF Seibert Cr.	18.0177	Coho	2.00	SN	
256			WSH	2.00	TAG	Presumed same as coho
447			8%	2.10	SSHIAP	
59	Bagley Creek	18.0183	Coho	4.70	SN	
68			Fall chum	1.30	Goin	Few chum historically to downstream of HW 101. TAG indicates no summer chum in Bagley.
260			WSH	4.70	TAG	Presumed same as coho
439			8%	6.30	SSHIAP	
441	Unnamed	18.0184	8%	1.80	SSHIAP	
440	Unnamed		8%	0.30	SSHIAP	LB trib enters 0184 at RM 1.0
437	Unnamed		8%	0.40	SSHIAP	LB trib enters Bagley at RM 5.2

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
438	Unnamed		8%	0.20	SSHIAP	RB trib enters Unnamed at RM 0.2
NA	Morse Creek	18.0185	S/F chinook		Goin	SN reports distribution to RM 3.1. Hatchery strays only, no historic S/F chinook run.
301			SP chinook	4.70	Goin	Historic run spawned from RM 3.0-4.7, extirpated.
78			Coho	4.70	SN	TAG reports spawning from RM 0.5-4.7
92			Pink	4.50	SN	TAG/Goin report spawning occurs from RM 3.0-4.5. SN reports pink distribution to RM 4.7
89			Chum	3.50	Goin	SN reports distribution to RM 3.1.
70			WSH	4.70	SN, TAG	
93			SSH	4.70	SN, TAG	TAG indicates lowermost extent of spawning unknown
436			8%	4.70	SSHIAP	
435	Unnamed		8%	0.30	SSHIAP	RB trib enters Morse at RM 3.0
79	Mining Cr.		Coho	0.20	TAG	
NA			Chum	Mouth	Goin	High numbers of chum historically spawning in mouth
81	Lees Creek	18.0232	Coho	3.80	SN	
110			Chum	0.80	Goin	Chum observed to HW 101 only (1940s observations)
71			WSH	0.80	Goin	Known to HW 101 only
272			WSH	3.80	TAG	Presumed upstream distribution same as coho
433			8%	4.30	SSHIAP	
80	EF Lees Cr.	18.0233	Coho	3.20	TAG	SN reports distribution to RM 1.0
100			WSH	3.20	TAG	Presumed distribution same as coho
434			8%	4.00	SSHIAP	
102	Ennis Creek	18.0234	SP chinook	4.90	Goin	Chinook presence possibly influenced by past release of Elwha water at Rayonier mill. Lowermost extent of spawning unknown
82			Coho	5.00	SN, TAG	
346			Chum	1.00	Goin, Randy Johnson	Historic run, extirpated. Distribution estimated by Randy Johnson based on river morphology.
73			WSH	5.00	SN, TAG	TAG reports lowermost extent of spawning at RM 0.2

GIS Ref	Stream	WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
432			8%	5.00	SSHIAP	
306	White Creek	18.0235	Coho			SN reports distribution to RM 0.3, but Rymer indicates historic run only due to extensive culverting, currently extirpated
307			WSH			SN reports distribution to RM 0.3, but Rymer indicates historic run only due to extensive culverting, currently extirpated
430			8%	3.00	SSHIAP	
431	Unnamed		8%	0.60	SSHIAP	LB trib enters White at RM 2.7
308	Peabody Creek	18.0245	Coho	1.60	TAG	TAG indicates historic presence only, currently extirpated. SN reports distribution to RM 2.0, but likely only extended to ONP boundary (RM 1.6).
428			8%	3.00	SSHIAP	
429	Unnamed		8%	0.30	SSHIAP	RB trib enters Peabody at RM 2.0
83	Valley Creek	18.0249	Coho	1.20	TAG	
343			Chum	1.75	Goin	Historic presence, run currently extirpated
74			WSH	1.20	TAG	
427			8%	3.90	SSHIAP	
84	Tumwater Creek	18.0256	Coho	2.50	TAG/ Rymer	TAG reports spawning to powerline, SN reports distribution to RM 3.0
342			Chum	1.30	Goin	Historic run, currently extirpated.
75			WSH	2.50	TAG/Goin	TAG reports spawning to powerline, SN reports distribution to RM 3.0
423			8%	5.20	SSHIAP	
426	Unnamed	18.0257	8%	0.30	SSHIAP	
420	Unnamed	18.0258	8%	0.40	SSHIAP	
425	Unnamed		8%	0.20	SSHIAP	RB trib enters Tumwater at RM 3.2
421	Unnamed	18.0261	8%	0.20	SSHIAP	
422	Unnamed	18.0262	8%	0.20	SSHIAP	

GIS Ref	Stream				WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
424		Unnamed			18.0263	8%	0.40	SSHIAP	
103	Dry Creek				18.0265	Coho	1.00	Rymer	SN reports distribution to RM 3.4, but upper portion of drainage no longer thought to be accessible
341						Chum	1.00	Goin	Historic run to falls. Currently extirpated.
104						WSH	1.00	Rymer	SN reports distribution to RM 0.9
414						8%	3.20	SSHIAP	
418		Unnamed			18.0268	8%	3.30	SSHIAP	
417			Unnamed		18.0269	8%	1.50	SSHIAP	
419			Unnamed			8%	0.20	SSHIAP	RB trib enters 0268 at RM 2.5
416		Unnamed			18.0270	8%	1.80	SSHIAP	
415			Unnamed			8%	0.20	SSHIAP	LB trib enters 0270 at RM 1.1
	Elwha River				18.0272	Anadromous species			Historic anadromous extent to ~RM 39, to Lake Sutherland and Indian Cr., to RM 2.8 on Little R., and short lower segments of many other tribs. (not noted on map). Unknown historic extent for individual species.
88						SF chinook	4.90	SN, TAG	
87						Coho	4.90	TAG	SN reports distribution to RM 13.5, but impassable dam at RM 4.9
95						pink	4.90	TAG	
91						Fall chum	3.30	Goin/TAG	TAG reports spawning upstream to HW 112
105						SSH	4.90	SN, TAG	
77						WSH	4.90	SN, TAG	
90		Bosco Creek				Fall chum	1.00	McHenry	
345						Pink	1.00	McHenry	Historic, not observed in many years
85						coho	1.00	McHenry	
76						WSH	1.00	McHenry	
NA		Boston Creek				Coho	0.20	McHenry	LB side channel just upstream of mouth, not noted on map
NA						Chum	0.20	McHenry	LB side channel just upstream of mouth, not noted on map
NA						Pink	0.20	McHenry	LB side channel just upstream of mouth, not noted on map

GIS Ref	Stream		WRIA Index	Fish Species	Uppermost Extent (RM)	Source	Comments
86	Unnamed			Coho	0.30	TAG	LB slough entering Elwha at RM 1.5
413	Unnamed		18.0276	8%	0.10	SSHIAP	
412	Unnamed		18.0277	8%	0.10	SSHIAP	
411	Unnamed		18.0281	12%	0.10	SSHIAP	
	Indian Creek						
407		Unnamed	18.0284	8%	1.00	SSHIAP	
408		Unnamed		8%	0.20	SSHIAP	RB trib enters Indian at RM 1.8
409		Unnamed		8%	0.50	SSHIAP	LB trib enters Indian at RM 2.8
410	Unnamed		18.0332	8%	0.30	SSHIAP	
406	Freeman Cr		18.0334	12%	0.30	SSHIAP	
405	Hughes		18.0339	12%	0.90	SSHIAP	
403	Unnamed		18.0356	8%	0.40	SSHIAP	
402	Griff Cr		18.0357	8%	0.80	SSHIAP	
404	Unnamed		18.0364	12%	0.10	SSHIAP	
401	Unnamed		18.0366	8%	0.40	SSHIAP	

Sources - Lloyd Beebe, local resident and owner of Olympic Game Farm
Randy Cooper, WDFW Biologist
Dick Goin, local resident and sport fisher
Paul Hansen, Clallam Conservation District
Randy Johnson, WDFW Biologist
Ray Johnson, Biologist
Mike McHenry, Elwha Klallam
Biologist
Kerry Perkins, NRCS
Byron Rot, Jamestown S'Klallam Biologist
Tim Rymer, WDFW Biologist
Salmon and Steelhead Inventory and Assessment Project (SSHIAP), Northwest Indian Fisheries Comm.
Streamnet (SN), WDFW Database
Technical Advisory Group (TAG)

HABITAT LIMITING FACTORS BY SUB-BASIN

General

The habitat elements considered in the Water Resource Inventory Area (WRIA) 18 habitat limiting factors analysis include:

- Fish Access (human-caused fish passage barriers, screening)
- Floodplain Modifications (constrictions, loss of floodplain access, loss of sidechannel habitat)
- Channel Condition (pools, LWD)
- Substrate (fine sediment, aggradation, degradation, bed stability)
- Riparian Condition (shade, bank stability, LWD recruitment)
- Water Quality (temperature, fecal coliform contamination, toxics)
- Water Quantity (instream flows, alteration of natural hydrology)
- Biological Processes (fish carcass nutrients, invasive species)
- Lake Habitat
- Estuarine

Lakes do not play an important role as anadromous salmonid habitat in WRIA 18, so are not included within the individual watershed discussions. Similarly, the presence of invasive species was not identified as a significant habitat limiting factor in the freshwater streams, so will also not be included within the individual watershed discussions.

Watershed discussions are presented moving from the east side of the WRIA to the west side, and for streams with identified tributaries within the anadromous zone, the tributaries are ordered from lowermost to uppermost in each drainage. WRIA index numbers (Williams et al. 1975), are also referenced (where they exist) for further consistency and clarity. Additional location information for most streams is available on the fish species distribution maps (see separate Maps file included with this report).

Bell Creek 18.0001

Location

Bell Creek is a relatively small independent drainage to salt water on the east side of the Dungeness plateau, entering Washington Harbor on the eastern marine shoreline near the mouth of Sequim Bay.

General

The Jamestown S'Klallam Tribe commissioned a habitat inventory (De Lorm 1999) that provided an inventory of basic habitat features of Bell Creek, from the mouth to the headwaters. In addition, the project intent was to map past, current, and planned projects that have occurred along the stream corridor and assess the cumulative impacts of the various actions on each other and on the watershed as a whole.

Fish Access

Although several culverts are identified in De Lorm (1999), it does not appear the culverts were evaluated for fish passage. However, many small fish (species unidentified) were found in the confined reach extending from the fork at RM 2.0 to Happy Valley (De Lorm 1999). A culvert at the outlet of the lower pond at Carrie Blake Park (~RM 1.4), which was previously identified as a barrier, has been removed and passage may no longer be a concern at this site (TAG).

Upstream anadromous access is blocked by a natural waterfall at RM 3.0. Fish passage is also affected by low flow conditions. Lack of instream flow is identified as a fish passage concern in the vicinity of Carrie Blake Park. In addition, the TAG identified a chronically unscreened irrigation diversion just upstream of Carrie Blake Park, which diverts up to 50% of the water in Bell Creek. The diversion operation and water use are by separate groups (landowner and City of Sequim), creating conflicts in headgate operation coordination. The HB 2514 Watershed Planning Unit should investigate alternatives to maintain instream flow in Bell Creek, and the Department of Ecology/Department of Fish and Wildlife should ensure enforcement of the screening requirements on the irrigation diversion, to ensure that juvenile and adult fish are not entrained in the irrigation diversion.

Several segments of lower Bell Creek (downstream of the forks at RM 2.0) and the fork that flows under and along Third Avenue in Sequim are reported to be completely obstructed due to presence of blackberries and reed canary grass (De Lorm 1999). It is unknown to what extent these areas may preclude upstream adult salmonid passage or strand juvenile salmonids.

Floodplain Modifications

The configuration of Bell Creek is likely altered from historic condition. Joel Freudenthal indicates that Bell Hill historically drained to a wetland complex at the base of the hill, which soaked into coarse sediments that are the result of a prehistoric channel of the Dungeness River. It is thought there was no historic direct surface water connection between the wetland and Bell Creek. Historically, Bell Creek is thought to have been primarily spring fed, with stable flows and limited floodplain. This former wetland and agricultural area has been wholly replaced with urban land uses within the City of Sequim. Much of the historic wetland complex at the base of Bell Hill has been eliminated, and runoff has been routed directly, via surface water channels, to Bell Creek, increasing flow fluctuation. The wetland complex was connected to Bell Creek to provide for efficient transfer of irrigation water from the Highland and other irrigation systems to the Bell Creek system. Recent maps (1957 USGS topo) also show a tributary to Bell Creek originating in the vicinity of the Silberhorn Road intersection with River Road, near the Dungeness River. This tributary was also constructed as an irrigation ditch connection to Sequim Prairie and Bell Creek, to irrigate one of the most productive soil types in the valley.

The lower 2.0 miles of Bell Creek are channelized, and the lower 0.25 miles are diked (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report), effectively eliminating the stream's access to its floodplain and estuarine wetlands and increasing stream energy during high flows. In 1999, Clallam County completed a restoration project on a previous dairy farm in the estuary, which included removal of two marine dikes and construction of several estuarine channels. Immediately upstream of the estuary the stream is channelized for approximately 800 feet. The stream has been remeandered, and/or restored (with LWD added, riparian fencing, and riparian plantings) to its natural location for approximately the next 4,000 feet by Clallam County and the DOT as mitigation for the Sequim Bypass. Portions upstream of that point (within the City of Sequim), have also been remeandered, but the majority of the streambed remains channelized (in the former floodplain of the Dungeness River) until the creek enters the ravine section. The Bell Creek watershed is in an area that is rapidly being developed. There is currently a development proposal upstream of Highway 101, where the developer is indicating a desire for channel reconstruction. Channel reconstruction may be beneficial, but the developer is proposing that only a small riparian buffer would be provided.

Channel Condition

Within the anadromous use zone, all areas that have not previously been restored are extremely deficient in LWD and pools (TAG, Randy Johnson). Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Substrate

Gravel substrate condition is good in certain areas in the stream, particularly in the lower system from RM 0.4-0.6. However, the channel bed downstream of Schmuck Road is heavily cemented with fines. The sediment transport capacity is low, as the creek does not flood much and the natural gradient is low. Local governments should ensure that adequate stormwater protection is implemented to ensure that natural hydrology is maintained as this watershed is developed.

Riparian Condition

De Lorm (1999) reports the riparian condition to be generally poor throughout much of the length of Bell Creek. There are, however, some segments where the canopy coverage remains generally good. From the mouth to Schmuck Rd., there are some alders 1-4' diameter and a few small Douglas fir, but the riparian condition is generally poor and non-functional.

Water Quality

Bell Creek is designated as Class AA waters. Bell Creek is listed on the Clean Water Act Section 303(d) list of impaired waterbodies, based on elevated fecal coliform counts (Barecca 1998). Although fecal coliform is not known to directly adversely affect salmonids, it is often an indicator of other water quality impacts in the watershed that can adversely affect salmonids. These include direct animal access to the channel which affects riparian condition and bank stability, high fine sediment levels in the substrate from stormwater or agricultural runoff, and high nutrient levels in the stream which may cause excessive plant growth and affect dissolved oxygen levels. Water quality has been most impacted to date by unrestricted animal access in the watershed; however, there is increasing concern about stormwater as urban/rural development occurs in the watershed.

Water Quantity

Flows in Bell Creek are heavily influenced by groundwater return flows from irrigation diversions from the Dungeness River. Reduction of irrigation acreage and reduced conveyance loss through leakage have decreased groundwater infiltration to Bell Creek, particularly during low flow periods, with an associated reduction in surface water flows. During low flow periods, instream flow is further compromised by a chronically unscreened irrigation diversion just upstream of Carrie Blake Park, which diverts up to 50% of the water (see Fish Access section above). The HB 2514 Watershed Planning Unit should investigate alternatives to maintain instream flow in Bell Creek.

Stormwater runoff from developed areas is an increasing concern in Bell Creek, with increased incidence of flood events in Sequim in recent years. Effects of stormwater runoff are expected to increase significantly as the basin is further developed. The primary impacts at this time are from runoff from the Bell Hill development. Local governments should ensure that natural hydrology in the Bell creek watershed is maintained as the watershed is developed.

A proposal to release treated Class A water from the City of Sequim wastewater treatment plant to Bell Creek is currently under consideration. The proposal is to release .6 cfs of water into Bell Creek during winter months, and approximately one-tenth of that during summer months (Cynthia Nelson). Although augmentation of summer low flows may benefit salmonids in Bell Creek, there are a number of concerns associated with this proposal that should be thoroughly considered. The release of treated water in winter months has the potential to increase both the frequency and magnitude of storm flows, which are already identified as a concern in Bell Creek. This has the potential to alter the channel characteristics created by the bank-full flow, altering habitat conditions for salmonids. Release of water during summer months should also be reviewed, to ensure that the temperature of the released water will not adversely affect salmonids.

The Highland Irrigation ditch intercepts stormwater runoff from several gullies, and the ditch has a history of bursting, releasing high flows and large amounts of fine sediment into Bell Creek. Although this typically occurs upstream of the anadromous access area, the downstream channel is impacted by the instantaneous increase in flow and the significant downstream sedimentation that results.

Instream flow recommendations have been made for Bell Creek, based on toe width measurements of 9.8 feet made at Schmuck Rd.. [NOTE: Toe width is a method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.] Recommended instream flows are 11.0 cfs for the period November-January (coho spawning), 7.0 cfs for February, 22.0 cfs for March-April (steelhead spawning), 14.0 cfs for May-June, and 4.0 cfs for the period July-October (steelhead rearing) (Beecher and Caldwell 1997*)*. As noted above, instream flows are influenced by groundwater return flows from irrigation. It is likely that toe width of the channel has increased due irrigation groundwater return flow and routing of stormwater through the irrigation delivery system to Bell Creek, artificially increasing peak flow frequency and magnitude in the channel. The limited flow data that is available for Bell Creek was not reviewed to ascertain consistency with recommended instream flows.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The lower portion of Bell Creek, prior to entry into Washington Harbor, has been diked and highly confined for many years. This effectively eliminated stream and tidal interchange with the floodplain and historic salt marsh habitat. However, in 1999 Clallam County completed a restoration project on a previous dairy farm in the estuary, which included removal of two marine dikes and construction of several estuarine channels. This is expected to restore estuarine wetlands adjacent to the stream's mouth, but the stream itself remains diked in this area and is not functionally connected to its estuary. The northern end of Washington Harbor is adversely impacted by the presence of road and dike across the harbor, which is discussed in the Marine Habitat Limiting Factors section of this report.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Bell Creek:

- **County/City should adopt and implement a stormwater strategy for this rapidly developing watershed that will remediate current stormwater effects and minimize additional future effects**
- **Stabilize the Highland Irrigation Ditch to ensure stability during high flow events to avoid potential for fine sediment contribution to Bell Creek**
- **Restore the lower, channelized reach of Bell Creek (downstream of Schmuck Road) and properly integrate with the estuary. Restoration must included removal of dikes, meandering of the channel, excavation of pools, and additions of LWD.**
- **Assess LWD status in Bell Creek and tributaries; develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout the watershed, and identify and correct areas affected by unrestricted animal access**
- **Complete comprehensive barrier inventory for Bell Creek, prioritize, and implement correction measures**
- **Review proposal to release treated Class A water into Bell Creek, and ensure any release does not adversely affect channel conditions or salmonid habitat**

In addition, the following action recommendations should be referred by the Lead Entity to other forums to be addressed:

- **WDFW should actively enforce screening requirements on the irrigation diversion upstream of Carrie Blake Park**

- **HB 2514 Planning Unit should review instream flow concerns and investigate alternatives for ensuring instream flow**

Gierin Creek 18.0004

Location

Gierin Creek is a relatively small independent drainage to salt water on the east side of the Dungeness plateau, entering salt water between Sequim Bay and the Dungeness River.

General

There are 8.3 miles of streams and tributaries in the Gierin Creek watershed. Primary land uses in the watershed are pasture/grassland (2%) and commercial timber (19%) (PSCRBT 1991). In addition, the majority of the lower portion of the Gierin Creek watershed is in a single ownership named "Graysmarsh", which is an approximately 140-acre fresh/brackish water marsh and associated agricultural uplands. The size of the marsh may be similar to historic, but a tide gate was installed at the mouth of the creek in approximately 1919 for agricultural purposes. In contemporary times, Graysmarsh has been managed exclusively for wildlife and fish habitat. Livestock are not allowed access to the marsh, nor do any agricultural practices occur within the marsh; there is some agriculture on uplands immediately adjacent to marshlands**.**

Fish Access

A fish ladder provides unrestricted adult salmonid passage at Victoria Falls at RM 1.3, although the ability of juvenile salmonids to pass upstream through this ladder is not known at this time. A tidegate, located at the mouth of Gierin Creek, may impair fish passage at certain tidal stages, although a significant amount of salt water passes through the tide gate. Adult salmon have also been observed upstream of the tidegate. In addition to impairment of fish passage, the primary effect of the tidegate is that salt water interchange with the historic estuary is severely limited.

Floodplain Modifications

The floodplain of Gierin Creek is generally intact. However, the main channel of Gierin Creek historically bisected the marsh with the outlet at the northeast corner of the marsh, but was rerouted along the southern edge of the marsh and discharged through the current location of the tidegate. This has disassociated much of the intertidal flow with the historic salt marsh area. With loss of flow through the historic salt marsh channels, they tend to accumulate sediments and need to be periodically dredged to remove accumulated sediment and vegetation, and to retain open water characteristics in the channels.

Channel Conditions

Streambanks throughout portions of the upper drainage are trampled due to unrestricted animal access. South of Holland Rd., the stream corridor is seriously degraded as a result of animal access, channelization, and residential development (PSCRBT 1991). The channel is generally lacking LWD, except for some presence in the forested reaches through Graysmarsh and isolated locations where LWD has been placed. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate

Maps file included with this report. Pools are also generally non-existent upstream of RM 1.5, except for isolated locations where pools have been dug as part of stream restoration efforts (TAG).

Substrate

No specific concerns identified regarding channel substrate at this time.

Riparian Condition

Riparian condition is considered to be generally good through Graysmarsh to RM 1.5; the channel flowing through the wooded area on the south side of the marsh likely has more canopy cover than the historic natural channel, which flowed diagonally across the marsh with limited tree cover.

Most of Gierin Creek downstream of Port Williams Road has been fenced to exclude livestock. Some problems with stock access to the channel continue upstream of Port Williams Road, although this is not continuous. Riparian habitat from Holland Road to Port Williams Road is generally poor, but stock have been excluded and riparian planting has been done. Riparian habitat upstream of Port Williams Road is poor to non-existant (Paul Hansen).

Water Quality

Gierin Creek is designated as Class AA waters. Water quality in Gierin Creek is adversely affected by direct animal waste input due to animal access to the channel (PSCRBT 1991), although animal access issues are thought to be generally corrected downstream of Holland Road (Paul Hansen, TAG). Animal access to the stream remains a concern upstream of Holland Road. Dredging of channels in Graysmarsh has been done on a periodic basis to remove vegetation and sediment that obstruct the channels. This may be in part due to increased sediment and nutrients from animal access and pasture runoff upstream of Graysmarsh, but is also a consequence of decreased tidal flux into the estuary.

Water Quantity

Flows in Gierin Creek are thought to be heavily influenced by groundwater return flows from irrigation diversions from the Dungeness River. Irrigation conservation in the Dungeness River and reduction in amount of irrigated acreage have likely resulted in decreased flows in Gierin Creek, particularly during low flow periods.

Instream flow recommendations, based on toe width measurements of 9.1 feet made at Holland Rd., have been made for Gierin Creek. Recommended instream flows are 10.0 cfs for the period November-January (coho spawning), 7.0 cfs for February, 20.0 for March-April (steelhead spawning), 13.0 cfs for May-June, and 4.0 cfs for the period July-October (steelhead rearing). Instream flow recommendations, based on the hydrologic base flow at the tide gate weir are 8.0 cfs for the period November-May, 11.0 cfs for June-July, and 9.0 cfs for the period August-October (Beecher and Caldwell 1997***).*** As noted above, instream flows are influenced by groundwater return flows from irrigation. Toe-width is primarily influence by bank-full flows in winter months, however it may be additionally influenced in this watershed by irrigation groundwater returns and past land use. The limited flow data that is available for Gierin Creek was not reviewed to ascertain consistency with recommended instream flows.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine Conditions

Evidence indicates that at least 115 acres of Graysmarsh were once salt marsh (Randy Johnson). This area provided estuarine rearing habitat for Gierin Creek salmonids, and likely also was used for rearing by juvenile salmon originating from neighboring watersheds. As a result of the tidegate at the mouth of the estuary, only approximately 30 acres of salt marsh remains. The remaining salt marsh is also not well linked to the stream corridors. As a result of the decreased tidal interchange, channels in the estuary marsh tend to fill with sediment; dredging of the channels has been conducted on a periodic basis to retain the open water channels for duck habitat. WDFW and the Jamestown S'Klallam Tribe have recommended that Graysmarsh owners consider removing the tidegate, allowing the saltmarsh habitat to naturally restore. In addition to benefits to salmon, steelhead, cutthroat, and possibly waterfowl, this would allow sediment to move through the marsh, reducing or eliminating the "need" for maintenance dredging.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Gierin Creek:

- **Pursue removal of the tidegate and restoration of saltmarsh habitat in the estuary, including returning Gierin Creek to its former meandering location, which essentially bisected the marsh**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout watershed, particularly upstream of Holland Rd., and identify and correct areas affected by unrestricted animal access**

Cassalery Creek 18.0015

Location

Cassalery Creek is a relatively small independent drainage to salt water on the east side of the Dungeness plateau, entering salt water between Sequim Bay and the Dungeness River.

General

Cassalery Creek is approximately 4 miles in length, draining low elevation land on the east side of the lower Dungeness Valley. The stream is low gradient, with low velocity flows, flowing primarily through rural agricultural land. Several habitat improvement/fencing projects have been recently implemented by the Clallam Conservation District, and more are planned.

Fish Access

Adult salmon access was impaired by a culvert near the mouth until approximately 1990 (PSCRBT 1991). The culvert, which extends through the natural beach berm at the mouth of Cassalery Cr., has been modified to allow salmon access. However, the culvert frequently plugs, especially during winter storms, creating an obstruction to flow. Salmon have been seen in the vicinity of the outlet (TAG), and salmon and steelhead have been observed spawning on the Coon property (upstream of Jamestown Road) by Conservation District personnel (Paul Hansen).

The partially blocking culvert under Jamestown Road was replaced with a bottomless arch by Clallam Conservation District in 1999. This should decrease the large sediment accumulation that formerly occurred upstream.

Streamkeepers report that the culvert at reach #2 (Taylor Ranch Rd., RM 1.1) has a “precipitous drop”, but the impacts to fish passage are unspecified. The problem appears to be associated with the gradient within the culvert; the downstream end was surveyed (September 1998, normal streamflow) as being approximately 5-inches below water level (Paul Hansen). They also indicate there are four culverts north of Woodcock Rd., with the lower two obstructing fish passage. Specific culvert fish passage assessments and extent of habitat availability are currently unavailable.

Floodplain Modifications

Most of the length of Cassalery Creek below the springs has been artificially straightened and confined. The Creek is severely channelized downstream of Jamestown Road. This channelization, loss of floodplain, and loss of tidal energy has increased sediment accumulations in the channel in the lowermost 0.5 miles of the stream. This is likely further compounded due to frequent clogging of the culvert at the mouth of Cassalery Creek at high flows.

Channel Conditions/Substrate

Streambanks are trampled through much of the watershed due to unrestricted animal access (PSCRBT 1991). Streamkeepers note that instream habitat is heavily silted, lacks cover, with LWD presence only in the lower portion of the stream. The Clallam Conservation District completed a habitat restoration project in the reach from Jamestown Road upstream in 1999, including replacement of the culvert under Jamestown Road with a bottomless arch, removal of silt, placement of stream gravels, placement of LWD, construction of pools, and fencing to exclude cattle access. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Streamkeepers report the creek north of Jamestown Rd. is heavily silted from past upstream activity and overgrown with vegetation. There is little gravel substrate, and dense willow and other vegetation blocks segments of the stream. Benthic macroinvertebrate sampling conducted by Streamkeepers, looking at number of taxa and EPT Richness, scored as poor**.**

Riparian

The PSCRBT (1991) indicated a lack of good riparian cover throughout Cassalery Creek. Streamkeepers indicate that canopy varies widely, from none in two of the sampled reaches to 85% in the downstream sample reach (with only 30% conifers); no riparian widths were identified. Even the downstream sample reach would likely rank as poor using the habitat ranking criteria in Appendix 1, due to the low occurrence of conifer in the riparian area.

Water Quality

Cassalery Creek is designated as Class AA waters. Cassalery Creek is listed on the Clean Water Act 303(d) list for fecal coliform contamination (Barecca 1998). The PSCRBT (1991) reported that water quality in Cassalery Creek is adversely affected by direct animal waste input due to unrestricted animal access to the channel. Nitrate results are suggestive of increased nutrient loading, but the accuracy is in doubt (Streamkeepers); dissolved oxygen sampling indicated a high of 13 mg/L, a low of 9.3 mg/L, and an average of 10.2 mg/L; temperature sampling indicated a high of 14.9^{o}C, a low of 8^{o}C, and an average of 11.3^{o}C.

The Clallam Conservation District crew reported chlorine presence and impacts when working just downstream of the Sunland Sewage Treatment Plant (Kerry Perkins).

Water Quantity

Cassalery Creek is predominantly spring-fed, with limited inputs from the irrigation system; flow is fairly uniform throughout the year.

Streamkeepers noted increasing use of creek water by landowners for irrigation purposes and for maintenance of ponds, but noted a lack of data on effects to instream flow. North of Jamestown Rd., there are several man-made diversions which divert stream flow into the adjacent fields. The Department of Ecology should review these uses to ensure they are appropriately permitted. The need to establish and ensure instream flows should be referred to the HB 2514 Planning Unit.

Instream flow recommendations, based on toe width measurements of 5.7 feet made at Woodcock Rd., have been made for Cassalery Creek. Recommended instream flows are 5.0 cfs for the period November-January (coho spawning), 3.0 cfs for February, 12.0 cfs for March-April (steelhead spawning), 8.0 cfs for May-June, and 2.0 cfs for the period July-October (steelhead rearing)(Beecher and Caldwell 1997). Toe-width is primarily influence by bank-full flows in winter months, however it may be additionally influenced in this watershed by irrigation groundwater returns and past land use. The limited flow data that is available for Cassalery Creek was not reviewed to ascertain consistency with recommended instream flows.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The culvert at the mouth of Cassalery Creek (~100 feet in length) is thought to significantly alter estuarine conditions at the mouth of the creek. It is unclear whether Cassalery Creek historically had open flow to Dungeness Bay at all flows, or whether it may have been similar to other streams in this area, which have natural sand berms that isolate creek flows from salt water at low flows. In either case, the stream would have likely naturally formed a wetland pond/marsh on the upstream side of the berm. The presence of the culvert likely alters the natural tidal influx and exchange process, limiting estuarine conditions that would be beneficial to salmonids, although the extent of limitations is unknown. However, the loss of natural estuarine conditions may be balanced to some extent by the free passage conditions to salt water at all flows. The culvert frequently plugs, especially during winter storms, flooding the area upstream for at least 1,200 feet and as much as one-half mile wide, and has to be manually cleared by the downstream landowners (Streamkeepers). These obstructions occur most frequently at spawning season and although salmon have been seen in the vicinity of the outlet, none have been observed to traverse it. Potential juvenile stranding and mortality that results from the ponding effect is unknown. Estuarine restoration potential would likely be dependent on acquisition of the McGinnis farm at the mouth of the creek (TAG).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Cassalery Creek:

- **Develop and implement a strategy for restoring estuarine processes and fish passage in Cassalery Creek**
- **Complete comprehensive barrier inventory for Cassalery Creek (particularly upstream of Woodcock Rd.), prioritize, and implement correction measures**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout the watershed, and identify and correct areas affected by unrestricted animal access**

In addition, the following action recommendations should be referred by the Lead Entity to other forums to be addressed:

- **Department of Ecology should conduct a comprehensive assessment of water diversions from Cassalery Creek, determine consistency with water rights, and enforce against unauthorized water withdrawals**
- **The need to establish and ensure instream flows in Cassalery Creek should be referred to the HB 2514 Planning Unit**

- **Department of Ecology should regularly monitor for chlorine presence downstream of Sunland Sewage Treatment Plant; remediate if necessary**

Cooper Creek 18.0017

Location

Cooper Creek is a relatively small independent drainage to salt water on the east side of the Dungeness plateau, entering salt water between Sequim Bay and the Dungeness River.

General

Cooper Creek is a short (approximately one mile) drainage that flows directly to salt water. It has similar characteristics to other neighboring drainages, draining low elevation areas and affected by irrigation from the Dungeness River. Juvenile coho salmon and adult cutthroat trout have been observed in the lower watershed (Randy Johnson).

Fish Access

Prior to 1995, a tide gate at the mouth of Cooper Creek was an approximately 95% barrier to fish ingress and a total barrier to tidal flux. In 1995, a small portion of the tide gate (about 1-1/2 square feet) was removed to allow fish passage. Significant tidal flux now occurs, andit is assumed that associated fish passage conditions have also improved considerably. A water level control structure (to maintain high water levels to attract waterfowl) located in a tidal channel within the estuary severely impairs fish access into and out of approximately four acres of salt marsh. No other impediments to fish passage are known to exist in Cooper Creek.

Channel Conditions

The majority of Cooper Creek has been channelized. Few good pools and scant LWD exist. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Riparian Condition

Riparian condition is generally poor, composed primarily of reed canary grass, willow, wild rose, and a few alder.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

Tidal flux into the Cooper Creek estuary was only partially restored by the 1995 tidegate modification project. Approximately 10 acres of salt marsh are being maintained by this tidal action. Salmonid use of the salt marsh could likely be significantly improved by increasing the amount of tidal flux occurring within the estuary.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Cooper Creek:

- **Modify the tidegate to allow significantly greater tidal flux into the Cooper Creek estuary**
- **Modify or remove the water level control structure in the estuary to allow unimpeded fish passage**
- **Restore the stream to a meandering configuration, utilizing historic natural channel, where practicable**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional coniferous riparian zones**

Dungeness River 18.0018

Location

The Dungeness River is one of the two largest drainages in WRIA 18, and includes numerous tributaries. However, the discussion of habitat limiting factors in the Dungeness River section is limited to conditions in the mainstem Dungeness; habitat conditions in salmon and steelhead-bearing tributaries to the Dungeness River are discussed under separate stream headings.

General

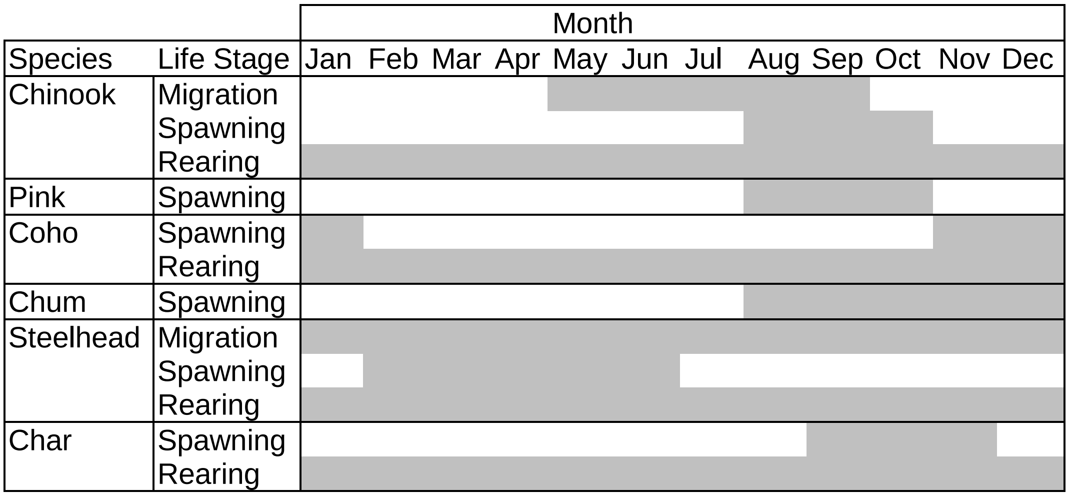
The Dungeness River drains 198 square miles. The mainstem extends 31.9 miles and its primary tributary, the Gray Wolf River, adds another 17.4 miles. In addition, there are an additional 256.2 miles of tributaries in the basin (Williams et al. 1975). Information on the in-river timing of anadromous salmonids at various life stages in presented in Figure 14.

Reach-specific habitat condition ratings are provided for most of the specific habitat elements for the Dungeness River. These ratings generally follow the habitat condition rating criteria in Appendix 1, using a composite of information from watershed studies and TAG experience. In many cases, the rating may be based on composite professional experience of the TAG.

Fish Access

The uppermost extent of anadromous fish access on the mainstem Dungeness River is limited by a natural falls at RM 18.7 (just upstream of the mouth of Gold Creek).

Figure 14: Timing of life stages of anadromous salmonids on the Dungeness River (modified from Hiss 1993)



The primary fish access concern in the mainstem Dungeness River is that low stream flows during late summer-early fall impede adult salmon migration and decrease useable juvenile habitat in over nine miles of river (PSCRBT 1991, Lichatowich 1990, Orsborn and Ralph 1992). Particular areas of concern are from the mouth to the Schoolhouse Br. (RM 0.85) where slip face cascades may present a migration obstacle at lower tidal elevations, and from Hurd Cr. to Ward Br. (RM 2.7-3.5) where slip face cascades may also present an obstacle to upstream migration during low flows (Orsborn and Ralph 1994). From the Schoolhouse Br. to Matriotti Cr. (RM 0.85-1.9), the thalweg is well defined, generally providing passage even at low flows (Orsborn and Ralph 1994). Anadromous fish access in the Dungeness watershed is also affected by bedload aggradation in some portions of the lower river between the mouth and the railroad trestle. If fish need water of certain depth and can normally use side channels, then aggradation will require river flow to be much higher than in the past to provide the same depth of water in the main channel and access to side channels. Increased flow requirements resulting from identified areas of bed aggradation suggest that irrigation diversion poses a greater problem now than historically. If the problem of streambed aggradation can be resolved, flow requirements for maximum fish use could decrease (Hiss 1993).

The Dungeness hatchery maintained an adult salmon collection rack across the Dungeness at RM 10.8, from April to after Christmas, until approximately 1970 (Lichatowich interview with Dick Goin). Although some chinook and other species are known to have gotten past the rack, when in place, its presence clearly influenced the use of the upper Dungeness and Gray Wolf drainages by anadromous salmon.

Orsborn and Ralph (1994) indicate that the extent of rearing habitat in the Dungeness is not well understood, and recommend a systematic, seasonal survey for at least 2 consecutive years to determine the extent of rearing distribution.

Fish migration to the Dungeness River is likely also affected by irrigation return flows of Dungeness River water through other stream systems. For example, the higher than expected coho returns to McDonald Creek are thought to be the result of attraction of Dungeness coho to irrigation return flows that are dumped into McDonald Creek.

Floodplain Modifications

> ***"The river was not pristine, but certainly wasn't anywhere near the destructive, destroyed, almost totally degraded system we have now."***
> (Lichatowich interview with Dick Goin)

The period from the end of WW II to the 1980s was a time when many citizens believed they could do what they pleased in the river. This led to cleaning with bulldozers, channel changes, construction in the floodplain, armoring of banks, construction of dikes, etc. One reason for this attitude is that property owners own title to the land (and river bed) to the center of the river. Some actions were done for flood control to protect property. These actions undoubtedly harmed wild fish spawning and rearing, and increased sediment problems in the river (Clark and Clark 1996). Dick Goin recalls that the greatest extent of impact was due to extensive bulldozing in the channel from the 1960s through the mid-1970s (Lichatowich interview with Dick Goin).

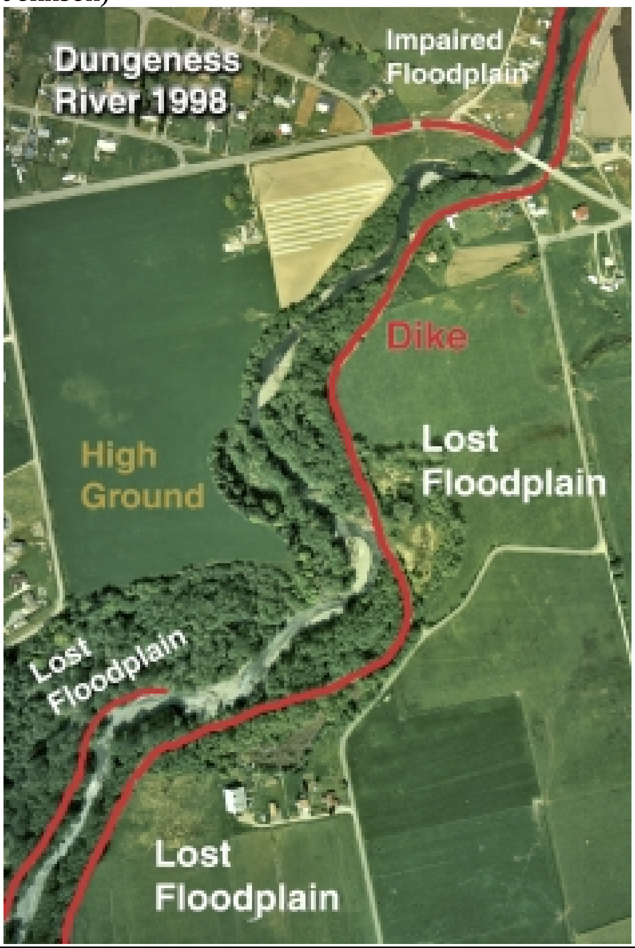
Flood and erosion control efforts actually date back to much earlier in the century. Dick Goin recalls that prior to the use of bulldozers, as noted above, flood and erosion control involved the use of cobble filled log cribs (Lichatowich interview with Dick Goin). These created some deep scour pools that were excellent adult salmon and steelhead holding structures. Other recollections of Dick Goin (Lichatowich interview with Dick Goin):

- the river had more deep pools in the 1950s and 1960s, absolutely no question about that,
- in the 1940s and 1950s, the river had more meander and was much slower, but in no sense primitive,
- doesn't remember wide meanders, as you see in other streams in the area, and
- the river changed to an aggraded condition after the war, with very graphic changes in the river associated with use of logging trucks, bulldozers, and other equipment

The floodplain of the Dungeness River is severely altered from natural condition from the mouth to the WDFW Hatchery at RM 10.8. Alterations are from diking, floodplain constrictions at bridge sites, and from unnatural rates of channel downcutting or sediment accretion. Road crossings at Highway101, Anderson Road, Woodcock Road, and Old Olympic Highway each constrict the channel/floodplain and affect the alignment of the channel within the floodplain upstream of the constriction. In addition, dikes preclude the ability of high flows to access the historic floodplain, utilizing the floodplain to reduce stream energy and to store and transport sediment. Figure 15 shows the loss of floodplain access in the reach of the Dungeness River upstream of the Ward Bridge (Woodcock Rd.). Floodplain constrictions and modifications throughout the lower Dungeness River are identified on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) and more specifically on Map 9 (Lower Dungeness Basin Revetments and Bank Stabilization) in the separate Maps file included with this report.

The configuration of the historic floodplain in the lower Dungeness watershed (prior to diking) allowed the river to actually export sediment from the system, rather than just storing the sediment (Joel Freudenthal). The flooding, which used to occur in the lower watershed historically expanded out of the Dungeness mainstem into the Meadowbrook, Cassalery, and Cooper creek watersheds. This provided a large area to export sediment, differing from the current condition in which all sediment that exits the system is routed through the Dungeness mainstem to Dungeness Bay. Additionally, sediments which were historically routed to Dungeness Bay or the Strait of Juan de Fuca were distributed across a much larger area (from the

Figure 15: Loss of floodplain access due to diking upstream of Ward Bridge (photo courtesy of Randy Johnson)



current boat launch to Cassalery Creek), as compared with the current concentrated location at the existing river mouth.

Areas of the lower 10.8 miles of the Dungeness River, where the channel is constricted by earthen and rock bank protection and dikes, are shown on the Lower Dungeness Revetment and Bank Stabilization (in the separate Maps file included with this report). In addition, dikes originally constructed to handle a 100-year flood now barely are able to handle a 25-year flood, due to the aggradation of sediment in diked portions of the channel (Dungeness River Restoration Workgroup 1997, Army Corps of Engineers files). The PSCRBT (1991) identified bank erosion, aggrading and braiding of the channel, and lack of off-channel habitat as being concerns throughout the Dungeness River.

Floodplain side channels provide highly productive spawning and rearing habitat for salmon and steelhead. Side channels are actively utilized by juvenile salmonids for rearing, where there is greater food abundance and lower energy requirements than in the flow of the main channel. Side channels typically have high contribution of ground water to the channel and are often protected from the ravages of food flows, therefore providing stable high quality spawning habitat that is actively sought and utilized by salmonids (Figure 16). Side channel habitats that are well vegetated with mature trees and located on the floodplain fringe are often the highest quality, as compared to braided channels in the unvegetated floodplain, which are often unstable. However, the availability of side channel habitats is adversely affected by diking and floodplain constrictions that eliminate the connectivity of the main channel with the full extent of the meander belt. Diking severely restricts the ability of the Dungeness River to access its floodplain, and to provide for off-channel habitat. Upper reach data and scientific literature (Winter, personal communication, as referenced in Hiss 1993) clearly show the value of keeping side channels. Channelizing, diking, and bedload aggradation reduce the potential access and use of side channels and remove essential habitat diversity. Loss of side channel habitat is particularly apparent in those portions of the Dungeness River that have been heavily diked, such as below Ward Bridge. Although not well documented, it is possible that loss of side channel habitat may be a key contributor to the severe decline of lower river spawning stocks, such as lower river pinks. Scour studies and redd pumping in the lower river have indicated little potential for egg survival in mainstem redds. The Jamestown S'Klallam Tribe has completed an

Figure 16: Pink Salmon Spawning in Side Channel at Upper End of Kincaid Island

evaluation of existing side channel habitat on the Dungeness and is a good source to contact regarding identified side channel restoration opportunities. Protection and restoration of side channel habitat should be considered a high restoration priority, where practicable. The Dungeness River Restoration Workgroup (1997) recommends that side channel areas in the river upstream of the Highway 101, Railroad, Old Olympic Highway, and Ward bridges be investigated for development of enhanced off-channel rearing area. Table 5 presents reach specific floodplain modifications.

Channel Condition

Pool condition varies throughout the lower Dungeness River. A summary of pool characteristics and pool condition rating are identified in Table 6. Although not substantiated by direct habitat assessment data, Dick Goin indicates it is his general observation that the presence of pools/holes in the lower Dungeness River has dramatically decreased over the last 5-10 years. This reduction is possibly associated with rain-on-snow events in the watershed which have moved large amounts of channel substrate.

Historically, removal of LWD and log jams was a prominent element of flood control activities on the Dungeness River. Stable log jams are now scarce throughout the lower section (lower 10.8 miles) of the Dungeness River (Orsborn and Ralph 1994, as referenced in Dungeness River Restoration Workgroup 1997). LWD that is present is primarily composed of small pieces located mainly outside the channel, with few key pieces likely to form logjams. Recruitment of key piece LWD or creation of LWD capture locations are critical to the formation of logjams in the river. In a sand and gravel bedded river such as the Dungeness, much of the structure that defines the channel is provided by imbedded wood and debris jams (Abbe and Montgomery 1996, as referenced in Dungeness River Restoration Workgroup 1997). Removal of debris jams, perceived as being a flood control hazard, has resulted in increased velocities, with associated channel instability and bank erosion (Dungeness River Restoration Workgroup 1997). In addition, removal of debris jams has likely also resulted in reduced pool frequency and depth, reduced sediment storage and stability, and reduction of side-channel habitat. Table 7 identifies LWD sampling information and condition by river reach. Specific reaches of the lower Dungeness, where lack of LWD is identified to be of concern, are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Substrate

There is significant scientific disagreement regarding the effects of human activities in the watershed. Hiss (1989) concluded that width and channel stability of the Dungeness River (RM 4-11) has not changed radically due to human impacts (bridges, diking, logging). In the same year, Kohler et al (1989) concluded that geology (primarily sedimentary with and overlay of lake deposits on top of glacial and alluvial morrains) is responsible for the inherent instability in the watershed, and that logging and road building have contributed "miniscule" amounts of sediment input. However, the TAG indicates there was little technical evidence to support the conclusions of Kohler et al. Both of these reports contradict the collective opinion of the TAG, which is that although there is high natural instability of soils in the watershed, the rate of slides, erosion, and channel instability have been significantly accelerated by human activities in the watershed. A summary of reach-specific habitat condition data for the lower 10.8 miles of the Dungeness River mainstem is presented in Table 8.

There are three major landslides (deep-seated failures) in the Dungeness watershed: Gold Creek, Silver Creek, and the Gray Wolf. The Gold Creek failure is an active and chronic contributor, with 58% of the sediment yield from undisturbed forest areas, and 42% associated with disturbed or clearcut areas. Slides in the upper watershed are due both to natural and human-induced causes (PSCRBT 1991). The Silver Creek failure is active, but Forest Road 2860 and revegetation capture most of the sediment; a large failure occurred in 1972. The status of the Gray Wolf failure is unknown. The basin-wide sediment yield is dominated by high values associated with glaciers, despite only 0.6% of the watershed being covered with glaciers (Dungeness Area Watershed Analysis Cooperative Team [DAWACT] 1995). Significant slides occurred in the Gold Creek watershed in 1968, 1969, 1972, 1975, 1978, 1980, 1989, 1990, and 1991.

Roads increase both the potential for increased mass wasting (failure of sidecast road construction material, failure resulting from concentrated or blocked drainage across road), and the amount of fine sediment delivered to the stream channel. The steeper, mountainous parts of the region were last to be logged. In 1949, there were only 8.3 miles of logging road constructed on Forest Service lands in the Dungeness watershed. By 1983, the road mileage had increased by a factor of 10, with a doubling of road mileage between 1965 and 1983. Logging no doubt increased, but useful records are not available (Orsborn and Ralph 1994). The USFS Watershed Analysis (DAWACT 1995) identifies the threshold road density of concern to be 2.5 mi/mi^2. Five of the 12 subbasins on the Olympic National Forest (not only in Dungeness watershed) exceed the threshold of concern. Two subwatershed riparian reserve zones in the Dungeness watershed exceed the threshold (Caraco Creek is at 3 mi/mi^2, and Gold Creek is at 2.7 mi/mi^2); Pats Creek is just slightly below the threshold at 2.4 mi/mi^2. These thresholds were not compared with the habitat condition ratings in Appendix 1, because the presence of valley bottom roads in these drainages was not evaluated.

Table 5: Floodplain modifications and condition for identified reaches of the Dungeness River

Stream Segment	**Floodplain Condition** (TAG)	**Comments**	**Information Source**
Mouth –Schoolhouse Br. (RM 0.0-0.85)	Poor	Channel confined by dikes on both sides throughout its length (Dungeness Homeowners and COE dikes); COE dike originally constructed to 100-year flood now only handles 25-year flow due to bed aggradation	Orsborn and Ralph 1994; Jamestown S'Klallam Tribe 1992
Schoolhouse Br. – Matriotti Cr. (RM 0.85-1.9)	Poor	Dikes and levees occur along much of length with most set back from immediate channel margin	Orsborn and Ralph 1994
Matriotti Cr. – Hurd Cr. (RM 1.9-2.7)	Poor	Impingement imposed by nearshore levees restricts the amplitude of meanders so channel is straight for long reaches (L. Beebee property)	Orsborn and Ralph 1994
Hurd Cr. – Ward Br. (RM 2.7-3.25)	Poor	Bank protection common through half of reach	Orsborn and Ralph 1994
Ward Br. – Old Olympic HW Br. (RM 3.25-4.0)	Good	Channel and floodplain constrictions exist at Ward Br. and have been improved with the reconstruction of the new Old Olympic HW Br.; thalweg instability upstream and downstream of Ward Br.	Dungeness River Restoration Workgroup 1997; TAG
Old Olympic HW Br. – RR Br. (RM 4.0-5.65)	Good	Braided channel reach; several large side channels offer off-channel rearing potential, but access during low flows limited (juvenile stranding observed); severe bank erosion downstream of RM 5.5 and major channel changes from 1966 to 1993 with channel widening due to excess bedload; channel constrictions at old Olympic and RR bridges	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
RR Br. – HW 101 Br. (RM 5.65-6.4)	Poor/Fair	Over-widened channel with low habitat diversity, old channel on left side of channel margin may present opportunity for off channel enhancement; severe bank erosion on the right bank downstream of HW 101	Orsborn and Ralph 1994
HW 101 Br. – Bear Cr. (RM 6.4-7.5)	Poor/Fair	Extensive channel braiding; restriction of bedload transport by HW 101 bridge piers and openings result in large accumulation of bedload	Orsborn and Ralph 1994
Bear Cr. – Powerline Crsng. (RM RM 7.5-8.8)	Poor	Right bank is diked from RM 7.7-8.2 (Dungeness Meadows dike); straightened channel with limited habitat diversity	Dungeness River Restoration Workgroup 1997; Orsborn and Ralph 1994
Powerline Crsng. – Canyon Cr. RM 8.8-10.8)	Poor	More natural meander; extensive riprapping and diking along both banks (~9000 ft of the 4.0 miles of bankline); lower Haller and Hatchery Stub dikes seriously constrict the channel; Kincaid and upper Haller dikes are forcing the river toward sites of active bank erosion	Dungeness River Restoration Workgroup 1997
Upstream of RM 10.8	Good	Channel naturally confined by narrow valleys and steep side slopes on USFS ownership; floodplain restoration options limited to near confluence of Dungeness and Gray Wolf and lower 0.5 miles of Gold Cr.	Orsborn and Ralph 1994

Table 6: Pool characteristics and condition rating for the Dungeness River

Stream Segment	**Pool Condition**	**Comments**	**Information Source**
Mouth –Schoolhouse Br. (RM 0.0-0.85)	Poor	Pools limited to meander bends, but sufficient to provide some adult holding habitat	Orsborn and Ralph 1994
Schoolhouse Br. – Matriotti Cr. (RM 0.85-1.9)	Poor	Number of channel meanders that provide several deep scour pools for adult holding, 20.3 pools/mi with 75% >3' deep	Orsborn and Ralph 1994
Matriotti Cr. – Hurd Cr. (RM 1.9-2.7)	Poor	Low flow pools limited to areas where flow shifts across channel; pools lack cover, are short, and have high velocities; 16.7 pools/mi with 80% >3' deep	Orsborn and Ralph 1994
Hurd Cr. – Ward Br. (RM 2.7-3.25)	Poor	20.2 pools/mi with 73% >3' deep	Orsborn and Ralph 1994
Ward Br. – Old Olympic HW Br. (RM 3.25-4.0)	Poor	16.4 pools/mi with 75% >3' deep, large accumulations of LWD form deep pools	Orsborn and Ralph 1994
Old Olympic HW Br. – RR Br. (RM 4.0-5.65)	Poor	Few pools, severe bank erosion and channel migration created long shallow riffle habitat upstream of RM 4.8; 18.3 pools/mi with 81% >3' deep; stranding of juvenile chinook in pools adjacent to wetted channel some with temp. >64^{o}F	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
RR Br. – HW 101 Br. (RM 5.65-6.4)	Poor	Pools limited to meander bends with little cover and high velocities; 14.8 pools/mi with 50% >3' deep; stranding of juvenile chinook in pools adjacent to wetted channel some with temp. >64^{o}F	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
HW 101 Br. – Bear Cr. (RM 6.4-7.5)	Poor	Pool habitat very limited and primarily at meander bends with little cover and high velocities; 15.3 pools/mi with 81% >3' deep; stranding of juvenile chinook in pools adjacent to wetted channel some with temp. >64^{o}F	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
Bear Cr. – Powerline Crsng. (RM RM 7.5-8.8)	Poor	Little resting habitat or cover; very limited habitat diversity; 3.9 pools/mi with 100% >3' deep; stranding of juvenile chinook in pools adjacent to wetted channel some with temp. >64^{o}F	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
Powerline Crsng. – Canyon Cr. RM 8.8-10.8)	Poor	Excellent deep scour pool adjacent to eroding bluff on right bank; 18.2 pools/mi with 50% >3' deep	Orsborn and Ralph 1994

Table 7: Available LWD sampling data and condition for reaches of the Dungeness River

Stream Segment	**LWD Condition**	**Comments**	**Information Source**
Mouth –Schoolhouse Br. (RM 0.0-0.85)	Poor	Habitat complexity minimal due to lack of LWD except at RM 0.3	Orsborn and Ralph 1994
Schoolhouse Br. – Matriotti Cr. (RM 0.85-1.9)	Poor	Relatively abundant, but generally located along channel margins, most small size; lack of habitat function	Randy Johnson, Joel Freudenthal, Paul Hansen
Matriotti Cr. – Hurd Cr. (RM 1.9-2.7)	Poor	Habitat complexity limited by limited amount of LWD	Orsborn and Ralph 1994
Hurd Cr. – Ward Br. (RM 2.7-3.25)	Poor	Woody debris limited to 3 large debris jams	Orsborn and Ralph 1994
Ward Br. – Old Olympic HW Br. (RM 3.25-4.0)	Poor	Minimal habitat complexity due to lack of LWD and dominated by small pieces, however, several large accumulations of LWD create deep pools and channel roughness	Dungeness River Restoration Workgroup 1997; Orsborn and Ralph 1994
Old Olympic HW Br. – RR Br. (RM 4.0-5.65)	Poor	LWD limited with a few engineered log jams for 0.5 miles below RR Bridge. LWD is more abundant from that point to just upstream of Old Olympic Highway	Byron Rot
RR Br. – HW 101 Br. (RM 5.65-6.4)	Poor	Three engineered log jams account for all of the stable LWD in this reach	Byron Rot
HW 101 Br. – Bear Cr. (RM 6.4-7.5)	Poor	Four engineered log jams and some scattered unstable LWD pieces	Byron Rot
Bear Cr. – Powerline Crsng. (RM RM 7.5-8.8)	Poor	Very limited habitat diversity. Several bank-based LWD jams were added just upstream of Dungeness Meadows Dike.	Byron Rot
Powerline Crsng. – Canyon Cr. RM 8.8-10.8)	Poor	Stream energy in this reach precludes significant accumulations of LWD	TAG
Upstream of RM 10.8	Poor	Additional LWD needed to stabilize sediment	Dungeness River Restoration Workgroup 1997

Table 8: Substrate condition for identified reaches in the Dungeness River.

Stream Segment	Substrate Condition	Comments	Information Source
Mouth –Schoolhouse Br. (RM 0.0-0.85)	Poor	Excessive sediment accumulation and instability; bed instability after spawning and armored bed substrate thought to be associated with lack of LWD; fines from Gold Cr. slide still coat gravels in low gradient reaches near Schoolhouse Br.; bed particle size is within the range preferred by spawning chinook and pink but high percentage of sands and silts and the impacted nature of substrate suggests that actual spawning is limited	Dungeness River Restoration Workgroup 1997; Orsborn and Ralph 1994
Schoolhouse Br. – – Hurd Cr. (RM 0.85-2.7)	Poor	Bed instability during flood events is thought to be associated with lack of LWD; excessive sediment accumulation and increases in stream energy due to channel confinement by dikes, aggravated by changes in channel shape, which further increases stream energy exerted on the stream bed during elevated flows	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997; Joel Freudenthal
Hurd Cr. – Ward Br. (RM 2.7-3.25)	Poor	Spawning gravel abundant, but bed instability may limit spawning productivity; extensive reworking of gravel bar margins due to focussed flows through bridge; bed instability after spawning and armored bed substrate thought to be associated with lack of LWD	Orsborn and Ralph 1994
Ward Br. – Old Olympic HW Br. (RM 3.25-4.0)	Poor	Bed instability after spawning and armored bed substrate thought to be associated with lack of LWD; significant sediment aggradation upstream of Ward Br.; significant scour observed in 1993, potentially associated with gravel mining	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
Old Olympic HW Br. – RR Br. (RM 4.0-5.65)	Poor	Bed instability after spawning and armored bed substrate thought to be associated with lack of LWD; visual observation indicates high percentage fines	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
RR Br. – HW 101 Br. (RM 5.65-6.4)	Poor	Bed instability after spawning and armored bed substrate thought to be associated with lack of LWD	Orsborn and Ralph 1994
HW 101 Br. – Bear Cr. (RM 6.4-7.5)	Poor	Restriction on bedload transport by HW 101 bridge piers and openings result in large accumulation of bedload; spawning habitat limited due to depth, substrate, and velocity conditions	Orsborn and Ralph 1994
Bear Cr. – Powerline Crsng. (RM 7.5-8.8)	Poor	Bed materials coarse, spawning habitat essentially non-existent; extremely high levels of vertical and horizontal bed instability	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997
Powerline Crsng. – Canyon Cr. RM 8.8-10.8)		Two bluffs upstream of the powerline may contribute substantial sediment; channel downcutting has isolated the Highland irrigation intake	Dungeness River Restoration Workgroup 1997
Upstream of RM 10.8		LWD needed to stabilize sediment input from Gold Cr. and to retain spawning gravels	Dungeness River Restoration Workgroup 1997

Figure 18:Culvert and road failure on Forest Road 2860 in upper Dungeness watershed

There was a very high rate of forest road failure on USFS land resulting from the winter of 1998-99. This is particularly evident on Forest Roads 2860, 2870, and 2880**.** The amount of mass wasting that occurred is extensive, and the amount of additional mass wasting potential is of even greater concern. Forest Road 2860 was identified as one of the largest contributors of fine sediment to the Dungeness River (DAWACT 1995). Figure 18 shows one of the many major road and culvert failures on Forest Road 2860 during the winter of 1998-99, of which most of the material entered the Dungeness River below. It is being considered for potential abandonment, but there remains a very high risk of mass wasting and sedimentation until a final decision and abandonment actions are implemented. Forest Road 2870 is constructed across the mid-slope of a very large active mass failure. As a result of the 1998-99 winter, there are numerous sites on the road that are impassable (Figure 17). The USFS is currently plagued by a lack of adequate funding to provide the necessary maintenance of existing USFS roads, much less the extensive repair work necessary to provide continued public access and to minimize potential of further significant mass wasting and erosion in the upper Dungeness watershed (Ben Kizer, USFS, personal communication). Forest road management has been a long-standing concern, as the PSCRBT (1991) identified the lack of forest practice administration and enforcement (regarding road construction and maintenance) as increasing sedimentation from road associated slides, and which should be considered a habitat limiting factor.

Figure 17 Forest Road 2870 – Road constructed mid-slope on large mass failure

Spawning habitat, having the requisite depth, velocity, and substrate characteristics for both chinook and pink appears to be extremely limited in the mainstem Dungeness River. Spawning habitat from R< 6.4 to 10.8 is limited by extensive bed armoring, with spawning occurring in areas prone to bed scour and fill (Dungeness River Restoration Workgroup 1997). The limited spawning habitat is distributed in small patches and seems to be highly susceptible to scour and aggradation, even during moderate winter storm events (Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997).

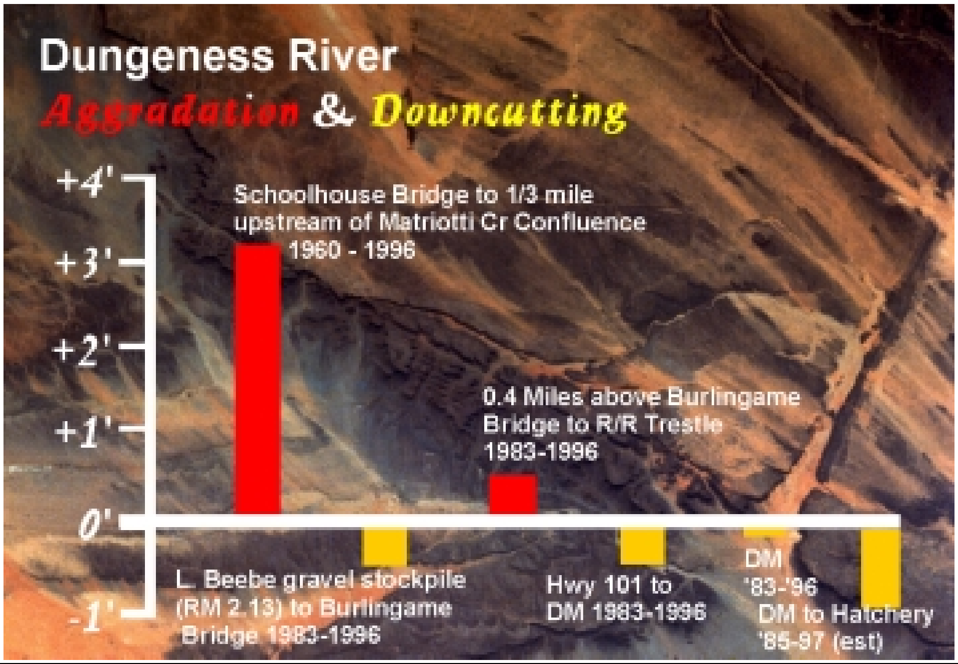
Chinook and pink salmon redds in the lower 10.8 miles of river are largely unsuccessful because the locations chosen for redd construction appear to scour deeply at even moderate flow events. As a result of a 2040 cfs flood flow on 12/10/94 (slightly higher than the average daily flood flow of 1900 cfs), almost all of the scour chains (used to measure gravel stability) were scoured out and/or buried within the lower 10 miles of the Dungeness River (Orsborn and Ralph 1994). At flows of 3500-4000 cfs., recruits per spawner for pink salmon drop below one (Lichatowich 1992). The flood magnitude in Gold Creek appears to have increased by 35% as a result of the 1969 slide in Gold Creek, raising the flood magnitude in the Dungeness River to a total of 4,100 cfs. (Orsborn and Ralph 1994).

There is concern, however, that the scour chain study may not accurately represent current conditions regarding bed scour in the Dungeness River (Joel Freudenthal). Conditions in the river prior to the scour chain study were greatly influenced by the large amount and wide distribution of gravel mining operations that were occurring in the river during that time as an effort to reduce perceived channel aggradation. The scour chain study was implemented in winter with normal flood flows, but followed a winter that was the driest on record for Sequim, and in which a channel-forming flood flow did not occur. Consequently, the cumulative effect of over two years of gravel removal operations may have resulted in greater stream bed instability than would have occurred under more normal conditions. In addition, the data from the scour chain study, in conjunction with data indicating total mortality of redds constructed adjacent to gravel traps, and the knowledge that gravel removal alters the sediment supply to the river, have resulted in almost a total cessation of gravel removal from the river. Therefore, the scour chain study may not be representative of substrate conditions in recent years. The Jamestown S'Klallam Tribe installed 61 scour chains at various locations in the lower Dungeness River in the fall of 1999 (with plans for an equivalent number to be installed in 2000), and the data generated by that study will be more indicative of current bed stability in the lower river. During installation of the scour monitors in 1999, Byron Rot found the gravel in the Olympic Game Farm reach to be of good spawnable size and easy to penetrate (no armoring), in stark constrast to the reach downstream of the Railroad Bridge.

Installation of gravel traps along the shore (during low flows) on point bars may contribute to the instability of nearby spawning areas. Chinook have been observed spawning in close proximity to gravel traps, with subsequent loss of the eggs in the redds due to the channel regrading that occurs in the vicinity of the gravel traps. From 1991 to 1994, over 40 Hydraulic Project approvals (HPAs) were issued that allowed removal of river gravels; the locations and amounts removed were largely unrestricted and undocumented (Orsborn and Ralph 1994).

A frequently encountered opinion encountered with residents of the Dungeness River watershed is that the channel bed of the Dungeness River is aggrading (the elevation of the bed materials is rising). This opinion appears to be based on a combination of known high contribution of sediment from slides (deep-seated failures and shallow-rapid landslides) in the upper watershed and indications from the Corps of Engineers that dikes built in the lower watershed to handle a 200-year flood (0.5% flow recurrence interval) are now only capable of handling the 10-year flood (Joel Freudenthal). However, data from throughout the lower 10.8 miles of the Dungeness (Figure 19, composite of channel elevation cross-section data from Corps of Engineers files 1960, Dungeness River Restoration Workgroup 1997, and Northwest Hydraulic Consultants 1987) indicate that although the floodplain bounded by the dikes in the vicinity of the Schoolhouse Bridge has aggraded significantly from 1960-1996, other sections of the river (both up and downstream) have been relatively stable since 1983, with 4 of the other 5 sample sites actually showing channel degradation. In fact, in Meadow Creek (a Dungeness River side channel which drains Dungeness Meadows development) and another side channel across the Dungeness River, this downcutting has lowered the local water table and resulted in a significant seasonal and total loss of access to some of the highest quality side channel habitats on the Dungeness River (Joel Freudenthal). The river is degrading in some sections and aggrading in other sections, both affecting passage or access to side channels. The data do not appear to support the general perception of channel aggradation throughout the watershed.

Figure 19: Channel aggradation and downcutting (in feet) at several locations in the lower 10.8 miles of the Dungeness River (analysis and figure courtesy of Randy Johnson)



<u>Riparian</u>

Riparian condition varies throughout the Dungeness. The PSCRBT (1991) and TAG identify the upper Dungeness (upstream of RM 10.8) as having excellent streambank cover, and the lower portion (downstream of RM 10.8) as having poor riparian condition (sporadic streambank cover, primarily deciduous vegetation, lack of conifer, pasture land, armored riprap banks). However, there are some sites in the lower river that are currently in good condition, and which should be protected (see Habitat in Need of Protection chapter of this report) to ensure no further adverse riparian impacts. Riparian condition for identified reaches of the Dungeness River is identified in Table 9.

Table 9: Riparian condition for identified reaches of the Dungeness River

Stream Segment	Riparian Condition	Comments	Information Source
Mouth –Schoolhouse Br. (RM 0.0-0.85)	Poor	Channel is narrow enough to gain some benefit from shading provided by trees in riparian zone	Orsborn and Ralph 1994
Schoolhouse Br. – Matriotti Cr. (RM 0.85-1.9)	Poor	Some shading from riparian trees except at meander bends where channel width exceeds the height of riparian trees	Orsborn and Ralph 1994
Matriotti Cr. – Hurd Cr. (RM 1.9-2.7)	Poor	Olympic Game Farm dike is directly adjacent to the channel, cutting off a mostly intact riparian forest. Some riparian forest exists on the east side, but is generally confined by the Corps dike.	Byron Rot
Hurd Cr. - Old Olympic HW Br. (RM 2.7-4.0)	Poor	Riparian vegetation present, but dominated by young deciduous	Dungeness River Restoration Workgroup 1997
Old Olympic HW Br. – RR Br. (RM 4.0-5.65)	Fair/Good	Riparian zone along existing channel continuous except for 1500 ft. along left bank at RM 5.5, does not extend outside channel migration zone	Dungeness River Restoration Workgroup 1997
RR Br. – HW 101 Br. (RM 5.65-6.4)	Poor/Good	Riparian zone continuous along existing channel, does not extend outside channel migration zone	Dungeness River Restoration Workgroup 1997
HW 101 Br. – Bear Cr. (RM 6.4-7.5)	Poor	Riparian forest lacking in number of sections along reach	Dungeness River Restoration Workgroup 1997
Bear Cr. – Powerline Crsng. (RM RM 7.5-8.8)	Poor	Riparian forest lacking in number of sections along reach	Dungeness River Restoration Workgroup 1997
Powerline Crsng. – Canyon Cr. RM 8.8-10.8)	Poor/Good	Right bank riparian condition good, left bank riparian clearing and residential development has reduced vegetation to short willows	Orsborn and Ralph 1994; Dungeness River Restoration Workgroup 1997

Water Quality

The reach of the Dungeness River from the mouth to Canyon Creek (RM 10.8) is designated as Class A waters. Upstream of RM 10.8, and all tributaries, are designated as Class AA waters. The Strait of Juan de Fuca and all unclassified streams (Bell, Gierin, Cassalery, McDonald, Siebert, Bagley) are designated as Class AA waters. The Dungeness River is naturally turbid from glacial runoff through much of the year; excess turbidity was not noted as a concern (TAG).

Although the Dungeness may meet the water quality temperature standard of $<18^{o}$C, extensive portions of the lower river exceed the preferred maxima for chinook and pink ($<14^{o}$C preferred for chinook spawning, $<12.8^{o}$C preferred for pink spawning, and $<13.3^{o}$C preferred for rearing) (Orsborn and Ralph 1994). Temperature data support a trend of increasing mean temperature since the 1950s, of perhaps as much as 2^{o}F (Clark and Clark 1996). Water temperatures in shallow mainstem areas are elevated to $>60^{o}$F (Lichatowich 1990, as referenced in Orsborn and Ralph 1992). Rearing habitat is seasonally limited by water withdrawals and elevated temperature in the lower river (RM 3.5-8.8) (Dungeness River Restoration Workgroup 1997).

Orsborn and Ralph (1994) recommend sampling of summertime dissolved oxygen in the lower 5 miles of the Dungeness, where empirical evidence (extensive algae growth and bacterial mats) suggests high nutrient loading with associated likelihood of low dissolved oxygen levels. PSCRBT (1991) and the TAG indicate that both small and commercial farms, with poor management and high livestock concentrations, are significant sources of bacterial and nutrient contamination. Nutrient loading occurs primarily through groundwater, as there is little direct animal access to the mainstem Dungeness (TAG). In addition, approximately 82% of the soils within the watershed have severe limitations for on-site septic use (PSCRBT 1991).

In addition to the impacts to instream hydrology resulting from irrigation diversions from the Dungeness River, irrigation ditches convey pollutants to receiving waters through irrigation return flows (PSCRBT 1991). There are six tailwater returns (channels returning surface water flow resulting from unused water from irrigation diversions and/or irrigation runoff to surface water channels) on Matriotti Creek, 2 on Hurd Creek (upstream of the current hatchery barrier);, 3 on Gierin Creek, and 4 on Cassalery Creek. In addition, adult and juvenile salmonids are attracted into bypass channels at fish screen sites that return juvenile or adult fish back to the main channel. There are 5 actual screen return channels. A habitat restoration project was done in the Highland Ditch screen bypass channel to enhance habitat conditions actively utilized by salmonids for rearing and spawning. Spawning has also been identified in the Sequim Prairie screen bypass channel (TAG).

Water Quantity

Dungeness flows are naturally influenced by snow melt from the Olympic Mountains, with a bimodal distribution of flows. Winter peak flows are in response to rain or rain-on-snow events, but the larger sustained peak flows are actually in spring (Clark and Clark 1996). Water flows have been recorded in the Dungeness River by USGS since 1923. Average mean monthly flows in the Dungeness River range from 175 cfs in September to 706 cfs in June (Orsborn and Ralph 1994, as referenced in Bishop and Morgan 1996). Peak flows (greater than 4,000 cfs) have been more numerous from 1976 to present, compared with the period of 1962-1975 (Lichatowich 1992, as referenced in Bishop and Morgan 1996). Besides gravel scour and redd destruction, juvenile salmonids present in the stream may have difficulty maintaining position in increased flows and may be displaced downstream or be swept into the estuary. Increased juvenile competition or increased mortality from salinity intolerance may result (Bishop and Morgan 1996).

There are currently 3500+ groundwater wells catalogued in the Dungeness watershed (Clark and Soule 1993; and update prepared by Soule and Clark 1995; as referenced in Clark and Clark 1996). Recent comparison of well-water levels indicates lowering of groundwater levels in many cases (some cases as much as 10 feet). One commonly indicated change that affects groundwater levels is lessening of seasonal irrigation use (Clark and Clark 1996).

The Dungeness River is on the CWA 303(d) List of impaired water bodies for instream flow. Extensive irrigation systems in the Dungeness Valley decrease instream flow, particularly from April through October, jeopardizing salmon stocks. A total of 581 cfs. has been appropriated under water rights of the Dungeness River, while the average August-September flows measure only 187-227 cfs. (Barecca 1998).

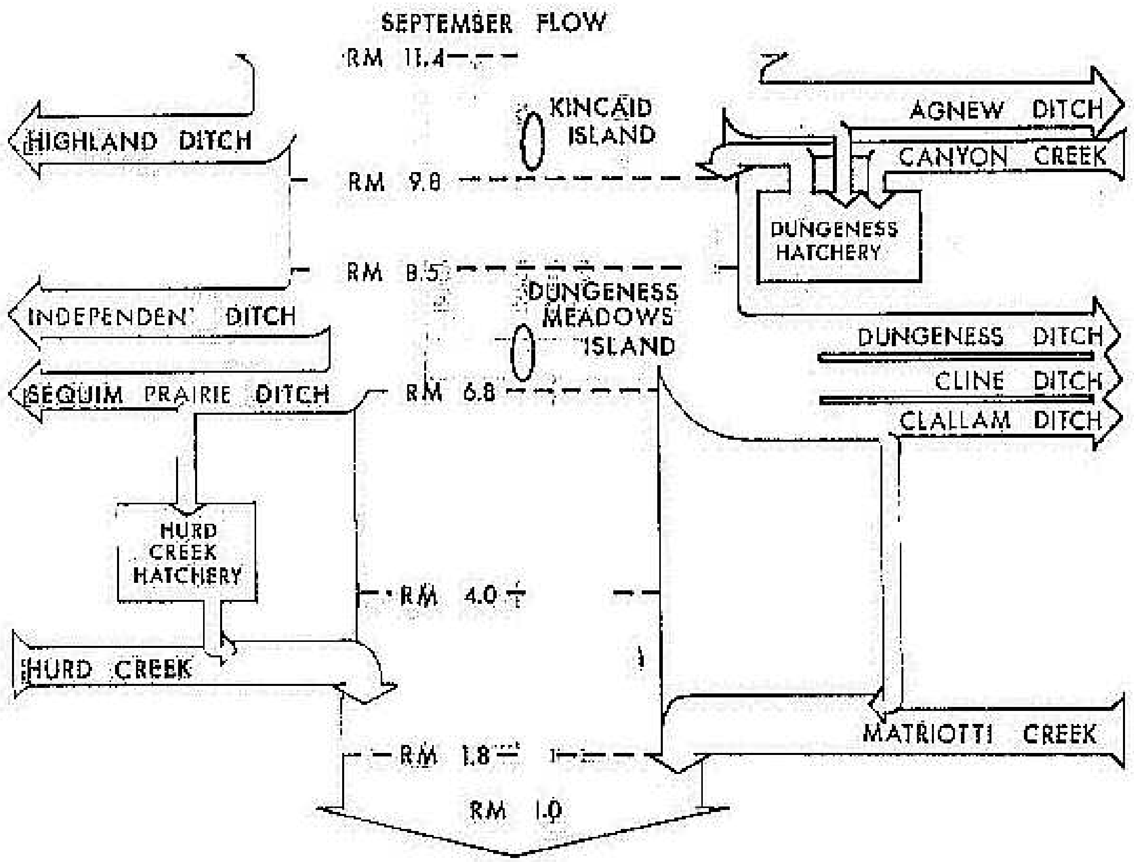
The presence of an extensive irrigation system within the Dungeness valley is unique in western Washington. The era of irrigation in the Dungeness valley began with the raising of the first irrigation headgate on the Sequim Prairie ditch in 1896. Other ditch companies and districts followed, and by 1921 there were nine organizations diverting water from the Dungeness River to irrigate agricultural land. The early pioneers were motivated by the desire to make a better living than could be afforded by farming the dry prairie in the rain shadow of the Olympic Mountains. The earliest settlers had great success growing crops on the bottomlands of the Dungeness River, but these lands were soon claimed and farming outside of the bottoms was not very productive due to the low precipitation in the area. The Dungeness River was seen by a few as a source of water to convert the dry land into productive farmland (Keeting 1976, as referenced in PSCRBT

Table 10: Sequim-Dungeness Peninsula Irrigation Water Rights (modified from Haberman 1988)

Irrigation Company/District	Priority Date	Max. Withdrawal (cfs)	Acreage Allowed
Sequim Prairie Company	Nov. 1895	20.0	1000
Eureka Company	Jan. 1897	23.08	1154
Clallam Company	Jan. 1902	60.0	3000
Independent Company	Jan. 1906	40.0	2000
Dungeness Company	Jan. 1911	70.94	3547
Highland District	Jan. 1915	70.14	3507
Agnew District	Jan. 1918	146.0	7300
Cline District	Jan 1919	46.0	2300
Dungeness District	Jan. 1921	42.0	2100
Total		518.16	25,908

1991). Table 10 lists the major irrigation companies and districts, with some pertinent data on the irrigation water rights. Figure 20 provides a schematic of the general location and effect of irrigation withdrawals on flow in Dungeness River. The irrigation system was mapped in 1998 as part of the Comprehensive Water Conservation Plan (Montgomery, 1999) and contains approximately 62 miles of main ditch canal and another 111 miles of secondary ditches and laterals. Water diverted from the river is used for irrigation, stockwater, and domestic. Irrigation districts and individual users were adjudicated in 1924 to receive a total of 581 cfs to legally serve 28,000 acres (Cynthia Nelson). Estimates vary regarding the actual number of acres that were historically directly irrigated, ranging from 7,500 to 11,000 acres at the peak (Eckert 1998, PSCRBT 1991). Currently approximately 6,000 acres are irrigated annually, but the irrigated acreage may vary from year to year for the estimated 3300 acres of commercial farms, 4400 acres of small farms, 3000-4000 acres of lawns and gardens (Montgomery 1999, PSCRBT 1991). The number of irrigated acres in the Dungeness area used for commercial farms decreased from 11,970 in 1954 to 4,748 in 1987; the number of dairy farms decreased from 679 in 1954 to 27 in 1987 (DAWACT 1995). Diversion of water for irrigation accentuates low flows, hinders anadromous fish passage, decreases juvenile rearing areas and increases aggradation of the streambed (PSCRBT 1991). The irrigation delivery system has historically had significant conveyance losses through seepage, which tends to increase groundwater levels and provides additional flow to tributary streams to the Dungeness River and other independent streams in the Dungeness Area Watershed. These conveyance losses have been the focus of water conservation and efficiency improvements over the past several years. The irrigation system also transfers stormwater flows to other streams (Bear and Matriotti creeks) that would otherwise not be significantly affected by stormwater flows. In the case of the Agnew and Highland Districts, the stormwater conveyance may include some Dungeness River stormwater flows early in the storm

Figure 20: Dungeness River reaches affected by irrigation withdrawal. Vertical scale represents approximate river mile. Arrow width represents relative amount of typical summer flow. (from Hiss 1991)



season, with later flows representing stormwater runoff into the main irrigation canals after the outtakes from the Dungeness River have been shut off. Other irrigation companies aren't significantly impacted by stormwater runoff except during extreme events, but do shut down their outtakes when the Dungeness River becomes too turbid for stockwater use (Mike Jeldness, personal communication).

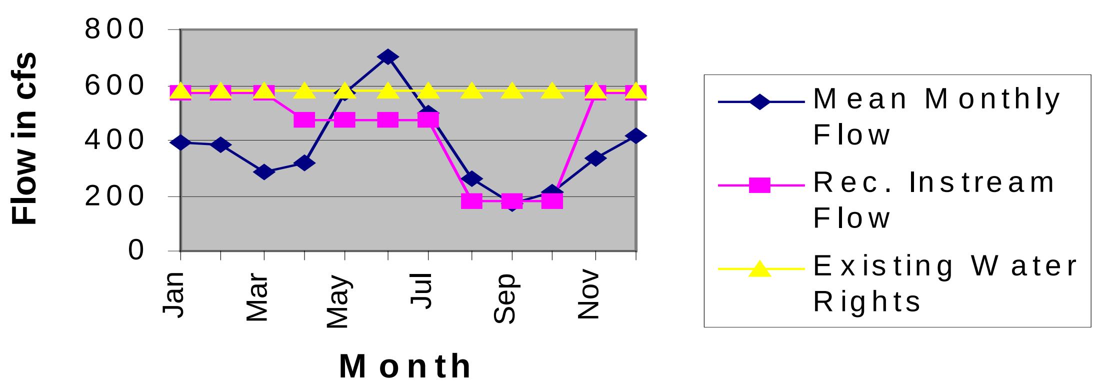
Instream flow reduction, due to irrigation withdrawals, has been a long-standing concern in the Dungeness River. The 1927-1929 Report (Washington Department of Fish and Game 1930, as referenced in Clark and Clark 1996) indicated hatchery conditions downstream of the hatchery (RM 10.8) as very unsatisfactory, and noted that irrigation companies depleted the river of water during the spawning season and irrigation ditches were still not successfully screened. The primary fish access concern in the mainstem Dungeness River is that low stream flows during late summer/early fall impede adult salmon migration and decrease usable juvenile habitat in over nine miles of river (PSCRBT 1991, Lichatowich 1990, Orsborn and Ralph 1992). As the rate of flow is artificially lowered in August and September, the potential for development of barriers to upstream passage caused by shallow riffles is increased, preventing adult pink and chinook from reaching preferred spawning grounds (Wampler and Hiss 1991). Spawning habitat in reaches subjected to water withdrawals is substantially reduced compared to pre-withdrawal conditions. Surveys of the lower river indicated a number of locations where juvenile salmonids were trapped in pools or other low spots along the margin of the wetted channel, some of which were lost as water depths dropped and temperatures exceeded 68°F. There are a number of side channels in the lower river (from downstream of the Railroad Br. to the Ward Br.) with good water quality, but the value of these side channels is decreased as access is cut off because of irrigation induced low flow (Orsborn and Ralph 1994). Reduction of instream flow, due to infiltration loss or subsurface flow (not related to irrigation impacts), has been observed downstream of the Highway 101 bridge (Orsborn and Ralph 1994).

The U.S. Fish and Wildlife Service carried out an Instream Flow Incremental Methodology (IFIM) study in 1988-1989, to establish a relationship between stream flow and usable habitat for different life stages of salmonids. The IFIM study showed that only 45% of the wetted useable area (WUA) was achieved for adult chinook salmon holding and migration at the lowest flows measured at the sample sites. At the lowest recorded flows, WUA for spawning was reduced by 90% (Hiss and Lichatowich 1990, as referenced in Bishop and Morgan 1996), with the critical time period of concern being August-October. Instream flow recommendations have been developed for the mainstem Dungeness River (Wampler and Hiss 1991; Hiss 1993; Hiss 1995, as referenced in Clark and Clark 1996). Instream flow recommendations for maximum fish habitat use are:

November – March	575 cfs
April – July	475 cfs
August – October	180 cfs

Average flows in the Dungeness River upstream of the irrigation diversions (at RM 11.8) are 227 cfs in August, and 187 cfs in early September. The average discharge at the USGS gauging station for 51 years of record (1924-1930, 1938-1981) is 388 ft3/sec (USGS 1981, as referenced in Tetra Tech 1988). The instream flow recommendations exceed the average flow from November through April (Figure 21). The Dungeness-Quilcene Water Resource Management Plan recommends that the instream flow recommendations be reviewed as IFIM models are

Figure 21: Dungeness River Mean Monthly Flows and Recommended Instream Flows (from Bishop and Morgan 1996)(Note-Since 1994, water rights during the period Aug. 1-Sep. 15 are limited to no more than half of the flow at RM 11.8)

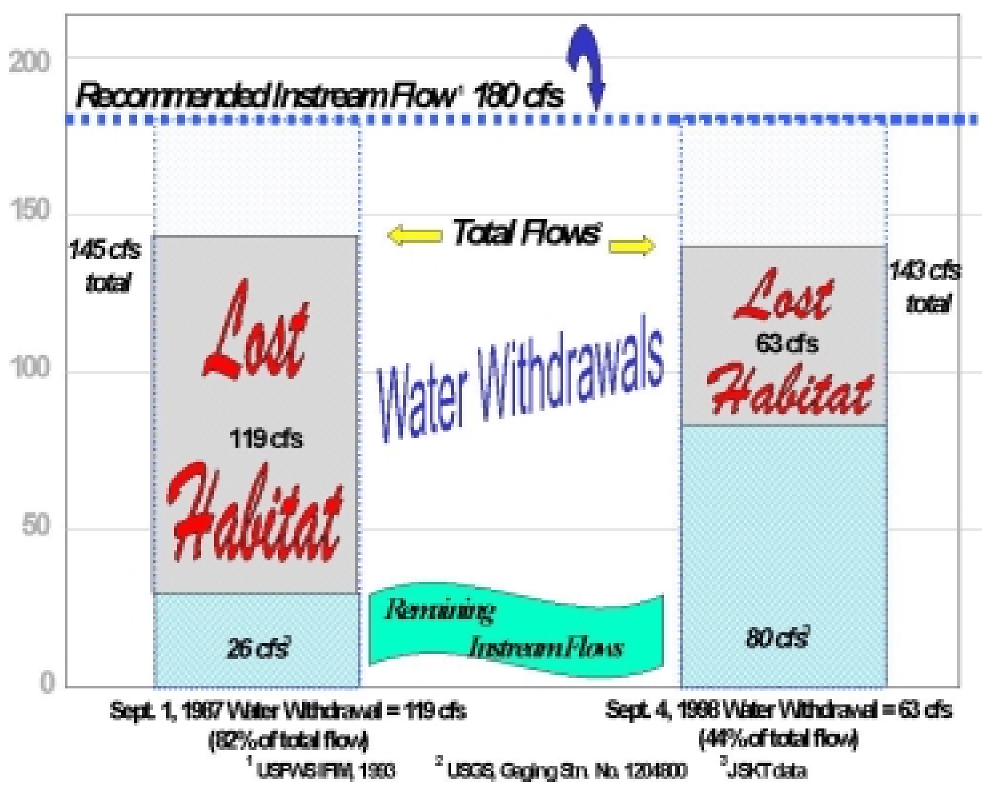


updated which could reflect the channel conditions in the Dungeness more closely. However, it is apparent that it is necessary to maintain the entire river flow in the channel during the lowest flow periods for full benefit to salmon.

In 1994, as part of the Dungeness/Quilcene Plan, irrigators agreed to restrict water withdrawals to no more than 50% of the flow at RM 11.8, during the period August 1-September 15. In 1998, this agreement was expanded and formalized when the irrigation districts and companies signed a Trust Water Rights Agreement with the Department of Ecology. The agreement effectively reduced the amount of water rights for beneficial use in the Dungeness and preserved agreements for conservation. The TWR agreement indicated that the irrigators could cumulatively divert up to a maximum of 156 cfs instantaneously to irrigate up to 7,000 acres (with no more than 50% of the flow at RM 11.8 during the period August 1-September 15), a substantial reduction from the 1924 adjudication of 518 cfs and 25,908 acres. The irrigation diversion rate is likely to be lower than the 156 cfs maximum over time. In order to protect water users from the "use it or lose it" provisions of Washington water law, the agreement established a trust for conserved water. The trust dedicated two-thirds of conserved water to instream flow and one-third was reserved for potential agricultural use. Although water withdrawals exceeding 80% of the instream flow were documented in the late 1980's, the Trust Water Rights Agreement limited the water users to a maximum instantaneous withdrawal not to exceed 50% of the instream flow as measured at the USGS gauging station year round. In 1999, water users completed a comprehensive water conservation plan containing detailed structural and management recommendations designed to conserve water (Montgomery, 1999).

Water conservation in the last decade has resulted in a seasonal average reduction of approximately 15%, (Figure 22) but significant water conservation savings have been achieved in

Figure 22: Comparison of Instream Flow and Water Withdrawal from the Dungeness River (Sept., 1987 and Sept., 1998, under similar flow conditions)(courtesy of Ann Seiter)



the late summer spawning season. Figure 22 illustrates a comparison of water withdrawals between early September, 1987 and the same period in 1998, under similar flow regimes. The 1987 example shows a diversion of 82% while in 1998 the diversion was 45%. Since implementation of the 1994 agreement on water withdrawals from the Dungeness River, pink salmon spawning distribution has changed. In recent years (odd-years only) they have been observed spawning throughout the river system, especially in side channels on the lower mainstem Dungeness River (Joel Freudenthal).

Instream flows, based on fish needs, have been recommended for the Dungeness River, tributaries, and independent drainages in the Dungeness Area Watershed, but have not yet been incorporated into rule. Instream flows are being considered as part of the HB 2514 Watershed Planning Process. Some members of the TAG have expressed concern that the models used in setting instream flows may not be appropriate for the hydrologic conditions on the north Olympic Peninsula (see Water Quantity segment of Introduction chapter). Further work may be warranted to refine instream flow recommendations for this area. However, as water conservation continues in the Dungeness, it is likely to result in decreased flows in the lower Dungeness tributaries that are heavily influenced by groundwater contribution, leakage, and tailwater returns from irrigation.

There has also been a proliferation of regulatorily exempt shallow groundwater wells in the lower Dungeness Area Watershed, associated with the extensive urban/rural development that is occurring. There is a high likelihood that these wells are in continuity with surface water flows in the Dungeness, tributaries, and independent streams. The shallow aquifer supporting these wells is artificially affected by groundwater return flows from irrigation in the watershed. The effect on surface water flows has not been quantified.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998, others). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage. The Dungeness River Restoration Workgroup (1997) recommends further study to identify the role and abundance requirements for nutrients provided by salmon carcasses.

Estuarine

The character of the Dungeness River estuary has significantly changed over time. Scientific studies assessing the extent of changes over time differ in their conclusions. Bortelson et al. (1980) indicate there has not been a decline in the amount of estuarine wetlands, based on a review of estuary conditions as referenced on 1855 and 1956 U.S. Geologic Survey maps. However, both the character and function of the estuary appears to have significantly changed from historic condition, as indicated in Figure 23. This comparison is based on an interpretation by Randy Johnson of the 1855 estuary drawing in relation to a 1999 aerial photo, with reference points indicated for comparison. Clearly, the configuration of the delta has significantly changed over time. The primary concern, however, is not the extent of loss of wetlands (as evaluated by Bortelson et al. 1980), but rather the loss of physical and biological function of the historic estuary.

There has been a loss of multiple distributaries (primary channels in the tidal interchange area) over time, reducing the tidal interface area and ability of the river to effectively discharge sediment load. The historic delta provided a long low-gradient area (Figure 23, from the blue dot to west of the yellow dot) that was tidally-influenced low-salinity water. This excellent rearing and transition habitat for juvenile salmonids has been lost. During historic peak flows in the lower Dungeness River, the river overtopped the banks, sending flows and sediment across the floodplain and through other floodplain channels. Diking of the lower Dungeness River as early as the 1850s eliminated the opportunity for the river to use the floodplain to transport and store peak flows and associated sediment. All of the transported sediment in the river is currently routed through the main channel directly to Dungeness Bay. The routing of the river flow within the current primary channel also eliminated virtually all of the historic low-gradient and salt marsh estuarine habitat. Salt water intrusion currently only extends a matter of 600-800 feet up from the mouth of the Dungeness River, to approximately the northernmost extent of tree vegetation. It is clear that the delta has prograded significantly, with upland areas currently extending >2,000 feet further north into Dungeness Bay than in 1855.

Action Recommendations

The Dungeness River Restoration Workgroup has developed a habitat restoration strategy for the lower 10.8 miles of the Dungeness River (Dungeness River Restoration Workgroup 1997). Several of the following salmonid habitat restoration action recommendations for the Dungeness River directly result from their efforts. These action recommendations are not ranked, although the TAG indicates that sequencing of several of the recommendations is critical to habitat restoration success. In particular, it is critical to address problems associated with forest roads in the headwaters, and to restore functional floodplain processes (in the lower 2.6 miles of the Dungeness and upstream) early on to better ensure success of other important habitat restoration actions.

- **Provide necessary maintenance/restoration on forest roads in the upper watershed (and tributaries) to minimize potential of sediment delivery downstream. Numerous roads have remaining areas that are at very high risk of failure, and should receive immediate attention, and consideration for abandonment. Reduce forest road densities to <2.4 mi/mi^2, which is the identified road density threshold of concern identified in the Federal Watershed Analysis.**
- **Reestablish functional channel and floodplain in the lower 2.6 miles through dike management and constriction abatement (Dungeness River Restoration Workgroup 1997)**
- **Abate man-made constrictions upstream of the Corps dike (everything upstream of RM 2.6) (Dungeness River Restoration Workgroup 1997)**
- **Restore functional riparian zones throughout watershed, and identify and correct areas affected by unrestricted animal access. Restore suitable riparian vegetation and riparian-adjacent upland vegetation (Dungeness River Restoration Workgroup 1997)**
- **County should adopt and implement a stormwater strategy for this rapidly developing watershed, including tributaries, that will remediate current stormwater effects and minimize additional future effects**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Manage sediment to stabilize the channel and reduce the risk of flooding (Dungeness River restoration Workgroup 1997)**

Figure 23: Comparison of Dungeness River delta characteristics in 1855 (left) and 1999 (right)

- **Construct and/or protect side channels (Dungeness River Restoration Workgroup 1997)**
- **Conserve instream flows (Dungeness River Restoration Workgroup 1997). Review instream flow needs for the various salmonid species, as evaluated by the IFIM study, to determine critical periods and flows (Jamestown S'Klallam Tribe 1992).**
- **Implement the recommendations of the Dungeness/Quilcene Plan, including the adoption of instream flows for the Dungeness River and development and implementation of a plan to restore flow. Identify and recommend in-stream flow needs to the HB2514 Planning Unit for implementation.**
- **Improve efficiency of irrigation distribution network and commit conserved water to instream flow through incorporation into the Trust Water Rights process. Develop water use plan to reduce dependence on shallow groundwater withdrawals (Jamestown S'Klallam Tribe 1992).**
- **Develop and implement a strategy to restore estuarine functions and habitat**

Detailed reach-specific action recommendations developed by the Dungeness River Restoration Workgroup are included in the Dungeness River "Blue Book" (Dungeness River Restoration Workgroup 1997).

Meadowbrook Creek 18.0020

Location

Meadowbrook Creek is a relatively small low elevation drainage immediately east of the mouth of the Dungeness River that historically drained either into the mouth of the Dungeness River or directly to Dungeness Bay. The stream is generally low gradient, with limited flushing capability.

General

This tributary, located near the mouth of the Dungeness River, is identified in the 1855 depiction as being an independent tributary to Dungeness Bay (Figure 23). In recent years, the mouth of Meadowbrook Creek has been either tributary to the lower Dungeness, or entering Dungeness Bay immediately adjacent to the Dungeness River. In the spring of 1999, shoreline erosion east of the mouth of the Dungeness River broke through a meander in lower Meadowbrook, moving the mouth of the creek approx. 1,400 ft. to the east, and eliminating 15 acres of intertidal estuary from direct connection with Meadowbrook Creek. The mouth now enters directly into Dungeness Bay.

Fish Access

No fish access concerns are identified.

Floodplain Modifications

Historic wetland function in the lower 1,000 yards of the stream has been significantly altered by channelization and fill associated with adjacent land uses (primarily agriculture). Prior to construction of the levees along the lower Dungeness River, Meadowbrook Creek was heavily influenced by flooding in the Dungeness River. Construction of the dike on the lower Dungeness has dramatically reduced the sediment loading and also eliminated dramatic increases in stream energy previously associated with floodwaters from the Dungeness. The loss of these processes may be a causal factor of the erosion/loss of estuary that is occurring at the mouth.

The Sequim-Dungeness Way bridge at the mouth of Meadowbrook Creek severely restricts tidal flux as well as floodplain function. Increasing the span of the bridge would help restore floodplain function.

Channel Condition

Pool presence throughout Meadowbrook Creek is characterized as poor (Randy Johnson). LWD is reported to be totally depleted, except for a few short sections where LWD has been placed (TAG, see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in separate Maps file included with this report).

Riparian Condition

The TAG characterizes the riparian condition in Meadowbrook Creek as poor, with a lack of woody vegetation in most areas. Uncontrolled animal access, adversely affecting physical habitat features and water quality, is of major concern upstream of the Sequim-Dungeness Road, and in some areas downstream of the Sequim-Dungeness Road (TAG).

Water Quality/Quantity

Water temperature exceeds optimal levels for salmon spawning and rearing (Joel Freudenthal).

Instream flow recommendations have been made for Meadowbrook Creek, based on toe width measurements of 10.8 feet made at Sequim-Dungeness Highway. Recommended instream flows are 12.0 cfs for the period November-January (coho spawning), 8.0 cfs for February, 24.0 cfs for March-April (steelhead spawning), 16.0 cfs for May-June, and 5.0 cfs for the period July-October (steelhead rearing) (Beecher and Caldwell 1997***).*** Toe-width is primarily influenced by bank-full flows in winter months, however it may be additionally influenced in this watershed by irrigation groundwater returns and past land use. Instream flows in Meadowbrook Creek may be influenced by groundwater return flows from irrigation. The limited flow data that is available for Meadowbrook Creek was not reviewed to ascertain consistency with recommended instream flows.

The Department of Ecology is currently conducting scientific research (collecting water quality and flow information) on Meadowbrook Creek (Cynthia Nelson).

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

Whether Meadowbrook Creek is a tributary to the Dungeness River or an independent drainage to Dungeness Bay has likely alternated over time. The connection of the lower creek to the Dungeness River was severed in 1999, as the berm separating the creek from Dungeness Bay was breached by marine water. The previous estuarine slough portion of the lower creek is now disassociated from the creek. Estuarine habitat could be improved with a widening of the Sequim-Dungeness Way bridge, which would increase tidal flux upstream of the bridge.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Meadowbrook Creek:

- **Restore functions of historic wetlands associated with lower Meadowbrook Creek.**
- **Identify and correct areas affected by unrestricted animal access**
- **Increase the span of the Sequim-Dungeness Way bridge to improve floodplain function**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout watershed**

Matriotti Creek 18.0021

Location

Matriotti Creek is one of the largest low elevation tributaries to the lower Dungeness River, entering the left bank (looking downstream) at RM 1.9.

Fish Access

Culvert(s) in Bear Creek, (tributary to Matriotti Creek, not to be confused with nearby Bear Creek 18.0030), are noted as being at least partial barriers to fish access (TAG). Fish access to the upper 0.25-0.5 mi. of Matriotti Creek is blocked by a 3-foot drop where it flows across the Agnew Ditch (TAG). The precluded area includes some good habitat, including a large wetland.

Floodplain Modifications

The character and location of Matriotti Creek is altered significantly from historic condition. The drainage was channelized from Ward Road to Atterberry Road (RM 0.3 to 5.8), although significant portions of this reach have benefited from restoration projects within the last 15 years. The TAG indicates it is unknown whether the channel upstream of Bear Creek (left bank tributary entering Matriotti at RM 3.6, not the same as Bear Creek 18.0030) actually existed historically, or whether it is an artifact of the irrigation delivery system. Historically, the TAG believes Matriotti Creek likely had greater meander and flowed through numerous wetlands.

Streambanks are trampled in parts of the drainage due to unrestricted animal access, with significant impacts through the Olympic Game Farm (Randy Johnson; PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1992). There are two tributaries to Matriotti Creek, between Hooker and Adder roads that are currently captured by the Dungeness

Irrigation Company. The use and diversion of these tributaries into the irrigation system should be reviewed by the HB 2514 Watershed Planning Unit. Reconnection of these tributaries to Matriotti Creek would provide small amounts of additional habitat, wetlands, and flow to Matriotti Creek.

Channel Condition

Pool presence within the unrestored sections of Matriotti Creek is characterized as poor (Randy Johnson). The only significant LWD downstream of Atterberry Road is wood that has been placed as part of habitat restoration projects. The quality and quantity of wood varies between projects (Randy Johnson, Paul Hansen); LWD condition is poor outside the restored sections. The stream reach between Spath and Runnion Roads (west of Carlsborg Road) is severely degraded (Walt Blendermann). Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

The Dungeness Irrigation Company system transfers stormwater flows to Matriotti Creek, which would otherwise not be significantly affected by the stormwater flows. High fine sediment loads are conveyed to Matriotti Creek during flood events in the Dungeness River through the irrigation network (TAG).

Substrate

A number of habitat restoration projects have been done in the Matriotti Creek drainage to improve habitat conditions. These projects have included removal of accumulated fine sediments and addition of gravels to the sections of restored channel. No specific substrate concerns were identified at this time.

Riparian Condition

Streamside vegetation is generally destroyed due to animal access and agricultural practices, with significant impacts through the Olympic Game Farm (PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1992, TAG). There is a lack of woody vegetation in most areas (TAG).

Water Quality

Matriotti Creek is listed on the Clean Water Act Section 303(d) list of impaired waterbodies, based on elevated fecal coliform counts (Barecca 1998). Direct animal waste input due to animal access is common throughout the drainage, with significant impacts through the Olympic Game Farm (PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1992). Coliform counts were very high in the unconfined reach between Runnion and Spath roads, although stock have been removed (TAG). Water quality is also adversely affected by return flows from various irrigation ditches (TAG). Although fecal coliform is not known to directly adversely affect salmonids, it is often an indicator of other water quality impacts in the watershed that can adversely affect salmonids. These include direct animal access to the channel which affects riparian condition and bank stability, high fine sediment levels in the substrate from stormwater or agricultural runoff, and high nutrient levels in the stream which may cause excessive plant growth and affect dissolved oxygen levels.

Water Quantity

There are two tributaries to Matriotti Creek, between Hooker and Atterberry roads that are currently captured by the Dungeness Irrigation Company. The use and diversion of these tributaries into the irrigation system should be reviewed by the HB 2514 Watershed Planning Unit. Reconnection of these tributaries to Matriotti Creek would provide small amounts of additional habitat, wetlands, and flow to Matriotti Creek.

Stormwater flows and high fine sediment loads are conveyed to Matriotti Creek through irrigation delivery systems. These may be Dungeness River water early in the storm season, and stormwater runoff into the main irrigation canals once the outake from the Dungeness River is shut down (Mike Jeldness, personal communication). Matriotti Creek would otherwise not normally be significantly affected by stormwater flows (TAG).

Instream flow recommendations, based on toe width measurements of 11.8 feet made at Lamar Lane, have been made for Matriotti Creek. Recommended instream flows are 14.0 cfs for the period November-January (coho spawning), 10.0 cfs for February, 27.0 cfs for March-April (steelhead spawning), 18.0 cfs for May-June, and 5.0 cfs for the period July-October (steelhead rearing) (Beecher and Caldwell 1997***).*** Instream flows in Matriotti Creek are likely influenced by groundwater return flows and stormwater flows from irrigation. Although toe-width is primarily determined by bank full flow events, toe width may have increased due to increased stormwater flows and increased groundwater delivered through the irrigation systems. The limited flow data that is available for Matriotti Creek was not reviewed to ascertain consistency with recommended instream flows.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Matriotti Creek:

- **County should adopt and implement a stormwater strategy for this rapidly developing watershed, including tributaries, that will remediate current stormwater effects and minimize additional future effects**
- **Restore functional channel conditions between Runnion Road and Old Olympic Highway**
- **Identify and correct areas affected by unrestricted animal access**
- **Cease the release of fine sediment-laden stormwater from irrigation delivery systems to Matriotti Creek**

- **Complete comprehensive barrier inventory for Matriotti Creek, prioritize, and implement correction measures**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout watershed**

In addition, the following action recommendations should be referred by the Lead Entity to other forums to be addressed:

- **Refer restoration of tributary flows to Matriotti Creek (between Hooker and Atterberry roads) to the HB2514 Planning Unit for resolution**

Hurd Creek 18.0028

Location

Hurd Creek is a relatively small low elevation tributary to the lower Dungeness River, entering the right bank (looking downstream) at RM 2.7. It is a short low gradient stream, providing significant high quality tributary rearing and refuge habitat.

Fish Access

The majority of spawning and rearing habitat in Hurd Creek is in the spring fed lower ¼ mile of stream (downstream of Woodcock Road). Adult salmonid access was precluded upstream of the hatchery rack near Woodcock Road (RM 0.5), although WDFW provided adult access beginning in 1999. The TAG indicates there is little adult spawning habitat upstream of Woodcock Road. Some juvenile salmonids are currently passing upstream of the hatchery rack to access rearing habitat.

Floodplain Modifications

No floodplain modification concerns are identified at this time.

Channel Condition

PSCRBT (1991) indicates the stream is heavily impacted by unrestricted animal access to the channel, with trampled stream banks. However, the TAG indicates that animal access problems have been resolved and are no longer a significant concern. Downstream of Woodcock Road, there are some log jams and beaver dams, and some remnant individual LWD pieces. Upstream of Woodcock Road (where some juvenile salmon presence has been noted (TAG)), LWD condition is poor.

The channel through WDFW property, adjacent to Hurd Creek Hatchery, has been completely modified to allow for its use as a component of current and historic hatchery activities, and no longer functions as a natural channel or salmonid habitat. Some of the most extensive channel alterations are for hatchery activities that are no longer used, providing opportunities for restoration.

Substrate

Substrate downstream of Woodcock Road supports anadromous salmonid spawning; no concerns of fine sediment or substrate instability were identified.

Riparian Condition

PSCRBT (1991) indicates that stream banks are trampled, and streamside vegetation is absent or in poor condition. However, the TAG characterizes much of Hurd Creek as being fully overstoried with riparian vegetation, with the major area of concern being the WDFW-owned hatchery property, which lacks riparian vegetation.

Water Quality

PSCRBT (1991) indicates the stream is heavily impacted by unrestricted animal access to the channel, with trampled stream banks. However, the TAG indicates that animal access problems have been resolved and are no longer a significant concern.

Water Quantity

No water quantity concerns have been identified.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Hurd Creek:

- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout watershed, particularly on WDFW-owned hatchery property**

Bear Creek 18.0030

Location

Bear Creek is a medium sized low elevation tributary to the lower Dungeness River, entering the left bank (looking downstream) at RM 7.3.

Fish Access

The TAG reported that a low dam used for irrigation pumping (just upstream of the current confluence of Bear Creek with the mainstem Dungeness River) had formed a barrier to upstream fish passage. The channel downstream of the dam was much lower than prior to the 1990 flood, and had headcut back to the dam. Sediment buildup has occurred upstream of the dam over time, and all upstream culverts in Bear Creek are set at the grade established by the dam. If the dam is to be removed, there is concern that the channel might head cut further upstream than the dam site, unless grade controls were incorporated with the dam removal. However, the Dungeness River and the mouth of Bear Creek have recently aggraded (Joel Freudenthal), resolving the previous passage barrier, and no longer appears to be at risk of a major regrade. Fish passage access at or below the dam site should be monitored.

Floodplain Modifications

The mouth of Bear Creek changed as a result of the 1990 flood, when the end of the Dungeness Meadows dike blew out, rerouting the main flow down a previous side channel of the Dungeness River and capturing the previous lower portion of Bear Creek into the main Dungeness River channel. However, this is a natural phenomenon, not requiring restoration.

Bear Creek crosses its own alluvial fan where it leaves the foothills and hits the former geomorphic floodplain of the Dungeness River. This alluvial fan is functioning and acting like a normal alluvial fan, with resultant channel instability which threatens some private roads. Several projects have been implemented in the last 5 years by landowners to attempt to stabilize the alluvial fan; these projects have met with limited success (Joel Freudenthal).

Riparian Condition

The downstream end of Bear Creek has some mature riparian alder, but only an estimated 25% of the stream has what could be characterized as fair riparian condition (TAG), with the remainder rating as poor. The upstream portion of Bear Creek has several areas where cattle access to the channel is unrestricted, which would benefit from fencing and riparian revegetation. There are no identified water temperature concerns in Bear Creek (TAG).

Water Quality

Stormwater flows and high fine sediment loads are conveyed from the Dungeness River to Bear Creek through the Agnew Irrigation Company delivery system during peak flow events in the Dungeness River. Bear Creek would otherwise not normally be affected by stormwater flows (TAG).

Water Quantity

Stormwater flows and high fine sediment loads are conveyed to Bear Creek through the Agnew Irrigation Company delivery system. The stormwater conveyance may include some Dungeness River stormwater flows early in the storm season, with later flows representing stormwater runoff into the main irrigation canals after the outtakes from the Dungeness River have been shut off (Mike Jeldness, personal communication). Bear Creek would otherwise not normally be significantly affected by stormwater flows (TAG). Channel toe-width is primarily determined by bank full flow events, but may be increased due to increased stormwater flows and increased groundwater delivered through the irrigation systems.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Bear Creek:

- **Monitor fish passage conditions at and downstream of the low irrigation dam; maintain function of the Bear Creek alluvial fan.**
- **Identify and correct areas affected by unrestricted animal access, fence and revegetate to reestablish functional riparian zones throughout the watershed**
- **The Agnew Irrigation Company should cease the release of fine sediment-laden stormwater flows to Bear Creek**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**

Canyon Creek 18.0038

Location

Canyon Creek is the uppermost tributary draining to the lower Dungeness River. It is mid-elevation, draining the Dungeness foothills, and enters the left bank (looking downstream) at RM 10.8.

Fish Access

A hatchery water intake dam at RM 0.08 is a complete barrier to upstream fish passage. WDFW currently has funds allotted to engineer and construct modifications to the dam for fish passage, or to fully restore physical and biological processes by removal of the dam. There is approximately 1.5-2.0 miles of potential habitat upstream of the dam, although only the upper 1/3 of the additional habitat is considered to be currently in good condition.

Floodplain Modifications

Canyon Creek, downstream of the County Road, is altered significantly from historic condition. The TAG believes that lower Canyon Creek previously paralleled the Dungeness River for approximately 1,800 feet downstream of the current mouth, and that this was probably the best habitat in Canyon Creek. This reach was channelized directly to the Dungeness, and the previous lower channel area was used for pond construction at the WDFW hatchery. The resulting channel is higher gradient than the previous natural channel, and in combination with the sediment transport alteration created by the dam, the resulting substrate in lower Canyon Creek is larger than desired for spawning or rearing, and there is little habitat diversity. The left bank is also confined by a WDFW-owned dike made up of river gravels. Restoration of the historic low gradient habitat that paralleled the Dungeness River would likely require the relocation of the adult holding pond and a 0.5-acre rearing pond at the hatchery to an area that is outside the floodplain.

Channel Condition

From the County Road to the mouth, there is little LWD present, and limited riparian vegetation to provide future LWD (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in separate Maps file included with this report). Upstream of the dam, Canyon Creek has abundant LWD, with additional LWD contribution potential, as the canyon has not yet been logged. LWD is generally stable, as Canyon Creek typically does not have enough energy to actively move LWD.

Substrate

Approximately 0.25 miles upstream of the dam, habitat is adversely affected by an active slide. The system upstream of the dam is unraveling, with significant water quality and quantity concerns. Periodic high bedload transport, high fine sediment levels, and high turbidity are all identified as concerns (TAG).

There are no LWD or other channel features to hold gravel and fine sediment in the portion of Canyon Creek downstream of the dam, consequently the substrate is coarse, providing little spawning potential.

Riparian Condition

Riparian condition is poor downstream of the dam, with sparse deciduous vegetation. Riparian condition is generally good upstream of the dam, as it is located in a deep ravine that has not been logged.

Water Quality

Water quality is periodically affected by high turbidity levels resulting from the active slide upstream of the dam.

Water Quantity

No water quantity concerns have been identified.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Canyon Creek:

- **At a minimum, restore fish passage past the water intake dam, with dam removal as the preferred option to restore biological processes**
- **Evaluate restoration potential of historic lower portion of Canyon Creek, through the terrace immediately adjacent to the Dungeness River; implement as practicable**
- **Evaluate potential to stabilize active slide upstream of dam**
- **Restore natural sediment transport downstream of dam**
- **Introduce LWD to the channel downstream of the dam to retain river gravels, provide habitat diversity, and restore spawning habitat**
- **Protect intact riparian zones upstream of the dam, restore functional riparian zones downstream of the dam**

Caraco Creek 18.0046

Location

Caraco Creek is a mid-elevation tributary to the Dungeness River canyon, entering the left bank (looking downstream) at RM 12.1. No anadromous salmonid use of Caraco Creek is known.

General

Road densities in the watershed are high, at 3.0 mi/mi^2 (DAWACT 1995). This level is in excess of the 2.5 mi/mi^2 threshold of concern identified in the USFS Watershed Analysis.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Caraco Creek:

- **Reduce the forest road density in the Caraco Creek watershed,**
- **Maintain remaining forest roads in a manner that minimizes potential of mass wasting and fine sediment erosion**

Gray Wolf River 18.0048

Location

The Gray Wolf River is the largest tributary to the Dungeness River, draining the mountainous portions of the upper watershed and entering the right bank (looking downstream) of the Dungeness River at RM 15.8.

Fish Access

A series of natural falls/cascades at RM 9.0, and just upstream of confluence of the 3-forks (Gray Wolf River, Cameron Creek, and Grand Creek), impair or prevent upstream anadromous salmonid access. Due to limited survey effort and accessibility problems in this remote area, there is very limited information on the specific extent of upstream presence of individual salmon and steelhead species.

Floodplain Modifications

The Gray Wolf is located in a deep narrow canyon, which is naturally confined by topography.

Channel Condition

From the mouth to RM 9.3, pools occupied 27.6% of the wetted channel, average distance between pools was 200 ft., 192 pools were >3 ft. deep, mean pool depth equaled 4.4 ft., and mean residual pool depth was 2.9 ft. (Orsborn and Ralph 1994). Dick Goin has observed a loss of pools in the vicinity of the bridge in recent years. These values would normally be considered as poor pool condition for a channel >15m wide, but may be representative of the historic natural pool condition to be encountered in this channel.

LWD is present throughout the channel corridor, but few pieces are located within the channel. Most pieces are located on the edge of the ordinary high water mark. There was conjecture in the TAG that the USFS may have bucked LWD, which floated out on high water, however, Lloyd Beebe (sport fisher, resident) doesn't ever recall seeing any saw cuts on the LWD that remained in the channel. Other TAG participants believe the LWD location and abundance may be close to the natural state, as there are few features for the LWD to lock into in the active channel during high flows.

No information was accessed indicating fine sediment concerns; however, fine sediment would likely carry through the Gray Wolf and be deposited downstream. Fine sediment , particularly from forest roads in the upper watershed, is identified as a concern for the Dungeness River. Forest roads in the Gray Wolf watershed (including tributaries) should be evaluated , and actions taken to minimize the entry of fine sediment to downstream areas.

Riparian Condition

Riparian condition was reported to not be of concern in the Gray Wolf River (TAG), although the importance of retaining intact riparian vegetation in the canyon was identified as a high priority.

Water Quality/Water Quantity

Water quality and abundance are not of concern in the Gray Wolf watershed.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Gray Wolf River:

- **Maintain riparian condition in Gray Wolf canyon**
- **Evaluate the forest road network in the watershed and implement actions necessary to prevent entry of fines and mass wasting events to the Gray Wolf River**

Gold Creek 18.0121

Location

Gold Creek is a medium-sized tributary to the upper Dungeness River, entering the right bank (looking downstream) of the Dungeness River at RM 18.7.

Fish Access

Upriver pink, coho, and steelhead spawning is reported to have historically occurred to RM 1.5 (Streamnet), but slides in lower Gold Creek have limited anadromous salmonid access in recent years to only the lower 0.1 mile. Several LWD and rock barriers have prevented migration upstream of this point, and map gradient in lower Gold Cr. is >6% (Orsborn and Ralph 1994), which is greater than typically used by salmon for spawning. However, Randy Cooper reports that over 1,000 pink salmon were observed spawning up to RM 0.3 in 1999. Access was likely improved by higher flow conditions than in prior years.

Floodplain Modifications

Gold Creek is located in a confined canyon, which has been significantly affected by large mass wasting events. Gabion baskets (wire mesh baskets filled with coarse gravel) were used to attempt to stabilize the slide and provide fish passage through the slide area(TAG). This has highly altered channel condition and stream energy, potentially affecting the success of restoration efforts in the lower channel.

Channel Condition

The lower 0.5 mi. of Gold Creek has abundant LWD, which is buried under large amounts of slide material. Gold Creek is currently reworking a channel through this slide material, and it is too early in this process to identify what the channel characteristics will be once the channel reaches a new equilibrium.

Substrate

PSCRBT (1991) identifies the roads in the Gold Cr. drainage as actively eroding. Natural deep mass wasting problems result from Vashon Ice Sheet drifts (Golder 1993, as referenced in Clark and Clark 1996). Logging, road building, bank erosion, and channel changes, have further exacerbated erosion contribution from natural deep-seated failures and increased the occurrence of shallow-rapid landslides. Approximately 58% of sediment yield is estimated to be from undisturbed forested areas, with 42% associated with disturbed or clearcut area. The road density in the watershed is high, at 2.7 mi/mi^2 (DAWACT 1995). The channel substrate in lower Gold Creek is composed of a combination of large amounts of LWD and large outwash material in the slide debris. This has resulted in a steep gradient step-pool habitat that prevents upstream anadromous fish access.

Riparian Condition

Riparian condition in the Gold Creek watershed has been significantly affected by mass wasting events and past forest practices. Upper Gold Creek is at a relatively high elevation in the Mountain Hemlock Zone. Bon Jon Pass, which forms the upper limit of the Gold Creek Watershed, as well as the Gold Creek Valley itself, is a large, U-Shaped valley, created by glaciers as they migrated up the valley and over the divide. It provides an excellent funnel for south winds from Hood Canal to travel down valley. Riparian zones and forest stands adjacent to clear-cuts were subject to recurrent blowdown events, and consequent recurrent timber salvage of the blowdown. Over time, the entire valley floor to the stream was harvested or salvaged. Mountain Hemlock is notorious for difficulty in re-establishing stands under such conditions due to the depth of snow that accumulates in the clearcuts. Although the watershed is entirely within USFS ownership, and is now designated as riparian reserve, it may be several decades before hydrologic maturity occurs in the upper Gold Creek valley. In the meantime, the depth of snow and high wind velocities provide ideal conditions for rain-on-snow events. The resultant increased flow and greatly increased stream energy (especially when viewed in conjunction with removal of LWD when the road was constructed through the canyon below) may have more than anything to do with the severity and ongoing nature of the Gold Creek slide.

Water Quality

Water temperature data have been collected, indicating temperatures above the level considered optimal for salmonid spawning and incubation (Joel Freudenthal). Water temperature is likely affected by poor riparian condition in the upper watershed. The flood magnitude in Gold Creek appears to have increased by 35% as a result of the 1969 slide in Gold Creek, raising the flood magnitude in the Dungeness River to a total of 4,100 cfs. (Orsborn and Ralph 1994).

Water Quantity

Runoff from forested areas has likely been significantly increased as a result of extensive forest harvests and roads in the upper watershed (TAG), but flow information is not available to verify the extent of any changes that have occurred.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Action Recommendations

The following salmonid habitat restoration actions are recommended for Gold Creek:

- **Maintain forest roads in a manner that minimizes potential of mass wasting and fine sediment erosion**
- **Identify and map deep-seated failures and areas prone to shallow-rapid landslides; prevent land use activities (roads and harvest) that will exacerbate sediment contribution from these areas**
- **Restore natural channel characteristics in gabion-controlled section of lower basin**
- **Maintain >60% of watershed in a condition that provides hydrologic maturity (>age 25) (Wild Salmonid Policy)**
- **Restore forest road density to <2.4 mi/mi^2, which is the threshold density of concern identified in the Federal Watershed Analysis; confine roads to areas not sensitive to mass failures**

These habitat restoration action recommendations are considered to be of equal importance.

Silver Creek 18.0131

Location

Silver Creek is a medium-sized tributary to the upper Dungeness River, entering upstream of Dungeness Falls on the right bank (looking downstream) of the Dungeness River at RM 22.1.

General

The major landslide that occurred in Silver Creek in 1972, in saturated glacial till, briefly dammed the Dungeness River. It is thought to have been precipitated by increased saturation in the year or so following a large clearcut above (according to Long, as referenced in Clark and Clark 1996). The slide was the result of a clearcut, which was used to pay to expand the road network for future harvest on that side of the upper river.   Consequently, the road that was constructed was much larger than needed for the clearcut.   Unfortunately, the triple switchback that was built did not make it through the winter, and took most of the valley wall with it.   The slide proceeded down the narrow valley, scouring to bedrock up to about 180 feet on the valley walls as it went toward the river, briefly damming it.   A conservative estimate of the slide volume, made by Joel Freudenthal, was 300,000 cubic yards minimum, plus whatever it picked up during its travels down to the river scouring the valley walls.   Most of the slide material moved down river to the Dungeness, but a large logjam remained which was a fish blockage.   An attempt was made to restore passage by cutting out the logjam with chainsaws.   The logjam failed during the next flood (~1979), and all of the sediment behind the jam moved downriver.   Many of the locals blame this second slug of sediment for much of the damage that occurred above Dungeness Meadows during the 1980's.   The Silver Creek slide was a major, if not the major sediment impact in the Dungeness River over the last 30 years. Slides remain active, but Forest Road 2860 and revegetation captures much of the sediment, preventing it from passing to downstream areas in the Dungeness River (DAWACT 1995).

Action Recommendations

The following salmonid habitat restoration actions are recommended for Silver Creek:

- **Restore stability of slide prone areas; ensure road cross-drainage is maintained; consider abandonment of roads located on active and potential slide areas; provide sediment retention BMPs on active slides where practicable**
- **Avoid future road construction on slide prone areas**

These habitat restoration action recommendations are considered to be of equal importance.

McDonald Creek 18.0160

Location

McDonald Creek is a significant independent drainage to salt water, entering the Strait of Juan de Fuca between the western end of Dungeness Spit and Green Point. Primary land uses in McDonald Creek are commercial timber (83%) and private woodlots (9%) (PSCRBT 1991).

Fish Passage

An irrigation screen bypass dam is located immediately upstream of Highway 101. Adult salmon have been observed to jump over the dam at high flows. A fishway was installed to provide adult passage at all flow conditions. There is concern that the current fishway may not provide effective upstream passage for all anadromous salmonid species, or for juvenile salmonids.

Floodplain Modifications/Channel Condition/Substrate

This creek is impacted by timber harvest on Forest Service lands in the upper watershed that occurred in the 1980s-early 1990s. Portions of the stream channels in the upper watershed are incised in steep ravines within former glacial lakebeds. Timber harvest in several locations resulted in damage to the ravine walls and subsequent sediment inputs into the upper watershed. There is also sediment and bank erosion from the rechannelization attempt next to the Solmar subdivision (done without Hydraulic Project Approval). Other large areas of commercial and state forest lands were harvested in the early 1990s and are now in a state of recovery of hydrologic maturity. Large portions of the upper watershed have also been permanently converted to non-forest cover by residential development on Lost Mountain in the eastern side, and off Blue Mountain Road on the western side of the watershed. Many of the upper portions of the stream are critically depleted of LWD (stream cleanout of LWD occurred in the 1950s). Channel instability between the mouth and Highway 101 is further impacted by LWD depletion (Randy Johnson). Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Habitat surveys in 1992 and 1993 found pool percentage to be poor and pool frequency to be fair below RM 4.9, with a low gradient dominated channel bed. Condition of LWD (degree of decay) was fair to good. Key piece density was poor throughout the lower 9 miles. Between RM 4.9 and 6.7, pool percentage and pool frequency were fair, with most pools formed by boulders or bedrock. Channel gradient was 2-4% with gravel as the dominant substrate. LWD condition was fair. Between RM 6.7 and 8.5, the channel gradient ranged between 4-8% with outcrops of bedrock common. Given the gradient class, pool percentage was good, with pool frequency fair; LWD condition was fair (Bernthal and Rot 1999).

The stream is confined and channelized from the Agnew Ditch to Highway 101 (0.1 miles)(Joel Freudenthal). The substrate is generally made up of large gravel/rocks or sandy sediment, neither providing good substrate for salmon production (PSCRBT 1991). Macroinvertebrate sampling showed RM 2.1-3.9 to be degraded with low levels of EPT taxa, and all taxa in general. Substrate was cobble dominated with high levels of fine sediment (Bernthal and Rot 1999). Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Riparian Condition

McDonald Creek is located in a deep ravine. Riparian condition is reported to be good, although increased conifer presence would be beneficial (TAG). In the vicinity of the Solmar subdivision, riparian condition varies from fair to poor. In some cases, lawns and/or riprapped bulkheads extend to the edge of the channel (Randy Johnson).

Water Quality

Wilson (1988) indicated elevated coliform bacterial contamination. McDonald Creek serves as conveyance for portions of Agnew Ditch, where past water quality samples have indicated high bacterial levels. In August 1993, six temperature monitors were installed. Water temperature was poor at RM 2.0, 4.3, and 6.5, and fair at RM 0.1 and 8.3 (Bernthal and Rot 1999). Temperature thresholds were substantially exceeded only at RM 2.0, just downstream of a large residential development.

Water Quantity

Irrigation practices likely indirectly affect salmon presence and abundance in McDonald Creek. The section of McDonald Creek from RM 5.0 to 2.0 is used for conveyance of irrigation water by the Agnew Irrigation District. Dungeness River water is conveyed through the Agnew ditch to RM 5.0, where it is dumped into McDonald Creek. This conveyed water is subsequently removed from McDonald Creek at RM 2.0. Although there is no appreciable loss of flow, this practice may cause Dungeness River fish to home into McDonald Creek and reduce the homing ability of native McDonald Creek fish (McHenry et al. 1996).

Instream flow recommendations, based on toe width measurements of 24.3 feet made at Old Olympic Highway, have been made for McDonald Creek. Recommended instream flows are 36.0 cfs for the period November-January (coho spawning), 24.0 cfs for February, 63.0 cfs for March-April (steelhead spawning), 42.0 cfs for May-June, and 15.0 cfs for the period July-October (steelhead rearing) (Beecher and Caldwell 1997). The limited flow data that is available for McDonald Creek was not reviewed to ascertain consistency with recommended instream flows.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The McDonald Creek estuary is likely similar to historic condition. Steep, confined topography in the lower watershed and high wave energy at the mouth probably combine to prevent any significantly large estuary from developing (Randy Johnson). A berm of sand/small gravel forms across the mouth of the creek during low flows in the summer, sealing off the creek from direct flow interaction with salt water. This effectively limits juvenile and adult salmonid migration (upstream and downstream) until flows increase enough to open a channel through the berm.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for McDonald Creek:

- **Evaluate cause of channel instability and develop and implement a corrective plan**
- **Reforest timber harvested areas in the rain-on-snow zone; ensure that future timber harvest is done in a manner that maintains hydrologic maturity in the upper watershed**
- **Restore LWD presence and function from the mouth upstream to the mouth of Pederson Creek (RM 4.9) ; addition of LWD in upper watershed to provide channel and bank stability may also be beneficial**
- **Monitor/restore landslides on USFS lands**
- **Identify options to reduce/eliminate the influence of Dungeness River water, conveyed through the irrigation system, on homing ability of Dungeness and McDonald origin salmonids**

Siebert Creek 18.0173

Location

Siebert Creek is a significant independent drainage to salt water, entering the Strait of Juan de Fuca at Green Point. The Siebert Creek watershed includes 31.2 miles of mainstem stream and tributaries. Primary land uses are commercial timber, Olympic National Park, and private woodlots.

Fish Access/Floodplain Modifications

Clallam County removed the double box culverts at the Old Olympic Highway in 1998 (prior 13-foot drop at outlet, originally constructed in 1916), and replaced them with a bridge. The former highway location is still protected by riprap and bank armoring, resulting in channel constriction, bank erosion, and channel instability downstream. Stream energy appears to have actually increased as a result of the culvert removal (Joel Freudenthal). Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

A fishway provides passage through the Highway 101 culvert, which would otherwise be impassable. The fishway has not always been maintained to allow unhindered fish passage (Randy Johnson).

Channel Condition/Substrate

PSCRBT (1991) characterizes Siebert Creek as having ideal fish habitat throughout, except in the East Fork. A few eroding stream banks were noted in the lower section, particularly immediately downstream of Highway 101.

Habitat surveys in lower Siebert Creek found a low gradient, gravel bed channel with bedrock outcrops between RM 6.4 and 8.0. Pool percentage was rated fair to poor (41% to 29%), with critically low levels of LWD (0.96 pieces/100 feet) (McHenry 1992, as referenced in McHenry et al. 1996, Bernthal and Rot 1999). Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report. The few LWD pieces were generally in good condition (level of decay). Excessive fines (avg. 22.7% <0.85 mm) occurred in the reach below RM 3.4 (the only area sampled)(Bernthal and Rot 1999). Juvenile fish populations in Siebert Creek exhibited low overall densities (0.22 fish/m^2), which reflected the degraded habitat and channel conditions. Riffle-dependent species, including steelhead and cutthroat comprised 82% of the fish observed, while coho salmon, which require pool habitat for rearing, accounted for only 18% of the total (McHenry 1992, as referenced in McHenry et al. 1996). Macroinvertebrate sampling found relatively high levels of EPT taxa (>50%) at all sampling sites (RM 0.1, 0.8, 1.0, 1.5, 2.5, 2.6, 3.5, and 3.9)(Bernthal and Rot 1999).

The headwaters of Siebert Creek are located in the foothills of ONP, and are generally in excellent condition, and not prone to rain-on-snow flooding. Previous landslide concerns on East Fork Siebert Cr. (PSCRBT 1991) have been mostly corrected through NRCS (Joel Freudenthal).

Emery Creek, a seasonal tributary to Siebert Creek entering the right bank at RM 3.4, is not known to directly support anadromous salmonids (natural barrier just upstream of mouth), but does impact habitat downstream in Siebert Creek. It has been extensively straightened and channelized in the past. The substrate in this tributary is impacted by fine sedimentation of the gravels from periodic slumps of clay from adjacent hill slopes**.** An old County landfill may also be contributing pollutants to the creek (PSCRBT 1991).

Riparian Condition

Much of the stream flows through a wooded ravine that is well vegetated and undisturbed.

Water Quality

Wilson (1988, as referenced in PSCRBT 1991) reported low levels of bacterial contamination; recent testing indicates few fecals (Joel Freudenthal). Temperature monitoring during August 1993 found fair conditions at RM 0.1, 1.6, and 3.1, with good conditions at RM 9.4 (Bernthal and Rot 1999).

Water Quantity

Instream flow recommendations have been made for Siebert Creek, based on toe width measurements of 24.5 feet made at Old Olympic Highway. Recommended instream flows are 36.0 cfs for the period November-January (coho spawning), 24.0 cfs for February, 63.0 cfs for March-April (steelhead spawning), 42.0 cfs for May-June, and 15.0 cfs for the period July-October (steelhead rearing)(Beecher and Caldwell 1997)**.**

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The Siebert Creek estuary is likely similar to historic condition. Steep, confined topography in the lower watershed and high wave energy at the mouth probably combine to prevent any significantly large estuary from developing (Randy Johnson). A berm of sand/small gravel forms across the mouth of the creek during low flows in the summer, sealing off the creek from flow interaction with salt water. This effectively limits juvenile and adult salmonid migration (upstream and downstream) until flows increase enough to open a channel through the berm.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Siebert Creek:

- **Reduce the flow energy increase that resulted from removal of the culverts at Old Olympic Highway**
- **Develop and implement a short-term LWD strategy in lower Siebert Creek to restore LWD presence and pools, particularly from the mouth to Highway 101**
- **Abandon/relocate the forest road on East Fork**
- **Restore stability of slide prone areas; ensure road cross-drainage is maintained; consider abandonment of roads located on active slide areas; provide sediment retention BMPs on active slides where practicable**

Bagley Creek 18.0183

Location

Bagley Creek is a medium-sized independent drainage to salt water, entering the Strait of Juan de Fuca approximately 2 miles west of Green Point. The Bagley Creek drainage has approximately 9.5 miles of streams and tributaries**.** The predominant land use in the drainage is commercial forest or private woodlots, with pasture/grassland representing 12% and rural residential representing 5% (PSCRBT 1991).

Fish Access

Culverts at three road crossings have been evaluated as fish passage barriers (WDFW Fish Passage Barrier Database 1999). The 332-foot long concrete box culvert under Highway 101 is considered to be a fish passage barrier. PSCRBT (1991) indicated no recent sightings of adult salmon or sea-run cutthroat upstream of the Highway 101 culverts; WSDOT verifies their databse shows the Highway 101 culvert to be a complete barrier to fish passage. Restoration could be accomplished with construction of a fishway within the culvert, which would provide access to 11,942 m^2 of spawning habitat, and 22, 028 m^2 of rearing habitat (WDFW Fish Barrier Database). Upstream of the Highway 101 culvert, there are two additional culverts within 0.2 miles that are also considered to be fish passage barriers.

The upstream extent of historic salmonid use is to a natural falls at RM 4.7.

Floodplain Modifications

The lowest culvert on Bagley Creek Road (0.2 miles upstream of Highway 101) is installed too low, causing sediment deposition upstream, and limiting flows during peak flow events. This also results in bank erosion upstream, and the “need” for continued dredging of the channel upstream of the culvert. Also, the lower reaches of Bagley Creek are thought to be naturally unstable.

Channel Condition/Substrate/Riparian

Habitat north of Highway 101 appears to have high fine sediment levels, and LWD is clumped into a series of marginally passable deposits (Mike McHenry, Carl Ward). Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report. Habitat south of Highway 101 (for approximately 1 mile) is less than ideal, with trampled stream banks, little riparian canopy, and direct animal access to the stream (PSCRBT 1991). Streamkeeper inventories estimate canopy cover to be 50-100%, but conifer cover to be only 0-20%.

The Bagley Creek watershed is mostly composed of very shallow soils over glacial till. These conditions make Bagley Creek the most responsive creek in the County to flooding caused by intense rainfall or low-elevation rain-on-snow events. Miscellaneous streamflow measurements published by USGS indicate that Bagley Creek had a peak flow of almost 350 cfs in a flood in 1948, an extremely high flow for a watershed of this size (note peak flows of 36 cfs. from 1997-1999, below). The soils in the remainder of the watershed that are not till are relatively deep, highly erosive silts, deposited in shallow lakebeds as the glaciers retreated. An unpermitted constructed crossing of the upper creek, in association with anticipated development, resulted in large amounts of fine sediments being introduced to the system in 1992. Deposits from this event are still present throughout the system. This watershed is currently at risk of permanent conversion of the forested portions of the headwaters to non-forest cover by residential development (TAG).

The Streamkeepers identified two major bank erosion areas approximately 300 and 350 yards upstream of the mouth that resulted from January 1999 rains. Stream surveys conducted from July 1997 – April 1999 estimate surface substrate composition to be 20% gravel and 35% cobble.

Benthic Invertebrate sampling, conducted in October, 1998, yielded a Benthic Index of Biological Integrity (B-IBI) score of 42, which is interpreted as good.

Water Quality

Bagley Creek is listed on the Clean Water Act Section 303(d) list of impaired waterbodies, based on elevated fecal coliform counts (Barecca 1998). Although fecal coliform is not known to directly adversely affect salmonids, it is often an indicator of other water quality impacts in the watershed that can adversely affect salmonids. These include direct animal access to the channel which affects riparian condition and bank stability, high fine sediment levels in the substrate from stormwater or agricultural runoff, and high nutrient levels in the stream which may cause excessive plant growth and affect dissolved oxygen levels.

Water temperature data collected by Streamkeepers indicate a high temperature of 13.2^{o}C, a low of 4.5^{o}C, and an average of 8.6^{o}C; dissolved oxygen samples indicate a high of 13.7 mg/L, a low of 7.7 mg/L, and an average of 11.6 mg/L.

Water Quantity

Quarterly flow measurements collected by Streamkeepers for July 1997 – April 1999 indicate a high flow of 36 cfs. (1/24/98), a low flow of 1.7 cfs. (7/26/97), and a mean flow of 7.4 cfs. Instream flow recommendations have been made for Bagley Creek, based on toe width measurements of 12.6 feet made at Highway 101. Recommended instream flows are 15.0 cfs for the period November-January (coho spawning), 10.0 cfs for February, 29 cfs for March-April (steelhead spawning), 20.0 cfs for May-June, and 6.0 cfs for the period July-October (steelhead rearing) (Beecher and Caldwell 1997).

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The Bagley Creek estuary is likely similar to historic condition. A berm of sand/small gravel forms across the mouth of the creek during low flows in the summer, sealing off the creek from flow interaction with salt water. This effectively limits juvenile and adult salmonid migration (upstream and downstream) until flows increase enough to open a channel through the berm. Barecca (1998) reports there are community concerns of runoff and erosion problems at Bagley bluffs, although these concerns are reported to relate primarily to presence of trees and other slide material on the marine shoreline that makes beach walking difficult (Joel Freudenthal). However, these natural ecological processes are typically beneficial to fish life and marine nearshore ecology, and have unfortunately been lost on much of the WRIA 18 marine shoreline as a result of shoreline armoring.

<u>Action Recommendations</u>

The following ranked salmonid habitat restoration actions are recommended for Bagley Creek:

- **Limit conversion of upper watershed to non-forest cover**
- **Evaluate fish passage through logjams in lower Bagley Creek and implement remedial modifications, where warranted (Mike McHenry)**
- **Provide unrestricted fish passage through the Highway 101 culvert and correct the additional two fish passage barriers upstream**
- **Prevent animal access to channel upstream of Highway 101 and restore functional riparian zones through this area**
- **Replace the lowermost culvert on Bagley Creek Rd. to prevent backwatering during peak flow events and bank erosion and sediment deposition upstream of the culvert**
- **Restore LWD presence throughout the channel. Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored.**
- **Adopt and implement instream flow requirements**

Morse Creek 18.0185

<u>Location</u>

Morse Creek is the largest of the independent drainages to salt water between the Dungeness and Elwha rivers, entering the Strait of Juan de Fuca approximately 2 miles east of Port Angeles. Morse Creek is a moderate sized watershed that drains steep headwaters of Olympic National Park including Hurricane Ridge, Mt. Angeles, and Deer Park. Like other watersheds on the North Olympic Peninsula that accumulate significant snowpack, Morse Creek exhibits two peaks in annual discharge (one associated with winter rainstorms and the other resulting from spring snowmelt). Morse Creek is known to have produced a high diversity of salmon species in greater numbers than would be expected for a stream of its size. Habitat quality and conditions are excellent in the watershed above the Olympic National Park boundary at RM 9.0. Habitat conditions that are thought to have contributed to Morse Creek's historic high productivity included:

- North facing stream – water remained cool (aspect of potentially lesser influence than snow melt contribution and groundwater)
- Bimodal peaks in discharge
- Abundance of log jams and LWD throughout anadromous zone
- High nutrient levels from large returns of adult salmon and steelhead
- High quality open estuary behind stable sand spit, with open access to salt water

In addition, Morse Creek is noted to have variable pH changes through the seasons due to water flow through basalt in upper watershed, although the effects to stream productivity are not clear. The productivity of Morse Creek was also historically influenced by associated estuarine habitat in Port Angeles Harbor. Port Angeles harbor has been subsequently degraded from a variety of land-uses including inter-tidal filling, shore armoring, log storage, pulp mill operations, and urban run-off (see Marine Habitat section).

Fish Access

No artificial fish migration barriers are known to exist in this watershed. Economic and Engineering Services, Inc. (1996) indicates that a series of boulder/bedrock cascades at RM 3.8 are thought to be migration barriers to anadromous and resident salmonids. The Stream Catalog (Williams et al. 1975) also shows a barrier at approximately RM 3.8, but the TAG indicates anadromous distribution occurs upstream to the natural falls at RM 4.9, which is a complete barrier to anadromous salmonids. However, there is speculation that steelhead may have been able to pass this barrier at some time in the past. A geologic fault runs under Morse Creek at the falls, and the size of the falls may have been less at some point in the past. Two steep tributaries, Frog and Mining creeks flow into Morse Creek downstream of the falls. The distribution of fish within these tributaries is thought to be limited by stream gradient. A population of rainbow trout exists above the falls at RM 4.9; the uppermost extent of distribution is unknown.

Floodplain Modifications

The floodplain upstream of Four Seasons Park (RM 2.0-4.9) is relatively unconfined by human activities though the stream becomes moderately confined by canyon walls. Downstream from the upstream extent of Four Seasons Park to Highway 101 (RM 1.2-2.0), Morse Creek is diked and armored, effectively confining the creek between the dike and a bedrock outcrop. Here the channel is spanned by two bridges (Highway 101 and the railroad trestle). Both the Highway 101 bridge and the railroad trestle constrict the floodplain. The area between these constrictions has also been confined with armored banks, creating high hydraulic energy conditions and poor habitat. Homes have been constructed behind the dike at Four Seasons Park, limiting the potential for restoration without property acquisition.

Below Highway 101 Morse Creek is effectively diked on both banks (from RM 1.2 – mouth). This alluvial reach was formerly unconfined and meandering. Downstream, the car bridge to Four Seasons Park (RM 0.5) had previously constricted the floodplain, but reconstruction of the bridge to provide a 110-foot span has improved conditions. A foot bridge (golf course crossing) at Four Seasons Ranch (RM 0.1) ties into the diking on both sides of the channel. The TAG estimates that >80% of the floodplain capacity has been lost in the area downstream of RM 1.75. Constriction of the channel and floodplain areas results in greater channel scour during high flow events, and the elimination of escape cover outside the active channel (Economic and Engineering Services, Inc. 1996). There is limited development in this lower river floodplain area, including a golf course and a limited number of homes on the floodplain fringe. However, much of the floodplain area remains between the dike and the Four Seasons Ranch homes, providing significant floodplain restoration potential. Restoration would likely require property acquisition or conservation easement.

Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report. A comprehensive flood plain study would be beneficial in determining the effects of loss of floodplain and potential for recovery.

Channel Conditions

Lower Morse Creek was channelized in the late 1950s to facilitate housing development. Bulldozers were used to create a uniform straightened channel. As a result of the hydro-modifications, pool habitat and suitable spawning gravel have been almost completely lost from lower Morse Creek. The percentage of pool area in the lower mile of Morse Creek has been estimated at 12%, with only three pools in the first mile (0.18 pools/100 m). The extreme channel simplification and associated lack of channel diversity downstream of RM 1.75 has eliminated refugia for juvenile salmonids (coho and steelhead) over-wintering in the lower river, likely resulting in them being flushed to saltwater during high flow events. From the mouth to RM 2.0, the stream is characterized as a continuous riffle with no deep pools, sidechannel habitat, or backwater areas; from RM 2.0-3.8, the channel was characterized as 40% pool/60% riffle (Economic and engineering services, Inc. (1996).

Historically, log jams and LWD were abundant all the way from the mouth to the falls (Dick Goin). LWD is thought to have been recruited from the adjacent riparian area, as the potential to move LWD of key piece size in the creek was negligible. The canyon was logged in 1948, and the presence of logjams and LWD has degraded since then. Extensive stream cleaning and debris removal occurred in lower Morse Creek beginning in the 1940's. In the 1970's, a large number of logs washed downstream during a high flow event and built up behind the railroad trestle, which constricts the channel. This backed up water and created local flooding upstream of the trestle. Landowners filed a lawsuit to remove the logs. During a later flood event the railroad dynamited the logjams at the trestle, which created a dam-break flood downstream, resulting in a loss of much of the remaining LWD from the system. In previous years, Rayonier used a crane to remove LWD that built up behind the trestle, preventing the movement of LWD to downstream areas. The City of Port Angeles currently owns the trestle and intends to retain the trestle as part of a trail system. However, it continues to constrain the channel.

Peninsula College conducted an inventory of LWD in the lower mile of Morse Creek and found only one piece >24" diameter and >20' in length. This rates as very poor when compared to the NMFS Coastal Salmon Conservation Working Guidance (September 1996) of >80 pieces/mile >24" diameter >50 ft. length. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

<u>Substrate</u>

Morse Creek is not considered to have ever been a gravel rich system (Dick Goin). The creek has moderate gravel availability, historically alternating between hardpan and gravel from the mouth to the falls. There currently is very limited gravel availability throughout the system; there is a small area of spawning gravels just upstream of the estuary where some chum and coho spawn, but the next spawning area occurs over a mile upstream. This is of particular concern below Four Seasons Park, where gravel is lacking, leaving mainly coarse substrate. Habitat inventories found no suitable spawning gravels below Highway 101 (Peninsula College, Unpublished Data; Economic and Engineering Services, Inc. 1996). This is likely related to historic channelization, hydraulic constrictions and the lack of LWD throughout the anadromous zone to hold gravel. There are no currently identified fine sediment concerns.

<u>Riparian Condition</u>

The Morse Creek riparian corridor is largely vegetated, although not fully functional. It is rare to find areas with <50-feet of riparian vegetation, except in Four Seasons Park and the estuary where there is little remaining riparian vegetation (TAG). Outside of Olympic National Park logging has occurred to the stream edge. As a result, the dominant canopy is deciduous trees, which do not provide high quality LWD recruitment potential. Riparian vegetation downstream of Highway 101 is primarily young deciduous. Some of the riparian vegetation downstream of Highway 101 is located on or behind dikes and would be subject to disturbance or elimination in the event that the dikes are removed or relocated. The TAG indicated that even when mature trees do fall in the riparian zone or in the creek, they are typically removed or destabilized by local residents. The Four Seasons Ranch homeowners are also known to systematically remove vegetation in the estuary to enhance view corridors.

Water Quality

Summer stream temperatures are typically cool and the water is well oxygenated in the lower reaches as the result of groundwater contributions (Clallam County, Unpublished Data). An abandoned fly ash dump is located just above Morse Creek at RM 1.5 (on the west side of the stream). This site has recently been evaluated by the Environmental Protection Agency as a potential site for inclusion under the federal Superfund cleanup. This evaluation included an assessment of groundwater quality beneath the dump site. Because the dump received a variety of materials, including chlorine compounds associated with the pulp bleaching process at the mill site, there are concerns that toxic compounds including dioxin may leach to Morse Creek.

The TAG identified stormwater runoff from Highway 101 and other impermeable surfaces as a concern. Hydrocarbons, anti-freeze, metals and sand originating from paved surfaces are delivered directly to Morse Creek during storm events. There does not appear to be a concerted strategy or effort to manage the adverse effects of stormwater runoff throughout WRIA 18.

Water Quantity

Like other watersheds on the North Olympic Peninsula that accumulate significant snowpack, Morse Creek exhibits two peaks in annual discharge (one associated with winter rainstorms and the other resulting from spring snowmelt). The average flow discharge is 130 cfs, with normal low flow of 10-15 cfs (Economic and Engineering services, Inc. (1996). Morse Creek is potentially over-appropriated, considering the amount of water diverted out of the basin in comparison to instream flow needs for fish. The primary diversion is from the dam at RM 7.0, initially constructed to provide water to the City of Port Angeles and later used for hydro-power generation. The City has recently abandoned its hydro-power operation, but maintains a 19 CFS water right in Morse Creek. Although the City has since moved its water supply to the Elwha River, it still retains its water right in the event of emergencies. The dam is currently operated by the PUD, to provide domestic drinking water to Clallam County residents. The PUD draws less water than previously used by the City of Port Angeles, but the emergency water right for the City remains. Total surface water rights for Morse Creek are 24 cfs, with an additional 72 water claims (Economic and Engineering Services, Inc. 1996), and new water right demands and applications are likely as the area east of Port Angeles develops.

There are likely stormwater impacts resulting from altered hydrology in Morse Creek (greater frequency and magnitude of peak storm flows). Runoff occurs from impervious surfaces associated with existing development, constructed largely without stormwater detention and treatment facilities. It is likely that the creek has been adversely affected by stormwater, but the extent of impact is difficult to assess because of the extent of other channel modifications. Both the Mining Creek and Frog Creek watersheds are platted for urban development. Both of these areas are in the rain-on-snow zone in the Morse Creek watershed. Even if the existing Critical Area Ordinances are enforced, new development will likely result in additional significant stormwater impacts (Joel Freudenthal). Clallam County currently has not adopted or implemented the protection provisions of the Puget Sound Stormwater Manual. There does not appear to be a concerted strategy or effort to manage the adverse effects of stormwater runoff throughout WRIA 18.

An interesting development impact is related to disturbance of geologic features. The glacial materials in the watershed are stored in terraces behind glacial till terrace walls. When land grading "nicks" these till walls, it appears to create a notch from which the water stored in the terrace above flows out. This results in increased flow for several months until the water level in the upstream terrace finds a new equilibrium with the level of the notch. This may also affect the extent of potential groundwater storage and groundwater flows to Morse Creek, but the extent of effect is unquantified.

Biological Processes

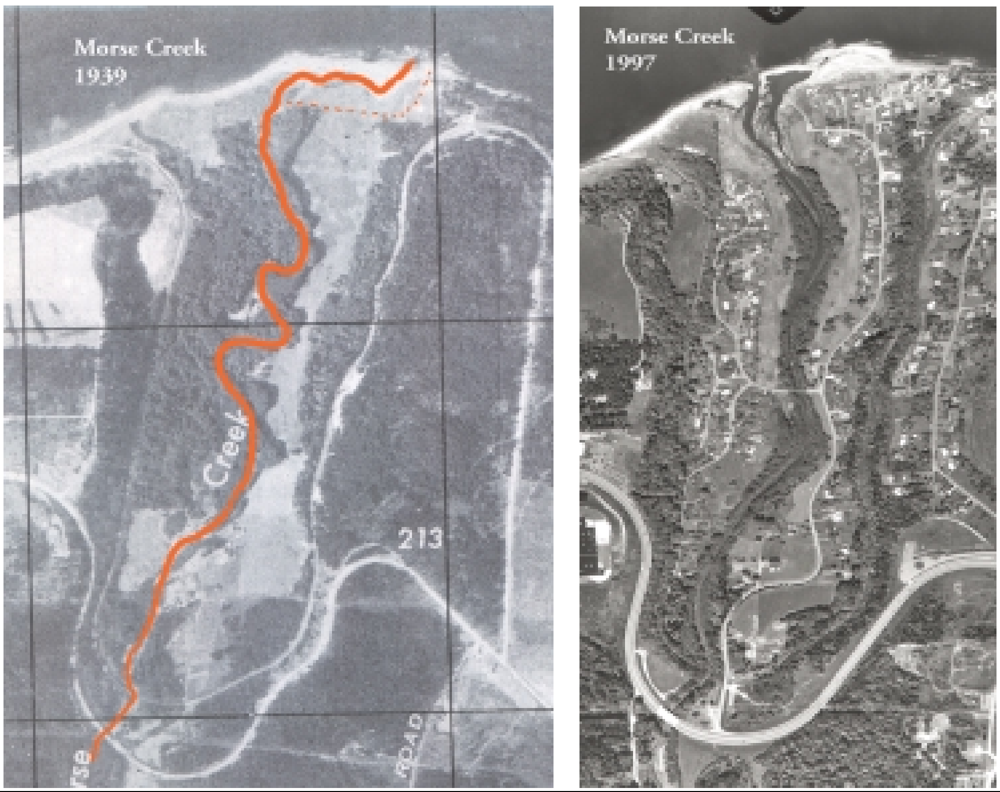
The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. Adult salmon and steelhead spawning escapements have significantly declined to a fraction of their historic abundance, raising concerns about a lack of marine-derived nutrients returning back to the system in the form of salmon carcasses. The ability to retain nutrients in the system may also be limited due to the extent of channelization in the lower river.

Estuarine

The historic estuary conditions have been substantially altered and the characteristics of the once productive estuary have been lost. Figure 24 allows comparison of Morse Creek estuary conditions in 1939 and 1997. The historic estuary configuration was a spit-built estuary, with a sand spit running parallel with the marine shoreline towards the east to the mouth. Upstream of the mouth was a very sinuous wood-rich channel behind the spit. There is also an indication of salt marsh inside the historic spit on the left bank with connection to the main channel. This provided both a rich area for juvenile salmon rearing and for adults to mill prior to migration upriver. The Morse Creek estuary was considered to be a fantastic estuary for a stream of its size, and likely contributed significantly to the higher than expected salmon production that originated from Morse Creek.

The spit and estuary (approx. 1,200 feet in length) were intact in the 1939 aerial photo (Figure 24), and remained substantially intact into the 1950's. A side channel on the west side of the mouth (noted by orange dotted line in Figure 24) was diverted in the late 1940s during the initial development of the Four Season's Ranch, cutting off the western corner of the estuary. Sometime thereafter, the lower 3/8 mile of river, that had been very sinuous, was straightened along with removal of the extensive amount of large wood that was in the estuarine portion of the river (Dick Goin). These changes resulted in a simplified channel that now drained directly to saltwater. The widened channel lost its ability to transport sediment through the lower reaches. The channel change resulted in almost total loss of the highly productive estuary, and loss of area for juvenile rearing and adult holding prior to migration upriver.

Figure 24: Comparison of 1939 (with channel highlighted) and 1997 Aerial Views of Morse Creek Estuary (photo courtesy of Randy Johnson)



The loss of the sand spit that formed the Morse Creek estuary may, in large part, be the result of loss of longshore drift from the marine bluffs to the west of Morse Creek. This is evident when comparing aerial photos of Bagley, Siebert, and McDonald creeks, all of which are similar sub-tidally, but Morse Creek lacks the berm of littoral sands that these other creeks receive from the adjacent bluffs (Joel Freudenthal).

Additionally, productivity of Morse Creek salmon is thought to be heavily influenced by the quality of habitat conditions in Port Angeles harbor. The Port Angeles harbor historically functioned as a large estuary, providing high quality rearing areas for many salmonid species. The harbor has been extensively altered from a variety of cumulative physical effects (see Marine Habitat section).

__Ranked Action Recommendations__

The TAG identifies the following habitat restoration components as most important to the restoration of Morse Creek:

- **Restore floodplain function downstream of RM 1.7, including the removal/pull back of dikes, elimination of floodplain constrictions, and restoration of natural banks**
- **Restore LWD presence throughout the channel downstream of the natural falls at RM 4.9; develop and implement a short-term LWD strategy to provide LWD presence and**

habitat diversity until full riparian function is restored; ensure that LWD is passed downstream of the railroad trestle
- **Reestablish estuarine characteristics and function similar to historic conditions**
- **Restore riparian function by encouraging conifer regeneration in deciduous stands that historically had a conifer component**
- **Restore longshore littoral drift from marine bluffs to the west of Morse Creek**

These are ranked with equal importance, although it is recognized that floodplain recovery will likely be needed in order for LWD restoration efforts to be successful. LWD restoration could be locally successful upstream of Four Seasons Park independent of floodplain recovery efforts. LWD restoration efforts should focus on recruitment of key piece sized conifer capable of remaining stable in the channel, creating in-channel diversity, and retaining gravel and smaller LWD.

Lees Creek 18.0232

Location

Lees Creek is a medium-sized independent drainage to salt water, entering the Strait of Juan de Fuca just east of Port Angeles.

General

Lees Creek currently supports very low numbers of anadromous salmon, limited to a few returning coho and steelhead. Lees Creek is a "naturally closed channel" through the summer, as the mouth of the channel is isolated from the Strait of Juan de Fuca by a natural sand spit during low flow periods. Ingress or egress access for anadromous salmon is only provided when flows and tides increase to the extent that the sand spit is overtopped. Historically, closed streams may have had fewer anadromous fish as compared to streams with fully developed estuaries. The Highway 101 culvert has been a barrier since approximately 1940 (Dick Goin). In addition, Lees Creek rapidly degraded following the construction of the Eckland saw mill in the late 1940s, which dumped large amount of wood waste directly into the stream channel. Cutthroat populations occur in the upper portions of both the East and West forks.

Fish Access

The following fish passage barriers have been identified on Lees Creek:
- RM 0.1 – perched culvert on private road is a barrier to anadromous fish passage (Walt Blendermann believes this to be a total barrier, Tim Rymer indicates it is a partial barrier) and is deteriorating
- Highway 101 - box culvert recently repaired, the slope and velocity within the culvert remain difficult for fish to pass; there remains some debate on the passability of the culvert; additional modification is necessary (monitoring and design currently in progress, reconstruction [if needed] to occur in 2001 (Carl Ward))
- Marsden Rd. - twin culvert on WF marginally passable, culvert on EF is partial velocity barrier
- Pierce Rd. - private landowner concrete lined channel upstream of road, may be velocity barrier

The existing old railroad bridge marks the confluence of Lees Creek with the Strait of Juan de Fuca. Economic and Engineering Services, Inc. (1996) indicated that the absence of an established stream corridor through the sand berm north of the railroad bridge presented a migration barrier, but as noted above, this is likely reflective of the natural condition. A large rock forms a natural barrier on the East Fork approximately 0.25 miles downstream of Draper Road.

Streamkeepers indicate that undersized culverts (sites unidentified) create backwater conditions during storm events, but there are no indications as to whether these create fish passage barriers.

Floodplain Modifications

Upstream of Highway 101, a previous floodplain constriction associated with the Leighland Avenue crossing of the stream, has been corrected with construction of a bridge. On the East Fork, concrete bulkheads have been built below Marsden Road, above Leighland Avenue, and upstream of Benson Road. As identified in the barrier section above, a private landowner has lined the channel with concrete upstream of Pierce Rd. At the powerlines, an unpermitted set of double culverts was installed, severely constricting the floodplain. Unrestricted animal access is also of concern upstream of the powerlines. In the vicinity of Draper Road, where the channel flattens out, there are numerous floodplain constrictions, unrestricted cattle access to the stream, and channel ditching and draining. On the West Fork, downstream of Monroe Road, a wetland area has been channelized, with several floodplain constrictions. Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Channel Conditions

Pool occurrence and frequency is considered good in the low gradient wetland areas in the upper watershed, but there are few if any pools in the lower reaches of the creek (TAG). The general lack of pools in the lower reaches is confirmed in the Streamkeepers report. The lack of pools is likely associated with a combination of lack of LWD and/or excessive sediment.

Lees Creek is chronically depleted of LWD throughout the watershed. Historic logging and conversion of riparian forest to pasture or housing development are thought to be primary causes of this depletion. This condition is also reflected in the Streamkeepers report, and existing LWD is noted to be primarily deciduous. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Substrate

The watershed is characterized by fine sandy substrate, with limited patches of spawning gravels. The creek is low gradient/low velocity in the upper watershed, and has naturally poor gravel availability. Fine sediment levels in spawning gravels have, however, likely been increased by land management practices within the watershed.

The Streamkeepers identified numerous locations where bank ersoison occurred during the winter of 1998-99. There is also indication of substantial bedload movement as several gravel bars increased significantly in size over the winter.

Riparian Condition

Riparian condition is considered to be fair in the ravine areas and in the low gradient wetland areas with riparian vegetation dominated by deciduous species. Riparian condition is considered poor, however, in agriculture areas on both the East and West forks. Approximately 25% of the East Fork has horse and hobby farms where the riparian vegetation has been removed, there is direct access of farm animals to the creek, and the banks have been trampled. Similar impacts occur on the West Fork in the vicinity of Monroe Road.

Water Quality

Water quality is affected in the agricultural areas of both the East and West Forks. Approximately 25% of the East Fork has horse and hobby farms where the riparian vegetation has been removed, there is direct access of farm animals to the creek, and the banks have been trampled. Similar impacts occur on the West Fork in the vicinity of Monroe Road. Streamkeepers identified the reach from Draper Rd. to ½ mile upstream of Highway 101 as a possible source of fertilizers and pesticides.

Stormwater runoff water quality from Highway 101 is of concern, with reports of very noticeable presence of petroleum substances during and after storm events (Tim Rymer, Joel Freudenthal).

Stormwater runoff from the Rayonier landfill drains to East Fork Lees Creek. Stormwater from both the Daishowa and a second Rayonier landfill drains to West Fork Lees Creek. These landfills are known to contain boiler ash, recovery ash, sludge, and dredge disposal (Dick Goin). The specific effects of stormwater runoff from these landfills are unknown, although the Streamkeepers indicate there is contamination from the landfill, made worse during the 1998-99 high flows. Clallam County currently has not adopted or implemented the protection provisions of the Puget Sound Stormwater Manual. There does not appear to be a concerted strategy or effort to manage the adverse effects of stormwater runoff throughout WRIA 18.

Streamkeepers monitored dissolved oxygen, indicating a high of 12 mg/L, a low of 8.0 mg/L, and average of 10.6 mg/L; temperature indicated a high of 15^{o}C, a low of 1.5^{o}C, and average of 7.91^{o}C.

Water Quantity

Streamkeepers conducted quarterly flow measurements from August, 1997 to May, 1999, reporting a high flow of 19.2 cfs (11/1/97), a low flow of 0.4 cfs (10/17/98), and an average flow of 5.33 cfs.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

There is virtually no estuary at the mouth of Lees Creek. Lees Creek is a "closed channel" through the summer, as the mouth of the channel is isolated from the Strait of Juan de Fuca by a natural sand spit during low flow periods. Ingress or egress access for anadromous salmon is only provided when flows and tides increase to the extent that the sand spit is overtopped. This is probably similar to the natural historic condition. Historically, closed streams may have had fewer anadromous fish as compared to streams with fully developed estuaries. The productivity of Lees Creek is also directly tied to estuarine conditions in Port Angeles harbor, previously noted as degraded.

Ranked Action Recommendations

The TAG identifies the following habitat restoration components as most important to the restoration of Lees Creek:

- **Improve passage conditions, initially at Highway 101 and at RM 0.1, and subsequently at other locations**
- **Restore riparian presence and function, develop and implement a short-term LWD recovery strategy, and fence livestock away from the channel on agricultural areas on both the East and West forks**
- **Identify and remove/correct floodplain constrictions**
- **Evaluate flow and water quality impacts of runoff from the mill landfills, Highway 101, and agricultural areas of concern; remediate identified problems**
- **Educate landowners in the watershed on the importance of providing functional salmon habitat, particularly in regard to LWD, riparian vegetation, and preventing animal access to the channel**

These actions are ranked in order of salmonid restoration importance.

Ennis Creek 18.0234

Location

Ennis Creek is a significant independent drainage to salt water, entering salt water at the eastern end of Port Angeles harbor.

General

Ennis Creek is the smallest snow fed stream on the North Olympic Peninsula. The headwaters of Ennis Creek are located within Olympic National Park. Ennis Creek is generally considered the healthiest of the Port Angeles urban streams. Steelhead, coho, cutthroat and char have been observed in the basin in recent years. Smolt trapping conducted in 1998 showed that steelhead are currently the most abundant species in Ennis Creek (Unpublished Data, WDFW). Ennis Creek is generally steep and is confined within much of its length by valley side slopes.

White Creek, a major tributary that enters Ennis Creek at RM 0.3, is heavily degraded from urbanization (including construction of a motel over the watercourse, which is now encased in a bottomless culvert) and has little production potential due to extensive culverting and impassible culverts.

A Klallam village site (Y'inis) was historically located at the mouth of Ennis Creek. In the late nineteenth century the first cooperative colony in Washington was constructed at this location. A large pulp mill followed in the 1930's.

Peninsula College (Walton letter to Van Hernest (City of Port Angeles) 1983) calculated juvenile salmonid population densities for Ennis Creek (Table 11).

Table 11: Juvenile salmonid population densities (fish/m^2) for Ennis Creek (from Walton 1983)

Stream Reach	**Coho**	**Steelhead**	**Cutthroat**
Rayonier parking lot to mouth of White Creek	0.253	0.75	0.430
Upstream of Highway 101	0.300	0.35	0.375

<u>Fish Access</u>

The Highway 101 culvert is a concrete box culvert with a fishway. The County road downstream of the Highway 101 has a bottomless culvert that is undersized. Although both culverts are considered to provide less than desirable fish passage conditions, they are currently not considered to be total barriers. However, the Highway 101 fishway is currently unmaintained. A water diversion dam site at approximately RM 3.0, which was previously a partial blockage, was removed in the late 1980's. The bottomless culverts in lower White Creek are accessible to salmonids, but there is little, if any, production potential. In addition, the 800-foot culvert in White Creek under Highway 101 is a barrier to salmon passage. The WDFW Fish Passage Barrier database (1999) indicates that removal and replacement of this culvert would provide access to an additional 4772 m^2 of spawning habitat and 5945 m^2 of rearing habitat. However, the TAG indicate that the channel in the upper watershed is steep and tightly confined, and that available habitat is degraded as a result of extensive development in the headwaters, withdrawal of domestic water from wells immediately adjacent to the stream, runoff from the old garbage dump, and numerous locations where recreational vehicles regularly run through the channel. In addition, the cost to remove and replace the culvert would be exorbitant.

<u>Floodplain Modifications</u>

Ennis Creek is generally confined within much of its length by valley side slopes. The floodplain downstream of the White Creek (RM 0.2) is channelized and fully constrained by dikes, armored banks, the Rayonier Mill parking lot, and several bridges associated with the mill. The mill is currently being dismantled and a cleanup of the site will be conducted in the next several years. The lower portion of the creek is constrained on the east side by the Port Angeles wastewater treatment plant. Upstream of Highway 101 the Ennis Creek floodplain is less constrained, though some urban development may encroach upon the floodplain. Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

White Creek is entirely confined within a bottomless culvert that extends from Front Street to First Street. Upstream another culvert and an additional box culvert further confine the channel. These upstream culverts are impassible.

Channel Conditions

Channel gradient is steep and the channel is confined throughout most of its length within a steep ravine. The channel upstream of the old dam site (RM 3.0) converts from gravel to a cobble and bedrock dominated channel. Obstructions including large wood and boulders are critical in forming a step-pool profile in this geomorphic channel type.

LWD presence is generally poor below RM 3.0, as most of the existing riparian forest has been logged at least once. There is second-growth conifer presence within the ravine, although probably at a lower density than occurred prior to logging. LWD presence in the upper watershed is much better, particularly in Olympic National Park, where no logging has occurred. Specific reaches that have been identified as deficient in LWD are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Substrate

Gravel is limited within the channel and deposits are confined primarily to the lower reaches. The channel upstream of RM 3.0 converts from gravel to a cobble and bedrock dominated channel bed. Obstructions create a step-pool profile and gravel is typically stored above these obstructions. No fine sediment, or bed aggradation or degradation concerns have been currently identified. Several slides are known to have occurred in the upper watershed this past winter (1998-1999); the impacts from these slides have not been evaluated.

Riparian Condition

The channel upstream of RM 0.2 is generally confined within a steep deep ravine. The ravine has previously been logged, but the riparian zone is generally intact within the ravine, with good second-growth conifer presence. Downstream of RM 0.2, there is no riparian presence due to encroachment of the channel as it flows through the mill site.

Water Quality

There is potential leaching to Ennis Creek from the Rayonier and Daishowa landfills (located between Lees Cr. and Ennis Cr.). Any contamination would occur through groundwater leaching, as there are no direct surface runoff channels known to occur. The Rayonier mill is known to have contaminated soils, groundwater, Ennis Creek, and Port Angeles harbor with various toxic substances including dioxin, heavy metals and PCB’s (Superfund Technical Assessment and Response Team 1998). For example, the finishing room, which is located just above the east bank of Ennis Creek, is known to have leaked hydraulic oil to the stream (Dick Goin). The mill site is currently in the assessment phase of what is expected to be a multi-year cleanup effort.

Ennis Creek also receives direct drainage from the Port Angeles Golf and Country Club, with potential impacts of pesticides and nutrients, although specific sampling has not been conducted. County/City should monitor water quality in vicinity of the golf course.

Heavy petroleum product presence has been reported in stormwater runoff from Highway 101. WSDOT is constructing a stormwater facility, which should lessen highway runoff pollutant loading to the creek. The ability to construct more effective water quantity and quality improvements is severely limited by the small amount of space out of the floodplain and not adjacent to areas of high landslide potential (Joel Freudenthal).

Recent water quality monitoring detected elevated fecal coliform levels. Clallam County Environmental Health Division has discovered a direct sewage discharge to the creek, which is believed to be related to the elevated fecal coliform levels. The landowner and the City of Port Angeles have been directed to connect the residence to the City sewer.

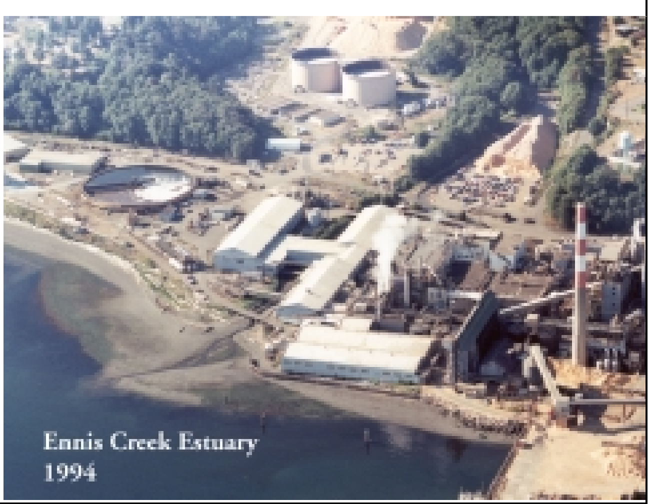
Water Quantity

Summer base flows are maintained by snow runoff and groundwater infiltration into the upper reaches. There are peak flow concerns associated with stormwater runoff from Highway 101 and other urban development.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Figure 25: Aerial View of Ennis Creek Estuary (1994) Prior to Removal of Rayonier Mill (photo courtesy of Randy Johnson)



Estuarine

The lower channel and estuary have been significantly channelized over time (Figure 25). Historically, Ennis Creek emerged from the bluff over an alluvial fan prior to discharging to Port Angeles harbor. It is not clear whether Ennis Creek had a fluvial (sand spit) or tidal estuary (open). Ennis Creek flow was large enough, even during summer low flows, to likely have maintained an open connection with marine waters. However, the limited physical space available between the alluvial fan and the intertidal zone would seem to preclude the formation of true tidal estuary. Examination of historic photographs indicate Ennis Creek discharging directly to the harbor over a broad inter-tidal flat (Joel Freudenthal). Most of the old Rayonier mill site was located on intertidal fill. Nearshore currents and shoreline sediment drift cells flow away from the mouth of Ennis Creek in both directions (Schwartz et al. 1991).

As part of the overall Rayonier mill clean-up, the Lower Elwha Tribe has asked the company to include physical restoration of the lower channel and estuary. The company, Tribe, and WDFW are developing a restoration plan that will be implemented at the end of the site cleanup process. The details of this plan are currently under negotiation.

Ranked Action Recommendations

The TAG identifies the following habitat restoration components as most important to the restoration of Ennis Creek:

- **Restoration of natural floodplain function in the lower channelized portions of Ennis Creek**
- **Restoration of the Ennis Creek intertidal estuary**
- **Secure passage through Highway 101 by maintaining fishway/replace culvert with bridge**
- **Collect and treat stormwater from Highway 101 and other impermeable surfaces**
- **Restore damaged riparian areas and LWD presence and function throughout the channel**
- **County/City should monitor water quality in the vicinity of the golf course**

These actions are ranked in order of salmonid habitat restoration importance.

Peabody Creek 18.0245

Location

Peabody Creek is a relatively small independent drainage to salt water, entering Port Angeles harbor in downtown Port Angeles.

General

Peabody Creek is a rain dominated watershed that drains off the low foothills paralleling the Strait of Juan de Fuca. The 4.8 mile long stream drains through heavily urbanized areas of Port Angeles. Sewage was historically discharged directly to Peabody Creek. Vast quantities of stormwater are currently routed into the creek. Historic logging has occurred throughout the watershed. A portion of upper stream corridor was included in recent additions to Olympic National Park associated with the Hurricane Ridge Road. Coho and possibly chum salmon have been historically observed, but are thought to be extirpated. Currently only cutthroat trout are known to utilize this creek.

Fish Access

Fish passage is a major limiting factor for anadromous salmonids in Peabody Creek. At least five major barriers have been created mostly to facilitate road crossings within the City of Port Angeles. A series of connected concrete box culverts and metal culverts connect the mouth of Peabody upstream through downtown Port Angeles for a distance of approximately 3000 feet (WDFW Fish Passage Barrier database 1999). This system of culverts is considered a serious impediment of fish passage. After briefly daylighting through a trailer park, Peabody Creek enters a concrete box culvert at Peabody Street. This culvert has a 30” drop and is marginally passable. Further upstream culverts at 5th, 8th, and Park streets are also identified as impassible to fish. Upstream of the 3000 ft. culvert at the mouth, approximately 1000 ft. of stream is encased in culverts. In total, the culverts represent a direct loss of approximately 0.8 miles of stream habitat. Restoration will require removal and replacement of each of these culverts.

Floodplain Modifications

Although most of Peabody Creek is within a deep ravine, the stream channel is further constrained by development. A significant length of the creek is confined within culverts. Between Lincoln and Peabody Street the creek is channelized between a trailer park and the County parking lot. Some houses have been constructed in the ravine between Peabody and 5th Streets. A BMX bicycle race track has been constructed adjacent and through Peabody Creek between 8th Street and Park Street. Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Channel Condition

Like many of the streams that drain through urban Port Angeles, Peabody Creek is severely degraded. Park Street represents a demarcation of channel conditions. North (downstream) of Park Street the channel is incised, mostly plane-bed (little or no pool structure), and the channel bed is composed mostly of cobble sized substrate. South (upstream) of Park Street, Peabody Creek drains through remnant old growth and cut over forests now managed by Olympic National Park. Within this reach the channel morphology is largely pool-riffle and large accumulations of wood act as pool forming agents. The wood also acts to store gravels and smaller sediments favored by salmonids for spawning, although natural gradient probably would preclude access to anadromous salmonids.

Downstream of Park Street there is almost no functional wood present in the channel (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report). Upstream of Park Street there is good abundance of large wood, including some larger conifer recruited from the riparian forest.

Substrate

There is very little available spawning gravel downstream of Park Street. The channel is clearly incised in this reach and is likely responding to increased stormwater inputs, which increase sheer stress on the bed surface. This effect has likely been exacerbated by depletion of large wood and culverts that were installed on a steep gradient.

Upstream of potential anadromous habitat, on Olympic National Park ownership, the stream is encased within two small-diameter (~4 ft.) culverts buried under 30-40 feet of fill. This material is apparently spoils from the Hurricane Ridge Road construction. The spoils were placed in the valley bottom of Peabody Creek on top of culverts as a disposal site. The culverts are approximately 30 years old and deteriorating, representing both a significant risk to downstream habitat and a public safety hazard. If the culverts fail or are blocked, the large fills could fail catastrophically sending a flood wave and large amounts of sediment downstream.

Riparian Condition

In those portions of Peabody Creek downstream of Park Street that are not contained within culverts, the riparian vegetation within the ravine is generally represented by sparse, medium-aged, deciduous species such as red alder and big leaf maple. Upstream of Park Street riparian vegetation is mixed and includes some large conifers of approximately 100 years age.

Water Quality/Quantity

Like other streams draining through Port Angeles, Peabody Creek was historically used as a sewer and storm drain. Although raw sewage is no longer discharged, Peabody Creek receives abundant storm drain runoff. There appears to be no effort to address this problem by the City of Port Angeles and some members of the TAG believe there is active resistance to changing historic storm water routing practices. The storm drains deliver a mixture of pollutants, largely associated with road surfaces. In addition, Streamkeepers indicate that residents of the City Center Trailer Court have noted that the creek level rises when William Shore Pool is drained, presumably due to pool water dumped into the storm sewer system above the park. If this occurs, the draining of chlorine-laden water to the stream is likely to adversely affect fish life both in the channel and potentially in Port Angeles harbor.

Fine sediment is known to be a serious problem and Peabody Creek typically has very high turbidities during storm events. In terms of water quantity, elevated peak flows from stormwater inputs are a serious problem. Large proportions of the watershed's historic wetlands have been filled.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

Peabody Creek currently discharges through a culvert directly to a confined intertidal area in Port Angeles harbor, consisting of less than an acre of fine grained substrate bounded by a heavily armored seawall. No eelgrass or other vegetation exists in this intertidal area. The intertidal and adjacent subtidal area is periodically dredged to facilitate boats docking at the Coast Guard dock. The TAG is not aware of any information describing the historic conditions at this location.

Ranked Action Recommendations

The TAG identifies the following as the habitat components most important to the restoration of Peabody Creek:

- **Correction of passage problems**

- **Collection and treatment of stormwater**
- **Removal of instream fill on ONP lands**
- **LWD/Riparian improvement projects**

Although Peabody Creek historically supported coho and possibly chum salmon, the number and magnitude of limiting factors result in little restoration potential for the stream as it currently exists. Restoration would require extensive culvert removal, extensive stormwater retrofit, and property acquisition in heavily urbanized portions of Port Angeles. Restoration should be considered for continued support of cutthroat, water quality, and other salmonids, but may rank low for salmon and steelhead in comparison to restoration benefits in other streams in WRIA 18.

Valley Creek 18.0249

Location

Valley Creek is a relatively small independent drainage to salt water, entering salt water near the western end of Port Angeles harbor.

General

Valley Creek has been significantly altered to accommodate urban and industrial development in Port Angeles. The level of habitat degradation has been great enough to extirpate all salmonid species except for cutthroat trout. Ironically, with the construction of a created 1.5 acre estuary in 1998, Valley Creek is now the primary focus of restoration efforts within the urban streams of Port Angeles. A conceptual restoration plan for the watershed has been developed (McHenry and Odenweller 1998).

Fish Access

Significant impediments to fish passage have been constructed in Valley Creek. A 2640-foot series of box and metal culverts extends from the mouth of Valley Creek upstream to 6th Street. The culverts are smooth-bottomed, are placed at gradients up to 2.1% and contain at least one hydraulic jump. This culvert system almost certainly limits fish access (coho and steelhead known to access to Highway 101), particularly at low tidal stages. At the Highway 101 crossing (RM 1.2), Valley Creek enters an 8 ft. X 7 ft. smooth bottomed concrete box culvert, 58 feet in length. This structure is considered to be the current upstream limit of salmon distribution in Valley Creek. This structure is on the WSDOT six-year list for corrective treatments, with potential to open an additional 4158 m^2 of spawning habitat and 7725 m^2 of rearing habitat. Restoration will require removal and replacement of both these culverts. On the East Fork of Valley Creek the Laurel Street culvert is a possible blockage. Other potential barriers may exist above Laurel Street, however these have not been fully evaluated.

Floodplain Modifications

Downstream of Highway 101, either culverts or roads effectively confine Valley Creek. Upstream of the entrance to the Valley Creek culvert system at 6th Street, Valley Creek is confined between roads on both sides of the channel for an additional 2000 ft. Upstream of this point to Highway 101, Valley Creek has been confined to the east side of its historic floodplain, largely to accommodate a floodplain road and now abandoned farm. Upstream of Highway 101, Valley Creek flows through its valley bottom largely unconstrained. Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Channel Conditions

A dichotomy of channel conditions in Valley Creek exists upstream and downstream of Highway 101. Downstream of Highway 101, Valley Creek has been extensively hydromodified to accommodate urban and industrial growth. As previously noted, extensive reaches of Valley Creek are culverted and channelized. In combination with loss of large wood and altered hydrology from stormwater discharges, the channel conditions downstream of Highway 101 are extremely hostile to salmon. The incised channel maintains little spawning gravel, has few complex pools and is uniformly plane-bed in structure. Upstream of Highway 101, Valley Creek maintains a pool-riffle type channel that gradually steepens. As the gradient increases (approx. 1 mile upstream of Highway 101), bedrock outcrops become more prevalent and habitats favored by salmon gradually become less abundant.

Large woody debris abundance is chronically low throughout Valley Creek (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report). Almost no large wood is present downstream of Highway 101 with the exception of a few pieces of alder. Upstream of Highway 101, there are low densities of large wood, some of which are large enough to store sediment and form scour pools.

Substrate

No specific information is available on substrate condition. Several locations were identified where stormwater is discharged at the top of the slope, resulting in slides and siltation of downstream areas, especially downstream of the confluence with Mill creek (Economic and Engineering Services 1996).

Riparian Condition

Riparian conditions mimic the in-channel wood distributions. Downstream of Highway 101, through the channelized reach, riparian vegetation is limited to a thin strip of vegetation between the rip-rapped road edges on each side of Valley Creek. Exotic vegetation such as Japanese Knotweed and Himalayan blackberry are thriving. Upstream of RM 1.0, riparian conditions improve and much of the channel is bordered by second growth timber, heavily dominated by deciduous species. Maintenance to keep power lines free of vegetation has occurred recently, resulting in a near loss of all trees along the east bank of Valley Creek at RM 1.5. A power line management plan should be developed that eliminates future adverse impacts to salmonids in Valley Creek.

Water Quality/Quantity

Summer stream temperature profiles appear to be cool and stable indicating a strong groundwater influence during low flows. Stormwater impacts to Valley Creek are considered severe. Sixty percent of the watershed is in urban land use, with 50% of that land in impervious surface (TetraTech 1988). Watershed impervious surfaces exceeding 3-10% have been shown to cause degradation of salmonid habitat (WDFW and WWTIT 1997). An extensive area of urban Port

Angeles including large areas of Pine and Cherry Streets are routed through a series of drains to the Valley Street culvert system. This stormwater has little physical effect to Valley Creek, as it is introduced directly into the culverted reach. However, it does directly deliver pollutants derived from impermeable surfaces directly to lower Valley Creek, the Valley Creek estuary, and Port Angeles Harbor, and the volume of stormwater release would also have to be effectively addressed in order to restore the lower channel. Additionally, the City of Port Angeles has a stormwater overflow drain that drains directly to the estuary. Fecal coliform monitoring conducted by Clallam County showed some elevated bacterial counts, possible associated with failing septic systems.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

Valley Creek is the site of a well-publicized estuary restoration project completed in 1998. This project was actually a mitigation project for filling of a log pond by the Port of Port Angeles. The newly created estuary, although actually representing only a 1.5 acre opening in the otherwise heavily armored Port Angeles harbor shoreline, perhaps represents an important change in local shoreline management philosophies. Historically, the Valley Creek estuary was much different, likely discharging to the harbor over an intertidal flat shortly after passing through the bluffs. This area has since been filled and culverted to accommodate urban waterfront development. The Valley and Tumwater Creek estuaries may have interacted because of their physical proximity (separated by a narrow bluff). The restoration project, although likely beneficial to salmonid resources, probably does not replicate the historic estuary condition, and there is no monitoring of the effect or benefit of the estuary project to salmon resources.

Ranked Action Recommendations

The TAG agrees with the recommendations of the conceptual restoration plan for Valley Creek (McHenry and Odenweller 1998). This report establishes strategies for the watershed that include:

- **Improve passage conditions and eliminate large reaches of culverts**
- **Restore the lower ¾ mile of stream by re-meandering , restoring LWD, and recreating pools to the maximum extent possible**
- **Reestablish floodplain process by reducing or eliminating floodplain constrictions, particularly downstream of Highway 101**
- **Remediate stormwater management in the watershed to collect, treat, and discharge stormwater in a manner that avoids adverse impacts to Valley Creek and other surface waters**
- **Restore riparian vegetation communities and instream large wood**

In addition to these goals, the TAG recommends obtaining natural floodplain easements or land acquisition downstream of Highway 101. Such easements or land acquisition would facilitate restoration by allowing enough physical space to accommodate floodplain and riparian rehabilitation measures. A critical piece of property, north of Highway 101 was recently donated to the City of Port Angeles in 1998. This property includes 0.5 miles of stream corridor that was previously platted for development.

Tumwater Creek 18.0256

Location

Tumwater Creek is a relatively small independent drainage to salt water, entering salt water near the western end of Port Angeles harbor.

General

Tumwater Creek is another stream in Port Angeles which is heavily impacted by urban and industrial development in the lower reaches. Rural development and impacts of stormwater runoff have created serious habitat problems throughout the watershed. Sediment yield from a stormwater related massive gully head-cutting off Black Diamond Road is so great that Tumwater Creek remains highly turbid throughout the winter. Although this has been a long-standing problem, the extent of impact worsened as a result of increased slide and erosion activity in 1997. Tumwater Creek historically supported populations of coho, chum and steelhead. Chum salmon have been extirpated and coho and steelhead productivity is currently limited. Smolt trapping conducted in 1998 yielded only 119 and 320 coho and steelhead smolts, respectively (Unpublished Data, WDFW).

Fish Access

The TAG identified no impassible barriers. Tumwater Creek is routed through a box culvert under Marine Drive and just upstream under Tumwater Street. Both culverts are smooth box culvert designs and may be partial barriers at certain flow regimes. Upstream, passage through another smooth concrete box culvert under Highway 101 was improved several years ago by WDFW, which installed a series of baffles in the bottom of the culvert. County culverts under Black Diamond Road are considered partial barriers.

Floodplain Modifications

Tumwater Creek is completely constrained by culverts, bulkheads, armoring, and the Highway 101 truck route in the lower 0.5 mile of stream. From Port Angeles harbor to Marine Drive, Tumwater Creek is routed through a log storage yard in a straight line between sheetpile bulkheads and short reaches of culvert. There is no collection or treatment of log sort yard runoff, with sediment and hydrocarbons discharged directly to the Creek. Moving upstream, Tumwater Creek flows through a series of culverts underneath Marine Drive, Tumwater Street, and daylighting temporarily before flowing under the Highway 101 truck route. Further upstream, the creek has been moved to the east side of its historic floodplain and armored to accommodate construction of the truck route and a gas station. Upstream of the 8th Street bridge, Tumwater Creek is unconstrained except for the Highway 101 culvert crossing. Specific reaches where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

Channel Conditions

A dichotomy of channel conditions in Tumwater Creek exists above and below the 8th Street Bridge. Below this point Tumwater Creek has been extensively hydromodified to accommodate urban and industrial development. As previously noted extensive reaches of Tumwater Creek are culverted and channelized. In combination with loss of large wood and stormwater discharges, the channel conditions below are extremely hostile to salmon. This reach could be characterized as a “shotgun barrel”. The channel has little spawning gravel; few complex pools and is uniformly plane-bed in structure. Heavy recruitment of fine sediment from the slope failure west of Black Diamond Road is visibly accumulating in the lower reaches of Tumwater Creek. Above the 8th Street Bridge, Tumwater Creek maintains a pool-riffle type channel that gradually steepens, until leveling out near its headwaters at the south end of Black Diamond Road. This reach appears to mostly stable alternating between a step-pool and pool-riffle morphology.

Large woody debris abundance is chronically low throughout Tumwater Creek (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report). Almost no large wood is present downstream of Highway 101, with the exception of a few pieces of alder. Above Highway 101 there are low densities of large wood, some of which are large enough to store sediment and form scour pools.

Substrate

Fine sediment generated from a massive stormwater related gully headcutting to the west of Black Diamond Road (just north of Alice Road) is a major impact in Tumwater Creek. Stormwater from Black Diamond, Alice, and Hoar roads has been routed into a small draw that historically had a very small drainage area. In addition, the road cuts from these roads have intercepted huge volumes of groundwater that can be seen percolating into ditch lines. With the additional flows, the gully walls have collapsed due to increased undercutting by the stormwater runoff. Steady head-cutting continues towards Black Diamond Road, delivering large amounts of sediment to Tumwater Creek. The road itself will likely be consumed by the failure at some point in the future. Fine sediment from this slope failure is adversely impacting substrate downstream to the mouth. Efforts to negotiate a solution to this problem have to date, been unsuccessful, primarily because some landowners will not accept rerouting water into historical drainage ways. As a result, the failure continues to discharge large amounts of sediment to Tumwater Creek.

Riparian Condition

Riparian conditions mimic in-channel wood distributions. Below the 8th Street Bridge, through the channelized reach, riparian vegetation is limited to a thin strip of young deciduous vegetation between the armored banks of Tumwater Creek and the Highway 101 truck route. No riparian vegetation exists downstream of Tumwater Road, where the Creek flows through culverts and bulkheads. Upstream of Highway 101, riparian vegetation is dominated by mixed second-growth timber, though some areas have been converted to pasture. Logging practices within the ravine portions of Tumwater Creek are a concern from a slope stability standpoint.

Water Quality/Quantity

Tumwater Creek is adversely affected by altered hydrology and other water quality impacts from stormwater runoff, but the effects are masked by the high sediment load from the massive stormwater related headcut off Black Diamond Road. Other water quality concerns include stormwater impacts from both Highway 101 and the Highway 101 truck route.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

The Tumwater Creek estuary historically discharged to intertidal flats just to the north of the bluffs. This area has been filled to accommodate industrial expansion. Tumwater Creek now flows through a severely confined channel through the log yard and discharges directly to the harbor. Fluvially transported sediment discharged at the mouth has created a small sandy intertidal flat, which is periodically dredged by the Port of Port Angeles to facilitate log booming operations. This practice should be reviewed in light of recent studies (SAIC 1999) indicating that sediments in Port Angeles harbor have been adversely affected by log booming.

Ranked Action Recommendations

The TAG identifies the following habitat restoration components as most important to the restoration of Tumwater Creek:

- **Remediate stormwater management in the watershed to collect, treat, and discharge stormwater in a manner that avoids adverse impacts to Tumwater Creek and other surface waters; particular attention should be given to eliminating stormwater discharges that are creating major sediment contribution off Black Diamond Road, and taking measures to stabilize erosion from the gully**
- **Restore functional estuary processes**
- **Remove channel constrictions in the lower channel and restore functional floodplain processes**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout the watershed**

These actions are ranked in order of salmonid restoration importance.

Dry Creek 18.0265

Location

Dry Creek is a relatively small independent drainage to salt water, entering salt water approximately half way between Angeles Point and the west end of Port Angeles harbor.

General

Dry Creek is a small watershed on the west side of Port Angeles that drains foothills immediately south of Highway 101. Downstream of Highway 101, Dry Creek flows across a broad glacial out-wash plain. This area was historically forested with very large cedars. This vegetative community is indicative of a perched water table, which reflects the presence of an impermeable glacial till layer just below the soil surface. Much of this area has been filled to accommodate industrial development east of Dry Creek. After flowing over this glacial out-wash plain, Dry Creek flows over a bedrock cascade and enters a ravine flowing another mile north before entering the Strait of Juan de Fuca near Angeles Point.

Fish Access

A natural bedrock outcrop at RM 1.0 creates an impassible cascade for anadromous fish. This barrier was assessed by WDF at least a decade ago, which concluded that it would be difficult to provide passage at this site. Limited numbers of coho salmon utilize the lower reaches of Dry Creek. Although large numbers of coho have been observed in recent years, it is likely that these fish were strays from the Elwha Klallam Tribal Hatchery on the Elwha River (Mike McHenry). The Port Angeles industrial pipeline, which carries water from the Elwha River to the pulp mills in Port Angeles, crosses Dry Creek. Leaks from this pipeline during some years may attract Elwha hatchery coho to Dry Creek. Above the cascades, a population of resident cutthroat inhabits the drainage.

Floodplain Modifications

There is no development within the anadromous portion of Dry Creek, as it flows through an incised canyon. The industrial water supply pipeline from the Elwha River crosses Dry Creek at RM 0.5. The pipeline and access road are armored and inhibit the fluvial transport of sediment. A sediment wedge can clearly be seen upstream of the pipeline on aerial photographs. An abandoned road crossing, that has since failed, is located just above the falls at RM 1.0. Concrete culverts were never removed and are still wedged in the channel. The previously mentioned runway expansion resulted in the filling of the original Dry Creek channel. Development on the glacial out-wash plain including the airport, log storage yards, and gravel pits have resulted in the greatest stormwater runoff impacts to the overall channel network.

In 1992, the Port of Port Angeles rerouted a portion of Dry Creek upstream of the falls to accommodate extension of a runway at the Fairchild Airfield. Dry Creek was diverted into a created channel and routed into a small west bank tributary of Dry Creek. The channel to which Dry Creek was routed was much smaller than necessary to contain the peak flow events that Dry Creek generated. In response the tributary has now down cut approximately 20 feet and is head-cutting through the recreated channel and now through the western tributary. The erosion is so severe in places that barriers to cutthroat trout migration have been created.

Channel Conditions/Substrate

Channel conditions in the lower 1.5 miles of Dry Creek are severely degraded. Downstream of the falls (RM 1.0), Dry Creek has significantly aggraded with large deposits of coarse and fine sediment. The channel has a very high width to depth ratio, and lacks significant pool development. In combination with the low flow characteristics of the watershed, significant amounts of water are lost subsurface, creating reaches of intermittent flow. From the falls upstream 700-800 feet, channel down-cutting in response to the rerouting project has heavily influenced channel conditions. Within this reach, the severe down-cutting has resulted in a rectangular channel cross-section. Very coarse substrate lines the channel bed. Pools have been completely eliminated as well. Upstream of this point, habitat conditions improve. The upper portion of the channel relocation contains good habitat characteristics. However, this reach is threatened by head-cutting associated with the gradient adjustment from rerouting Dry Creek into its small west bank tributary at RM 1.5. Channel conditions south of the airport are reasonably good as Dry Creek meanders through low-gradient reaches of pool-riffle type channel. South of Highway 101, gradient climbs rapidly, as the channel becomes primarily step-pool in nature.

Channel Conditions/Riparian

Riparian and LWD conditions have been altered throughout the watershed. In channel large wood abundance is chronically low (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report). Historic logging eliminated the original stands of large cedar found within the watershed. Second-growth stands of timber have regrown in the headwaters and along the lower reaches of Dry Creek. However, virtually the entire headwaters have been harvested in the last decade. The middle reaches of Dry Creek, which include the glacial out-wash plain have been most altered. Agricultural activities and rural housing development have limited riparian vegetation in some areas to a thin strip of brush or young stands of deciduous trees. Through the stream relocation project area, diverse native vegetation was replanted, however it is still very young and affords little canopy to date. LWD is virtually non-existent in the anadromous reach downstream of RM 1.0, and riparian condition is recovering second growth, with good conifer presence, but which is not yet providing full riparian function.

Water Quality/Quantity

Water quality is generally good throughout Dry Creek with one notable exception. Dry Creek is on the CWA 303(d) List of impaired water bodies, for temperature (Barecca 1998). The tributary that drains south and east of the airport heats rapidly and has very low dissolved oxygen during the summer. This tributary drains from the east and enters Dry Creek at the point of the channel relocation. The contribution from this tributary is enough to degrade water quality at least through the stream relocation reach. Surveys indicate that almost no cutthroat trout inhabit this reach. Downstream of the falls (RM 1.0), water quality conditions improve probably a result of the combination of increased canopy and groundwater contribution.

Increases in storm-water runoff to Dry Creek are primary causes for habitat degradation. Two factors are responsible: 1) loss of wetlands from historic filling and draining projects, and 2) increases in rain-on-snow runoff events in the headwaters. The latter has been particularly evident the last few years, as the recently clear-cut headwaters now accumulate more snow and are thus susceptible to these storm events. This effect should moderate over time, as vegetation grows to become hydrologically mature. Loss of historic wetlands likely cannot be fully mitigated due to development, however, improvements in storm-water management are necessary to address the extensive impacts to the channel.

Low flows are also a concern in Dry Creek. Reaches of Dry Creek were likely historically intermittent, however the extent is not known. It appears that upstream of the falls and north of Highway 101, through the glacial out-wash plain, Dry Creek maintains surface flows throughout the low flow season. This is likely because of the shallow impermeable soil layer, which prevents loss of flow to groundwater. The anadromous reach of Dry Creek (downstream of RM 1.0) is currently the most susceptible to intermittent flow conditions. Conditions within the very wide, sediment filled channel are conducive to loss of surface flow due to infiltration into the gravel deposits.

Biological Processes

The critical ecological role of marine nutrients, derived from salmonid carcasses, in supporting aquatic food webs and riparian vegetation has been documented by several authors (Bilby et al. 1996, Michael 1998). Diminished numbers of salmonids returning to spawn in freshwater streams has resulted in nutrient deficiencies compared to historic conditions, affecting productivity potential. However, no data are available regarding the specific nutrient status and habitat importance of fish carcass nutrients in this drainage.

Estuarine

No significant estuary exists at the mouth of Dry Creek, which is likely similar to historic condition.

Ranked Action Recommendations

The TAG identifies the following habitat restoration components as most important to the restoration of Dry Creek:

- **Remediate stormwater impacts to the channel; ensure that stormwater impacts resulting from future construction in the watershed are fully addressed at the time of construction**
- **Prevent further head-cutting in relocated reaches of Dry Creek**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until full riparian function is restored**
- **Restore functional riparian zones throughout the watershed**

These actions are ranked in order of salmonid restoration importance. In addition, the effects of the pipeline crossing on sediment transport should be further investigated.

Elwha River 18.0265

Location

The Elwha River is one of the two largest drainages in WRIA 18, located on the western edge of the WRIA. Although there are numerous tributaries to the Elwha River, only a couple (Bosco and Boston creeks) are located downstream of Elwha Dam, within the current anadromous zone. These are relic channels and are addressed as part of the Elwha River discussion.

General

The Elwha River is the largest and historically the most productive river within WRIA 18, and possibly the Olympic Peninsula. The Elwha supported legendary runs of salmon including at least ten species of anadromous salmonids (summer/fall chinook, spring chinook, coho, winter steelhead, summer steelhead, pink, chum, sockeye, sea-run cutthroat, native char). Hydroelectric dams constructed in the early part of the century at RM 4.9 and 13.2 without fish passage facilities prevented salmon from reaching their historic spawning and rearing areas. This immediately eliminated up-river production of coho, spring and summer chinook, winter and summer run steelhead, and char. Some lower river stocks suck as pinks, chums remained at relatively high abundance into the mid 1960's. However, ecological changes associated with the dams, including the truncation of gravel recruitment in combination with channelizaton, ultimately led to the collapse of these stocks by the 1970's. Today, natural production of salmon is limited to just a few areas in the lower river. Hatchery supplementation is necessary to maintain production of summer/fall chinook, fall coho and winter steelhead. Interested readers are referred to an extensive detailed history of the Elwha River, its relationship to the Port Angeles area, and the early development of this area, presented in DRAFT – Historical Assessment of the Elwha River (Johnson 1994).

The Elwha Ecosystem and Recovery Act was signed into law by President Bush in 1992. This law asked the Department of Interior to study the best ways to restore the resources of the Elwha River while protecting the interests of the city of Port Angeles, and the local pulp mill (Daishowa) which utilizes the power generated from the two Elwha River hydroelectric dams. Detailed environmental assessments (DOI 1994: DOI 1996) have concluded that the most effective means of restoring the Elwha is through the simultaneous removal of the two dams. An independent assessment by the Elwha Citizens Advisory Group has reached a slightly different conclusion: an initial removal of the Elwha Dam followed by an evaluation period of up to ten-years. At the end of this evaluation a decision would then be made concerning the utility of removing the Glines Canyon Dam. At this time, negotiations are taking place between the owners of the dams and the National Park Service concerning transfer of ownership to the Federal government. However, no actual funds have been appropriated for the removal of either structure as of the date of publication of this report.

The TAG believes that restoration planning in the Elwha is complicated by the uncertainty surrounding dam removal scenarios. The TAG strongly believes that restoration of the Elwha River is significantly compromised by proposals advocating removal of only the lower dam, and can only occur following the removal of both dams. The scenario of staging removal of the dams has a number of disadvantages including the failure to restore physical processes upon which habitat is formed, continued lack of access for stocks that require upstream habitat, and economic inefficiency. Additionally, any recovery realized from access to habitat above Elwha Dam would likely be temporarily lost following removal of Glines Canyon Dam in a staged removal scenario.

Fish Access

Access to over 70 miles of salmonid spawning and rearing habitat has been precluded since 1910, by construction of the Elwha Dam (RM 4.9). Restoration potential was further impaired by construction of the Glines Canyon Dam (RM 13.2) in 1927. These hydroelectric dams are complete barriers to upstream adult passage of salmonids; no fish passage facilities have been constructed. Initial attempts were made to provide a flume for fish passage over the dam, but these proved to be ineffective. Providing passage would be a costly and difficult task as the lower dam is approximately 100 feet tall while the upper dam is over 200 feet tall. Both dams are located in rocky canyons with vertical rock walls. Adult passage is only one part of the problem; neither hydroelectric facility is currently fitted with a diversion screen capable of passing downstream migrants. Experiments have been conducted with Eicher screens at the Elwha facility in the past. These results showed some promise, however plans to relicense these facilities, and therefore mitigate for damages to fish have largely been shelved in pursuit of the Elwha Act.

The original Elwha dam blew out on October 30, 1911 (scouring under the dam to a depth of 60 feet and releasing the entire storage of 12,000 acre feet in 1 ½ hours (Journal of Electricity, Power and Gas 1915, as referenced in Johnson 1994)), leaving a free-flowing river underneath the structure. However, it is unlikely that any fish were able to ascend the river between October 1911 and December 1914, when repairs to the dam were completed (Johnson 1994). Twelve years after the dam blowout, the event was recalled:

> Four miles of backwater was rushing down over the valley below. It was quite an exciting time to see the people with their lanterns, calling to one another and rushing for the hill. The valley was practically covered with water for a short period of time, but there was not very serious damage done. After the water receded, there were fish found all over the valley and even in some of the trees (The Olympic Tribune 12/19/1924, as referenced in Johnson 1994).

Two of the main tributaries historically used by salmon and steelhead are Little Creek and Indian Creek, both located upstream of Elwha Dam , but downstream of Glines Canyon Dam. Historic upstream limits of salmon in the mainstem Elwha are not well documented and likely varied by species. The Elwha Report (Department of Interior et al. 1994) indicates the historic upper extent of summer/fall chinook at RM 34, with spring chinook extending further upstream to the mouth of Delabarre Creek (~RM 40). Experimental releases of radio tagged summer steelhead in the mid-1980's showed that fish migrated to RM 39**.** Tributaries to the upper Elwha (upstream of the upper end of Lake Mills) are largely quite steep and probably only supported salmon in their lower reaches. This implies that upriver stocks adapted to mainstem habitat such as summer and winter steelhead, spring/summer chinook, coho, and possibly pink salmon likely dominated the upper portion of the Elwha River.

The number of Elwha River native anadromous salmonids has dropped from an estimated 380,000 (or more) to fewer than 3,000 (1995). Existing stocks in the lower river that are unsupported by artificial propagation would likely decline to extinction if the current conditions (No Action alternative) are maintained (ONP 1996). Salmon and steelhead production potential has been estimated for the various Elwha River restoration alternatives (ONP 1995). These data are presented in Table 12, including the estimated production under the No Action (current status) alternative. An Elwha River Fisheries Studies report (Dept. of Fisheries 1971) provided an independent estimate that the area upstream of the dams could support an additional 8,500 chinook; other species were not addressed.

Floodplain Modifications

Like most large rivers in western Washington, the Elwha River's floodplain has been altered and encroached upon. The lower river has been diked in several places, most significant being the Army Corps dike on the Lower Elwha Klallam Tribe's reservation. This dike is set back approximately 1000' from the current active channel, and beyond the limits of the current meander belt. However, if the meander belt were to widen with restoration of the lower Elwha floodplain, the dike would prevent channel migration toward the eastern portions of the valley, which have been developed for housing. However, it is not considered structurally capable of constraining channel migration if the meander belt is widened, as it may be if the dams are removed (U.S. Army Corps of Engineers 1994, as referenced in ONP 1995). Dikes have also been constructed to protect the City of Port Angeles industrial water line at RM 3.5, and on the west side of the estuary. The latter has severely impacted estuary processes and is responsible for eliminating all flow through one of the historic distributaries. Other constrictions include the

Table 12: Estimated wild production (#fish/yr) for salmon and steelhead and time (years) to recovery (modified from ONP 1995)*

Species	**No Action****	**Modified Dam Retention**	**Glines Canyon Dam Removal**	**Elwha Dam Removal**	**Removal of Both Dams**
chinook	1,500-2,000 fish***	16,060 fish 29-33 years	25,670 fish 29-33 years	20,020 fish 29-33 years	31,360 fish 21-25 years
coho	<500 fish ***	24,960 fish 29-32 years	31,190 fish 22-25 years	27,680 fish 26-29 years	34,570 fish 15-18 years
chum	200-500 fish	0 fish	0 fish	negligible	36,000 fish 18-21 years
pink	0-50 fish	0 fish	0 fish	negligible	274,286 fish 16-20 years
steelhead	<500 fish	7,297 fish 29-32 years	9,017 fish 30-35 years	8,272 fish 30-35 years	10,100 fish 15-18 years
sockeye	0 fish	0 fish	0 fish	6,500 fish 12-20 years	6,500 fish 12-20 years

* Assumes no outplanting. Outplanting may reduce recovery time by as much as half.

** No Action (existing conditions) would not result in any new wild salmon or steelhead. These figures are estimates of current production of wild anadromous fish in the Elwha River (P. Crain, Lower Elwha Klallam Tribal hatchery, personal communication, 1995)

*** All Elwha chinook and coho stocks are considered a composite of wild and hatchery stocks industrial water supply intake structure at RM 3.7, and the spur dike below the one-way bridge (~RM 3.6). The spur dike has had an impact on channel meander patterns and is at least partially responsible for a loss of meander in the river over time. Specific reaches of the lower Elwha where the floodplain is constrained are noted on Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report.

The construction of two mainstem hydroelectric dams at RM 4.9 and 13.2 has inundated approximately six miles of mainstem river. The natural floodplain is constricted and the bank/riparian condition is compromised by the Hot Springs Road in the reach between the Glines and Elwha Dams, which includes both private and Olympic National Park ownership. This road is one of the primary access points to Olympic National Park. Substantial amounts of rip-rap have been used to maintain the road location over time. Additionally, several large groins have been built to manage meander patterns. Upstream of Lake Mills the Elwha is free flowing and unconstrained, except where it is bounded in places by canyon walls.

Channel Conditions

Channel conditions in the Elwha have been dramatically affected by the construction of two mainstem dams. Each dam created an upstream reservoir that together have inundated approximately six miles of free-flowing riverine habitat. Additionally, the dams have truncated the recruitment of alluvium (riverbed sands and gravels) to channel reaches downstream of each dam. Large alluvial deposits have been created at the upstream end of each reservoir. The USGS estimates that the volume of material stored in alluvial fans at Glines Canyon and Elwha Reservoirs to be 12.0 and 3.0 million cubic yards, respectively (ONP 1995**.** If the Elwha were free-flowing, this material would have been transported downstream to nourish the channel, floodplain, and estuary with gravel and fine-grained sediments. Construction of the dams has truncated this supply of material for some 85 years. Over time, the channel below Elwha and Glines Canyon Dam has decreased horizontally, incised vertically, and the bed has coarsened. Present estimates, based on interpretation of visual evidence of terraces downstream of the dams, are that the riverbed downstream of the dams may be 1 to 5 feet lower and more channelized because of the dams (ONP 1995). These changes have profound implications for salmon. The average substrate size in the lower river is now dominated by large cobble, substrate that is generally too large to provide spawning habitat for salmon. Historic side-channel and other off-channel refuge areas critical for over-wintering species such as coho are now largely isolated from the mainstem.

These effects have been exacerbated by human activities such as diking. Attempts to control flooding by modification of channel meander patterns have also occurred.

Constrained deep canyon reaches of the Elwha probably were never influenced to a great degree by large wood in terms of channel morphology. Conversely, large wood was critical to habitat forming process in unconstrained alluvial reaches. Anecdotal observations note that the lower Elwha was formerly composed of many very large logjams that provided important habitat to anadromous fish (Dick Goin, Lower Elwha tribal elder reports to Mike McHenry). Large wood is currently chronically low in the Elwha River below Elwha Dam (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in the separate Maps file included with this report). Large wood recruited from upstream reaches is generally not transported through the reservoirs. Some small pieces that float to the dams are passed during floods, however these pieces are typically broken after free-falling over the spillways.

Riparian Condition

Riparian vegetation downstream of RM 4.9 is currently dominated by deciduous species including black cottonwood, red alder, and big leaf maple. It is unknown how this compares to the historic condition. Many of the cottonwoods are very large (4-6' diameter) and can provide at least temporary habitat function. In Olympic National Park stands of late successional conifer forest are common, particularly on terraces adjacent to the river. Douglas-fir, hemlock, and western red-cedar are climax species. Riparian reestablishment would be required adjacent to restored channels through areas currently occupied by the Lake Aldwell and Lake Mills reservoirs. The shoreline of Lake Sutherland has also been heavily developed, with much of the mature wooded riparian vegetation removed, and limited potential for riparian restoration.

Water Quality

The Elwha River is on the CWA 303(d) List of impaired water bodies, for temperature (resulting from thermal impacts associated with the operation of the dams) and for presence of PCBs (Barecca 1998). Otherwise, water quality in the Elwha is generally excellent. The Elwha provides domestic and industrial water to the City of Port Angeles, the Elwha Tribe, and several small community based systems. Because most of the watershed is located within the Olympic National Park, water quality impacts commonly associated with most streams on the Olympic Peninsula are uncommon. Little River and Lake Sutherland/Indian Creek which are located outside of ONP and have been developed for housing and commercial timber harvest, represent exceptions within the drainage. Increased sediment yield from logging has been noted in Little River (TAG observations of landslides from clearcuts). Runoff and septics from dense housing developments on the shores of Lake Sutherland may increase the potential for nutrient enrichment in the lake.

As noted the biggest water quality problem on the Elwha is elevated summer stream temperature. Because the reservoirs act as thermal sinks in the summer, the upper layers stratify with warm water on the surface and cooler water below. Water intakes to the hydroelectric generators were constructed so that only surface water can be drawn. As a result, warm water is delivered to downstream channel reaches. This effect is magnified in low snowpack years. Summer water temperatures as high as 69 degrees have been measured in the lower river. In comparison water temperatures rarely exceed 58 degrees in the river above Lake Mills (Unpublished Data Lower Elwha Klallam Tribe). The heat storage effect of the dams is estimated to increase the temperature in the river below each dam by 2-4^{o} C. Logging and agricultural activities conducted in the lower watershed outside the Park boundaries exacerbate the elevated water temperatures (Dept. of Interior et al. 1994). Elevated temperatures are thought to be responsible for outbreaks of the gill parasite *Dermocystidium* which has caused pre-spawning mortality of up to 70% in some years for summer chinook salmon (WDF et al. 1993). This parasite may also be partially responsible for the decline of pink salmon in the Elwha River.

Data on other physical water quality parameters, such as pH, water temperature, specific conductance and water clarity have been collected by USGS (unpublished data, USGS database), Hosey and Associates (1988), and McCormick (1995) (all as referenced in Munn et al. 1998). Mean water temperature at the USGS gaging station at McDonald Bridge from 1974 to 1986 was 8.4^{o}C, ranging from 1.2 to 14.4^{o}C. pH ranged from 6.7 to 10.0, with a mean of 7.6.

Water Quantity

Water quantity is a potentially serious limiting factor in the Elwha River during low snow pack years. As previously noted, the Elwha River is susceptible to thermal heating effects from the reservoirs. These effects may be further compounded by water withdrawals from surface and groundwater sources of the Elwha. Water is withdrawn from the river for private, municipal, industrial, and fish propagation purposes. Flow patterns fluctuate depending on power needs and withdrawals for domestic and municipal use. Gauging records are available for a nearly 100 year period on the Elwha. An Elwha River Fisheries studies report (Dept. of Fisheries 1971) indicated a mean annual flow of 1,550 cfs, with a average minimum flow of 350 cfs. Review of Orsborn (1988) indicates these flows are still representative (Joel Freudenthal). The combined water rights for all uses from the Elwha River are approximately 215 cfs. The largest water right belongs to the City of Port Angeles, which has a combined industrial/domestic use water right of 150 cfs. In periods of extreme low summer flows, this could represent 75% of the total flow (200 cfs.). The vast majority of this water has been collected and piped to two paper mills in Port Angeles Harbor. In 1997, Rayonier closed its pulp facility, resulting in a much lower withdrawal rate from the Elwha. Although the full allocation has never been taken, water withdrawals in some years approaches 50% of the flow.

An extensive low flow study was conducted in the summer of 1998, a low snow pack year (Orsborn & Orsborn 1998). The objectives of this study were to assess the effects of water diversions on the current channel morphology and fish habitat. The results showed that the lowest measured flows were between 260-310 cfs depending upon location within the lower river. Based upon the current river morphology, which is extremely wide and shallow, the authors found that for flows less than about 300 cfs the loss of surface area of the wetted channel will cause habitat conditions to be reduced.

Although the Elwha Dam is operated at “run of the river”, Lake mills (reservoir upstream of Glines Canyon Dam) may be drawn down up to ten feet to meet power needs. The water storage capacity of Lake Mills (4,000 acre-feet) is not great, but drawdown and refill periods significantly alter the natural flow regime throughout the lower river. Historically, the dams were allowed to have even more control of the river. Prior to the 1975 agreement with WDF that limited the drawdowns to 10 feet or less, up to 30,000 acre-feet of storage was utilized for power generation. On more than one occasion, downstream flows were effectively reduced to zero for a period of time and it was a regular occurrence to rapidly alter flow to meet power needs. On these occasions, there are numerous reports of stranding of salmonid fry.

Biological Processes

In the pre-dam Elwha, salmon and trout brought nutrients from the sea in the form of body weight or biomass all along the river and its tributaries. The carcasses fed at least 22 species of birds and mammals, as well as fish resources in the river. The river was well used by the 10 runs of native anadromous salon and trout; there was no month of the year when one or another of the species was not migrating upstream, spawning, rearing, or passing juveniles out to sea. In addition to feeding an abundance of wildlife species, native anadromous fish also returned important minerals and nutrients to the river. Two nutrients, phosphorous and nitrogen, often limit biological productivity in northwest streams. Each year, decomposition of the salmonid carcasses provided more than 13,000 pounds of these essential nutrients to the Elwha River under natural conditions (Dept. of Interior et al. 1994). The nutrients, absorbed by aquatic plants and animals, formed the base for an in-stream food chain that fed, among others, juvenile salmon and trout.

The return of adult salmonid biomass and nutrients to the Elwha has been nearly eliminated, with anadromous salmonid passage precluded upstream of RM 4.9, and return of many of the adults to the hatchery where they do not contribute to the in-stream food chain. The potential biomass contribution for the various Elwha restoration actions is presented in Table 13. From this data, it is clear that full support of the historic ecosystem productivity potential will be dependent on returning all anadromous species, and particularly pink and chum salmon, to the upper Elwha.

Table 13: Potential Salmonid Carcass Biomass (lbs.) Contributed to the Elwha River Ecosystem From Salmon Runs with at Least Fair Restoration Potential (modified from ONP 1995)

Species	**Dam Retention**	**Removal of Glines Dam**	**Removal of Elwha Dam**	**Removal of Both Dams**
Spring Chinook	0	35,000	35,000	35,000
Fall Chinook	0	135,700	135,700	140,400
Coho	109,700	113,700	113,700	117,600
Chum	0	0	0	236,000
Pink	0	0	0	261,200
Sockeye	0	0	27,600	27,600
Total	109,700	284,400	312,000	817,800

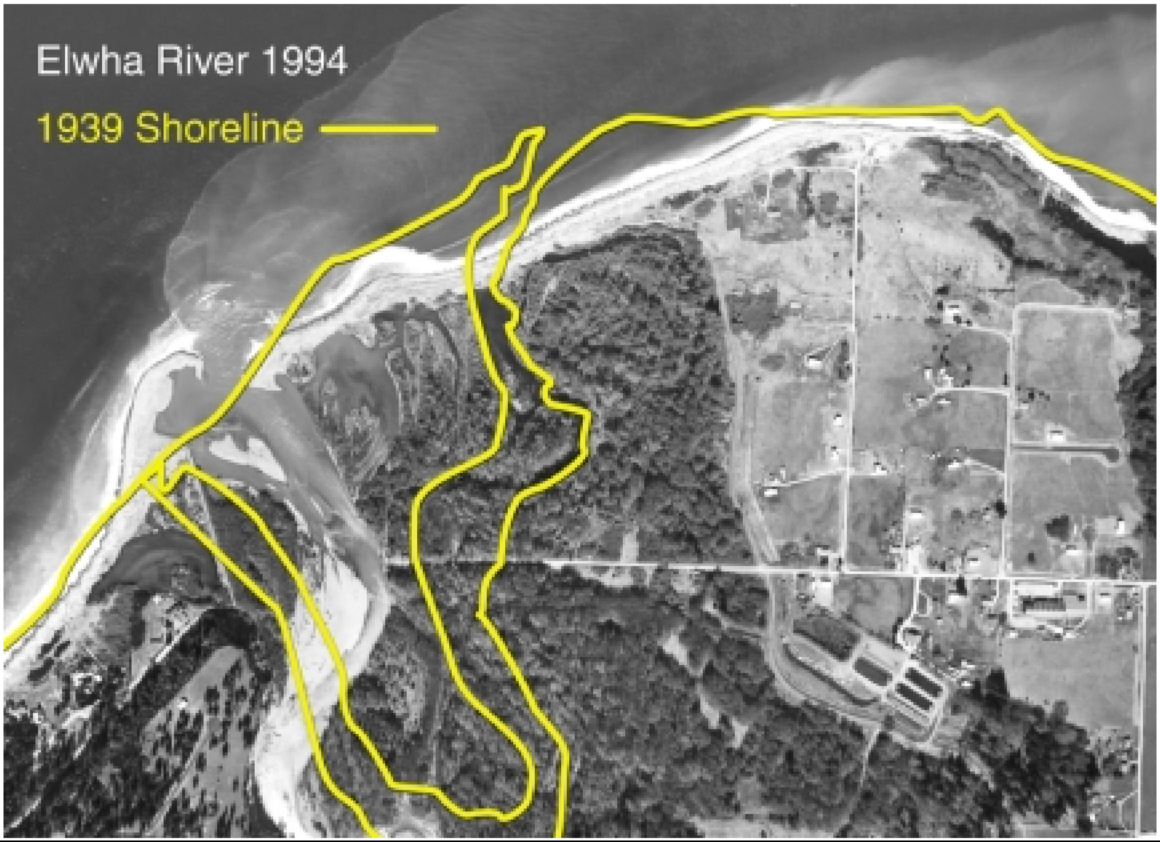
Current nutrient data indicate that the Elwha River and its tributaries are oligotrophic. USGS sampling in 1997 indicated that the concentrations of nitrogen and phosphorous were generally low, with most samples having concentrations below detection limits. They concluded that restoring salmon runs to the Elwha River system will affect the ecosystem profoundly. Decaying carcasses of migrating salmon will be the source of large quantities of nutrients to the Elwha River. The complex instream habitat of the mainstem will enhance cycling of these nutrients because carcasses will be retained long enough to be assimilated, thereby increasing primary and secondary production, size of immature salmonids, and overall higher salmon recruitment (Munn et al. 1998).

Estuarine Condition

Probably the greatest impact to the Elwha River estuary has been the cessation of recruitment of fluvially transported sediments. The dams have prevented millions of yards of sand and gravel from reaching the lower river. It is estimated that 274,000 cubic yards of material are prevented from reaching the estuarine and nearshore environments each year (ONP 1995). Like the channel itself, the estuary has degraded; at least 1200 ft. of shoreline has been eroded based upon measurements taken from aerial photographs. The change in shoreline configuration from 1939 to 1994 is shown in Figure 26.

The current beach morphology is steep, lined with large cobbles, with kelp beds offshore. This high energy environment is very different from its historic condition. Historic descriptions describe the Elwha beach as gently sloping, with sand and gravel deposits. Tribal members recollect gathering clams. Eelgrass beds were likely prevalent. The resulting loss of juvenile refugia, change in benthic communities, and reduction of food resources may cause salmonids (particularly chinook) to migrate to sea earlier, at smaller size, and in poorer condition than with healthy estuarine conditions. Estuarine/marine survival of Elwha hatchery chinook is among the lowest of any Puget Sound chinook stock (Scott et al. 1992).

Figure 26: Aerial View of the Elwha River Estuary (1994) with Overlay of Shoreline Configuration as it Existed in 1939 (photo courtesy of Randy Johnson)



Maps created by the War Department in the 1890's depict the mouth of the Elwha with three distinct distributaries. In 1891, there were three distributary channels at the mouth of the Elwha, by 1908 these had apparently evolved into two channels, and by 1926 there was one channel diverted to the east towards Angeles Point. By 1950, there were again two channels entering the Strait of Juan de Fuca (Hosey and Associates 1988, as references in Schwartz 1994). Today only a single mouth exists. The previous east channel is now a ponded slough, isolated behind the marine beach and inland of its former mouth. High tide floods the river mouth to a distance of approximately 1,200 feet inland from the beach, to just east of the bluff on the west bank of the lower river. During times when the tide backs up to this point, or river discharge is high, water flows into the slough linking it more directly to the main river channel (Pat Crain, communication, as referenced in Schwartz 1994).

The loss of channel diversity at the river mouth is not solely attributable to loss of sediment recruitment. A 500' flood control dike was constructed along the west side of the estuary in the

1960's to protect a small number of homes/cabins on Place Rd. This dike cut off the western-most distributary, and restricts the current mouth from moving to the west.

<u>Ranked Action Recommendations</u>

The TAG strongly agrees with the conclusions drawn by Department of Interior regarding restoration of the Elwha River. Scenarios for removing only the lower dam or staging removal of both dams are either likely to fail, seriously delay recovery of the Elwha Rivers salmon stocks, or result in loss of restoration gains resulting from the removal of the lower dam. Additionally the TAG finds that restoration of the Elwha is not confined to dam removal alone. Floodplain and channel conditions are currently severely altered, particularly in the floodplain downstream of Elwha Dam, and it is simplistic to believe that dam removal alone equates with ecosystem restoration in the Elwha River. The TAG believes that significant restoration actions could and should occur in the lower Elwha River prior to dam removal. These actions can help prepare the lower river for the dramatic changes expected following dam removal. Specifically, the highest priorities for the Elwha include:

- **Systematic restructuring of the lower and middle river with large wood**
- **Removal of selected dikes and other channel constrictions**
- **Riparian restoration**
- **Acquisition/conservation easement access and set back of structures constructed within the channel migration zone**

In the dam removal Environmental Impact Statement (EIS) process, the cost of interim gravel supplementation downstream of Elwha Dam was evaluated and found to be cost prohibitive (on the order of $300,000/year, not including a collection strategy from the deltas). In addition, the bulk of the sediment is located in Lake Mills, upstream of Glines Canyon Dam and within the Olympic National Park (Pat Crain.

MARINE HABITAT LIMITING FACTORS

Marine intertidal, nearshore, and sub-tidal areas provide critical habitat for salmonids, particularly for juvenile salmonid smolts as they migrate from freshwater to marine environments. Shallow nearshore areas are known to provide rearing habitat and shallow-water migration corridors that offer protection from predators. Subtidal areas also provide rearing support for salmonids, including production of benthic prey items. Marine intertidal, near-shore, and subtidal habitats have been significantly altered throughout WRIA 18.

Documented Use of Near-Shore Marine Areas by Juvenile Salmonids

Beach seine studies in Dungeness Bay in 1994 (Hiss 1994) documented the presence and use of nearshore habitat by juvenile salmonids. Seining was conducted from April1-June 3. Juvenile pink salmon migration began the first week of April, peaked in late April, and ended the third week of May (most cleared by late April). Juvenile chum began before the first week of April, continuing at low levels into the first week of June. Wild coho began before the first week of April, peaked in mid-May, continuing into the first week of June. There was a general transition movement of fish from the shallow inner bay to deeper waters in the outer bay.

Coho entered the intertidal zone when only a few pink salmon remained. Coho had a greater likelihood to encounter juvenile chum, but they had also largely completed migration into Dungeness Bay. Hatchery releases of coho in April of the prior year could have contributed to predation and loss of juvenile pink salmon. No chinook smolts were encountered, perhaps due to extremely small escapements in 1992 and 1993. Historically, hatchery procedures required coho smolt release during March and April to make pond space available. This was well in advance of migration timing for wild coho, occurring right on top of emergence and downstream migration of pink and chum fry (Johnson 1973, as referenced in Hiss 1994). Unnaturally high pink mortality may have followed (Lichatowich 1992, as referenced in Hiss 1994). Hatchery coho releases have been delayed to June since 1995, to minimize potential impacts to pink salmon.

No additional studies documenting juvenile salmonid use of marine nearshore and sub-tidal habitats were identified.

Shoreline Armoring

Nearshore areas provide support for salmonids in a number of ways:

1. migration corridors for juvenile salmon and protection from predators,
2. suitable substrate and detritus retention to produce the benthic food organisms on which many juvenile salmonids are dependent, and
3. primary production areas for baitfish species (primarily surf smelt and sand lance) which support salmonids at later life stages.

These areas are particularly important for chinook and chum, which have the greatest dependence of the salmon species on estuarine and near-shore habitats (Aitkin 1998).

The identified effects of shoreline armoring on finfish resources have not been specifically assessed, nevertheless, all indications are that shoreline armoring adversely effects ecosystem function and the fish resources that use these habitats. Schreffler et al. (1995) identified several case studies related to the physical effects for shoreline armoring, and identified the potential and observed effects of shoreline armoring. The following impacts have been identified as typically being associated with armoring of shorelines with bulkheads (Canning and Shipman 1995, Schreffler et al. 1995):

1. sediment supply to beaches is cut off, leading to starvation of the beaches of the sand and other fine-grained materials that typically make up a beach,
2. the hard face of the shoreline armoring, particularly concrete bulkheads, reflects energy back onto the beach, thus exacerbating beach erosion,
3. over time, sand and gravel beaches are transformed to large gravel and cobbles, possibly to bedrock or hard clay, exposing the footings of bulkheads and leading to undermining and failure,
4. embedded logs and vegetation which shades the upper beach are eliminated, thus degrading the value of the beach for baitfish spawning habitat,
5. transformation of the character of the beach affects the kinds of life the beach can support, and
6. the degradation of the beach results in loss of the shallow, nearshore migration corridors for salmonids that provide protection from predation.

Some of the observations in Schreffler et al. (1995) are the result of an interview with D. Pentilla (WDFW), who has extensive experience evaluating shorelines for baitfish spawning potential. He reported the following observed effects of shoreline armoring:

1. reduced sediment input from feeder bluffs to nearshore area,
2. permanent loss of habitat above +5 feet Mean Low-Low Water (MLLW) (Note: This represents the suitable habitat area for surf smelt and sand lance spawning),
3. loss of riparian vegetation that provides shade to the upper beach (Note: shade minimizes desiccation of baitfish eggs that are laid in high intertidal gravels and sands), and
4. change in substrate from finer to coarser-grained material.

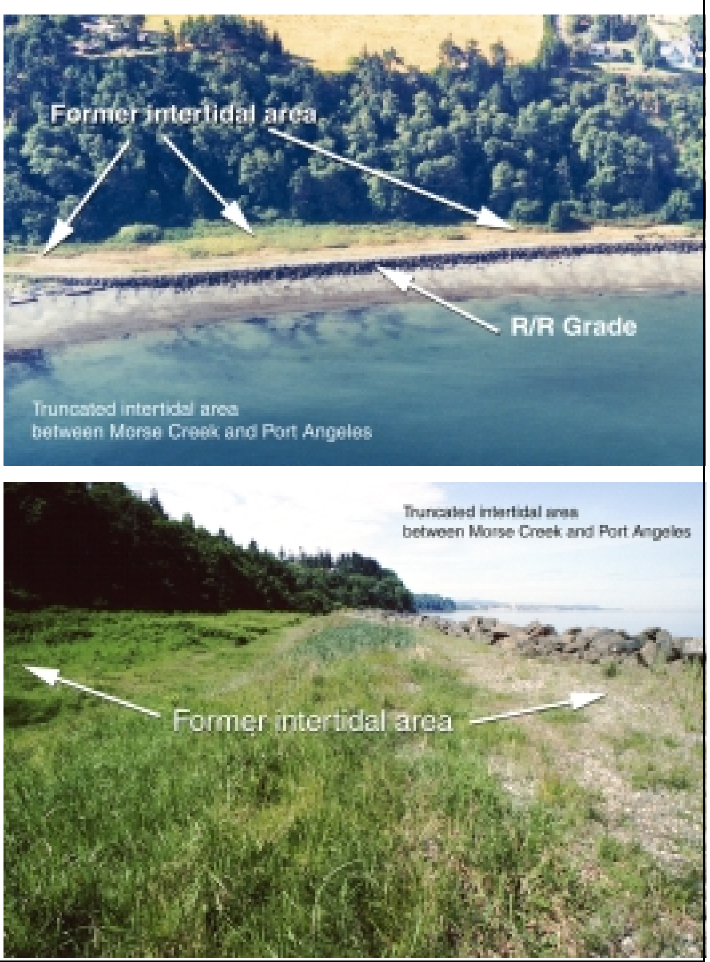
Baitfish, upon which chinook and coho salmon prey, are particularly susceptible to impacts of shoreline armoring. Because surf smelt (<u>Hypometus pretiosus pretiosus</u>) spawn high in the intertidal zone (from +7 ft mean low-low water (MLLW) to extreme high-high water (EHHW) in fine grained substrate, they are particularly susceptible to permanent habitat loss. Sand lance (<u>Ammodytes hexapterus</u>) form localized schools that are usually associated with clean sandy bottoms. They are susceptible to deleterious effects of shoreline armoring because of preference for spawning high in intertidal (+5 feet MLLW to mean high-high water (MHHW)), in substrates varying from sand to sandy gravel (Canning and Shipman 1995). Documented surf smelt and sand lance shoreline spawning areas in WRIA 18, and armored marine shorelines, are identified on Map 10 (WRIA 18 Marine Armoring , Degraded Estuaries and Documented Baitfish Spawning, in the separate Maps file included with this report).

As noted above, shoreline armoring is known to affect littoral drift. The increased energy from wave reflection off the vertical face of bulkheads results in degradation of the beach materials, and loss of ability of the beach to retain detritus. One of the major biological effects that results from disrupting littoral drift is the loss or reduction of nutrients and food sources needed to sustain juvenile salmonids. Because juvenile salmonids are actively feeding during their outmigration, they need prey of appropriate quantities at the right time. Thus, growth rates of juvenile salmonids may be negatively impacted if their natural food supply is reduced or cut off due to shoreline armoring, adversely affecting their survival (Canning and Shipman 1995).

Approximately 90% of the western WRIA 18 shoreline (Morse Creek to Elwha River) has been armored, significantly altering natural shorelines processes and functions. The most extensive shoreline armoring is from the mouth of Dry Creek to the mouth of Morse Creek, including most all of Port Angeles harbor (see Map 10 (WRIA 18 Marine Armoring, Degraded Estuaries, and Documented Baitfish Spawning), in the separate Maps file included with this report). The shoreline from the mouth of Morse Creek to the end of Ediz Hook was armored in the early part of the 20th century, associated with the installation of the railroad line and fill, and development of the Port Angeles waterfront. Much of this armoring was associated with fill encroachment well into the natural intertidal area and armoring of the fill on the marine side.

Figure 27 shows the armored shoreline west of Morse Creek in relation to the marine bluffs, which are the location of the historic natural shoreline. This area was likely a broad intertidal shoreline, possibly with extensive eelgrass beds, prior to construction of the rail line. There is little intertidal area remaining off the face of the rail line fill. In addition, the recruitment of sediment from the bluffs to feed natural shoreline processes has been eliminated. The rail line has since been abandoned and turned into a waterfront trail, however, the loss of intertidal habitat remains. The loss of the sand spit that formed the Morse Creek estuary may, in large part, be the result of loss of longshore drift from the marine bluffs to the west of Morse Creek. This is evident when comparing aerial photos of Bagley, Siebert, and McDonald creeks, all of which are similar sub-tidally, but Morse Creek lacks the berm of littoral sands that these other creeks receive from the adjacent bluffs (Joel Freudenthal).

Figure 27: Aerial and Ground Views of Historic Intertidal Area Lost as a Result of Railway Construction West of Morse Creek (photos courtesy of Randy Johnson)



Similarly, the shoreline from the mouth of Ennis Creek to the Daishowa mill was extensively modified as Port Angeles developed. Broad intertidal areas at the mouths of Peabody, Valley, and Tumwater creeks were filled and armored, forming the area on which much of downtown Port Angeles was built. The intertidal area was transformed to an abrupt deep armored shoreline capable of supporting marine shipping.

In 1930, an industrial waterline was buried along the toe of 3.3 miles of eroding sea cliff west of the root of Ediz Hook. A 2,400 –foot section of the pipeline was initially

Figure 28: Armoring of Industrial Waterline Below Shoreline Feeder Bluffs Between Angeles Point and Daishowa Mill (photo courtesy of Randy Johnson)

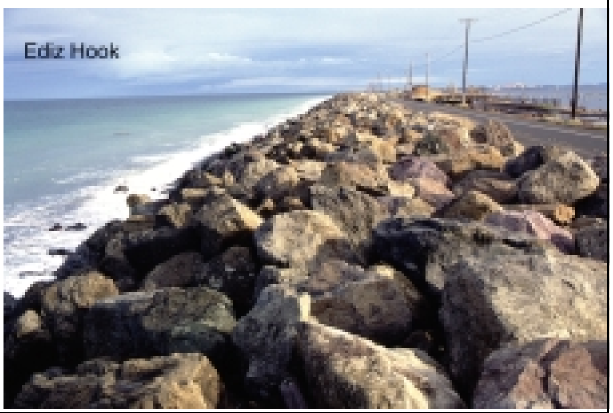
protected by construction of a wooden bulkhead. Between 1958 and 1961, protective works in the form of steel piling and rock riprap along 6,800 ft of the pipeline were completed (Figure 28). Because of the resulting reduced rate of sea-cliff retreat, the supply of littoral detritus contributed by sea-cliff erosion was reduced from 270,000 yd^3/yr in 1911, to 95,000 yd^3/yr in 1930, to 40,000yd^3/yr in 1961. This represented an 89% reduction from the estimated total available material prior to the construction of Elwha Dam and the pipeline (USCOE 1971, as referenced in Galster 1978). This shoreline armoring is thought by members of the TAG to be the greatest impact to the integrity of Ediz Hook. This armoring reduced the contribution of shoreline sediments in the shoreline drift cell that extends from the mouth of the Elwha to the end of Ediz Hook, and increased shoreline energy. Dick Goin remembers the outer side of Ediz Hook as a broad natural beach consisting of small gravel and sand, where one could walk and picnic. The loss of shoreline sediment from the armoring of the water line resulted in the loss of the beach on the outer side of Ediz Hook, putting the integrity of the hook at risk. Dick Goin recalls occasional natural breaching of Ediz hook in the 1930-1940s (prior to there being a Coast Guard station or other significant development on the outer hook), which would naturally repair itself.

During the 50-year period from 1911-1961, the distal bulb of Ediz Hook grew at decreasing rates a total of 352 ft, apportioned as follows:

1870-1917	4.2 ft/yr	39,000yd^3/yr
1917-1948	3.7 ft/yr	34,000 yd^3/yr
1948-1970	1.8 ft/yr	17,000 yd^3/yr

In addition to the 56% reduction in distal bulb growth, a corresponding steepening of beach profile and increase in erosion of littoral detritus from the foreshore west of the distal bulb on the strait side of the hook was experienced. On the basis of bathymetry changes between 1940 and 1970, engineers calculated that an estimated 82,000 yd^3/yr was eroded from the foreshore area west of the root of Ediz Hook, 26,000 yd^3/yr was eroded from the root and neck, and 39,000 yd^3/yr was accreted to the distal bulb. This provided clear evidence that the bulb was being extended at the expense of the western portion of the hook (USCOE 1971, as referenced in Galster 1978). By the mid-1930s, the loss of beach nourishment was manifest in damage to facilities on Ediz Hook. This resulted in a variety of efforts by the U.S. Coast Guard, City of Port Angeles, and Crown Zellerbach (previous owners of the Daishowa mill) between 1937 and 1970 to armor the outer hook to preserve its integrity. In 1977-78 the USCOE completed installation of armoring throughout the outer length of Ediz Hook (Figure 29) coupled with a test of beach nourishment.

Figure 29: View of USCOE armoring of outer Ediz Hook (looking east) (photo courtesy of Randy Johnson)



The loss of sediment transport from the Elwha River, in combination with the reduction of sediment contribution from shoreline bluffs has significantly affected shoreline sediment transport, and the configuration of nearshore areas. It is estimated that prior to construction of the two dams on the Elwha River, and protection of the base of the bluffs to the east, that 350,000 yd^3/yr of sediment was transported to Ediz Hook (50,000 yd^3/yr contributed by the Elwha River, 290,000 yd^3/yr (note slight difference from estimates in Galster, 1978 above) from the bluffs between the Elwha and Ediz Hook, and the rest from shorelines to the west of the Elwha mouth) (Schwartz 1994). Corps of Engineers (1971, 1976, as referenced in Schwartz 1994) wave analyses indicate a sediment transport capacity of 280, 000 yd^3/yr past the bluffs located to the east of the Elwha River delta, 270,000 yd^3/yr at the west end of Ediz Hook, and 379,000 yd^3/yr at the east end of Ediz Hook. However, sediment transport volumes to Ediz Hook in recent years are estimated to be 90,000 yd^3/yr from all sources to the west. Clearly, the capacity for sediment transport along this shoreline is far greater than the presently available supply, and is evidenced by tests in which tracer cobbles placed approximately in the middle of the outer hook showed movement from 0-25 ft/day, averaging 8.8 ft/day over a 2.5 yr period (Galster 1978).

The removal of the Elwha dams would have a positive effect on the nourishment of Ediz Hook, but would probably not eliminate the need for supplemental beach nourishment. Even the positive effects from removal of the industrial water line and its protective works from the beach west of the hook, allowing the bluffs to erode and further restore natural nourishment, would not eliminate the requirement for some artificial nourishment (Galster 1978).

The shoreline from Morse Creek to the 3 Crabs restaurant at the eastern side of the mouth of the Dungeness River is relatively unarmored. However, there are increasing proposals to armor the shoreline east of Morse Creek, and to dredge the mouth of Morse Creek. Much of the nearshore production potential of the west WRIA 18 shoreline has already been significantly altered due to shoreline armoring; effects of further armoring to habitat and shoreline processes should be carefully weighed prior to approval of any additional shoreline armoring.

From the 3 Crabs restaurant east to the mouth of Cooper Creek, approximately two thirds of the residential shoreline is armored, alternating between armored and unarmored lots or sections of shoreline. Interestingly, the armored shoreline just to the east of 3 Crabs restaurant is actually prograding, while the unarmored shoreline immediately to the west of 3 Crabs (mouth of Meadowbrook Creek) is actively eroding, likely the result of the armoring of the shoreline to the east. From the mouth of Cooper Creek to the mouth of Washington Harbor (near the mouth of Sequim Bay) the shoreline has little armoring. Bortelson et al (1980) concluded there was little change in the amount of intertidal estuary in Dungeness Bay, but Randy Johnson (Personal Communication) estimates that approximately 77% of the salt marsh that existed in 1855 from

Dungeness Bay to Graysmarsh has been lost. Like on Ediz Hook, Dick Goin recalls that the spit would periodically breech, with most naturally resealing.

An additional feature that undoubtedly impedes/impacts fish migration and longshore sediment transport is the Rayonier pier (at the old mill site just west of the mouth of Ennis Creek)(Ann Schaffer, Personal communication). The pier is currently in an advanced state of disrepair, and offers an excellent restoration opportunity, either by removal or reconfiguration.

Eutrophication and Loss of Intertidal/Nearshore Vegetated Habitat

Clark and Clark (1996) report that the original town of Dungeness was moved from inner to outer Dungeness Bay in 1857 because of concerns that the inner bay was filling with silt. This coincides with the diking of salt marsh habitat at the mouth of the Dungeness River, which was underway in 1855 (Bortleson et al 1980). The diking of estuarine marshes often causes the rapid accumulation of sediment within adjacent undiked parts of the estuary, as has been documented in England (Inglis and Kestner 1958), China (Schubel and Hirschberg 1982) and France (Avoine et al 1981). The lowermost part of the Dungeness River was likely channelized at roughly the same time period as the salt marsh diking activity. The channelization and diking of the lower reaches of creeks and rivers has been implicated in the catastrophically high rates of delta progradation on numerous Olympic Peninsula streams, including the Dungeness, Big Quilcene, and Little Quilcene Rivers and Jimmycomelately and Snow Creeks (unpublished WDFW data).

A key nearshore habitat concern is the loss of eelgrass (*Zostera marina*) habitat in the intertidal/shallow subtidal area. Eelgrass provides valuable habitat for a variety of marine species, including very productive rearing habitat for rearing juvenile salmonids, and spawning habitat for herring. It is likely that extensive eelgrass meadows have been eliminated with the filling of intertidal areas from Washington Harbor to Port Angeles harbor. In addition, the loss of natural shoreline sediment processes due to shoreline armoring, particularly from Morse Creek to Dry Creek, has likely resulted in a loss of potential eelgrass habitat. In addition, remaining eelgrass meadows appear to be at risk of eutrophication and elimination due to the increasing presence of ulvoid mats (*Ulva spp*.).

Ulva (spp) are an opportunistic green macroalgae that form dense mats which reduce light and oxygen, creating an anoxic environment (Hull 1987, Hernandez et al. 1997, as referenced in Shaffer and Burge in press). Ulvoid blooms, promoted by nutrient loading, appear to have a negative impact on nearshore invertebrate and fish communities, as well a other vegetated habitats such as eelgrass beds (Blankenship 1993; Carpenter et al. 1998; Hagerman et al. 1996; Inkpen and Embry 1998; Isaksson et al. 1994; Macfarlane 1988; Short et al. 1995; Sogard and Able 1991; Vitousek et al. 1997; Wilson 1995; Wright 1989; as referenced in Shaffer and Burge in press). Ulvoid mats may affect habitat conditions by changing the physical hydrography of the intertidal area. Physical changes may include a decrease in water flow, increased sedimentation, and a decrease in tidal flushing. Ulvoid mats may also prevent access to benthic prey organisms by creating a barrier over the substrate, and may result in mortality of benthic organisms and shellfish by smothering and creating low oxygen/anoxic conditions (Shaffer and Burge, in press).

Existence of extensive ulvoid mats have been identified in Dungeness Bay, along the Jamestown shoreline, and in and immediately outside the mouth of Washington Harbor. Wilson (1993) mapped and compared eelgrass presence in 1993 with presence in 1987. The most noticeable change was the overall 31 percent decline in eelgrass acreage from 1987 to 1993. While some of the decline was likely due to shoreline processes (sediment deposits from the Dungeness River and eroding marine bluffs, erosion and sediment transport in and out of Dungeness Bay by tidal action, shoreline alterations created by storm wave impact along the 3 Crabs to Graysmarsh shoreline), the presence of large areas covered by algae (584 acres of predominantly *Ulva spp*., some of which were formerly eelgrass beds of various densities) is also responsible for the observed results (Wilson 1993). An extensive increase in the presence of ulvoid mats is reported both inside and outside the mouth of Washington Harbor (Anne Shaffer). It is unknown to what extent these areas may have previously been eelgrass. In addition, another important contributing factor for the decline in eelgrass presence was the 11% narrowing of the intertidal shelf along the 3 Crabs to Graysmarsh shoreline from 1987 to 1993.

Washington Harbor, a broad intertidal estuary, is located at the mouth of Bell Creek (north of the mouth of Sequim Bay). The harbor likely provided intertidal estuarine habitat for salmonids originating from Bell Creek as well as neighboring streams. Intertidal water exchange to the north end of the harbor was significantly restricted by the construction of a 650-foot long fill causeway across the tidelands to support the Sequim Wastewater Treatment Plant outfall (Figure 30). This fill resulted in the direct loss of approximately 13,000 $ft.^2$ of intertidal area under the road fill, assuming an average fill base width of 20 ft. In addition, approximately 10-12 acres of intertidal estuary in the north end of the bay was adversely affected by reduction of tidal flux and hypersalinity, which has also developed as a result of reduced tidal interchange. Although tidal flow access was maintained through a couple of culverts through the causeway, it is conjectured that the location of the culverts in the middle of the causeway limits the ability of juvenile salmon to access and use the natural shoreline. No studies on either historic or current salmonid utilization of the northern end of the harbor are available. This area is identified as significant shorebird habitat. The area north of the causeway also historically supported a large eelgrass bed, which has since been eliminated by construction of the causeway (Joel Freudenthal). The north end of the estuary appears to be filling with sediment, as the opportunity for sediment transport from the north bay is severely limited by presence of the causeway.

Figure 30: Saltwater Flow Constriction to North end of Washington Harbor Resulting from Sequim Wastewater Treatment Plant Outfall Dike (photo courtesy of Randy Johnson)

Marine Sediment/Water Quality

Kelp forests and drift mats of kelp and other debris also provide benefits to salmonids and species on which they prey. There is currently no identified reduction of kelp habitats in WRA 18, and it is possible that kelp habitat has increased with the coarsening of nearshore substrate, resulting from the reduction in shoreline sediment transport. Kelp habitats are primarily at risk from dredging activities and toxic spills, and care should be taken to avoid adverse impacts from human-induced activities.

Port Angeles harbor is on the CWA 303(d) List of impaired water bodies, for dissolved oxygen and PCBs (note that PCBs were proposed for removal from the

303(d) list in 1998, but no action has yet been taken). Low dissolved oxygen levels were found consistently in Port Angeles harbor in the late summer and early fall (Barecca 1998). Wood waste deposits are a large contributor to the dissolved oxygen problem, with poor water circulation/ flushing and organic loading from surface runoff also contributing. Wood waste covers approximately 25% (500 acres, 400 of which are in the north and west portions of the harbor, in the active log booming grounds near the Daishowa facility) of the bottom of Port Angeles harbor, primarily in nearshore log booming areas. Dense mats of sulphate-reducing bacteria populating fine wood waste were noted at several sites in the harbor (SAIC 1999). In addition to affecting dissolved oxygen in the water column, these conditions also adversely affect the benthic macroinvertebrate community, upon which many marine organisms (including salmonids) feed. The benthic community was identified as healthy in the central harbor, but stressed or disturbed conditions were generally observed in the log booming grounds. Degraded benthic habitat was observed at 5 sampling stations in the western harbor (SAIC 1999).

Limited sediment sampling near the Daishowa outfall , outside of Port Angeles harbor, has shown zinc levels in excess of Sediment Quality Standards. Further sampling is planned as part of the NPDES permit (Barecca 1998).

Marine water sampling (Plews 1991, as referenced in PSCRBT 1991) indicated water quality to be very good.

Marine Mammals

Seal haulouts occur at the end of Dungeness Spit and at Graveyard Spit (maximum count 259 seals, Young 1989) in Dungeness Bay (PSCRBT 1991). No significant water quality contamination has been associated with these seal haulout areas. There are numerous observations of direct marine mammal predation on salmon caught in gill nets in Dungeness Bay. When WDF developed estimates of predation on net caught salmon in the early 1980s, Dungeness Bay was noted as having one of the highest identified predation rates in Puget Sound (25% of the setnet salmon harvest).

Oil and Toxic Spills

The marine shorelines and resources of WRIA 18 are at risk of significant adverse impacts from oil spills and other toxic spills in the marine environment. There are large marinas and docking facilities located within Port Angeles harbor, and fuel is transferred in Port Angeles harbor from barges to top of the fuel tanks of ocean-going freighters and tankers (fuel leitering). Port Angeles is also the pick up point where ships destined for Puget Sound and the Strait of Georgia pick up marine navigation pilots, requiring them to pass in close proximity to the end of Ediz Hook. All of these pose a significant risk of chronic (small volume) or catastrophic toxic spills. Catastrophic spills have the potential to eradicate the productivity of the marine environment for extended periods of time. This risk factor does not lend itself well to restoration activities; the only viable mechanism to address this concern is diligent prevention.

<u>Marine Habitat Action Recommendations</u>

The following salmonid habitat restoration actions are recommended for nearshore and subtidal marine areas within WRIA 18:

- **Restore shoreline sediment transport from the Elwha River and the feeder bluff between the Elwha River and the west end of Ediz Hook**
- **Restore the littoral drift from marine bluffs to the west of Morse Creek**
- **Minimize the growth of *Ulva (spp)* by eliminating point and non-point source nutrient delivery to shallow embayments with limited tidal flushing**
- **Evaluate the effects of shoreline armoring on shoreline sediment transport and nearshore sediment composition, and implement corrective actions, where appropriate**
- **Modify log-booming practices in Port Angeles harbor to eliminate the accumulation of wood debris on the bottom of the harbor, and restore subtidal substrate conditions that are affecting dissolved oxygen in the waters of the harbor and benthic production in areas affected by accumulations of wood waste**
- **Restore unrestricted tidal flow and flushing to the north end of Washington Harbor**
- **Remove or reconfigure the Rayonier pier to provide unrestricted nearshore salmonid migration and longshore sediment transport**

These marine habitat action recommendations are not ranked; all are considered important to support the anadromous salmonid resources of WRIA 18 and other major watersheds that use the nearshore areas.

ASSESSMENT OF HABITAT LIMITING FACTORS

The intent of HB 2496 and watershed restoration is to determine what stream restoration actions are appropriate to provide healthy, productive populations of salmon that will support sport, commercial, and tribal fisheries, and salmon for future generations. This goal requires a higher standard of habitat protection than what would be necessary to just ensure continued existence of the species. Although there remains some debate on specific habitat thresholds necessary for productive salmon habitat, there is broad consensus that salmon require:

- cool, clean, well-oxygenated water,
- instream flows that mimic the natural hydrology of the watershed, maintaining adequate flows during low flow periods and minimizing the frequency and magnitude of peak flows (stormwater),
- clean spawning gravels not clogged with fine sediment or toxic materials,
- presence of instream pools that will support juvenile rearing and resting areas for returning adults,
- abundance of instream large woody debris, particularly large key pieces, that provide cover, create pools, and provide habitat diversity,
- free, unobstructed migration for juveniles and adults to and from the stream of origin,
- broad, dense riparian stands of mature conifer that provides cover, shade, LWD recruitment, etc., and
- estuarine conditions that support production of prey organisms for juvenile outmigrants as well as for juvenile salmonid rearing and for returning adults.

A more detailed discussion of the role of healthy habitat is included in a previous chapter of this report.

Salmonid Habitat Concerns

The occurrence and severity of habitat limiting factors varies between watersheds within WRIA 18 and between reaches within individual watersheds. Combined, these limiting factors significantly reduce the salmonid production potential of the streams in WRIA 18. Initial significant impacts date back as much as a century ago, with the advent of agriculture and timber practices, and urban development in the Port Angeles area. The loss of anadromous salmon and steelhead access to the Elwha River dates back to the construction of Elwha Dam in 1910. Irrigation withdrawals from the Dungeness River commenced in 1896. However, perhaps the most extensive habitat alterations occurred post-World War II, with rapid development and the availability of heavy equipment. The availability of heavy equipment provided the capability to alter the configuration of the stream channels and floodplain, to reconfigure upland areas, and to build roads into previously marginally accessible steep-gradient headwater areas. The ability to build forest roads on steep slopes, and to remove the timber via trucks, resulted in rapid logging of the headwater areas for many of the WRIA 18 streams. Current habitat condition has even been compromised by past well-intended actions to restore habitat, such as removal of log jams to ensure fish passage, that are now known to have been very detrimental to habitat quality and diversity.

Road construction and logging in upper watershed forested areas have increased the rate of mass wasting and sedimentation to streams. Removal of timber and conversion of forestland to rural development, in the rain-on-snow zone in the upper portions of watersheds of WRIA 18, have significantly increased run-off during storm events. Agriculture and development in the lower watersheds have resulted in floodplain constriction and channelization, increased sedimentation of stream gravels, loss of LWD and instream pools, and elimination or significant reduction in the presence of functional riparian buffers. Water withdrawals for irrigation, domestic, and industrial use substantially reduce the availability of instream flow during adult salmon upstream migration and spawning, and result in spawning redds being constructed in channel areas that are extremely susceptible to sediment scour and deposition. The increase in impervious surface associated with various land uses increases the frequency and magnitude of stormwater runoff, and decreases the infiltration of precipitation to groundwater. All of these factors combine to compromise the productive capacity of stream habitat.

Productivity potential is further compromised by the severe decline in numbers of adult salmonids that have returned to these streams to spawn in recent years, whose carcasses provide the marine nutrient base that serves as the foundation of the food web for juvenile salmonids and other stream associated invertebrates, fish, and wildlife. Loss of adult salmonids and their spawning behavior also has an effect on the nature of channel substrate and channel shape. Large numbers of spawning salmonids modify riverine habitat in ways beneficial to future generations of salmonids; loss of these geomorphic functions which salmon perform results in further habitat degradation. Changes in salmonid abundance, and relative abundance between different species can change the fundamental predator/prey relationships which developed between salmonid populations over thousands of years. This loss of ecosystem function also causes reduced productivity of the ecosystems which salmonids inhabit.

Estuaries, which provide critical rearing and transition habitat for salmonids (as they move as juveniles from fresh to salt water, and as adults from the marine environment back to fresh water), have been physically altered at the mouth of many of the streams in WRIA 18, dramatically affecting the habitat and physical functions characteristic of natural estuaries. The habitat quality and physical processes of the nearshore marine environment, which support juvenile salmonid rearing and migration and production of food fish on which salmonids prey, has also been severely impacted throughout much of WRIA 18. Nearshore habitat has been significantly altered due to extensive armoring of the marine shoreline, alteration of the longshore littoral drift process (resulting from shoreline armoring and alteration of the sediment supply from streams), and loss of productive eelgrass habitats. Marine sub-tidal areas in Port Angeles harbor are adversely affected by accumulation of wood chips and wood debris resulting from a long history of log-rafting.

Habitat Condition Rating

As noted above, there is often significant variability in the status of specific habitat elements between different reaches of the stream. In the Habitat Limiting Factors by Sub-Basin chapter, reach-specific information is provided for streams, where available. Composite reach data and streamwide information and data are summarized in
Table 14 as representative habitat condition ratings (Good, Fair, and Poor) by stream, for each of the identified habitat elements in the previous chapter of this report. The Salmonid Habitat Condition Rating Standards used to develop these habitat condition ratings are included for reference in Appendix A. The ratings represent the composite habitat condition for a stream; some reaches of the stream may be better or worse.
Table 14 also provides information on the relative reliability of the source information (quantitative studies/published reports, personal experience of TAG members, or reports from TAG members not based on personal experience) on which the habitat condition ratings were

based. Action recommendations to address the identified habitat limiting factors for each stream are included in the Habitat Limiting Factors by Subbasin chapter.   However, the common thread between the action recommendations is restoration of natural stream stability through restoration of stream and floodplain ecological function (represented by "good" habitat ratings for each of the specific habitat elements). These functions are not only critical to restoring salmonid populations in these watersheds, but are also critical to the overall stream function and quality of life on the north Olympic Peninsula.

Table 14 also identifies those streams/habitat elements for which insufficient information was available to make a habitat condition assessment. These are noted in the table as Data Gaps (DG). The absence of a stream in the list does not necessarily imply that the stream is in good health. Some streams may not be listed because they have not been visited, or no information is available. Others may show more impacts because they are easily accessible and have been the focus of more extensive scientific observations and study.

Table 14 provides a quick visual reference to indicate the relative health and relative knowledge base of individual streams, in relation to salmonid habitat, and to provide a relative comparison of habitat condition within and between streams. The summary information in the table is useful as a general guide to habitat problem "hot spots" that warrant restoration consideration, or additional assessment data collection to guide habitat restoration. However, the Habitat Limiting Factors by Subbasin chapter should be consulted for specific stream information and action recommendations on which to base specific habitat restoration proposals. The potential benefit of proposed habitat restoration actions may be limited due to number of habitat problems in a stream, higher priority limiting factors that should be addressed first, sequencing of projects to ensure effectiveness, etc.

Habitat Restoration Potential

Despite the extensive impacts that have occurred to fresh and marine water habitats in WRIA 18, and the number of "fair" or "poor" habitat ratings that exist throughout the area, there are a number of reasons to be optimistic regarding the future of salmonid habitat in WRIA 18. The greatest habitat restoration potential in WRIA 18 is in the systems that were historically the largest producers of salmon: the Elwha River, the Dungeness River (including tributaries), to a lesser extent Morse Creek, and the nearshore marine habitat. However, habitat restoration in other independent streams should also be considered, as these streams contribute to the overall productivity of WRIA 18, and may also provide habitat utilized by the primary production streams. Habitat protection and restoration action recommendations for individual streams are identified in the Habitat Limiting Factors by Subbasin chapter of this report.

The potential for removal of the dam(s) on the Elwha River continues to slowly progress towards becoming reality. Dam removal and associated habitat restoration would open extensive amounts of high quality habitat and help restore what was historically a very productive system, providing perhaps the greatest restoration potential on the Olympic Peninsula, and possibly in the entire Northwest. In the interim, it is critical to preserve and restore salmon habitat downstream of the dams to ensure that Elwha salmonid stocks remain for upriver restoration.

Significant habitat improvement progress has also been made in the Dungeness River and tributaries. Agreements with the Dungeness Water Users Association have improved instream flows in the mainstem Dungeness, particularly during low flows in late summer and fall.

However, flows may still be below recommended instream flows. Numerous habitat restoration projects have been conducted in the mainstem Dungeness and tributaries, improving salmonid habitat conditions. Continued work is needed to address other watershed segments or habitat problems that remain, to ensure that the benefits of restoration activities can be fully realized. Assessment work is currently underway to evaluate the potential of restoring floodplain function in the severely constricted lower Dungeness River (downstream of Ward Bridge). Restoration of this area would be particularly beneficial to chinook, pink, and early chum stocks.

Morse Creek was historically also a producer of large numbers of salmonids, particularly in relation to its size.   Restoration of floodplain and estuarine function are critical to restoring the productivity of Morse Creek. The watershed has significant restoration potential, but it will likely be necessary to acquire land or obtain conservation easements in the historic floodplain to facilitate restoration actions necessary to restore habitat function.

Restoration projects in other streams in WRIA 18 should be considered in relation to the production potential of the stream and the anticipated benefits of the restoration project. Several of the streams have areas where habitat is currently in relatively good condition, and these areas should be protected. Other habitats, such as Graysmarsh on Gierin Creek, and Washington Harbor, have potential to provide excellent habitat and warrant special consideration. Unfortunately, the habitat in some streams (particularly those in the urban Port Angeles area) has been severely impacted, limiting the potential benefits of restoration.

Table 14: Assessment of Habitat Limiting Factor Severity for Major Salmonid-Bearing Watersheds within WRIA 18

				Channel Conditions				Water Quality			Hydrology			
Stream	**WRIA Index**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Condition**	**Temp/ DO***	**Fecal ***	**Toxics ***	**Peak Flow**	**Low Flow**	**Estuarine**	**Lack of Nutrients**
Bell Creek	18.0001	**DG**	**NA**	**P2**	**P2**	**P2**	**P2**	**P1**	**P1**	**DG**	**F2**	**P2**	**F2**	**DG**
Gierin Creek	18.0004	**G2**	**G2**	**P2**	**P2**	**P2**	**G2**	**G1**	**DG**	**DG**	**G2**	**G2**	**F2**	**DG**
Cassalery Creek	18.0015	**P1**	**G2**	**P1**	**P1**	**F2**	**P1**	**F-G1**	**P1**	**DG**	**G2**	**G2**	**P2**	**DG**
Cooper Creek	18.0017	**P2**	**G2**	**P2**	**P2**	**P2**	**P2**	**P-G1**	**F1**	**DG**	**G2**	**G2**	**P2**	**DG**
Dungeness River	18.0018	**F2**	**P1**	**P1**	**P1**	**P1**	**P-F1**	**P1**	**G2**	**DG**	**P2**	**P1**	**P2**	**DG**
Meadowbrook Cr.	18.0020	**G2**	**G2**	**P2**	**P2**	**P2**	**P2**	**P1**	**P1**	**DG**	**G2**	**G2**	**NA**	**DG**
Matriotti Creek	18.0021	**F2**	**G2**	**P2**	**P2**	**P2**	**P1**	**P1**	**P1**	**DG**	**G2**	**G2**	**NA**	**DG**
Hurd Creek	18.0028	**F2**	**G2**	**P2**	**F2**	**F-G2**	**F2**	**P2**	**?**	**DG**	**NA**	**NA**	**NA**	**DG**
Bear Creek	18.0030	**F2**	**P2**	**P2**	**P2**	**F2**	**F2**	**G2**	**DG**	**DG**	**P2**	**P2**	**NA**	**DG**
Canyon Creek	18.0038	**P2**	**P2**	**P-F2**	**P-G2**	**P-G2**	**P-G2**	**G2**	**DG**	**DG**	**DG**	**DG**	**NA**	**DG**
Gray Wolf River	18.0048	**G2**	**G2**	**F2**	**F2**	**G2**	**G2**	**G2**	**G2**	**DG**	**G2**	**G2**	**NA**	**DG**
Gold Creek	18.0121	**P2**	**P2**	**F2**	**P2**	**P2**	**P2**	**DG**	**DG**	**DG**	**P2**	**NA**	**NA**	**DG**
McDonald Creek	18.0160	**G2**	**F2**	**P1**	**P-F1**	**P1**	**F2**	**P-F1**	**F1**	**DG**	**F2**	**NA**	**G2**	**DG**
Siebert Creek	18.0173	**G2**	**G2**	**P1**	**P1**	**P1**	**G2**	**F1**	**G1**	**DG**	**P2**	**G2**	**G2**	**DG**
Bagley Creek	18.0183	**P1**	**F2**	**F2**	**P2**	**P2**	**F2**	**G2**	**P1**	**DG**	**P2**	**NA**	**G2**	**DG**
Morse Creek	18.0185	**G2**	**P2**	**P2**	**P1**	**P1**	**F2**	**DG**	**DG**	**P2**	**P2**	**G2**	**P2**	**DG**
Lees Creek	18.0232	**P2**	**G2**	**P2**	**P2**	**P2**	**P2**	**G1**	**G1**	**F3**	**F2**	**NA**	**F2**	**DG**
Ennis Creek	18.0234	**F1**	**P2**	**P2**	**P-G2**	**F2**	**G2**	**DG**	**DG**	**P2**	**G2**	**G2**	**P2**	**DG**
Peabody Creek	18.0245	**P1**	**P2**	**P2**	**P2**	**P2**	**P2**	**DG**	**DG**	**P3**	**P2**	**F2**	**P2**	**DG**
Valley Creek	18.0249	**P3**	**P3**	**P3**	**P3**	**P3**	**P3**	**G3**	**F3**	**DG**	**P1**	**F2**	**P2**	**DG**
Tumwater Creek	18.0256	**F2**	**P2**	**P2**	**P2**	**P2**	**F2**	**DG**	**DG**	**DG**	**P2**	**DG**	**P2**	**DG**
Dry Creek	18.0265	**G2**	**F2**	**P2**	**P2**	**P2**	**F2**	**P1**	**DG**	**DG**	**P2**	**P2**	**F2**	**DG**
Elwha River	18.0272	**P1**	**F2**	**P2**	**F2**	**P1**	**G2**	**P1**	**DG**	**G2**	**G2**	**G2**	**F2**	**P1**
Bosco Creek		**G2**	**F2**	**G2**	**G2**	**F2**	**F2**	**G2**	**DG**	**DG**	**DG**	**F2**	**NA**	**DG**

* Clallam County may have water quality data that has not been incorporated in this document

Habitat Condition Ratings
G = Average habitat condition considered to be good for the listed watershed

F = Average habitat condition considered to be fair for the listed watershed
P = Average habitat condition considered to be poor for the listed watershed
DG = Data Gap

Basis for Designated Habitat Condition Rating
1= Quantitative studies or published reports documenting habitat limiting factor.
2= Personal experience of TAG members.
3= Reports by TAG members not based on personal experience.

HABITAT IN NEED OF PROTECTION

Previous chapters in this report identify salmonid habitat throughout WRIA 18 that has been adversely impacted by the broad suite of land uses that exist in the WRIA, and which would benefit from habitat restoration projects. However, there are a number of habitat areas that remain in relatively good condition, where existing habitat functions should be protected. These areas serve as the foundation upon which habitat restoration and salmonid recovery efforts are most effectively built. Protection of functional salmonid habitat is typically always more cost and functionally effective than restoration of degraded habitat. Habitat protection can be provided through acquisition, conservation easement, or specific protection under critical area ordinances or other regulatory processes administered by local land use managers.

It is not practicable to prioritize areas recommended for acquisition or conservation easement, as opportunities often only arise as willing sellers surface, and there is typically a very limited timeframe in which to respond. The following stream reaches and/or protection strategies are identified as important to ensure continued function of high quality salmonid habitat, or areas that are critical to restoration of natural floodplain function:

Washington Harbor (mouth of Bell Creek)

This marine estuary has long been recognized as providing very high quality fish and wildlife habitat. The Interagency Committee for Outdoor Recreation (IAC) has committed $3.2 million towards acquisition of property in and immediately adjacent to Washington Harbor. Unfortunately, there has been a lack of willing sellers. Funds should be retained to utilize for any acquisition or conservation easement opportunities that may arise.

Gierin Creek

Seek acquisition or conservation easement to maintain the integrity of Graysmarsh, which provides current function as important salmonid rearing area, and to maintain the potential to restore the area to tidal saltmarsh.

Meadowbrook Creek

Provide protection for wetlands in lower Meadowbrook Creek. This habitat is currently impaired by livestock operations, but current impacts are correctable. The main concern is to prevent further encroachment on this saltmarsh/estuarine habitat by development or more intensive agriculture.

Dungeness River

Seek acquisition or conservation easement on Severson property, from Highway 101 to approximately 800 feet downstream of the Railroad Bridge. The property is located on the mainstem Dungeness River, has excellent mature coniferous riparian vegetation, and existing side-channel habitat.

Seek acquisition or conservation easement of the land on the east bank of the Dungeness River from the Railroad Bridge upstream for approximately 2000 feet. This area has a intact riparian forest and existing side-channel habitat.

Seek acquisition or conservation easement of any forested riparian/side-channel habitat from Woodcock Road (Ward Bridge) upstream to Dungeness Meadows dike, or any land that is necessary to maintain the integrity of the historic floodplain/meander zone.

Beebe Creek

Seek acquisition or conservation easement of Beebe Creek, although the entirety of this creek is artificially constructed. It currently provides very highly productive habitat for chum salmon and other salmonids, and represents very stable habitat in the lower portion of the Dungeness Valley, where mainstem and tributary habitat have been adversely impacted.

Gray Wolf River

Maintain integrity of existing riparian vegetation within the Gray Wolf Canyon, to Three Forks.

Morse Creek

Ensure that the integrity of the watershed upstream of Four Seasons Park is maintained. Much of the upper watershed is on unstable slopes, that are at high risk of slope failure from logging or development in this area.

Seek acquisition or conservation easement on the George Raines (current owner) property. Although the channel of Morse Creek has been modified through this reach (RM 1.2-1.7), the lack of development encroachment and the presence of mature forest on this property provides perhaps the best opportunity to restore historic channel configuration and increase channel meander.

Ennis Creek

Maintain integrity of the riparian zone through the canyon area, from the mouth upstream to the upper extent of anadromy, providing a riparian connection up to Olympic National Park.

Elwha River

Seek acquisition or conservation easement protection of all historic floodplain and adjacent riparian areas downstream of the Olympic National Park boundary. Although the floodplain through this zone is currently altered by the effects of the dams, it is very important to ensure that the historic floodplain remains available for channel adjustments associated with dam removal.

DATA GAPS

WRIA 18 has two of the most studied streams in Washington. An extensive library of documents exists relating to fish and water resources in the Dungeness River watershed, much of it associated with the Dungeness/Quilcene pilot project to address the allocation and use of water resources and the long-standing partnership efforts to restore flows and salmonid habitat in the Dungeness River. Extensive environmental review has been conducted on the Elwha River, associated with the pending removal of the Elwha and Glines Canyon dams. There are also considerable data on longshore sediment transport to the east of the Elwha River. However, despite the work that has been done in these areas, there are a number of streams or habitat elements for which insufficient data are available on which to analyze habitat limiting factors.

Data Gaps by Habitat Element

Fish Access

An inventory of fish passage barriers on state highways has been completed for WRIA 18. However, there is no existing comprehensive inventory of barriers on county or private roads. A comprehensive inventory is needed to ensure that fish passage barrier projects are prioritized correctly, and that the benefits of funded habitat restoration projects are realized. The comprehensive inventory should include an evaluation of adult and juvenile passage potential at each potential barrier, as well as an assessment of available spawning and rearing habitat upstream of the site.

Floodplain Modifications

Although channel constrictions and diking are common on many of the WRIA 18 streams, information is quite limited on the extent to which these constrictions have impaired floodplain function. Most floodplain constrictions were designed to convey flows up to a given flood stage, but the effects to side-channel connectivity, sediment transport, flow velocity, substrate stability, riparian integrity, etc. are not well studied or documented. Studies identifying the cause-effect linkage of floodplain constrictions on salmonid habitat would improve the knowledge base used to address current problems and avoid similar problems in the future.

Channel Conditions

Many of the streams in WRIA 18 are identified as being deficient in LWD or pool frequency, particularly in relation to historic condition. There is limited quantitative data to determine the extent of deficiency in relation to target conditions. Collection of quantitative data would be beneficial in determining appropriate extent of restoration actions, and in providing a baseline for future comparison.

Substrate

The TAG provided a qualitative assessment of substrate condition for most streams in WRIA 18, but there was little quantitative data on which to base substrate recommendations. Of particular concern is the lack of any quantitative information on the relative percentage of fines (particles <0.85 mm) that are present in the gravels; fines exceeding 11% are known to adversely affect salmonid egg incubation in the gravels. Without substrate quantitative baseline data, it is possible that we may not be recognizing cases where substrate condition is a salmonid habitat limiting factor. A structured substrate sampling program over time would provide improved baseline data on which to make decisions and a reference base for evaluation of habitat restoration benefits.

The Dungeness River Restoration Workgroup (1997) indicates that a study is needed to identify sediment sources in the upper Dungeness River (upstream of RM 10.8), and to determine how to return sedimentation rates to natural levels. Orsborn and Ralph (1994) indicate that sedimentation effects in the upper Dungeness range from little effect from slope failures (Koehler 1988) to 200% above background due to land use activities (R. Stephens). Further work is needed to better resolve outstanding scientific differences.

Riparian

Riparian condition was identified as a habitat limiting factor for many streams in WRIA 18. However, no quantitative sampling data were available to identify specific locations needing riparian restoration. As a result, riparian recommendations are quite general. Participants in the TAG recommended that an evaluation of riparian condition be done, using remote sensing and aerial photography. This would provide improved baseline data on which to make decisions and a reference base for evaluation of habitat restoration benefits.

Water Quality

The availability of water quality data for most streams is limited. The Streamkeepers program is collecting data on certain water quality parameters, but the sampling is confined to only a subset of streams and it is unclear whether the sampling frequency is sufficient to sense acute water temperature concerns during late summer-early fall. Clallam County may have additional data that was not considered in this report.

Water quality concerns were identified as a habitat concern in several of the drainages in WRIA 18, although specific sampling data was unavailable to determine to what extent these concerns are warranted. The portion of Bell Creek downstream of the Sunland Wastewater Treatment Plant was noted as having limited aquatic life in comparison to other sections of the stream. Additional monitoring would be beneficial in determining the presence and extent of any problems. The streams from Morse Creek west to Ennis Creek are identified as potentially being adversely impacted by groundwater and runoff from an old County landfill and landfills operated by Rayonier and Daishowa. Runoff from Highway 101 and other roads was identified as a concern for several streams, particularly those in the urban Port Angeles area (Morse Creek to Dry Creek). Potential dissolved oxygen concerns were identified in the lower Dungeness River and Ennis Creek. All of these concerns would benefit from collection of additional data.

Marine nutrients, provided by salmon carcasses, have been documented as providing the nutrient base for the aquatic food web, as well as contributing significantly to the nutrient base for the riparian zone and resources that use the riparian area. The returning salmon and steelhead run sizes are much lower than historic levels for most of the streams in WRIA 18, with several stocks extirpated. Little is known regarding current marine nutrient levels in comparison to historic levels and the implications to stream productivity resulting from the loss of marine nutrients.

Water Quantity

Instream flows have been recommended for many of the streams in WRIA 18, but here are concerns of some TAG participants that the “toe width” model, on which the recommendations are based, may not be representative of conditions in Olympic Peninsula streams. This is of particular concern for those streams in the rainshadow of the Olympic Mountains. The toe width and IFIM models should continue to be refined to ensure that they provide flow data that is appropriate for the streams in WRIA 18.

The salmonid habitat in most all of the streams in WRIA 18 is noted as being adversely affected by the increased frequency and magnitude of peak flows due to stormwater runoff. This runoff results from increased rate and volume of runoff from impervious surfaces, increased rain-on-snow runoff from areas converted to non-forest, and the channeling of runoff that alters natural infiltration and runoff patterns. This impact is not likely to benefit substantially from further data collection; rather, the local governments should complete actions necessary to implement effective stormwater protection ordinances.

Estuarine

There is no question that the estuaries of many of the streams in WRIA 18 have been severely altered. Little is known, however, regarding the key role that these estuarine areas play in salmon production.

Nearshore/Marine

Much of the marine shoreline of WRIA 18 has been altered. Further study would be beneficial to identify the likely effects of removal of shoreline armoring (particularly to the west of Morse Creek and from the base of Ediz Hook to the Elwha River).

Eelgrass and kelp habitats have been documented as very important to salmonids. Eelgrass habitat is being replaced by Ulva (spp), which appears to provide little salmonid habitat benefit. Wilson (1993) and several TAG participants recommend a comprehensive regular assessment of eelgrass and Ulva presence (Wilson 1993 recommends every 3 years), particularly in Dungeness Bay to Washington Harbor where increasing Ulva presence is documented. This study should look not only at the conversion area, but also the local conditions that appear to favor conversion to Ulva.

Other

The extent of rearing habitat in the Dungeness River and associated side channels is not well understood. Additional study would be beneficial to determine the extent of rearing use, and the presence of additional rearing areas that are disassociated from the river due to current habitat conditions. In addition, further work is needed to identify the salmonid use (beneficial or detrimental) of the irrigation return flow channels.

LITERATURE CITED

Amerman, K. and J. Orsborn. 1987. An analysis of streamflow on streams on the Olympic Peninsula in Washington State.

Avoine, J., G.P. Allen, M. Nichols, J.C. Salomon, and C. Larsonneur. 1981. Suspended-sediment transport in the Seine Estuary, France: effect of man-made modifications on estuary-shelf sedimentology. Mar. Geol. 40: 119-137.

Barreca, J.. June, 1998. Needs assessment for the eastern Olympic water quality management area. Washington State Department of Ecology, Water Quality Program, WQ-98-20.

Beamer, E.M. and R.G. LaRock. 1998. Fish use and water quality associated with a levee crossing the tidally influenced portion of Browns Slough, Skagit River Estuary, Washington. Prepared for Skagit County Diking District No. 22.

Beecher, H. and B. Caldwell. 1997. Proposed instream flows for Dungeness tributaries**.**

Bishop, S. and A. Morgan. 1996. Critical habitat issues by basin for natural chinook stocks in the coastal and Puget Sound areas of Washington. Northwest Indian Fisheries Commission.

Bortleson, G.C., M.J. Chrzastowski, and A.K. Helgerson. 1980. Historical changes of shoreline and wetland at eleven major deltas in the Puget Sound region, Washington. USGS Hydrologic Investigations Atlas HA-617.

Burgner, R. L., J.T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distributions and origins of steelhead trout (*Oncorhynchus mykiss*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 51, 92 p.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F. W. Waknitz, and I.V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261 p.

Cederholm, C.J. and W.J. Scarlett. 1981. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-1981, p. 98-110. In: E.L. Brannon and W.O. Salo (eds.). Proceedings of the Salmon and Trout Migratory Behavior Symposium. School of Fisheries, University of Washington, Seattle, WA.

Chapman, D.W. 1965. Net production of juvenile coho salmon in three Oregon streams. Trans. Am. Fish. Soc. 94:40-52.

Clark, V., L. Newborn, and W. Clark. June, 1995. A manual of tools for understanding the natural history of the Dungeness River watershed.

Clark, W. and V. Clark. January, 1996. Keys to an understanding of the natural history of the Dungeness River system. Prepared for the Jamestown S'Klallam Tribe, Blyn, WA.

Congleton, J.L., S.K. Davis, and S.R. Foley. 1981. Distribution, abundance and outmigration timing of chum and chinook salmon fry in the Skagit salt marsh. Pages 153 to 163 *in* E.L. Brannon and E.O. Salo, editors. Salmon and Trout Migratory Behavior Symposium. School of Fisheries, Univ. of Washington, Seattle, WA.

Corps of Engineers, U.S. 1960. File data in Seattle office showing Dungeness River channel cross-section profiles.

DeLorm, L. 1999. Bell Creek wetland/watershed protection project. Prepared for Jamestown S'Klallam Tribe, Blyn, WA.

Department of Ecology and Members of the Dungeness River Water Users Association. Memorandum of Understanding to transfer Water Under Trust Water Rights Program, Chapter 90.42 RCW, Between the State of Washington Department of Ecology and Members of the Dungeness River Water Users Association.

Department of Fisheries. 1971. Elwha River Fisheries Studies.

Department of Interior, Department of Commerce, Lower Elwha S'Klallam Tribe. 1994. The Elwha Report – Restoration of the Elwha River ecosystem and native anadromous fisheries. A Report Submitted Pursuant to Public Law 102-495.

Department of Interior. 1997. Elwha River ecosystem and fisheries restoration project. Elwha Technical Series PN-95-8.

Dungeness Area Watershed Analysis Cooperative Team. 1995. Dungeness Area watershed analysis, including Gray Wolf River and MacDonald, Siebert and Johnson creeks. Prepared or USDA Forrest Service, Olympic National Forest.

Dungeness- Quilcene Water Resources Management Plan, Chapter 6: East Clallam County – Dungeness Watershed Recommendations.

Dungeness River Restoration Work Group. July, 1997. Recommended restoration projects for the Dungeness River. Prepared for Dungeness River Management Team.

Eckert, P. 1998. The social construction of a watershed – changing rights and changing land. University of Washington Doctoral Dissertation.

Economic and Engineering Services, Inc.. 1996. City of Port Angeles Stormwater Management Plan, Technical App. Vol. III, Stream and Fish Habitat Survey. City of Port Angeles Public Works.

Environmental Protection Agency (EPA). 1999. Expanded Site Inventory – Rayonier Pulp Mill, Port Angeles.

Galster, R.W.. 1978. Ediz Hook--A case history of coastal erosion and mitigation. Washington Division of Geology and Earth Resources, Bulletin 78.

Hartman, G. F. 1965. The role of behaviour in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 22:1035-1081.

Healy, M.C. 1980A. The ecology of juvenile salmon in Georgia Strait, British Columbia. Pages 203 to 229 *in* W. McNeil and D. Himsworth, editors. Salmonid Ecosystems of the North Pacific. Oregon State University Press.

Healy. M.C. 1980B. Utilization of the Nanaimo River estuary by juvenile chinook salmon, Oncorhynchus tshawytscha. Fish. Bull. 77: 653-668.

Hirschi, R. Personal communication with Randy Johnson, 1999. Habitat biologist, Hadlock, WA.

Hiss, J.M.. Recommended instream flows for the lower Dungeness River, Prepared for Dungeness-Quilcene Regional Planning Group. USFWS, Western Washington Fishery Resource Office, Olympia.

Hiss, J.M. and J. Lichatowich. Sept. 25, 1990. Executive sSummary of Dungeness River IFIM Study for the Dungeness River Management Team.

Hiss, J.M.. Sept. 3, 1991. Instream Flow Recommendations for the Dungeness-Quilcene area salmon and steelhead streams. Prepared for Dungeness-Quilcene Regional Planning Group. USFWS, Western Washington Fishery Resource Office, Olympia.

Hiss, J.M. 1993. Instream Flow Recommendations for the Dungeness-Quilcene area salmon and steelhead streams. USFWS Western Fishery Resource Office, Olympia, WA.

Hiss, J.M.. Nov. 18, 1994. Migration of juvenile pink salmon (Oncorhyncus gorbuscha) through Dungeness Bay, Clallam County Washington. Prepared for the National Park Service, Olympic National Park, Port Angeles, Washington, USFWS, Western Washington Fishery Resource Office, Olympia.

Hiss, J.. 1994. Elwha River chum salmon surveys. USFWS, Western Washington Fisheries Research Office, Olympia, WA.

Hiss, J.M.. June, 1995. Environmental factors influencing spawning escapement of Dungeness River pink salmon (O. gorbuscha) 1959-1993.Prepared for the National Park Service, Olympic National Park, Port Angeles, WA.

Hiss, J.. 1995. Elwha River chum salmon spawner survey and escapement estimate. USFWS, Western Washington Fisheries Research Office, Olympia, WA.

Hoar, W.S. 1958. The evolution of migratory behaviour among juvenile salmon of the genus Oncorhynchus. J. Fish. Res. Board. Can. 15:391-428.

Hunter, J.G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16:835-886

Inglis, C.C. and F.J. Kestner. 1958. Changes in the Wash as affected by training walls and reclamation works. Proc. Instn. Civil Engrs 11: 435-466.

Ivankov, V.N. and V.L. Andreyev. 1971. The South Kuril chum (Oncorhynchus keta) ecology, population structure and the modeling of the population. J. Ichthyol. 11:511-524.

Jamestown S'Klallam Tribe. 1992. Dungeness River Water Resources Status and Issues. Submitted to the Dungeness-Quilcene Regional Planning Group by the Jamestown S'Klallam Tribe, August 25, 1992.

Jeldness, M.. The Sequim-Dungeness Valley Agricultural Water Users Association 1998 Flow Report.

Johnson, P. 1994. DRAFT – Historical Assessment of Elwha River Fisheries. Olympic National Park.

Johnson, Randy. Personal Communication. Washington Department of Fish and Wildlife. Port Angeles, WA.

Larkin, P.A. 1977. Pacific Salmon, p. 156-186. In: J.A. Gulland (ed.). Fish population dynamics. J. Wiley & Sons, New York, NY.

Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River Estuary. Tech. Rep. 25, Westwater Research Centre, Univ. of British Columbia.

Levy, D.A. and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River Estuary. Can. J. Fish. Aquat. Sci 39: 270-276.

Lichatowich, J. Undated. Oral History of Dungeness River, Part 1 – Interview with Dick Goin.

Lichatowich, J.. August, 1992. Dungeness River Pink and Chinook Salmon Historical Abundance, Current Status, and Restoration. Prepared for the Jamestown S'Klallam Tribe, Blyn, WA.

Lichatowich, J. 1993. The status of anadromous fish stocks in the streams of Eastern Jefferson County, Washington. Final Report prepared for the Dungeness-Quilcene Pilot Project, Jamestown S'Klallam Tribe, Sequim, WA.

MacDonald, J.S., I.K. Birtwell, and G.M. Kruzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell River estuary. Can. J. Fish. Aquat. Sci. 44: 1233-1246.

Marshall, A.R., C. Smith, R. Brix, W. Dammers, J. Hymer, L. Lavoy. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. In: Genetic Diversity Units and Major Ancestral Lineages of Salmonid Fishes in Washington. Wash. Dept. Fish and Wildlife. Technical Report Number RAD 95-02.

Mason, J.C. 1974. Behavioral ecology of chum salmon fry (Oncorhynchus keta) in a small estuary. J. Fish. Res. Board Can. 31: 83-92.

McHenry, Mike. Personal Communication. Lower Elwha Klallam Tribe. Port Angeles, WA.

McHenry, M. and L. Odenweller. 1998. Restoration of and Urbanized Watershed in the City of Port Angeles: Recommendations for Improved Salmonid Habitat in Valley Creek, Washington. Lower Elwha Klallam Tribe, Port Angeles, WA.

Meehan, W.R., F.J. Swanson, and J.R. Sedell. 1977. Influences of riparian vegetation on aquatic ecosystems with particular reference to salmonid fishes and their food supply. P. 137-145. In: R.R. Johnson and D. A. Jones (eds.). Importance, Preservation and Management of Riparian Habitat: A Symposium held at Tucson, Arizona, July 9, 1977. U.S. Forest Serv. Gen Tech. Rep. RM-43

Miller, J.L. and C.A. Simenstad. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. Estuaries 20: 792-806.

Miller, R.R. 1965. Quaternary freshwater fishes of North America. In: The Quaternary of the United States. Princeton University Press, Princeton, New Jersey. Pp. 569-581.

Montgomery Water Group, Inc., Pacific Groundwater Group, and The Environmental Company. 1999. Dungeness River Agricultural Water Users Association Comprehensive Water Conservation Plan. Prepared for Washington State Department of Ecology.

Munn, M.D., R.W. Black, A.L. Haggland, M.A. Hummling, and R.L. Huffman. 1998. An Assessment of Stream Habitat and Nutrients in the Elwha River Basin: Implications for Restoration. U.S. Geological Survey Water Resources Investigations Report 98-4223.

National Marine Fisheries Commission. 1996. Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. NMFS Northwest Region Office, Portland OR.

Neave, F. 1949. Game fish populations of the Cowichan River. Bull. Fish. Res. Board Can. 84:1-32

Nielsen, J.L. 1994. Invasive cohorts: impacts of hatchery-reared coho salmon on the trophic, developmental, and genetic ecology of wild stocks. Pages 361 to 385 *in* Strouder, D.J., K.L. Fresh, and R.J. Feller, editors. Theory and application in fish feeding ecology. University of South Carolina Press, Columbia, South Carolina.

Northwest Hydraulic Consultants, Inc. 1987. Dungeness River Study Final Report. Prepared for Clallam County Department of Public Works.

Olympic National Park. 1995. Final Environmental Impact Statement – Elwha River Ecosystem Restoration. Olympic National Park, WA.

Olympic National Park. 1996. Draft Environmental Impact Statement – Elwha River Ecosystem Restoration Implementation. Olympic National Park, WA.

Orsborn, J.F. and S.C. Ralph. November, 1992. An Aquatic Resource Assessment of the Dungeness River Basin System: Problem Definition, Information Assessment and Study Design. Prepared for Jamestown S'Klallam Tribe.

Orsborn, J.F. and S.C. Ralph. November, 1994. An Aquatic Resource Assessment of the Dungeness River Basin System: Phase II – Physical Channel Analysis, Hydrology, and Hydraulics and Phase III – Fisheries Habitat Survey. Prepared for Jamestown S'Klallam Tribe and Quilcene Ranger District.

Peterson, N.P. 1980. The role of spring ponds in the winter ecology and natural production of coho salmon (*Oncorhynchus kisutch*) on the Olympic Peninsula, Washington. M. Sc. Thesis. University of Washington Seattle, WA 96 p.

PSCRBT (Puget Sound Cooperative River Basin Team). June, 1991. Dungeness River Area Watershed – Clallam County Washington. Prepared for Dungeness River Area Watershed Management Committee by Request of Clallam County.

PSCRBT (Puget Sound Coperative River Basin Team). 1993. Port Angeles Regional Watershed, Clallam County, Washington. Prepared for Port Angeles Watershed Management Committee by request of Clallam County.

Rymer, Tim. Personal Communication. Washington Department of Fish and Wildlife. Port Angeles, WA.

SAIC (Science Applications International Corporation). 1999. Port Angeles Harbor Wood Waste Study, Port Angeles, Washington. Prepared for Washington State Dept. of Ecology, Olympia, WA.

Scarlett, W.J. and C.J. Cederholm. 1984. Juvenile coho salmon fall-winter utilization of two small tributaries of the Clearwater River, Jefferson County, Washington, p. 227-242. In: J.M. Walton and D. B. Houston (eds.). Proceedings of the Olympic Wild Fish Conference, March 23-25, 1983. Fisheries Technology Program, Peninsula College, Port Angeles, WA.

Schafer, Anne. Personal Communication. Washington Department of Fish and Wildlife. Port Angeles, WA.

Shreffler, D.K., C.A. Simenstad and R.M. Thom. 1992. Foraging by juvenile salmon in a restored estuarine wetland. Estuaries 15(2): 204-213.

Schubel, J.R. and D.J. Hirschberg. 1982. The Yangtze Estuary: its origin and development. Pages 646 to 691 *in* V.S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York.

Schwartz, M. et al. 1991. Quantification of Net Shore Drift Rates in Washington State and the Strait of Juan de Fuca. Prepared for Shorelands and Coastal Zone Management Program, Department of Ecology, Olympia, WA.

Schwartz, M.L. 1994. Beach Geomorphology at the Elwha River Delta in Connection with Removal of the Elwha and Glines Canyon Dams. Prepared for Lower Elwha Tribal Council. Coastal Consultants, Bellingham, WA.

Scott, J.B., S.D. Moore, and R.A. Moore. 1992. Review of the Chinook Exploitation Rate Indicator Stoci Program for the Washington Coast and Puget Sound. Draft Report for the Pacific Salmon Commission. 103 pp.

Scrivener, J.C. and B.C. Andersen. 1982. Logging impacts and some mechanisms which determine the size of spring and summer populations of coho salmon fry in Carnation Creek, p. 257-272. In: G.F. Hartman (ed.) Proceedings of the Carnation Creek Workshop: a ten year review. Pacific Biological Station, Nanaimo, BC.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Onchorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dep. Fish Game Fish Bull. 98, 375 p.

Simenstad, C.A. and E.O. Salo. 1982. Foraging success as a determinant of estuarine and near-shore carrying capacity of juvenile chum salmon (Oncorhynchus keta) in Hood Canal, Washington, p. 21-37. In: B.R. Meltreff and .A. Neve (eds.) Proceedings of the North Pacific Aquaculture Symposium. Alaska Sea Grant Rep. 82-2.

Smith, C.J. and P. Wampler. Dungeness River Chinook Salmon Rebuilding Project, Progress Report 1992-1993. USFWS, Western Washington Fishery Resource Office, Olympia, WA.

SSHIAP (Salmon and Steelhead Habitat Inventory, Assessment, and Planning). 1999. Stream Segment Maps Indicating 8% and/or 12% Gradient Breaks in WRIA 18 Streams. Ted Labbe, Pt. No Pt. Treaty Council, Kingston, WA.

Streamkeepers. 1999 (Draft). Draft Water Quality and Streamwalk reports for 8 Streams in Port Angeles Vicinity. Clallam County Department of Community Development.

Superfund Technical Assessment and Response Team (START), Region 10. 1998. Rayonier Pulp Mill Expanded Site Inspection TDD: 97-06-0010. Contract 68-W6-0008. Submitted to U.S. Environmental Protection Agency, Seattle, WA.

Tschaplinski, P.J. 1982. Aspects of the population biology of estuary-reared and stream-reared juvenile coho salmon in Carnation Creek: a summary of current research. Pages 289 to 307 *in* G. Hartman, editor. Proceedings of the Carnation Creek Workshop, a 10 year review.

Walters, C.J., R. Hilborn, R. Peterman, and M. Staley. 1978. Model for examining early ocean limitation of Pacific salmon production. J. Fish. Res. Board Can. 35: 1303-1315.

Walton, J., Peninsula College. 1983. Letter to C. Dan Hernest, City of Port Angeles.

Wampler, P.L. and J.M. Hiss. 1991. Fish Habitat Analysis for the Dungeness River Using the Instream Flow Incremental Methodology, USFWS, Western Washington Fishery Resource Office, Olympia.

Washington Dept. Fisheries, Washington Dept. Wildlife, and Western Washington Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory. Olympia, WA.

Washington Dept. Fish and Wildlife. 1998. Salmonid Stock Inventory. Appendix Bull Trout and Dolly Varden. Olympia, WA.

Washington Dept. Fisheries, Washington Dept. Wildlife, and Western Washington Indian Tribes. 1994. 1992 Washington State Salmon and Steelhead Stock Inventory. Appendices. Olympia, WA

Washington State Department of Ecology and Members of the Dungeness River Water Users Association. 1998. Memorandum of Understanding to Transfer Water Under Trust Water Rights Program Chapter 90.42 RCW.

Wetherall, J.A. 1971. Estimation of survival rates for chinook salmon during their downstream migration in the Green River, Washington. Doctoral dissertation. College of Fisheries, U. Wash. 170 p.

Williams, W., R.M. Laramie, and J.J. Ames. 1975. A Catalog of Washington Streams and Salmon Utilization – Volume 1, Puget Sound Region. Washington Department of Fisheries, Olympia, WA.

Withler, I.L. 1966. Variability in life history characteristics of steelhead trout (*Salmo gairdneri*) along the Pacific coast of North America. J. Fish. Res. Board. Can. 23 (3): 365-393.

APPENDICES

APPENDIX 1 - SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

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 (Table 1) 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, with the expectation that it will be modified or replaced as better data become available.

Table 15. Source documents

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmnoid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 2. These ratings are not intended to be used as thresholds for regulatary purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG should be used to assign the appropriate ratings. A set of narrative standards will be developed in the near future to provide guidance in this situation.

In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters they were not. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented here or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report.

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Table 16. WCC salmonid habitat condition ratings

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
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

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
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)	Diameter (m)	Length (m)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		
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

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
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
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*
Lakes (further work needed)						
Estuaries (further work needed)						

GLOSSARY

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams, but migrate to lakes for feeding as subadults and adults. Compare fluvial.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one species.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confluence: Joining.

Connectivity: Unbroken linkages in a landscape, often referred to in the context of mainstem connection with side-channels.

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed.

Distributaries: Divergent channels of a stream occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife and plants be protected and restored.

Endangered Species: Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: An abrupt increase in water discharge; typically flows that overtop streambanks.

Floodplain: Lowland areas that are periodically inundated by the lateral overflow of streams or rivers.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare *adfluvial*.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically and geologically similar habitats. A GDU may consist of a single stock

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Instream Flow Incremental Methodology. Flow modeling methodology used to determine incremental gains in fish habitat, for individual species, at different flow levels.

Intermittent stream. Stream that has interrupted flow or does not flow continuously. Compare *perennial stream*.

Interspecific interactions. Interactions between different species.

Intraspecific interactions: Interactions within a species.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. Usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt*.

Plunge pool: Basin scoured out by vertically falling water.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids); consisting of a depression that is created and the covered.

Resident fish: Fish species that complete their entire life cycle in freshwater.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

SASSI: Salmon and Steelhead Stock Inventory.

SSHIAP: The Salmon and Steelhead Habitat Inventory and Assessment Project directed by the Northwest Indian Fisheries Commission.

Salmonid: Fish of the family salmonidae, including salmon, trout, and char.

Salmon: Includes all species of the genus Oncorhyncus

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originate from specific watersheds as juveniles and generally return to their birth stream to spawn as adults.

Stream reach: Section of a stream between two points.

Subbasin: One of the smaller watersheds that combine to form a larger watershed.

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Toe width. A method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.]

Watershed: Entire area that contributes both surface and underground water to a particular lake or river.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoration*.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.