Jefferson County Shoreline Master Program Update:

Shoreline Inventory and Analysis

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By

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11

Introduction

The purpose of this report is to provide a baseline inventory of conditions within the shoreline jurisdiction of Jefferson County, Washington, in preparation of an update of the Shoreline Master Program (SMP). This inventory of conditions is necessary in order to complete our SMP in compliance with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58 and its implementation guidelines Washington Administrative Code (WAC) 173-26. This inventory will serve as a "snapshot in time" of existing shoreline conditions that include current development, course-scale ecological function and shoreline natural resources. In addition, it will provide a framework and the background information necessary to make shoreline designations. A state mandated update of Jefferson County's SMP is due in 2011. However, Jefferson County is on schedule to complete an updated SMP by June of 2007.

Jurisdiction of the SMA includes shorelands- defined as lands 200 feet landward of the ordinary high water mark (OHWM) of waters that have been designated as "shoreline" or "shorelines of statewide significance." These designations were established in 1972 and are described in WAC 173-18. Generally, "shorelines of statewide significance" include portions of Puget Sound and other marine water bodies, rivers west of the Cascade Range crest with mean annual flow of 1000 cubic feet per second (cfs) or greater, rivers east of the crest with a mean annual flow of 200 cfs or greater and freshwater lakes 1000 acres or larger. Shorelines of the state include shorelines of statewide significance *and* all marine shorelines and the shorelines of all other streams and rivers with a mean annual flow of 20 cfs or greater and lakes that have a surface area 20 acres or larger. Associated wetlands of the shorelines of the state also are considered shorelines of the state.

Within Jefferson County there are approximately 253 miles of marine shoreline, 367 miles of streams and rivers as well as 18 miles of lake shoreline that meet the definition of shoreline of the state. Marine shorelines that fall within the county's jurisdiction all lie in the eastern part of the county on greater Puget Sound. The marine shoreline in the western part of the county on the Pacific Ocean is Federal property- Olympic National Park and the Hoh and Quinault Indian Reservations, hence is generally not under the jurisdiction of the SMA. The approximately 199 miles of shoreline in the eastern part of the county on Puget Sound is mostly within SMA jurisdiction, except for military and other Federal lands. Several rivers have reaches that meet the requirements to be shorelines of statewide significance; they are the Hoh River, Clearwater River and portions of the Bogacheil and Quinault Rivers- all flowing west into the Pacific Ocean. Other rivers and streams that meet the definition of shorelines of the state are Goodman Creek, numerous tributaries to the Hoh River, Mosquito Creek, Cedar Creek, Snahapish River, numerous tributaries to the Clearwater River, Sollecks River and portions of the Salmon River and Matheny Creek in the west side of the county. In the eastern side of the county rivers and streams that meet the requirements as shorelines of the state are Salmon Creek, Snow Creek, Chimacum Creek, Little Quilcene River , Big Quilcene River, Dosewallips River and Duckabush River.

This rough draft covers the coarse-scale ecological function of the shoreline, including not only natural conditions, but also how these might be affected by existing shoreline alterations. Ecological function and shoreline conditions include drift cell dynamics, shoreline alterations, eelgrass and riparian cover along the nearshore. In

streams and rivers it includes such factors as channel condition, salmon habitat and riparian cover. Preliminary reach breaks are also assigned- based primarily on habitat factors, land use and sediment transport, as a starting point to updating SMP shoreline designations.

Context

Jefferson County is on the Olympic Peninsula in northwest Washington State (Map 1). It stretches from the Pacific Ocean in the west through the high country of the Olympic Mountains to Puget Sound in the east (Map 2). To the north it bounded by Clallam County and the Strait of Juan de Fuca, the southeast Mason County and the southwest Grays Harbor County. Its population in 2004 was about 26,000 people, primarily living in the eastern part of the county. The county seat and most only incorporated city is Port Townsend with a population of about 8,500.Other population centers include Port Hadlock, Chimacum and Irondale (the "Tri-Area"), Port Ludlow, Brinnon and Quilcene. Olympic National Park and Olympic National Forest include most of the Olympic Mountains in the center of the county. West of the Olympic Mountains Jefferson County is lightly populated, mostly commercial and Department of Natural Resources timberlands.

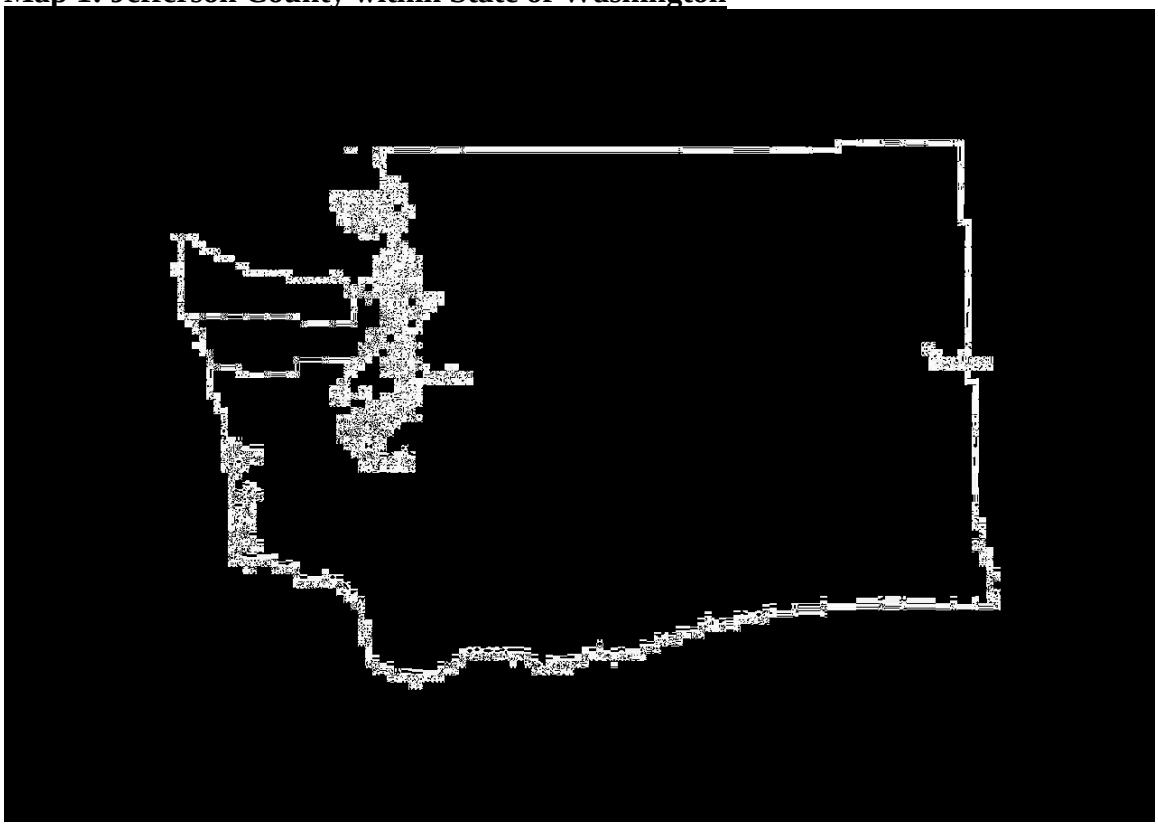
Climate

Jefferson County has a maritime climate dominated by moderate temperatures and abundant moisture. Maximum temperatures average in the mid forties in January in the lowlands, in the summer average maximum temperatures range from 77 F in Quilcene in the eastern part to 69 F in Clearwater in the west. Temperatures in the lowlands rarely reach the nineties or fall into the teens in this region.

Some of the most extreme variations of annual precipitation in the United States occur on the Olympic Peninsula. In Jefferson County annual precipitation varies between 126 inches at Spruce in the western foothills of the Olympic Mountains, to approximately 240 inches on Mt. Olympus at the crest of the mountains, to 50 inches in Quilcene along Hood Canal to 18 inches in Port Townsend on the northeast tip of the Olympic Peninsula. Measurable precipitation falls on 176 days in Clearwater and 116 in Port Townsend. This pattern of annual precipitation is caused by a dominant winter storm tract from the southwest creating a rain shadow over the northeastern Olympic Peninsula. Storms dump their moisture as they rise over the mountains and air-dries and warms as it falls into the Puget Sound-Strait of Juan de Fuca Trough. A storm that dumps heavy rain on the western slopes of the Olympic Mountains might only create a light mist along the Strait of Juan de Fuca. A majority of precipitation falls between October and April, as rain below 1000 ft. and snow above 2500ft. Rain in the mid summer is relatively rare with high pressure aloft and moderate temperatures predominating.

Severe flooding and coastal bluff landslides often occur when there is a heavy snowfall followed by rain. This creates a situation where the accumulated precipitation of several storms runs off the landscape over a very short time. An example of this phenomenon are the storms of the winter of 1996-97 which triggered numerous, massive, coastal bluff landslides in the Puget Sound region.

Map 1: Jefferson County within State of Washington



Topography

Coniferous forest, high precipitation and large rivers characterize Jefferson County west of the Olympic Mountains. Some of the largest trees in the world grow here in a temperate rainforest ecosystem. Some of the larger rivers, such as the Hoh, Queets and Quinault are glacially fed at their headwaters. In their lower reaches these rivers meander over large floodplains. The landscape is generally hilly in the west but rises dramatically to the east in the Olympic Mountains. Although not particularly high (Mt Olympus is the tallest peak at 7969 feet) they are rugged mountains comprised of relatively recent metamorphic rock. The broad hilly country between the Olympics and the Pacific Ocean has not been glaciated for at least the past 17,000 years (Abbe 2000).
The landscape in Eastern Jefferson County was shaped by repeated glaciations, the last retreating about 12,000 years ago. This left a hilly landscape of layered glacial and outwash sediments with little exposed bedrock. The shoreline is now characterized by bluffs carved out of these glacial sediments, often topped by douglas fir and hemlock forest. Several sizable rivers flow east out of the Olympic Mountains and into Hood Canal, providing salmon habitat and forming relatively large delta estuaries. Prairies occurred along Discovery Bay, on Protection Island and in Port Townsend in the drier northeast section of the study area- few remnants of this ecosystem exist today.

Marine Shoreline

Beaches and the shoreline reflect the geology in the eastern part of Jefferson County that is dominated by glacial deposits. The erosion of these glacial deposits has created large, often unstable, bluffs towering over sand, gravel and cobble beaches. Beach sediment is derived primarily by the erosion of these bluffs (referred to as feeder or contributing bluffs) and net shore drift, created by the prevailing wave and current direction, transports the sediment to depositional zones- often creating spits or barrier beaches. This process of net shore drift moving sediment over time from a feeder bluff to a depositional shoreform creates unique drift cells- stretches of shoreline where sediment flow is essentially isolated from adjacent stretches of shoreline. Thus, drift cells are a useful landscape delineation for planners to use in dividing the shoreline into manageable stretches for analyses and characterization.

Drift cell function affects shoreline morphology and in areas where shoreline armoring creates a condition where a drift cell does not function properly than shoreline morphology can be affected. For example, in a drift cell where sediment from bluffs is no longer allowed to reach the intertidal due to shoreline armoring, the depositional beach at the terminus of the cell could experience accelerated erosion even though it maybe miles "down drift" from the impacted bluffs. Beaches in front of armored shorelines can also lose fine sediment by the increased wave reflection off of the armoring. Over time a heavily armored area can lose its beaches and be subject to increased shoreline erosion- the sediment that is necessary to sustain the beaches is no longer reaching them or is not staying on the beach.

In Eastern Jefferson County there are several areas of erosion resistant basalt, notably along Hood Canal in the vicinity of Brinnon and the Olele Point area north of Port Ludlow, where there is little or no net shore drift of sediment.

The ecology of the shoreline is laid out on this geological framework. Abundant glacially derived sediment, eroded off of bluffs, creates beaches of primarily comprised of sand and pea gravel overlying cobble. Sand lance and surf smelt (referred to as forage fish) prefer to spawn on beaches of mixed sand and pea gravel (Penttila 2000). Eelgrass beds offshore depend on sediment high in sand and pea gravel and are not able to thrive in small sediment deprived systems dominated by cobble (Hirschi 1999). Salmon rely on forage fish for food and eelgrass beds for cover and foraging habitat. Overhanging vegetation is important for providing shade for surf smelt and sand lance eggs, serving as a source of terrestrial insect for consumption by marine fishes and providing cover at high tide (Brennan 2004). Bluff top trees are also favorite spots for nesting and perching by bald eagles. Other important attributes noted in this study are waterfowl concentrations, seal haul out and pupping sites and the mouths of salmon streams. Also noted are salt marshes and estuaries, which are important habitat for migrating salmonids (Hirschi et al 2003a).

Methods

The information contained in this report is the result of a large literature search for both published and unpublished work. In addition, local sources provided many useful observations. A full bibliography is contained at the end of the report. Here are the sources used most often:

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Long, K., N.E. Harrington and P.J. Mackrow. 2003. *Forage fish spawning site investigation for Eastern Jefferson County, Northeastern Kitsap County and North Mason County*, North Olympic Salmon Coalition, Second year status report to the Jefferson County Marine Resources Committee

Penttila, D. 2000. *Documented spawning areas of the pacific herring (Clupea), surf smelt(Hymomesus) and Pacific Sand Lance(Ammodytes) in East Jefferson County*, Washington State Department of Fish and Wildlife, Marine Resources Division Manuscript Report

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Acknowledgements

I am grateful for personal observations and knowledge that the following experts gave to me regarding their unique knowledge of Jefferson County. Jill Silver for her knowledge and opening up her library on the Hoh watershed. Camille Speck for information regarding shellfish populations. Ron Hirschi for answering many questions about salmonid use of pocket estuaries and other local natural history observations. Ginna Correa for encouragement and inspiration as well as her two excellent reports on the Habitat Limiting Factors for Salmon in WRIAs 16 and 17. Barbara Nightengale for opening up extensive library to me. Ted Labbe and Steve Todd from the Point No Point Treaty Council for providing personal observations and historical information about the shoreline.

Shoreline Inventory and Analyses

Below you will find the inventory and analyses of Jefferson County's shorelines- starting in the southeast and ending in the southwest. Rivers and streams are grouped with their associated nearshore segment. Lakes are placed within the basin descriptions. The descriptions of the rivers and streams on the West End of Jefferson County follow. There are no marine shorelines within the county's jurisdiction on the West End.

The shorelines are broken up by basins or by groups of drift cells for inventory and analyses. In each section you will find an inventory containing ecological characteristics, animal habitat, human use, historical resources, shoreline modifications, endangered species, anadromous fish use, public access and restoration opportunities. In addition, the shoreline is broken into preliminary reaches of similar characteristics for later consideration of shoreline designations. For marine shorelines this was done in areas based on net shore drift, level of development and habitat type. For freshwater shorelines reaches where delineated based primarily on habitat.

The maps for this report are included in the mapbook contained at the end of the report.

Fulton Creek and Associated Nearshore

Fulton Creek flows out the foothills of the Olympics into Hood Canal north of Triton Cove (Map 3). Most of the upper watershed is within the Olympic National Forest. This nearshore segment extends from the Mason/ Jefferson County line, just north of Triton Cove, to north side of McDaniel Cove. The estuary of Fulton Creek is significant habitat and there is a small estuary where McDonald Creek enters McDaniel Cove. Major

human impacts to the shoreline in this segment are vacation homes with their associated shoreline armoring and docks, and US Highway 101.

Ecological Background

The first section of this shoreline is comprised of about 400 meters of basalt from the Crescent Formation dating from the Middle Eocene (WDOE 1978). There is no appreciable net drift in this segment. Eelgrass is patchy throughout this section with little or no overhanging riparian vegetation (WDNR 2001).

To the north starts drift cell JE-30 with net shore drift to the northeast for 1.7 km. Evidence of northeastward drift includes northeastward delta and stream mouth offset near the beginning of the drift cell, northeastward beach width increase up to the Fulton Creek delta, and the accumulation of sediment on the southwestern side of basalt outcroppings near the terminus of the drift cell. This drift cell contains two areas of significant fluvial input, Fulton Creek and a smaller, unnamed drainage approximately a half mile south of Fulton Creek. The drift cell terminates 550 yards to the northeast of where Fulton Creek passes under Highway 101 (Johannessen, 1992). Uplands within this drift cell are comprised largely of Vashon Lodgement Till and an area of Vashon Recessional Outwash around Fulton Creek. In this drift cell the bluffs are considered unstable south of Fulton Creek and there is at least one area of recent land sliding (DOE 1978).

Eelgrass is continuous for the 360 yards south of the unnamed tributary south of Fulton Creek (WDNR 2001). At the small delta created by this tributary there is a public access shell fishing site (Speck personal communication, 2004). Riparian is largely absent from the southern portion of this drift cell. North of the unnamed tributary, across the Fulton Creek Delta and north to the terminus of the drift cell there are patchy eelgrass beds. Riparian vegetation increases to the north- covering approximately 40% of the northern part of this drift cell (WDNR 2001). The Fulton Creek Delta has numerous salt marsh habitat and tidal creeks. Coho, Fall Chum, Cutthroat Trout, Steelhead and Pink salmon spawn in Fulton Creek. In addition the estuary was found to be important habitat for juvenile Coho, Chum and Chinook. Some of this use is clearly non-natal and indicates the importance of this estuary as part of the regional salmonid migratory corridor (Hirschi 2003a).

North of Fulton Creek the shoreline is comprised of basalt for the next third of a mile to the northeast, and there is no appreciable net shore drift (Johannessen 1992). This part of the shoreline has patchy oysters and mussels and abundant algae (WDNR 2001).

Drift cell JE-29 originates a half mile northeast of the mouth of Fulton Creek. Net shore drift continues for 640 yards to the McDaniel Creek delta. Indications of northeasterly drift include sediment accumulations along the southwestern side of numerous rock outcroppings which partially interrupt the flow of sediment in this cell and sediment size decrease over the length of the cell (Johannessen 1992). The uplands along this drift cell are comprised of basalt with some overlying glacial till deposits (DOE 1978). There is patchy eelgrass in this drift cell south of McDaniel Cove and little riparian vegetation. Within the cove there are oysters. Coho, Cutthroat and Fall Chum spawn in McDonald Creek.

No appreciable net shore drift occurs between the terminus of this drift cell at the head of the cove north to the Duckabush delta. This shore consists of basalt and isolated pocket beaches (Johannessen 1992). The northern side of McDaniel Cove has retained complete riparian vegetation and a continuous eelgrass bed.

Shoreline Alterations

There is a boat ramp at Triton Cove State Park and numerous private staircases in this area. Where the unnamed small creek a half-mile south of Fulton Creek enters Hood Canal there is extensive bulkheading and fill. This has restricted the creek's access to the historical delta by pushing the creek channel to the southern edge of the bulkhead. Just south of Fulton Creek's delta, a cabin is built out onto fill fronted by a bulkhead. The northern part of Fulton Creek Delta is covered in fill atop which sits a parking lot for a private club. In McDaniel Cove there is fill on the southern part of the estuary and a large berm that juts out from the southern shore. Fill in the intertidal zone eliminates shallow water habitat for migrating juvenile pink and chum salmon. On the upside, none of these shoreline modifications appear to have had a major adverse effect on along shore transport of sediment. Highway 101 has restricted channel migration where it crosses Fulton Creek and McDonald Creek, again impacting estuary habitat.

Restoration Opportunities

Removing fill in the Fulton Creek Delta, the delta of the small unnamed creek south of Fulton Creek and from McDaniel Cove would increase shallow water estuarial habitat for migrating juvenile salmonids. The fill around the mouth of the unnamed creek south of Fulton Creek is owned by WDFW and used as a parking area for a shell fishing site. Therefore it is a good candidate for restoration as the State already owns the property. Removing or modifying the filled parking area could create a more functional estuary for the small stream and improve along shore drift.

Public Access

There is public access to the shoreline at Triton Cove State Park as well as a boat ramp. The WDFW tideland south of Fulton Creek has public access at a turnout off of Hwy 101. The north side of McDaniel Cove is public tideland with boat access only.

Preliminary Nearshore Reaches

Triton Cove: County line to north to the origin of drift cell JE-30.
Fulton South: Beginning of drift cell JE-30 north to the south edge of the Fulton Creek delta.
Fulton Creek Delta: south edge to north edge of Fulton Creek delta.
Fulton North: Fulton Creek delta to origin of drift cell JE-29.
South MacDaniel: drift cell JE-29.
MacDaniel Cove: mouth of MacDonald Creek to north edge of McDaniel Cove.

Fulton Creek

Overview

Fulton Creek flows into Hood Canal between north of Triton Cove (Map 3). Steep concave headwaters drain bedrock slopes followed by a reduced gradient channel flowing through a series of glacially deposited benches. A steep confined section follows downstream with steep cascade reaches emptying into a short alluvial fan (Correa 2003). This watershed meets the requirement of a Shoreline of the State below the point where the South Fork of Fulton Creek meets the main stem at river-mile 1.05 (WDOE 2001b). There are no known artificial barriers to anadromous fish in this section of creek, however there is a barrier at the natural falls at river-mile 0.9 (Correa 2003). Of a total of 5353 acres of watershed 4845 acres are within Olympic National Forest maintaining water quality for the downstream portion that lies within our jurisdiction (Correa 2003).

Anadromous Fish

Fulton Creek supports coho, fall chum and pink salmon spawning and cutthroat and steelhead trout as well. The available habitat below the anadromous barrier has supported up to 100 coho and 1000 fall chum as recently as 1996 but these numbers of spawners have not been seen since. Escapement goals have not been set for this watershed (Correa 2003). Chris May listed Fulton Creek as a Class A Nodal Riparian Corridor (NRC) is his 2003 study of salmonid refugia in Jefferson County. This creek continues to have some of the best remaining habitat for salmon in East Jefferson County (May and Peterson 2003). Riparian habitat is in good condition with 72% of this watershed being hydrologically mature (>70 crown coverage and <75% of crown coverage in hardwoods or shrubs) (Correa 2003). Nonetheless, large woody debris is unfortunately largely absent from the section of creek below the falls (Correa 2003). Sediment data for this watershed is lacking, although most likely sediment supply is within historical levels (Correa 2003).

Channel Modification

There are four areas of bank armoring and/ or diking in the lower watershed. This results in a loss of floodplain habitat. Fill associate with Hwy 101 and immediately downstream of Highway 101 eliminates estuary habitat (Correa 2003 and WDOE 2001).

Restoration Opportunities

See the Fulton Creek nearshore segment for description of restoration opportunities. The main issues that should be addressed are the Highway 101 crossing and fill in the estuary.

Preliminary Reaches

It is recommended that this be treated as one reach from the stream mouth to the end of the Shoreline of the State Designation.

Duckabush River and Black Point

Overview

From the northern edge of McDaniel Cove to the northern edge of Pleasant Harbor is a marine shoreline that encompasses the major estuary of the Duckabush River and Black Point (Map 3). The area south of the Duckabush is primarily a basaltic shoreline with a few pocket beaches. Residential development is concentrated just south of the Duckabush Delta and on the north and east sides of Black Point and around Pleasant Harbor. There is a recreational marina in the naturally protected anchorage of Pleasant Harbor. Significant natural areas in this area include the sparsely developed marine shoreline north of McDaniel Cove, the Duckabush River and delta, the south side of Black Point and Quatsop Point spit.

Ecological Background

Between the northern edge of McDaniel Cove and the Duckabush Delta (Duckabush South) there are several areas of patchy and continuous eelgrass beds. This basaltic shoreline support little riparian vegetation, riparian vegetation does increase to 20% just south of the Duckabush delta- this total has been adversely affected by residential clearing (WDNR 2001).

The next drift cell begins at the central portion of the Duckabush River Delta and continues to the cuspate spit at the tip of Quatsop Point. The abundant sediment sources for this drift cell are alongshore, from the feeder bluff on the south side of Quatsop Point, and fluvial sources from the Duckabush River (Johannessen, 1992). The feeder bluff is comprised of Vashon Till overlying older undifferentiated stratified glacial sediment and is an area of numerous landslides (DOE 1978 and 2001). The intertidal zone in the delta is about 750 feet wide and narrows around the south side of Quatsop Point to a 30 foot wide beach (DNR 2001).

The Duckabush Delta, the south side of Black Point and Quatsop Point are rich habitat (Map 3). This estuary and delta are home to trumpeter swans, bald eagles and regionally significant winter waterfowl use. Harbor seals haul out here throughout the year and pupping occurs in the winter (WDFW 2004). The extensive mud and gravel flats are rich shellfish beds with millions of harvestable oysters and clams (Speck, personnel communication 2003). Higher up, salt marsh habitat dominates the Duckabush Delta. In the lower intertidal and subtidal, eelgrass beds are continuous from the delta to Quatsop Point. Herring use this eelgrass for spawning (Penttila 2000). The southern part of the tide flats and estuary are on the 303d list for fecal coliform concentrations (WDOE 1998). Just to the east of the delta there is abundant riparian vegetation. At the drift cell terminus at Quatsop Point an exemplary cuspate spit forms, enclosing a high salt marsh (WDOE 2001 and WDNR 2001).

The first drift cell to the north of Quatsop Point, JE-27, originates at the northeast portion of Black Point and has a southward net shore drift for a mile along a sinuous shore to Quatsop Point. This area is exposed to northerly and northeasterly fetch that controls net-shore drift. Evidence of this includes a southward sediment size decrease, southeastward stream mouth offset and the southeastward progradation of Quatsop Point

spit. The cell terminus is located at Quatsop Point (Johannessen 1992 and Correa 2003). Bluffs on the northern half of this drift cell are comprised of Vashon Lodgement till and are stable whereas the bluffs comprised of Vashon advance outwash in the southern half of the drift cell (except for the spit) are unstable and feed abundant sand and gravel to the intertidal. A small drainage that flows through a tidal swimming lagoon in the middle part of the drift cell also contributes fluvial sediment to the intertidal (Map3)(WDOE 1978 and WDNR 2001). This lagoon is a very unusual tidal feature that is essentially a kettle lake with an intertidal inlet (Ted Labbe, personal communication 2004). Kettle lakes are formed when glacial recessional outwash buries or partially buries large blocks of ice. When the ice melts, if the depression is not filled with sediment, it can become a pond or lake. Several other kettle type depressions occur inland on Black Point.

Eelgrass beds are patchy throughout drift cell JE-27. Herring spawn along the entire shore (Penttila et al. 2000). Dune grasses are found at the terminus of the cell. The swimming lagoon has a very unique biology and intertidal community (Hirschi, personal communication 2003). The inlet to the lagoon is fringed with salt marsh. The beach north of the outlet is used by sand lance for spawning. Overhanging riparian vegetation is present over about half of this drift cell (WDNR 2001). Surf smelt use beach on the north and south sides of Quatsop Point for spawning.

The reach south of Boston Point consists of several basalt outcroppings separated by pocket beaches. There is no net drift in this area. The central pocket beach is a documented sand lance spawning site (Penttila 2000). Pacific herring spawn just offshore throughout this area and into Pleasant Harbor (Bargmann 1998).

A short (550 yard) drift cell, JE-26, begins at the northeastern most basalt outcropping and has a westward and then southwestward net shore-drift across the northern portion of Black Point and then into Pleasant Harbor. Drift sediment is derived from Vashon till overlying basalt. Pleasant Harbor is a natural harbor bounded on the northwest by Vashon lodgement till which is intermediately stable and on the south by Vashon advance outwash that is classified as unstable. To the east the shore is comprised of Vashon lodgement till and basalt. There is an accretionary beach at the head of the harbor and beach deposits on both sides of the mouth of the harbor.

Patchy eelgrass is found throughout Pleasant Harbor and a narrow bed lines the northern side of the harbor (Correa 2003 and WDNR 2001). Salt marsh habitat is found on the north side of the mouth and at the head of the harbor (WDNR 2001 and WDOE 1982).

Shoreline Alterations

South of the Duckabush River there are several rail boat launches. Built on fill, Highway 101 cuts across the extensive estuary of the Duckabush River, restricting access to side channels and preventing channel migration. Several side roads in this vicinity also constrict channels in the estuary as well. On the northern edge of the estuary there is cement bulkheading and possible fill of salt marsh habitat. The bulkheading does not appear to significantly effect along shore drift of sediment, however some of the homes behind the bulkhead may be built on fill placed over salt marsh.

Just north of Quatsop Point bulkheads front a small housing development at Lackawanda Beach. This, combined with a dock in this area may have some effect on the

along shore transport of sediment within drift cell JE-27 to Quatsop Point. Some of these bulkheads front fill and do not appear to be protecting structures. Further north, closer to the origin of this drift cell, numerous staircases lead onto the beach. Approximately 13.8% of this drift cell is bulkheaded, primarily in the sediment transport zone (Hirschi 2003a).

Although there is relatively little bulkheading within drift cell JE-26 there are eleven stair structures within its 787 yards.

Within Pleasant Harbor there are numerous private docks on the south side of the harbor and a marina on the north side. In general, shade created by docks can have adverse effects on eelgrass.

Restoration Opportunities

Modifying the Highway 101 crossing of the Duckabush Delta to allow for more tidal exchange and channel migration would increase salt marsh and estuarial habitat. Bulkheads at Lackwanda Beach that are not protecting structures could be removed to increase upper intertidal habitat.

Public Access

The Duckabush Delta is owned by WDFW and is accessible from Highway 101. Part of the shoreline on southern Black Point is owned by WDNR and is accessible by boat. There is a state park with a boat ramp in Pleasant Harbor.

Historical Resources

The Duckabush River Bridge is on the National Historical Register.

Preliminary Nearshore Reaches

South Duckabush: North edge of McDaniel Cove to south edge of Duckabush River delta.
Duckabush Delta: south to north edge edges of the Duckabush River Delta to the edge of residential development just east of the delta.
North Duckabush Delta: the residential area on the north edge of the Duckabush Delta.
South Black Point: Duckabush delta to the edge of Quatsop Point (JE-28).
Quatsop Point: encompassing the spit at the termini of drift cells JE-28 and JE-27.
JE-27 Reach: from the origin of drift cell JE-27 to the edge of Quatsop Point spit.
Boston Point: Area of no net drift around Boston Point.
JE-26: Drift cell JE-26 just east of Pleasant Harbor.
Pleasant Harbor: From north to south entrances of Pleasant Harbor.

Duckabush River

Overview

The Duckabush River is one of the largest rivers flowing into Hood Canal (Map 3). Its watershed covers approximately 75 square miles of the eastern Olympic Mountains. The Duckabush main stem is 24.5 miles long with 50 tributaries contributing an additional 94.3 stream miles. Average annual discharge is 411 cfs at river mile 4.9 (Correa 2003). The upper 75% of the watershed is protected in Olympic National Park and as USFS Wilderness. Shoreline of the State designation currently stops at the edge of the Olympic National Forest at river mile 2.3, however the county's jurisdiction extends to private inholdings within the National Forest. The furthest upstream extent of these inholdings is just downstream from the gauging station at river mile 4.9. In this lower section the Duckabush River valley is characterized by steep walls and a relatively wide floodplain.

Anadromous Fish

Chinook, coho, fall and summer chum, pink salmon and steelhead and sea run cutthroat trout utilize the entire lower segment of the Duckabush River. There are no artificial barriers to anadromous fish is this stretch of river. Two large side channels upstream from the BPA power lines are used heavily by chum salmon for spawning. The river has recently broken through the head of one of these side channels and it may become the new main channel (Correa 2003). Downstream of the National Forest boundary stream bank armoring restricts the floodplain. Floodplain connectivity rates fair overall but poor in the lowest half mile of the river. Below river mile 3.0 removal of large woody debris and rural residential development have confined the river to a single channel limiting side channel spawning and rearing habitat for salmonids. Of the salmon stocks in the Duckabush, Chinook are rated critical, summer chum, pinks and winter steelhead are considered depressed and fall chum and coho are considered healthy in SASSI. Additionally, summer chum are listed as threatened under the Endangered Species Act (ESA) (Correa 2003).

Anadromous Fish Habitat

The Duckabush River below river mile 7.5 was designated a class A nodal-riparian corridor by May and Peterson 2003. A class A nodal riparian corridor is one in which natural ecological integrity has been retained and historical population and diversity of salmonids remains largely intact (May and Peterson 2003).

In the lower Duckabush road density is 2.2 miles per square mile of watershed. Roads have contributed to 31 mass wasting events (33% of the total) in the lower eight miles of watershed. It is estimated that 78% of these events contributed sediment to the river (USFS 1998).

Within the Olympic National Forest the river is within a riparian reserve program which preserves floodplain riparian vegetation (Correa 2003). However in the lower reaches of the river below the Olympic National Forest, impacts of development are evident. 25% of the riparian zone (by area) is impacted by development below river mile 3.0 (12% urban/ commercial, 9% rural residences and 3% dikes and roads). Approximately 32% of the riparian zone (the area 200 ft from the stream- the same zone as that under shoreline jurisdiction) is small diameter trees less than 12 inches in

diameter, 66% is medium diameter between 12 and 20 inches, 2% has no trees and there are no large trees over 20 inches in diameter (Correa 2003).

The hydrological maturity of the lower eight miles of watershed was analyzed by the USFS. Approximately 16% (181 acres) of the lower watershed is less than 30 years old, 67% (7458 acres) is between 31 and 95 years old, 9% (1022 acres) is between 96 and 297 years old and 0.3% is greater than 297 years old (USFS 1998). There are recent clear cuts in the lower two miles of the watershed (Correa 2003).

Preliminary Reach Breaks

The mouth, the National Forest Boundary, and the edge of the last private inholding.

Dosewallips River and the Brinnon Shoreline

This marine shoreline extends from the northern edge of Pleasant Harbor to the head of Right Smart Cove north of Brinnon (Map 4). It includes two drift cells and the large estuary and river delta of the Dosewallips River. The Dosewallips River is the largest river in eastern Jefferson County with a watershed draining the northeastern Olympic Mountains. North of the lower Dosewallips is located the town of Brinnon. There is a small commercial district in Brinnon and several residential neighborhoods. There is residential and vacation homes both north and south of Brinnon on Hood Canal.

Ecological Background

Between the Dosewallips River and Pleasant Harbor extends drift cell JE-25 that encompasses the south Dosewallips reach. It originates at the southern edge of the Dosewallips River Delta with net shore drift to the southeast for 2.1 km to Pleasant Harbor. Northeastward fetch becomes the controlling factor in this area because this area is sheltered from south winds by Black Point. Southwestward net shore-drift is indicated by minor southwestward beach width increase, sediment size decrease and southwestward spit progradation just inside the mouth of Pleasant Harbor. The end of this spit is the cell terminus (Johannessen 1992). There is an abundant fluvial sediment source at the beginning of the cell, and moderately abundant alongshore sediment in the remainder of the drift cell. Most of the shoreline of this drift cell is comprised of Vashon lodgement till and is considered of intermediate stability. There is an area of unstable bluff face about 450 meters south of the southern edge of the Dosewallips Delta (WDOE 1978).

Over half of this drift cell has overhanging vegetation. There are patchy eelgrass beds near the southern terminus of the drift cell (WDNR 2001). Sand lance spawn on the beaches just north of the mouth of the harbor (Penttila 2000).

The Dosewallips Delta is facing Hood Canal in front of the town of Brinnon and the Delta is included in the Brinnon Reach (Map 4). The southern portion of the

Dosewallips River Delta is an area of divergence between drift cell JE-25 to the south and JE-24 to the north. It is also the active part of the delta where the river flow meets the sea. Large amounts of fluvial sediment create, on average, a 150 meter wide intertidal zone primarily of sand and gravel (WDNR 2001 and Correa 2003).

The Dosewallips delta contains many tidal channels and large amounts of salt marsh habitat. This is important salmonid habitat and juvenile pink and chum have been found here in Wolcott Slough (Hirschi et al. 2003a). The Dosewallips supports runs of pink, chinook, fall and summer chum and coho salmon as well as steelhead and cutthroat trout. It is also an important recreational and tribal shellfish site (Speck, personal communication 2003). Bald eagles and great blue herons nest in Dosewallips State Park (WDFW 2004)

Drift cell JE-24 begins at the northern edge of the Dosewallips Delta with net shore drift continues 3.3 miles north of Brinnon into Right Smart Cove. Slope stability is intermediate to stable through out this drift cell with Vashon Till overlying basalt, the exception being about a half mile of unstable Vashon Recessional Outwash just north of the Dosewallips Delta. A substantial portion of the nearshore sediment in this drift cell appears to originate from the Dosewallips River. Evidence of northward drift include a general increase in beach width, accumulation of sediment on the south side of a rip rap seawall and boat ramp at Seal Rock, and the northerly directed mouth of Turner Creek. The drift cell terminus is located at Right Smart Cove at the eastern end of a spit that encloses a large tidal lagoon (Johannessen 1992 and WDOE 2001).

There is high salt marsh along the tidal lagoon at the northern terminus of the drift cell. Herring spawn in the eelgrass from the mouth of Turner Creek up into Right Smart Cove. Patches of barnacles and oysters are found along this entire segment of shoreline. Sand lance spawn on the beach at the terminus of this drift cell (Penttila 2000 and Long et al 2003).

Shoreline Alterations

North of Pleasant Harbor there is a residential area with numerous staircases, some with large decks and small boathouses built on the upper intertidal zone. 21.2 % of this drift cell is bulkheaded (Hirschi et al 2003). Although much of the sediment for this drift cell is fluvial in nature from the Dosewallips River this much armoring can have significant impacts on the transport of alongshore sediment. In addition the upper intertidal structures mentioned above can decrease the amount of beach habitat necessary for forage fish spawning.

In the southern part of the Dosewallips Delta (Brinnon Reach) there is a derelict barge or backfilled wooden bulkheaded area that has impacted shallow water habitat. Highway 101 truncates several sloughs and restricts channel migration near the mouth of the Dosewallips. Other diked and filled areas occur in the Dosewallips State Park campground and to the north of the main channel of the river.

North of Brinnon drift cell JE-24 is 17.1% bulkheaded, including several sections of bulkhead extending below the high water mark (Hirschi et al 2003b). This can decrease shallow water habitat and the recruitment of sediment into the nearshore in addition it can also impact the along shore transport of sediment, particularly in the area just north of Seal Rock Campground where there are numerous private boat ramps (WDOE 2001).

Restoration Opportunities

Removing or replacing bulkheads with soft bank protection methods would improve along shore transport of sediment north and south of Brinnon, as would the removal of boat ramps. Several dikes are currently being removed from the Dosewallips estuary- this work will improve and increase estuarial habitat. The Highway 101 crossing of the Dosewallips River delta truncates and restricts river and tidal channels; restoring the hydrological function of these channels presents a restoration opportunity.

Public Access

Dosewallips State Park offers public camping and access to the delta and uplands at he mouth of the Dosewallips River. Olympic National Forest's Seal Rock Campground is north of Brinnon and offers camping and shoreline access.

Preliminary Nearshore Reaches

South Dosewallips: Drift cell JE-25, south edge of Dosewallips River delta to northern edge of Pleasant Harbor
Brinnon: Dosewallips River delta
North Brinnon: northern edge of Dosewallips delta to the end of drift cell JE-24, in Right Smart Cove

Dosewallips River

The Dosewallips River drains the eastern Olympic Mountains from its headwaters in the vicinity of Mt. Claywood emptying into Hood Canal at the town of Brinnon (Map 4). The watershed covers approximately 78,000 acres or 122 square miles (USFS 1999). The mainstem of the Dosewallips is 28.3 miles long with tributaries contributing another 140 miles. Overall, the tributaries are steep and the lower mainstem relatively gradual with meanders (Correa 2003 and USFS 1999). Private inholding and hence county jurisdiction ends at about river mile 9- a mile downstream from the Steelhead Campground. Currently the Shoreline of the State designation ends at the Olympic National Forest Boundary at about river mile 6.

The upper 60% of the watershed is in Olympic National Park, the middle 30% is in the National Forest and the lower 10% is in private ownership with land use dominated by residential development, pastureland and timberland. Annual average discharge is 446 cfs at the gauging station at river mile 7.1. There are two runoff peaks- one associated with the winter rains between November and February and another associated with snowmelt in May and June (USFS 1999 and Correa 2003).

Anadromous Fish

The Dosewallips supports chinook, fall and summer chum, pink and coho salmon as well as steelhead and cutthroat trout spawning (Correa 2003 and May 2003). Chinook are part of the Mid- Hood Canal stock and are rated as critical with escapement below the critical escapement threshold of 400 fish for the stock. The Mid Hood-Canal stock includes chinook in the Hamma Hamma, Duckabush and Dosewallips Rivers. Spawning takes place in the lower 12 miles of river between September and October with most spawning taking place below river mile 6.7 (Correa 2003). Summer chum spawn in the lower 2.3 miles of river from mid-September to mid-October. They are rated as a depressed stock in SASSI and are federally listed as threatened under the Endangered Species Act. It is a native stock with wild production.

Dosewallips summer chum declined in the 1980's but have recently demonstrated an improvement (Correa 2003). Fall and late-fall chum also spawn in the Dosewallips and these stocks are rated as healthy. Coho spawn primarily in the lower 12 miles of the mainstem and in the lower reaches of numerous tributaries. This coho stock is wild production of mixed composition due to past hatchery releases. Its SASSI stock status is rated as unknown. Pink salmon are rated as depressed after a decline from returns ranging from 400,000 to 100,000 spawners in the 1960s to 10,000 to 40,000 spawners in the 1980s to low returns in the late 1990s of about 2000 to 3000 spawners. Spawning takes place in the lower seven miles of the mainstem. Summer steelhead stocks are rated as unknown in SASSI and winter steelhead are rated as depressed (Correa 2003).

Anadromous Fish Habitat

There are no artificial barriers to anadromous fish in the Dosewallips, although a natural falls is a complete barrier at river-mile 12.5. However, starting in the 1880s, development has transformed the lower river from a valley with many side channels, wetlands and logjams to a channelized river with adjacent farmland. Restricted access to major side channels and floodplain due to diking occurs in the lower mile, at river-mile 2 at the lazy C housing development and in the vicinity of river-mile 5 a mile long side channel has been isolated. Side channels are important spawning areas and over wintering areas for salmonids (Correa 2003 and May and Peterson 2003).

The Dosewallips, below the anadromous fish barrier at river-mile 12.5, was found to harbor some of the best remaining refugia for salmonids in eastern Jefferson County (May and Peterson 2003). In particular several reaches are noted for the high quality of spawning habitat. These are: river-mile 0-1.8 Brinnon flats to Lazy C flats, river-mile 4.5 to 5.3 Walcott Flats and river-mile 7-7.8 Middle-River flats.

Restoration Opportunities

Efforts should be made to open up side channel and floodplain habitat from bank armoring and channelization. A recent property acquisition by Jefferson County in the vicinity of the Lazy C development will prevent development and allow for the natural creation of side channels. As mentioned above, in the nearshore segment, much work needs to be done in the lower Dosewallips and estuary to restore a more natural estuary with side channels and salt marshes.

Preliminary Reach Breaks

At river-miles 0, 1.8, 4.5, 5.3, 6 to take into account the spawning reaches mentioned above and jurisdictional boundaries.

Jackson Cove

This shoreline stretches from the head of Right Smart Cove to Point Whitney and encompasses Jackson Cove, Wawa Point and Pulali Point (Map 5). Unlike most of Jefferson County's marine shoreline this area is dominated by a rocky basaltic shoreline with pocket beaches. Three drift cells occur within this section of shoreline and several areas of no net drift. This shoreline is free from Highway 101 which veers inland to go over Mount Walker, hence it is a bit less developed of an area with scattered residential development, a boy scout camp and the State Shellfish Lab at Point Whitney. Jackson Cove was identified in the Willamette Valley- Puget Trough- Georgia Basin Ecoregional Assessment as a priority conservation area for its high quality nearshore and terrestrial habitat.

Ecological Background

Along the eastern shore of Right Smart Cove drift cell JE-23 extends from 200 meters west of Wawa Point 300 meters to the northwest to converge with drift cell JE-24 at the head of Right Smart Cove. Glacial drift overlies basalt at the cell origin, where a thin, coarse gravel beach sits atop a wide, basalt wave-cut platform (Johannessen 1992). Pacific herring spawn in eelgrass along the entire length of Right Smart Cove. Sand lance spawn on the beaches on the east side of Right Smart Cove (WDFW 2005). Riparian vegetation overhangs about 25% of the shoreline in this reach (WDNR 2001 and Penttila 2000).

A large salt marsh lagoon is situated behind the barrier beach at the head of Right Smart Cove and is part of the Wawa Point bald eagle territory (WDFW 2004).

Wawa Point is comprised of basalt and there is no net drift in this area (Johannessen 1992). There is a bald eagle nest on Wawa Point (WDFW 2004).

North of Wawa Point, within the WaWa point reach, there is no appreciable net shore drift along this basaltic shoreline for 660 meters (Johannessen 1992). Eelgrass is continuous and herring use it for spawning substrate (WDNR 2001 and Penttila 2000). Riparian vegetation covers about half of the shoreline (WDNR 2001).

Western Jackson Cove reach encompasses drift cell JE-22 and is isolated between areas of no net drift. It stretches for 900 meters along the western shore of Jackson Cove to terminate at southern edge of the Spencer Creek delta. There is little sediment transported in this drift cell due to a lack of overlying sediment on the basalt (Johannessen 1992). Marple Creek supports spawning populations of coho and chum salmon (Correa 2003). Eelgrass is continuous throughout this reach of shoreline (WDNR 2001). Herring use this eelgrass for spawning substrate from Wawa Point north to the middle of Jackson Cove (WDNR 2001 and Penttila 2000).

Jackson Cove from Spencer Creek delta around Pulali Point is an area of no net drift with pocket beaches between basaltic headlands and a large alluvial fan at the mouth of Spencer Creek. Spencer Creek supports Coho and Chum salmon spawning. Sand lance spawn on the beach near the Boy Scout Camp, east of Spencer Creek (Penttila 2000). Patchy eelgrass beds grow off shore between Spencer Creek and Pulali Point (WDNR 2001). Osprey and Bald Eagles nest in the vicinity of Pulali Point while all of Jackson Cove is bald eagle territory (WDFW 2004). This area is rather unique for Jefferson County, being a basaltic cliff dominated shoreline reminiscent of many areas of the San Juan Islands.

One half mile north of Pulali Point the Point Whitney reach begins concurrent with drift cell JE -21 and continues northward for 1.5 miles to end at the 100 yard wide beach just north of the Point Whitney Shellfish Lab (Johannessen 1992). Herring spawn on the eelgrass off of Pulali Point north to Point Whitney (Penttila 2000). Although riparian vegetation increases to about 30 % in the north, it is absent in front of the State Shellfish Lab. There is a small wetland located behind a barrier beach 900 yards south of Pt. Whitney. The accretionary beach at northern end of this reach encloses a lagoon that has been highly altered for use by the shellfish hatchery at the State Shellfish Lab at Point Whitney (Correa 2003, WDOE 2001 and Johannessen 1992). However, the lagoon and the surrounding tidelands are a popular shell fishing spot for clams and oysters (Speck personal communication 2003). Sand lance and surf smelt spawn on the beach in front of and to the north of the shellfish lab (WDFW 2004).

Shoreline Alterations

The terminus of drift cell JE-23 in Right Smart Cove is bulkheaded with cement high up in the intertidal and does not appear to have led to a coarsening of beach sediment (based on aerial photos)(WDOE 2001). Just south of the mouth of Marple Creek there is bulkheading and fill. Approximately 20% of the West Jackson Cove reach (drift cell JE-22) is armored (Hirschi et al 2003). The shoreline in front of Camp Parson in Jackson Cove is completely bulkheaded. The area between Camp Parsons and Pt Whitney is largely free of modifications accept for a few docks and short bulkheads. The area around Point Whitney Shellfish Lab is highly altered with bulkheading in front of the parking lot and the lagoon reshaped to serve a now inactive shellfish hatchery.

Restoration Opportunities

The removal of the bulkhead in front of Camp Parsons would afford better access to the beach for the Boy Scouts and create more of a natural backshore; currently there are few if any structures that are being protected by it. The fill near the mouth of Marple Creek could be removed to improve net shore drift. Extensive restoration of the area surrounding Pt. Whitney could be undertaken by relocating the parking lot to an upland location, removing fill and returning the spit and lagoon to a more natural state.

Public Access

The only public shoreline access by land to this area is at the State Shellfish Lab at Pt. Whitney with a beach and a boat ramp. There is DNR tideland just southeast of Camp Parsons with no current public access by land. However, this may be a site where public access can be obtained either through Boy Scout land or other private lands off of Pulali Point Road.

Preliminary Nearshore Reaches

Right Smart Cove: WaWa Point northwest to the head of Right Smart Cove
Right Smart Cove Lagoon: The salt marsh lagoon at the head of Right Smart Cove
WaWa Point: WaWa Point north to the origin of drift cell JE-22 in Jackson Cove
West Jackson Cove: Drift cell JE-22
Jackson Cove: Area of no net drift within Jackson Cove and around Pulali Point
Point Whitney: drift cell JE-21, facing Dabob Bay
Point Whitney Lagoon: modified lagoon adjacent to Point Whitney State Shellfish Lab

Quilcene Bay

Quilcene Bay contains three drift cells and a large area of no net drift (Map 6). There are forested headlands along much of the backshore and large mud flats in northern end of Quilcene Bay. The sizable Little and Big Quilcene Rivers flow into northern Quilcene Bay through the town of Quilcene creating an extensive estuary at the head of the bay. Although the town of Quilcene is situated inland, associated with it are a marina and shellfish processing area on the northwest shore of the bay. The harvesting of clams and oysters are a major business in this part of Jefferson County. Residential development is concentrated in the northwest and northeast shores of the bay. Three lakes lay within the Quilcene Bay basin: Lords Lake and Lake Leland which drain into the Little Quilcene watershed and Rice Lake which is part of the Donovan Creek watershed. Further north than Brinnon, thus further into the rain shadow of the Olympic Mountains, Quilcene receives about 50 inches of precipitation a year.

Preliminary Nearshore Reaches (Map 6)

West Quilcene Bay: Point Whitney to Quilcene Boat Haven, encompassing drift cells JE-19, JE-19/ JE-20 and JE-20.
Quilcene Boat Haven: one reach encompassing the Quilcene Boat Haven and the shellfish aquaculture facility immediately to the north.
Linger Longer: The residential area north of the Boat Haven to the southern edge of the Indian George estuary.
Quilcene Estuary: from Indian George estuary north to encompass the estuaries of the Big and Little Quilcene Rivers and Donovan Creek.
East Quilcene: From the east edge of the Donovan Creek Estuary south to the terminus of drift cell JE-18.
JE-18: North edge of Fisherman's Point Salt Marsh to the terminus of drift cell JE-18.
Fisherman's Point Salt Marsh: Encompasses the marsh and barrier beach at Fisherman's Point.

Ecological Background

In the West Quilcene Bay reach between Point Whitney and the Quilcene Boat Haven two drift cells diverge from an area a half mile south of Frenchmen's Point (Map 6). This divergent area contains actively eroding feeder bluffs of glacial drift intermittently overlying areas of basalt. Drift cell JE-20 originates in this area of divergence and northerly fetch from Quilcene Bay creates southward net shore drift for one mile to the confluence with drift cell JE-21 just north of Point Whitney. North of this divergent feeder bluff area, southern fetch governs the net shore drift of sediment in drift cell JE-19 north to its terminus at the Quilcene Boat Haven (Johannessen 1992). A stream draining Devil's Lake also contributes fluvial sediment to this drift cell (Correa 2003).

This is an area of few homes and steep eroding bluffs. Riparian vegetation is nearly continuous throughout this stretch of shoreline (WDOE 2001). Patchy eelgrass beds occur throughout. Oysters and barnacles are continuous (WDNR 2001). Bald eagles also use this area as habitat (WDFW 2004). Surf smelt spawn just south of Frenchman's Point and at the beach about 500 yards south of the Boat Haven (Long et al. 2003). Sand lance spawn just south of the Boat Haven (Penttila 2000).

The Quilcene Boat Haven has a small marina and a shellfish hatchery and boat ramp immediately to the north. Eelgrass is patchy in front of the Boat Haven. Just north of this is a residential area along Linger Longer Road. Eelgrass is continuous along this reach and hardshelled clams are abundant.

Between the Quilcene Boat Haven to a point approximately 1.3 km south of East Quilcene there is no appreciable net shore drift within the Quilcene Estuary reach (Johannessen 1992). The delta of the Big Quilcene River, the Little Quilcene River and Donovan Creek lie with in this section. It is an area of winding tidal channels and salt marsh (Correa 2003). Eelgrass is continuous throughout the northern end of the bay and herring use it for spawning (WDNR 2001 and Penttila 2000). Quilcene Bay is famous for its clam and oysters and there are several commercial and recreational shellfish harvesting areas throughout the bay. For example, the allowable, sustainable harvest of manila clams for the WDFW property on Linger Longer Road was about 39,000 pounds in 2003 (Speck, personnel communication 2003). Every effort should be made to preserve water quality to allow for the flourishing of the shellfish industry here. Unfortunately the northern part of the Quilcene Bay is on the TMDL 303d list due to fecal coliform contamination and is periodically closed to shellfish harvest (WDOE 1998 and Correa 2003). In the winter large concentrations of waterfowl are found in northern Quilcene Bay including trumpeter swans, brandt and diving ducks (WDFW 2004).

Drift cell JE-18 begins just south of Fisherman's Point in a broad area of divergent drift at the base of the Bolton Peninsula. Governed by southern fetch, net shore drift is northward for 2.6 miles along the eastern shore of Quilcene Bay. Its origin is at a poorly vegetated, eroding bluff comprised of glacial drift. Northwestward net shore drift is indicated by a northwestward bluff vegetation increase, northeastward spit progradation enclosing a salt marsh north of Fisherman's Point, northerly sediment size decrease, nearshore bars oriented northwest-southeast and sediment accumulations on the south side of a filled area in northern Quilcene Bay. The cell's terminus is located at the base of this filled area, as shallow depths prohibit waves from forming that are large

enough to cause significant amount of sediment transport. Northern Quilcene Bay is slowly shoaling with sediment transported from the Quilcene Rivers and Donovan Creek. The bluffs along this drift cell are generally considered unstable with many recent landslides. Except for the area immediately surrounding Fisherman's Point, which is comprised of Tertiary Sandstone, these bluffs are made up of Double Bluff Drift and undifferentiated glacial stratified sediment predating the Vashon Glaciation (Johhannessen 1992 and WDOE 1978).

Surf smelt spawn throughout the southern two thirds of this drift cell (Long et al. 2003). A two acre salt marsh is enclosed by a spit just north of Fisherman's Point (Fisherman's Point Saltmarsh)(Leon and Driscoll 1975 and WDOE 2000). North of Fisherman's Point, eelgrass beds are continuous throughout the reach and herring use it for spawning (WDNR 2001 and Penttila 2000). The east shore of Quilcene Bay is a year round haul out site and seasonal pupping site for harbor seals (WDFW 2004). Riparian vegetation is heavy through the reach (WDNR 2001).

Shoreline Alterations

Shoreline alterations are concentrated in near the boat haven, east Quilcene and in the area of no net drift in northern Quilcene Bay. North of Point Whitney, shoreline modifications are absent from the West Quilcene Bay reach. At the terminus of JE-19 the Quilcene Boat Haven and residential and business areas to the north are extensively bulkheaded (WDNR 2001, WDOE 2001, Hirschi et al 2003b). However, bulkheads to the north encroach into the nearshore, impacting vital shallow water habitat for migrating juvenile salmonids (Correa 2003). The estuary of Indian George Creek has been partially restored by removing dikes, fill associated with a parking lot at a WDFW shellfish harvesting site and an abandoned barge. In the Quilcene Estuary diking has eliminated large amounts of high salt marsh, intertidal channels and riparian vegetation based on differences between the 1880's coastal surveys and current air photos (Correa 2003). A large area of fill extends into the intertidal zone in East Quilcene Bay at the terminus of drift cell JE-18. This fill eliminates shallow water habitat. Despite this feature, drift cell JE-18 has retained fluvial function with little shoreline alteration south of its terminus (WDOE 2001).

Restoration Opportunities

Restoration needs in Quilcene Bay are centered in the deltas of the Big and Little Quilcene Rivers. In the lower Big Quilcene River potential actions include the removal of dikes, restoration of salt marsh habitat and the reconnection of the main river channel with tidal channels. Plans for this are currently being developed by the Jefferson County Public Works and other partners. Between the Quilcene Boat Haven and Indian George Creek, in the Linger Longer reach the shoreline could be further restored by using soft armoring techniques. Removing dikes on both banks could restore the estuary of the Little Quilcene River. East Quilcene Road interferes with natural backshore sediment processes and constricts Donovan Creek; if possible the road should be reconfigured to allow for these processes. Acquiring and removing filled area at terminus of drift cell JE-

18 would allow for natural deposition of sediment into northern Quilcene Bay and increase shallow water habitat.

Public Access

Public access to Quilcene Bay is available by land at Pt. Whitney Shellfish Lab, on Port land of off Linger Longer Road, the public shell fishing site of off Linger Longer Road (owned by WDNR upkeep by WDFW), WDFW property in the Quilcene Delta and East Quilcene County Park. WDNR also owns the shoreline south of the Quilcene boat haven.

Big Quilcene River

The Big Quilcene River flows out of the Olympic Mountains, south of the town of Quilcene and into Quilcene Bay (Map 7). Its watershed is 69.5 square miles with a main stem length of 19 miles and tributary length of 80 miles with elevations up 7800 feet. 31% of the watershed (the headwaters of the Big Quilcene) is protected in the USFS Buckhorn Wilderness and the Olympic National Park. Downstream of this most of the watershed is managed as commercial timberland. Jefferson county zoning indicates 93% of the watershed as timberland (includes public and private working timberland), 4% rural residential, 0.2% agricultural and 0.1% commercial (Correa 2003).

The city of Port Townsend maintains a 30 cfs water right. This water is diverted out of the basin at river mile 9.4 (Ames et al. 2000). What effect his diversion has on the overall hydrology and fish habitat quality is unknown (Correa 2003).

There are no natural barriers to anadromous fish below the National Forest boundary at about river-mile 4.0. However, the Quilcene National Fish Hatchery operates an electronic weir at river-mile 2.8. When this weir is in operation between September and December it is a total barrier to upstream passage of fish. It is also a barrier during low river flows. In addition the fish hatchery diverts water form the Big Quilcene and also from Penny Creek, a tributary. This water intake structure permanently blocks fish access to Penny Creek- a potentially excellent refugia area (Correa 2003, May and Peterson, 2003).

From the mouth to river-mile 1.1 the extensive diking and armoring isolates the river form its flood plain. This has also lead to channel aggradation, which has increased channel streambed elevation and extended the river mouth 1700 feet into the estuary between 1971 and 1993. In sum these modifications have lead to a nearly complete loss of floodplain habitat (Correa 2003). Large woody debris is for the most part absent and there is no pool habitat for salmonids. However, this section remains important as habitat as it supports spawning by fall chum, summer chum and pink salmon. Summer chum salmon are an ESA listed species as threatened. Temperatures in this section where rated as poor for spawning and rearing at the Rogers Street Bridge (river-mile 1.1) (Correa 2003 and May and Peterson 2003). This reach was listed on the 1998 303d list due to poor fish habitat (WDOE 1998).

From river-mile 1.1 to the Fish Hatchery at river-mile 2.8 habitat improves somewhat. Between the river-mile 1.1 and the Highway 101 Bridge large woody debris is accumulating although overall levels are still low. This section has good instream

structure and side channel development. The riparian zone is also recovering (Correa 2003). This section supports fall and summer chum, coho and pink salmon (May and Petersen 2003).

The reach of the river that flows by and through the National Fish Hatchery has been modified by riprap, water diversion and an electronic fish weir (Correa 2003). Upstream to the National Forest Boundary the river flows by the Hiddendale residential development where there is some diking and rap rip and development in the flood plain. However, in general, the channel is allowed to migrate in this section. The frequency of pools increases in this section as well. The condition of the riparian is poor throughout the Hiddendale development due to clearing (Correa 2003).

Restoration Opportunities

If possible, allow for fish passage into Penny Creek around the Fish Hatchery water intake. Allow for fish passage upstream of the Fish Hatchery and make habitat improvements in this area. Below river mile 1.1 the extensive diking and constricting of the channel needs to be addressed by removing dikes and fill. Increasing estuary function and salt marsh habitat is important for summer chum survival.

Preliminary Reach Breaks

At the Rogers Street Bridge (river- mile 1.1), the fish hatchery (river-mile 2.8) and at the National Forest boundary.

Little Quilcene River

The Little Quilcene River's headwaters are on the northern side of Mount Townsend in the northeast Olympic Mountains (Map 7). It flows generally southeast to empty into northern Quilcene Bay just north of the town of Quilcene. In contrast to other rivers flowing out of the northeast Olympic Mountains, very little of the Little Quilcene's headwaters are protected in the National Park or National Forest Wilderness. County jurisdiction begins at river mile 6 at the Olympic National Forest boundary. Downstream from there it flows through commercial timberland for a roughly two miles and then through rural residential land, and finally through about a half mile of agricultural land just upstream from the mouth. A total of 52% of the watershed is zoned forestry, 17% rural residential and 0.8 % agriculture (Correa 2003) A portion of the middle reach, west of and roughly parallel to Highway 101, is on the 1998 303d list for water temperature (WDOE 1998). There are no barriers to fish migration in the lower six miles of the river (Correa 2003).

There is a water diversion of 9.6 cfs with a 6 cfs minimum flow requirement for the City of Port Townsend's water supply into Lords Lake. This diversion is within the national forest at river-mile 7.1, however this affects the downstream water flow within the county's jurisdiction.

Summer chum, fall chum and coho salmon and winter steelhead trout spawn in the Little Quilcene. This summer chum salmon run is part of the Hood Canal Summer Chum ESU and is listed as an ESA threatened species. Both the fall and summer runs of

chum have been extremely low in recent years and both runs contain strays from the Big Quilcene hatchery (Correa 2003). The coho run on the Little Quilcene is a distinct stock from that on the Big Quilcene with a significantly latter run timing. The status and origin are unknown of the winter steelhead run on the Little Quilcene (Correa 2003).

The lower Little Quilcene was divided up into three Nodal Riparian Corridors, all classified as type B, by May and Peterson. The first extends from the mouth to river mile 0.8. This reach of stream has been heavily impacted by channelization, loss of floodplain habitat, levee construction, upstream water withdrawal, loss of large woody debris, forest conversion to agriculture and pastureland, gravel dredging and residential land uses. It, however, remains however important spawning habitat for summer and fall chum salmon (May and Peterson 2003). The lower 0.2 miles has good pool habitat but this habitat feature diminishes upstream. Due to the poor condition of the streamside riparian, dominated by alder and invasive species, the future recruitment of coniferous large woody debris looks poor (Correa 2003).

The second nodal riparian corridor is from river mile 0.8 to river-mile 3.0. This reach of stream has also been impacted by loss of large woody debris and conversion of floodplain habitat to agriculture and pastureland. This area again serves as spawning habitat for summer chum and other salmonids. It is estimated that about 50% of the floodplain of the lower Little Quilcene has been developed (May and Peterson 2003).

The final nodal riparian corridor is from the river-mile 3.0 to the anadromous barrier at river-mile 6.8. For our study we will limit discussion to the National Forest Service Boundary at river-mile 6.0. Data sets covering this entire section are rare, however, there is some data for certain segments within this reach. Between river-miles 2.7 and 5.2 percent pool habitat is poor at 23 to 25 %. Large woody debris is generally lacking, however, it appears that there is a potential for recruitment if the riparian zone can be preserved. The riparian zone is rather narrow but does appear to have a high percentage of conifers (Correa 2003).

Restoration Opportunities

In the middle reach of the Little Quilcene riparian plantings would shade the river and improve habitat where there is a lack of riparian cover. Floodplain acquisition and restoration could be completed where possible to provide off channel rearing opportunities for salmonids. In the lower reach riparian planting would lead to increasing future large woody debris recruitment. In the delta and estuary removing or pulling back dikes and levees to create channel sinuosity and connectivity. This action would also increase salt marsh habitat.

Preliminary Reach Breaks

Reach breaks for the Little Quilcene to reflect habitat type, condition and land use patterns: river mouth, river-mile 0.8, river-mile 3.0 and the Olympic National Forest Boundary.

Lake Leland

Lake Leland is in the Little Quilcene River watershed and is located north of Quilcene (Map 7). Its surface area is 108 acres. It is surrounded by moderately dense rural residential development (Rural Residential 1:5). It is presumed habitat for coho, steelhead and cutthroat trout and bald eagle foraging territory. Growth of the invasive weeds reed canary grass and brazilian elodea have created habitat problems and extremely low dissolved oxygen conditions in the summer (Correa 2003). Leland creek downstream of Lake Leland also has issues with high temperatures- this issue may extend to the lake as well. There is public access to the lake via a county boat launch and a county park that includes camping.

Lords Lake

Lords Lake reservoir is part of the water supply system for the City of Port Townsend (Map 7). Created by damming Howe Creek, water is diverted from the Little Quilcene River into it. The city has a 9.6 cfs water right to the Little Quilcene River to fill Lords Lake. Water from the lake is used during times when water cannot be diverted for use from the Big Quilcene River due to low flows or excessive suspended sediment. There is no public access to Lords Lake.

Rice Lake

Rice Lake is located north of Quilcene and has a surface area of 20.3 acres. The northwest portion of its watershed is zoned RR 1:5, the remainder of the watershed is a mix of commercial and rural forest and RR 1:20. Wood ducks nest along its shores (WDFW 2004). Rice Lake drains via a small tributary to Donovan Creek and then into Quilcene Bay.

Dabob Bay

Dabob Bay is a long bay with relatively little development along its shores and steep eroding feeder bluffs interspersed with low, forested bluffs (Map 8). There are several spit and salt marsh complexes, including the estuary of Tarboo Creek at Dabob Bay's northern tip, Broad Spit, Tarboo Bay, the mouth of Camp Discovery Creek and at Zelatched Point. These marshes have been found to be important stops for migrating juvenile summer chum. Tarboo Creek flows into Tarboo Bay and is supports runs of coho and fall chum salmon.

Dabob Bay has some residential and vacation homes along its shores primarily concentrated at Lindsey's Beach, Camp Discovery and Camp Harmony. The U.S. Navy uses Dabob Bay as a torpedo and submarine testing area and a small base at Zelatched Point supports these operations. Overall this region maintains a rural natural character. As in Quilcene Bay, Dabob Bay is a major shellfish producing area.

Tarboo Lake is located adjacent to the upper Tarboo Creek watershed, although it has no outlet a brief characterization of it is included in this section.

Ecological Background

Dabob Bay is bounded by long drift cells on each side, to the west JE-17 (5.9 miles) and JE-16 (13 miles) to the east. JE-17 originates on the southern Bolton Peninsula and has a general northward net shore drift along the western shore of Dabob Bay to terminate at Tarboo Bay. It originates from a broad zone of drift divergence west of Red Bluff included in the south Bolton Peninsula reach. This feeder bluff consists of red course grained sandstone and conglomerate that is overlain by sandy glacial drift fronted by a poorly sorted beach. This steep bluff is poorly vegetated and has experienced recent slope failure. Evidence of northeast followed by northern drift includes the presence of red sand on the beach northeast of the red sandstone outcrop at the cell origin, northward sediment size decrease, northward progradation of Broad Spit, and the northeastward progradation of nearshore bars at the head of the bay. Protected within these bars is Tarboo Bay, composed primarily of mad flat and slowly filling with sediment supplied by Tarboo Creek (Johannessen 1992). The shoreline along the west side of Dabob Bay is generally considered unstable, except for low areas around Lindsey's Beach and Broad Spit. The bluffs here are, in general, comprised of a shallow layer of Vashon Till overlying thicker layers of undifferentiated stratified sediments and a base of Double Bluff Drift. It is prone to failure and contributes abundant sediment to the nearshore (WDOE 1978 and Correa 2003).

Eelgrass beds are patchy or continuous throughout this drift cell. However, they are absent from Tarboo Bay (WDNR 2001). Broad Spit has both commercial and recreational shellfish harvesting (Correa 2003). There is also a Bald Eagle nest at Broad Spit. Broad Spit contains a salt marsh of about two acres, sand lance and surf smelt spawn on the north side of the spit, and juvenile summer chum were found in the salt marsh and along shore (Leon and Driscoll 1975; Penttila 2000; Long et al. 2003; Bahls 2004). Sand lance and surf smelt spawning are documented at nine sites north of Broad Spit in the northwest Dabob Bay reach (Long et al. 2003). Riparian vegetation appears to be healthy in these reaches along western Dabob Bay except in areas of absence due to bluff erosion and isolated development (WDOE 2001).

In the East Dabob Bay reach runs the longest drift cell in Eastern Jefferson County, JE-16, net shore drift is northward for 13 miles from just north of Oak Head to Long Spit. The drift cell originates within the broad zone of divergence between Tskutsko Point and Oak Head. Northward net shore drift is indicated by northward and northeastward stream mouth offset throughout the drift cell, northward spit progradation north of Camp Harmony, sediment accumulation on the south side of rock groins north of Camp Harmony, the erosional nature of the bluff at the southwest shore 1.3 mile north of Camp Discovery and the northward bluff vegetation increase north of this location and the northward progradation of the mile long spit (Long Spit) at the drift cell's terminus (Johannessen 1992). Along this shoreline there are numerous areas of recent sliding and, except for some areas of low marsh and Long Spit, it is classified as unstable. In general the bluffs here are comprised of a relatively thin layer of Vashon Till, overlying Vashon advance outwash, a large layer (several hundred feet) of undifferentiated stratified sediments on a base layer of Double Bluff Drift. Numerous slides mark the shoreline, including a spectacular slide between Long Spit and Camp Discovery that is roughly 120 yards high, 160 yards wide and extends about 100 yards into the intertidal (WDOE shoreline photo #010522-111636). Just south of this slide are several homes perched on top of similar, steep, high bluffs (WDOE 2001 and WDOE 1978).

Eelgrass beds are patchy at the origin of the drift cell, but with few exceptions, are continuous along East Dabob Bay (WDNR 2001). A salt marsh lagoon at the mouth of a presumed salmon stream occurs just north of Zelatched Point (Correa 2003). Dabob Bay is a major breeding habitat for bald eagles with recent nests near Camp Harmony, at Tabook Point, South of Tabook Point and at Tskutsko Point. There is a Great Blue Heron rookery at Zelatched Point. Osprey nest at the northern end of Tarboo Bay, near Camp Discovery and at Zelatched Point (WDFW 2004). Camp Discovery Creek salt marsh was seined for fish use by Hirschi in 2002 and found to harbor juvenile chinook, coho and chum salmon (Hirschi et al. 2003a). This watershed also supports coho and chum spawning (Correa 2003). Forage fish spawn in numerous locations along this drift cell. Sand lance spawn south of Tabook Point, just south of Long Spit and near the terminus of Long Spit. Surf smelt and sand lance spawn discontinuously (9 confirmed sites) from Tabook Point 1.5 mile to the north. There is another cluster of four spawning sites due west of Silent Lake and another cluster of five stretching for a kilometer south of Camp Discovery (Penttila 2000 and Long et al. 2003). It is clear from the multitude of forage fish beach spawning sites that Dabob Bay it is an important area for health of these stocks. Every effort should be made to preserve the eroding bluffs that contribute sediment to the nearshore to maintain these beaches (Correa 2003).

The barrier spits at the head of Tarboo Bay and Long Spit are home to rare plant communities of native salt marsh and berm plants such as red fescue and Japanese beachpea. It is identified as one of the best spit habitats with native vegetation in Washington State and is currently protected by the Washington Department of Natural Resources' Natural Heritage Program and is jointly owned by the DNR and The Nature Conservancy. The adjoining lagoons were seined for fish use by Peter Bahls of the Northwest Watershed Institute in 2003 and these habitats were found to harbor significant populations of both natal and nonnatal juvenile chinook, summer and fall chum, coho and cutthroat trout (Bahls 2004).

Tarboo Creek runs into the head of the bay and supports coho, chinook and chum salmon spawning and the lower mile of the creek is in pristine condition and is owned by WDFW (Correa 2003). For this reason the Tarboo Bay estuary, spit and lagoon complex should also be afforded county protection as a natural shoreline.

Shoreline Alterations

Lindsey's beach and several areas north of Tabook Point on the east shore are relatively heavily armored (60% at Lindseys Beach) fortunately these are pockets between pristine and relatively untouched shoreline. There are several houses perched on top of eroding bluffs that could be a problem if property owners want to armor the toe of bluff in an attempt to decrease the rate of erosion i.e. the home in ecology photo number 010522-110544. Generous setbacks should be encouraged or required to preserve property values and ecological function. In general, however, fluvial processes appear to be healthy in western Dabob Bay with shoreline armoring concentrated in areas without bluffs and hence, most likely not contributing much sediment to the nearshore. These no bluff areas were about 11% armored (out of a total of 13 km) versus about 2% of the high or low bluff armored (out of a total of 23 km) (Hirschi et al. 2003b).

Along the eastern shore of the bay drift cell JE-16 is 6% armored out of 19 km of total length (Hirschi et al 2003b). Some of these structures may interfere with the along shore transport of sediment- particularly a set of groins south of Camp Discovery.

Restoration Opportunities

Remove shoreline structures that interfere with along shore transport of sediment and replacement with soft bank armoring. Otherwise there are few restoration opportunities within Dabob Bay- the protection of the high quality habitat within the bay should be paramount.

Public Access

At the head of Tarboo Bay there is public WDFW land. There is boat access to Broad Spit, with DNR tideland with extensive shellfish beds and county owned uplands. There are WDFW public tidelands on the east shore of the bay north of and adjacent to Camp Discovery and another North of Tabook Point. Between the Navy Property at Zelatched Point and Fishermen's Harbor there is South Toandos State Park that includes the beaches along this shoreline, but no upland access.

Preliminary Nearshore Reaches

South Bolton Peninsula: Area of divergence drift between drift cells JE-17 and JE-18.
Lindsey Beach: From the origin of drift cell JE-17 to the southern edge of Broad Spit.
Broad Spit: Encompasses Broad Spit county land.
Northwest Dabob Bay: north edge of Broad Spit to the southern edge of Tarboo Bay barrier spit.
Tarboo Bay Barrier Spits: Encompasses the barrier spit on the western side of the bay.
Tarboo Bay: Area north of the barrier spits and Long Spit.
Long Spit: shoreline on and adjacent to Long Spit that is currently WDNR Natural Heritage Area.
East Dabob: Area between Long Spit and the origin of drift cell JE-16.

Tarboo Lake

Tarboo Lake is located between Hwy 104 and Lake Leland within commercial forestland (Map 19). It has no outlet and has surface area of 20.3 acres. There has been no recent timber cutting adjacent to the lake. It is a popular trout fishing lake. Public access is provided by a WDFW owned boat ramp.

Southern Toandos Peninsula and Thorndyke Bay

This Hood Canal shoreline faces Kitsap County (Map 9). The uplands are relatively low glacial deposits and the dominant land use is commercial timberland. Areas of shoreline residential use are concentrated at the southern end of the Toandos

Peninsula, south of the Thorndyke estuary, South Point and Bridgehaven. There are long stretches of pristine shoreline south of the Thorndyke Creek estuary. The Thorndyke estuary is one of the finest examples of an unaltered creek estuary in Jefferson County. There are three drift cells along this shoreline. The Nature Conservancy has identified this area as a priority conservation area.

Ecological Background

The first reach along this shoreline is Southwest Toandos Peninsula that a zone of divergence that encompasses sediment sources for drift cells JE-16 and JE-15. The first drift cell in this shoreline, JE-15, has its origin at the broad zone of divergence between Tskutsko Point and Oak Head. Sediment is derived from bluffs cut into sandy glacial drift of the Double Bluff formation, pre Vashon Stade sediments and Vashon till. Net shore drift is to the southeast past Oak Head and Northeast to Hazel Point were the drift cell terminates at the end of a cuspate spit. Net shore drift is indicated by northeastward progradation of the bay mouth spit cross the mouth of Fisherman's Harbor and progradation of the cuspate spit at Hazel Point. It is thought that much of the sediment is lost to deep water (70 to 90 yards deep) immediately off of the point (Johannessen 1992). This shoreline is generally considered unstable with numerous recent landslides (WDOE 1978)

Major habitat features along this drift cell include a brackish marsh just northwest of Oak Head, Fisherman's Harbor estuary and mud flats and a salt marsh enclosed by Hazel Point. Two small drainages into Fisherman's harbor support chum and coho spawning (Correa 2003). Surf smelt spawn just northwest of Oak Head in the Southwest Toandos Reach (Long et al. 2003). Bald eagle territory includes the area between Tskutsko Point and Oak Head and the area between Fisherman's Harbor and Hazel Point. Several bald eagle nests are located in this vicinity (WDFW 2004). Riparian vegetation covers 60 to 80 percent of this shoreline, eelgrass beds are patchy to continuous throughout (WDNR 2001).

The East Toandos reach encompasses drift cell JE-14 and most of JE-13, from Hazel Point north to the Thorndyke estuary (Maps 9and 10). 2.25 miles northwest of Hazel Point begins drift cell JE-14 that has a net shore drift to the southeast to terminate at Hazel Point. Drift here is governed by a northerly fetch of up to 17 miles causing southward and southeastward net shore drift. Evidence of southward drift includes the buildup of sediment on the north side of boat ramps, southward stream mouth offset, and the progradation of Hazel Point (Johannessen 1992). Bluffs in this drift cell and in the zone of divergence to the north are considered unstable with several recent landslides. These bluffs are of similar composition to others on the Toandos Peninsula. Vashon Till overlying thicker layers of Possession Drift, older, undifferentiated stratified sediments and Double Bluff Drift (WDOE 1978).

Salt marshes occur at Hazel Point and behind an alongshore spit 1.7 km to the north (WDOE 1982 and 2000). The northern marsh may have been encroached upon from the north by the development of a road and boat ramp. Sand lance spawn just south of this salt marsh, these forage fish also spawn further north in the zone of divergence between JE-14 and JE-13 (Penttila 2000). Riparian vegetation is abundant throughout this drift cell except in a few areas of development and bluff face sliding (WDOE 2000).

Eelgrass is patchy in the northern section of this drift cell and largely absent toward the south (WDNR 2001). There is a bald eagle nest located north of Hazel Point (WDFW 2003).

Drift cell JE-13 originates from the same zone of divergence as JE-14, 3.6 km north of Hazel Point, and net shore drift is generally northeastward for 17 km to terminate at the northern tip of the South Point spit. Drift cell sediment is initially derived from exposed bluffs cut into sandy glacial drift and streams that are found intermittently along the cell. Northward and northeastward net shore drift to Thorndyke Bay is indicated by northward off set of two small deltas located two and one miles south of Brown Point, nearshore bars oriented northeast-southwest that are moving northward in the southern portion of the cell, progradation of two looped bars (that bear a superficial resemblance to cuspate spit but are much blunter) from uplands which project seaward just slightly and the northward stream mouth offset on these features (Johannessen 1992).

Eelgrass beds are patchy throughout the length of this cell (WDNR 2001). In general the East Toandos shoreline reach retains it function with undisturbed feeder bluffs interspersed by lower banks covered in healthy riparian vegetation. There is little shoreline alteration to interrupt along shore drift. Numerous alongshore spit salt marshes, often associated with small stream mouths occur, primarily on Navy property, between the origin of the cell and Thorndyke Bay (WDOE 2001). These are interesting features and should be investigated for juvenile salmonid use and protected from development. There are several bald eagle nests in the vicinity of Brown Point (WDFW 2004). Sand lance spawn in several locations north and south of Brown Point including on the along shore spit formations mentioned above (Penttila 2000 and Long et al. 2003).

Thorndyke Creek estuary is an example of an intact estuary of a mid sized stream, rare in the Puget Sound Basin. It is unique for several reasons, including the lack of road crossings, little residential development and beaver dams built in the lower reaches of the stream down to the high tide line (Correa, 2003 and Hirschi personal communication 2001). It has a large (32 acre) marsh and mud flat complex enclosed by a barrier beach (Leon and Driscoll 1975). Bald eagles and osprey nest in this area. Thorndyke Bay is a regionally significant over wintering site for waterfowl (WDFW 2004). This estuary should keep its natural designation and be protected from intrusive use do to its high value of habitat.

The North Thorndyke reach stretches between the Thorndyke Estuary and South Point. Just north of the estuary several homes sit on top of eroding bluffs (WDOE 2001). This is an area of frequent slides that contribute abundant sediment to this long drift cell (JE-13) and the shoreline is characterized by these eroding bluffs between areas of heavy riparian vegetation (WDOE 2001 and WDNR 2001). Sand lance spawn just north of the estuary (Penttila 2000). Nordstrom Creek runs into Hood Canal just south of South Point, its mouth is marked by a small salt marsh of the type favored by juvenile salmonids and coho and steelhead spawn upstream (Hirschi, personal communication 2004 and Correa 2003). There are a few houses in this area and appears to be a well functioning ecosystem.

South Point and Bridgehaven (South Point Reach), developments on the spit complex at the terminus of drift cell JE-13 have severely altered the deposition zone of this drift cell. Historically, net shore drift continued north of here to terminate at the head of Squamish Harbor (where JE-12 now terminates) however the dredging the entrance of

the marina at Bridgehaven and the jetty to the north of this entrance have interrupted continued net shore drift to the north (Hirschi et al 2003b and Johannessen 1992). The former ferry terminal at South Point also interrupts alongshore transport of sediment (Correa 2003).

Despite this shoreline alteration, Penttila found that sand lance spawn both south of South Point and north along the outside of the spit, however, in latter surveys conducted by North Olympic Salmon Coalition in 2003 no spawn was found (although this can be a result of sample timing) (Penttila 2000 and Long et al. 2003). Due to the armoring of this shoreline, a coarsening and eroding of the beach has occurred along the southern half of Bridgehaven, that has likely resulted in a decrease in the fine sediments needed by forage fish to spawn (Hirschi et al. 2003b). Behind Bridgehaven in a slough dredged for a marina, juvenile salmonids were not found, whereas they were found immediately to the north in the unaltered backshore of the spit at the origin of drift cell JE-12. In addition, an undersized culvert restricts the salt marsh on the inland side of South Point causing the loss of more juvenile salmonid habitat (Hirschi 2003b). Eelgrass beds are continuous along the outside of the spit (WDNR 2001).

Shoreline Alterations

There is no shoreline armoring of note along drift cell JE-15 in the Southwest, Oak Head and South Toandos Reaches. However there are several docks and over water structures in Fisherman's Harbor some of which look as if they have fallen into disrepair and may be able to be removed (WDOE 2001).

Just north of Hazel Point a residential bulkhead extends into the upper intertidal zone, possibly interfering with along shore transport of sediment to the point. This house is also set on the very seaward edge of the bulkhead. Besides this drift cell JE-14 is in good shape. The feeder bluffs in the zone of divergence between JE-14 and JE-13 are not armored. JE-13 is subject to only minor bulkheading until the broad point 1600 meters south of the Thorndyke Creek estuary. There are several extensive bulkheads and a private gazebo or deck structure on the backshore. Between the Thorndyke Estuary and South Point (North Thorndyke Reach) there are no bulkheads or shoreline alterations of note. Just south of the old South Point ferry dock there are several cement bulkheads that extend into the upper intertidal. From South Point ferry dock (now abandoned) northward through the Bridgehaven development the shoreline is severely altered. The entire outer shoreline of the former spit has been armored with riprap or concrete bulkheads while the complete interior side of the spit has a wooden seawall with backfill. In addition the former salt marsh has been dredged to provide for marina space. The access road to Bridgehaven blocks what little salt marsh remains. There is a riprap jetty north of the entrance to the marina that stops along shore transport of sediment. For a more in depth discussion of the effects of these alterations see the ecological background section above see Hirschi et al 2003b.

Restoration Opportunities

Unused docks and piling could be pulled from Fisherman Harbor. The South Point/ Bridgehaven area needs major study and action to improve sediment function and provide

salt marsh habitat for juvenile salmonids. This area is so impacted by development that immediate restoration actions are not clear. As a more immediate action, the remnant South Point salt marsh could be opened up with a bigger culvert to provide fish access.

Public Access

South Toandos State Park provides access at Oak Head via boat. Brown Points DNR tidelands are accessible by boat. The possibility of upland access to this area should be considered through Pope Resources land or Navy property.

Preliminary Nearshore Reaches

Southwest Toandos: Area of divergence between drift cell JE-15 and JE-16.
Oak Head: Origin of drift cell JE-15 to entrance to Fisherman's Harbor.
Fisherman's Harbor: East to west entrance of Fisherman's Harbor.
South Toandos: Fisherman's Harbor to Hazel Point.
East Toandos: Hazel Point to west edge of Thorndyke Estuary.
Thorndyke Estuary: West edge of Thorndyke Estuary to east edge.
North Thorndyke: East edge of Thorndyke Estuary to south edge of South Point Ferry Dock.
South Point: South Point ferry dock to the north jetty encompassing the spit and marina.
South Point Marsh: the remnant small marsh south of the South Point marina.

Sandy Shore Lake

Sandy Shore Lake is in the upper Thorndyke Creek watershed and is presumed coho, cutthroat and steelhead habitat (Map 10)(Correa 2003). Its surface area is 34.9 acres. The surrounding area is commercial timberland. South of the lake there is a recent timber cut as determined from aerial photography. Pope Resources owns the surrounding property and allows conditional recreation use of their land.

Wahl Lake

Wahl Lake is south of Hwy 104 near Shine (Map 10). Its surface area is 21.6 acres. It is located on commercial timberland owned by Pope Resources, and the surrounding area has seen some recent logging. This lake is home to several rare wetland plants and plant assemblages. Efforts should be made to protect these features. As with other Pope resources lands it is open to limited recreation use.

Squamish Harbor

Introduction

This shoreline stretches from the just north of the Bridgehaven development to the Hood Canal Bridge (Map 10). The southwestern shore of Squamish Harbor has little development and is generally in pristine condition. Shine Creek enters the Harbor at its

head after flowing through a large wetland. Near the head of the harbor and along its northern shore (Shine) there is moderately dense residential development. East of Shine there is an area of massive erosion that threatens several structures on the top of the bluffs.

Ecological Background

Immediately to the north of the jetty at the entrance to Bridgehaven Marina begins drift cell JE-12 which continues north for about two miles to terminate at the head of Squamish Harbor, near the mouth of Shine Creek. The spit (South Point Spit Reach) at the origin of the cell used to be prograding to the north but this seems to have ceased and the spit has now become detached from the mainland, due to the reduction of sediment reaching it, possibly resulting from the shoreline alterations at Bridgehaven (Johannessen 1992). Sand lance spawn on the northern tip of the spit (Penttila 2000). Northward net shore drift in this part of Squamish Harbor is indicated by northward beach increase (north of the spit), sediment accumulations on the south side of several large trees lying across the beach, and the northward progradation of the small spit 300 yards south of terminus of the cell (Johanessen 1992).

The southern part of this drift cell, in the South Squamish reach, from the origin to the small point about 1.25 miles to the north has very healthy riparian vegetation (100%) often with large trees growing far out over and sometimes into the intertidal. This may be due to the fact that this area is protected to semi protected from southern fetch (Correa 2003 and WDNR 2001). In the nearshore eelgrass beds are continuous along the outside and the inside of the spit and patchier further north to the point mentioned above. These sorts of areas have the potential to be extremely good fish habitat with eelgrass to provide cover during low tide and the riparian zone providing foraging and cover during high tide. The characteristics of this reach are quite unique and should be preserved. A small stream enters Squamish Harbor near the northern end of this reach and is presumed cutthroat trout habitat (Correa 2003).

Development increases in the North Squamish reach to the head of the harbor and riparian vegetation decreases to cover about 20% of the shoreline (WDNR 2001). Eelgrass beds are patchy throughout with barnacles and ulva (WDNR 2001). There is also a bald eagle nest in this area (WDFW 2004).

At the terminus of this drift cell is the Shine Creek Estuary, with an extensive salt marsh totaling 85 acres with about 5 acres of intertidal habitat. Seawater exchange with this wetland is somewhat constricted by the culverts under Shine Road (Correa 2003). However this remains a large relatively undisturbed wetland. Shine Creek supports chum, coho salmon and cutthroat and steelhead trout spawning. The wetlands are also important rearing habitat for natal and non-natal juvenile pink, chum, coho and chinook salmon (Hirschi et al 2003a).

The northern shore of Squamish Harbor (The Shine Reach) is bounded by drift cell JE-11 which encompasses net shore drift for two miles from the large glacial drift bluff a half mile south west of the Hood Canal Bridge to the head of the harbor, converging with drift cell JE-12. Abundant sediment is derived from a high bluff in the Termination Point Reach comprised of various layers of glacial sediment with a house perched precariously on the top. This shoreline is classified as unstable recent landslide

(WDOE 1978). Net shore drift to the west is indicated by sediment accumulations on the eastside of obstacles and the westward prograding spit at the mouth of Shine Creek.

With the exception of the area in front of the feeder bluff eelgrass is continuous in the eastern half of Shine Reach and patchy in the western end. Riparian vegetation is sparse along this reach never reaching more than 10% of the shoreline (WDNR 2001). This is primarily due to clearing for views in front of the many houses along this stretch of shoreline (WDOE 2001). Sand lance spawn along the western end of this reach and herring spawn in the eelgrass beds offshore (Penttila 2000).

Shoreline Alterations

Shoreline armoring is absent from the South Squamish Reach. In the North Squamish Reach roughly 30% of the drift cell is armored (Hirschi et al 2003b). This armoring may interfere with along shore transport of sediment and beach substrate composition. Fill and several culverts under Shine Road that modify and restrict flow modify the Shine Creek estuary, however these culverts do not present a fish passage issue (Correa 2003). Shoreline armoring is prevalent along in the Shine Reach, with about 26% of this reach armored (Hirschi et al 2003b). Two boat ramps, one at a county park, extend into the intertidal with parking lots located on fill. There are several large riprap bulkheads covering the bluff in front of luxury homes. At the terminus of the cell in the depositional zone there are several cement bulkheads that may have limited usefulness- this not being an erosional zone. Sediment for this drift cell primarily comes from the large feeder bluff in the Termination Point reach. Erosion and land sliding is an inherent feature of this area (WDOE 2001).

The footing of the Hood Canal Bridge is a filled and armored area that interferes with the along shore transport of sediment (Johannessen 1992).

Restoration Opportunities

The South Squamish reach is in pristine condition and should be targeted for protection; part of it is already DNR timberlands. The restoration of flow under Shine Road to the Shine Creek estuary would allow for the formation of more salt marsh habitat (Correa 2003). The removal or reconfiguration of the boat ramps on the north side of the bay to allow for along shore transportation of sediment and increase shallow water habitat. In the North Squamish and Shine reaches alternatives to bulkheads and restoration of nearshore riparian habitat would improve along shore transport of sediment and habitat.

Public Access

Case Shoal off shore in the southern part of the Squamish Harbor, only exposed at low tide, is owned by the WDNR and is open to recreational shell fishing. The WDNR timberland north of the spit, on the west side of the bay is public access, however there are no facilities or improvements for public access. Hicks County Park on the north shore of the Squamish Harbor has a boat ramp and there are public WDNR tidelands to the east of the park.

Preliminary Reaches

South Point Spit: The spit north of Bridgehaven and South Point developments.
South Squamish: The southern undeveloped part of drift cell JE-12.
North Squamish: The northern developed portion of drift cell JE-12.
Shine Creek estuary: Areas inside the spit at the head of Squamish Harbor that are part of the extensive estuary of Shine Creek.
Shine: Drift cell JE-11.
Termination Point: From the origin of drift cell JE-11 to the southern edge of fill for the Hood Canal Bridge.
Hood Canal Bridge: the footing for the Hood Canal Bridge including the boat ramp to the north.

Hood Canal Bridge to Tala Point

Introduction

This shoreline is situated between the Hood Canal Bridge and Port Ludlow and contains some very pristine areas in Bywater Bay and around Hood Head (Map 11). Residential development is concentrated in the White Rock Cove and Paradise Bay reaches however some scatted homes are found throughout this section of shoreline. Hood Head is an island connected to the mainland by a tombolo and is predominately undisturbed by development. Development pressures in this area are concentrated south of Tala Point, White Rock Cove and Bywater Bay.

Ecological Background

Drift cell JE-10 originates at the depositional bluffs at Termination Point and continues north to the head of Bywater Bay. At the base of the bridge, significant progradation seaward, to the southwest, occurred allowing sediment to continue to travel northward (Johannessen 1992). A freshwater marsh occurs on the landward side of Shine Tidelands State Park, it is, however, cut off from saltwater by riprap fronting a parking lot (Correa 2003). Eroding bluffs dominate the shoreline of the Bywater Bay reach and are unstable from just north of the parking lot to the mouth of a small creek 500 yards south of the end of Seven Sisters Road. Beach width and riparian vegetation increase northward to where the drift cell terminates in a 500-yard long broad sand and pea gravel spit at the head of Bywater Bay in Wolfe Property State Park (Johannessen 1992).

An osprey pair nests on the peninsula jutting into the tidal lagoon formed by the spit. As of 1999 there was a blue heron colony of three nests near the end of Seven Sisters Road (WDFW 2004). Sand lance and surf smelt spawn along the Wolfe Property S.P. reach from near the end of Seven Sisters Road northward to the beginning of the spit (Penttila, 2000). Brown kelp and eelgrass are continuous to patchy in Bywater Bay, with several dense beds of eelgrass about 200 meters north of the Hood Canal Bridge (WDNR 2001 and Woodruff et. al. 2002). Chum salmon are found in the large tidal lagoon in Wolfe Property State Park created by the spit at the head of Bywater Bay. In addition, the small creek draining into the tidal lagoon presumably provides cutthroat trout habitat

(Correa 2003). Water quality in this entire shore segment is good and it is approved for shellfish harvest (WDH 2003). The area at the head of Bywater Bay and the tidal lagoon formed by this spit is popular with recreational clam and oyster harvesters (Speck personal communication 2003).

Drift cell JE-9 originates at the erosional headland at the southern tip of Hood Head and net shore drift is to the north one mile to terminate at the head of Bywater Bay (Johannessen 1992). The end of this drift cell encloses a salt marsh along the northeastern shore of Hood Head. Riparian vegetation along this segment is generally heavy with the exception of the erosional headlands on the southern end (WDOE 2000). Eelgrass is patchy in this area of Bywater Bay (WDNR 2001).

The next drift cell, JE-8, extends from the feeder bluffs on south Hood Head a mile to the northeast to terminate at Pt. Hannon on Whiskey Spit. South Hood Head is a steep headland of glacial drift that supplies abundant sand and gravel to the intertidal (Johannessen 1992). This bluff is comprised of Vashon lodgement fill overlying a layer of undifferentiated stratified sediments and this overlying a layer Possession drift. Although Vashon lodgement fill is considered relatively stable the underlying sediments are considered unstable on slopes greater that the angle of repose- generally slopes greater than 30° to 39°. Hence, several recent landslides mark this area and, as with all the bluffs on the east side of Hood Head, landslide hazard is considered high (WDOE 1978).

Riparian vegetation is heavy in the northern half of drift cell JE-8 whereas in the southern half much of the riparian vegetation has slid into the nearshore. Large wood in the intertidal can be important salmon habitat (Hirschi 1999). Sand lance spawning is documented along the south side of Whiskey Spit (Penttila 2000). Patches of eelgrass and ulva are found along the southern and eastern sides of Hood Head (WDNR 2001).

An open water lagoon, with no outlet to the nearshore, surrounded by marsh is found at the base of Whiskey Spit. Juvenile chinook salmon have been observed along Pt. Hannon spit feeding on sand lance. The remainder of the spit is covered in dune grass; the only disturbance being a small abandoned cabin and navigational light and thus has been identified as an example of a healthy cuspate spit habitat type (Correa 2003). This spit should be protected in its current state.

Drift cell JE-7 extends for 4.9 miles from the erosional feeder bluffs at Tala Point in the north to Pt. Hannon in the south. The sediment source in this drift cell comes from eroding bluffs composed of sandy glacial drift found in the northern and central parts of the cell. Beach characteristics and sediment composition vary as several points alter the beach exposure levels. Sandy drift material is abundant in the bluffs close to Tala Point but are relatively scarce further south where the bluffs are composed of silt and clay-rich glacial till, with little sand or gravel to replenish the beach (Johannessen 1992). Near Tala Point tall bluff top trees harbor a bald eagle nest and an osprey nest (WDFW 2004). The sandy gravel beaches south of Tala Point (East Tala Point Reach) provide sand lance and surf smelt spawning habitat. Additionally there is a surf smelt spawning beach in this reach (Long et al. 2003 and Penttila 2000). The riparian vegetation along this reach is nearly continuous. A brackish marsh is situated south of the unnamed broad point south of Tala Point. Clearing of riparian vegetation for views has occurred, particularly north of Paradise Bay and in White Rock Cove (WDOE 2001). Patches of focus, barnacles, ulva, and soft brown kelp, with continuous eelgrass beds, are present in White Rock Cove. The

remaining shoreline from Paradise Bay to Tala Point is semi protected with the majority of the abundant sediment coming from backshore sources. Patches of barnacles, eelgrass and ulva, with some soft brown kelp, are found in the nearshore of these reaches (WDNR 2001 and Correa 2003).

Net shore drift in cell JE-7 creates the tombolo to North Hood Head, a narrow, low berm that is overtopped at high storm tides. The drift cell terminates at Point Hannon, a cuspate spit that extends more than 300 yards from the uplands and is a zone of drift convergence in common with drift cell JE-8 (Johannessen 1992). Patches of ulva and continuous eelgrass occur along this reach (WDNR 2001). A Bald Eagle nest is located on the northern bluffs of Hood Head (WDFW 2002).

Shoreline Alterations

Just to the north of the Hood Canal Bridge a long riprap bulkhead protects the road and parking lot at Shine Tidelands State Park. Moving the parking lot to the south would eliminate the need for this bulkhead (Correa 2003). Besides some shoreline armoring above the intertidal zone along the west side of Hood Head, Bywater Bay is largely free of bulkheads. No shoreline armoring exists on the north or east sides of Hood Head (Hirschi et al. 2003). White Rock Cove is 20% armored with riprap (WDNR 2001). To the north of Paradise Bay a private access road with a bulkheaded landing extends into the intertidal and interrupts net shore drift (Correa 2003). Just north of this, a large riprap bulkhead attempts to protect a large stairway structure and a house situated close to the edge of a slumping bluff (WDOE 2001). The high bluff at the origin of the drift cell at Tala Point is armored at the toe, which interrupts sediment source for drift cells JE-6 and JE-7 (Correa 2003).

Restoration Opportunities

Moving the parking lot to the south and removing the bulkhead at Shine Tidelands State Park would open up the marsh to the nearshore, providing rearing habitat for migrating chum and pink salmon (Correa 2003). Several bulkheads extending into the nearshore in the Tala Shores area could be removed to allow for improved along shore transport of sediment. Removal of riprap at the base of the bluff at Tala Point would improve the natural rate of sediment input into the nearshore.

Public Access

Just north of the Hood Canal Bridge Shine State Park provides access to the shoreline north to Hood Head. In addition there is another parking area at the end of Seven Sisters Road for beach access north to Wolfe Property State Park. Adjacent to Wolfe Property Park to the east there is DNR shoreline that stretches around Point Hannon and covers the northeast shore of Hood Head. Point Hannon is owned by state parks. North of the Paradise Bay development there is DNR owned public access shoreline that ends just south of the broad point south of Tala Point. A water access primitive campground is planned for state park land on Point Hannon.

Preliminary Nearshore Reaches (Map 11)

Hood Canal Bridge: Southern edge of fill to the north edge of the boat ramp.
Bywater Bay: North edge of Hood Canal Bridge boat ramp to the southern boundary of Wolfe Property State Park.
Wolfe Property SP: Wolfe Property State Park Boundary north to include the area of no net drift within the lagoon at Wolfe Property State Park and the head of Bywater Bay.
JE-9: Drift cell JE-9 on the western side of Hood Head.
South Hood Head: Feeder bluff in area of drift divergence on southern Hood Head.
East Hood Head: Drift cell JE-8 on the east side of Hood Head.
North Hood Head: From western boundary of Wolfe Property State Park to Point Hannon
White Rock Cove: from western boundary of Wolfe Property State Park north to just south of Paradise Bay.
Paradise Bay: From the point south of Paradise Bay north to a spot 570 feet south of the broad point south of Tala Point.
East Tala Point: Area south of primary feeder bluffs for JE-7 includes contributing bluffs.
Tala Point: Divergent area between drift cells JE-6 and JE-7 and the feeder buffs at the origins of both of these drift cells.

Port Ludlow

Port Ludlow is designated a Master Planned Resort and is an area of intense residential development (Map 12). Development pressures facing this area include a possible expansion of the marina and condominium development within the shoreline jurisdiction. Port Ludlow retains some valuable natural habitat including at least one salmon spawning creek (Ludlow Creek) several salt marsh areas and numerous forage fish spawning beaches. Two drift cells occur in this area as well as extensive back bay areas of no net shore drift. The geology of this area is comprised mainly of glacial drift derived bluffs, however there are several areas of basaltic outcroppings in southwest Ludlow Bay and further north at Basalt Point.

Ecological Background

The tall eroding feeder bluffs on Tala Point provide much of the sediment for the south shore of Port Ludlow Bay. Tala Point is a classic feeder bluff with little vegetation due to near constant erosion. Drift cell JE-6 begins at this feeder bluff and net shore drift continues southeast for about two miles into Port Ludlow Harbor. Further west, In the West Tala Point Reach, contributing bluffs, often forested with patches of even aged trees indicating past bluff failures, add more sediment to this drift cell. There is abundant evidence of recent landslides along this shoreline including large boulders in the intertidal. Net shore drift continues to the west, through the South Ludlow Bay reach to form an accretionary beach in front of a salt marsh. Several groins placed to capture sediment and a turn of the century shipwreck interfere with net shore drift (Johannessen 1992 and Correa 2003). Development has also encroached on the salt marsh within the

Ludlow Salt Marsh reach. However, the salt marsh does remain important habitat for juvenile salmonids, and it does not appear that there have been any significant loses of marsh habitat in recent years (comparing 1997 and 2001 Ecology shoreline photos). The stream flowing into the marsh supports cutthroat trout (Correa 2003).

Eelgrass beds are continuous and riparian vegetation is heavy in the West Tala Point reach. Eelgrass beds are patchy to continuous within the South Ludlow Bay reach with riparian vegetation decreasing to the west in this reach (WDNR 2001). This is due to clearing of trees for development and views. The Tala Point bald eagle territory includes the Tala Point and West Tala Point reaches (WDFW 2004). Sand lance spawn on the depositional beach at the barrier beach at the western end of the South Ludlow Bay reach (Long et al. 2003 and Penttila 2000).

The back bay area of West Port Ludlow contains the small estuary of Ludlow Creek, which support coho, chum, cutthroat and steelhead. This estuary is truncated by fill and culverts associated with the Paradise Bay Road crossing. Juvenile cutthroat and coho are found in the tidal channels cut into the road fill. In North Port Ludlow there is an area of fill and scattered residential development with scattered riparian vegetation. There is a surf smelt spawning site just west of the marina (Long et al 2003). The small stream entering Ludlow Bay between Ludlow Creek and the marina support cutthroat trout and possibly chum salmon- although available habitat is limited due to a blocking culvert at the Oak Bay Road crossing (Hirschi 1999). In the Marina reach there is major shoreline alteration associated with the marina and resort (WDOE 2001). Patchy eelgrass beds occur throughout the North Ludlow and Marina reach. Personal docks are also abundant throughout Ludlow Bay, which can have an adverse effect on the growth of eelgrass.

North of Port Ludlow drift cell JE-5, encompasses two reaches Mats Mats in the north and Ludlow Spit in the south. Originating just south of Basalt Point net shore drift is to the south for 2.6 miles to the marina at Port Ludlow. Sediment for this drift cell is supplied by a contributing bluff comprised of compact glacial till, sometimes overlying basalt at the beginning of the cell, a feeder bluff south of this supplying sediment rich in gravel and another contributing bluff south of the village of Mats Mats. This southernmost contributing bluff, near the southern end the Mats Mats reach, has a large housing development atop it. Poor drainage control appears to have aggravated and accelerated bluff erosion. This development corresponds very well to the area listed as unstable recent slides in the Coastal Zone Atlas (Johannessen 1999 and WDOE 1982). The drift cell terminates at the depositional beach, in the Ludlow Spit reach, in front of the Port Ludlow resort and restaurant. This is a modified spit complex that still maintains a wide beach with minimal shoreline armoring.

Forage fish spawning along the Mats Mats reach is extraordinary with one sand lance spawning sites and nine winter surf smelt sites found by North Olympic Salmon Coalition studies in the past few years. Two summer surf smelt spawning sites were also found- a rarity in East Jefferson County (Long et al. 2003). These findings reconfirm and expand the spawning sites documented by Dan Penttila of WDFW in the nineties (Penttila 2000). Riparian vegetation is sparse along the northern part of this shoreline, although in the middle it covers roughly 60% of backshore. Clearing for views has contributed to the spottiness of backshore riparian vegetation. The preservation of existing vegetation might alleviate some of the problems of erosion of the bluffs in the

North Port Ludlow development (Johannessen 1999 and WDOE 2001). Eelgrass beds are continuous in the southern portion of this reach and patchy at north end (WDNR 2001).

Two sand lance spawning sites were found on Ludlow Spit and WDFW found surf smelt spawning in this reach in the 1990's (Long et al 2003 and Penttila 2000). Eelgrass beds are patchy in this reach (WDNR 2001).

Shoreline Alterations

The few groins and bulkheads along the southern shore of Port Ludlow Bay do not appear to significantly impact the overall transport of sediment to the accretion beach at the terminus of drift cell JE-6. A greater threat to this drift cell would be armoring of the contributing or feeder bluffs near Tala Point. Development has encroached into the salt marsh at the terminus of drift cell JE-6. There are several docks in the vicinity of The Twins in the southwest part of the harbor. The Paradise Road crossing at Ludlow Creek, although not a barrier to fish, does interfere with the natural aggradation of the salt marsh into the bay. The marina on the north side of the bay could be impacting the growth of eelgrass. The back of the marina is completely armored and this area was probably a salt marsh enclosed by the spit and was severely altered when the mill was built in the 1800's. The tidal pond that is behind the marina was historically a salt marsh. Despite the high level of development at Port Ludlow, natural shore forms have largely been maintained.

Between the barge harbor at Mats Mats and Port Ludlow, drift cell JE-4 is about 9% armored with a majority of this armoring in the sediment transport zone.

Restoration Opportunities

Fluvial flow under the Paradise Bay Road crossing could be improved. As the docks are replaced in Port Ludlow the opportunity to add light wells to them should be explored. There is currently an experiment going on at the NW Maritime center dock in Port Townsend exploring this possibility for building "eelgrass friendly" docks, the results of this study could be applied here. The restoration of a more natural lagoon with flow into the bay and a vegetated shoreline on the current site of the tidal pond behind the marina has the potential to increase juvenile migratory salmonid habitat. The need for some of the bulkheads north of Port Ludlow should be explored and bulkheads should be taken out if they are not needed. The restoration of native vegetation on the bluffs north of Port Ludlow may help stabilize the bluffs.

Public Access

The beaches of Port Ludlow are private.

Preliminary Nearshore Reaches:

West Tala Point: Origin of drift cell JE-6 to the southern edge of RR 1:20 zoning
South Ludlow Bay: from this point to the terminus of drift cell JE-6
Ludlow Salt Marsh: The salt marsh at the terminus of drift cell JE-6

West Ludlow Bay: from this point to the mouth of Ludlow Creek
The Twins: the two basaltic islands in the southern bay
North Ludlow Bay: mouth of Ludlow Creek to the edge of the bulkhead behind the marina
Marina: From the west edge of the bulkhead to the point at the southeast corner of the marina
Tidal Pond: the tidal pond behind the marina.
Ludlow Spit: from the south east corner of the marina to the lot line between the sewage treatment plant and the house to the north.
Mats Mats: from the sewage treatment plant north to the south jetty at the barge harbor near Basalt Point.

Mats Mats Bay

A zone of no net shore drift exists between the barge harbor located south of Basalt Point, north to Olele Point and includes Mats Mats Bay (Map 12). The only sediment present is on small isolated pocket beaches between basalt outcroppings. Within Mats Mats Bay there is not enough wave action to create net shore drift (Johanessen 1992).

Riparian vegetation has been cleared around the Mats Mats quarry barge harbor in the Barge Harbor reach. North of this, in the southern entrance to Mats Mats Bay, however the riparian buffer some of the most intact riparian zone in this area. Most of Mats Mats Bay has a developed and cleared shoreline with the exception of the area around the mouth of Piddlin Creek. Piddlin Creek supports chum and cutthroat trout and once supported coho. However past land use practices (clear-cutting the upper watershed) and an impassable culvert at Oak Bay Road have extirpated the coho. Efforts are underway by Trout Unlimited to reintroduce coho and fix the culvert (Hirschi 1999). The mouth of Piddlin Creek and a small drainage to the south once formed a wetland complex but the total loss of original habitat is unclear. Water quality is a problem in Mats Mats Bay with it being listed for fecal coliform pollution in the 303d list in 2004. Offshore, the Colvos Rocks are a seal pupping and haul out area (WDFW 2004). Riparian vegetation is largely intact along the in the Olele Point reach, this area also supports at least one pair of nesting bald eagles (WDFW 2002 and Correa 2003). Patchy eelgrass beds line the entrance of Mats Mats Bay (WDNR 2001).

Shoreline Alterations

The barge harbor has several rock jetties associated with it. There are numerous docks within Mats Mats Bay.

Restoration Opportunities

If the basalt quarry ceases operations and comes up for sale it could be an excellent park and restoration site. Riparian vegetation could be planted throughout the shore of Mats Mats Bay where it is lacking.

Public Access

There is public access to Mats Mats Bay at the public boat ramp on the south side of the bay.

Preliminary Nearshore Reaches (Map 12)

Olele Point: Olele Point to the northern edge of Mats Mats Bay.
Mats Mats Bay: northern edge of Mats Mats Bay to northern jetty of barge harbor.
Barge Harbor: north to south jetties of barge harbor.

Oak Bay

This shoreline stretches from Olele Point to the Port Townsend Ship Canal (Map 13). Development along this shoreline is nearly continuous but rarely intense having seen piecemeal housing construction, lot by lot, versus the housing developments in Port Ludlow. Much of this shoreline has sandstone outcroppings at the base of the bluff so the amount of sediment transported is moderate. Four drift cells extend from Olele Point to the Ship Canal.

Ecological Background

The southernmost reach in this segment of shoreline is the West Olele Point reach encompassing drift cells JE-3 and JE-4 (Map 13). In drift cell JE-4 net shore drift is to the west from glacial drift deposits immediately to the west of the basaltic headland of Olele Point. The depositional area for this cell is the beach (spit) in front of a salt marsh 780 yards west of Olele Point. Likely there is some continuity of drift with drift cell JE-3 the next drift cell to the west. This is a reinterpretation of the original drift cell study published in 1992 by Johannessen (Johannessen 1999). Drift cell JE-3 continues to the west 330 yards to a broad 120 yard long beach that serves as a shared depositional shore form with drift cell JE-2.

Riparian habitat is fragmented along reach with only about 20% left after clearing for views (WDNR 2001 and WDOE 2000). Eelgrass, however, is nearly continuous along drift cell JE-4 and patchy eelgrass beds occur in front of drift cell JE-3 (WDNR 2001). A salt marsh occurs behind the depositional spit at the terminus of drift cell JE-4 and has been incrementally filled in for development and is truncated by a driveway (Hirschi 1999 and WDOE 2000). Sand lance also spawn along the beach fronting the marsh and at the shared terminus of cells JE-3 and JE-2 (Penttila 2000).

Drift cell JE-2 in the South Oak Bay reach, extends from a zone of divergence about 1.5 miles northwest of Olele Point to the shared zone of deposition with JE-3 a mile west of Olele Point. Net shore drift is to the south a local reversal due to the sheltering of this shoreline from fetch by Olele Point. Sediment is derived from Vashon till overlying Quimper sandstone. Along much of the reach advance outwash sand and gravel underlies the till. This layer supplies the greatest amount of sediment to the beach. Mass wasting is not extensive due to the relatively erosion resistant sandstone toe of the

bluff, thus landslide hazards are low. Erosion in this area is generally triggered by surface water flow and ground saturation (Johannessen 1999). Eelgrass beds are patchy throughout this reach (WDNR 2001). Riparian vegetation ranges form 20% to 50% with patches of trees separated by areas cleared for views. There is a bald eagle nest in the northern part of this reach (WDFW 2004).

The Oak Bay reach encompasses much of drift cell JE-1 form its origin to the beginning of the spit at Oak Bay County Park. Drift cell JE-1 originates at the same zone of divergence as drift cell JE-2 and has a northward net shore drift for 5km to Oak Bay County Park. A small amount of sediment is transported in this drift cell, its geology being similar to that of JE-2. Northward net shore drift is indicated by sediment size decrease, northward bluff vegetation increase and beach width increase. The cell terminates at half-mile long bayhead spit, which has been anchored with riprap in northern Oak Bay, and the cell terminus is at the riprap jetty on the western side of the Portage Canal within the Oak Bay Spit reach (Johannessen 1999).

Eelgrass beds are continuous in the northern part of this reach and patchy in the south, providing a migratory corridor for juvenile salmonids (WDNR 2001). Riparian vegetation is patchy, being cleared in front of many houses to provide views, locally there are several large intact regions. Due to the fact that vegetation can reduce surface runoff, the primary cause of bluff erosion in this drift cell, every effort should be made to preserve riparian and bluff top vegetation. Surf smelt spawn on a pocket beach in the southern part of the reach (Long et al. 2003).

The Oak Bay Spit reach includes the accretionary zone of drift cell JE-1 includes about a kilometer of shore in the minor embayment in the northwest corner of Oak Bay that has developed into a spit and barrier beach system. The north side is a broad depositional beach and spit that has been bulkheaded to stabilize it for a campground and parking lot associated with the Oak Bay County Park. This spit and the jetty on the west side of the Portage Canal keep the 4.5 acre salt marsh isolated from the bay, although there is seepage through the rip rap and severe weather can cause the spit to break. Sand lance spawn on this beach (Penttila 2000). A small creek enters Oak Bay here where the original spit likely started (Johannessen 1999). The mouth of Little Goose Creek once entered the extensive salt marsh now trapped behind the riprap associated with the park and canal. Thus, due to the loss of habitat coho have not been seen in this creek for over ten years (Hirschi 1999).

Shoreline Alterations

The salt marsh on the north side of Olele Point has been encroached on by residential development. There are relatively few bulkheads along this stretch of shoreline. However at the terminus of drift cell JE-2 at the spit in front of the salt marsh at Oak Bay County Park there is major shoreline alteration. The front of the spit is armored with riprap for park access and campground, combined with the jetty along the ship canal this cuts off the salt marsh from the nearshore under most conditions. In addition a Little Goose Creek, a small coho stream was rerouted out of the marsh and through a culvert. For further discussion of how this has affected habitat see the ecological background above.

Restoration Opportunities

The salt marsh at Olele Point could be partially restored. There is a restoration plan to increase access to the Oak Bay County Park salt marsh, although this has been put on hold as it has naturally opened to the bay due to storm conditions.

Public Access

There are DNR tidelands south of Oak Bay County Park accessible by boat. Oak Bay County Park has beach and salt marsh access, shellfish beds and camping.

Preliminary Nearshore Reaches

West Olele: Drift cells JE-3 and JE-4;
South Oak Bay: Drift cell JE-2
Southwest Oak Bay: Divergent zone JE-1/ JE-2.
Oak Bay: origin of drift cell JE-1 to beginning of spit at Oak Bay County Park.
Oak Bay Spit: Spit at Oak Bay County Park.
Oak Bay Salt Marsh: Salt Marsh at Oak Bay County Park.

South Indian Island and Marrowstone Island

Indian and Marrowstone Islands are situated between Port Townsend Bay and Admiralty Inlet (Map 14). Except for the southern shore that is a county park, Indian Island is owned by Naval Magazine Indian Island, a naval munitions base for forces stationed in Puget Sound hence is not within county jurisdiction. Connected by a causeway build on fill to Indian Island, Marrowstone is primarily rural residential with state parks at both the northern end (Fort Flagler) and at the south end at Kinney Point (accessible only by boat). Growth on Marrowstone has been slowed by the general lack of fresh water although this may change with the construction of a public water system. Between the two islands is Kilisut Harbor and Scow Bay with rich shellfish beds, herring spawning grounds and large concentrations of over wintering waterfowl. Johannessen's 1992 detailed study of drift cells stopped at 48° N. Previous work by Kueler 1988 mapped the drift cells north of 48° N. Detailed narratives were not part of Kueler's work although depositional and accretionary areas were mapped. For the remainder of this report drift cell descriptions are taken from Kueler's work with the geological background taken from the Coastal Zone Atlas.

Ecological Background

Drift cell JEF-2 extends from a zone of divergence between Kinney and Lip Lip Points on Marrowstone Island northwestward to the rip rap jetty on the east side of the Portage Canal. Sediment to this drift cell is supplied by erosion in the zone of divergence and contributing bluffs on southeastern Marrowstone Island in the Lip Lip and Kinney Point reaches. Major depositional areas occur in the South Indian reach, on the barrier

spit fronting a lagoon between the islands and on the barrier beaches protecting salt marshes in the last kilometer of the drift cell.

The east side of the Portage Canal is an area of no net drift and in the northern half contains bluffs comprised of hard shale and mudstone (WDOE 1978). Sand lance spawn along the southeast shore of the Portage Canal and at two pocket beaches between the north end of the Portage Canal and the navy property boundary (Penttila 2000).

Patchy eelgrass beds occur throughout drift cell JEF-2 (WDNR 2001). There is a bald eagle nest on Kinney Point. This part of Oak Bay serves as an over wintering area for waterfowl including Brant (WDFW 2004). Except for a small amount of development on Southwest Marrowstone including a bulkheaded section in front of the "Ecologic Center" resort this is a rather pristine reach of shoreline with intact, protected, feeder bluffs and extensive salt marshes.

Juvenile salmonids are found in South Indian Island marsh (Hirschi et al. 2003). Migratory habitat could be improved by replacing undersized culverts under the road between Marrowstone and Indian Islands to allow for the passage of juvenile salmonids (Correa 2003). In the county park on South Indian Island riparian vegetation has been preserved and as are extensive salt marshes. South Indian Island is a popular area for recreational clam digging (Speck personal communication 2003). Sand lance spawn on the barrier beach connecting the islands and along the central portion of Indian Island's southern coast (Long et al. 2003 and Penttila 2000). A salt marsh is protected by an extensive barrier beach along the southern part of the Portage Canal (WDOE 2001).

The remainder of Indian Island will not be covered by this report. It is owned by the US Navy, thus is not under county jurisdiction. However, briefly it should be noted that habitat on Indian Island is regionally significant as it is an important nesting area for Bald Eagles (8 pairs) and its beaches are host to numerous spawning sites for surf smelt and sand lance (Bill Kalina personal communication 2000, Penttila 2000 and Long et al. 2003).

The East Marrowstone reach is concurrent with drift cell JEF-3 that begins at the zone of divergence with JEF-2 and net shore drift is generally northward along the entire eastern side of Marrowstone Island. The drift cell terminates at the cuspate spit at Marrowstone Point (Kueler 1988). In general, the uplands are stable, however the immediate bluff faces along most of this segment are unstable and marked by many small slides (WDOE 1978). North of Sound View Cemetery, for example, there are a number of houses now very close to the bluff edge (several meters) where the bluff has shown a steady retreat due to many, rather small, block slides coming off a steep bluff of compacted fine, silty, Vashon advance outwash. Each slide taking down only a couple of meters of bluff top, but, in aggregate, creating a serious threat to property. Lack of bluff top vegetation, ground and surface water erosion and bluff toe erosion all appear to have contributed to this problem (personal observation).

Eelgrass beds are patchy to continuous along East Marrowstone Island. Riparian vegetation is fragmented due to clearing for views in the southern portion (south of East Beach Co. Park) but is mostly intact in the northern portion (Correa 2003). An interesting rocky intertidal zone occurs at Nodule Point where there is an outcropping of tertiary sandstone. Sand lance spawn on the depositional beach along Marrowstone Point (Penttila 2003). There are bald eagle nests at Nodule Point, near East Beach and near the end of Schwartz Road (WDFW 2002).

The next two drift cells JEF-4 and JEF-5, concurrent with North Flagler and Flagler Campground North reaches respectively, occur completely within Fort Flagler State Park and govern net shore drift on the northern shore of Marrowstone Island. Both drift cells begin at a large feeder bluff a half mile east of Marrowstone Point (Flagler Bluff reach). Sediment is derived from 100 ft tall bluffs comprised of Vashon Till overlying advance outwash sediments. Net shore drift in the North Flagler reach is to the east from this feeder bluff and terminates at the cuspate spit at Marrowstone Point. Net shore drift in JEF-5 extends from the same feeder bluff as JEF-4 for two miles to the southwest tip of Rat Island (Kueler 1988). Rat Island was originally a spit but was breached some time in the middle part of last century, it is its own reach (Correa 2003).

Eelgrass is absent along this segment of shoreline, except for patchy beds around Rat Island (WDNR 2001). Bald eagles nest above the feeder bluff in Flagler Bluffs reach (WDFW 2003). Riparian vegetation is largely absent from the high bluff areas, however, it is present in the lower bluff areas in the along this shoreline. Also, large woody debris is recruited off of the tops of the high bluffs as they erode. Rat Island is a haul out and pupping site for harbor seals and a nesting area for gulls (WDFW 2004). The parking lot and campground at Fort Flagler is constructed on fill placed on top of approximately 22 acres of historic salt marsh (Correa 2003). A brackish marsh at Marrowstone Point apparently did not have an outlet to Admiralty Inlet (Correa 2003). Marrowstone Point is home to prairie plants including menzies larkspur (*Delphinium menziesii*) and chocolate lily (*Frittilaria lanceolata*).

Drift cell JEF-6 originates at a zone of divergence one mile north of Mystery Bay and net shore drift extents about two miles to the north to terminate inside the spit at Fort Flagler. This drift cell is within relatively sheltered Kilisut Harbor with limited southern fetch (Kueler 1988). Sediment is derived from eroding bluffs near the origin of the cell and alongshore (WDNR 2001). Depositional beaches occur in the middle of the cell (in the North Kilisut Reach) and at the terminus (in the Flagler Campground South Reach) (Keuler 1988).

Eelgrass occurs in patchy beds throughout this drift cell (WDNR 2001). Herring spawn on eelgrass throughout Kilisut Harbor. Surf smelt spawn in the northern part of the Kilisut Harbor Reach (Penttila 2000 and Long at el. 2003). There is little riparian vegetation in the North Kilisut and Kilisut reaches (WDNR 2001). The depositional beach in the North Kilisut Reach encloses a salt marsh. This part of Kilisut harbor is also an important over wintering area for brandt and other waterfowl (WDFW 2002).

Drift cell JEF-7 originates in the same zone of divergence JEF-6. Net shore drift is to the south for one mile into Mystery Bay, terminating in the vicinity of Mystery Bay State Park (Kueler 1988). Sediments are derived from Vashon till and advance outwash deposits (WDOE 1978). A depositional spit at the northern tip of Mystery Bay encloses a salt marsh lagoon (WDOE 1978). Another salt marsh is protected behind a barrier beach within Mystery Bay State Park. Within Mystery Bay there is no net shore drift. A small salt marsh is isolated by driveway fill at the southern tip of the bay (Correa 2003).

Eelgrass is nearly continuous north of, and within, Mystery Bay except for patchy beds at the head of the bay (WDNR 2001). Sand lance spawn on the beaches just north of Mystery Bay and just south of, and in, the State Park (Penttila 2000). Kilisut Harbor and Mystery Bay are regionally significant over wintering areas for diving ducks. Significant development around Nordland has eliminated riparian vegetation on the eastern shore of

the bay; in contrast, about 65% of riparian vegetation remains on the western shore (WDNR 2001).

An area of divergence occurs from the relatively tall bluffs cut into shale and mudstone on northern side of Griffiths Point. Kueler shows some net drift occurring to the east into Mystery Bay, however the current DOE Coastal Zone Atlas shows this as an area of divergence but no significant drift to the east (Kueler 1988 and WDOE 2003). To the west and then south from this zone of divergence, drift cell JEF-9 encompasses net shore drift for 1.7 miles into southern Scow Bay. Sediment is derived from mixed shale/mudstone and glacial till feeder bluffs in southern Kilisut Harbor (Kueler 1988).

Riparian vegetation along this segment is fragmented due to clearing for views (WDOE 2001). Eelgrass is continuous along the Scow Bay reach (WDNR 2001). Surf smelt and sand lance use this shoreline for spawning (Long et al. 2003 and Penttila 2000). This is an important over wintering area for waterfowl and spawning grounds for herring (indeed herring roe is important food for diving ducks). There is commercial aquaculture in Scow Bay. Southern Scow Bay has extensive salt marshes (Scow Bay March Reach), The value of this salt marsh habitat for migratory juvenile salmonids could be improved by increasing the water flow under the causeway by building a bridge or replacing the culverts (Correa 2003).

Shoreline Alterations

There is a bulkhead that extends into the high water in front of the "Ecologic Center" resort on South Marrowstone. The parking lot for South Indian Island County Park is constructed on fill placed behind a riprap bulkhead on the beach. Little or no armoring occurs on East Marrowstone except for the bulkhead protecting the parking lot at East Beach County Park. An abandoned pier at Fort Flagler State Park interferes with along shore transport of sediment; its removal would improve sediment transport to the south side of Marrowstone Point.

A riprap bulkhead protecting the coast guard facility interferes with sediment transport along the north side of Marrowstone Point in the North Flagler Reach. The terminus of drift cell JEF-5 in front of the campground at Fort Flagler is altered: historically Rat Island was a spit extending from the point. In the 1940's this spit was breached by dragging boats over it during military exercises (Hirschi et al 2003a). Since that time a combination of currents and the interruption of sediment transport has kept Rat Island separated from Marrowstone Island except during low tides. This interruption of along shore sediment transport has been caused by the little used boat ramp on the north side of the point (Hirschi et al 2003a). In addition, this spit enclosed what was historically an approximately 22-acre salt marsh where the campground now sits (Correa 2003).

On the inside of Kilisut Harbor there is a boat ramp and dock at Fort Flagler with some nearby associated bulkheading. However, this drift cell, JEF-6, is not highly altered and its there is very little armoring of its contributing and feeder bluffs Within the North Kilisut and Kilisut reaches. To the south there is extensive bulkheading in front of the feeder and contributing bluffs in drift cell JEF-7 (South Kilisut Reach) amounting to 32.5% of the total length of the drift cell (Hirschi et al. 2003b). This could lead or have already contributed to erosion of the along-shore and depositional spits just north of

Mystery Bay State Park. Within Mystery Bay State Park there is a dock and boat ramp. In the Nordland Reach there are three docks associated with the town of Nordland and several building and filled areas intruding into the nearshore. Just south and north of the Nordland Store, State Highway 116 is bulkheaded, possibly eliminating shallow water habitat for juvenile salmonids. At the head of Mystery Bay a driveway truncates a salt marsh. In Scow Bay there is a smattering of residential bulkheading amounting to 16.1% of the total length of the drift cell JEF-9, a small house built on stilts over the intertidal, and eleven staircases. At the head of Scow Bay the causeway that connects Marrowstone Island to Indian Island interrupts tidal flow.

Restoration Opportunities

A larger culvert or culverts could be placed under the causeway between Marrowstone and Indian Islands to improve tidal exchange between Scow Bay and Oak Bay. This would improve migratory habitat for juvenile salmonids (Correa 2003). Moving the parking lot at East Beach County Park to an upland site would increase shallow water habitat for migratory salmonids (pinks and chum). Removal of an abandoned pier at Fort Flagler along with random creosote pilings in this area would improve transport of sediment north to the terminus of drift cell JEF-3 at Marrowstone Point and decrease toxin input to the water from creosote. The removal of the bulkhead and restoration of the salt marsh at Marrowstone Point would improve beach habitat and increase migratory salmonid habitat. This may entail the removal or relocation of the USGS laboratory at Marrowstone Point and/ or the automated Coast Guard light (Correa 2003). If the little used boat ramp on the north side of the spit, by the campground at Fort Flagler was removed it would improve sediment transport to the terminus of the drift cell on Rat Island (Hirschi 2003b). Restoring at least part of the historic saltmarsh at the campground at Fort Flagler could improve habitat for juvenile salmonids and other saltmarsh dependent species.

In the South Kilisut reach the removing bulkheads within drift cell JEF-7 would improve sediment recruitment and could help sustain beaches north of Mystery Bay. Removal of fill within a salt marsh in the North Kilisut reach would increase salt marsh habitat (Correa 2003). A driveway truncating the salt marsh at the head of Mystery Bay could be removed to provide access to salmonids and other creatures- a neighboring driveway can be used for access (as is evident from the WDOE shoreline photos). Unused creosoted pilings could be removed from Mystery Bay State Park to decrease possible toxin input into the water (Correa 2003).

Public Access

At the southern tip of Marrowstone, Kinney Point is owned by Washington State Parks and the tidelands are owned by DNR (DNR –404A). Although currently only accessible by boat this State Park property abuts the end of Baldwin Road, so upland access could be possible with parking and road improvements. On the east side of Marrowstone Island there is beach access at East Beach County Park. Fort Flagler at the north end of the island provides access to miles of shoreline along with a campground, shellfish beds and a boat ramp. Mystery Bay State Park in Nordland has about 700 feet of public access

shoreline, a boat ramp and dock. In Scow Bay there is DNR shoreline accessible by boat. There is a street easement extending to the water at Strawberry Lane to the west of Flagler Road where public access from land might be possible, but parking may be a problem due to lack of space between the bluff and the road. The entire south shore of Indian Island is public access and there are several parking areas at South Indian Island County Park off of Highway 116.

Preliminary Nearshore Reaches

Ship Canal: Southern end of ship canal jetty north to the edge of Naval Magazine Indian. Island.
South Indian Island: Ship canal jetty east to edge of Marrowstone Island
South Marrowstone Island: East to edge of Marrowstone Island to the western boundary of Kinney Point State Park property.
Kinney Point State Park: Kinney Point State Park property.
Lip Lip Point: Northeastern edge of Kinney Point State Park property to origin of drift cell JEF-3.
East Marrowstone: Origin of drift cell JEF-3 to Marrowstone Point.
North Flagler: Drift cell JEF-4 and eastern part of divergent zone.
Flagler Bluffs: Feeder bluffs in zone of divergence JEF-4/JEF-5.
Flagler Campground North: Drift cell JEF-5.
Rat Island
Flagler Campground South: State Park boundary north to the end of the spit by the campground.
North Kilisut: Origin of drift cell JEF-6 north to the State Park boundary.
Kilisut: Area of divergence JEF-6/ JEF-7.
South Kilisut: Origin of drift cell JEF-7 to the north edge of the salt marsh enclosed by the alongshore spit north of Mystery Bay State Park.
Mystery Bay Salt Marsh: The salt marsh lagoon enclosed by the alongshore spit north of Mystery Bay State Park**.**
Mystery Bay West: from the eastern edge of the salt marsh to the western edge of Mystery Bay State Park;
Mystery Bay State Park.
Nordland: From eastern edge of Mystery Bay State park to the head of the bay (where the driveway truncates a salt marsh).
Scow Bay: From the head point to the terminus of drift cell JEF-9 in Scow Bay.
Scow Bay Marsh: The area of undefined drift at the head of Scow Bay.

Port Townsend Bay

This area contains the most intense development within the county's jurisdiction at Port Hadlock and by the Port Townsend Paper Mill as well as the relatively undeveloped areas south of Hadlock and between Chimacum Creek and Glen Cove (Map 15). The significant watershed of Chimacum Creek enters Port Townsend Bay at Irondale. This shoreline is within the watershed of the Tri-area UGA around Port Hadlock and Irondale. There are five drift cells within this area and a portion of another. Climate for this area is

drier that further south in the county with rainfall in Chimacum being about 28 inches a year and 18 inches a year in Port Townsend.

Ecological Background

The western side of the Portage Canal is an area of no net drift (Map 15). Drift cell JEF-16 begins at the northwest edge of the broad point to the north of the Portage Canal and continues about a kilometer to terminate on a depositional beach just to the west of the Inn at Port Hadlock. The average rate of erosion near the origin of the drift cell is 4 cm a year based on a greater than twenty year record (Kueler 1988). Sediment is derived from contributing bluffs of till overlying sandstone at the origin of the cell and just east of the Inn at Port Hadlock (Johannessen 1999). The depositional beach just west of the Inn at Port Hadlock encloses a small salt marsh, that is part of the Hadlock Lagoon Reach (WDOE 2001).

Riparian vegetation is fragmented along this section of shoreline (WDNR 2001 and WDOE 2001). Eelgrass is continuous and sand lance spawn at both the origin and at the terminus of this drift cell (WDNR 2001 and Penttila 2000). The small salt marsh enclosed by the depositional beach does have exchange with the bay and provides habitat suitable for juvenile salmonids (Hirschi 1999).

Skunk Island is a basaltic outcropping covered in vegetation just south of Port Hadlock. It remains in its natural state and is currently designated as natural.

Drift cell JEF-17 originates north of Port Hadlock and net shore drift is south to terminate at the spit south of lower Port Hadlock. Sediment is derived from the steep feeder bluffs south of Irondale. The bluff is comprised of sandy recessional outwash, over till, over advance glacial outwash which, in sum, provides abundant sediment to the nearshore. This bluff (Hadlock Bluffs) has not experienced any large failures recently, however it remains the only long-term sediment source for drift cells JEF-17 and JEF-18 (Johannessen 1999). This shoreline is classified as unstable with recent landslides (WDOE 1978). A wide depositional beach is present along the Port Hadlock waterfront and continues to form a long (780 yard) depositional spit enclosing a large tidal lagoon south of lower Port Hadlock (Hadlock Lagoon). This spit still appears to be prograding to the southeast (Johannessen 1999).

Riparian vegetation in the Hadlock Bluffs Reach is largely intact; unfortunately it is largely absent from the Hadlock Waterfront Reach (WDOE 2001). Sand lance spawn along the length of these reaches. Surf smelt spawn just north of the waterfront (Penttila 2000). Eelgrass is continuous along Hadlock Bluffs Reach and patchy beds occur in front of the waterfront, spit and lagoon (WNDR 2001). The lagoon contains shallow water foraging habitat for juvenile salmonids (Hirschi 1999). Low and high salt marsh lines the fringe of this lagoon (Leon and Driscoll 1976). A small unnamed stream flows into the lagoon and at one time possibly provided salmonid spawning habitat, however recent use was not found (Hirschi 1999). This lagoon is also an important area for over wintering waterfowl (WDFW 2003).

Drift cell JEF-18 originates from the same feeder bluffs as JEF-17. Net shore drift is northward to the mouth of Chimacum Creek in the Old Log Dump Reach. Most likely a salt marsh spit complex was present just south of Chimacum Creek by a prograding spit, however this was filled long ago to provide log storage for the Port Townsend paper

mill and iron mill in Irondale (Johannessen 1999). Currently, a small accretionary beach forms at the end of the extensive bulkheading and fill (Kueler 1988). The former log dump property is now publicly owned and a restoration project has been funded by the State Salmon Recovery Funding Board (SSRFB) to remove the fill and restore the depositional beach (Correa 2003).

Riparian vegetation is present, along the moderately high feeder bluffs, at southern part the Old Log Dump Reach. However, it is absent throughout the modified part of this reach (WDOE 2001). Clam digging is locally popular at the mouth of Chimacum Creek (Speck, personnel communication). The estuary of Chimacum Creek contains salt and brackish marsh (WDFW 2003). The estuary is an important rearing habitat for juvenile coho and summer chum. The summer chum salmon run has been restored to Chimacum Creek after being extirpated in the early 1990's (for more information see section on Chimacum Creek freshwater) and the estuary and nearshore are important nursery habitat for this species (Hirschi, personal communication). The riparian zone is intact along the lower section of Chimacum Creek (WDOE 2001). Eelgrass beds offshore provide more habitat (WDNR 2001). Sand lance spawn in one of the small beaches bounded by riprap in front of the former log dump (Penttila 2000 and Long et al. 2003). The mouth of Chimacum Creek is also important habitat for waterfowl (WDFW 2003).

Between the mouth of Chimacum Creek and Kala Point two drift cells occur, diverging from a shared feeder bluff- this reach South Kala Bluff Reach stretches from the mouth of Chimacum Creek to the edge of the Kala Point Spit (Kueler 1988). This feeder bluff, comprised of advance outwash overlain by glacial till, contributes high quality sediment to the nearshore (Johannessen 1999). This 330 yard wide bluff just north of Chimacum Creek feeds the short drift cell JEF-19 with sediment for net shore drift to the south to terminate at the mouth of Chimacum Creek. It also feeds sediment into drift cell JEF-20 that has northeastern ward net shore drift to terminate at the mouth of the lagoon on Kala Point, a cuspate spit. This lagoon with its associated tidal channels is encircled by the spit and maintains a vigorous tidal exchange with Port Townsend Bay. These reaches are not subject to any shoreline modification and demonstrate natural function (Johannessen 1999).

Eelgrass beds are patchy to continuous in the South Kala Point Reach providing a migratory corridor for juvenile salmonids and spawning substrate for herring. The lagoon at Kala Point and its associated 8.5-acre salt marsh are likely intimately associated with the success of out migrating salmonids from Chimacum Creek (Hirschi 1999 and Leon and Driscoll 1976). Sand lance spawn just south of the outlet to the lagoon and on the north side of the point (Penttila 2000). This shoreline is host to a Bald Eagle territory and significant waterfowl concentrations (WDFW 2003). Riparian vegetation is largely intact, but some bluff-top clearing has occurred for new home sites (WDOE 2001). The bluff immediately to the north of Chimacum Creek was recently purchased with Salmon Recovery Funds.

Drift cell JEF-21 originates from a zone of divergence in the southern shore of Old Fort Townsend and net shore drift is to the south to the lagoon entrance on the southern side of Kala Point (Kueler 1988 and Johannessen 1999). The North Kala Bluffs Reach encompasses this drift cell and part of the zone of divergence to the north. These

bluffs are comprised of glacial till overlying Vashon advance outwash sediments and are classified as unstable with many recent slides (WDOE 1978).

Eelgrass meadows are continuous along this shoreline and the Port Townsend Bay herring stock uses them for spawning substrate (Penttila 2000 and WDNR 2001). Sand lance and surf smelt spawn on the beaches in Old Fort Townsend State Park and the North Kala Point Bluffs Reach. This shoreline is also one of the few in Jefferson County were summer surf smelt spawn. Historically, there have been bald eagle nests along this shoreline and it is a bald eagle territory (WDFW 2004). Riparian vegetation is generally healthy in this segment. While some bluff top clearing has occurred, there has historically an effort in the Kala Point Development to preserve riparian vegetation (WDOE 2001). This has maintained relatively stable bluffs and preserved shoreline ecology.

The next drift cell and the last in this segment, JEF-22, originates from the same feeder bluff as JEF-21 in Old Fort Townsend State Park. Net shore drift is to the northeast and then northwest to Point Wilson, being interrupted along the modified portions of shoreline by the Port Townsend Paper Mill and City of Port Townsend. A major depositional beach occurs just south of the Paper Mill, enclosing a salt marsh (Keuler 1988 and WDOE 2001). The City of Port Townsend boundary is just north of the Paper Mill and lies outside of the scope of this study. For more information about the shoreline of the City of Port Townsend refer to the inventory prepared for their SMP update by Barbara Nightengale.

South of the Paper Mill this drift cell is rather pristine and is contained in the Port Townsend Bay Reach. Eelgrass is continuous along this segment becoming patchy in front of the barrier beach just south of the Paper Mill, and again serves as spawning substrate for herring (WDNR 2001 and Penttila 2000). Surf smelt spawn in the southern portion of this drift cell and sand lance spawn on the beach in the center of Glen Cove (Penttila 2000). The pond and marsh at Glen Cove harbors significant waterfowl concentrations (WDFW 2004). Riparian vegetation from the origin of this drift cell north to Glen Cove is intact (WDOE 2001).

Shoreline Alterations

A large marina with about 100 small slips is located in front of the Inn at Port Hadlock hotel in drift cell JEF-16, however based on an examination of WDOE shore photos it does not appear to significantly effect net shore drift (WDNR 2001 and WDOE 2001). Approximately 177 meters of this drift cell are armored representing about 17% of its total shoreline. Modification appears concentrated along the low bank area near the origin of the cell (Hirschi et al. 2003 and WDOE 2001). Three wooden bulkheads along the contributing bluff area of this drift cell may limit sediment recruitment into the nearshore (Johannessen 1999).

Numerous docks, bulkheads, a boat ramp and other structures are present along the Lower Hadlock waterfront. Extensive bulkheading has occurred just north of the waterfront in front of low bank residential property. On the spit south of Hadlock there has been some bulkheading and a dock associated with a house (Johannessen 1999 and WDOE 2001). Overall shoreline armoring impacts 335 yards of this drift cell or 31% of its length (Hirschi et al. 2003). However, it appears that net shore drift is not completely impaired as the spit southeast of the waterfront continues to prograde.

The Old Log Dump Reach is extensively modified with 513 yards of bulkhead fronting fill in its depositional zone along the former iron mill and log dump sites. This site has been publicly acquired for a park and this rock bulkhead and fill is slated to be removed in order to restore shallow water habitat for juvenile salmonids and beach habitat for forage fish spawning (Hirschi et al. 2003 and Correa 2003).

A dock and boat ramp on the north side of Kala Point do not appear to impede significant amounts net shore drift (WDOE 2001). A bulkhead extends into the intertidal in Old Fort Townsend State Park. The salt marsh at Glen Cove is extensively filled and modified for settling ponds and other structures associated with the Port Townsend Paper Company mill. The paper mill is build out over the water and is the site of extensive bulkheading and shoreline armoring. There are also several large docks and barge unloading facilities at this location. The shoreline north of the mill to the City of Port Townsend boundary is bulkheaded, fronting a converted railroad grade and isolating the bluff from the nearshore (WDOE 2001 and Correa 2003).

Restoration Opportunities

The lower Hadlock waterfront should be examined for opportunities to remove alterations that interfere with along shore transport of sediment. The restoration of the beach at the old log dump is a major project and has received funding. This should improve estuarine and forage fish spawning habitat. The removal of the filled bulkheaded area at Old Fort Townsend would improve the along shore transport of sediment and increase shallow water nearshore habitat. The opening of an outlet that would allow fish passage to the lagoon south of the paper mill would increase salt marsh habitat for summer chum and pink salmon. Studies and possible modification of the paper mill to allow for less disruption to salmon migration should be explored. Alterations to the mill could happen as part of normal maintenance and refurbishment of the mill. The removal or modification of the Larry Scott Trail north of the paper mill would allow for the recruitment of sediment into the nearshore.

Public Access

There is a public boat ramp on the lower Hadlock waterfront. In Irondale the shoreline from the old iron mill site to Chimacum Creek is a combination county park and WDFW lands. A major restoration is slated to happen here with the removal of fill associated with the log dump and the reestablishment of a beach. There is waterfront access at Old Fort Townsend State Park south of Port Townsend. Between the Port Townsend Paper Mill and the Port of Port Townsend there is a public waterfront trail (the Larry Scott Trail).

Preliminary Nearshore Reaches

PT Ship Canal West: West side of Pt Ship Canal from the jetty north to the origin of drift cell JE-16.
Drift cell JEF-16: From origin of the drift cell to the edge just east of the Inn at Port Hadlock.

Inn at Port Hadlock: the area around the Inn at Port Hadlock (designated commercial in the overturned UGA plan).
Hadlock Lagoon: From just west of the Inn at Port Hadlock to just south of the boat ramp in Lower Hadlock, encompassing the lagoon and salt marsh south of the Lower Hadlock.
Hadlock Waterfront: commercial area in Lower Hadlock including the working waterfront.
Hadlock Bluffs: The bluff area north of the waterfront that is mostly residential.
Old Log Dump: County and WDFW land slated to be restored to a beach just south of the mouth of Chimacum Creek.
Chimacum Creek Estuary: Lower reach of Chimacum Creek under tidal influence.
Kala Bluffs: area just north of Chimacum Creek encompasses drift cell JE-19 and the feeder bluff for JE-20.
Kala Point: Kala Point spit including the salt marsh lagoon in the center of the spit.
North Kala Bluffs: The shoreline from the north edge of Kala Point Spit to the south boundary of Old Fort Townsend State Park.
Port Townsend Bay: The shoreline from the north edge of Old Fort Townsend State Park to just south of the Paper Mill.
Paper Mill: The area around the Port Townsend Paper Mill north to the City of Port Townsend boundary.

Chimacum Creek

Chimacum Creek's headwaters are in the coastal hills south of Chimacum with a watershed size of about 33 square miles (Map 16). It flows north through the towns of Chimacum, Port Hadlock and Irondale to flow into Port Townsend Bay near Irondale. The shoreline of the state begins at the mouth and stretches to the fork at about river-mile 2.9 to create the east and west forks (this differs from the current designation which extends to the confluence with Naylor's Creek). From the mouth to river-mile 1.3 the creek flows through a tightly constricted ravine with good riparian habitat and fair pool habitat. For the lower 0.2 mile the creek is estuarine influenced and is relatively unimpacted by development with salt marsh and lagoon habitat. The shoreline south of its mouth is slated to be restored by the removal of acres of fill associated with an old log dump (Correa 2003). Between river-mile 1.3 and 2.9 the riparian is in generally good shape, it however, is an area of increasing commercial and residential development. This development, if surface water is not properly managed, is a long-term threat to the water quality in Chimacum Creek. Historically this area, and the broad agriculturally dominated valley upstream, was complex of beaver ponds and cedar and spruce swamp. This type of habitat provided excellent coho rearing habitat. Now much of this area has been drained and channelized resulting in an altered flow scheme and loss of 90% of juvenile salmonid rearing habitat in the watershed (Correa 2003). In order to preserve the ecological function of the lower water shed that is within the shoreline of the state designation it is imperative to continue recent actions in the upper watershed designed to improve water quality and fish habitat.

Anadromous Fish

Coho, summer chum, fall chum, steelhead and cutthroat utilize this watershed for spawning. Coho spawn from the lower reaches of the stream up to the headwaters and are considered a healthy stock with spawning surveys indicating an increasing trend. Summer chum were extirpated from Chimacum Creek in the early 1990s and have since been reintroduced. Summer chum spawned in the lower mile of creek, below the Irondale Road crossing. The population, already critical, was unable to spawn, after a culvert failure at Irondale road sent tons of fine sediments into the creek in the winter of 1985-1986. This had the effect of cementing the spawning gravels together, resulting in a lack of reproductive success and extirpation (Ray Lowrie, personal communication). This population has since been reintroduced with stock from Salmon Creek in a volunteer run broodstock hatchery program. The first returning spawning adults were counted in 1999 and in 2001 the estimated return, based on spawning surveys was about 900 adults (Correa 2003). Recent returns have been even higher estimated at over 1000 in the fall of 2004 (Al Latham personal communication 2004). It is interesting that in 2004 summer chum spawned up to Ness's Corner Road- a mile further than previously observed. This may have been a reestablishment of historical spawning habitat (Kevin Long, personal communication 2004).

Restoration Opportunities

Most of the restoration opportunities on Chimacum Creek occur upstream on the East and West Forks where there are projects that restore the channelized creek to a more natural function. In this lower section protection of key parcels and maintaining the riparian corridor and water quality is essential. At the mouth of the creek the removal of the log dump fill and creation of a beach should allow for more natural processes.

Preliminary Reach Breaks

Preliminary reach breaks at the end of tidal influence, Irondale Road and Nesses Corner Road crossing.

Gibbs Lake

Gibbs Lake is located southwest of Chimacum and is located in the Naylors Creek watershed which flows into Chimacum Creek (Map 16). Its surface area is 35.5 acres. The surrounding shorelands and uplands are a county park with access from Gibbs Lake Road. In high flow years coho salmon spawn just downstream from the lake in Naylor's Creek and also upstream of the lake to spawn in two small tributaries (Correa 2003). There is evidence that coho use Gibbs Lake for rearing and may get stuck in the lake during dry years (Doug Soehl, personal communication 2001).

Anderson Lake

Anderson Lake is located west of Chimacum is in the Chimacum Creek watershed (Map 16). Its surface area is 57.3 acres. Its outflow is to Chimacum Creek via Putaansuu Creek through a wetland with no definitive channel. It is surrounded by state park land and, except for park facilities, is quite pristine. It is a popular fishing spot in season and swimming and hiking around Anderson Lake is enjoyed by the public.

Peterson Lake

Peterson Lake is located south of Discovery Bay in the Chimacum Creek watershed (Map 16). Its surface area is 22.6 acres. The surrounding area is zoned commercial forestry and has seen recent (1999) clear cutting, although a buffer was left around the lake. It is a bald eagle territory. It is also presumed habitat for anadromous steelhead and cutthroat trout (Correa 2003). There is no public access.

The Mill Settling Pond

The Mill Settling Pond is a highly altered lake that serves industrial purposes located just east of the Port Townsend Paper Mill. Its total surface area is 30.5 acres. Presumably it has little habitat value. Historically this lake was part of a larger salt marsh in Glen Cove that included some of the filled area where the mill now sits and the 15-acre saltmarsh adjacent to it to the south. The Mill Settling Pond is currently designated an urban shoreline due to its industrial use.

Strait of Juan de Fuca and Discovery Bay

Background

This shoreline stretches from the boundary of the City of Port Townsend in the east to the boundary of Clallam County in the west. The shoreline along the Strait of Juan de Fuca is subject to the greatest wave action in Jefferson County and is characterized by tall, steep, eroding bluffs (Map 17). Discovery Bay is a protected embayment with some development in the areas around Cape George, Beckett Point and Adelma Beach (Map 18). It was here Captain Vancouver first anchored while exploring Puget Sound in 1792. Early in the development of Puget Sound it was the location of a lumber mill and port at Mill Point. Salmon and Snow Creeks drain into Discovery Bay and support populations of chum, coho, cutthroat and steelhead. Crocker Lake is in the Snow Creek watershed. The climate here is cool and dry with annual precipitation at Port Townsend about 18 inches a year and about 30 inches a year at the head of Discovery Bay (Phillips and Donaldson 1975). A brief discussion of Protection Island National Wildlife Refuge is included in this section.

Ecological Background

Middlepoint Reach encompasses drift cell JEF-23 originates at a zone of divergence between McCurdy Point and Cape George to the City of Port Townsend Boundary. These tall feeder bluffs (50-70m high) are comprised of Vashon Till overlying weaker layers of

advance outwash, unidentified glacial sediment and a basement of Double Bluff Formation (WDOE 1978 and Kueler 1988). In general there is a wave cut cliff under a steep vegetated slope topped with another tall cliff of glacial sediments (WDOE 2001). Net shore drift is east to Point Wilson in the City of Port Townsend. The bluffs in this reach are considered unstable in addition, east of McCurdy Point there are many recent and old landslides (WDOE 1978). The estimated annual rate of bluff retreat at the end of Elmira Street near the City/ County boundary is 6 cm a year (Kueler 1988).

There is little riparian vegetation in this area, however there is significant bluff top and bluff side vegetation along this shoreline. Some clearing for views has occurred which may accelerate the inevitable erosion of the shoreline in this reach (WDOE 2001). There is a bald eagle nest on McCurdy Point (WDFW 2004). Kelp is patchy throughout this reach (WDNR 2001).

Drift cell JEF-24 originates from the same feeder bluffs as drift cell JEF-23 and net shore drift is to the southwest to terminate at Beckett Point (Kueler 1988). Accretionary zones occur at the Cape George marina (historically a salt marsh) and at the terminus at Beckett Point, a cuspate spit. Erosion is severe just north of Cape George and has endangered homes (Gerstel et al. 1997). With exception of accretionary shoreforms this shoreline is considered unstable with frequent landslides (WDOE 1978). An enclosed brackish lagoon is located within Beckett Point with no open water outlet to the bay (Correa 2003).

There is a bald eagle nest near the origin of the cell and another near Beckett Point (WDFW 2004). Patchy beds of bull kelp (Nereocystis luetkeana) are found north of Cape George. Eelgrass beds are patchy in front of Cape George and Beckett Point and continuous in between (WDNR 2001). Riparian vegetation is largely intact between the Cape George development and Beckett Point, however some clearing for views has occurred (WDOE 2001). The Cape George development has seen extensive clearing, possibly contributing to erosion (WDOE 2001). Storm water entering the nearshore is an issue at Cape George, several private storm water drains enter the beach and one large storm drain empties into a ravine, which then drains untreated into the bay (Correa 2003).

The next drift cell JEF-25 originates at a zone of divergence south of Adelma Beach. Net shore drift is to the northwest for approximately 4.4 miles to terminate at the cuspate spit at Beckett Point (Kueler 1988). Sediment is derived from Vashon Till, undifferentiated Pleistocene sediments, and Vashon Advance outwash. This shoreline is generally considered unstable (WDOE 1978). Salt marshes occur behind deposition beaches in this drift cell, two in the vicinity of Tukey Spit and Chevy Chase and one at Beckett Point (Leon and Driscoll, 1975).

The two salt marshes- South and North Tukey Marshes- near Chevy Chase have no direct connection to the salt water and are contained by alongshore spits. South Tukey Marsh of these two appears to hold little or no open water whereas North Tukey Marsh of the two contains a lagoon (WDOE 2001). This northern marsh also has a small stand of Garry Oak (*Quercus garryanna*) and other native and uncommon prairie plants along its shores (Admiralty Audubon Society 1990). There is a Bald Eagle nest here as well (WDFW 2004). Sand lance spawn on the north side of both of these spits (Penttila 2000 and Long et al. 2003).

The steep, unstable bluffs south of Beckett Point (in the Beckett Point Prairie Reach) harbor uncommon prairie species, including prickly pear cactus (*Optunia*

fragilis), threadleaf phacelia (*Phacelia linearis*), menzies larkspur (*Delphinium menziessi*), chocolate lily (*Fritilaria lanceolatat*) and harvest brodiaea (*Brodiaea coronaria ssp. coronaria)* (Gorsline, personal communication, 2004). This is the only site in Jefferson County where prickly pear cactus and threadleaf phacelia are found and is rare example of the dry, post-glaciation vegetation on the northeast Olympic Peninsula. In addition, this area also harbors the only significant old grown douglas fir forest on the Quimper Peninsula. Most likely, it was passed over for cutting due to the trees being severely pruned and topped by strong winds out of the Strait of Juan de Fuca, and the very steep nature of the bluffs. It is a rare example of a douglas fir, madrona and snowberry dominated ecosystem. Every effort should be made to preserve these bluffs and ecosystems.

Eelgrass beds are patchy in front of Beckett Point and near Adelma Beach, otherwise eelgrass grows continuously along this shoreline and the Discovery Bay herring stock uses it for spawning (WDNR 2001 and Penttila 2000). Sand lance spawning habitat is continuous in the Adelma Beach and East Discovery Bay reaches (Penttila 2000 and Long et al. 2003). Riparian vegetation is spotty throughout this drift cell due to clearing in the Adelma Beach reach and erosive bluffs in the reaches north. A house is perched on top of an active feeder bluff (basically a landslide) in the South Beckett Point Bluffs Reach (WDOE 2001). In general, the area between Tukey and Beckett Point is a quite pristine area of erosive bluffs and forested slopes with intermittent meadows that harbor uncommon prairie plants (WDNR 2001 and WDOE 2001).

South Discovery Bay reach encompasses an area of net shore drift divergence and drift cell JEF-26 south of Adelma Beach to the Snow Creek Delta. Drift cell JEF-26 originates from this zone of divergence and net shore drift is to the south to terminate at the delta of Snow Creek (Kueler 1988 and Correa 2003). Sediment is derived from Vashon Till; along shore there is an area of tertiary basalt between Woodmans and Fairmont. There is a brackish marsh at Woodmans that is has no open water connection to the bay (WDOE 1978). A salt marsh at Fairmont is isolated from the bay by an abandoned railroad bed (Correa 2003 and WDOE 2001). A drift cell analysis is not available for Discovery Bay south of the 48th parallel (roughly from Woodmans south). Sediment is deposited at the head of the bay at the estuary formed by the deltas of Salmon and Snow creeks (Correa 2003).

Eelgrass is continuous in the northern part of this reach and patchy near the head of the bay and herring use it for spawning (WDNR 2001). Bald eagle nesting occurs near the origin of the cell and at Fairmont (WDFW 2004). Surf smelt spawn near the origin of the cell and in front of Woodmans. Sand lance spawn throughout Adelma Beach, in front of Woodmans and in front of Fairmont (Penttila 2000 and Long et al 2003). Riparian vegetation is generally sparse and absent from the southern part of the cell due to the abandoned railroad grade (WDNR 2001). The estuaries of Salmon and Snow Creek provide some salt marsh and shallow water habitat for juvenile salmonids. Salmon Creek supports spawning by summer chum and coho (Correa 2003). There is extensive shoreline modification is this area which limits estuary habitat (discussed further in shoreline modifications below).

The next drift cell in Discovery Bay, JEF-27, originates from a zone of divergence north of Mill Point and net shore drift is south to the delta of Salmon and Snow Creeks. A sharp alongshore spit occurs at Mill Point. Sediments are derived from

Vashon recessional outwash and bluffs are generally considered unstable with the exception of Mill Point and the depositional beaches and flats at the terminus of the cell (WDOE 1978 and Kueler 1988).

Eelgrass is patchy towards the end of the cell and in front of Mill Point it otherwise grows continuously along this drift cell (WDNR 2001). Herring use this eelgrass for spawning. Surf smelt spawn on the beach in front of the old millpond at the terminus of the cell. Sand lance spawn on the north side of Mill Point, just north of Trend West Condominiums and continuously for the last kilometer of the cell (Penttila 2000 and Long et al. 2003). Riparian vegetation covers about 20% of the shoreline south of Trend West and is heavy north of Mill Point. However, for the most part it is lacking over the remainder of this shoreline (WDNR 2001). A bald eagle nest occurs near the origin of the cell (WDFW 2004).

Drift cell JEF-28 originates from the same zone of divergence as drift cell JEF-27. Net shore drift is north 1.5 km to terminate on the cuspate spit at Contractor's Point sediments are derived form the same parent material as JEF-27. Depositional areas are at Kalset Point and Contractor's Point (Kueler 1988).

Eelgrass is continuous along this reach with patches of brown kelp and ulva. There is a salt marsh at Kalset Point. Oysters are found south of Contractors Point and an aquaculture facility is located at Kalset Point (WDNR 2001 and Correa 2003). Sand lance spawn at the origin of the cell and on Kalset Point and herring spawn off shore (Penttila 2000). The shoreline between Kalset and Contractor's spit is pristine with abundant riparian vegetation, as is the area south of Kalset Point (WDOE 2001 and Correa 2003). A bald eagle nest is located near the mouth of Contractors Creek and the spit is a haul out area for harbor seals (WDFW 2004).

The last nearshore reach in this study Gardiner stretches from the edge of Contractors Spit north to the Clallam County boundary it contains drift cell JEF-29. Drift cell JEF-29 originates on the north side of the Miller Peninsula in Clallam County and net shore drift is first east along the Strait of Juan de Fuca, past Diamond Point and then south to Contractor's Point (Kueler 1988). The last 2.9 miles of this drift cell occurs in Jefferson County where sediment transport is generally along shore with areas of deposition in front of the Gardiner salt marsh and Contractor's Point (Kueler 1988).

Eelgrass and ulva are continuous along this reach (WDNR 2001). Sand lance spawn along the Gardiner shoreline and on the north side of Contractor's Point (Penttila 2000). A large salt marsh occurs at Gardiner, although truncated by a road, it provides habitat suitable for juvenile salmonids (WDOE 2001). This salt marsh is also important waterfowl and shorebird habitat (WDFW 2004). Riparian vegetation in this segment is generally good with some clearing for views. A pristine area occurs south of Gardiner (WDOE 2001). Eagle Creek estuary on the Clallam/ Jefferson County line is a bar bound estuary with good salt marsh and good potential for fish use (Correa 2003). Sand lance continuously from the county line south through Gardiner (Penttila 2000).

Protection Island north of Discovery Bay is a National Wildlife Refuge and as it is federal land is not subject to county jurisdiction. Briefly, it should be mentioned that it harbors significant marine mammal populations and 80% of the nesting seabirds in Puget Sound. The surrounding waters and county shorelines provide foraging areas for these animals (Nightengale 2000).

Shoreline Alterations

The marina at Cape George is protected by a jetty that interrupts along shore transport of sediment and is constructed on a depositional beach or historic salt marsh. In addition, there is extensive shoreline armoring near the marina. There is extensive armoring with seawalls and riprap along the northwest shore of Beckett Point (WDOE 2001). Along shore drift is interrupted on the north side of Beckett point by a boat ramp and has lead to erosion on the down drift side of the boat ramp, toward the tip of the spit. The south side of Beckett Point has several sizable bulkheads, which may be adversely net shore drift of sediment.

There is extensive shoreline armoring and fill along the Adelma Beach reach, which may be affecting sediment recruitment into the nearshore (Correa 2003). In addition, it may interrupt along shore transport and increase wave reflection resulting in a coarsening of the beach.

South of Woodman's an aquaculture facility interrupts along shore transport of sediment (Correa 2003). Between Woodmans and the delta of Salmon and Snow Creeks the backshore is isolated by a bulkheaded railroad grade that is 2.5 km long. At Fairmont there is extensive armoring including structures build on armored fill extending into the nearshore (Correa 2003 and WDOE 2001). The salt marsh at Fairmont is isolated by the railroad grade (Correa 2003).

The shared delta of Salmon and Snow Creek is subject to extensive modification. Snow Creek and Salmon Creek used to converge 100 meters south of Hwy 101 and share an estuary. However, due to rechannelization Snow Creek and Salmon Creek now flow separately to the salt water. Snow Creek's estuarial function is largely lost due to channelization, dikes and fill and truncation by the abandoned railroad grade. Likewise, Salmon Creek has lost estuary and salt marsh habitat due to truncation by the railroad grade. Millponds to the northwest of the mouth of Salmon Creek have been truncated by road fill and habitat could be restored by removing this fill. Likewise, removing the fill under the railroad grade and pulling back dikes would increase intertidal salt marsh habitat and water flow (Correa 2003).

The Trend West condominiums in the JEF-27 Reach are build out on armored fill that extends over the intertidal, eliminating shallow water habitat essential for the migratory success of juvenile summer chum (Correa 2003). The mouth of Contractors Creek has been highly altered by being moved and forced through a series of undersized culverts. In addition, portions of Contractors Spit have been armored for a peripheral access road, eliminating 15 acres of historic salt marsh (Correa 2003 and WDOE 2001). The spit is also covered in invasive non-native vegetation (WDOE 2003).

Restoration Opportunities

The restoration of the combined estuary of Salmon and Snow Creek has received funding by the State Salmon Recovery Board. This restoration will improve water flow and natural vegetation by removing dikes and will also place large woody debris into the nearshore and estuary habitats. The removal of the bulkheaded railroad grade would increase shallow nearshore habitat and sediment recruitment into the nearshore. Contractors Spit is highly altered and the restoration of the salt marsh and creek mouth

would improve salmonid habitat. The removal of the Trendwest Condominiums from the nearshore would improve net shore drift and increase shallow water nearshore habitat. A soft bank solution to the continuing beach erosion problems at Beckett Point would preserve land values and the ecology of the spit. Non-native vegetation and douglas fir need be managed at the Beckett Point prickly pear cactus site to preserve its uncommon prairie ecosystem that is home to two plant species found nowhere else in Jefferson County.

Public Access

Although the residents of Discovery Bay often have access through private easements to Discovery Bay- public access is limited. Members of the public often walk the beach from North Beach County Park within the City of Port Townsend down to Middlepoint. There is access at the head of Discovery Bay in the estuaries of Salmon and Snow Creeks on WDFW property. There is a public boat ramp in Gardiner. There is also a stretch of DNR tidelands between Adelma Beach and Cape George with boat access.

Preliminary Nearshore Reaches (Map 17 and 18)

Middlepoint: Origin of drift cell JEF-23 to the City of Port Townsend boundary.
Juan de Fuca Bluffs: Divergence zone JEF-23/ JEF-24.
Cape George: Origin of drift cell JEF-24 to the northern edge of Beckett Point.
Beckett Point: Beckett Point Spit.
Beckett Point Prairie: Southern edge of Beckett Point to about 4000 feet to the south to where zoning changes from RR 1:20 to RR 1:5.
South Beckett Point Bluffs: From this point to the northern edge of the salt marsh north of Tukey Spit.
North Tukey Marsh: The salt marsh north of Tukey Spit.
Tukey Bluffs: The bluff reach between North Tukey Marsh and South Tukey Marsh.
South Tukey Marsh: The southern of two salt marshes near Tukey.
East Discovery Bay: From the east edge of this marsh south to Adelma beach.
Adelma Beach: The shoreline adjacent to the residential development at and near Adelma Beach.
Southeast Discovery Bay: From the south edge of Adelma Beach south to the Salmon/ Snow Creek delta.
Salmon/ Snow Creek Delta: The combined nearshore area near the mouths of Salmon and Snow Creek
JEF-27: Drift cell JEF-27 including Mill Point.
JEF-27/ JEF-28: The area of drift divergence between drift cells JEF-27 and JEF-28.
JEF-28: Drift cell JEF-28 south of Contractors Point.
Gardiner: The shoreline from the terminus of drift cell JEF-29 to the Jefferson/ Clallam County boundary.
Gardiner Marsh: The salt marsh near Gardiner.

Snow Creek

Snow Creek's headwaters are in the eastern foothills of the Olympic flow is to the north to Discovery Bay (Map 19). The section with meets shoreline of the state criteria runs parallel to Hwy 101 from just north of Crocker Lake to Discovery Bay. This section is a mix of rural residential and agricultural land adjacent to the creek and commercial forestry dominating the watershed. Originally a meandering creek that flowed into Salmon Creek, the valley was cleared for agriculture and the creek rechannelized to flow along the right side of the valley to empty directly into Discovery Bay. Its riparian zone, once dominated by conifers is now dominated by deciduous trees and is rather narrow (76% if less than 66 feet) (Correa 2003).

Anadromous Fish

Snow Creek support runs of coho, steelhead and summer chum salmon. Coho and steelhead are listed as critical in SASSI and summer chum are listed as threatened under the Endangered Species Act (Correa 2003).

Restoration Opportunities

Portions of Snow Creek could be remeandered and riparian planting could take place to improve channel condition and riparian cover. The extensive restoration of the estuary by the North Olympic Salmon Coalition should improve juvenile salmonid survival.

Preliminary Reach Breaks

Due to consistent management needs along its length Snow Creek it can be treated as one reach for the SMP.

Crocker Lake

Crocker Lake is in the Snow Creek watershed and is an area of low-density residential and agricultural lands (Map 19). Its total surface area is 74 acres. Its waters are used as rearing habitat by coho salmon and its waters are closed to fishing due to the presence downstream of the Snow Creek Research Station operated by WDFW. It is bald eagle territory (WDFW 2005). There is a public boat launch on Crocker Lake. Possible restoration might include the planting of native riparian vegetation along its shores and the control of non-native reed canary grass.

West End Streams and Rivers

Bogachiel River

The Bogachiel River has its headwater in the Olympic Mountains in the Seven Lakes Basin and flows west to meet with the Quillayute River west of Forks in Clallam County

(Map 20). The section that this report pertains to is about four miles of the river upstream of the Clallam County line to the boundary of Olympic National Park. It is a Shoreline of Statewide Significance.

The Bogachiel supports coho, summer, fall and spring chinook salmon and winter and summer steelhead trout. The coho and fall chinook populations are listed as healthy whereas the summer chinook stock is listed as threatened. The status of the spring chinook stock is unknown. The winter steelhead trout run is listed as healthy and status of the summer steelhead run is listed as unknown.

Collapsing banks have been a problem in this section of the Bogachiel leading to sedimentation of the streambed. This erosion has also presented trouble for the roads in the area with several of them having to have been moved back from the river. Channel incision has also exposed clay layers, the erosion of which has led to a worsening of sediment quality. This parameter is listed as "poor" in the HLFA (Smith and Caldwell 2000). The area in the vicinity of Hemp Hill Creek is listed on the 303d list for high water temperatures and low dissolved oxygen. Large woody debris (LWD) levels are low downstream of Hemp Hill Creek and better upstream. Although systematic data is lacking the riparian condition of this stretch of river is though to be "fair" (Smith and Caldwell 2000).

Preliminary Reaches

This section of the Bogachiel should be treated as one reach.

Goodman Creek

Goodman Creek flows into the Pacific south of the Quillayute River and north of Mosquito Creek (Map 20). The lower two miles of creek are within Olympic National Park and the headwaters are in the coastal hills west of Hwy 101. There is little data on this watershed. Fall coho salmon and winter steelhead and cutthroat trout spawn in Goodman Creek but the status of these stocks are unknown (Smith 2000). There are three blocking culverts on left bank tributaries to Goodman Creek created by roads G 3300 and G 3310 that effect coho, steelhead and cutthroat habitat. Blocking culverts are also created by roads G 2170 and G 2100, effecting coho, cutthroat and steelhead habitat on five right bank tributaries. Goodman Creek contains a high density of wetlands indicating high ground water inputs. In general, large woody debris and other habitat data are lacking, however it has been noted that LWD and spawning gravel are lacking from road G 2108 to the G 3000 bridge (Jill Silver, personal communication as cited in Smith 2000). The primary means of restoration in this watershed should be the replacement of blocking culverts to open up anadromous habitat.

Preliminary Reaches

Goodman Creek should be treated as one reach.

Public Access

The upper watershed is WDNR land.

Mosquito Creek

There is little data on this creek. The lower mile and a half or so are within Olympic National Park. The headwaters are in the coastal hills west of US Hwy 101. Fall Coho and winter steelhead use this watershed for spawning; the health of these runs remains unknown (Smith 2000). There are several blocking culverts on Mosquito Creek- these should be replaced to open up anadromous fish habitat (Jill Silver, personal communication).

Preliminary Reaches

Mosquito Creek should be treated as one reach.

Public Access

Mosquito Creek flows through WDNR land for about a mile just upstream of the National Park Boundary.

Hoh River and Tributaries

Overview

The headwaters of the Hoh River are in the snowfields and glaciers of Mount Olympus (Map 20). This glacially fed river tumbles out of the Olympic and winds its way across a broad floodplain through the coastal hills. The upper watershed is protected in the Olympic National Park and the lower most mile or so of river lies within the Hoh Indian Reservation. The Hoh watershed, and other watersheds on the west side of the Olympic Peninsula, are subject to the greatest annual precipitation in the US outside of Hawaii, ranging from 70-100 inches of precipitation at the coast to 150-200 inches a year in the foothills of the Olympics. Although data is sparse for the higher elevations, during the 1957-1958 water year 542 inches of snow was recorded at Blue Glacier at the headwaters of the Hoh. Precipitation was 15 % below normal that year in the lowlands. The resulting temperate rainforest supports the growth of enormous moss covered conifers and big leaf maples. Between the National Park and the Hoh reservation most of the land is working timberland either privately or DNR owned and has been subject to timber harvest. From the ocean to the national park boundary the mainstem of the Hoh is classified as a shoreline of statewide significance. Its tributaries Nolan Creek, Winfield Creek, Maple Creek, Owl Creek and the South Fork of the Hoh River all are shorelines of the state.

The Hoh watershed supports breeding populations of bald eagles, harlequin duck, marbled murrelets and spotted owls (WDFW 2004)

Anadromous Fish

The Hoh River supports chinook, coho, fall chum salmon, steelhead and cutthroat trout and char spawning. All runs are though to be of native origin with few outside

introductions. The spring/ summer Chinook run is thought to be stable with most spawning occurring within the national park. Fall chinook are classified as healthy in SASSI. However all of these chinook runs have shown some recent decline. The fall chum run is in a long-term decline and was probably never numerous. The fall coho run is healthy, but again, has shown some recent decline. The status of the Hoh steelhead, cutthroat and char runs are unknown. It is thought that the Hoh River system supports the largest run of char on the coast (Smith 2000).

Fish Habitat

No barriers to anadromous fish occur on the mainstem of the Hoh, however roads have reduced access to the floodplain and cedar spalts and blocking culverts have cut off tributary habitat. Loss of floodplain habitat can reduce the amount the overall rearing habitat of the watershed leading to reduced fish returns. Loss of tributary habitat reduces the amount habitat available for spawning and rearing.

Cedar spalts are waste wood left over from salvage operations. Instream accumulations can impede water flow elevating water temperatures and leach tannins into the water thereby effecting water quality. Large sections of Nolan Creek and a 200ft section of Winfield Creek are impacted by cedar spalts (Jill Silver, personal communication). This has contributed to sections of Winfield and Nolan Creek being on the 1998 303d list for elevated water temperature (WDOE 1998). Many other smaller tributaries (not shorelines of the state) to the Hoh that are affected by cedar spalts include Pins Creek, Braden Creek, Sand Creek, Clear Creek Elk Creek, Lost Creek and Red Creek (Jill Silver, personal communication).

Blocking culverts occur on the following tributaries as well as several unnamed smaller tributaries to the Hoh River: Dismal Creek, Alder Creek, Nolan Creek, Braden Creek, Canyon Creek, Cassel Creek, Mosquito Creek, Cedar Creek, Rock Creek, Elk Creek, Hell Roaring Creek, and Iota Creek. In addition there are numerous unnamed tributaries affected as well as many acres of floodplain habitat.

Roads in the floodplain have also reduced floodplain habitat. During floods these act as dikes isolating the river from the floodplain. Floodplain habitat is not only important as rearing habitat for salmonids, but also for ground water recharge and flow moderation in the Hoh (Smith 2000). The Upper Hoh Road is of particular concern as it not only impacts floodplain habitat but the river impacts the road- creating a need to shore up the road with- costing the county millions of dollars. Traditionally the county has shored up the road with rock riprap, which has an adverse effect on salmonid habitat. Recently, however engineered logjams have been placed to try to protect the road while improving salmon habitat. The logjams have had trouble remaining in place although they are still providing some protection for the road. A larger project utilizing engineered logjams by the Washington State Department of Transportation was completed in 2004 to protect Hwy 101. The move from using rock to engineered logjams to stabilize channel migration has the potential for protecting infrastructure while enhancing fish habitat.

Riparian condition in the Hoh Basin is variable. The upper reaches within the National Park remain in good condition. Historically, the watershed was dominated by large old growth hemlock and Sitka Spuce, however in the middle reaches of the Hoh, previous to regulation, much of these areas were logged right up to the waters edge. Thus,

most of the mainstem of the Hoh downstream of the South Fork has poor riparian condition, as well as lower Winfield Creek and Maple Creek. . The riparian condition of the South Fork of the Hoh is rated as fair. Good riparian conditions occur in Nolan, upper Winfield and Owl Creeks (Smith 2000).

Water quality problems exist in the Hoh watershed portions of the following tributaries are on the 1998 WDOE 303d list for high water temperature: Anderson, Nolan, Small, Willoughby, Maple, Owl and Canyon Creeks as well as a portion of the South Fork of the Hoh River.

Restoration Opportunities

Throughout the Hoh basin fish access to tributary and floodplain habitat needs to be increased by the replacing of blocking culverts. In addition, the removal of cedar spalts would increase habitat access and improve water quality. The acquisition and protection of existing high quality floodplain habitat is a high priority. Riparian plantings of conifers needs to be done to increase the long-term recruitment of large woody debris.

Preliminary Reaches

Preliminary reach breaks at the following locations: the Hoh Tribe Reservation Boundary, 101 Highway bridge, National Park Boundary. The following tributaries should be considered their own reach: Nolan Creek, Winfield Creek, Maple Creek, Owl Creek and South Fork Hoh River.

Public Access

There are five WDNR campgrounds along the Hoh River-

Cedar Creek

Cedar Creek is a small independent drainage south of the Hoh River. Most of the lower watershed is in Olympic National Park. About a mile of the creek upstream of the Olympic National Park is within the Shoreline of the State jurisdiction. This section runs through private timberland.

Cedar Creek supports coho and winter steelhead trout spawning. The status of these stocks is unknown (Smith and Caldwell 2000).

Preliminary Reaches

Cedar Creek should be treated as one reach.

Kalalock Creek

Kalalock Creek runs south through private and state timberland and then west through Olympic National Park to empty into the Pacific Between the Queets and Hoh Rivers (Map 20). Shoreline of the State designation begins at the National Park Boundary

(roughly river-mile 1) and continues roughly 2 miles upstream to where the West Fork of Kalalock Creek branches from the mainstem.

The total watershed is 13,649 acres in size with the portion upstream of the National Park being about evenly split between WDNR timberlands and private timberlands. Land use is predominately forestry. Although the timber harvest history for the private lands isn't known it is surmised that the WDNR land were most heavily harvested between the 1940s and mid1980s (Smith and Caldwell 2000).

The reach upstream from the National Park is on the 303d list for water temperature (WDOE 1998).

Kalalock Creek supports coho salmon, winter steelhead, bull trout and coastal cutthroat trout. Historically a small run of chum salmon was also present on the watershed (Smith and Caldwell 2000). All of these runs are wild, native stocks and there current status is unknown.

Preliminary Reaches

Kalalock Creek should be treated as one reach.

Clearwater River and Tributaries

The Clearwater River is a tributary of the Queets that drains the foothills between the Queets and Hoh Rivers. It is a shoreline of statewide significance downstream of Miller Creek to the National Park Boundary. Upstream of this it classified and a shoreline of the state as are its tributaries Hurst Creek, Miller Creek, Christmas Creek, Snahapish River, Stequaleho Creek and Sollecks River. Washington DNR lands comprise 79% of the Clearwater Basin. These are managed as part of the Olympic Experimental Forest, which has the objective of managing the landscape for both habitat conservation and timber production. The riparian conservation plan for this forest includes both riparian buffers and wind throw buffers around these. Upstream of the confluence with the Snahapish River both the mainstem of the Clearwater and the Snahapish are part of the Clearwater Corridor Natural Resource Conservation Area (NRCA). Upstream of this point as well the entire watershed is owned by the WDNR including the significant tributaries of Stequaleho Creek and the Sollecks River.

Anadromous Fish

Chinook and steelhead spawn in the mainstem of the Clearwater, Miller Creek, Christmas Creek and the Sollecks and Snahapish Rivers. Coho spawn in the mainstem of the Clearwater and all accessible tributaries. Chum salmon spawn in he lower mainstem of the Clearwater River.

Habitat

Fish access conditions have not been fully mapped in the Clearwater watershed. Road density is rather high and there are likely many blockages to fish passage. This remains a data gap. Similarily, the impact of roads on the floodplains has not been fully assessed in

the Clearwater watershed. WDFW did document filled areas and blocked culverts to identify areas suitable for restoration. However, because there has not been a full study we do not know the full extent of the impacts. Likely the rating is not "good" (Smith 2000). The cutting off of side channels can adversely impact coho juvenile survival.

Sedimentation due to landslides and debris torrents has historically been a serious problem; much of this related to road failure and timber harvest activities. Levels of fine sediments in spawning gravels have been found to be directly related to road density. Egg mortality is directly related to higher levels of fine sediments in the spawning gravels. The rate of timber harvest has slowed in recent decades and the management of the upper Clearwater River as a NRCA by the DNR should improve the situation. Side cast roads have already been removed in the Miller and Christmas Creek drainages. However there is a data gap in determining if the rate of debris flow and sedimentation has actually decreased (Smith 2000).

Downstream of the Snahapish River confluence "good" riparian conditions were found on 54% of the buffer, 27% rated as "fair" and 19% rated as "poor". Upstream from this, including the tributaries of the Snahapish and Sollecks Rivers, Stequalho Creek and other tributaries the riparian condition were rated as such: 69% good, 19% fair and 11% poor. Levels of instream LWD are unknown, however in the Snahapish River levels of old growth LWD increased from 56 pieces per 100m in 1982 to 63 pieces per 100m in 1993 (McHenry et al. 1998 as cited in Smith 2000).

Restoration Opportunities

In the Clearwater Basin blocking culverts need to be replaced with fish friendly structures. Roads that are contributing to mass wasting and erosion need to be either decommissioned or repaired so they no longer contribute fine sediments to the system. Riparian planting where trees are lacking would provide shade and increase large woody debris input over the long term.

Preliminary Reaches

From the Quinault Reservation boundary to the confluence with Miller Creek (end of Shoreline of Statewide Significance designation.) The Snahapish River confluence to the upstream end of shoreline designation. The following tributaries should be considered each their own reach: Hurst Creek, Shale Creek, Miller Creek, Miller Creek-east fork, Christmas Creek, Snahapish River, Stequaleho Creek and the Sollecks River.

Salmon River

The Salmon River flows into the Queets River in Olympic National Park (Map 20). On some maps this stream is marked as Salmon Creek. From its headwaters in the Olympic National Forest and the Quinalt Indian Reservation the Salmon River flows through two sections of WDNR land and one privately held parcel before as well as the Quinalt Indian Reservation before flowing into the Queets River in Olympic National Park. The sections within the jurisdiction of the SMA are less than two miles in total length.

Land vegetation cover is rated as good for the Salmon River watershed with only19 % immature vegetation in the lower Salmon River the area within the scope of this study. High turbidity events are not common and are not chronic in the Salmon River.

An assessment of culverts found no blocking culverts in the lower Salmon River in 1998 and 1999 thus the lower river was rated as "good" for fish habitat access. An addition fish access to the floodplain was found to be good and there was no evidence that land use actions had isolated floodplain habitat.

Quinault River

The Quinault River drains the south eastern Olympic Mountains with the upper watershed completely protected in ONP. The headwaters are in vicinity of Mount Anderson and Mount Christie. A 4.9-mile section of the Quinault downstream of the park boundary and upstream of the Grays Harbor county line is classified as a shoreline of statewide significance. This section of river is upstream of Lake Quinault. The ownership of this section of river is the National Park on the northern bank and a mix of private and Olympic National Forest Land on the south bank. The vast majority of the river's watershed within this reach is protected either in Olympic National Park or in National Forest riparian reserve and wilderness.

The Quinault River has healthy runs of fall chinook, sockeye, winter steelhead trout, bull trout and Dolly Varden. Even though they are currently classified as "healthy" runs of coho, sockeye and winter steelhead have declined as compared to historical levels. The spring/ summer run of chinook is rated as depressed. The stock status of chum and pink salmon, cutthroat trout, bull trout and Dolly Varden is unknown. All of these species use this stretch of river to spawn or rear.

Water quality in the Quinault River, just upstream of the lake, can be poor with elevated temperatures in the summer. This may be a natural condition due to low elevation and channel width.

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