- Chapter 1 -

Overview of South Puget Sound

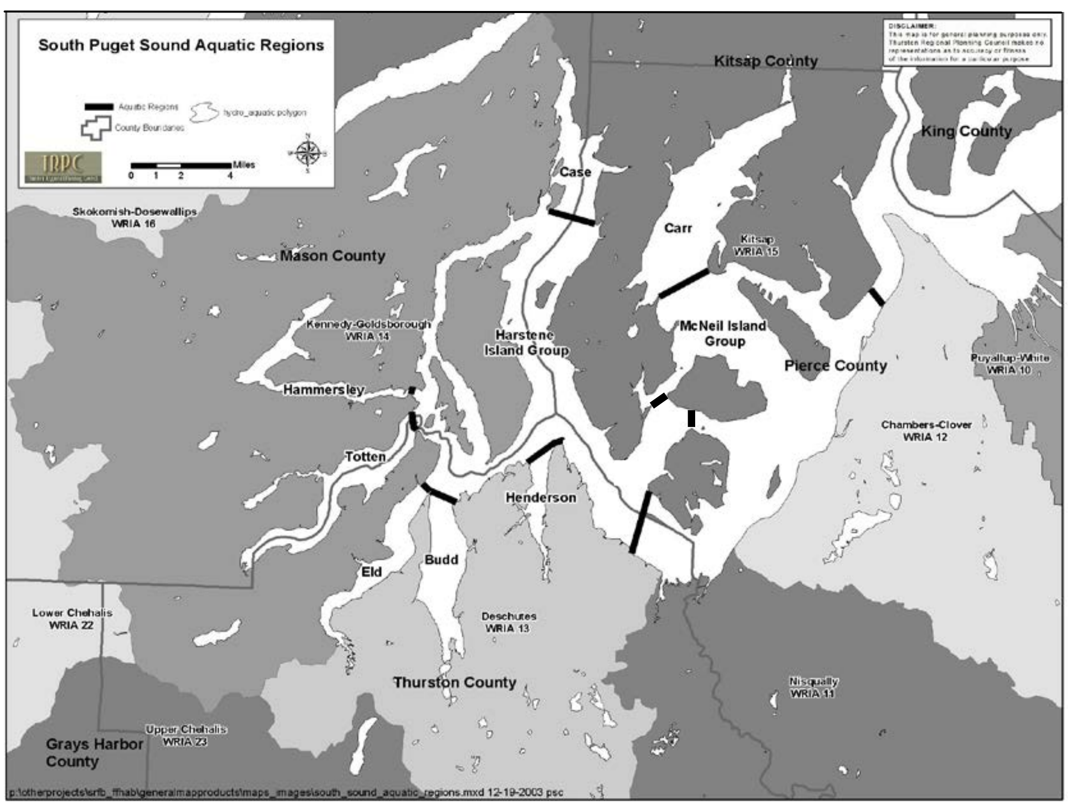
Marine Waters

South Puget Sound geographically lies within the Puget Lowland physiographic province, a broad, low-lying region situated between the Cascade Range to the east and the Olympic Mountains to the west. The dominant physiographic feature of this area is the glacial plains cut by numerous streams and dissected by the inlets of Puget Sound.

The term South Puget Sound used in this report includes the marine waters and related nearshore located south of the Tacoma Narrows Bridge. It is the southern end of the larger Puget Sound fjord estuary complex, an area separated from central Puget Sound by a narrow, shallow sill associated with the Tacoma Narrows (Burns 1985).

There are nine distinct South Puget Sound landscapes:

- Budd Inlet
- Case Inlet
- Hammersley Inlet & Oakland Bay
- Henderson Inlet
- Totten & Skookum Inlets
- Carr Inlet
- Eld Inlet
- Hartstene Island Group
- McNeil Island Group



The Nisqually River is the only major river system in the basin. Numerous streams drain into South Puget Sound that, when combined, rival the biological output of large Puget Sound systems. The total surface area of marine waters in South Puget Sound is approximately 394 square kilometers. More than 50% of South Puget Sound is less than 36.6 meters deep and only a very small percentage is deeper than 100 meters (Burns 1985).

Hydrographically, South Puget Sound is very different from the main basin of Puget Sound. Many of the larger scale physical and chemical processes found in greater Puget Sound are muted or accentuated in the smaller South Puget Sound subregion. This presents a unique set of conditions for physical, chemical, and biological interactions.

Numerous shallow, blind-end inlets divide South Puget Sound that causing poor circulation. As a result, water does not mix or dilute nutrient inputs to the same degree as the deeper, more tidally mixed areas such as the central Puget Sound basin, which has depths that often exceed 200 meters. The shallow nature of South Puget Sound, along with the slow flushing time, provides a greater amount of sandy habitat and makes many of the bays and inlets more productive then the rest of Puget Sound (Washington Department of Ecology Publication 02-03-020, September 2002). Two consequences of such conditions are:

1. Different florae and faunae associated with the different sediment and benthos of South Puget Sound, and

2. An increased risk of pollutant concentration from land derived sediments in the South Puget Sound catchment area.

Llansó (1998) investigated these types of effects and found that the inlet ends of South Puget Sound had lower florae and faunae species diversity compared to the rest of Puget Sound. Furthermore, the species present appear to be associated with a combination of fine sediments and low DO.

Case Inlet and Carr Inlet are larger and deeper than other South Puget Sound inlets. The north/south positioning of these inlets cause prevailing winds to attenuate tidal flushing, which combined with relatively low freshwater input at their heads, results in poor mixing. Thus, these inlets tend to have episodic plankton blooms promoted by still water conditions that quickly exhaust nutrients. The other inlets and bays in South Puget Sound are quite shallow and branched, resulting in poor flushing and similar patterns of blooms. The hydrological, biological, and geomorphologic attributes of South Puget Sound make the region susceptible the potential for both the build up of anthropogenic nutrients and pollutants combined with stratification, resulting in oxygen depletion. Budd Inlet, in particular, has been under scrutiny because of persistent problems of low dissolved oxygen due to persistent stratification and the decay of phytoplankton blooms (Washington Department of Ecology Publication 02-03-020 September 2002).

The intertidal region of South Puget Sound experiences twice-daily tide changes that expose large sand or mud flats, emergent salt marshes and beaches in estuaries, deltas and along shorelines. The mud and sand flats are typically devoid of emergent vegetation, but support eelgrass and benthic invertebrates that are essential food for higher order organisms. The emergent salt marsh has plants such as *Carex, Scirpus, Salicornia, Triglochin, and Distichlis,* among others. Salinity, substrate texture and the frequency and duration of floods govern these highly productive habitats. They also provide spawning habitat for many species of fish. Many shorelines have sandy beaches, often teeming with sand dollars. The flat, sandy areas of the nearshore are home to flounders, shrimp and worms, as well as seaweed beds that provide food and hiding places for millions of other creatures integral to the South Puget Sound food web. These distinct and highly productive intertidal zones provide habitat for many animal and fish species.

Freshwater

Five Watershed Resource Inventory Areas (WRIA) drain into South Puget Sound:

- WRIA 11 – Nisqually
- WRIA 12 – Chambers-Clover
- WRIA 13 – Deschutes
- WRIA 14 – Kennedy-Goldsborough
- WRIA 15 – Kitsap

Of these five WRIA, only the Nisqually, Deschutes, and Kennedy-Goldsborough WRIA drain exclusively into South Puget Sound. WRIA 15, Kitsap shares its drainage with Central Puget Sound north of the Tacoma Narrows and Hood Canal. WRIA 12, Chambers-Clover, also extends north of the Tacoma Narrows to Commencement Bay.

The following basin descriptions are excerpts from the Limiting Factors Analysis prepared for each watershed. The descriptions for WRIA 12 and 15 include some areas outside of the South Puget Sound study area.

WRIA 11 – Nisqually

Water Resource Inventory Area (WRIA) 11 includes the Nisqually River which originates from the Nisqually Glacier on the southwest slopes of Mount Rainier (Figure 6) and three independent tributaries (McAllister Creek an unnamed creek and Red Salmon Creek) draining directly into Puget Sound. The Nisqually River flows northwesterly for approximately 72 miles before joining Puget Sound. The entire basin encompasses approximately 720 square miles and the principle drainage basin; the Nisqually River includes over 331 identified streams and 715 linear miles of river and stream channels (Williams 1975). The Nisqually River and its tributaries and the salmon stocks they support, are described in detail later in this report.

The salmonid resources of the Nisqually River Basin has been adversely impacted through a variety of land use practices. Commercial timber activities have increased sediment loads, reduced large woody debris input and recruitment potential, and altered precipitation run-off patterns. The conversion of pristine valley bottomlands and wetlands to agricultural purposes and now to rural residential and hobby farms has reduced the natural biological processes of these parcels necessary for the natural production of salmonids in the Nisqually River Basin. The Nisqually River estuary has lost approximately 30 percent of its historical intertidal and subtidal habitat. Of critical importance to the natural production of salmonids is the 54 percent loss in intertidal emergent marsh habitats. The mainstem Nisqually River is constrained by a system of revetments and levees in the lower 5.2 river miles, remnant flood control dikes in areas near McKenna and maintained dikes that protect the Yelm Diversion Canal between RM 21.8 to 26.4. These channel containment structures inhibit lateral channel migration and have eliminated much of the spawning and rearing habitats that were once present. Off-channel habitat is available along river miles 10 through 25, with off-channel restoration particularly needed along river miles 21 through 26.2. (Kerwin 1999; Ellings March 2004)

WRIA 12 – Chambers-Clover

WRIA 12 is located in central Pierce County and is roughly triangular in shape, bounded by Puget Sound on the west, and extends east to near the community of Graham. Point Defiance and the southwest shore of Commencement Bay serve as the WRIA's northern boundary. The City of DuPont near the Nisqually River Basin is located near the southern boundary. The WRIA covers approximately 180 square miles (Clothier, et al 2003).

WRIA 12 comprises the Chambers-Clover Creek Basin and the neighboring small drainages of Sequalitchew (including American Lake and Murray Creek) and Puget Creeks in Pierce County, Washington. It also encompasses several independent stream drainages, including unnamed creeks draining from the North Tacoma area directly into Puget Sound, and Crystal Springs Creek. Important lakes within WRIA 12 are Lake Louise, Owens Marsh, and Steilacoom, Gravelly, American, Spanaway, Waughop, Charlton, and Wapato Lakes (Clothier, et al 2003). WRIA 12 includes approximately the western half of the City of Tacoma, all of the Cities of Lakewood and University Place, and the Towns of Steilacoom, Dupont, Fircrest, and Ruston. It also includes the unincorporated communities of Parkland, Spanaway, Elk Plain, Frederickson, and Midland. McChord Air Force Base and part of Fort Lewis occupy a large portion of the central and southern part of the basin (Clothier, et al 2003) (See Figure 2).

The steady pace of urbanization in this watershed has led to declining fisheries resources in WRIA 12 for over a century, with the exception of hatchery-raised fall Chinook salmon. Many alterations have been made to the streams and overall watershed in WRIA 12, beginning as early as 1853 and accelerating in the late 1800s (Consoer and Townsend 1977). Trends in fisheries production/escapement appear to be linked to habitat conditions, such as stream flow, water quality, human harvest, and natural predation. Human use and development have been major contributors to the current conditions. Impervious surfaces, runoff, pollution, and water consumption have taken their toll on WRIA 12 (Clothier, et al 2003). (Runge et al. 2003)

WRIA 13 – Deschutes

Located at the southern end of Puget Sound (Figure 1), Water Resource Inventory Area (WRIA) 13 is almost entirely within the bounds of Thurston County, with a small portion (the headwaters of the Deschutes River) in Lewis County. The drainages of the WRIA empty into three saltwater inlets that, in turn, define the major watersheds: Henderson Inlet to the East, centrally located Budd Inlet, and Eld Inlet to the West. The Deschutes River is the major hydrologic basin in WRIA 13, with a number of other smaller independent tributaries to salt water.

The Henderson Inlet watershed lies in the northeast section of WRIA 13 and has a total drainage area of about 29,275 acres (Thurston County 1989). The topography of the watershed is divided into three parts: the Dickerson Point peninsula, the Johnson Point peninsula, and the Woodland Creek Basin. The three areas drain surface water into Henderson Inlet. Most of the basin lies at an elevation of less than 200 feet above sea level. The inlet is about five miles long from Dickerson Point to the mouth of Woodland Creek, ranging from .25 to .75 miles wide, and covering 2.5 square miles in area. It has an average depth of 25 feet, and reaches its maximum depth of 60 feet near the mouth (Thurston County et al. 1995). The southern head of the inlet forms an estuary at the mouth of Woodland Creek and reveals large mudflats at low tide.

The Budd Inlet/Deschutes Watershed is comprised of 143 identified streams that provide over 256 linear miles of drainage. Total area of the watershed is 118,773 acres. The Deschutes River with its associated tributaries is the largest drainage system within the watershed. The 52 mile-long river drains approximately 166 square miles or about 84% of the total watershed. Other notable streams within the Budd Inlet drainage are Percival/Black Lake Ditch, Ellis, Moxlie/Indian , Adams, Mission and Schneider creeks.

The entire Eld Inlet watershed encompasses approximately 23,220 acres. The primary streams in the watershed are McLane Creek, it’s tributaries, and Green Cove Creek. The McLane Creek drainage system incorporates a total of 7,360 acres. It begins in the Black Hills and flows northward, forming Delphi Valley and terminating at the estuary of Mud Bay. The Delphi Valley and surrounding Black Hills exhibit a wide variety of topographies. The highest point is 807 feet in the Black Hills north of Black Lake, while the lowest is Mud Bay at sea level. Cedar Flats and Swift Creeks are the major tributaries of McLane Creek that originate in the Black Hills, while Perkins Creek enters McLane from the Cooper Point peninsula side. Green Cove Creek originates at Grass Lake on the Cooper Point peninsula and runs 3.6 miles north along the eastern boundary of the watershed emptying into Green Cove midway up the peninsula. (Haring and Konovsky 1999)

WRIA 14 – Kennedy-Goldsborough

The Kennedy-Goldsborough Basin (WRIA 14) covers about 381 square miles of southwest Puget Sound. The area is drained by many small independent streams; no major river system is present. Streams generally flow north and east from rolling hills located between the inlets of southern Puget Sound and the Olympic Mountains to the north. One hundred thirty-nine independent streams, traversing approximately 240 linear miles have been identified. Inlets and mudflats deposited at stream confluences provide a variety of marine habitats. Slow tidal interchange within the long, enclosed water bodies of Eld Inlet and Mud Bay, Totten Inlet and Oyster Bay, Skookum Inlet, Hammersley Inlet and Oakland Bay, and upper Case Inlet and North Bay provides nutrient enriched waters at stream outlets. Streams are generally lowland types with headwaters originating from springs, surface water drainage, wetlands, beaver ponds, or small lakes. Upper watersheds are typically moderately to heavily forested with large acreages of second and third growth coniferous trees. Most streams originate in steep ravines, gradually transition to broad valley bottoms dominated by alder and brush, then flow through tide flats. Rural and urban development are usually associated with the lower portions of streams near salt water bays. (Kuttel, 2002)

WRIA 15 - Kitsap

East WRIA 15, straddling the boundary between Pierce and Kitsap counties (there is also an extremely minimal part of this watershed in the northeastern corner of Mason County). The watershed lies between the northern end of Case Inlet on the west and the Tacoma Narrows and Colvos Passage on the east, including several islands in the eastern portion of southern Puget Sound. The watershed contains approximately 101,000 acres (158 mi2) of land and 144 miles of shoreline. It is composed of two large peninsulas and many islands. The three largest islands are Fox, McNeil, and Anderson. There are a number of smaller islands, including, Raft, Herron, Cutts, Eagle, Gertrude, Tanglewood, and Ketron. It includes the incorporated City of Gig Harbor, as well as a number of unincorporated communities.

The estimated population of the Key Peninsula/Gig Harbor/Islands (KGI) watershed in 1990 was approximately 54,000. This population is expected to increase to 65,000 in 2000, to 78,000 in 2010, and to 87,000 in 2020 (PSRC 1995, as referenced in KGI DRAFT 1999). Estimated populations for the KGI subwatersheds in 1994 were (KGI DRAFT 1999):

▸ Gig Harbor	22,000	
▸ Burley/Minter	18,000	
▸ Key Peninsula	9,000	
▸ Rocky Bay	1,000	
▸ Islands	3,700	(*Excludes McNeil Island prisoners*)

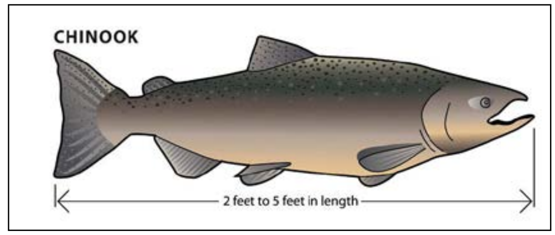
The largest population increases between 1990 and 2020 are expected in the Gig Harbor and Burley/Minter subwatersheds, which are both expected to double in population. (Haring 2000)

- Chapter 2 -

Chinook and Bull Trout Populations in South Puget Sound

1. Summary Profile of Listed Salmonids in the Puget Sound Nearshore

1A. Chinook (*Oncorhynchus tshawytscha*)



Ocean type (fall) Chinook typically migrate to sea during the first year of life, normally within three months of emergence. They spend the majority of their life in coastal waters and return to the natal stream in the fall a few days or weeks prior to spawning. In contrast, stream type (spring) Chinook rear for one or more years in fresh water prior to migrating to sea where they undertake extensive ocean migrations. They return to the natal stream in the spring or summer, several months prior to spawning (Healey 1998).

Although Chinook are generally considered to prefer deeper and faster spawning areas than other species in the genus *Oncorhynchus*, measurements recorded in the literature do not suggest that Chinook avoid shallow water and low flows. Their large body size may allow them to hold position in faster currents and displace larger spawning substrates than other Pacific salmon, hence the perceived preference for deeper and faster water. Chinook have been observed spawning in water ranging from ~ 2 inches (5 centimeters) to 15 feet (~ 4.6 meters) deep. They appear to select spawning sites with high subgravel flows. This preference may be related to the increased sensitivity of Chinook eggs to fluctuations in dissolved oxygen levels when compared to other species of Pacific salmon (Chinook produce the largest eggs, yielding a small surface-to-volume ratio) (Healey 1998).

Chinook fry appear to have more difficulty emerging from small substrate than large substrate. Most fry emergence occurs at night. Following emergence the fry move downstream, also principally at night. The fry may continue the downstream migration to the estuary, or take up residence in the stream for a few weeks to a year or more depending upon the life history strategy. Fry migrants typically range in size from 30 to 45 mm fork length. Fingerling migrants are larger, with a range of 50 to 120 mm fork length. While rearing in fresh water, Chinook feed primarily on larval and adult insects and zooplankton (Healey 1998).

Chinook fry feed in estuarine nearshore areas until they reach about 70 mm fork length, at which time they disperse to marine areas. Chinook rearing in estuarine areas are opportunistic feeders; they will consume a variety of prey ranging from chironomid larvae and zooplankton to mysids (opossum shrimps) and juvenile fish. Most fall Chinook do not migrate more than 1,000 km (about 620 miles) from their home stream during their ocean residence. Fish, particularly herring and sand lance, are the primary prey of Chinook during their ocean growth phase. However, invertebrates including euphausiids (krill), squid, and crab larvae are also important at times (Healey 1998).

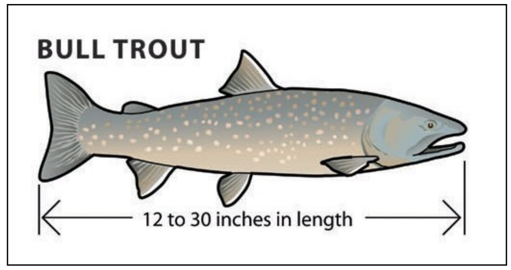
Nisqually Chinook Stock Profile

Stock Status:	The SaSI stock status is rated "Depressed" in 2002 due primarily to low stock productivity. The mean number of spawners for brood years 1988 through 1997 of 1,064 should have produced a mean number of recruits 5,062, even assuming low marine survival. However, the observed mean for these broods was only 3,815. In addition, the mean escapement is less than the recovery goal of 2,590.
Spawning Distribution:	Spawning occurs in the mainstem Nisqually from RM 15 to RM 40, Mashel River (RM 0.0 – RM 3.2), Ohop Creek (RM 0.0 – RM 6.2), Twenty-five Mile Creek (RM 0 – RM 0.6), Yelm Creek (RM 0.0 – RM 0.5), and Horn Creek (RM 0.0 – RM 0.5).
Spawning Timing:	Most spawning occurs from late September through October.
Genetic Analysis:	Chinook spawning in the mainstem Nisqually, Mashel River, and Ohop Creek were sampled in 1998, 1999, and 2000. Allele frequencies of the combined samples were similar to those of a few South Sound hatchery and wild populations. They were distinct from North Sound and other Washington Chinook. The extent of hatchery-origin fish in the genetic samples is currently unknown (Anne Marshall, WDFW, personal communication).
Stock Origin:	This is a mixed stock with composite production. The native Chinook stock may have been largely replaced by Soos Creek Hatchery (Green River) Chinook released into the Nisqually system and from Soos Creek Hatchery-origin strays from the Nisqually Tribe's Clear Creek and Kalama Creek hatcheries and the WDFW McAllister Creek Hatchery. Stock origin is difficult to determine because the life history and genetic composition of the native Nisqually stock may have resembled those of other South Sound Chinook stocks, including Green River and Puyallup (Anne Marshall, WDFW, personal communication). Current genetic and life history patterns could reflect native stock characteristics and/or extensive introgression with South Sound hatchery Chinook and so are not very informative (Puget Sound TRT 2001).

South Sound Tributaries Chinook Profile

Stock Status:	The evaluation of the South Sound Tributaries Chinook stock in the 1992 SASSI regarded all naturally spawning fish, including hatchery returns released or escaping above hatchery racks. These hatchery-origin adults, spawning in their basins of origin, were responsible for the large escapement numbers and the healthy rating for this stock in 1992. In SaSI 2002, the fall Chinook spawning aggregations observed in south Puget Sound independent tributaries are not rated. The Co-managers support this action with the following rationale: (1) The independent tributaries in South Puget Sound are not typical Chinook habitat because of relatively small stream size and low flows during the late summer/early fall spawning season. (2) The current low escapements (outside of streams that support on-station Chinook production programs) are likely the result of past hatchery plants or straying from either current South Sound hatchery production or viable South Sound natural populations. (3) Fall Chinook likely were not historically self-sustaining in these habitats and have little chance of perpetuating themselves through natural production. We do not regard fall Chinook spawning in generally small independent South Sound streams as being a distinct stock in the same sense that the term is used elsewhere in this inventory.
Spawning Distribution:	Most spawning takes place in McAllister Creek, Deschutes River, Percival Creek and other independent tributaries such as Woodland Creek, Mill Creek, Goldsborough Creek, Case Inlet streams, Carr Inlet streams, and East Kitsap streams.
Spawning Timing:	Spawning generally occurs from late September through October.
Genetic Analysis:	No genetic analysis has been done on South Sound Tribs Chinook.
Stock Origin:	South Sound tributaries are streams that we consider probably did not possess sustainable populations of Chinook historically. Present-day Chinook returns are due to the large releases from a number of South Sound hatcheries. Although locally returning Chinook are now used for broodstock at these hatcheries, their ancestry is largely Soos Creek Hatchery (Green River) Chinook.

1B. Bull trout (*Salvelinus confluentus*)



Bull trout reach sexual maturity at between four and seven years of age and are known to live as long as 12 years. They spawn in the fall after temperatures drop below 48 degrees Fahrenheit (8º C), in streams with cold, unpolluted water, clean gravels, and cobble substrate, and gentle stream slopes. Many spawning areas are associated with cold-water springs or areas where stream flow is influenced by groundwater. Bull trout eggs require a long incubation period compared to other salmon and trout (4-5 months), hatching in late winter or early spring. Fry remain in the stream bed for up to three weeks before emerging. Juvenile fish retain their fondness for the stream bottom and are often found at or near it.

Some bull trout may live near areas where they were hatched. Others migrate from streams to lakes, reservoirs, or saltwater a few weeks after emerging from the gravel.

The US Army Corps of Engineers published the following information in its draft 2004 document, "Bull Trout in the Nearshore."

> The only confirmed recent reference of bull trout from the South Puget Sound estuarine and nearshore waters is from Fresh et al. (1979). In 1978, from February 15 to July 20, a total of 47 species, 59,743 individual fish, and one bull trout were captured. This fish was caught by beach seine on April 17, 1978 at DeWolf Bight and examined for stomach contents, none present. Dewolf Bight is the only distinct point (presumed spit, external irregularity in the shoreline), approximately 1 km west from McAllister Creek, along the Nisqually Head or "west Delta" reach. Beaches in this area generally have gentle slopes and are predominately sand and mud. The bull trout capture date was the peak capture for chum salmon at Dewolf. This site had the second highest chum CPUE (136.6 day, 68.3 night) for all beach seine sites, highest was south Anderson Island (460.3 day, 92.8 night).
>
> Bull trout have also been captured in freshwater areas of the Nisqually, these fish presumably would have migrated from the nearby core area of the Puyallup River or other more northern areas. A single juvenile was collected during stream sampling in the lower reaches in the mid-1980's (WDFW 1998 in USFWS 2004). In the late 1990's, a single adult was observed at the Clear Creek Hatchery in mid-September. This fish was approximately 508 to 558 millimeters (20 to 22 inches) in size and presumed to be anadromous based on its "bright" coloration (J. Barr, Nisqually Tribe, pers. comm. 2003, in USFWS 2004).

Nisqually Bull Trout Stock Profile

Stock Status: Bull trout/Dolly Varden in the Nisqually River have been identified as a distinct stock based on their geographic distribution. Habitat is available for all life history forms: anadromous, fluvial, adfluvial, and resident. The only information available is the collection of one juvenile bull trout/Dolly Varden by Nisqually tribal biologists while stream sampling in the mid-1980s. No bull trout/Dolly Varden have been reported in the Nisqually tribal commercial fisheries. Spawn timing and locations are unknown (WDFW 1998).

Nisqually bull trout/Dolly Varden are native and are maintained by wild production. The stock status is Unknown. No data is available for this stock.

2. Chinook and Bull Trout Use of the Nearshore Habitat

Hypothesis formed by the Puget Sound Technical Recovery Team and the Puget Sound Action Team are used to explain how various nearshore habitats in South Puget Sound support juvenile salmonids. Little information exists on adult salmonid use of Puget Sound marine waters; however, it is assumed that many of the habitats beneficial to juvenile salmonids are also beneficial to adults. In South Puget Sound, habitat types are distributed throughout a larger landscape mosaic whose patterns and interconnections provide productive and protective habitat units and edges that support multiple life history trajectories. Salmonid use of many different habitats over wide geographic regions and over different periods contributes to the long-term viability of a salmon population by reducing the reliance of the population on any single element of the nearshore and marine landscape.

Viable salmon populations use the nearshore landscapes in four basic ways during their life history:

- Feeding and growth (rearing)
- Refuge from predation and extreme events
- Physiological transition
- Migratory corridors

(Simenstad 1982; William and Thom 2001)

Ongoing data collection is beginning to show that the use of South Puget Sound for these purposes is not exclusive to Nisqually Chinook and bull trout. Seining research and genetic testing conducted by biologists from the Squaxin Island and Nisqually Tribes reveal that juvenile Chinook from river systems north of the Tacoma Narrows use South Puget Sound ecosystems.

Utilization of the nearshore by salmonids occurs within a landscape system summarized into four broad habitat types:

- Open exposed shores
- Protected shorelines
- Pocket estuaries
- River and stream estuaries and deltas

Each of these broad classes includes a number of embedded smaller scale habitat types such as mudflats, eelgrass, blind channels, etc. Specific salmon habitats can occur in more than one of the four landscape classes.

Open exposed shoreline habitat provides critical functions, including feeding and growth, refuge from predators, migratory corridors, and to a lesser degree physiological transition, for primarily larger juvenile salmon once they transition into the neretic zone. While important year round, the open exposed shorelines become more important later in the calendar year as juvenile salmon life history types move out of the protected areas.

Protected shoreline habitat provides critical functions, including feeding and growth, refuge from predators, migratory corridors, and physiological transition, and is very important for early fry migrants (e.g., pocket estuary fry, delta fry) and may also be important to mature juvenile salmon (e.g., parr migrants and yearlings). Protected shorelines are more important to all life history stages earlier in the year before the water temperatures increase. Protected shorelines often host large spawning aggregations of forage fish, and are very important for generating prey base for fry migrants and providing refuge from predators and extreme events. Protected shorelines can provide important support for large numbers of early fry migrants because many occurrences of protected shorelines are in close proximity to the natal river mouth estuaries for independent populations of Puget Sound Chinook.

Pocket estuaries are smaller lagoon-type systems near shorelines composed of habitats such as un-vegetated flats, salt marsh, and tidal channels. Pocket estuaries provide critical functions, including rearing (feeding and growth), refuge from predators and extreme events and opportunity for physiological transition, for juvenile salmon, primarily early fry migrants of very small size. Pocket estuaries differ from intertidal habitats in larger estuaries because (a) the finer scale habitats included in the pocket estuaries are more associated with lower wave energy regimes, and (b) the presence of surface and groundwater freshwater inputs that dilute salinity seasonally (usually winter and spring). In addition, there are different types of pocket estuaries such as lagoon-type systems with or without freshwater and small systems that may be perennial or ephemeral.

River and stream mouth estuaries and deltas provide critical functions, including rearing (feeding and growth) and refuge from predators and extreme events, for primarily early fry migrants (pocket estuary) and delta fry, and the opportunity for physiological transition and migratory corridors for larger juvenile salmon life history types (parr migrants and yearlings). River and stream mouth estuaries include natal estuaries and deltas.

3. Chinook and Bull Trout Management in South Puget Sound

The State of Washington and Treaty Tribes jointly co-manage Chinook and bull trout populations in Puget Sound. Together, these governments work cooperatively on developing management programs for habitat, hatcheries, and harvests, especially for Chinook populations.

3A. Habitat Management

The state and the Treaty Tribes collectively develop the tools needed for analyzing the loss and degradation of freshwater and nearshore habitats for salmonids. The Salmon Stock and Inventory (SaSI), first produced in 1992, classifies the status of wild stocks that helps to gauge the efficacy of restoration efforts. The Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) is a computerized information system to catalog details about habitat as well as map fish stock distribution and status.

3B. Hatchery Management

Puget Sound Chinook hatchery production and harvest is co-managed by WDFW and the Treaty Tribes. The Puget Sound Management Plan, written in 1977, provides a framework for co-managers to set Chinook production and harvest goals. There are currently two conservation programs in South Sound, the rest are dedicated to harvest. The goal of harvest programs is to provide for recreational, commercial, and tribal fishing opportunity. The Nisqually River program is dedicated to both conservation and harvest. The long-term goal is to assist with restoration of naturally spawning populations of fall Chinook salmon in the Nisqually River and provide for tribal harvest in the river. The operation at Hupp Springs is also a conservation program that seeks to support the recovery of the White River spring Chinook salmon (Hatchery Scientific Review Group, Feb. 2002).

There are currently 11 hatchery facilities operating in South Sound. The Nisqually Indian Tribe operates two facilities, the State of Washington and the Squaxin Tribe co-manage a facility, and the state operates eight more by itself through the Department of Fish and Wildlife. The table on the next page lists the facilities that support Chinook production, the number of fish released, and the receiving watershed.

Chinook Production in South Sound (from the "2003-04 Future Brood Document")

	Fall Chinook Released		Spring Chinook Released		
Production Facility	Sub-yearling	Yearling	Sub-yearling	Yearling	Watershed
Chambers Creek	100,000	70,000			Chambers
Lakewood	100,000	130,000			Chambers
Garrison Springs	850,000				Chambers
Clear Creek	3,500,000				Nisqually
Kalama Creek	600,000				Nisqually
Tumwater Falls	3,800,000				Deschutes
Percival Cove		200,000			Deschutes
Coulter Creek	Supports Tumwater Falls Production				
Minter Creek	1,800,000				Minter
Hupp Springs			200,000	85,000	Minter
Total Production	10,750,000	400,000	200,000	85,000	

Operational Guidance For Hatcheries in South Sound

Several documents provide operational guidance, direction, or program descriptions for hatcheries in South Sound. These include the Future Brood Document, the Co-Managers Salmonid Disease Control Policy and the Hatchery Genetic Management Plan.

Currently, hatchery programs in Washington State are undergoing an extensive operational review by the Hatchery Scientific Review Group (HSRG). The task of the HSRG is to assemble, organize, and apply the best available scientific information available to provide guidance and recommendations to the policy makers and technical staff who are responsible for implementing hatchery reforms.

Future Brood Document

The Future Brood Document (FBD) is a pre-season planning document for fish hatchery production in Washington State for the upcoming brood stock collection season. The FBD is coordinated between WDFW, the Northwest Indian Fisheries Commission (NWIFC), and Federal fish hatcheries. Hatchery production by volunteers, schools, and Regional Fisheries Enhancement Groups are represented by WDFW. Every Puget Sound hatchery program is listed in the document by facility location, species, race, brood year, stock and WRIA number. Each program lists the egg take goal, transfers that occur throughout the year and the planting goal. Dates, fish size and pounds produced are listed for each transfer and plant. This document is reviewed annually and the co-managers agree to production numbers. Changes to the FBD require submission of an FBD change form and approval by the co-managers.

Co-Managers Salmonid Disease Control Policy

This policy was developed between the Co-Managers in order to provide guidance and policy control of how hatcheries will operate to minimize the risk of importation, dissemination, and amplification of pathogens known to adversely affect salmonids.

The policy divides the state into eight egg health management zones and 14 fish health management zones. The Policy provides direction for the care of broodstock, egg collection, egg and fish transfers within and between health zones.

Hatchery Genetic Management Plans

Listing of Puget Sound Fall Chinook as threatened under the Endanger Species Act required all hatcheries in Puget Sound to develop a Hatchery Genetic Management Plan (HGMP). All Chinook programs in South Sound have an HGMP. The HGMP's describe, in a format prescribed by NOAA Fisheries, the operation of each artificial production program for salmon and steelhead in the Puget Sound region and the potential effects of each program on listed species. The HGMP's have been provided to NOAA Fisheries for consideration as significant measures under Section 4 (d) of the Endangered Species Act.

The following Chinook HGMP's are listed for South Sound facilities:

- Chambers Creek Fall Chinook Yearling Program (Lakewood and Chambers)
- Garrison Springs Fall Chinook Fingerling Program
- Tumwater Falls Fall Chinook Fingerling Program
- Tumwater Falls Fall Chinook Yearling Program (Percival Cove)
- White River Spring Chinook (Minter Creek and Hupp Springs)
- Minter Creek Fall Chinook Fingerling Program
- Nisqually River Fall Chinook Fingerling Program (Clear Creek and Kalama Creek)

Neither the Treaty Tribes nor the State of Washington has a hatchery program for bull trout in South Puget Sound.

3C. Harvest Management

Chinook

Harvest management of Chinook populations within Puget Sound is implemented through the Puget Sound Comprehensive Chinook Management Plan – Harvest Management Component (Puget Sound Indian Tribes and WDFW, March 2004). State and tribal technical staff meet periodically in-season to exchange information and data, achieve consensus on in-season management actions, and prepare post-season reports. Additional meetings and exchanges occur as needed to develop recommendations relative to the management units' harvest and conservation objectives, resolve differences in approach, and review monitoring program results. Data from the monitoring programs form the basis for development and refinement of forecasting and assessment efforts.

The Harvest Management Plan consists of management guidelines for planning annual harvest regimes as they affect Puget Sound Chinook for the 2004 - 2009 management years. The Plan guides the implementation of fisheries in Washington, under the co-managers' jurisdiction, and considers the total harvest impacts of all fisheries on Puget Sound Chinook, including those in Alaska, British Columbia, and Oregon. The Plan's objectives can be stated succinctly as intent to:

> "Manage harvest of stronger salmon stocks to ensure that the incidental fishery-related mortality will not impede recovery of the productivity, abundance, and diversity of natural Puget Sound Chinook salmon populations to levels consistent with treaty-reserved fishing rights, and cultural and ecological values."

This Plan constrains harvest to the extent necessary to enable rebuilding of natural Chinook populations in the Puget Sound evolutionarily significant unit (ESU), provided that habitat capacity and productivity are protected and restored. It includes explicit measures to conserve and recover abundance, and preserve diversity among all the populations that make up the ESU. The ultimate goal of this plan, and of concurrent efforts to protect and restore properly functioning Chinook habitat, is to rebuild natural productivity so that natural Chinook populations will be sufficiently abundant and resilient to perform their natural ecological function in freshwater and marine systems, provide related cultural values to society, and sustain commercial, recreational, ceremonial, and subsistence harvest.

The co-managers and the Puget Sound Shared Strategy have adopted abundance and productivity goals for most Puget Sound Chinook populations, including Nisqually natural spawning Chinook. These goals represent best available information about the characteristics of recovered populations in Puget Sound. They are intended to guide all aspects of recovery planning, including components for management of harvest and hatchery production, and conservation and restoration of freshwater and marine habitat.

In order to achieve recovery, the Harvest Management Plan adopts fundamental objectives and guiding principles. The Plan will:

- Conserve the productivity, abundance, and diversity of the populations that make up the Puget Sound ESU.

- Manage risk: The development and implementation of the fishery mortality limits in this Plan incorporate measures to manage the risks, and compensate for the uncertainty associated with estimating current and future abundance and productivity of populations. In addition, the 'management error' associated with forecasting abundance and the impacts of a given harvest regime is built into simulating the long-term dynamics of individual populations. Furthermore, the plan commits the co-managers to ongoing monitoring, research, and analysis, to better quantify and determine the significance of risk factors, and to modify the plan as necessary to minimize such risks.

- Meet ESA jeopardy standards: The ESA standard, as interpreted by the NMFS, is that activities, such as harvest regulated by this plan, may be exempted from the prohibition of take, prescribed in Section 9, only if they do not “appreciably reduce the likelihood of survival and recovery” of the ESU (50 CFR 223 vol 65(1):173). This plan meets that standard, not just for the ESU as a whole, but in several respects sets a more rigorous standard for conserving the abundance, diversity, and productivity of each component population of natural Chinook within the ESU.

- Provide opportunity to harvest surplus production from other species and populations: This Plan provides for continued harvest of sockeye, pink, and coho salmon, as well as the abundant hatchery production of Chinook from Puget Sound and the Columbia River. This plan eliminates directed fisheries on depressed Puget Sound Chinook but permits incidental catch of these runs in fisheries aimed at other runs with harvestable surpluses. The level of incidental catch is constrained by specific conservative exploitation rate ceilings or other management objectives.

- Account for all sources of fishery-related mortality, whether landed or non-landed, incidental or directed, commercial or recreational, and occurring in the U.S. (including Alaska) or Canada, when assessing total exploitation rates.

- Follow the principles of the Puget Sound Salmon Management Plan (PSSMP), and other legal mandates pursuant to U.S. v. Washington (384 F. Supp. 312 (W.D. Wash. 1974), and U.S. v Oregon, in equitable sharing of harvest opportunity among tribes, and among treaty and non-treaty fishers.

- Achieve the guidelines on allocation of harvest benefits and conservation objectives that are defined in the 1999 Chinook Chapter of Annex IV to the Pacific Salmon Treaty.

- Protect Indian treaty rights: The exercise of fishing rights by individual tribes is limited to ‘usual and accustomed’ areas which were specifically described by sub-proceedings of U.S. v. Washington according to their historical use of salmon resources.

This plan is based on limits to the cumulative annual fishery-related mortality to each Puget Sound Chinook population. The limits are expressed either as an exploitation rate ceiling, which is the maximum fraction of the total abundance that can be subject to fishery-related mortality, or as a spawning escapement floor, which is the minimum abundance allowed to return to the natural spawning areas. In many cases, populations are aggregated into harvest management units because of the scale at which data that describe catch distribution are available. However, in every case, the fishery mortality limits apply to individual populations, and the effect of this plan on individual populations is the standard by which the guidelines were developed and will be the standard by which the plan’s performance will be ultimately evaluated.

The development and implementation of the fishery mortality limits in this plan incorporate measures to manage the risks and compensate for the uncertainty associated with quantifying the abundance and productivity of populations, where the information is available for such assessment. In addition, the ‘management error’ associated with forecasting abundance, and estimating the impacts of a given harvest regime, is built into the simulation of the future dynamics of individual populations which is the basis for selecting exploitation rate objectives for some units. Furthermore, the plan commits the co-managers to ongoing monitoring, research and analysis, to better quantify and determine the significance of risk factors, and to modify the plan as necessary to minimize such risks.

Historic data regarding harvest numbers for naturally spawning and hatchery Nisqually Chinook, including the location of their capture, follow on the next two pages.

Bull trout

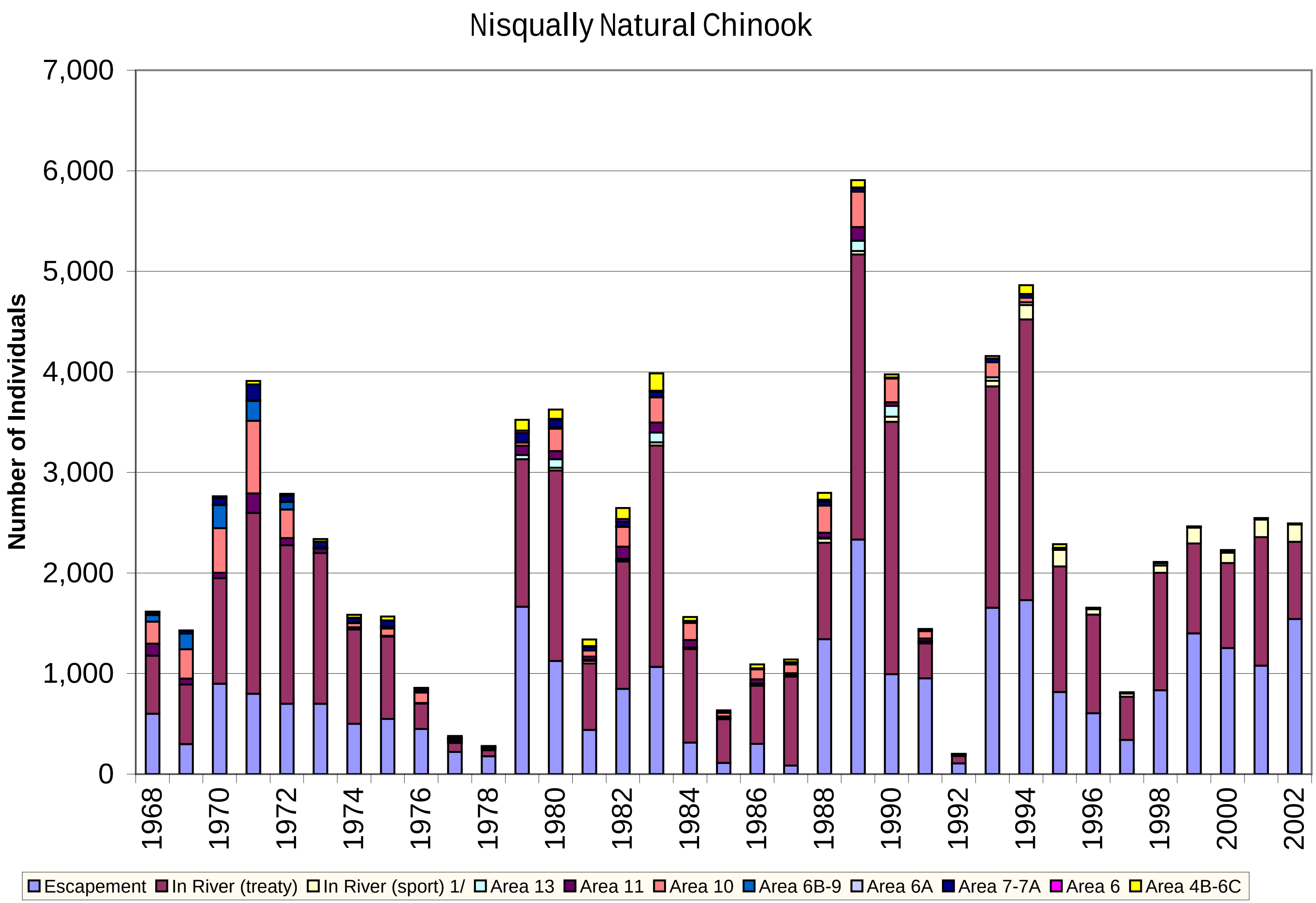
Bull trout are not known to utilize the freshwater habitats in South Puget Sound Tributaries to any great extent. There are very few, unverified reports of bull trout observations in this region. These reports are likely the result of misidentified fish, or strays from other systems. However, bull trout are known to be very dynamic, and could potentially utilize nearshore habitats in South Puget Sound.
There are no, directed bull trout fisheries, (treaty, non-treaty, commercial, or recreational) in South Puget Sound.

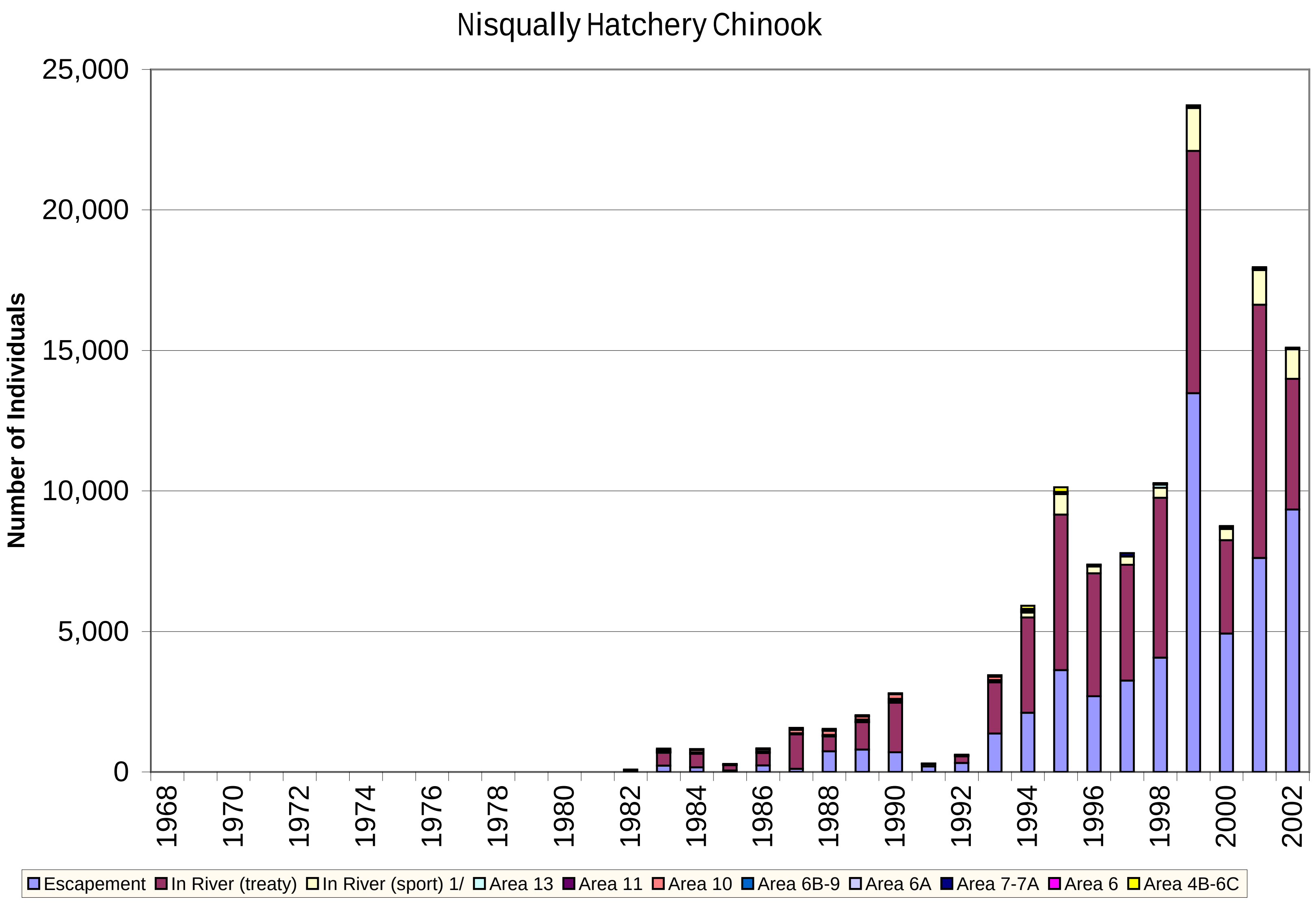
4. Recovery Planning for Chinook and Bull Trout

The NOAA National Marine Fisheries Service (NOAA Fisheries) and the US Fish and Wildlife Service (USFWS) listed Puget Sound Chinook salmon and coastal-Puget Sound bull trout as “threatened” species under the Endangered Species Act (ESA) in 1999. Listing under the ESA requires that NOAA Fisheries and USFWS prepare recovery plans for both species by geographic region. South Puget Sound is a subarea of the larger Puget Sound Evolutionary Significant Unit (ESU).

The State of Washington, however, determined that it would be in the state’s best interest to assist NOAA Fisheries in its efforts to write a draft recovery plan for the Puget Sound ESU and four other ESU regions. Both federal agencies agreed to this participation and Shared Strategy for Puget Sound (Shared Strategy) has become the regional group responsible for coordinating a draft recovery plan for listed salmonids in the Puget Sound ESU.

Assisting Shared Strategy in the task of preparing a South Puget Sound Chapter to the larger Puget Sound ESU recovery plan is the South Puget Sound Salmon Recovery Group (SPSSRG). SPSSRG is an ad hoc local planning group comprised of representatives from Tribes, state agencies, local governments, and salmon recovery organizations with jurisdictional interest in the South Puget Sound nearshore.


Nisqually Natural Chinook
Number of Individuals
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Escapement
In River (treaty)
In River (sport) 1/
Area 13
Area 11
Area 10
Area 6B-9
Area 6A
Area 7-7A
Area 6
Area 4B-6C


Nisqually Hatchery Chinook
Number of Individuals
25,000
20,000
15,000
10,000
5,000
0
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Escapement
In River (treaty)
In River (sport) 1/
Area 13
Area 11
Area 10
Area 6B-9
Area 6A
Area 7-7A
Area 6
Area 4B-6C

The ESA requires that recovery plans contain

1. Objective, measurable goals for delisting
2. A comprehensive list of the actions necessary to achieve the delisting goals
3. An estimate of the cost and time required to carry out those actions.

In addition, NOAA Fisheries Recovery Planning Guidelines suggest that recovery plans include an assessment of the factors that led to population declines and/or which are impeding recovery. Finally, it is important that the plans include a comprehensive monitoring and evaluation program for gauging the effectiveness of recovery measures and overall progress toward recovery.

5. Viable Salmonid Population Projections for Recovery

The recovery goal adopted by Shared Strategy for Nisqually Chinook is for wild populations to become self-sustaining at harvestable levels. Four interrelated parameters affect the potential outcome of this goal (McElhaney et al. 2000):

- Abundance There must be sufficient numbers of Chinook at various life stages to offset processes that affect population dynamics. These processes can include density effects, environmental variation, genetic processes, demographic stochasticity, ecological feedback, and catastrophes.

- Productivity The productivity of Chinook over its entire life cycle must ensure that the species is capable of consistently replacing itself. This factor is especially critical for Chinook during its freshwater productivity life-history stage.

- Spatial Distribution Chinook spatial structure depends fundamentally on habitat quality and its spatial configuration as well as the dynamics and dispersal characteristics of the species. A Chinook's ability to home to natal watersheds, natal tributaries within watersheds, and natal reaches within tributaries allows it to maintain a hierarchy of reproductive isolation. This spatial distribution engenders the unique "genetic stamp" for Nisqually Chinook.

- Diversity The ability of Chinook to survive within its unique its nearshore and freshwater habitat reflects varying traits, including anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology. Genetics dictate many of these traits while others are a combination of genetic and environmental factors. Any actions that affect the basic demographic and evolutionary processes for Chinook have the potential to alter its diversity.

Shared Strategy established planning ranges and targets that address the abundance and productivity parameters for Nisqually Chinook.[1] The planning range, as determined by several technical models, provides a broad estimate of the abundance needed for Nisqually Chinook to be viable over time. The wide range reflects variations in environmental conditions and uncertainty in historical information. The planning target provides a more specific measure within the range for evaluating the efficacy of recovery actions affecting habitat, harvest, and hatcheries. The target predicts the abundance and productivity of Chinook given a fully functioning estuary, improved freshwater conditions, restored access to blocked habitats, and poor ocean conditions.

The planning ranges and targets for Nisqually Chinook are:

Mean spawner abundance for 1996-2000	890
Planning range for abundance given a low-productivity rate of 1 recruit per spawner	13,000 – 17,000
Adult planning targets for abundance • Target given a low-productivity rate of 1 recruit per spawner • Target given a high-productivity rate of 3 recruits per spawner	 13,000 3,400
Juvenile planning targets for abundance • Target given a low-productivity rate of 1 recruit per spawner • Target given a high-productivity rate of 3 recruits per spawner	 1,000,000 730,000

Within the framework of the recovery planning process, the SPSSRG must identify actions and develop an appropriate implementation plan necessary for attaining the planning targets and ranges.

[1] Chinook Targets and Ranges, Version 5/8/02, Shared Strategy (http://www.sharedsalmonstrategy.org/goals.htm)

- Chapter 3 -

South Puget Sound Salmon Conceptual Model

If South Puget Sound is to have an ecosystem that supports Chinook and bull trout, there must be properly functioning nearshore habitats that serve their rearing, refuge, feeding, physiological transition, and migratory needs. The deterministic factors that influence properly functioning nearshore habitat conditions are natural processes.

This is the fundamental hypothesis to the South Puget Sound Salmon Conceptual Model. The purpose of having such a model is to organize our thinking about how the nearshore ecosystem supports viable populations of Chinook and bull trout (PSNRP 2003, Williams & Thom). It provides the context as to how the ecosystem should be functioning properly to support salmonids, and if not, why is it not functioning properly and which changes will be necessary.

1. Natural Processes

Natural processes are the essential building blocks that create habitats that form the ecosystems that support Chinook and bull trout.

The PSNERP Nearshore Science Team (2003) explained that:

> Ecosystem processes operate at naturally varying rates, frequencies, durations, and magnitudes that are controlled or constrained by various anthropogenic and natural factors. For example, climate landform, bathymetry, and geologic setting of an area constrain or control how biota, water, water, sediment, and organic matter are moved in the system. Processes also operate at various spatial and temporal scales and they can include such things as changes in chemical composition (e.g., nutrient transformations), biomass (e.g., production and consumption) and movement of material (e.g., sediment transport). For example, sediment can be transported over spatial scales of 1 to 100's of kilometers. In an estuary, sediments originate from the watershed, are transported downstream by river flow, and then moved episodically (eroded and deposited) by bi-directional water movements (tides and river flow) through the estuarine gradient. The sediment composition on a beach typically depends upon upland sources of material deposited directly on the beach, movements of material along the beach, and wind and wave action, which are a function of large-scale climate events.

Applying this approach to South Puget Sound, the SPSSRG analyzed the ecosystem and habitat niches of Chinook and bull trout to discern the key natural processes that contribute to their formation. The result of thinking reveals the following list of natural processes:

<u>Tidal exchange (Simenstad 2000)</u>

- Frequency and duration of tidal flooding is one critical determinant of emergent vegetation composition; salinity (degree of mixing of freshwater with salt water) is another important factor.

- Exposure to wave and current energy directly influences whether an environment will be accretionary or erosive, which are important determinants of marsh progradation, for instance.

- The drainage area and tidal prism of tidal marshes are the primary controls on the complexity of a dendritic tidal channel system.

- Hydrologic connections affect the input of plant and animal recruits, and the accumulation and residence time of detritus.

Sedimentation (Simenstad 2000)

- Sediment accretion and erosion often involves distant sediment sources, mechanisms of sediment transport and delivery, and the processes of deposition and resuspension/erosion.

- Sediment accretion can be critical to the natural maintenance and "health" of a marsh, both from the standpoint of maintaining the marsh surface relative to sediment compaction and sea level rise as well as the supply of nutrients for marsh plant production.

Nutrient Input (Simenstad 2000)

- Nutrient delivery by river and tidal hydrology mediates nutrient-limited plant growth.

- Nutrients are transformed and regenerated by below-ground soil processes regulated in part by the extent of anaerobic microbiota and porewater exchange, thus varying extensively between vegetated and unvegetated (e.g., mudflat) habitats at different tidal elevations.

- Trapping of detrital organic matter and incorporation into nutrient cycling pathways is directly linked to autochthonous and allochthonous sources and rates of supply, as well as features such as low energy side-channels and sloughs, which promote trapping.

Large Woody Debris Function in Spit Formation (Simenstad 2000)

- Disturbance of estuarine habitats by hydrological (strong tides and freshwater flow) and physical (e.g., large woody debris scouring) forces maintains a diverse matrix of habitats at different successional stages and topography.

- Deposition of large woody debris is also presumed to enhance cover and refuge for juvenile salmon, but this remains to be validated.

Organic Matter Composition (Simenstad 2000)

- Detritus is trapped and retained differentially by different plant communities.

- The residence time of detritus, and thus the rate and opportunity for decomposition, is to some degree determined by geomorphic features such as dendritic tidal channels and other geomorphic/ topographic features.

Food Web (Simenstad 2000)

- The spatial distribution of primary production across the landscape affects not only the rates, sources, and pathways of organic matter (detritus) but also physical refuge for juvenile salmon in the case of emergent and other macrophytic vegetation.

- Temporal diversification provides diverse sources of organic matter to the detritus pool that sustain secondary production over time. (Thom 1987).

- Nutrient cycling is tied to primary production not only as a source of nutrients but also it regulates nutrient cycling to some degree by affecting (through the extent of plant–root processes) anaerobic–aerobic geochemistry in soils.

Freshwater Input (Simenstad 2000)

- Physiological adaptation zones at the transition between areas of no salinity and increasing levels of salinity are critical for juvenile salmon; this is especially the case for juvenile chinook that appear to require extended periods (e.g., often weeks).

Prey Species Input (Simenstad 2000)

- Sites of concentrated production of preferred prey appear in specific habitats, substrates, vegetation, and tidal elevations and vary over space and time, driven in part by the same processes that affect salmon distribution (e.g., juvenile salmon).

- Prey trapping can occur by hydrodynamic action and is a prominent feature of the tidal–freshwater and brackish regions of estuaries where current reversals occur (e.g., Tschaplinski 1982, 1987)

- Prey organisms are exported from some habitats and supply food resources to larger invertebrates and small fishes, which are in turn preyed upon by larger nektonic organisms foraging in adjacent habitats and other regions of the estuary (Kneib 1997); salmon can fill several roles in this relay.

Sunlight Input (Fresh 2001)

- In parts of Puget Sound, shoreline development has resulted in the loss of eelgrass (*Zostera marina L.*) (Thom and Hallum 1990). One source of eelgrass loss is overwater structures, which cover the surface of the water, potentially affecting the submarine light environment and reducing eelgrass cover. Reductions in the amount of light reaching eelgrass can affect plant density, vigor, and size (both length and width), and, in the worst case, eliminate seagrass from beneath a structure (Dennison 1987; Zimmerman and others 1991; Abal and others 1994; Zimmerman and others 1995).

The Puget Sound Nearshore Ecosystem Restoration Projects Nearshore Science Team developed a conceptual model of the Puget Sound nearshore that has been adopted for use in South Puget Sound. The purpose of the model is to help guide thinking about how natural processes function in south Puget Sound and how these processes are influenced, positively or negatively, to affect salmonid habitat.

2. Objectives for Protecting Natural Processes

The ability of maintaining habitat in the South Puget Sound nearshore for juvenile Chinook and bull trout depends on protecting natural processes. The SPSSRG identified the following objectives to achieve that aim at protecting key natural processes in South Puget Sound:

Freshwater Input

- Protect the connectivity of tributaries to nearshore areas. Frequently, small tributaries are tightlined or filled as part of land development before flowing into marine waters. In order to allow for infiltration, nutrient and substrate contribution as well as maintenance of hydrologic regimes these areas should be restored, protected and preserved.

Tidal Exchange

- Maintain the connectivity of mouths of tributaries, estuaries, and wetlands to nearshore habitats.

- Ensure that overwater structures at tidal coves and wetlands have appropriate-sized openings to protect tidal flow. Such actions protect water quality and fish access as well as maintain the tidal prism (range between high and low tide). All development should ensure there is no net loss of the total acreage of available intertidal ecosystem.

Prey Species Input

- Identify and protect potential forage fish (herring, smelt, and sand lance) spawning areas. The Department of Fish and Wildlife have mapped these areas for South Puget Sound.

- Require riparian buffers along forage fish-spawning beaches - Research has shown that the eggs of herring, sand lance and surf smelt, important food sources for salmon, survive at higher percentages when they are on shaded beaches, whether created by plants or exposure-related conditions (Pentilla 2001). There are a number of guidance materials available for maintaining views and access while retaining vegetation along the shoreline (Herrara Environmental Consultants 2005; Manashe 1993; Myers et al. 1995).

Nutrient Input

- Require that new discharge facilities do not contribute pollutants and excessive artificial nutrients.

Large Wood Function in Spit Formation

- Prohibit new structures at dams or weirs that inhibit the passage of wood.

Food Web

- Model hatchery interactions, adjust stocking rates, and collect data. Start on a local scale and update existing South Puget Sound trophic level modeling.

Sunlight Input

- Allow sunlight input by requiring specific grating/materials for docks and other overwater structures.

Erosion/Sediment Transport

- Ensure that there is no net loss of erosion/sediment transport in each drift cell.

- Maintain the top slope of bluffs with native vegetation.

- Prevent the placement of structures on feeder bluffs that provide substrate inputs. Prevent further blocking of feeder bluffs by structures that do not pass substrate.

- Chapter 4 -

Human-Induced Stressors

In South Puget Sound, human activities have dramatically disrupted the function of many natural processes. These disruptions, termed "human-based stressors," change habitat, and ultimately, the ecosystem that Chinook and bull trout have adapted to through evolutionary development. On a temporal scale, many of these human-induced stressors have been sudden, creating significant impacts that have lead to declines in the viability of both species (PSNERP 2003).

Thus, the focal point of recovery efforts is to restore those natural processes that have experienced degradation through human activities. Doing this requires two steps. The first is to identify human-based stressors, which is the purpose of this chapter. The second step involves identifying the location of human-based stressors within the nine South Puget Sound landscape regions, which is the focus of the next chapter.

1. Conceptual Stressor Models

The SPSSRG identified twelve major human-induced stressors on natural processes specific to South Puget Sound. These are:

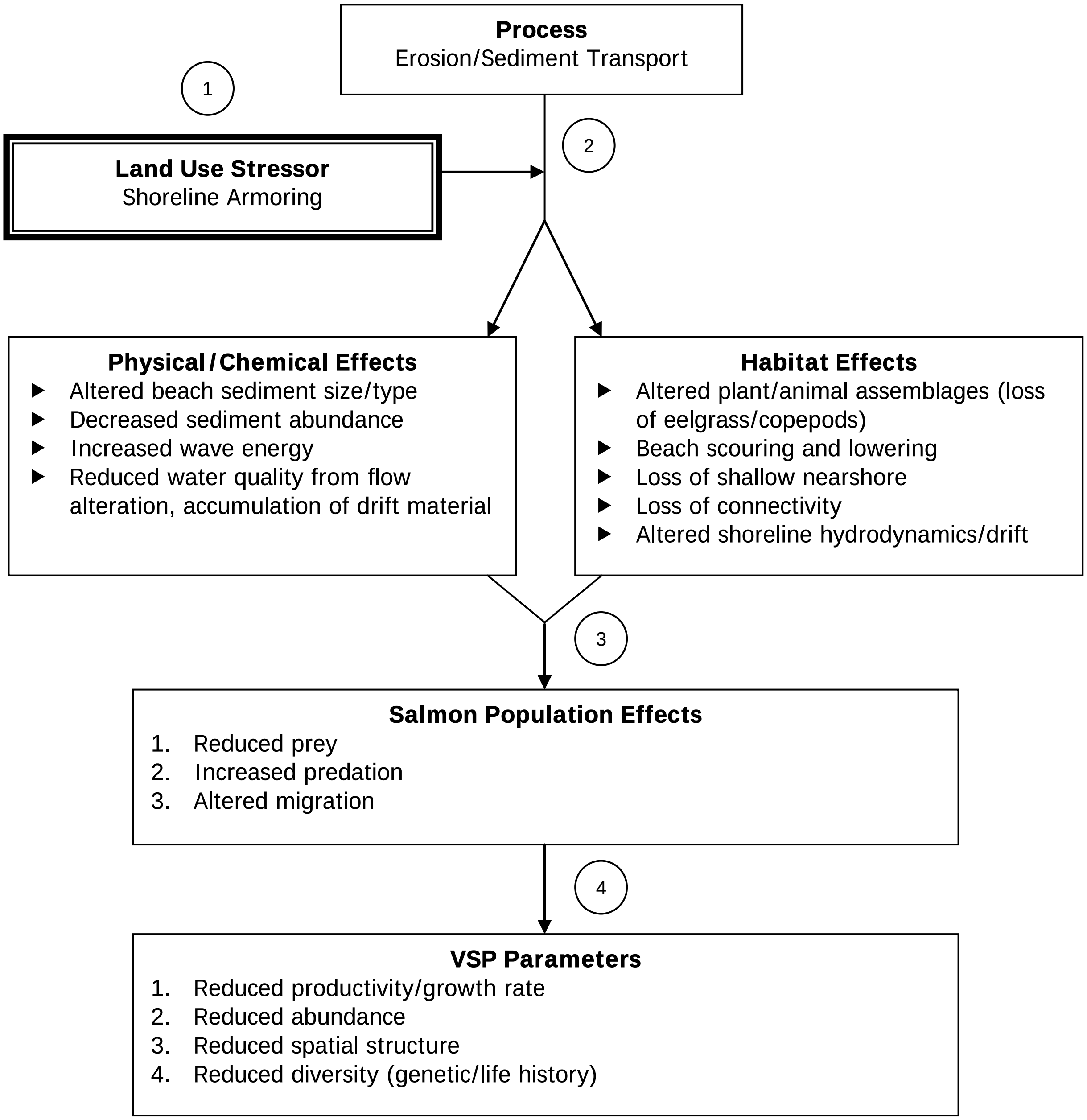
- Shoreline armoring
- Overwater structures
- Ramps
- Stormwater/Wastewater
- Landfill below the mean higher high water line
- Riparian loss
- Wetland and estuarine modification
- Input of toxic components
- Predation
- Boat traffic
- Invasive species
- Shellfish aquaculture

While this list is not exhaustive of all human-induced stressors, it does reflect those with the most significant impact on natural processes and the greatest prevalence throughout all of South Puget Sound.

To understand how these stressors affect Chinook and bull trout, the SPSSRG developed a series of conceptual models. These models are a graphic representation of the hypotheses regarding how stressors alter both the physical and chemical makeup of the environment and the creation of habitat. Each model also explores the resulting effect on Chinook and bull trout populations, which it then relates to viable salmon population parameters that influence planning targets specific for Chinook.

The following pages presents a conceptual model for each human-induced stressor.

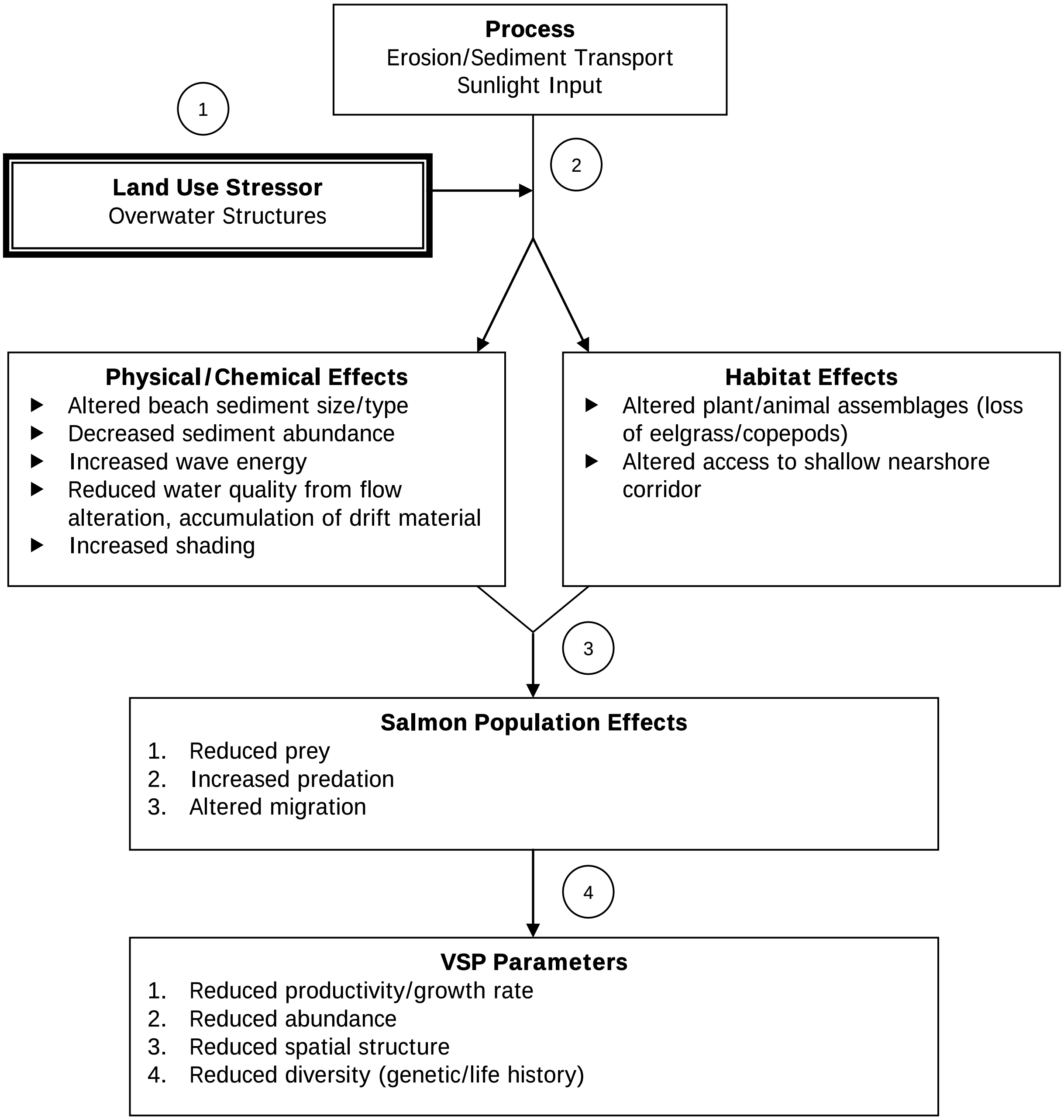
Shoreline Armoring



Hypothesis:

1. Shoreline Armoring impacts nearshore Erosion/Sediment Transport processes
2. Erosion/Sediment Transport processes have Physical/Chemical and Habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on Salmon Populations
4. Changes in Salmon Populations result in changes in the Viable Salmonid Population parameters (Productivity/Growth Rate, Abundance, Spatial Structure, Genetic/Life History Diversity)

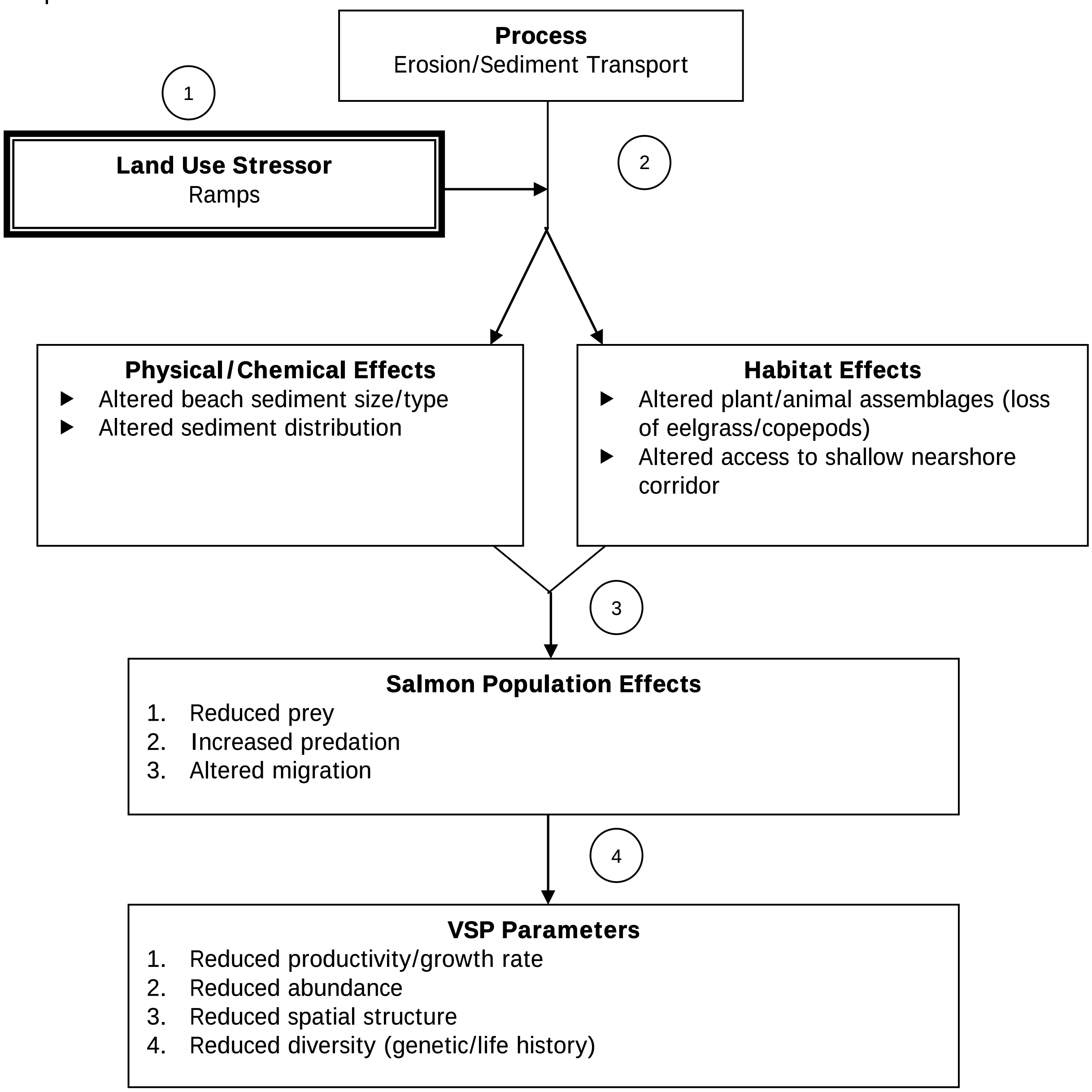
Overwater Structures



Hypothesis:

1. Overwater Structures impact nearshore Erosion/Sediment Transport and Sunlight Input processes
2. Erosion/Sediment Transport and Sunlight Input processes have Physical/Chemical and Habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on Salmon Populations
4. Changes in Salmon Populations result in changes in the Viable Salmonid Population parameters (Productivity/Growth Rate, Abundance, Spatial Structure, Genetic/Life History Diversity)

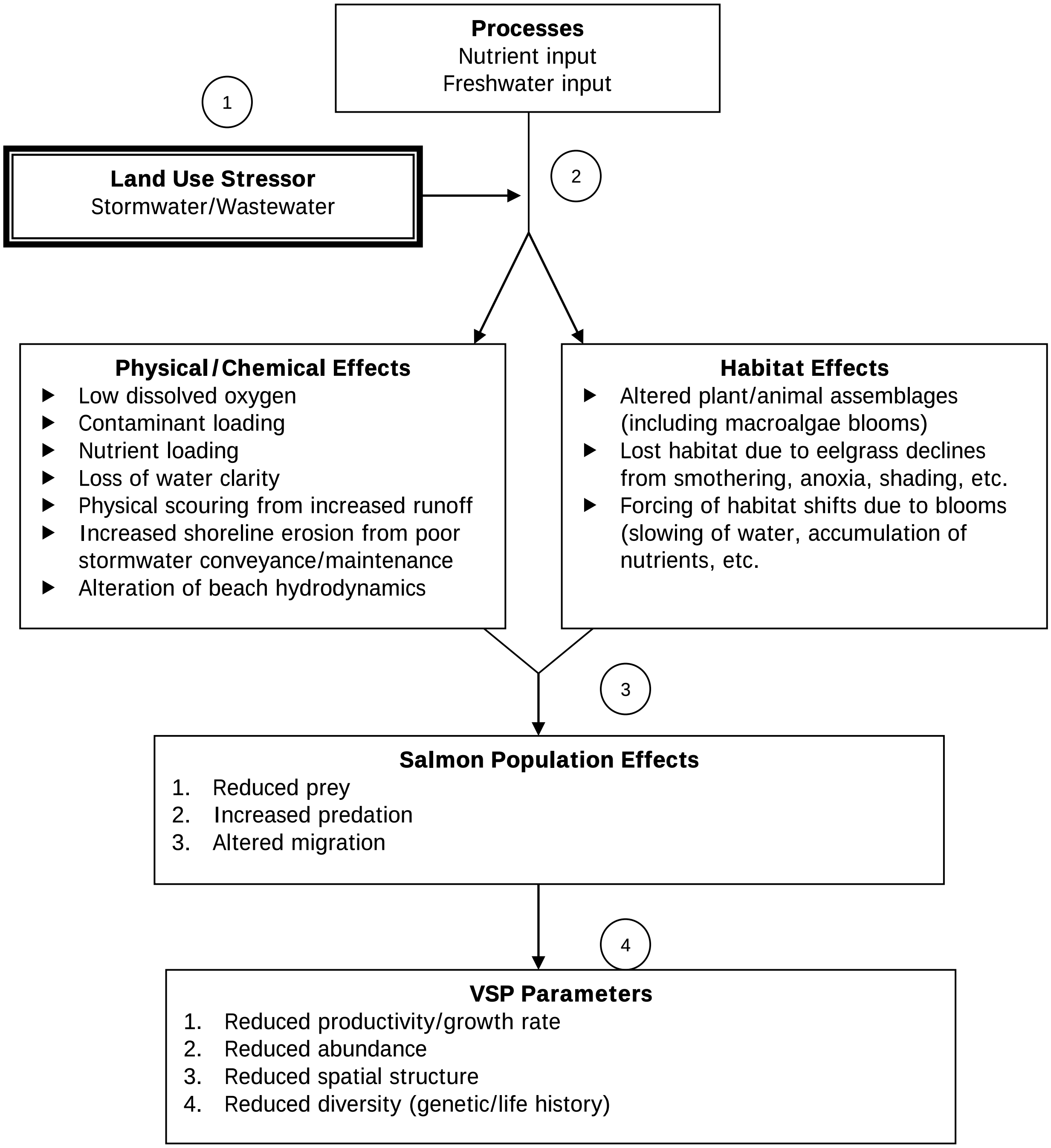
Ramps



Hypothesis:

1. Ramps impact nearshore Erosion/Sediment Transport processes
2. Erosion/Sediment Transport processes have Physical/Chemical and Habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on Salmon Populations
4. Changes in Salmon Populations result in changes in the Viable Salmonid Population parameters (Productivity/Growth Rate, Abundance, Spatial Structure, Genetic/Life History Diversity)

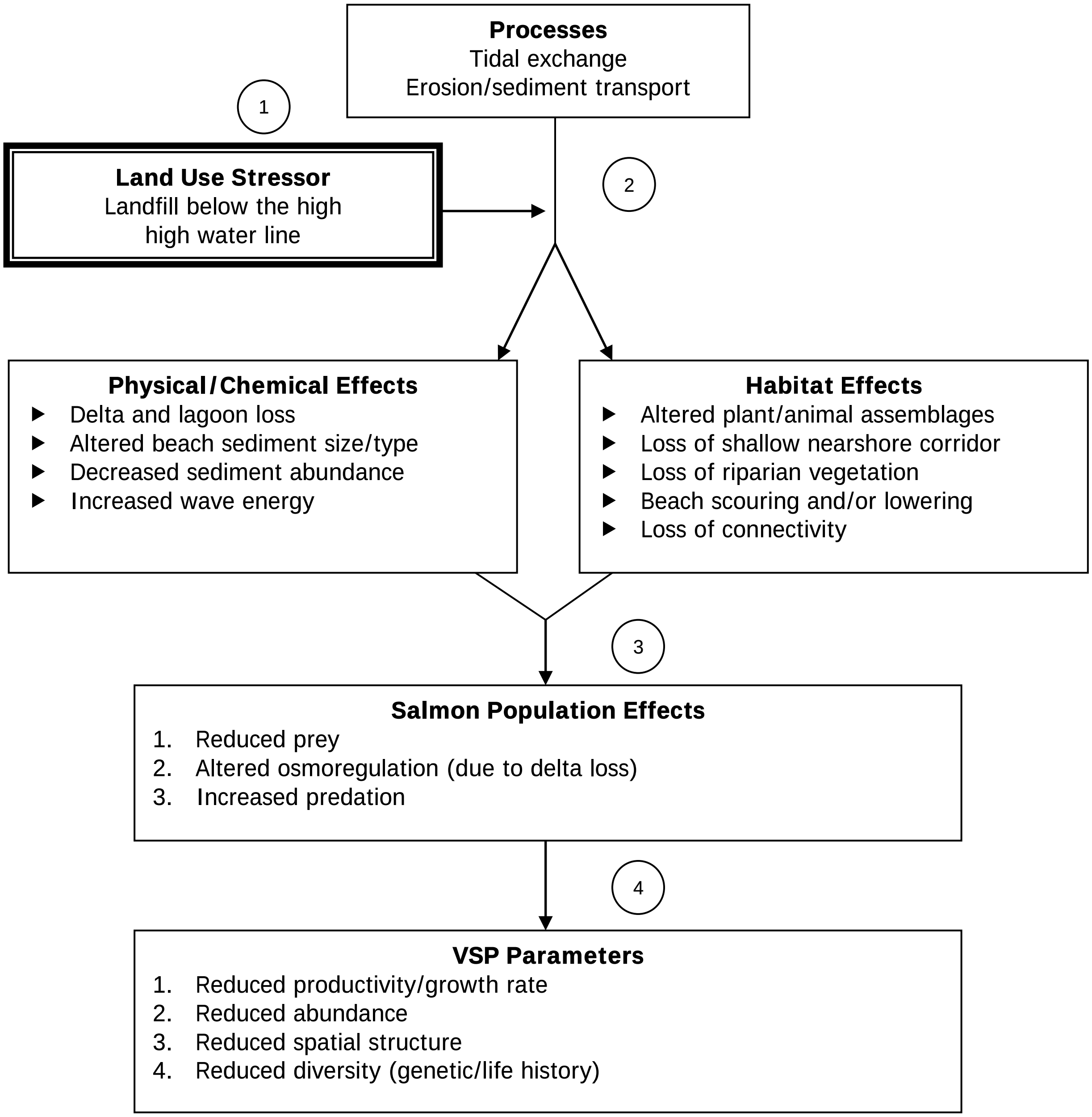
Stormwater/Wastewater



Hypothesis:

1. Stormwater/Wastewater impacts nearshore Nutrient and Freshwater Input processes
2. Nutrient and Freshwater Input processes have Physical/Chemical and Habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on Salmon Populations
4. Changes in Salmon Populations result in changes in the Viable Salmonid Population parameters (Productivity/Growth Rate, Abundance, Spatial Structure, Genetic/Life History Diversity)

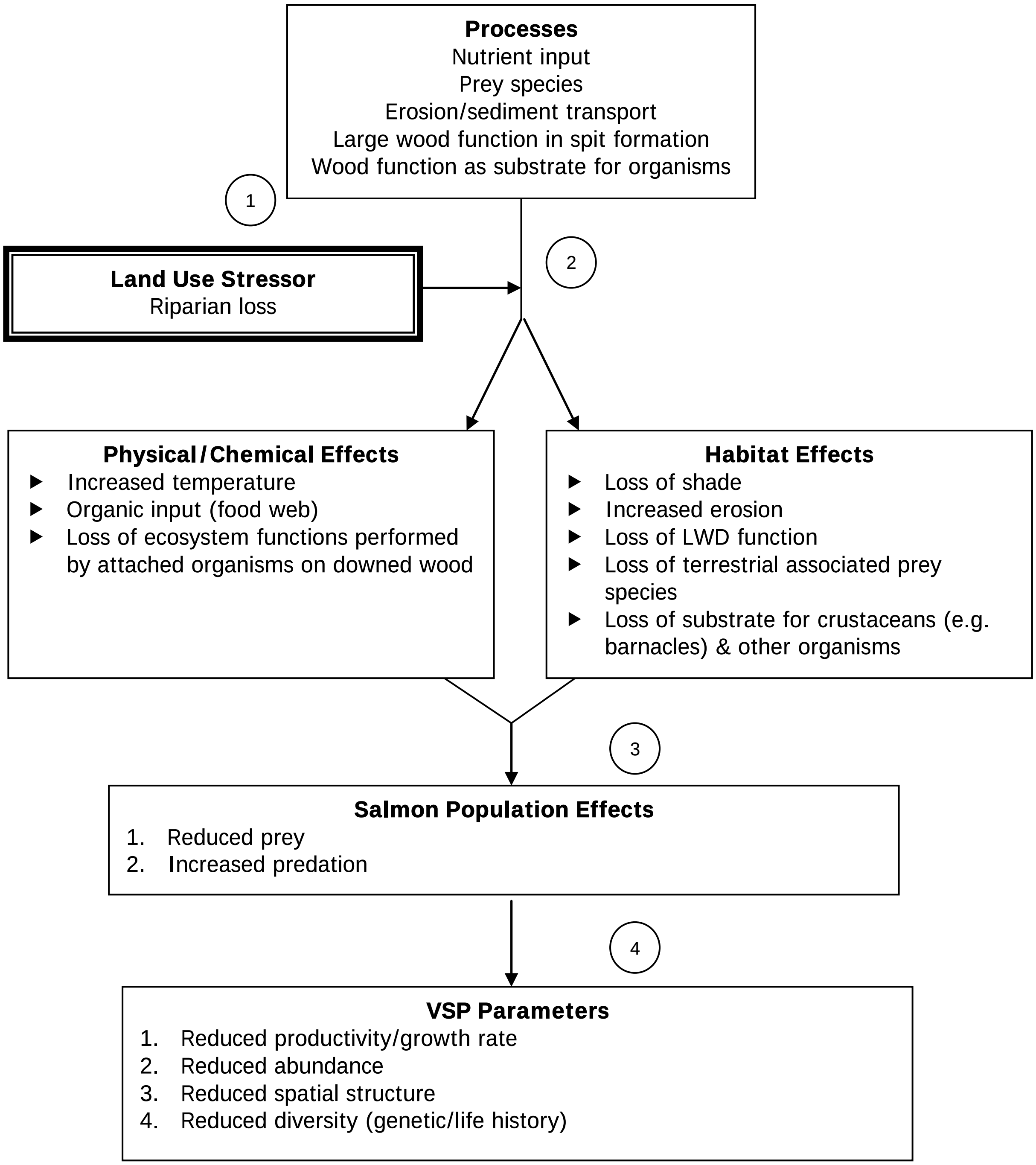
Landfill Below the Mean Higher High Water Line



Hypothesis:

1. Landfill impacts nearshore Tidal Exchange and Erosion/Sediment Transport processes
2. Tidal Exchange and Erosion/Sediment Transport processes have physical/chemical and habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on salmon populations
4. Changes in salmon populations result in changes in the VSP parameters

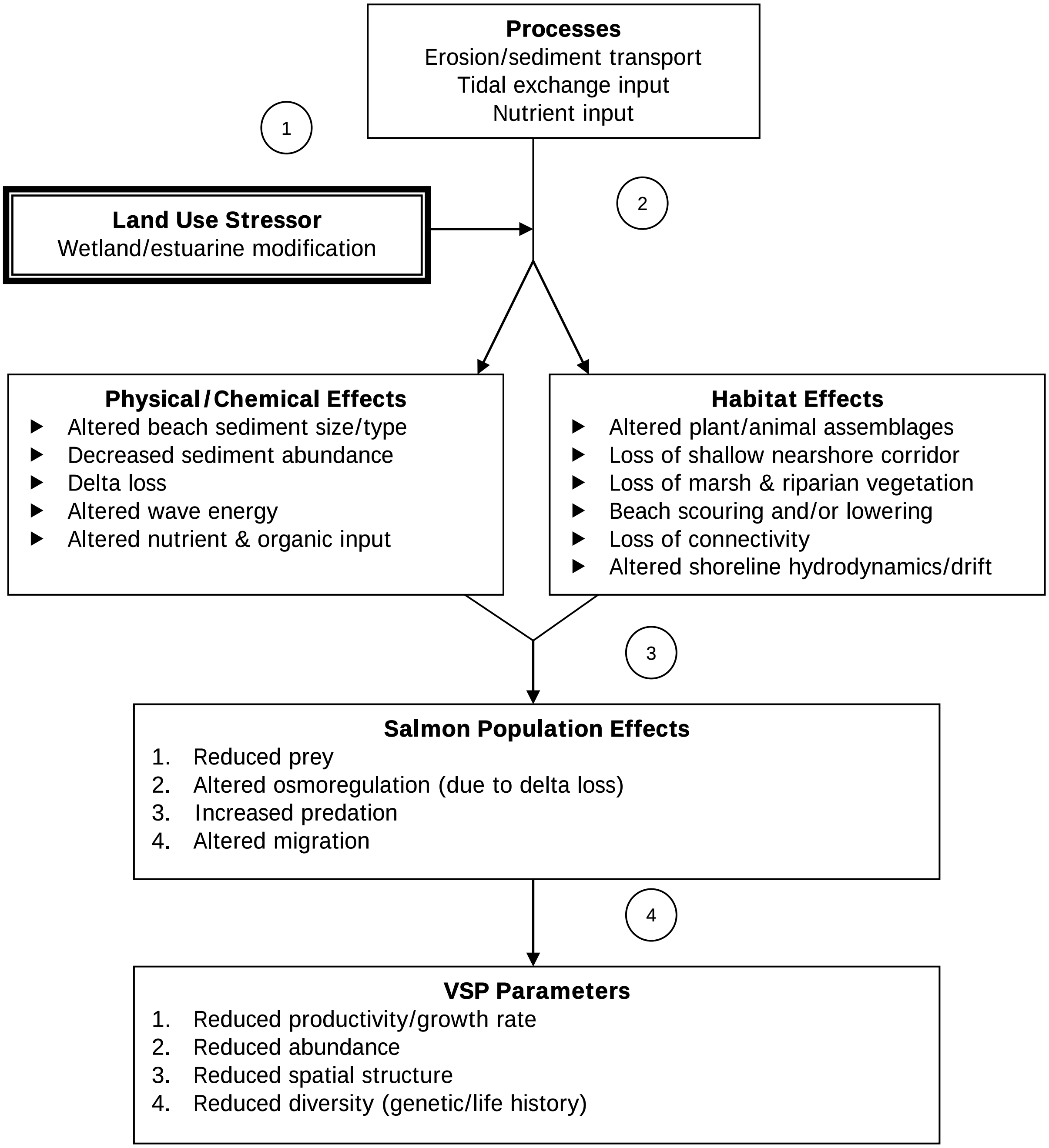
Riparian Loss



Hypothesis:

1. Riparian loss impacts nearshore nutrient input, erosion/sediment transport, and large wood processes
2. Nutrient input, erosion/sediment transport, and large wood processes have physical/chemical and habitat effects on the nearshore environment
3. Nearshore physical/chemical and habitat conditions have an effect on salmon populations
4. Changes in salmon populations result in changes in the viable salmonid population parameters

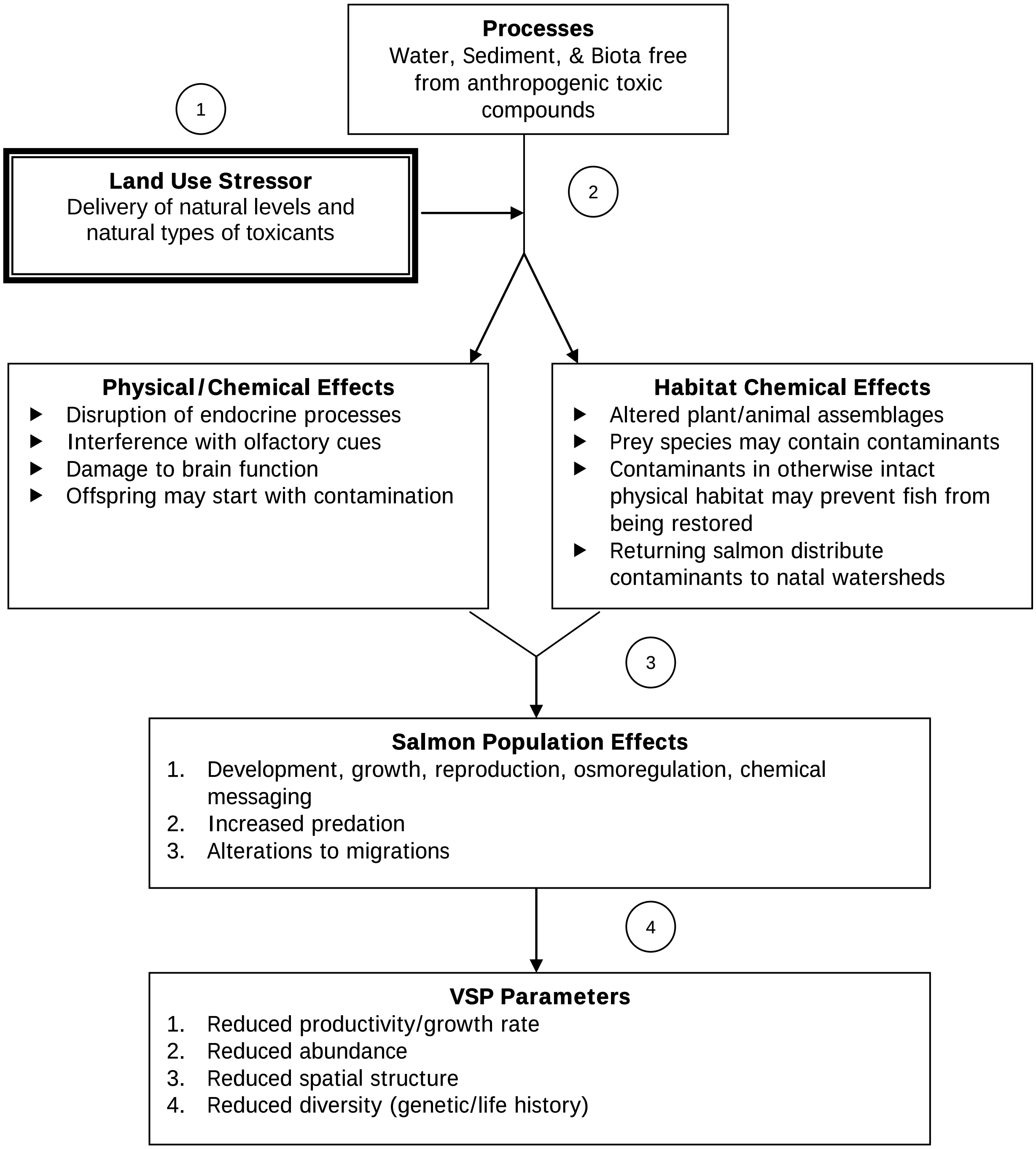
Wetland and Estuarine Modification



Hypothesis:

1. Wetland/estuarine modification impacts nearshore Tidal Exchange and Erosion/Sediment Transport processes
2. Erosion/Sediment Transport, Tidal Exchange and Nutrient Input processes have physical/chemical and habitat effects on the nearshore environment
3. Nearshore Physical/Chemical and Habitat conditions have an effect on salmon populations
4. Changes in salmon populations result in changes in the VSP parameters

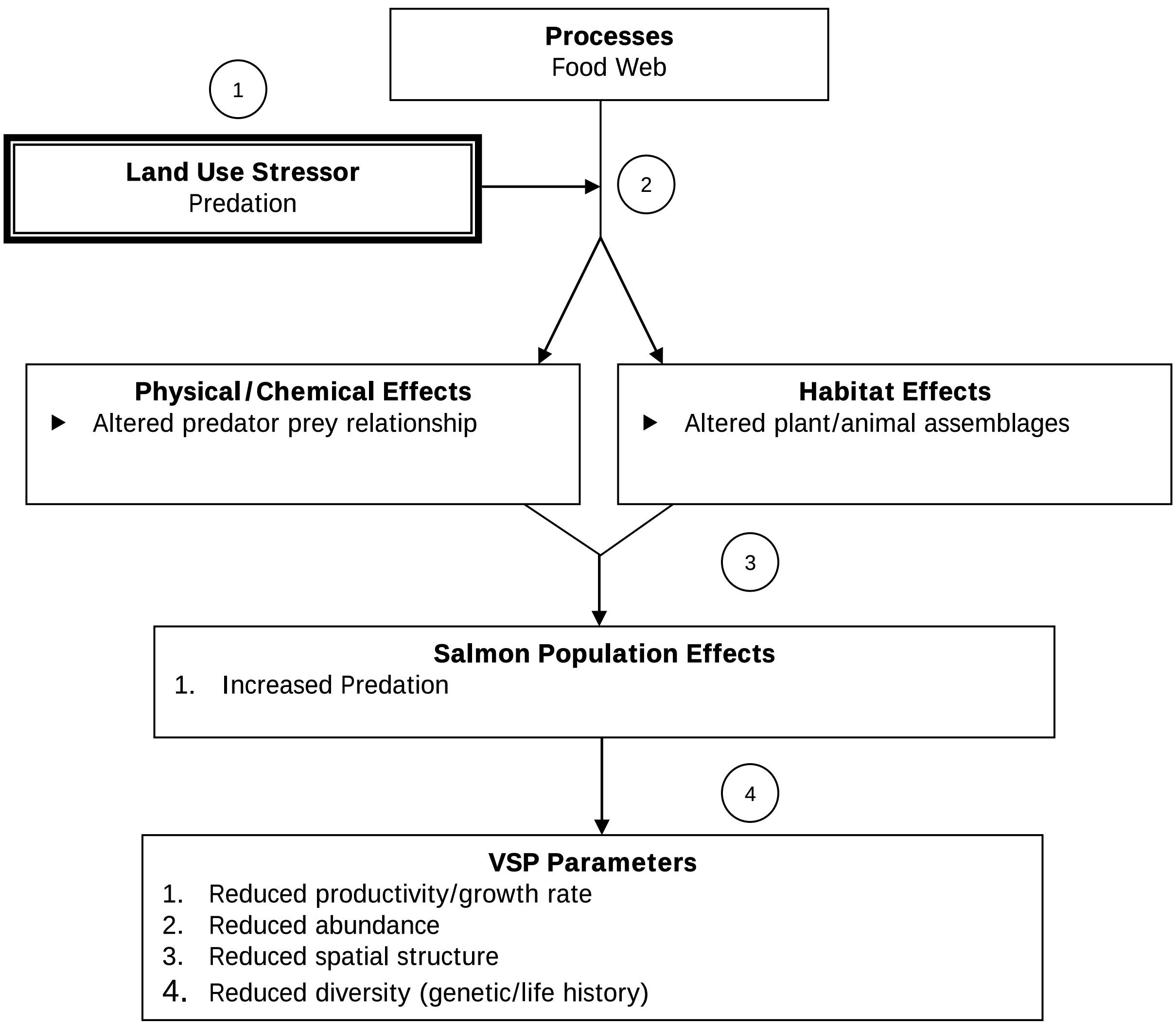
Input of Toxic Components



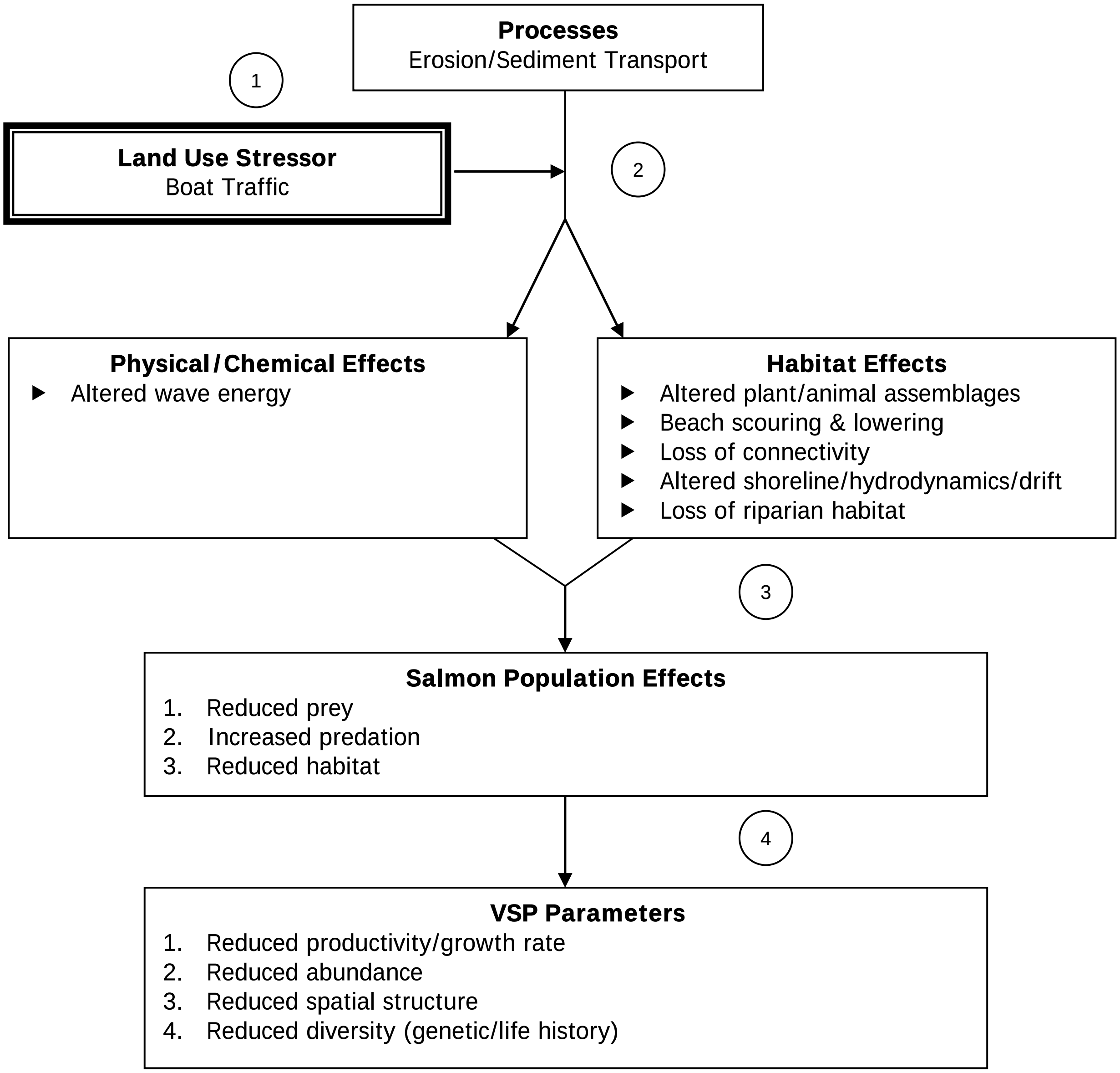
Hypothesis:

1. Anthropogenic toxic inputs contaminate the marine and nearshore water, biota, and sediments
2. Historic conditions provided clean water, sediment, and biota free of human-made toxic components
3. Toxic components can cause effects on salmonid processes
4. Changes in salmon populations result in changes in the VSP parameters

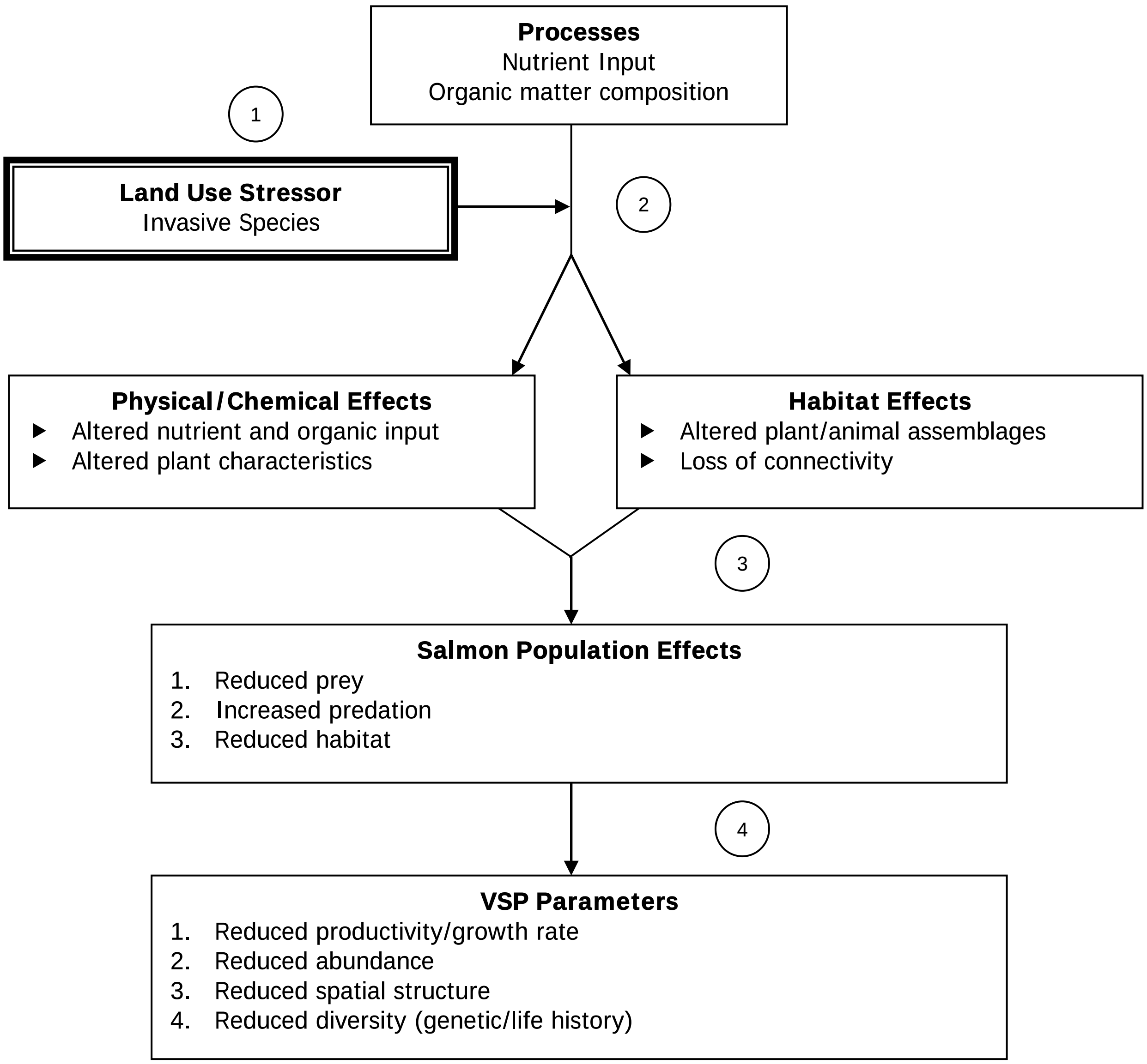
Predation



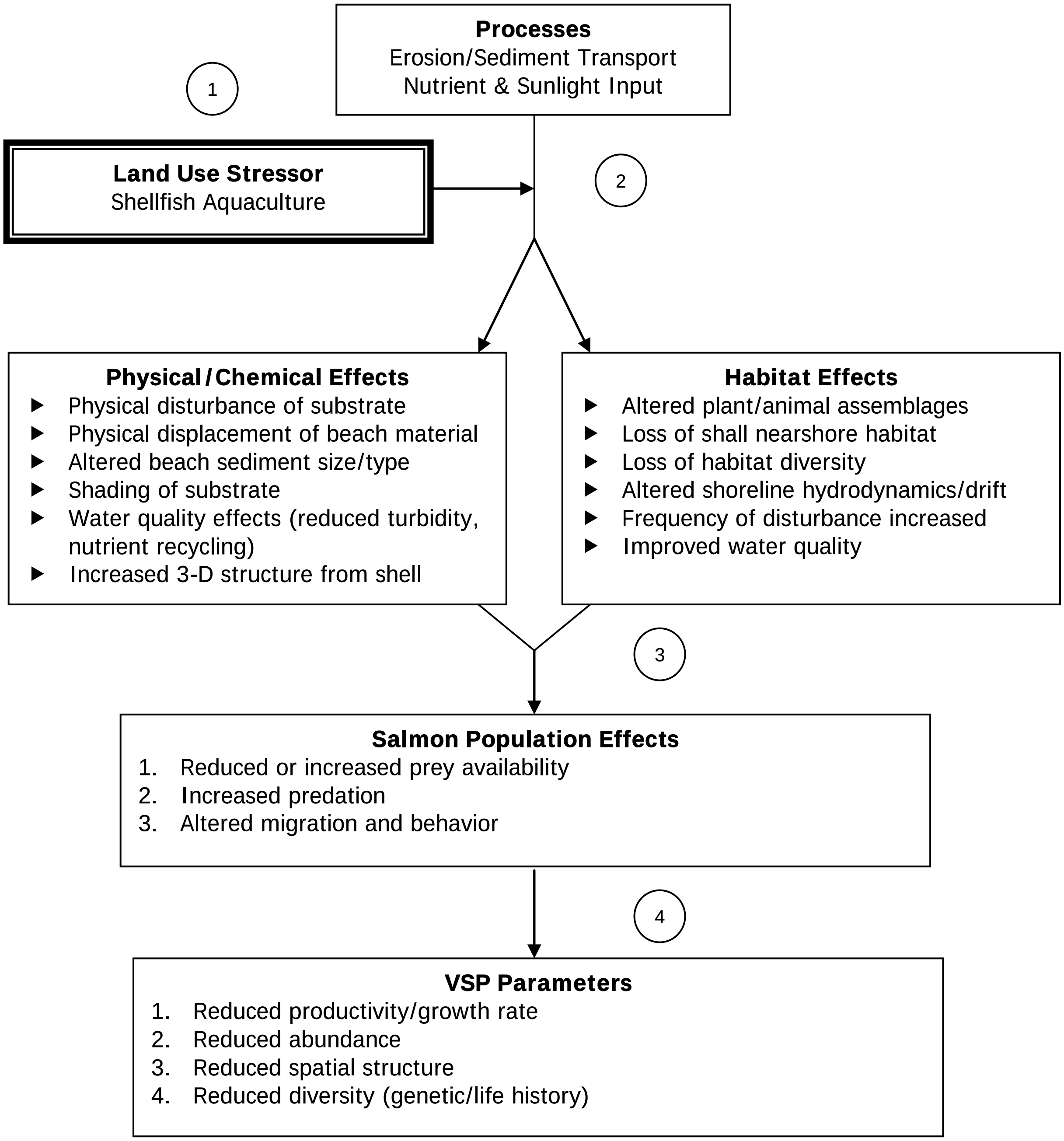
Hypothesis:
Increased predation on salmon has a negative effect on the food web leading to alterations in the biological features, including changes in the relationships between predators and their salmon prey. The resulting increase in predation leads to reduced salmon population, abundance, and spatial diversity.



Hypothesis:
Wakes from vessels have a negative effect on erosion which leads to alterations in the physical and biological habitat features, including changes in the plant and animal communities, loss of habitat, and loss of connectivity. The resulting increase in competition for prey resources, increased predation, and reduced habitat leads to reduced salmon population productivity, abundance, and life history diversity.



Hypothesis:
Invasive species have a negative effect on nutrient input and plant composition leading to alterations in the biological features, including changes in nutrients and plant characteristics. The resulting increase in competition for prey resources, increased predation, and reduced habitat leads to reduced salmon population productivity, abundance, and life history diversity.



Hypothesis:
Shellfish aquaculture in South Sound alters plant and animal assemblages and results in the loss of shallow nearshore habitat and habitat diversity important to salmon resources. These impacts may be potentially positive or negative depending on the type of aquaculture practice. We hypothesize that shellfish aquaculture reduces productivity, abundance, spatial structure, and diversity of salmon populations.

2. Distribution of Human-Induced Stressors in the South Puget Sound Nearshore

The SPSSRG conducted a landscape analysis of South Puget Sound to evaluate the functionality of its natural processes and habitat as well as the presence of human-induced stressors. To this end, the analysis divided South Puget Sound into nine distinct regions:

- Budd Inlet
- Carr Inlet
- Case Inlet
- Eld Inlet
- Hammersley Inlet and Oakland Bay
- Harstine Island Group
- Henderson Inlet
- McNeil Island Group
- Totten and Skookum Inlets

The map on page IV - 16 delineates these nine landscape regions.

This division of South Puget Sound has precedent; it is the same division used by the State of Washington and the Treaty Tribes for harvest planning and management (Puget Sound Indian Tribes and WDFW, 1986). It also reflects a very natural division of the South Puget Sound ecosystem into distinct geographic units that display their own unique characteristics. Assessment Units divide landscape regions into smaller segments that generally mirror the drift cells as delineated by the Washington State Department of Ecology (ShoreZone 2001).

The analysis relied on a combination of existing and original habitat assessments. The majority of the South Puget Sound shoreline was assessed recently as part of ongoing salmon recovery efforts. Information from these much more detailed reports has been summarized for inclusion in this document. For areas not covered by an existing report, an experienced habitat biologist familiar with the area used professional judgment to identify the landscape stressors affecting natural processes.

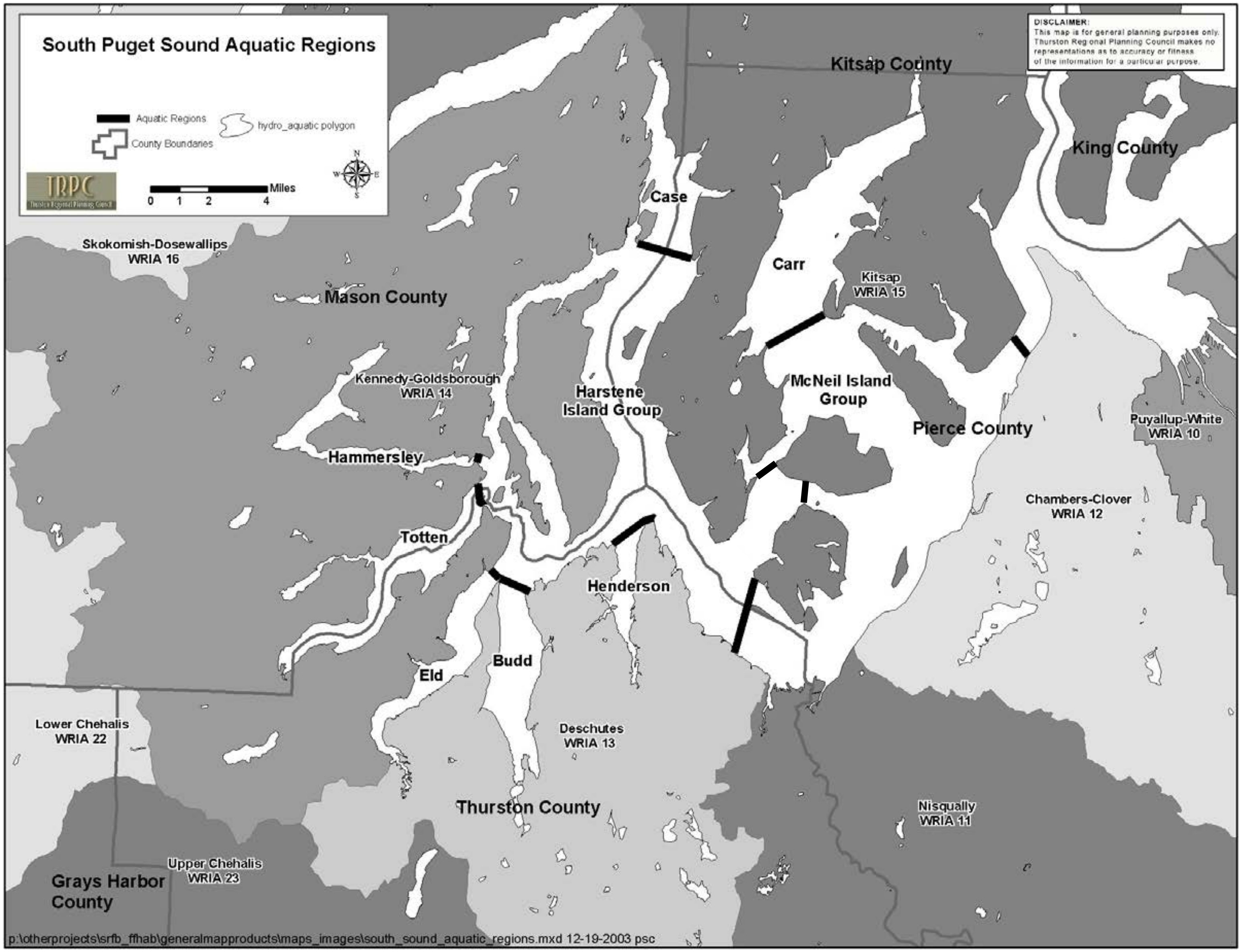
For Pierce County, the main source material was the "Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment (2003)." Tom Kantz, Pierce County, interpreted data from this assessment for integration into this report except for the portion of Pierce County located in Case Inlet that was interpreted by Scott Steltzner, Squaxin Island Indian Tribe.

For the landscape regions within Mason County, the main source material was the "Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment (2002)" and the "Greater Mason County Nearshore Habitat Assessment (2005)" which was interpreted by Scott Steltzner and Michelle Stevie, Squaxin Island Indian Tribe. This team also was responsible for preparing and interpreting original nearshore assessments for all of Totten and Skookum Inlets as well as the eastern shoreline of Dana Passage from Boston Harbor to Dickenson Point, as well as the Harstine Island group shoreline from Budd Inlet to Henderson Inlet.

For areas not covered by an existing report, an experienced habitat biologist familiar with the area used best professional judgment and interpretation of existing information sources to identify the landscape stressors affecting natural processes. Existing data sources included Washington ShoreZone Inventory, WDFW forage fish maps, and WDOE Shoreline Aerial Photos. Cindy Wilson of Thurston County and Margie Schirato of Washington State Department of Fish and Wildlife covered the Thurston County nearshore. Sayre Hodgson of the Nisqually Tribe covered the section of Pierce County shoreline from the Nisqually River mouth to the Tacoma Narrows bridge.

Joanne Schuett-Hames, Washington Department of Ecology, examined and interpreted existing data relating to water quality conditions for the nine landscape regions.

The landscape analysis, coupled with the conceptual model and discussion regarding human-induced stressors, served as a foundation for developing general protection and recovery actions. It was also essential for identifying significant data needs. The pages following the map of landscape regions are a summary of Appendix A. This summary is a quick guide to determine stressors, and ultimately actions that will eliminate, reduce, or mitigate impacts on natural processes for specific regions in South Puget Sound.


South Puget Sound Aquatic Regions
Aquatic Regions
County Boundaries
hydro_aquatic polygon
TRPC
Miles
0 1 2 4
DISCLAIMER:
This map is for general planning purposes only. Thurston Regional Planning Council makes no representations as to accuracy or fitness of the information for a particular purpose.
Kitsap County
King County
Case
Carr
Kitsap WRIA 15
Skokomish-Dosewallips WRIA 16
Mason County
Kennedy-Goldsborough WRIA 14
Harstene Island Group
McNeil Island Group
Pierce County
Puyallup-White WRIA 10
Hammersley
Totten
Chambers-Clover WRIA 12
Henderson
Budd
Eld
Lower Chehalis WRIA 22
Deschutes WRIA 13
Thurston County
Nisqually WRIA 11
Upper Chehalis WRIA 23
Grays Harbor County
p:\otherprojects\srfb_ffhab\generalmapproducts\maps_images\south_sound_aquatic_regions.mxd 12-19-2003 psc

Landscape Region / Assessment Unit	Assessment Unit	Shoreline Armoring	Overwater Structures	Ramps	Stormwater/ Wastewater	Landfill Below HHWL	Riparian Loss	Wetland & Estuarine Mod.	Input of Toxic Components	Predation	Boat Traffic	Invasive Species	Shellfish Aquaculture
Budd Inlet													
Doffelmeyer to Gull Harbor-North End		●					●	●					
South Budd Inlet		●	●	●	●	●	●	●	●		●		
Deschutes River-fish trap to Butler Cove		●	●		●	●	●	●	●		●		
Butler Cove to Big Tykle Cove		●	●		●		●				●		
Big Tykle Cove to Cooper Point		●	●		●		●				●		
Carr Inlet													
Green Point and Horsehead Bay		●	●				●						
Horsehead Bay to Raft Island, including Cutts Island		●	●				●						
Allen Point to Burley Lagoon		●											
Burley Lagoon		●	●				●						
Purdy Spit to entrance of Van Geldern Cove		●	●				●						
Case Inlet													
North Spit of Dutcher Cove to Mason County Line		●					●						
County Line to Power Line Crossing		●			●		●						
Eastern Power Line Crossing to Western Power Line Crossing					●	●							
Western Power Line Crossing to Fair Harbor		●					●	●					
Fair Harbor to Southern Tip of Stretch Island, Including Reach Island		●	●		●		●						

Landscape Region / Assessment Unit	Assessment Unit	Shoreline Armoring	Overwater Structures	Ramps	Stormwater/ Wastewater	Landfill Below OHWL	Riparian Loss	Wetland & Estuarine Mod.	Input of Toxic Components	Predation	Boat Traffic	Invasive Species	Shellfish Aquaculture
Eld Inlet													
Cooper Point to Green Cove (North end)		●			●		●	●					●
Green Cove to North End of Mud Bay		●			●		●	●					●
Mud Bay-South end of Eld Inlet		●	●		●		●	●					●
North of Mud Bay to Cove/Point (unnamed)		●			●		●	●					●
North side of Unnamed Cove to North side of Youngs Cove		●			●		●	●					●
Youngs Cove to Flapjack Point		●			●		●	●					●
Flapjack Point to Frye Cove		●			●		●	●					●
Frye Cove to Sanderson Harbor		●			●		●	●					●
Hammersley Inlet & Oakland Bay													
Hungerford Point to Libby Point							●						
Libby Point to Munson Point		●					●						
Munson Point to Bayshore					●			●					●
Bayshore to Eagle Point		●	●		●		●	●					
Eagle Point to Skookum Point		●					●	●					
Skookum Point to Arcadia		●			●								
Harstine Island Group													
Devils Head to North Entrance of Taylor Bay		●											
North Entrance of Taylor Bay to North Entrance of Whiteman Cove		●						●					
North Entrance of Whiteman Cove to Herron, Including Herron Island		●						●					
Herron to North Spit of Dutcher Cove		●					●						

Landscape Region / Assessment Unit	Assessment Unit	Shoreline Armoring	Overwater Structures	Ramps	Stormwater/ Wastewater	Landfill Below HHWL	Riparian Loss	Wetland & Estuarine Mod.	Input of Toxic Components	Predation	Boat Traffic	Invasive Species	Shellfish Aquaculture
Harstine Island Group (Continued)													
Stretch Island Bridge to Walkers Landing	●	●				●	●						
Walkers Landing to Hungerford Point	●	●				●	●						
Steamboat Island to Hunter Point		●					●						
Hunter Point to Sanderson Harbor		●			●		●	●					●
Dofflemyer Point to East Entrance of Little Fishtrap	●	●	●				●						
East Entrance of Little Fishtrap to Henderson Inlet	●	●											
Johnson Point to Baird Cove		●	●		●		●						
Baird Cove to Mill Bight	●	●	●		●		●						
Mill Bight to Dog Fish Bight		●					●						
Dog Fish Bight to Sandy Point		●				●		●					
Sandy Point to Butterball Cove	●	●			●			●					
Butterball Cove to DeWolf Bight	●	●											
DeWolf Bight to Hogum Bay	●	●					●						
Hogum Bay to Mc Neill Island Group (122 degrees 45') (Meridian Road)	●	●											●
Harstine Island- Dougall Point to Fudge Point, Including McMicken Island	●	●					●						
Harstine Island- McMicken Island to Brisco Point	●	●					●						
Harstine Island - Brisco Point to Salmon Point		●					●	●					●
Harstine Island- Salmon Point to Northwest Point of Harstine Island	●	●					●						●
Northwest Point of Harstine Island to Dougall Point	●	●					●						
Squaxin and Hope Islands	●		●										

Landscape Region / Assessment Unit	Assessment Unit	Shoreline Armoring	Overwater Structures	Ramps	Stormwater/ Wastewater	Landfill Below HHWL	Riparian Loss	Wetland & Estuarine Mod.	Input of Toxic Components	Predation	Boat Traffic	Invasive Species	Shellfish Aquaculture
Henderson Inlet													
Johnson Point to Woodland Creek		●	●				●	●					
South Henderson Inlet			●		●			●					
Woodard Bay to Henderson Inlet Line		●	●				●	●					
McNeil Island Group													
Harstene Island Line (122 degrees 45") to Nisqually Head/Luhr Beach		●											●
Nisqually Head/Luhr Beach to Mouth of Little McAllister													
Nisqually estuary to Gordon Point (near Steilacoom)		●				●		●					
Ketron Island													
Gordon Point (near Steilacoom) to the tip of Day Island		●	●		●	●		●					
Day Island to Tacoma Narrow Bridge		●	●			●		●					
Tacoma Narrows Bridge to Point Fosdick (EMU 3)													
Point Fosdick to Wollochet Bay (EMU 4)		●	●				●	●					
North Shore of Hales Passage to Green Point (EMU 5)		●	●				●	●					
Van Geldern Cove to Pitt Passage, including Pitt Island (EMU 9)		●	●				●	●					
Pitt Passage to Devil's Head (EMU 10)		●	●				●	●					
Fox Island shoreline (EMU 13)		●	●				●	●					
Anderson Island shoreline (EMU 14)		●	●				●	●					
McNeil Island shoreline (EMU 15)		●	●				●	●					

Landscape Region / Assessment Unit	Assessment Unit	Shoreline Armoring	Overwater Structures	Ramps	Stormwater/ Wastewater	Landfill Below HHWL	Riparian Loss	Wetland & Estuarine Mod.	Input of Toxic Components	Predation	Boat Traffic	Invasive Species	Shellfish Aquaculture
Totten and Skookum Inlet													
Arcadia to Windy Point		●					●						●
Windy Point to Barron Point (mouth of Skookum Inlet)							●						●
Little Skookum Inlet								●					●
Wildcat Harbor to Hurley Cove		●					●						●
Hurley Cove to County Line													●
County Line to West Side of Burns Cove								●					●
West Side of Burns Cove to Hudson Cove		●					●						●
Hudson Cove to East Entrance of Gallagher Cove		●					●						●
East Entrance of Gallagher Cove to Steamboat Island		●					●						●

3. Objectives for Reducing Impacts of Human Induced Stressors

Human-induced stressors have disrupted natural processes throughout South Puget Sound. Recovery of these natural processes will be critical to restoring the functionality of habitat for Chinook, bull trout, and other salmonids. To this effect, the SPSSRG set the following objectives for addressing human-induced stressors.

Shoreline Armoring

- Encourage removal of armoring from publicly owned sites – Cities, counties, and state parks often contain waterfront recreation areas with unnecessary armoring, such as Penrose State Park. Removal of these structures and restoring native vegetation can account for actual restoration of processes because of their relatively large size (PSNERP 2003) and provide excellent example sites for educational purposes.

- Identify and encourage removal of bulkheads not essential for protecting structures.

- Avoid the necessity of shoreline armoring by requiring setbacks and buffers.

- When feasible, require the use of soft shore protection measures to protect shorelines - Much of the bulkheading that has occurred in South Puget Sound does not address the cause of bank erosion, and in many cases has actually increased it. When bulkheading does become necessary, emphasis should be on using soft shore alternatives that mimic natural processes, using gravel, sand, logs, and root masses (Johannessen 2001).

- Institute a no net gain in armoring per drift cell – Local governments updating shoreline master programs and GMA critical areas ordinances can adopt a standard to protect existing shoreline function by placing moratoria on new armoring or collecting a resource impact fee for each armoring permit to help defray the cost of bulkhead removal and other nearshore restoration projects.

- Remove or modify shoreline armoring that is blocking the passage of materiel from feeder bluffs whenever possible (MacDonald et al. 1994).

Overwater Structures

- Formalize design criteria in overwater structures white paper (Williams and Thom 2001) – The Aquatic Habitat Guidelines Project developed a white paper with useful design criteria to prevent and minimize damage to nearshore environments. These criteria should be formally adopted in a public rule-making process for WDFW's Hydraulic Project Approval permit program, Corps of Engineers' Section 10 permits and other appropriate permits.

- Design overwater structures to let light through, to allow survival of subtidal and intertidal vegetation (Fresh et al. 2001).

- Seek funding and removal of old homes, floats, debris, old piling, anchors, and derelict vessels as opportunities arise.

- Minimize the number of docks by encouraging community facilities.

Ramps

- Minimize the number of ramps by encouraging community facilities.

- Provide incentives to residential property owners to give up individual ramps and marine railways.

- Identify and remove boat ramps that cloak sediment transport.

Stormwater/Wastewater

- Encourage the retrofit of stormwater systems using Low Impact Development practices by making funding available through state and federal grants and loans – Many urban areas could be retrofitted using LID principles to improve water retention, treatment and infiltration to the water table, especially as part of ongoing redevelopment projects.

- Encourage the retrofit of wastewater treatment plants to reuse reclaimed water – Wastewater that currently discharged into south Puget Sound can be treated to higher standards and used for irrigation, fire suppression, and wildlife habitat enhancement similar to the North Cove Sewage Treatment System or the City of Yelm's state of the art system.

- Promote land use practices that prevent stormwater flows – Development reduces the natural storage and buffering capacity of watersheds, resulting in greater stormwater runoff and a range of negative impacts to aquatic habitats. Where feasible, stormwater runoff should be prevented by preserving native land cover and natural drainage systems (forests, soils, wetlands, shorelines, stream corridors) and limiting the area and connectivity of impervious surfaces.

- Implement Comprehensive Stormwater Programs - Element SW 1.2 of the *2000 Puget Sound Water Quality Management Plan* calls on all cities and counties to adopt comprehensive stormwater programs to manage stormwater runoff.

- Include Nutrient Removal in On-Site Sewage System Design - Nutrient loadings to south Puget Sound are a significant water quality concern (see for example, WDOE 2002 at http://www.ecy.wa.gov/pubs/0203021.pdf). Nutrient sources include discharges from sewage treatment systems. In the Puget Sound region, on-site sewage systems are designed to meet bacteria standards to protect public health, but do little to remove nutrients. Systems installed in shoreline and riparian areas of south Puget Sound should be designed to reduce nitrogen concentrations as well.

- Improve Monitoring and Maintenance of On-Site Sewage Systems in Proximity to the Nearshore - In order for sewage systems to function effectively they must be properly sited, designed, installed, operated, monitored and maintained. Element OS-2 of the *2000 Puget Sound Water Quality Management Plan* calls on local health jurisdictions to adopt programs that provide for regular monitoring/maintenance of on-site systems and follow-up action to ensure that malfunctioning and failing systems are repaired or replaced. The plan further calls on local health jurisdictions to identify areas of special concern and use risk-based approaches to provide enhanced oversight in marine shoreline areas and other sensitive environments.

- Promote or require wastewater reuse - Municipalities and other dischargers should explore opportunities to recycle and reuse treated wastewater to reduce nutrient loadings to marine waters and to supplement and replenish limited freshwater supplies.

- Curtail new wastewater discharges to Puget Sound - Water quality studies indicate that wastewater discharges are contributing to the eutrophication of marine waters in South Sound (Newton et al. 1997). Element P-2.1 of the *2000 Puget Sound Water Quality Management Plan* calls on Ecology to pursue alternatives to marine wastewater discharges "whenever such alternatives are feasible, economically achievable and environmentally preferable. . . . Alternatives to be considered shall include, but not necessarily be limited to, the following: land application, reuse, additional treatment and the use of constructed wetlands."

- Reduce nutrient loadings from permitted wastewater facilities - State and federal law and the *2000 Puget Sound Water Quality Management Plan* call on Ecology to set water quality and sediment standards, to implement anti-degradation requirements, to incorporate conditions from Total Maximum Daily Load studies, and to issue NPDES permits to meet and implement these requirements. Increased nitrogen loadings and related problems with dissolved oxygen have been identified in many areas of South Puget Sound (PSAT 2004).

- Systematically reduce human-caused nutrient sources. Ecology marine monitoring data and studies have found the South Sound waters are susceptible to low dissolved oxygen conditions that can be caused by increased nutrients. A focused effort, South Puget Sound wide is needed to prevent human-associated nutrients from entering the South Sound.

- Implement a comprehensive street-sweeping program to reduce the amount of pollution in water runoff - Roads, highways, and bridges are sources of pollution such as sediment, heavy metals, oil, grease, and debris. Significant amounts of these pollutants are carried to Puget Sound by storm water when it rains (PSAT 2004). New technology in street sweeping equipment considerably reduces the amount of pollution found in runoff water.

Landfill Below the Mean Higher High Water Line

- Restrict any use of fill for any use or structure
- Seek removal of fill and structures below the mean higher high water line

Riparian Loss

- Reestablish and/or maintain existing riparian buffers along the nearshore - It is accepted that riparian buffers are important for salmon and trout in freshwater systems. Placing buffers along the marine nearshore would serve a similar purpose (Brennan and Culverwell 2001).
- Establish building setbacks that are protective of shoreline forests and other natural habitats, or allow the restoration of these habitats. Shoreline forests and other natural habitats provide important functions such as inputs of salmonid prey species and wood. Encroachment into these natural areas and forests leads to extensive physical/chemical, and habitat effects and impacts on salmonid populations (Williams and Thom 2001).
- Require native plantings along shoreline as a permit condition – Most bulkheads, overwater structures, and other appurtenances require a local building permit and several state or federal use permits. These permits should require the planting of native vegetation, even for renewal permits, so that a marine riparian area can eventually re-establish. There are a number of guidance materials available for maintaining views and access while retaining native vegetation along the shoreline (Manashe 1993; Meyers et al. 1995).
- Increase public ownership along the shoreline to protect riparian habitat.
- Encourage the retention of undeveloped shorelines in designated open space status to preserve riparian vegetation.

Wetland and Estuarine Modification

- Encourage dike and tide gate removal, and improve agricultural practices on marine and estuarine marshes. In the past, substantial loss of estuarine and tidally influenced wetlands was due to the diking and hydrologic isolation of the wetlands, primarily for agricultural purposes (PSAT 2004). Dike removal and restrictions on agricultural use of estuarine wetlands (fencing of cattle, etc.) would restore important estuarine functions. This can be accomplished through incentives and buy-back programs, some of which currently exist at the federal level, such as the

Conservation Reserve Program and the Wetland Reserve Program through the Natural Resources Conservation Service. Similar state and local programs could also be created and targeted toward wetland/estuarine restoration.

- Secure funding for estuarine restoration and monitoring – Most funding sources for restoration are capped at $5 million or less and require enormous resources on the part of local partnerships to find match. Restoring natural processes generally occurs at a larger geographic scale than structural restoration projects and may contain elements that are experimental until implemented and monitored (PSNERP 2003). These funding sources also limit the amount of the grant that can be spent on monitoring and adaptive management, so little is known as to the success of these projects. Increasing state and federal appropriations for restoration at larger scales and actively investing in effectiveness monitoring would improve restoration effectiveness.

- Promote projects that remove around the mouth of tributaries existing shoreline armoring and blockages, such as culverts, fill, and structures.

<u>Input of Toxic Components</u>

- Support public education efforts focusing on using Best Management Practices (BMPs) for preventing entry of toxic contaminants into nearshore and marine waters. For many years the ocean and inland marine waters were generally considered safe from harm by human actions. This is no longer the case; South Puget Sound nearshore and marine waters now have extensive contamination that can cause a broad suite of negative effects to salmonid populations (PSAT 2004).

- Study the use and affect of PBDEs on salmonid health - PBDEs (polybrominated diphenyl ethers) are persistent, bio-accumulating toxics used as flame-retardants in mattresses, carpets, etc. They have a structure similar to PCBs (polychlorinated biphenols), appear to behave similarly, and they are increasing in the environment in North America (PSAT 2004).

- Clean up Puget Sound toxic sediments, including South and Central Puget Sound. The opinion of this plan prefers removal of sediments as opposed to capping.

- Reduce pesticides use through public education – Educate the public about the problems related to pesticide use and provide stream buffers to help filter water before it reaches streams.

- Prevent oil spills through local and regional planning and implementation efforts.

Predation:

- Reduce or eliminate man-made predator buffets. Juveniles and returning adult salmon passing through confined stream mouths or altered waterways are prone to heavy predation, especially seals and sea lions.

Boat Traffic:

- Restrict vessel speed and/or redirect vessel routes - Many inlets and passages in South Puget Sound offer narrow and shallow openings for marine traffic. The wake from passing boats and ships passing through these constrictions can cause shoreline erosion and damage to the nearshore marine environment (WSDOT 2001). Much of this impact can be avoided by selectively controlling speeds and vessel routes located near sensitive areas.

- Require specific anchoring practices to prevent destruction to sensitive areas, such as eelgrass beds.

Invasive Species:

- Require that ballast water in commercial ships be exchanged or treated before release in South Puget Sound - Before a voyage commercial ships must take in water (ballast) for stability. Once a ship arrives at its destination port this water is released. A common method of non-native species introduction is by being carried in this ballast water (PSAT 2004). Requiring treatment of ship ballast would minimize introduction of non-native species.

- Establish a program or support volunteer efforts that remove invasive terrestrial non-native vegetation, such as scotch broom, from riparian areas (Manashe 1993; Meyers et al. 1995).

Shellfish Aquaculture:

- Identify shellfish aquaculture impacts and encourage improved management practices - The production and harvest of shellfish involves a variety of techniques that can negatively affect the nearshore environment. Practices should continue to be developed to avoid and mitigate potential negative impacts. One document that sets a solid framework for this work is the Pacific Coast Shellfish Growers Association's *Environmental Codes of Practice for the Pacific Coast Shellfish Industry*, adopted in 2002 to minimize an array of impacts associated with the most common industry practices.

- Chapter 5 -

Priority Areas for Achieving Habitat Protection and Restoration Objectives

This chapter identifies prioritized areas vital for sustaining juvenile Chinook, bull trout, and other salmonids within the South Puget Sound nearshore. Projects intended to achieve the protection and restoration objectives introduced in Chapters 4 and 5 will deliver the greatest benefit to salmonids from efforts directed at these areas.

Local, state, and federal agencies will find this chapter useful as a best available science tool for planning purposes or evaluating development proposals in proximity to fish and wildlife conservation areas that benefit juvenile salmonids, especially Chinook. Knowing what kind and why certain habitats are important to salmonids, as well as their locations, will result in more effective efforts aimed at protecting them. This plan encourages the integration of this information into comprehensive plans and critical areas ordinances, as well as identifying essential mitigation actions for development proposals.

Salmon recovery organizations will benefit equally from the detailed maps by identifying potential restoration and protection areas within a specific landscape. As an example, a salmon recovery organization interested in developing projects that increase the availability of prey resources in Carr Inlet will find through the appropriate map the location of high priority forage fish spawning beaches needing restoration.

Projects of any scale completed in the priority areas will provide a significant benefit to salmonids. It is important to note, however, that this does not dismiss the need for projects in non-high priority areas. While small-scale projects in non-high priority areas will likely deliver minimal benefit to salmonids, projects of a much larger scale can result in a positive, cumulative impact towards recovery.

The organization of this chapter first explores the methodology behind the selection of the six habitat types. It then follows with a series of maps by habitat type for each landscape showing the general location of priority protection and restoration areas. Map users should not rely solely on the maps. It is important to consult the original assessments or conduct site-specific investigations to assemble a more detailed analysis of a habitat-type and its individual restoration or protection project needs.

1. Methodology

Using existing information resources to develop habitat protection and restoration projects that benefit salmonids in the South Puget Sound Nearshore is a challenging task for two reasons. First, the extent of current literature and data about salmonid use of the Puget Sound nearshore in general, and South Puget Sound in particular, is quite limited. Secondly, that literature or data often focuses on habitat in specific subareas and/or relies on varying assessment methodologies. These factors complicate the use of these data resources for comparison purposes between one part of the planning area to another. This search for commonality in data is critical especially for identifying priority projects that benefit Chinook throughout the entire South Puget Sound region.

A survey of the best available science conducted by Steltzner (2005) reveals it is possible to identify, prioritize, and map projects for six discrete habitats common throughout the South Puget Sound Nearshore that are essential for salmonids from existing information resources. These are:

- Known forage fish spawning beaches
- Feeder bluffs
- Pocket estuaries
- Salmonid bearing freshwater tributaries
- Eelgrass beds
- Emergent marsh

Each of these habitats contributes to the four essential nearshore eco-system functions beneficial to juvenile salmonids described by Simenstad (1982) and William and Thom (2001). While acknowledging that relying solely on six habitat types to determine if these functions are being fulfilled is far from complete, it nonetheless allows for a reliable, first step, short-term project identification process until data gaps close. A summary of this research for each habitat-type follows below.

<u>Known forage fish spawning beaches</u>

Because adult and juvenile Chinook in particular rely on forage fish for a significant portion of their diet, protecting or restoring this asset is critical for foraging and growth (Healy 1980; Environment Canada 1994; Bargmann 1998). Forage fish spawn in sand and small gravel substrates in upper intertidal zones easily disrupted by nearshore energy, interrupted sediment supply, and shoreline armoring placed below the ordinary high water line.

Five nearshore assessments prepared for subareas within the planning area provided data on relative habitat quality.[1] Studies and GIS data from the Washington Department of Fish and Wildlife assisted in mapping known forage fish spawning areas. Based on the available data, all known forage fish spawning areas rated as a high

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[1]The five assessments are: <u>Greater Mason County Nearshore Habitat Assessment</u> (2005), <u>Draft Shoreline Sediment Survey and Assessment</u> (2004), <u>Key Peninsula, Gig Harbor, and Island (KGI) Nearshore Salmon Habitat Assessment</u> (2003), <u>Oakland Bay/Hammersley Inlet Nearshore Habitat Assessment</u> (2002), and <u>Totten Inlet/Little Skookum Inlet Nearshore Habitat Assessment</u> (1991). The assessments used differing methodologies to identify project areas.

priority for either protection or conservation. The limitation to using this data is the completeness of past surveys; there may be spawning beaches not yet observed.

Feeder bluffs

Feeder bluffs contribute sediment supply for sustaining beaches, organic matter, invertebrate prey, and groundwater supply to the nearshore (Macdonald et al. 1994; Simenstad and Cordell 2000).

Data sources for identifying and mapping feeder bluffs included the previously cited nearshore assessments, the Digital Coastal Atlas, and the Washington State ShoreZone Inventory. The presence of shoreline armoring determined if protection or restoration action was necessary.

The following attributes established the priority rating for protection or restoration projects:

Restoration		
	High	On or upstream of a known forage fish spawning beach with 50% or more of the shoreline armored
	Medium	On or upstream of a known forage fish spawning beach and less than 50% of the shoreline armored
	Low	Downstream of a known forage fish spawning beach
Protection		
	High	Upstream of a known forage fish spawning beach with no shoreline armoring
	Medium	Downstream of a known forage fish spawning beach with no shoreline armoring
	Low	Not used

There are several limitations to note when using this dataset. First, there is a gap in assessment data for the Mason County portion of Skookum Inlet, Oakland Bay, Hammersley Inlet, and the shoreline from the Nisqually estuary to the Tacoma Narrows. Second, while the assessments for Pierce and Mason Counties have underwent field verification, the Thurston County assessment relied on photo interpretation. Third, the dataset does not incorporate other sediment sources, such as streams, that could play a significant role in feeding spawning beaches. Lastly, forage fish surveys may be incomplete.

Pocket Estuaries

Pocket estuaries are “small scale estuaries located at the mouths of streams and small rivers and other semi-enclosed embayments within Puget Sound that have a tidal channel structure, intertidal marsh and/or mudflats, eelgrass beds and other features typical of larger estuaries” (Averill et al. November 2004). Pocket estuaries provide juvenile Chinook with a low wave energy refuge and a physiological transition zone with lower salinity levels (Beamer et al. 2003). The rich macro invertebrate community within pocket estuaries is also critical for foraging and growth.

The draft Regional Nearshore and Marine Chapter for the Puget Sound Recovery Plan identified and mapped locations of pocket estuaries in the planning area (Averill et al. November 2004). The plan relied on aerial images from the Washington Digital Coastal Atlas and used best professional judgment to score each pocket estuary according to criteria to determine if it was "properly functioning," "at risk," or "not properly functioning."[2] This plan interpreted "properly functioning" and "at risk" as protection areas and "not properly functioning" as restoration projects. The rating system used for prioritizing protection and restoration actions is adapted from the Mason County assessment. It reflects the likelihood of juvenile salmonids using a pocket estuary given its proximity to a salmon bearing stream or river.

Protection and Restoration Priorities

High	Salmon bearing stream present in the pocket estuary
Medium	Non-natal stream present in the pocket estuary and salmonid bearing stream or river within five miles
Low	Non-natal stream present in the pocket estuary and salmonid bearing stream or river further than five miles away

Using this approach does present several challenges. The first revolves around the definition itself, which is different from the existing one put forward by the Skagit System Cooperative and the Northwest Fisheries Science Center and has yet to undergo peer review. Furthermore, there has been no ground truthing of the identified pocket estuaries to test either the definition or the scoring criteria. The second issue is that the report did not define the physical boundaries of each pocket estuary and instead relied on a single geographic point. In order to clarify the boundaries of a pocket estuary visually on a map, the delineation of boundaries was by field biologists using their best professional judgment.

Salmonid Bearing Freshwater Tributaries

Chinook favor salmonid bearing freshwater tributaries habitats for feeding opportunities, refuge, and physiological transition for juveniles (Congleton et al. 1981; Healey 1982; Levy and Northcote 1982; Leavings 1982; Healey 1991; Simenstad et al. 1991; and Thorpe 1994).

Data for locating and mapping salmonid bearing freshwater tributaries in South Puget Sound is available through the A Catalog of Washington Streams and Salmon Utilization and the Washington State Salmon and Steelhead Inventory. Modeling by Anchor Environmental in the Mason County assessment delineated the extent of nearshore affected by such tributaries as one-half mile of nearshore as measured from the mouth.

[2] For further detail, consult Appendix A, page 3 of the report.

For the Nisqually River, however, the distance increases to five-mile of nearshore from the mouth as recommended by Averill et al. (November 2004).

The determination of whether restoration or protection of a salmonid bearing freshwater tributaries reflects the relative habitat quality rating as ascribed in each of the nearshore assessments. A standardized "high priority" rating assigned to each tributary reflects the lack of data available to assess their relative importance with one another.

Eelgrass Beds

Juvenile salmonids favor eelgrass beds for foraging, as a refuge from predators, and as a migratory corridor (Simenstad et al. 1981; Stober and Pierson 1984; Simenstad et al. 1988). Despite its relative scarcity in South Puget Sound, eelgrass is important to the nearshore food web for supporting salmonids (Williams et al. 2001).

The Washington ShoreZone Inventory identifies the location of known eelgrass beds in South Puget Sound. Sufficient data is not available, however, to determine if any of these beds are in need of restoration. Therefore, all eelgrass beds share a protection status until further information becomes available.

Information about the extent of eelgrass bed presence in an assessment unit serves as the basis for assigning priority status for protection efforts. If eelgrass beds cover a continuous swath, the priority rating is "high." If Washington ShoreZone Inventory describe the beds as "patchy," the priority rating is "medium." It should be noted that there is not enough information to construe if "patchy" reflects a natural or a degraded condition caused by one or more stressors.

Salt Marshes

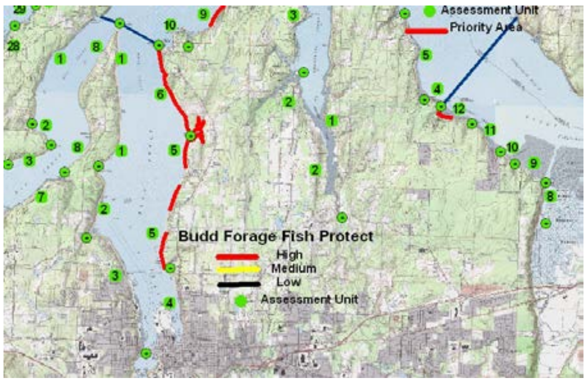
Juvenile salmonids are frequent users of salt marsh habitats (Simenstad et al. 1981; Healey 1980, 1982; Levy and Northcote 1981). Salt marsh supports a food web critical to juvenile salmonids (Leavings et al. 1991; Shreffler et al. 1992; Williams et al. 2001). Juveniles tend to migrate along the edges of marsh areas as well (Simenstad et al. 1999), which provide shelter from predators and wave energy.

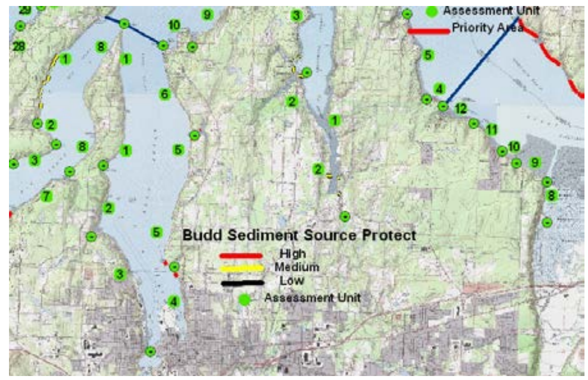
Again, the ShoreZone Inventory is the primary data resource for locating *Salicornia* sp. dominated lower and high native salt marsh in South Puget Sound. Sufficient data is not available to determine if any salt marshes are in need of restoration. Therefore, all salt marshes share a protection status until further information becomes available.

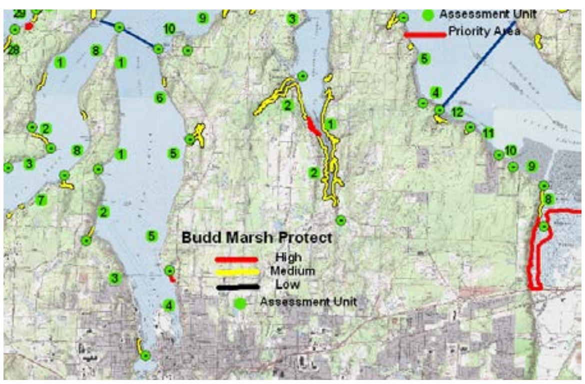
Information about the extent of salt marsh in an assessment unit serves as the basis for assigning priority status for protection efforts. If a salt marsh covers a continuous swath, the priority rating is "high." If Washington ShoreZone Inventory describes the marsh as "patchy," the priority rating is "medium." It should be noted that there is not enough information to construe if “patchy” reflects a natural or a degraded condition caused by one or more stressors.

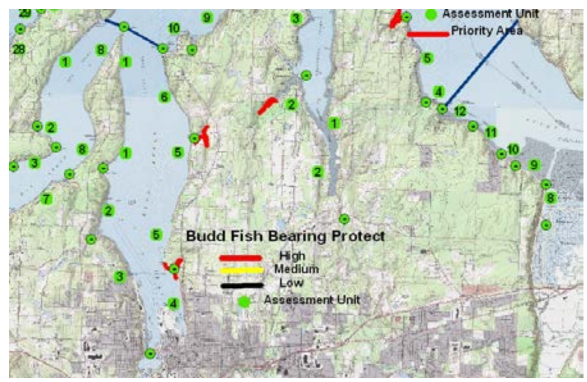
A limitation to relying solely on the ShoreZone Inventory is that its focus is on the shoreline; it is unknown if salt marshes situated further inland fail to show up in the inventory.

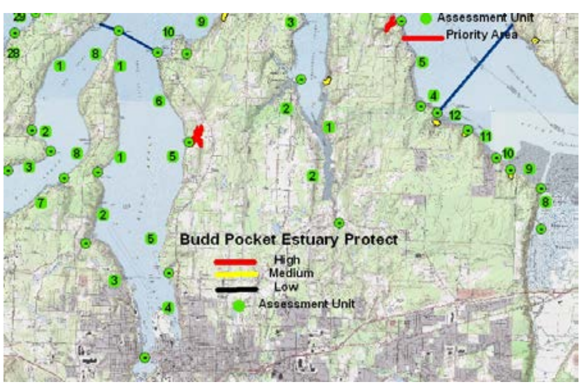
2A. Budd Inlet Priority Protection Areas











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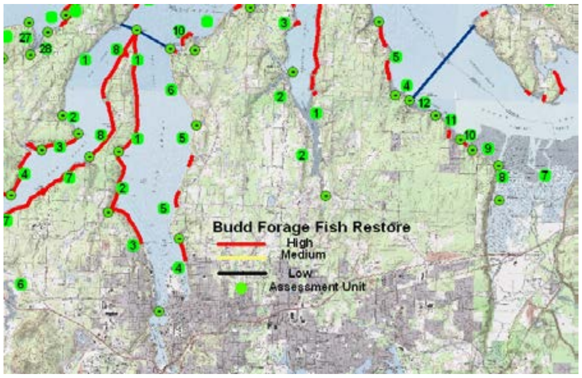

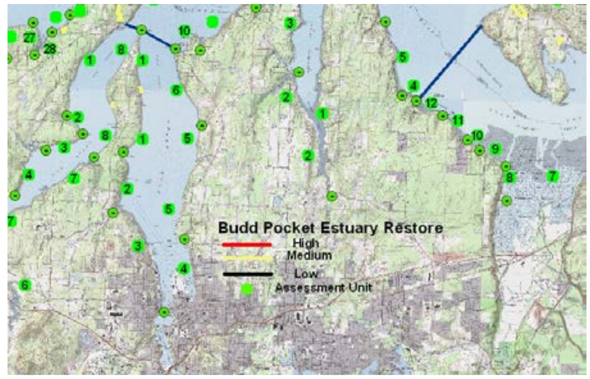

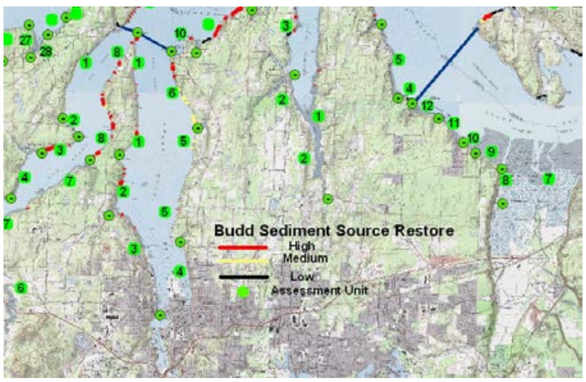

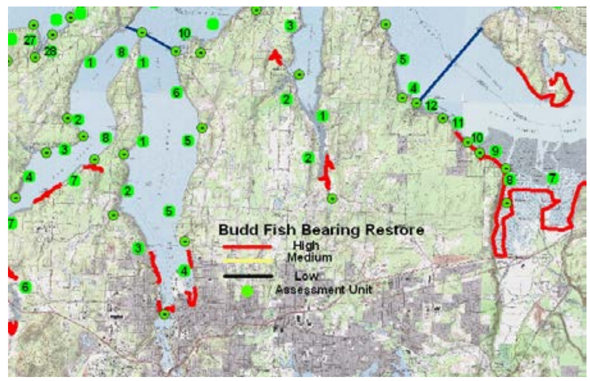

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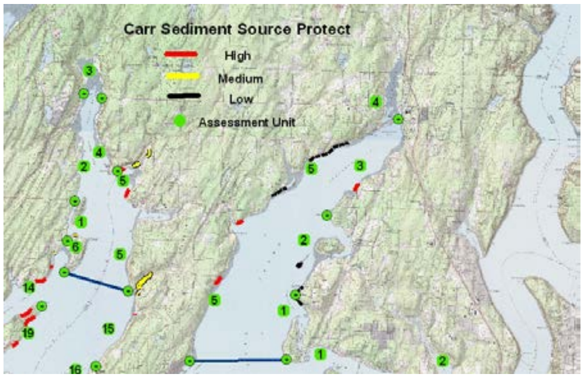

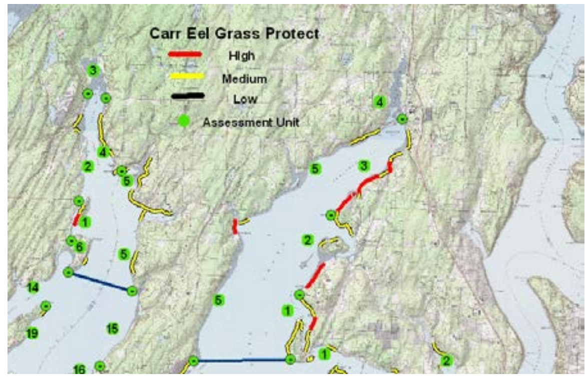

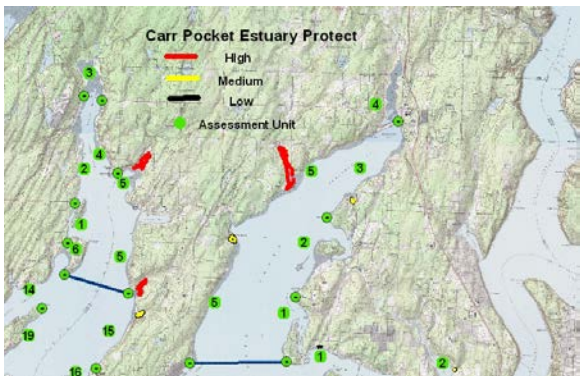

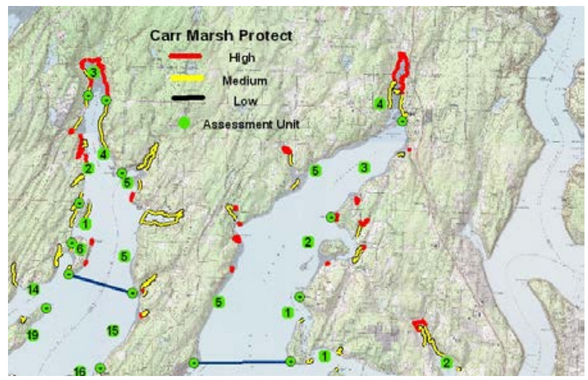

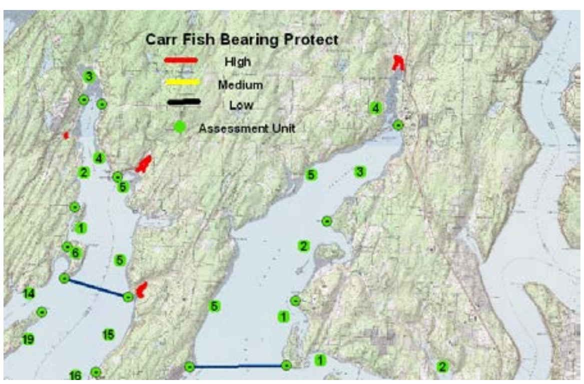

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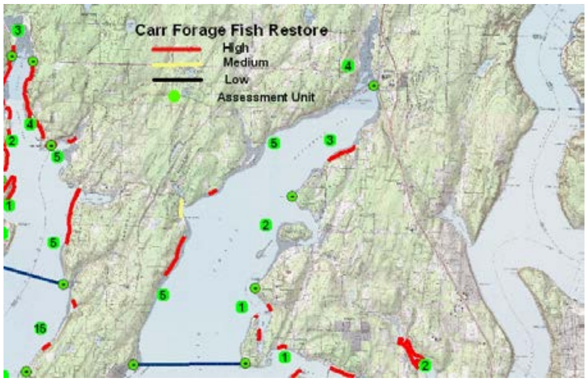

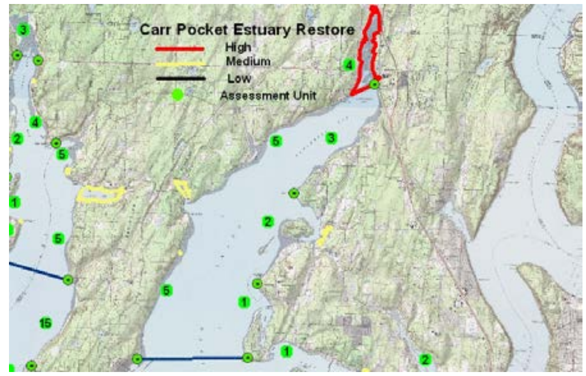

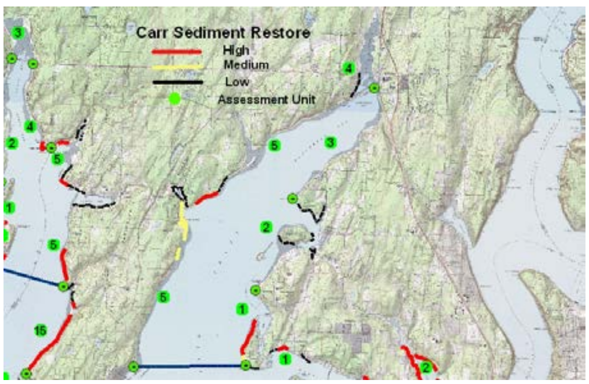

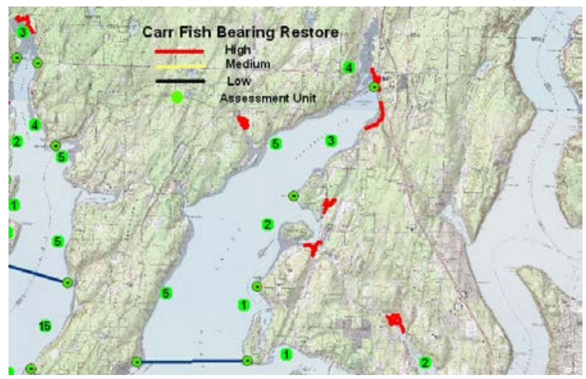

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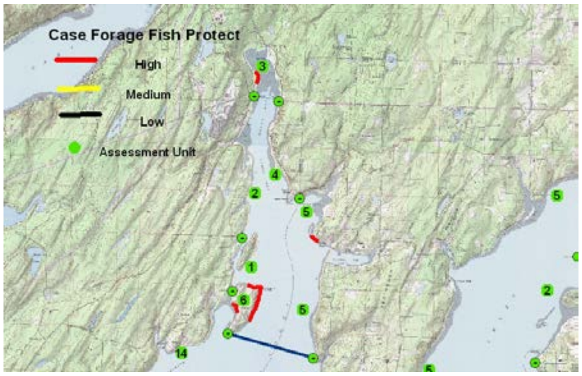
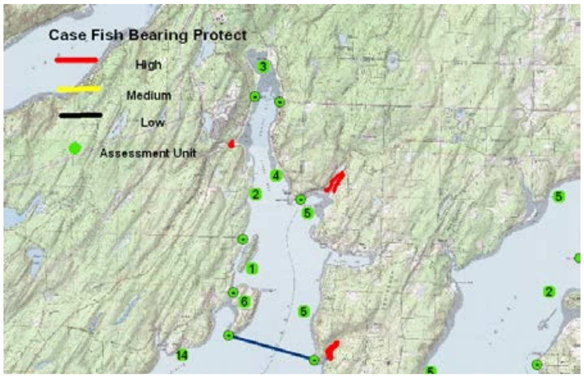
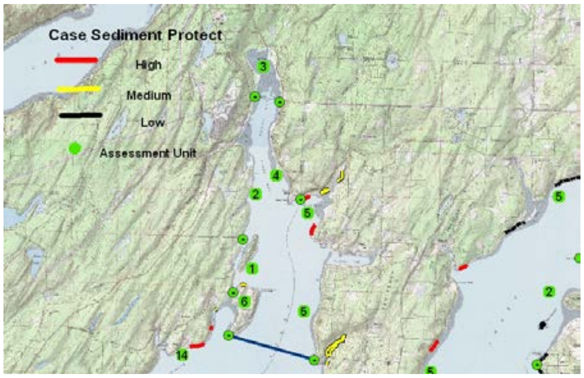
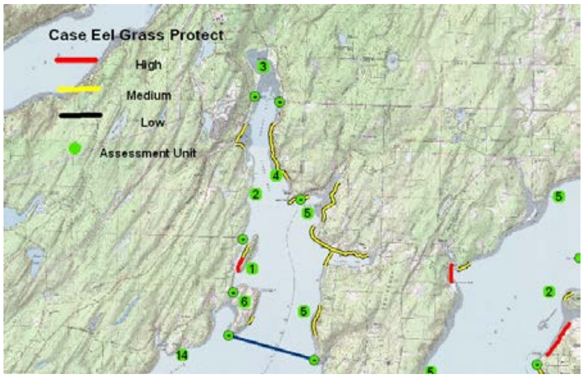
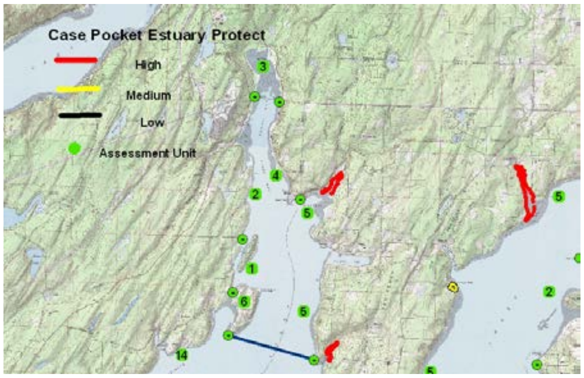
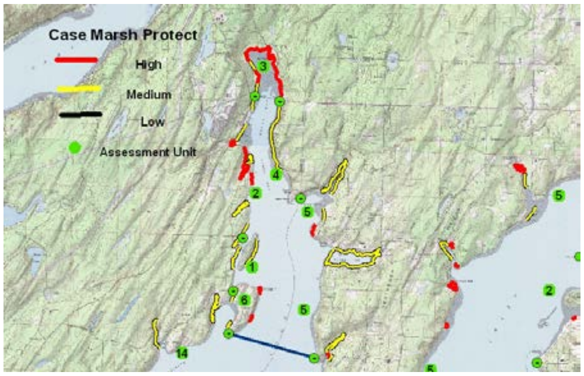




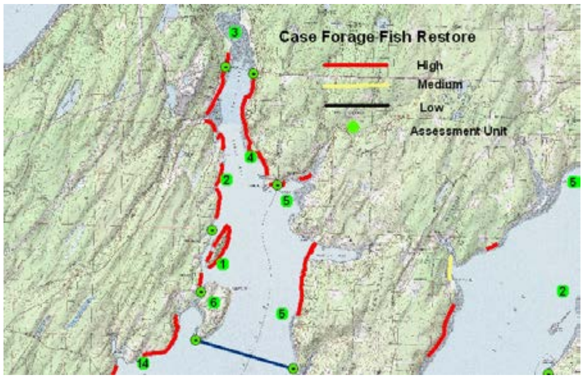


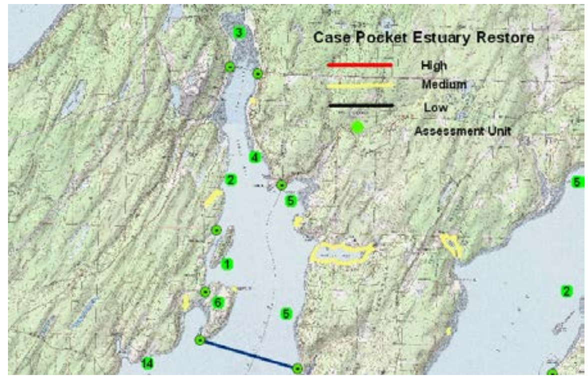


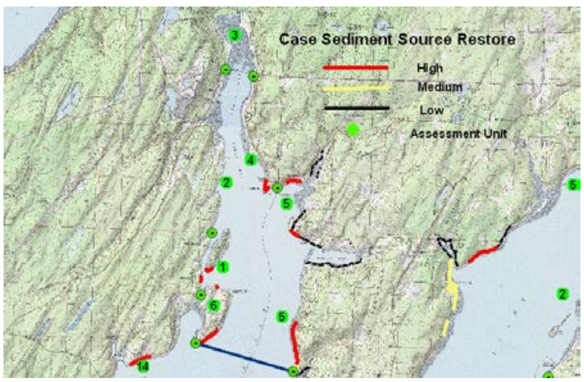


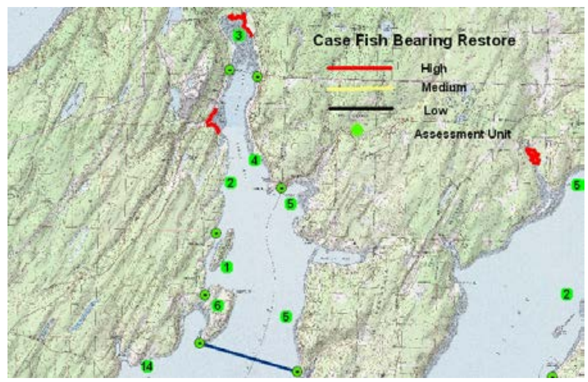


4B. Case Inlet Priority Restoration Areas

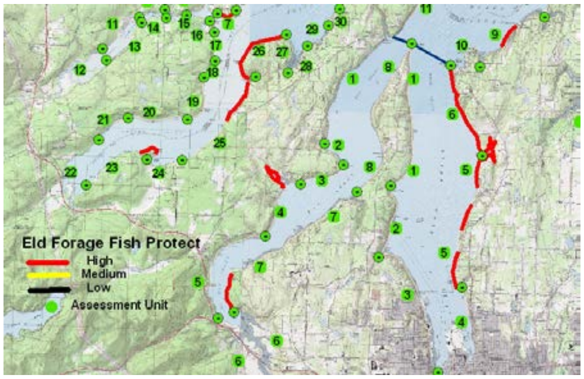


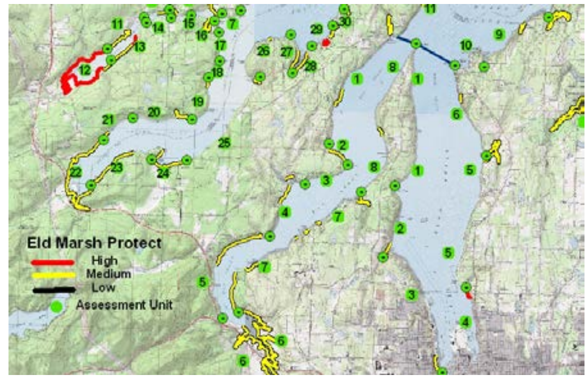


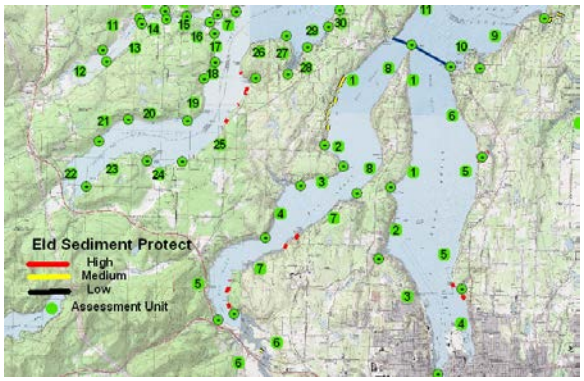




5A. Eld Inlet Priority Protection Areas







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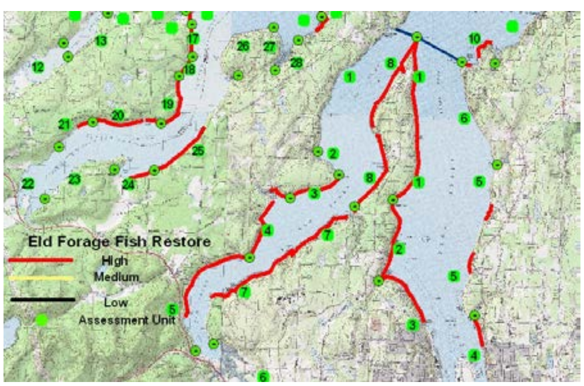
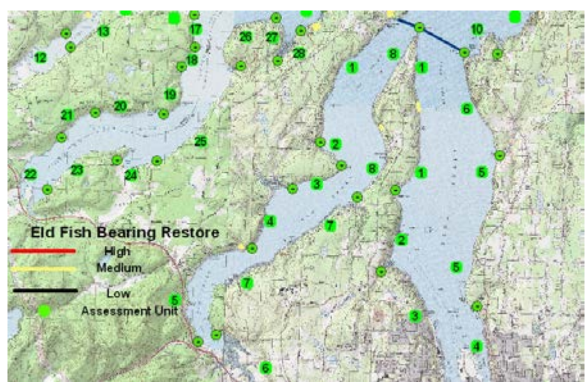
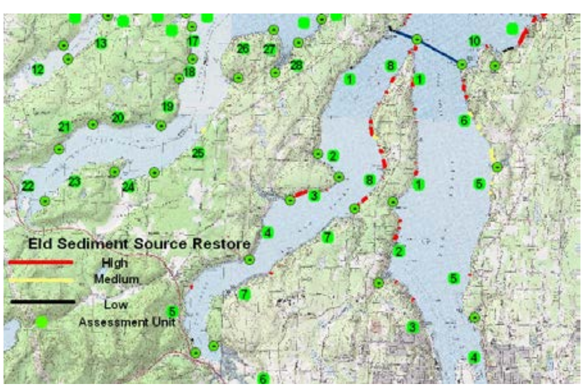
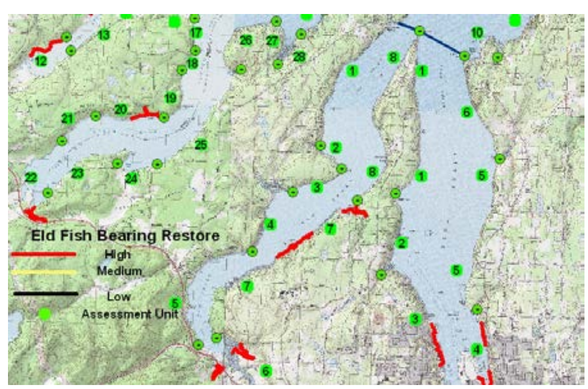
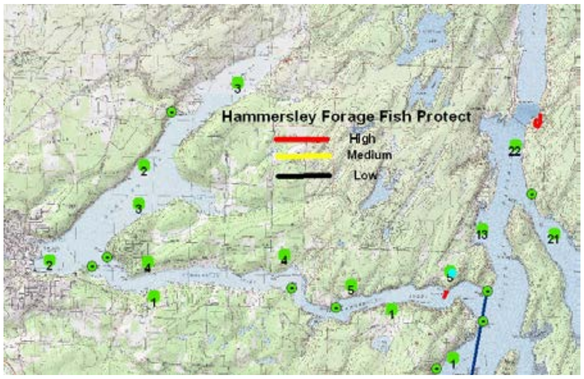


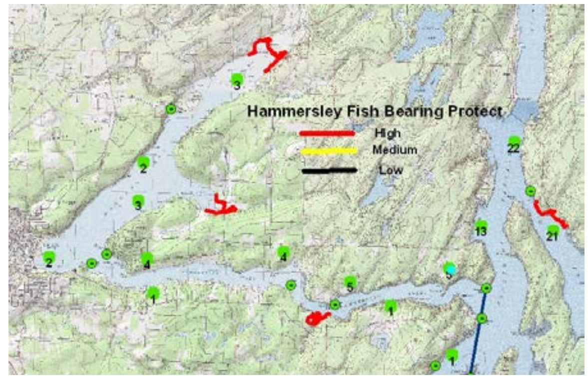


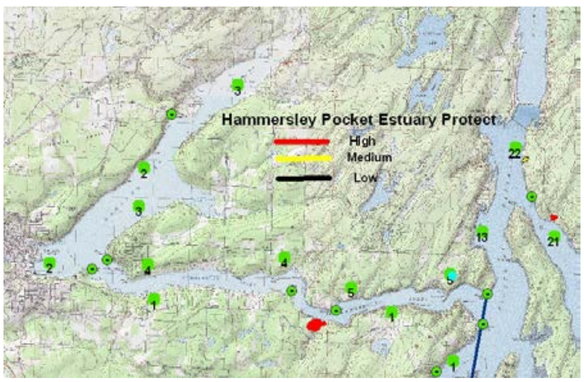


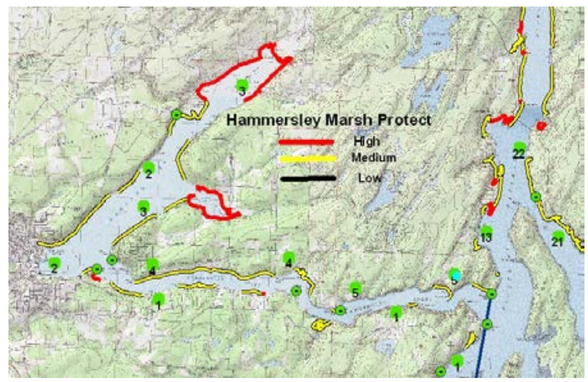


6A. Hammersley Inlet & Oakland Bay Priority Protection Areas









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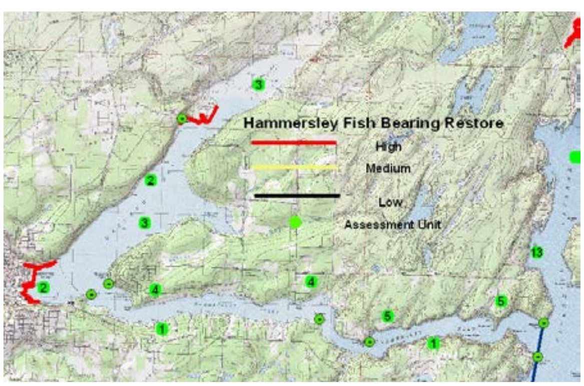
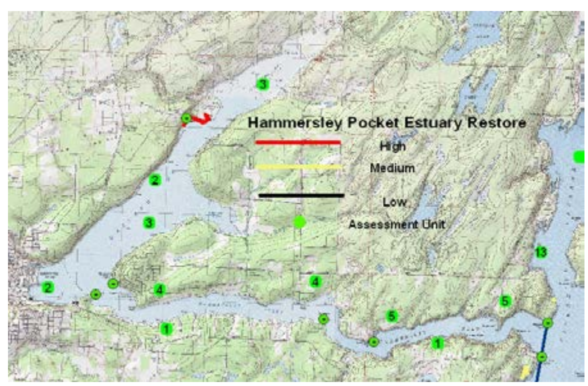
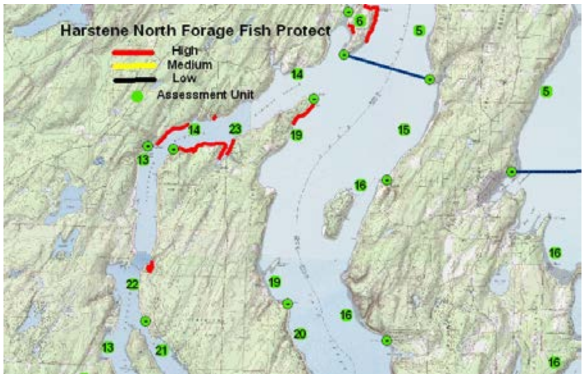
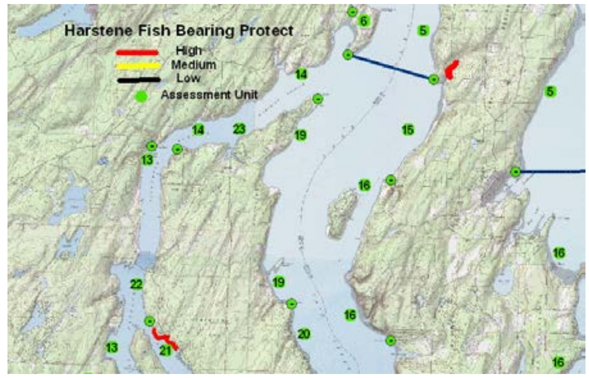
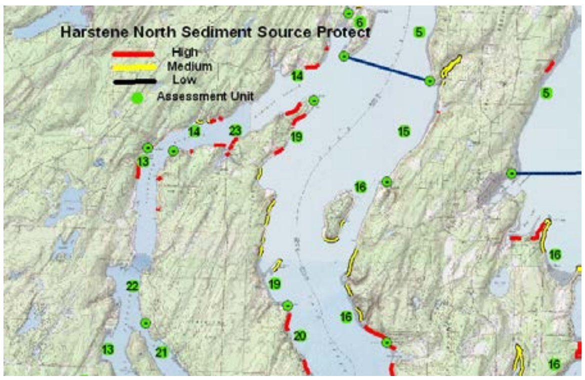


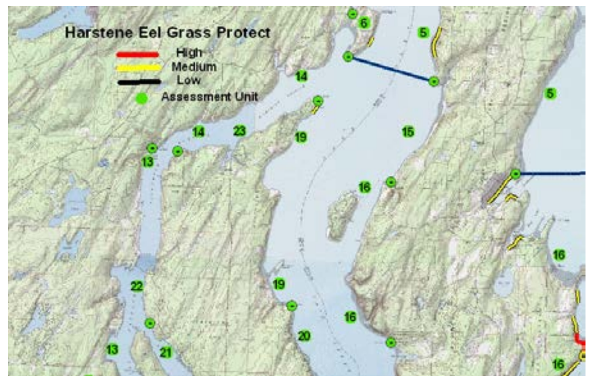


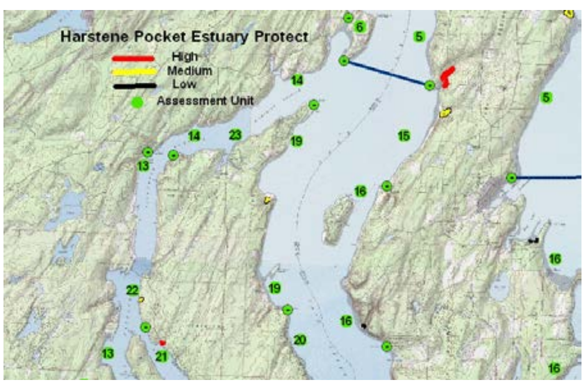
7A. North Harstine Island Group Priority Protection Areas

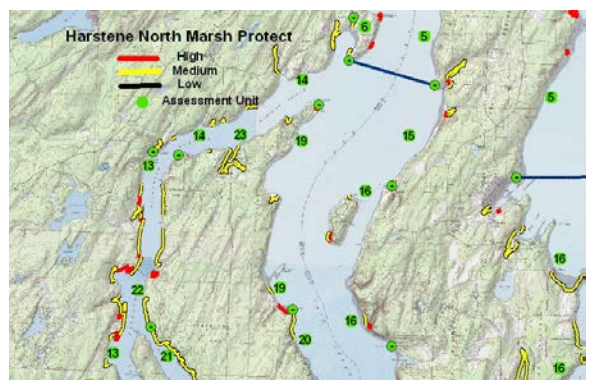












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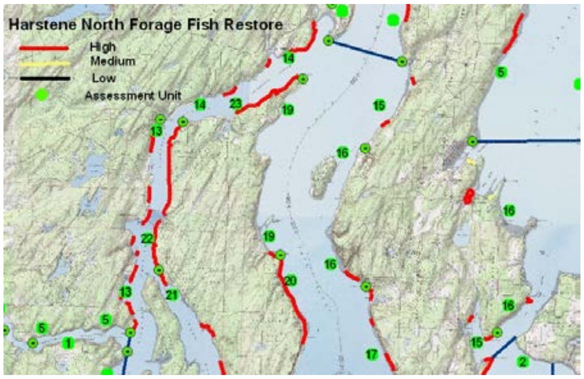

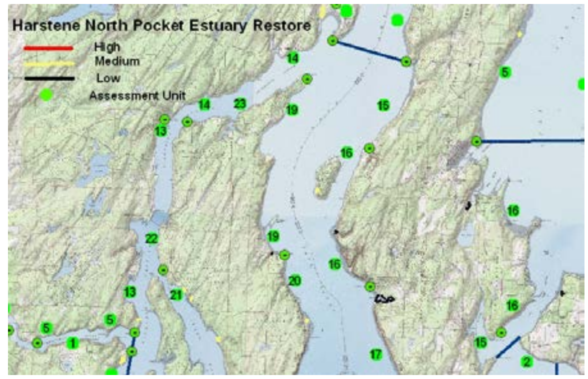

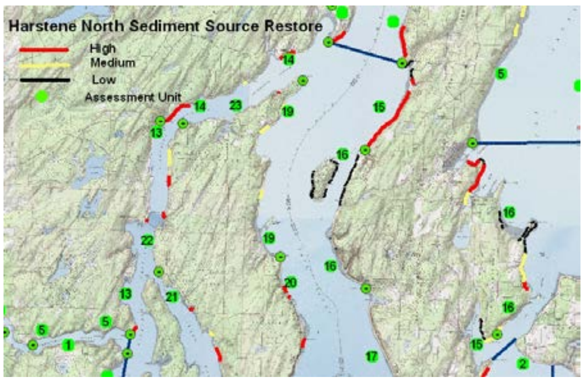

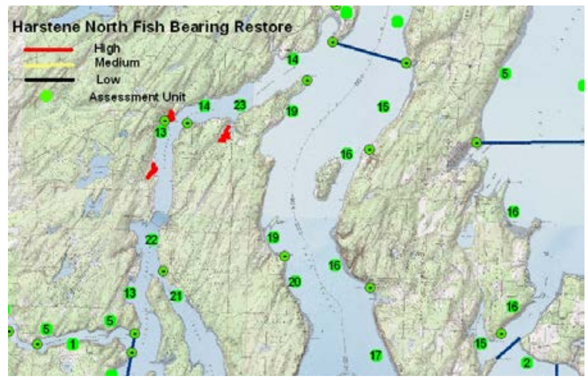

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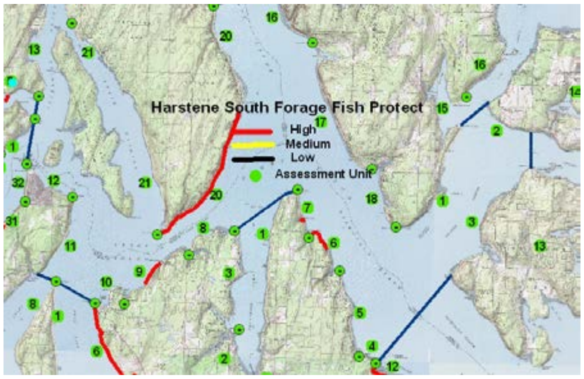
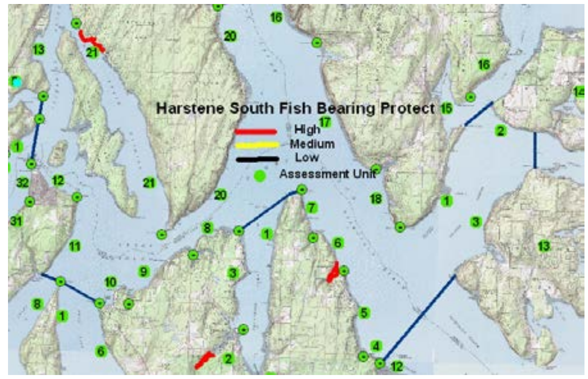
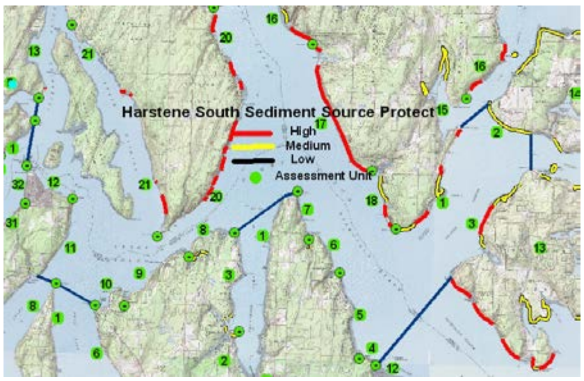
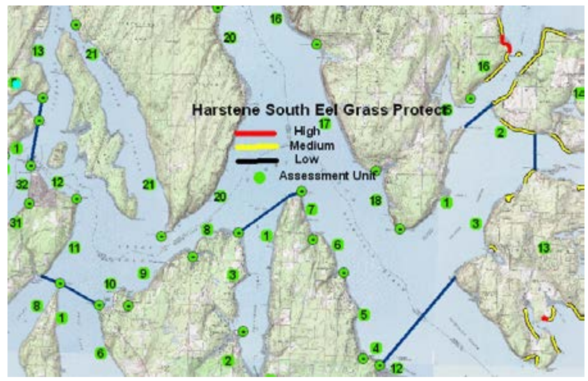
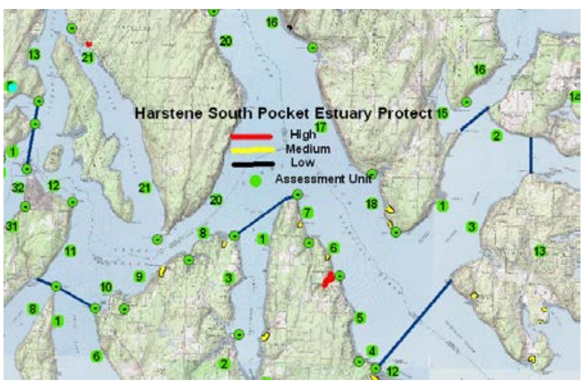
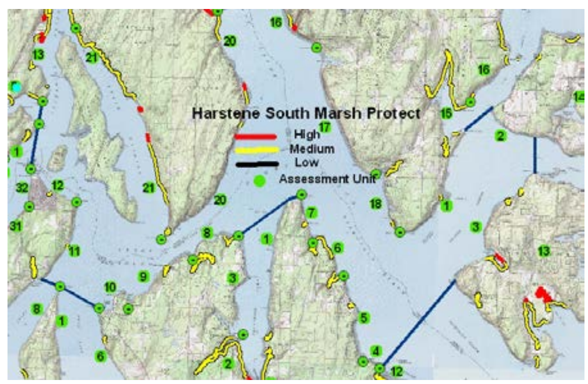




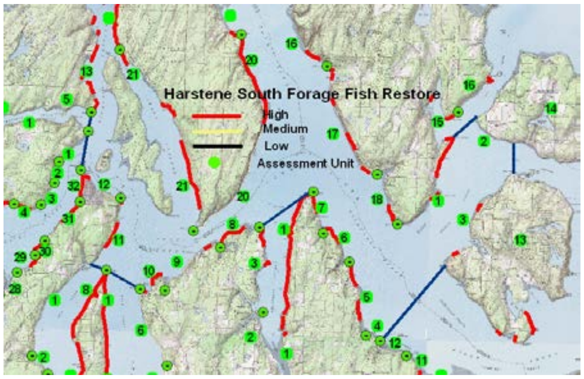


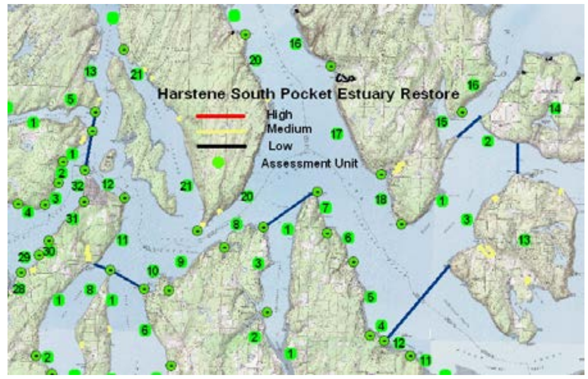


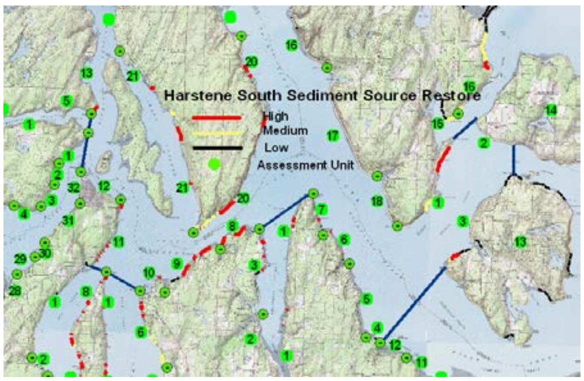




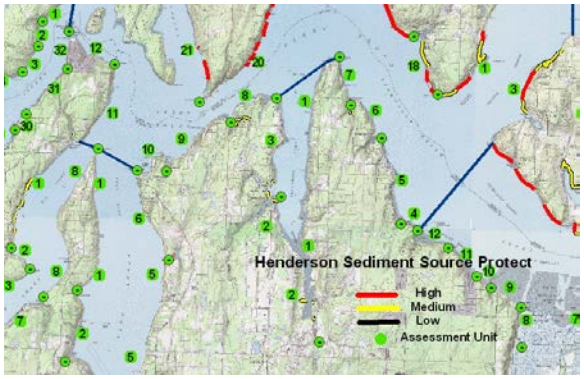
7D. South Harstine Island Group Priority Restoration Areas

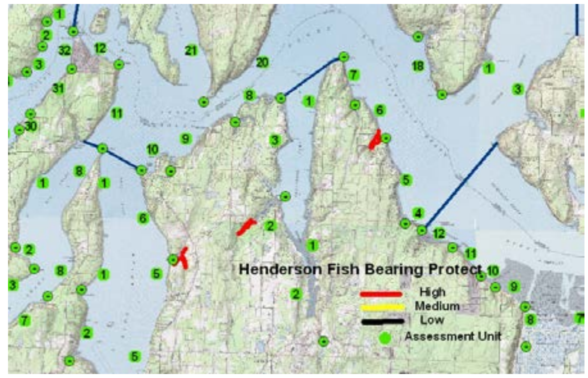


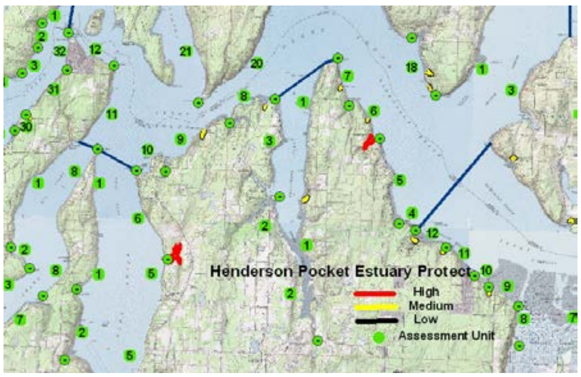


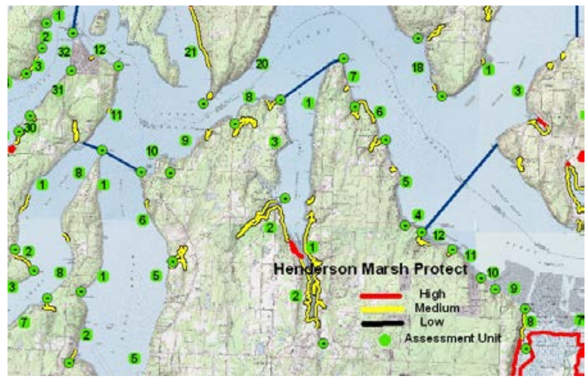


8A. Henderson Inlet Priority Protection Areas









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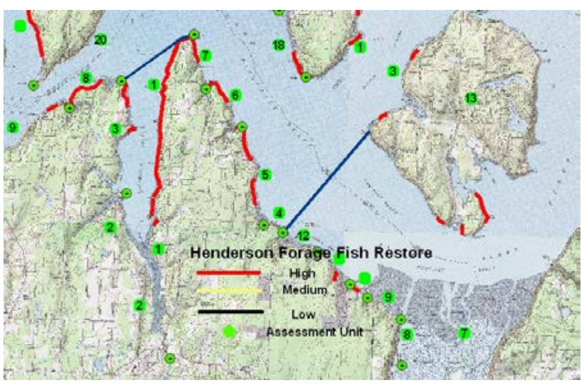
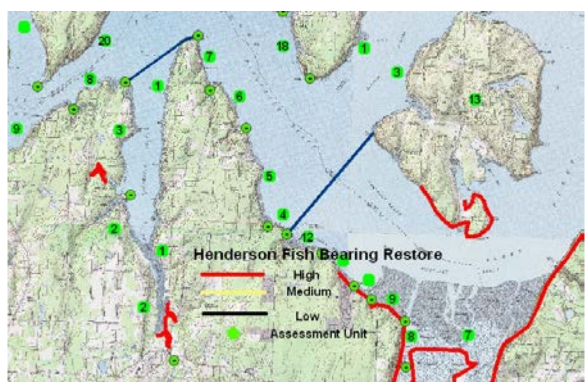
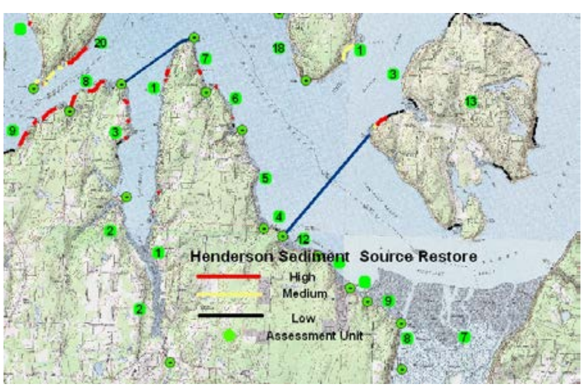
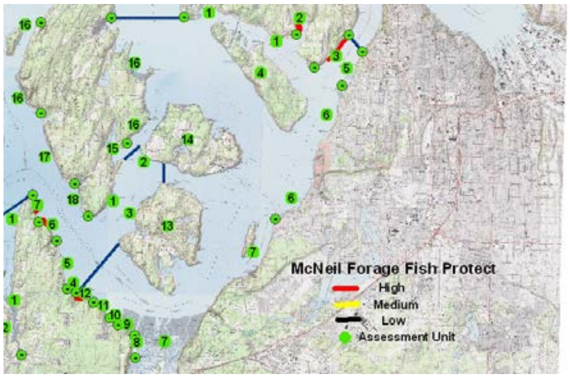
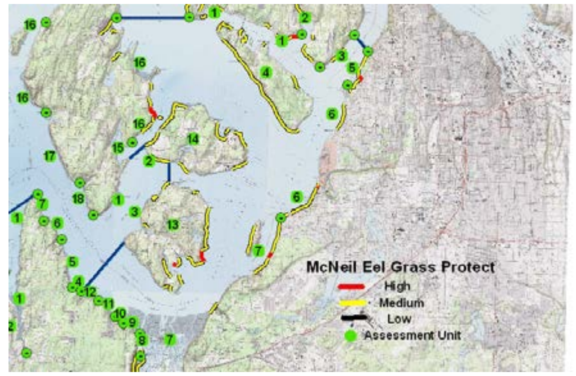


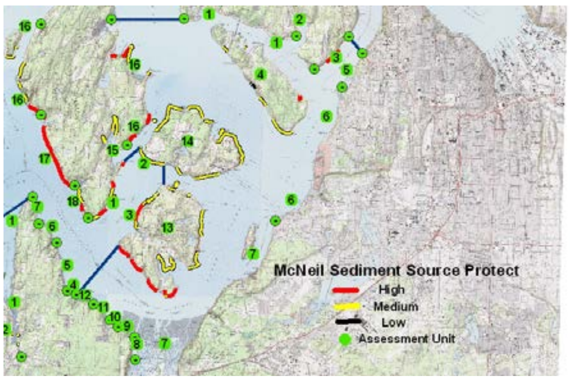


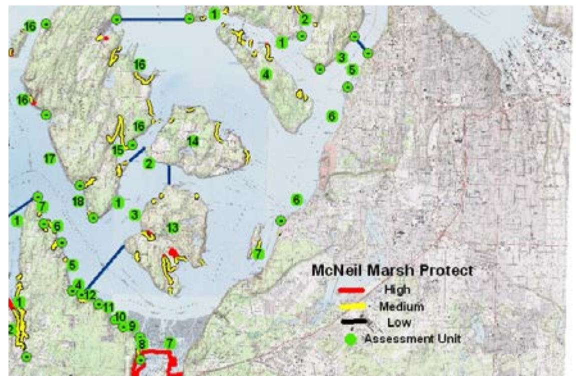


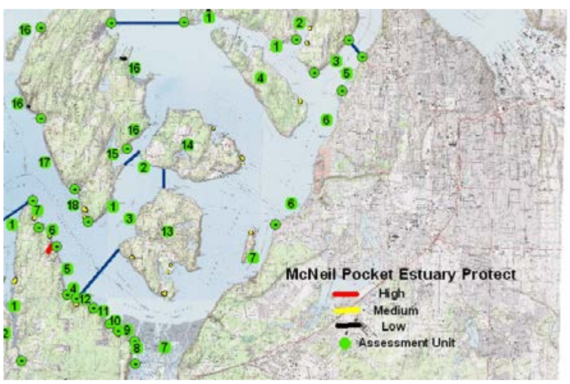
9A. McNeil Island Group Priority Protection Areas



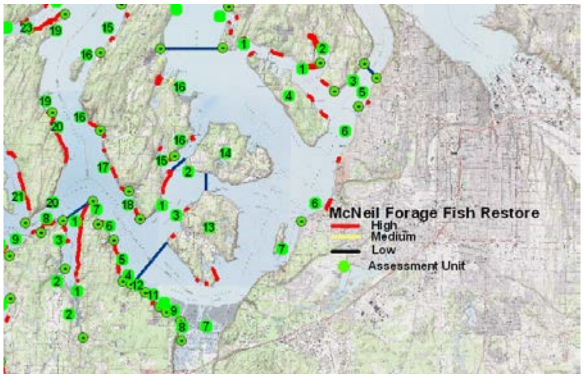


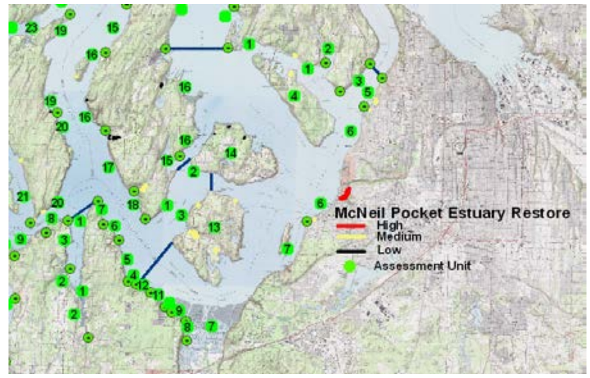


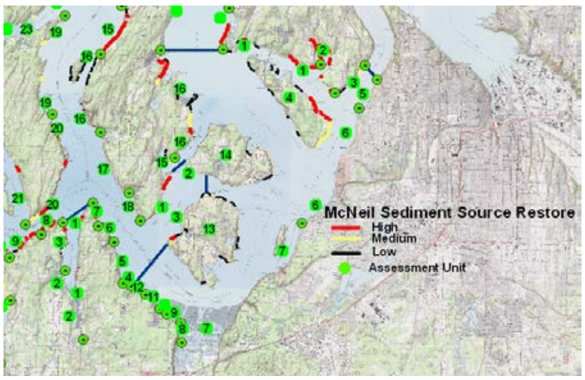


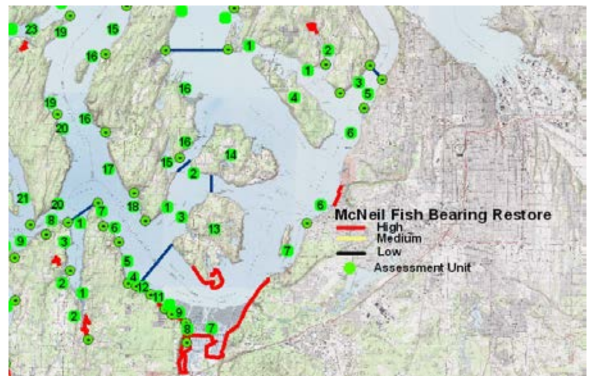


9B. McNeil Island Group Priority Restoration Areas

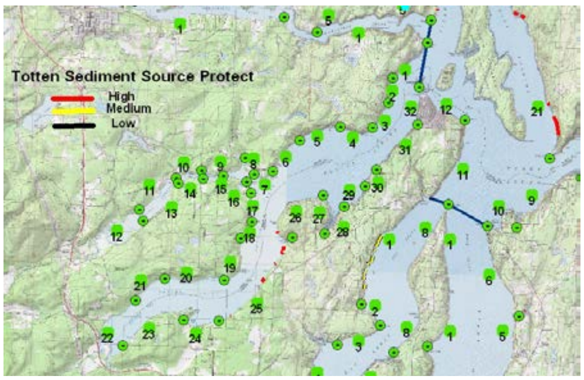


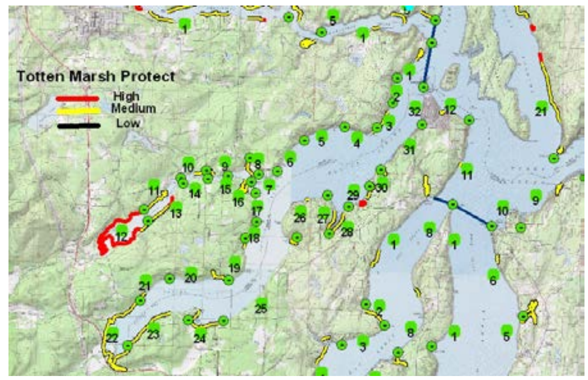


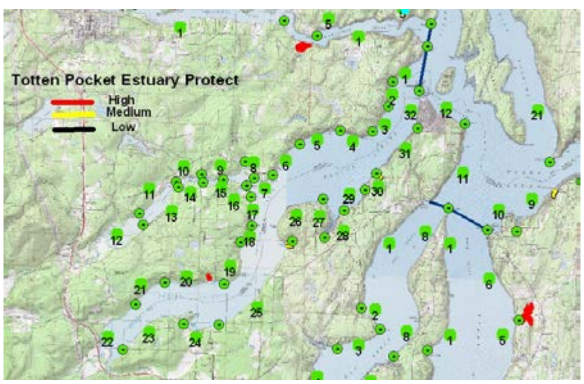




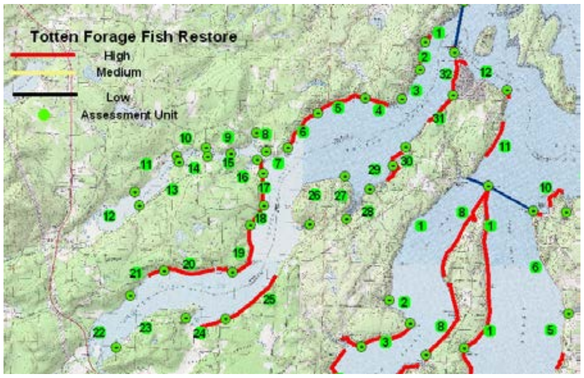
10A. Totten and Skookum Inlets Priority Protection Areas

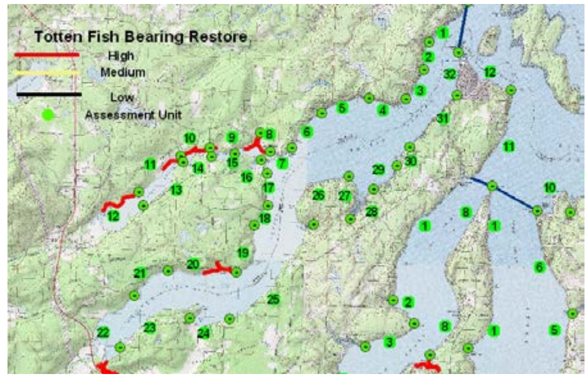


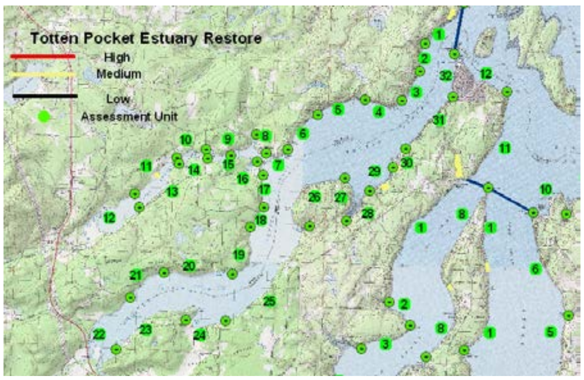




10B. Totten & Skookum Inlets Priority Restoration







- Chapter 6 -

Management Actions for Implementing Protection and Restoration Objectives in Priority Areas

The purpose of management actions is to provide a wide range of regulatory and voluntary options for achieving the protection and restoration objectives within priority areas.

Management Actions can consist of:

- Treaties, plans, policies, and regulations of tribes, counties, cities, state, and federal governments;
- Public and private restoration and conservation projects, including mandatory, voluntary, and incentive-based programs; and
- Educational efforts and other public outreach efforts.

This chapter first focuses on identifying existing management actions available to governments and salmon recovery organizations for implementing protection and recovery actions.[1] It then analyzes the adequacy of these existing tools, identifies gaps, and proposes changes that will ensure better implementation. The third section of this chapter focuses on a five-year management action plan with costs.

1A. Survey of Existing Management Actions for Protection and Recovery

The tables on the following page are a survey of existing management actions available to government and salmon recovery organizations with jurisdictional interest or focus within the South Puget Sound nearshore. Tables 6-1 and 6-2 examine management actions that achieve protection objectives while Tables 6-3 through 6-5 examine those management actions that achieve restoration objectives.

[1] "Governments" in the context of this report includes the State of Washington; the Squaxin Island and Nisqually Tribes; Pierce, Thurston, and Mason Counties; and the municipalities and special use districts within each of the aforementioned counties. "Salmon recovery organizations" include a wide range of nonprofit entities, such as the Regional Fisheries Enhancement Groups, land trusts, etc.

Table 6-1 General management action tools available to state agencies for implementing protection-based actions.

Protection Actions	Shoreline Management Act	Growth Management Act	Puget Sound Action Team Plan	Water Pollution Control Act	Water Rights	Aquatic Use Authority	Forest Practices Act/Forest & Fish	State Environmental Policy Act	Hydraulic Permit Approval	Aquaculture	Harvest	Hatchery
Freshwater Input	1,2,3	2,3	2	1,3	1			3	3			3
Tidal Exchange	1,2	2,3	2	1		4		3	3		3	3
Prey Species Input									3			
Wood Function as Substrate for Organisms	2	2,3	2				4		3			
Nutrient Input	2	2,3	2	1,2							3	3
Large Wood Function in Spit Formation	2	2,3	2				4		3			
Organic Matter Composition	2	2	2									
Food Web	2	2	2									
Sunlight Input	2	2	2			4	4		3			
Erosion/Sediment Transport	1,2	2,3	2	1		1,4	4	1,3	3		4	
Shoreline Forests	1			1			1					

Key: 1 - WDOE 3 - WDFW 2 - PSAT 4- WDNR

<u>Table 6-2</u> General management action tools available to local governments for implementing protection-based actions.

Protection Actions	Shoreline Management Plan	Critical Area Ordinances	State Environment Policy Act	On-site Sewage, sewers	Land use regulations	Floodplain Regulations	Stormwater	Non-point Pollution Ordinance	Drinking & reclaimed water, exempt wells
Freshwater Input	1,2,3,4	1,2,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,4	1,3
Tidal Exchange	1,2,3,4	1,2,3,4	1,2,3,4		3	3	3		
Prey Species Input	1,2,3,4	1,2,3,4	1,2,3,4	1	3	1,3	3	1	
Wood Function as Substrate for Organisms	1,2,3,4	1,2	1,2,3,4		1,3	1,3	3		
Nutrient Input	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	3	3	1,2,3,4	1,2,4	3
Large Wood Function in Spit Formation	1,2,3,4	1,2,3,4	1,2,3,4		3	3	3		
Organic Matter Composition	2	2	1,2,3,4	3	3	1,3			
Food Web	1,2,4	1,2,3,4	1,2,3,4	3	3	3			
Sunlight Input	1,2,3,4	1,2,3,4	1,2,3,4		3	3			
Erosion/Sediment Transport	1,2,3,4	1,2,3,4	1,2,3,4			1,2,3,4	1,2,3,4		

Key 1 - Thurston County 2 - Mason County 3 - City of Olympia 4 – Pierce County

Table 7 – 3 General management action tools available to state agencies for implementing recovery-based actions.

Recovery Actions	Shoreline Management Act	Puget Sound Action Plan	State Water Pollution Control Act	Aquaculture	Aquatic Use Authorizations	Weed Control/Invasives	State Environmental Policy Act	Hydraulic Permit Approval	Forest Practices Act/Fish & Forest	Biosolids	Toxics	Growth Management Act	Enforcement	Harvest - finfish & shellfish	Hatcheries
Shoreline Armoring	1,2,4	2	1		4		1,2,3	3				1,2,3 4,7			
Overwater Structures	1,2,4	2	1		4		1,2,3	3				4,7			
Ramps	1,2,4	2	1		4		1,3	3				4,7			
Stormwater/Wastewater	1,4	2	1		4		1,3			1		2,3,4 7			3
Landfill Below HHW Line	1,2,4		1		4		1,3	3				2,4,7			
Riparian Loss	1,2	2	1				1,3	1,3	3,4			2,3,4 ,7			
Wetland Estuarine Modification	1,2,4	2	1		4	1,4	1,2,3	3				3,7			
Input of Toxic Components	1	2	1			1						7			
Predation	1		1					3				7			3
Boat Traffic	1		1									7			3
Invasive Species	1	2	1		4	4,6						7			3
Shellfish Aquaculture	1,4	2	1	3,4	4,5							4,7		3	3
Net Pen Aquaculture	1,4		1	1,3,4	4							4,7		4	3

Key: 1 - WDOE 2 - PSAT 3 - WDFW 4- WDNR 5 - WDOH 6 - WDA 7 - DCTED

Table 7 – 4 General management action tools available to local governments for implementing recovery-based actions.

Preventative Regulations for Recovery Actions	Shoreline Management Plans	Critical Areas Ordinance	State Environmental Policy Act	On-site sewage disposal, sewers	Land use regulatins, floodplain laws	Stormwater	Non-Point Pollution Ordinance	Drinking water, reclaimed water, exempt wells	Boating Ordinance
Shoreline Armoring	1,2,3,4	1,2,3,4	1,2,3,4		1,2,3,4				
Overwater Structures	1,2,3,4	1,2,4	1,2,3,4		1,3				
Ramps	1,2,3,4	1,2,4	1,2,3,4		1,3				
Stormwater/Wastewater			1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,3	3	
Landfill Below HHW Line	1,2,3,4	1,2,4	1,2,3,4		1,3,4				
Riparian Loss	1,2,3,4	1,2,3,4	1,2,3,4		1,3,4	1,3			
Wetland Estuarine Modification	2,3	1,2,3,4	1,2,3,4		1,3,4				
Input of Toxic Components	2,3	1,2,3,4	1,2,3,4	1,2,3,4	1,3	1,2,3,4	1,3	3	
Predation	2,3	1,2,3,4	1,2,3,4		1,3				
Boat Traffic			1,2,3,4		1,3				1,2,3
Invasive Species	1,2,3,4	1,2,3	1,2,3,4		1,3				
Shellfish Aquaculture	1,2,4	1,2,4	1,2,3,4						
Net Pen Aquaculture	1,2,4	2	1,2,3,4						

Key 1 - Thurston County 2 - Mason County 3 - City of Olympia 4 - Pierce County

Table 7-5 General management action tools available to salmon recovery organizations for implementing recovery-based actions.

Recovery Actions	Salmon Recovery Funding Board (Lead Entities)	Regional Fisheries Enhancement Groups	Tribes	Site-Based Non-Governmental Organizations	Conservation Districts	Other Project Funding Sources	Watershed Councils	Nisqually National Wildlife Refuge	Public Parks & Trails	Non-site based educational groups	Land Trusts
Shoreline Armoring	●		●	●	●	●			●		●
Overwater Structures			●		●	●			●		
Ramps			●		●	●			●		
Stormwater/Wastewater			●	●	●	●	●				
Landfill Below HHW Line			●			●			●		●
Riparian Loss	●	●	●		●	●	●	●	●	●	●
Wetland Estuarine Modification	●	●	●	●	●	●	●	●	●	●	●
Input of Toxic Components			●	●	●	●	●		●		
Predation	●		●								
Boat Traffic			●						●		
Invasive Species	●		●		●	●	●		●		●
Shellfish Aquaculture			●		●	●			●		
Net Pen Aquaculture			●						●		

1B. Further Recovery Management Actions for Protection and Recovery

Despite the gamut of existing management actions available for implementing Chinook and bull trout recovery in South Puget Sound, more effort is necessary to ensure their full delisting. The SPSSRG identified six prioritized strategic directions that aim at intrinsically changing how we think about salmon recovery and the way we utilize existing resources to that end.

<u>Social Change</u>

Salmon recovery depends on a dramatic shift in community attitudes, and social change begins when society accepts a long-term view of the world that abandons the pursuit of short-term gain over long-term benefit. Bringing this change about requires

- Education and marketing efforts that nurture and celebrate wild salmon as an essential part of our community's culture – now and in the future
- Engaging local businesses, social groups, and religious organizations to become first supportive, then actively involved in salmon recovery efforts
- Translating public support into the necessary political will necessary for implementing the hard actions and delivering the level of resources demanded of salmon recovery
- Facilitating human development in a way that places more emphasis on protection through good design – acknowledging that people and salmon can live together successfully
- Teaching people about intact habitat by increasing their access opportunities to these areas

<u>Regional Leadership</u>

Salmon recovery in South Puget Sound will not be possible without cooperative leadership from government – the state, tribes, and local governments – and salmon recovery organizations. Progressive steps in this direction include:

- Forming a regional management body responsible for formulating and coordinating an ongoing regional approach to salmon recovery in South Puget Sound that sets and implements regional priorities and measures their short- and long-term success
- Establishing a permanent South Puget Sound science advisory team responsible for increasing the knowledge base of salmon recovery and making recommendations for further protection and recovery actions

Setting Financial Priorities

Salmon recovery is not possible without the commitment of financial resources to implement protection and recovery actions. Programmatically, state and local governments feel they have the necessary tools to bring new development in conformance with salmon recovery. However, the basic impetus missing behind these plans, policies, and law is the necessary funding to apply them in a thorough and deliberate manner. Personnel for adequate development review and enforcement are two key components to salmon recovery, but current funding resources fall far short of their needed levels given current budgetary constraints for environmental programs. More funding must go to these basic regulatory programs.

Furthermore, dealing with existing development is more problematic. Some of the worst impacts to salmon today emanate from established public and private developments that no longer meet current standards. Many private landowners lack the resources or the willingness to alter their properties to mitigate their impact to salmonids. State, tribal, and local governments have aging infrastructure that impact salmon, but the replacement or mitigation price exceeds local financial resources. Voluntary and publicly funded remedial efforts are the only approaches to fixing these problems. Current funding levels are inadequate and inconsistent to address this problem. Again, more dedicated funding in a steady stream is essential.

The community must also expedite its efforts aimed at acquiring land or development rights for properties adjacent to the nearshore that are important for salmonid habitat.

Support Innovation

Implementing salmon recovery in South Puget Sound demands new, innovative approaches. Governments and salmon recovery organizations must be prepared to take risks – biologically and politically – to facilitate success. Stepping up to the plate in this fashion, however, assumes that government and salmon recovery organizations be prepared to assume the public liability when such efforts fail.

Regulatory Effectiveness

Despite the availability of a wide-range of regulatory management actions available to state and local government, there remains plenty of room to use these tools more effectively on behalf of salmon recovery. Major points in this arena are:

- It is critical for permit review processes to focus on the cumulative impacts of projects. This is especially critical when evaluating a project's affect on natural processes; disruption of sediment transport is an excellent example.

- The review and permitting of development in the nearshore environment needs better coordination. Too many agencies with jurisdiction in the nearshore make it difficult for project proponents and reviewers alike to address salmon recovery mitigation adequately and comprehensively. A "one-agency" permitting or a clearinghouse approach is essential to long-term salmon recovery.

- A comprehensive regulatory approach to salmon recovery depends on strong interjurisdictional planning. Each level of government can no longer work in a vacuum thinking of its own jurisdictional interest for salmon recovery in South Puget Sound. Cooperation and integration of governmental regulatory efforts needs to be seamless to ensure there are no gaps that impact salmon when managing growth.

- Stronger and more effective enforcement is the glue that holds regulatory effectiveness together. This is more than a financial priority – it encompasses social change and regional leadership issues as well. Enforcement also entails the permit follow-through that many governments fail to do because of the lack of time and staff. State, tribal, and local governments need more funding and resources to develop and implement enforcement programs.

Protection through Land Use Planning

Communities need new approaches to managing growth. Through growth management programs, communities are beginning to explore the application of new tools that benefit salmon:

- Encourage open space with incentive programs and eliminate minimum lot size requirements for participating in them.

- Provide financial incentives to developers for low impact development.

- Prevent high-density development along shorelines outside of urban growth areas.

- Establish shoreline breaks in both urban and rural areas to protect habitat.

- Integrate salmon recovery efforts into Shoreline Management Plans and ordinances.

- Create salmon-friendly development standards for application by local governments throughout South Puget Sound.

1C. Five-Year Management Goals

The eventual recovery and maintenance of Chinook and bull trout populations in South Puget Sound is likely to be an effort that will take several generations. Reversing over 100 years of development impacts will be a slow and expensive process indeed. While government and salmon recovery organizations have completed many of the first steps towards salmon recovery, more effort is necessary, even if it is still organizational in nature. The SPSSRG proposes the following Five-Year Management Goals as essential for building the strong foundation necessary for ensuring salmon recovery is successful.

- Cooperative Planning

1. The SPSSRG intends to expand its salmon recovery efforts to include all South Puget Sound salmonids in both the nearshore and freshwater environments. This will allow refinement of current recovery efforts into a comprehensive approach. Estimated cost: $100,000

2. The formation of a Sound Puget Sound Advisory Science Team will continue to direct science-based analysis and recommendations for salmon recovery based on an adaptive management approach. Estimate cost over the five-year period: $250,000

3. Establishing a regional forum for cooperative, interjurisdictional salmon recovery planning. Estimated cost over the five-year period: $500,000

- Regulatory Improvements

1. Integration of South Puget Sound salmon recovery protection and recovery actions for the nearshore into state, tribal, and local government plans, policies, and development regulations. For local governments, this may include incorporating this document into Shoreline Management and Comprehensive Land Use Plans and regulations, adoption by reference for substantive authority under SEPA (WAC 197-11-660), and adopted as a citation for best available science pertaining to fish and wildlife habitat conservation areas. Estimated cost for four jurisdictions: $400,000

2. South Puget Sound state, tribal, and local governments will develop a strategic plan for improving project review and enforcement activities, including an analysis of proposed funding mechanisms. Estimated cost: $100,000

- Acquisition Activities

1. Governments, salmon recovery organizations, and land trusts will develop a strategic plan for acquisition and management of land or development rights for intact or nearly intact nearshore habitat supporting salmonids. Estimated cost: $100,000

2. Governments, salmon recovery organizations, and land trusts may need interim acquisition funding for intact or nearly intact nearshore habitat supporting salmonids under immediate development threat. Estimated cost for five-year period to acquire 50 acres: $3,000,000

- Restoration Activities

  Restoration efforts aimed at repairing disrupted natural processes that create habitat for salmon needs to continue at a funded level corresponding to the capacity of South Puget Sound salmon recovery organization to do the work. The goal is to do the equivalent of two miles of major nearshore reconstruction annually (such as the replacement of shoreline armoring with soft erosion control alternatives) and five miles of minor nearshore reconstruction. Estimated cost for the five-year period: $99,000,000

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South Puget Sound Landscape Summaries

Budd Inlet

Budd Inlet Water Quality Overview

- CWA 1998 Section 303(d) listings: dissolved oxygen, pH, sediment bioassay, and extensive chemical contamination. (Additional toxics listings are proposed for the 2002/2004 list.)
- Statification: Strong and persistent (BUD002), and moderate and infrequent (BUD005) (Newton et al. 2002).
- Dissolved Oxygen: very low, <3.0 mg/l (stations BUD002 & BUD005), (based on Ecology marine monitoring data).
- Ammonium-N: very high (stations BUD002 & BUD005), (based on Newton et al. 2002).
- Nitrite: highest concentration in Puget Sound found in inner Budd Inlet (BUD002), and high concentration also found at station BUD005; high nitrite can be an indicator of eutrophication (Newton et al. 2002).
- Sensitive to eutrophication (Newton et al. 2002).
- Sensitivity to added nutrients: very high (station BUD002), and not high (station BUD005) (based on Newton et al. 2002).
- Fecal Coliform Bacteria: Inner Budd Inlet appeared to have chronically high and persistent fecal coliform bacteria counts (>14 organisms per 100 mL) (Newton et al. 2002).
- Utilizing five indicators of water quality concern (strong stratification, low DO, limiting nutrients, high fecal coliform bacteria concentrations, and high ammonium concentrations) Budd Inlet was within the highest concern category for the state's marine stations during 1998 to 2000 (Newton et al. 2002).
- PCBs: detected in sediment study (Dutch et al. 2003).

Primary Stressors: Nutrients, toxics, dissolved oxygen, stratification

Dofflemyer to Gull Harbor-North End

- Burfoot park
- Low bank, intense residential development south of Boston Harbor area
- Sand beach
- Impacted riparian area
- Some upland agricultural uses
- Feeder bluffs
- Some armoring
- Documented surf smelt spawning area (4)
- Entire Inlet documented as Important Faunal Area (4)

- Documented as Critical Faunal Area along shoreline (4)
- Substrate mixed fine materials (4)
- Historial algal community (4)

Primary Stressors:	Wetland/Estuary Modification, Shoreline Armoring, Riparian Loss
Intact Areas:	Burfoot Park
Reference:	Cindy Wilson. Thurston County. 2004

Gull Harbor to Priest Point (Ellis Cove south end)

- Gull Harbor -New acquisition area for Capital Land Trust
- Gull Harbor provides side channel habitat
- Good riparian habitat
- Priest Point well preserved-owned by City of Olympia
- Shellfish Harvest Prohibited area
- Some upland agricultural uses
- Feeder bluffs
- Documented surf smelt spawning area (4)
- Historial algal community north of breakwater(4)
- Entire Inlet documented as Important Faunal Area (4)
- Documented as Critical Faunal Area along shoreline (4)
- Substrate mixed fine materials (4)
- Some armoring
- North Priest Point substrate sand (4)
- Possible Hazardous Materials site (8)

Primary Stressors:	Shoreline Armoring, Riparian Loss Wetland/Estuary Modification
Intact Areas:	Priest Point Park, Ellis Cove, North End of Gull Harbor
Reference:	Cindy Wilson. Thurston County. 2004

South Budd Inlet

- Cascade pole Hazardous waste clean-up site
- Port property-Industrial use
- Constriction between Budd Inlet and Capital Lake, causes loss of estuarine habitat
- Ship canal dredging
- Fish trap
- Roads and bridge crossings in Budd Inlet
- Shellfish Harvest Prohibited area

- Intensive residential development on eastern shoreline. Low bank, no riparian habitat
- Extensive armoring, highly modified shoreline
- Indian Moxlie creek enters eastern basin of inlet
- Deschutes River enters western basin of inlet
- Historical loss of delta and mudflats during construction of downtown Olympia
- Documented surf smelt spawning area (4)
- Entire Inlet documented as Important Faunal Area (4)
- Documented as Critical Faunal Area along shoreline (4)
- Primarily mudflat substrate, limited estuarine habitat remaining
- Lott discharge
- Stormwater discharge
- Haz-mat sites (8)
- Marinas (1) (8)

Primary Stressors: Wetland/Estuary Modification, Shoreline Armoring, Riparian Loss, Toxic Materials, Stormwater and Waste Water, Boat Traffic, Overwater Structures, Ramps, Landfill

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Deschutes River-fish trap to Butler Cove

- Potential Haz-Mat sites (8)
- Shellfish Harvest Prohibited area
- Industrial uses-upland and water based
- Tightlined streams with loss of nearshore habitat
- Fill in estuarine areas
- Steep slopes-erosion impacts
- Unstable slopes
- Minimal riparian habitat
- Marina
- Documented surf smelt spawning area (4)

Primary stressors: Toxic Materials, Stormwater and Waste Water, Riparian Loss Shoreline Armoring, Boat Traffic, Overwater Structures, Wetland/Estuary Modification, Toxic Materials, Landfill

Intact areas:

Reference: Cindy Wilson. Thurston County. 2004

Butler Cove to Big Tykle Cove

- Shellfish Harvest Prohibited area
- Upland land uses residential and golf course
- Some loss of riparian habitat with single family development
- Some docks and launch areas
- Some unstable slopes (4)
- Docks and armoring
- Documented surf smelt spawning area (4)

Primary stressors: Shoreline Armoring, Riparian Loss, Boat Traffic, Overwater Structures, Stormwater and Waste Water

Intact areas:

Reference: Cindy Wilson. Thurston County. 2004

Big Tykle Cove to Cooper Point

- Shellfish Harvest Prohibited area
- Docks and armoring
- Documented surf smelt spawning area (4)
- Signifcant armoring and docks

Primary stressors: Shoreline Armoring, Riparian Loss, Boat Traffic, Overwater Structures, Stormwater and Waste Water

Intact areas:

Reference: Cindy Wilson. Thurston County. 2004

Carr Inlet

Carr Inlet Water Quality Overview

- CWA 1998 Section 303(d) listings: dissolved oxygen and fecal coliform. (Additional listings proposed for the 2002/2004 303(d) list include pH, and for the waters of concern list include total PCBs in tissue, and six toxic sediment contaminants.)
- Stratification: rated moderate and infrequent (station CRR001), (Newton et al. 2002).
- Dissolved Oxygen: low, <5.0 mg/l (station CRR001); good. >5.0 mg/l (station BML001), (based on Ecology marine monitoring data).
- Ammonium-N: not high (station CRR001), (based on Newton et al. 2002).
- Nitrite: high ~~concentration~~ (station CRR001); high nitrite can be an indicator of eutrophication (Newton et al. 2002).
- Sensitive to eutrophication (Newton et al. 2002).
- Sensitivity to added nutrients: very high (station CRR001), (based on Newton et al. 2002).
- PCBs: detected in sediment study (Dutch et al. 2003).

Primary Stressors: Nutrients, toxics. dissolved oxygen

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Green Point and Horsehead Bay

- Active feeder bluffs from Green Point to mouth of Horsehead Bay
- Documented forage fish spawning areas in Horsehead Bay.
- Most of the upper shoreline a mix of sand and gravel that may be suitable for forage fish spawning.
- Most shorelines in this area have been substantially impacted by hardened shoreline, multiple docks, and lack of riparian vegetation.
- Little or no eelgrass from Green Point to the mouth of Horsehead Bay. Extensive eelgrass beds at the mouth of Horsehead Bay, but little eelgrass within the bay.

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Horsehead Bay to Raft Island, including Cutts Island

- Most of the upper shoreline is a mix of sand and gravel that may be suitable for forage fish spawning.
- Extensive eelgrass beds, especially north of Horsehead Bay to Raft Island, and around Allen Point.
- Most shorelines in this area (except Cutts Island) have been substantially impacted by hardened shoreline, multiple docks, and lack of riparian vegetation.
- Multiple dilapidated structures and bulkheads have been identified that are non-functioning or provide little value in protecting structures.
- Cutts Island has extensive eelgrass beds, active feeder bluffs, and overhanging trees that provide LWD.

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Allen Point to Burley Lagoon

- Most of the upper shoreline is a mix of sand and gravel that may be suitable for forage fish spawning.
- Documented surf smelt spawning in some areas
- Extensive eelgrass from Allen Point to Burley Lagoon
- Extensive shoreline hardening throughout area
- Many areas with good riparian condition

Primary Stressors: Shoreline Armoring

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Burley Lagoon

- Northern part of Burley Lagoon has undisturbed shoreline habitat with a wooded riparian zone, extensive marsh, and a tidal channel.
- Southern part of the lagoon is impacted by extensive shoreline armoring.
- The east shoreline at the entrance to Burley Lagoon has few positive habitat attributes (riparian buffer, fine-grained substrate, eelgrass, etc.) and is impacted by beach armoring and overwater structures.

- Water quality issues in Burley Lagoon

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Purdy Spit to entrance of Van Geldern Cove

- Area includes a wide variety of shoreline habitats, including open shoreline, inlets, spits, and lagoons
- Extensive shoreline armoring of Purdy Spit, but also extensive eelgrass along the length of the Purdy Spit
- Extensive eelgrass along entire open shoreline from Purdy Spit to entrance of Van Geldern Cove
- Documented forage fish spawning in some areas. Most of the open shoreline substrate appears suitable for forage fish spawning
- Some areas have extensive shoreline armoring and modification, including clearing of native vegetation
- Those areas with active feeder bluffs that are not suitable for shoreline development may retain more natural habitat features, including intact riparian conditions and LWD input.
- Minter Bay has relatively intact riparian vegetation and little shoreline armoring
- Glen Cove contains active feeder bluffs, extensive shoreline armoring, and areas of moderately good riparian condition

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Case Inlet

Case Inlet Water Quality Overview

- CWA 1998 Section 303(d) listings: pH, fecal coliform. (Additional listings proposed for the 2002/2004 303(d) list include dissolved oxygen and bis2-ethylhexyl phthalate, and for the waters of concern list include three toxic sediment contaminants.)
- Stratification: rated moderate and infrequent (station CSE002; Newton et al. 2002).
- Dissolved Oxygen: low, <5.0 mg/l (station CSE002), (based on Ecology marine monitoring data).
- Ammonium-N: high (station CSE002), (based on Newton et al. 2002).
- Nitrite: high (station CSE001 & CSE002); high nitrite can be an indicator of eutrophication (Newton et al. 2002).
- Eutrophication: sensitive (Newton et al. 2002).
- Sensitivity to added nutrients: very high (station CSE002), (based on Newton et al. 2002).

Primary Stressors: Nutrients, dissolved oxygen, toxics, pH

North Spit of Dutcher Cove to Mason County Line

- The unit primarily consists of Vaughn Bay and Rocky Bay. (2)
- Documented forage fish spawning near the entrances to both bays as well as within Rocky Bay. (5)
- Small active feeder bluffs are located within Rocky Bay. (2)
- The shoreline has been substantially impacted by shoreline hardening, multiple over water structures and a lack of riparian vegetation. (1, 2)
- Eelgrass is present between Dutcher Cove and Vaughn Bay, on the north side of Vaughn and Rocky bays and just offshore of both bays. (2)
- The heads of both bays have a higher habitat quality rating than the mouths and center. (2)
- The waters between Stretch Island and Key Peninsula are listed as impaired due to toxics. (7)
- Rocky Bay is listed as an impaired water body due to fecal coliform. (7)

Primary Stressors: Shoreline Armoring, Riparian Loss.

Intact Areas: Head of Rocky Bay.

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

County Line to Power Line Crossing

- Documented forage fish spawning along the entire unit. (5)
- The entire unit has a moderate amount of feeder bluffs. (3)
- Most shorelines, especially on the south end, have been impacted by shoreline hardening including the removal of much of the riparian vegetation. (1, 3)
- Extensive eelgrass beds are found offshore of Victor. (3)
- Shellfish aquaculture occurs throughout the unit. (3)
- The southern portion of the unit has been rated a priority restoration area. (3)
- The waters off of Rocky Point are listed as an impaired water body due to fecal coliform. (7)

Primary Stressors:	Shoreline Armoring, Riparian Loss. Stormwater & Wastewater.
Intact Areas:	Eelgrass beds off Victor.
Reference:	Greater Mason County Nearshore Habitat Assessment draft, 2004

Eastern Power Line Crossing to Western Power Line Crossing.

- This unit consists of the relatively intact mudflats and salt water marshes that make up the head of Case Inlet. (3)
- The riparian vegetation is largely intact. (3)
- Fill has been placed near the mouth of Coulter Creek partially chanalizing the creek. (3)
- Most of the unit has been rated as a priority conservation site. (3)
- The head and western side of this unit are listed as an impaired water body due to fecal coliform. (7)

Primary Stressors:	Landfill Below High Water Line, Stormwater & Wastewater.
Intact Areas:	The entire northwest portion of the unit.
Reference:	Greater Mason County Nearshore Habitat Assessment. Draft 2004

Western Power Line Crossing to Fair Harbor

- Documented forage fish spawning on all shorelines except inside of the lagoons. (5)
- Extensive shoreline armoring exists from Allyn to Sherwood Creek and from Fair Harbor to the sand spit. (3)

- Eelgrass beds are found off the mouth of Sherwood Creek. (3)
- Priority conservation areas include a creek mouth and sand spit providing high quality habitat. (3)
- Areas listed for priority restoration include the armored shoreline north of Sherwood Creek, the thin riparian zone south of Sherwood Creek and the estuary to the unnamed creek south of Sherwood Creek where a road has bisected the salt marsh. (3)

Primary Stressors: Shoreline Armoring, Riparian Loss, Wetland/Estuary Modification

Intact Areas: Sherwood Creek estuary, sand spit south of Sherwood Creek

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

Fair Harbor to Southern Tip of Stretch Island, Including Reach Island

- Documented forage fish spawning on all of Reach Island, the northeast side of Stretch Island and the shoreline between the two islands. (5)
- Active feeder bluffs are located on most of Stretch Island. (3)
- Almost all of the shoreline, except for a portion of eastern Stretch Island, has been substantially impacted by shoreline hardening. (1, 3)
- Eelgrass beds are present between Reach Island and the mainland and along the western shore of Stretch Island. (3)
- Areas identified for restoration include the shoreline north of the bridge to Stretch Island and the southwest shore of Stretch Island. (3)

Primary Stressors: Shoreline Armoring, Riparian Loss, Over Water Structures, Stormwater & Wastewater.

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

Eld Inlet

Eld Inlet Water Quality Overview

- CWA 1998 Section 303(d) listings: none. *(Additional listings proposed for the 2002/2004 waters of concern list include dissolved oxygen and pH.)*
- Stratification: rated moderate and infrequent (stations ELD001, ELD002), (Newton et al. 2002).
- Dissolved Oxygen: low, <5.0 mg/l (ELD001), good, >5.0 mg/l (ELD 002), (based on Ecology marine monitoring data).
- Ammonium-N: high (station ELD002), not high (station ELD001), (based on Newton et al. 2002).
- Sensitivity to added nutrients: not high (stations ELD001 & ELD002), (based on Newton et al. 2002).
- PCBs: detected in sediment study (Dutch et al. 2003).

Primary Stressors: Nutrients, dissolved oxygen

Cooper Point to Green Cove (North end)

- Shellfish Harvest Permitted area (8)
- 90% armoring (1) (8)
- Frequent dock and floats
- Upland residential and removal of riparian habitat (1) (8)
- Green Cove subject of Basin Plan
- Lots of floats and debris on beach
- Geoduck tubes and shellfish culture areas
- Unstable bluff areas
- Gravel/cobble substrate
- Water system on beach
- Documented surf smelt spawning area (4)
- Critcal species: Surf smelt (4)
- Important species Western Grebe
- Drift Cell northerly

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Green Cove to North End of Mud Bay

- With the exception of the Evergreen State College (TESC) property, nearly all of shoreline is armored and the riparian area removed.
- Shellfish Harvest Permitted area (8)
- Docks and armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Green Cove subject of Basin Plan
- Extensive presence of sand dollars on eastern shoreline
- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags,stakes, mesh and boxes on beach.
- Documented surf smelt spawning area (4)
- Critcal species: Pacific oyster and Surf smelt (4)
- Varying bluff areas, high and low bank
- Substrate gravel/cobble moving to silts as you move south

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture

Intact Areas: Most of The Evergreen State College property

Reference: Cindy Wilson. Thurston County. 2004

Mud Bay-South end of Eld Inlet

- Shellfish Harvest Permitted area (8)
- Docks and less armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags,stakes, mesh and boxes on beach.
- Estuarine wetlands-Category 1
- Drift cell NAD
- Public road and Highway 101 crossings of estuary and wetlands
- Historic agriculture use of estuary area
- Substrate silts and mud
- Primarily low bank

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture, Overwater Structures

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

North of Mud Bay to Cove/Point (unnamed)

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags, stakes, mesh and boxes on beach.
- Drift Cell to North
- Tightlining or blocking of almost every tributary stream to Eld Inlet
- Critical Species: Surf Smelt and Pacific Oyster

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

North side of Unnamed Cove to North side of Youngs Cove

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring outside of Park property (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags, stakes, mesh and boxes on beach.
- Drift Cell divergent zone
- Substrate cobble to large rock
- Critical Species: Surf Smelt

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas: Youngs Cove Internal

Reference: Cindy Wilson. Thurston County. 2004

Youngs Cove to Flapjack Point

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)

- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags, stakes, mesh and boxes on beach.
- Drift Cell to north
- Substrate cobble to large rock
- Critical Species: Surf Smelt

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Flapjack Point to Frye Cove

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Extensive shellfish culture operations. Including Geoduck, oysters, clams in bags,stakes, mesh and boxes on beach.
- Drift Cell to North
- Substrate cobble to large rock

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas: Frye Cove County Park

Reference: Cindy Wilson. Thurston County. 2004

Frye Cove to Sanderson Harbor

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Frequent overwater stairways and homes at edge of shoreline.
- Substrate cobble to large rock
- Critical Species: Surf Smelt

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas: Frye Cove County Park, Frye Cove internal

Reference: Cindy Wilson. Thurston County. 2004

Hammersley Inlet and Oakland Bay

Hammersley Inlet/Oakland Bay Water Quality Overview

- CWA 1998 Section 303(d) listings: fecal coliform. (Listings proposed for the 2002/2004 waters of concern list include dissolved oxygen and pH.)
- Statification: strong and intermittent (station OAK004; Newton et al. 2002).
- Dissolved Oxygen: good, >5.0 mg/l (station OAK004), (based on Ecology marine monitoring data).
- Ammonium-N: high (station OAK004), (based on Newton et al. 2002).
- Fecal Coliform Bacteria: two times, from 1998 to 2000, Oakland Bay had extremely high (>100 organisms per 100 mL) fecal coliform bacteria counts (Newton et al. 2002).
- Sensitivity to added nutrients: very high (station OAK004), (based on Newton et al. 2002).
- PCBs: detected in sediment study (Dutch et al. 2003).

Primary Stressors: Nutrients, dissolved oxygen, stratification

Hungerford Point to Libby Point

- Documented forage fish spawning at Cape Horn. (5)
- Active feeder bluffs are located along the entire unit. (4)
- The entire shoreline provides valuable high quality habitat to migrating juvenile salmon. (6)
- Rated with high riparian overhang. (6)
- There has been little modification of the shoreline. (1, 6)
- Cape Horn, the creek mouths and the active feeder bluffs have been rated as priority conservation sites due to exceptional habitat. (6)

Primary Stressors: Riparian Loss

Intact Areas: West of Cape Horn to Libby Point

Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Libby Point to Munson Point

- Less than 50% of shore has riparian overhang. (6)
- Almost the entire shoreline is residential resulting in extensive shoreline armoring along the entire length of the unit. (6, 4)
- Church Point provides a small high quality habitat refuge between relatively degraded shorelines. (6)

- Juvenile salmon out-migrating from the high quality areas on either end of the unit must use this degraded habitat as a migration corridor. (6)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas: Church Point

Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Munson Point to Bayshore

- Complex unit with long sandy beaches, estuaries, coves and salt marshes that provide quality habitat. (6, 4)
- Riparian overhang rated as high. (6)
- Some shoreline modification has occurred south of Chapman Cove; the rest of the shorelines are primarily unmodified. (6)
- Intensive shellfish aquaculture in upper Oakland Bay and Chapman Cove. (1, 6)
- The mouth of John's creek has been chanalized bypassing its estuary. (6)
- The dendritic channels in upper Oakland Bay, the upper of intertidal salt marsh of Chapman Cove and the sandy beach north of Munson Point have been rated as priority conservation areas. (6)
- The head of Oakland Bay is listed as an impaired water body due to fecal coliform. (7)

Primary Stressors: Shellfish Aquaculture, Wetland/Estuary Modification, Stormwater & Wastwater.

Intact Areas: North of Munson point, Upper Chapman Cove, Upper Oakland Bay.

Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Bayshore to Eagle Point

- An industrial and urbanized waterfront characterizes this shoreline. (1, 6, 4)
- The city of Shelton is located in the southern portion of the unit while state Hwy 3 runs along the rest of the shoreline. (1, 6)
- Riparian overhang is rated as fair to good from Bayshore to Shelton and poor from Shelton to Eagle Point. The riparian corridor along Hwy 3 is rated as having good overhang but is considered too shallow to allow proper functioning. (6)
- Most of the shoreline in this area, except near Bayshore, has been heavily modified by shoreline hardening. (1, 6)
- All of the streams mouths in this unit have been chanalized through the deltas. (6)

- Almost the entire unit has been rated as a priority restoration area. (6)
- Shelton Harbor is listed as an impaired water body due to fecal coliform. (7)
- Extensive floating log storage exists west of Eagle Point. (1, 6)

Primary Stressors: Shoreline Armoring, Over Water Structures, Riparian Loss, Wetland/Estuary Modification, Storm Water & Waste Water

Intact Areas:

Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Eagle Point to Skookum Point

- Eagle point has been rated a priority conservation site due to its high quality habitat. (6)
- The rest of the unit is residential resulting in a generally low percentage of riparian overhang. (6)
- Most of the unit has been intensely impacted by shoreline armoring and dikes. (1, 6)
- The mouths of the tributaries have been rated as priority restoration areas due to diking, bulkheading, and riparian loss. (6)

Primary Stressors: Shoreline Armoring, Riparian Loss, Wetland & Estuary Modification

Intact Areas: Eagle Point

Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Skookum Point to Arcadia

- Active feeder bluffs along the central portion of the unit. (4)
- Riparian overhang is generally rated as high. (6)
- There is little shoreline modification. (1, 6)
- The tributary mouths and feeder bluffs have been rated as priority conservation sites. (6)
- The marine waters off of Mill Creek are listed as an impaired water body due fecal coliform. (7)

Primary Stressors: Shoreline Armoring, Storm Water & Waste Water

Intact Areas: Mill Creek Estuary
Reference: Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment. 2002

Harstine Island Group

Harstine Island Group Water Quality Overview

- CWA 1998 Section 303(d) listings: Dissolved oxygen, fecal coliform, pH. (Additional listings proposed for the 2002/2004 303(d) list include bis(2-ethylhexyl)phthalate (sediment) and total PCBs (tissue), and for the waters of concern list include three toxics sediment parameters.)
- Stratification: ratings of moderate and infrequent (CSE001, NSQ002), and weak and infrequent (DNA001) (Newton et al. 2002).
- Dissolved Oxygen: very low, <3.0 mg/l (station NSQ002), low, <5.0 mg/l (station DNA001), good, >5.0 mg/l (station CSE001), excellent, >6.0 mg/l (station PCK001), (based on Ecology marine monitoring data).
- Ammonium-N: high (stations DNA001 & CSE001), not high (station NSQ002), (based on Newton et al. 2002).
- Nitrite: high (stations DNA001 & NSQ002); high nitrite can be an indicator of eutrophication (Newton et al. 2002).
- Sensitivity to added nutrients: not high (stations NSQ002, DNA001, & CSE001), (based on Newton et al. 2002).

Primary Stressors: Nutrients, dissolved oxygen, toxics. stratification

Devils Head to North Entrance of Taylor Bay

- Documented forage fish spawning on the southern end of the unit. Most of the shoreline except for Taylor Bay appears suitable for forage fish spawning. (2, 5)
- Active feeder bluffs are found along the entire unit. (2)
- Hardened shoreline on north end of Taylor Bay. (1, 2)
- Most areas retain good riparian condition. (2)

Primary Stressors: Shoreline Armoring

Intact Areas: Small cove between Devils Head and Taylor Bay

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

North Entrance of Taylor Bay to North Entrance of Whiteman Cove

- Documented forage fish spawning in the center and north ends of the unit. Most of the shoreline except for inside Whiteman Cove appears suitable for forage fish spawning. (2, 5)
- Active feeder bluffs along the entire unit. (2)
- Hardened shoreline exists across the entrance to Whiteman Cove. (1, 2)

- Most areas retain good riparian conditions. (2)
- Culverts, tide gates, and sheet pilings block the entrance to potential high quality habitat within Whiteman Cove. (2)

Primary Stressors: Shoreline Armoring, Wetland/Estuarine Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003)

North Entrance of Whiteman Cove to Herron, Including Herron Island

- Documented forage fish spawning in the southern end of the unit. Most of the shoreline appears suitable for forage fish spawning. (2, 5)
- Active feeder bluffs are located in the southern and central part of the unit as well as along a small section of southwest Herron Island. (2)
- Much of the shoreline in the north part of the unit near Herron, as well as most of Herron Island, has been impacted by shoreline hardening. (1, 2)
- The habitat quality of the small lagoon on the southwest of Herron Island was rated as high. (2)
- The tidal connection to a lagoon behind Camp Gallagher has been severed, removing potential high quality habitat. (2)

Primary Stressors: Shoreline Armoring, Wetland/Estuarine Modification

Intact Areas: The small lagoon on southwest Herron Island

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Herron to North Spit of Dutcher Cove

- Most of the shoreline appears to be suitable for forage fish spawning. (2)
- Active feeder bluffs are located inside Dutcher Cove. (2)
- Shoreline armoring has substantially impacted the entire unit except for Dutcher Cove. (2)
- Generally, the unit has a low percentage of overhanging riparian. (3)
- The relative habitat quality of Dutcher Cove was rated as high. (2)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas: Head of Dutcher Cove

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Stretch Island Bridge to Walkers Landing

- Documented forage fish spawning on all shorelines except inside of McLane Cove. (5)
- Active feeder bluffs from the Stretch Island Bridge to the entrance of McLane Cove. (3)
- There is little shoreline hardening except at the north entrance to McLane Cove. (1, 3)
- The riparian zone is relatively intact except for the shoreline along Walkers Landing. (3)
- The shoreline north of Stadium, the western shore of McLane Cove and the small group of inlets north of Walkers Landing have been categorized as conservation areas due to intact feeder bluffs and stream mouths.
- The shoreline around Walkers Landing has been designated a priority restoration area due to extensive development. (3)

Primary Stressors:	Shoreline Armoring, Riparian Loss, Landfill
Intact Areas:	Inlets North of Walkers Landing
Reference:	Greater Mason County Nearshore Habitat Assessment. Draft 2004

Walkers Landing to Hungerford Point

- Documented forage fish spawning on most of the shorelines of this unit. (5)
- Active feeder bluffs are present south of Walkers Landing as well as in the southern half of the unit. (3)
- Most of the shoreline, except for some back bays, has been substantially altered by shoreline hardening. (1, 3)
- Much of the shoreline has been impacted by the loss of riparian vegetation. (3)
- The shoreline adjacent to Walkers Landing has been recommended as a priority restoration area due to the loss of feeder bluffs and the riparian zone as well as shoreline hardening and the filling of portions of the marsh. (3)
- The mainland marshes from Graham Point to the south have been recommended as priority conservation areas. (3)

Primary Stressors:	Shoreline Armoring, Riparian Loss, Landfill
Intact Areas:	West side mainland marshes
Reference:	Greater Mason County Nearshore Habitat Assessment Draft 2004

Steamboat Island to Hunter Point

- Documented forage fish spawning along western sand bar of Steamboat Island, Carlyon Beach and Hunter Point. (5)
- Active feeder bluffs on Steamboat Island. (4)
- Almost 100% of the shoreline of Steamboat Island and Carlyon beach has been impacted by shoreline hardening. A large portion of the eastern half of the unit has experienced no shoreline hardening. (1,4)
- The western two-thirds of the unit have been impacted by the loss of riparian vegetation. (4)
- The shore along Carlyon Beach is a recommended priority restoration area. (4)

Primary Stressors: Shoreline Armoring, Riparian Loss.

Intact Areas:

Reference: Appendix Z. Greater Mason County Nearshore Habitat Assessment. Draft 2004

Hunter Point to Sanderson Harbor

- Shellfish Harvest Permitted area (8)
- Docks and 100% armoring (1) (8)
- Upland residential and removal of riparian habitat (1) (8)
- Drift Cell to the North
- Frequent overwater stairways and homes at edge of shoreline.
- Substrate cobble to large rock
- Critical Species: Surf Smelt

Primary Stressors: Shoreline Armoring, Riparian Loss, Stormwater & Wastewater, Wetland/Estuary Loss, Shellfish Aquaculture,

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

Dofflemyer Point to East Entrance of Little Fishtrap

- Documented forage fish spawning along all open shorelines. (5)
- Active feeder bluffs are located in the eastern half of the unit. (4)
- The western half of this unit has been substantially impacted by shoreline armoring and loss of riparian vegetation. (4)
- A marina, and associated over water structures, exists at Boston Harbor. (4)
- Little fish trap provides high quality habitat for rearing and migration. (4)

Primary Stressors: Shoreline Armoring, Riparian Loss, Over Water Structures.

Intact Areas: Little fish trap.

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

East Entrance of Little Fishtrap to Henderson Inlet

- Documented forage fish spawning along all open shorelines. (5)
- Active feeder bluffs are located throughout the unit. (4)
- Shoreline armoring exists at the entrances to Big and Little Fishtrap coves as well as along Dickenson Point. (1, 4)
- Big Fishtrap cove is recommended as a priority conservation area. (4)
- This unit provides generally good habitat for rearing and migration. (4)

Primary Stressors: Shoreline Armoring.

Intact Areas: Big fish trap.

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

Johnson Point to Baird Cove

- Low quality Gravel substrate in Baird Cove (4)
- Sand substrate in Ponsin Cove (4)
- Bulkheading north of Baird Cove –20% (4)
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Many pocket estuaries and inlets
- Zittels Marina at mouth of Baird Cove
- Feeder Bluffs

Primary Stressors: Overwater Structures, Shoreline Armoring, Riparian Loss, Stormwater & Wastwater.

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Baird Cove to Mill Bight

- High quality sand in Mill bight (4)
- Some armoring (20%)

- Signifcant Beach feeding processes near Mill Bight that lessen as shoreline moves north
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Mill Bight in Shellfish Harvest prohibited area
- Mill Bight contains estuarine wetland habitat
- Many pocket estuaries and inlets
- Puget Marina

Primary Stressors: Overwater Structures, Shoreline Armoring, Riparian Loss, Stormwater & Wastwater.

Intact Areas: Mill Bight and northern shoreline area

Reference: Cindy Wilson. Thurston County. 2004

Mill Bight to Dog Fish Bight

- Substantial armoring of shoreline- 60% (4)
- Significant beach feeding processes potential and where not bulkheaded (4) (1)
- Feeder bluffs (4) (1)
- 1980 mapping shows beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Permitted Area (1)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Dog Fish Bight to Sandy Point

- 100% bulkhead modified (4)
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Permitted Area (1)

Primary Stressors: Shoreline Armoring, Landfill, Wetland & Estuary Modification

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Sandy Point to Butterball Cove

- Tidal Aquatic Bed wetlands (8)
- High quality Sand in Big Slough Area and Sandy Point North (4)
- Big Slough/Tolmie State Park-No bulkheads (4)
- 75% of shoreline bulkheaded and/or modified (4)
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Conditional area up to Big Slough(1)
- Shellfish Harvest Permitted area north of Big Slough (1)
- 1998 303d Listed Waters (8)

Primary Stressors: Shoreline Armoring, Wetland & Estuary Loss, Stormwater & Wastwater

Intact Areas: Big slough area

Reference: Cindy Wilson. Thurston County. 2004

Butterball Cove to DeWolf Bight

- Tidal Aquatic Bed wetlands (8)
- Estuary loss to boat basin (1)
- High density population-Beachcrest (1) (8)
- Unstable slopes (4)
- Feeder Bluffs (4)
- 10% bulkhead modification, primarily at mouth of Butterball Cove (4)
- Butterball Cove- Mud substrate (4)
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Conditional area (1)

Primary Stressors: Shoreline Armoring

Intact Areas: Tolmie State Park, Portions of Butterball Cove

Reference: Cindy Wilson. Thurston County. 2004

DeWolf Bight to Hogum Bay

- Historical Estuary Area (8)
- Tidal Aquatic Bed wetlands (8)
- High density population-Beachcrest (1)
- Feeder bluffs (10) (8)
- No structure modifications (4)
- 1980 beach substrate and algal community (4)
- Nisqually Reach Shellfish Protection district (1)

- Shellfish Harvest Conditional area (1)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas: Portions of Hogum Bay

Reference: Cindy Wilson. Thurston County. 2004

Hogum Bay to Mc Neill Island Group (122 degrees 45') (Meridian Road)

- Historical Estuary area (8)
- Tidal Aquatic Bed wetlands (8)
- Modified slopes (4)
- Entire area is critical to birds (4)
- Mud silt/clay substrate (4)
- Bulkhead, launch and dock area –Public (1) (4)
- 50% modified by bulkhead (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Conditional area (1)
- 1998 303d Listed Waters (8)

Primary Stressors: Shoreline Armoring, Shellfish Aquaculture

Intact Areas: Portions of Hogam Bay

Reference: Cindy Wilson. Thurston County. 2004

Harstine Island- Dougall Point to Fudge Point, Including McMicken Island

- Documented forage fish spawning at Dougall Point and the eastern two-thirds of McMicken Island. (5)
- The feeder bluffs present along the entire unit are rated as exceptional in the north one-third of the unit. (3)
- The shorelines of Dougall Point have been substantially impacted by shoreline hardening. The lagoon has been recommended as a priority restoration site due to loss of the riparian corridor, shoreline hardening and a road built on the spit. (3)
- Eelgrass beds are present off Dougall Point. (3)
- The shoreline north of Fudge Point has been impacted by riparian loss and shoreline hardening. (3)
- The shoreline south of Dougall Point has been recommended as a priority conservation area due to the exceptional sediment supply and intact riparian corridor. (3)
- McMicken Island, protected as a state park, provides high quality habitat. (3)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas: McMiken Isaland and the shoreline south of Dougall Point

Reference: Greater Mason County Nearshore Habitat Assessment Draft 2004

Harstine Island- McMicken Island to Brisco Point

- Documented forage fish spawning on the southern two-thirds of the unit. (5)
- Active feeder bluffs are located along the entire unit. (3)
- There is extensive shoreline armoring between Fudge Point and Wilson Point. (1, 3)
- The shoreline north of Wilson Point retains good riparian conditions. (3)
- The shoreline from just north of Brisco Point to Wilson Point has been categorized as a priority conservation site due to intact riparian zone, exceptional feeder bluffs and the large woody debris potential. (3)
- The tip of Brisco Point has been impacted by shoreline hardening and the removal of riparian vegetation. (3)

Primary Stressors: Shoreline Armoring, Riparian Loss

Intact Areas: Portions of the Shoreline from Wilson Point to Brisco Point

Reference: Greater Mason County Nearshore Habitat Assessment Draft 2004

Harstine Island - Brisco Point to Salmon Point

- Documented forage fish spawning in the southern half of the unit. (5)
- Active feeder bluffs are found along the entire unit. (3)
- Extensive shoreline hardening exists in the north and center portions of the unit. (1, 3)
- The southern two-thirds of the unit have been impacted by shoreline hardening, riparian loss and shellfish aquaculture. (3)
- The shoreline adjacent to the southern end of Harstine road has been recommended for priority restoration as a result of alterations to the mouth of the salmon bearing stream and residential development. (3)

Primary Stressors: Shoreline Armoring, Riparian Loss, Wetland & Estuary Modification, Shellfish Aquaculture.

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment Draft 2004

Harstine Island- Salmon Point to Northwest Point of Harstine Island

- Documented forage fish spawning along the entire shoreline of this unit. (5)
- The northern two-thirds of the unit posses feeder bluffs rated as “moderate”. (3)
- The shorelines of the northern half of the unit have been impacted by shoreline armoring. (1, 3)
- Areas identified for conservation include the stream deltas in the very southern portion of the unit as well as the lagoon and associated mudflat located just north of the Harstine Island Bridge. (3)
- The shoreline from north of the bridge to the end of the unit has been recommended for restoration aimed at expanding an area of excellent habitat. (3)

Primary Stressors:	Shoreline Armoring, Riparian Loss, Shellfish Aquaculture
Intact Areas:	Lagoon north of the bridge
Reference:	Greater Mason County Nearshore Habitat Assessment Draft 2004

Northwest Point of Harstine Island to Dougall Point

- Documented forage fish spawning along the entire shoreline except for the inside of Jarrell Cove. (5)
- Feeder bluffs from Jarrell Cove to the small cove west of Dougall Point. (3)
- The shorelines of the small cove west of Dougall Point have been substantially affected by shoreline hardening and riparian removal. (1, 3)
- The stream/delta corridor along the western part of the unit has been identified for conservation. (3)
- Jarrell Cove and the shoreline extending to northeast corner of Harstine Island have been recommended as priority conservation sites. (3)
- Areas identified for restoration include the bluff west of Jarrell Cove, the hardened shorelines in Jarrell Cove and the shore adjacent to the Harstine Point Marina. (3)

Primary Stressors:	Shoreline Armoring, Riparian Loss
Intact Areas:	Western Jarrell Cove
Reference:	Greater Mason County Nearshore Habitat Assessment Draft 2004

Squaxin and Hope Islands

- Documented forage fish spawning on most beaches of both islands. (5)
- Feeder bluffs on portions of Squaxin Island. (3)
- There is little modification to the shoreline of either island. Both provide high quality habitat to migrating juvenile salmonids. (3, 4)
- Coho netpens are located in Peale Passage. (4)
- Derelict vessels on Squaxin Island. (4)
- Squaxin Island is in a protected status as an Indian reservation while Hope Island is a State Park. (4)

Primary Stressors: Overwater structures.

Intact Area: Almost the entire shoreline of both Islands is intact.

Reference: Greater Mason County Nearshore Habitat Assessment. Draft 2004

Henderson Inlet

Henderson Inlet Water Quality Overview

- CWA 1998 Section 303(d) listings: dissolved oxygen, fecal coliform. (Listings proposed for the 2002/2004 waters of concern list include pH and four toxic sediment contaminants.)
- Stratification: *data not available.*
- Dissolved Oxygen: excellent, >6.0 mg/l (station HND001), (based on Ecology marine monitoring data).
- Ammonium-N: no data (i.e., none reported in Newton et al. 2002).

Primary Stressors: Nutrients (assumed), toxics, dissolved oxygen

Johnson Point to Woodland Creek

- Documented Smelt spawning area
- Many pocket coves and inlets (1) (4) (8)
- 100% of Johnson Point itself is bulkheaded
- Significant armoring >60% to Swayne Road
- Mudflats primarily south of Swayne road
- Oyster and clam potential
- Shellfish Harvest Permitted, Conditional and Prohibited area-North to south

Primary Stressors: Shoreline Armoring, Riparian Loss, Wetland & Estuary Loss, Overwater Structures,

Intact Areas: South of Swayne Road in southern Henderson relatively undisturbed riparian area

Reference: Cindy Wilson. Thurston County. 2004

South Henderson Inlet

- Harmony Farms-Capital Land Trust
- Woodland Creek wetlands/tidal area publicly owned
- Generally undeveloped with good riparian habitat
- Road crossings and culverts impacting side channels, streams and tidally influenced wetland areas.
- Some riparian loss due to residential and agricultural uses
- Primarily mud flats and estuarine Category I wetlands
- Some isolated bulkheads, several docks and a launch on the western shore of Henderson
- Shellfish Harvest Prohibited area
- Mouth of Woodland Creek impacted by culverted road crossing

Primary Stressors: Wetland & Estuary Loss, Overwater Structures, Stormwater & Wastewater

Intact Areas: Riparian areas generally intact.

Reference: Cindy Wilson. Thurston County. 2004

Woodard Bay to Henderson Inlet Line

- Primarily mud flats and estuarine wetlands in Woodard Bay
- Significant armoring and riparian habitat removal
- Significant Bat habitat in Woodard Bay Preserve
- Historical log yard, long term impacts?
- Significant Seal pupping area at Woodard Bay
- 1980 Sand substrate
- Feeder bluffs present where not armored

Primary Stressors: Shoreline Armoring, Riparian Loss, Wetland & Estuary Loss, Overwater Structures,

Intact Areas: Woodard Bay Internal

Reference: Cindy Wilson. Thurston County. 2004

McNeil Island Group Water Quality Overview

- CWA 1998 Section 303(d) listings: fecal coliform. (Additional listings proposed for the 2002/2004 303(d) list include three toxic sediment contaminants, and total PCBs in tissue, and for the waters of concern list includes pH, and 15 toxic sediment contaminants.)
- Stratification: rated moderate and infrequent (station GOR001), (Newton et al. 2002).
- Dissolved Oxygen: good, >5.0 mg/l (stations GOR001 & NSQ001); excellent, >6.0 mg/l (station STL001), (based on Ecology marine monitoring data).
- Ammonium-N: not high (station GOR001), (based on Newton et al. 2002).
- Sensitivity to added nutrients: not high (station GOR001), (based on Newton et al. 2002).
- PCBs: detected in sediment study (Dutch et al. 2003).

Primary Stressors: Toxics

Harstene Island Line (122 degrees 45”) to Nisqually Head/Luhr Beach

- Historical Estuary area (8)
- Tidal Aquatic Bed wetlands (8)
- Modified slopes (4)
- Entire area is critical to birds (4)
- Mud silt/clay substrate (4)
- Bulkhead, launch and dock area –Public (1) (4)
- 50% modified by bulkhead (4)
- Nisqually Reach Shellfish Protection district (1)
- Shellfish Harvest Conditional area (1)

Primary Stressors: Shellfish Aquaculture, Shoreline Armoring.

Intact Areas: Portions of Hogam Bay

Reference: Sayre Hodgson. Nisqually Indian Tribe. 2004

Nisqually Head/Luhr Beach to Mouth of Little McAllister

- Adjacent Nisqually wildlife refuge
- I-5 crossing at mouth of creek
- Intensive land use at mouth
- High bluff area
- Some SFR and riparian clearing

- Little to no armoring
- Estuarine wetlands at mouth and on adjacent delta/refuge
- Woody debris

Primary Stressors:

Intact Areas:

Reference: Cindy Wilson. Thurston County. 2004

Nisqually estuary to Gordon Point (near Steilacoom)

- The Burlington Northern railroad line runs along this entire shoreline. The shoreline is highly armored and composed mainly of boulders and fill used to stabilize the rail line. Shoreline vegetation along the rail line has been removed, and in some areas the rail line isolates the shore from feeder bluffs. Near the Nisqually estuary, the rail line is farther from the shore and has less of an impact.
- Except for the rail line, this segment of shoreline is primarily forested, owned by Fort Lewis, and undeveloped, except for some houses and a marina near Gordon Point, and a gravel pit operation (with overwater structures) near Tatsolo Point.
- Below the rail line, and in areas where the rail line is set back farther from the sound, the substrate is composed mostly of sand or gravel and sand (WDNR 2001)
- About half of this shoreline is absent of eelgrass, and half has patchy eelgrass present (an area near the mouth of Sequalitchew Creek, and from Tatsolo Point to Gordon Point) (WDNR 2001)
- Nisqually estuary: this estuary provides some intact habitat (mudflats and estuarine emergent marsh) but the estuary has also been confined and modified by dikes and Interstate 5. See the Nisqually Chinook Recovery Plan (Nisqually Chinook Recovery Team 2001) for information on actions needed in the Nisqually estuary.
- Sequalitchew Creek outlet: estuary is divided and confined by the large culvert that passes under railroad. This limits the quantity and quality of available estuary habitat
- The rail line blocks or highly constricts numerous small streams that drain directly into Puget Sound along this shoreline. This impedes fish passage and reduces the quantity and quality of pocket estuary habitat along the shoreline.
- Ft. Lewis diverts water from Sequalitchew Lake, and releases it and effluent from the Solo Point wastewater treatment plant near Tatsolo Point. This limits the quantity, quality, accessibility of available estuary habitat.

Primary Stressor: Shoreline Armoring Landfill, Wetland/estuarine Modification

Intact Areas: Some parts of the Nisqually estuary are intact

Reference: Sayre Hodgson. Nisqually Indian Tribe. 2004

Ketron Island

- No shoreline modifications (WDNR Shorezone)
- Sandy beach on west shoreline, sand and gravel beach on east shoreline (WDNR Shorezone)
- Eelgrass is patch on west side of island and absent on east side (WDNR Shorezone)
- No documented forage fish spawning areas
- Some docks and removal of vegetation on the northern part of the island
- Feeder bluffs are present and not blocked by any structures
- Healthy marine riparian vegetation in most areas of the island

Primary Stressor: None.

Intact Areas: Southern two-thirds of Ketron Island.

Reference: Sayre Hodgson. Nisqually Indian Tribe. 2004

Gordon Point (near Steilacoom) to the tip of Day Island

- The railroad line parallels the water along this entire shoreline, often very close to the water. The rail line is associated with shoreline hardening (boulders and fill used to stabilize the track) and loss of riparian vegetation. In some areas the railroad isolates the shore from feeder bluffs.
- This shoreline has patches with no development directly next to the shore (except for the railroad) but also many areas such as Steilacoom, Sunset beach, and Day Island with houses or other development close to the shore and associated with shoreline hardening, docks and other overwater structures, and removal of vegetation
- Documented sand lance spawning and surf smelt spawning on shoreline directly south of Chambers Creek outlet and about 1.5 miles north of Chambers Creek (WDFW, 2003)
- Most of this shoreline is absent of eelgrass, but there is some patchy eelgrass south of Day Island. There are some stretches of patchy floating bull kelp north of Chambers Creek (WDNR 2001)
- Substrate along this shoreline is composed of mostly sand or gravel and sand beaches (WDNR 2001)
- Chambers Creek outlet: estuary is modified by shoreline hardening, industrial development, and removal of riparian vegetation. The railroad bridge crossing confines the creek outlet, reducing quantity and quality of estuary habitat. Marina at mouth of Chambers Creek has overwater structures. There is a sewage treatment plant outlet here also.

- Steilacoom Creek outlet: railroad crosses outlet over a bridge, leaving this pocket estuary somewhat intact but also somewhat impacted by bank hardening and confinement.
- Extensive gravel pit operation just north of Chambers Creek has removed shoreline vegetation, modified the shoreline and removed feeder bluffs. The operation has some overwater and in-water structures

Primary Stressor: Shoreline Armoring, Landfill, Wetland/Estuarine Modification

Intact Areas:

Reference: Sayre Hodgson. Nisqually Indian Tribe. 2004

Day Island to Tacoma Narrow Bridge

- Railroad parallels close to the shore along this section Riparian vegetation has been removed, the shoreline has been armored with boulders and fill to stabilize the track, and in some areas the track isolates feeder bluffs from the main shore. There are a few areas where the track is farther from the shore, allowing for healthier vegetation and a more natural beach substrate and slope.
- Some stretches of this shoreline are absent of development (other than the railroad track and housing built well upslope), while other areas have houses built very close to the shore, docks, and loss of riparian vegetation and shoreline armoring.
- Documented sand lance spawning spawning on shoreline less than one mile north of Day Island (WDFW, 2003)
- Titlow Lagoon: 2 lagoon ponds, outflow is a constrained culvert through RR track, which impairs connectivity and fish access
- This shoreline is absent of eelgrass except for some patchy eelgrass between Day Island and the Tacoma Narrows bridge. Most of this shoreline has patchy or continuous floating bull kelp (WDNR 2001).
- Most of this shoreline is composed of gravel and sand beaches (WDNR 2001)
- The marina on the northeast side of Day Island has overwater structures

Primary Stressor: Shoreline Armoring, Landfill,

Intact Areas:

Reference: Sayre Hodgson. Nisqually Indian Tribe. 2004

Tacoma Narrows Bridge to Point Fosdick (EMU 3)

- Consists of high-bank, open shoreline with numerous active feeder bluffs
- Densely wooded riparian buffer is present throughout most of the area and contributes LWD to the shoreline

- There is very little shoreline development, although houses cover much of the landscape inland from the tops of the bluffs
- Upper shoreline appears to be suitable for forage fish spawning, and sand lance spawning has been documented
- Kelp beds widespread in the mostly gravel, cobble, or boulder shallow subtidal zone
- Eelgrass present only near Point Fosdick

Primary Stressors:

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Point Fosdick to Wollochet Bay (EMU 4)

- The open shoreline has a low bank, and is heavily developed with extensive bulkheading
- Very little native vegetation has been left intact
- Within Wollochet Bay, the shoreline is heavily developed, including extensive bulkheading, docks and overwater structures
- Some eelgrass at the mouth of the bay
- Within the bay, the upper beach is primarily sand and potentially suitable habitat for forage fish spawning
- Head of the bay is a relatively large estuary with extensive marsh edge and large mudflat exposed at low tide. Relatively less development has occurred here and the shoreline is in a mostly natural state.

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

North Shore of Hales Passage to Green Point (EMU 5)

- Most of the shoreline is open (with exception of Shaws Cove)
- Most of the shoreline is developed and bulkheaded
- Many bulkheads appear to provide little functional value
- Active feeder bluffs in a few locations
- Eelgrass occurs in only a few locations

- Most of the upper shoreline appears to be suitable for forage fish spawning, although only sand lance have been known to spawn in this area

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Van Geldern Cove to Pitt Passage, including Pitt Island (EMU 9)

- Van Geldern Cove has marsh and eelgrass habitat, but also has areas of extensive bulkheading and numerous piers and docks.
- Mayo Cove has marsh and eelgrass habitat, but also has areas of extensive bulkheading and numerous piers and floating docks.
- Penrose State Park within Mayo Cove has densely wooded riparian buffer, active feeder bluffs, and patches of eelgrass.
- South Head includes natural undisturbed shoreline with active feeder bluffs and LWD input.
- Pitt Passage has largely undeveloped shoreline with active feeder bluffs, LWD inputs and abundant eelgrass, and substrate appears suitable for forage fish spawning. Other areas have extensive bulkheading with little forested riparian habitat.
- Forage fish spawning areas documented in short reaches at the entrance to Van Geldern Cove and in Mayo Cove.

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Pitt Passage to Devil's Head (EMU 10)

- Most areas appear suitable for forage fish spawning, while documented surf smelt and sand lance spawning exists primarily south of Filucy Bay
- Within Filucy Bay has been greatly impacted by the level of shoreline development including extensive residential development, and shoreline hardening. There are also a number of private docks, small floats as well as a marina.

- The north cove of Filucy Bay has a marsh fringe and a shallow tidal channel, is bordered by densely wooded riparian buffer.
- Filucy Bay also contains several derelict structures and bulkheads that apparently serve no function
- Habitat along the open shorelines of Pitts Passage and south of Filucy Bay are relatively intact with multiple feeder bluffs and wooded riparian buffer.
- Eelgrass is present along Pitt Passage, but not in Filucy Bay or the open shorelines south of Filucy Bay.

Primary Stressors:	Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification
Intact Areas:	
Reference:	Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Fox Island shoreline (EMU 13)

- The northern shoreline has extensive development, including shoreline hardening, and the adjoining upland areas have been cleared and developed, with only small pockets of wooded habitat remaining near the shoreline.
- The shoreline of Tanglewood Island is mostly undisturbed, except for the northern tip which has extensive shoreline modification associated with the lighthouse station
- The southern shoreline is high bank, particularly around Gibson Point, and tends to have somewhat less shoreline development that the northern shoreline
- Most of the upper beach substrate along Fox Island appears suitable for forage fish spawning.
- Dense eelgrass beds occur along some reaches of the southern shoreline

Primary Stressors:	Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification
Intact Areas:	
Reference:	Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Anderson Island shoreline (EMU 14)

- Open shorelines generally provide moderate habitat quality, but some shorelines have been degraded by shoreline armoring and other shoreline development

- Higher quality habitats are associated with protected inlets and lagoons, although much of the habitat has been degraded by shoreline hardening, overwater structures, and removal of much of the forested buffer.
- Highest quality habitat is in Carlson Bay and the head of Oro Bay
- In Oro Bay, the culvert under Ekenstem-Johnson Road is a partial blockage to juvenile salmonids to an extensive marsh upstream of the road
- A dike blocks tidal exchange and fish access to an extensive wetland and marsh at the head of East Oro Bay
- Potentially suitable forage fish spawning habitat is found in much of the open shoreline
- Eelgrass is found in only a few locations along the northern, southern, and eastern shorelines

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

McNeil Island shoreline (EMU 15)

- The shoreline has been left in a mostly natural state, but some areas have been extensively modified
- Along the southeast shoreline at the site of the main correctional facility there exists a ferry terminal, small pier, boat ramp, a bulkhead, and extensive riprap
- Still Harbor has experienced moderate shoreline alteration including shore sections of bulkhead
- Four small creeks have been impounded, which restricts flow and fish access, and greatly impacts the establishment of marsh habitat
- As extensive marsh exists on the eastern shoreline
- Most of the eelgrass is concentrated along the west shoreline of the island in Pitt Passage
- In many locations around the island there appears to be suitable forage fish spawning habitat

Primary Stressors: Shoreline Armoring, Overwater Structures, Riparian Loss, Wetland/Estuary Modification

Intact Areas:

Reference: Key Peninsula, Gig Harbor, and Islands Watershed Nearshore Salmon Habitat Assessment. 2003

Totten and Little Skookum Inlets

Totten & Little Skookum Inlets Water Quality Overview

- CWA 1998 Section 303(d) listings: none. (Listings proposed for the 2002/2004 waters of concern list include dissolved oxygen, pH, and four toxic sediment contaminants.)
- Stratification: rated moderate and infrequent (stations TOT001, TOT002; Newton et al. 2002).
- Dissolved Oxygen: good, >5.0 mg/l (station TOT001), (based on Ecology marine monitoring data).
- Ammonium-N: high (station TOT002), not high (station TOT001) (based on Newton et al. 2002).
- Sensitivity to added nutrients: high (stations TOT001 & TOT002), (based on Newton et al. 2002).

Primary Stressors: Nutrients

Arcadia to Windy Point

- Most of the shoreline has documented forage fish spawning. (5)
- Shoreline armoring impacts the north portion of the unit. (1, 4)
- There has been a moderate amount of removal of the riparian buffer in the center of unit. Much of the rest of the shoreline retains good riparian buffers. (4)

Primary Stressors: Shoreline Armoring, Riparian Loss, Shellfish Aquaculture

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

Windy Point to Barron Point (mouth of Skookum Inlet)

- Documented forage fish spawning along all shorelines. (5)
- Active feeder bluffs are located throughout the unit. (4)
- The south portion of the unit has little riparian buffers. (4)

Primary Stressors: Riparian Loss, Shellfish Aquaculture

Intact Areas: Feeder Bluffs

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

Little Skookum Inlet

- Moderate feeder bluffs located on the south end of unit. (4)
- Several shellfish operations are located throughout the inlet. (1, 4)
- The shoreline riparian is generally intact. (4)
- Western end of inlet is diked off. (4)
- There is extensive WDNR land holdings located on the western end of the inlet. (4)
- Little Skookum Inlet posses some of the most unmodified habitat in South Puget Sound. (4)

Primary Stressors: Wetland/Estuary Modification , Shellfish Aquaculture

Intact Areas: Port Blakely timber company recreation area

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

Wildcat Harbor to Hurley Cove

- Documented forage fish spawning along the whole unit. (5)
- Some feeder bluffs are located on the southern end. (4)
- Little to no riparian vegetation on north end of unit. (4)
- Extensive shoreline armoring on Kamilche point. (1, 4)
- Shellfish aquaculture located on southern end of unit. (4)

Primary Stressors: Shoreline Armoring, Riparian Loss, Shellfish Aquaculture

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

Hurley Cove to County Line

- Documented forage fish spawning on northeast portion of the unit. (5)
- Feeder bluffs located in Bowman Cove. (4)
- Riparian vegetation is generally intact throughout the unit. (4)
- Shellfish aquaculture in southern and center of the unit. (4)
- Extensive mudflats and salt marsh at southern end of unit provide excellent habitat. Some land ownership by WDNR between Hwy 101 and county line. (1, 4)

Primary Stressors: Shellfish Aquaculture

Intact Areas: Kennedy Creek estuary and associated salt marsh

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

County Line to West Side of Burns Cove

- Documented forage fish spawning on Burns Point. (5)
- Limited feeder bluffs west of Burns Point. (1,4)
- Oyster Bay Road cuts off a small amount of marsh habitat (4).
- The shoreline is generally intact with minimal shoreline hardening and removal of riparian vegetation. (1,4)

Primary Stressors: Wetland/estuary modification, shellfish Aquaculture

Intact Areas: The western part of the shoreline of this unit is relatively intact

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

West Side of Burns Cove to Hudson Cove

- Documented forage fish spawning throughout the unit . (5)
- Active feeder bluffs in the center of the unit. (4)
- Approximately half of the riparian overhang has been removed from the unit (1,4)
- The spit across from Deepwater Point is almost entirely residential to the high water line resulting in shoreline armoring and removal of riparian vegetation. (1,4)
- Shoreline armoring has occurred on the south end of the unit. (4)

Primary Stressors: Shoreline Armoring, Riparian Loss, Shellfish Aquaculture

Intact Areas: None

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

Hudson Cove to East Entrance of Gallagher Cove

- Documented forage fish spawning throughout the entire unit. (5)
- Active feeder bluffs throughout the unit. (4)
- The shoreline is almost completely natural. (4)

- Emergent marsh is present in Gallagher Cove . (4)
- Shoreline armoring and riparian loss in Gallagher Cove. (4)

Primary Stressors: Shellfish Aquaculture, Shoreline Armoring, Riparian Loss

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004

East Entrance of Gallagher Cove to Steamboat Island

- Documented forage fish spawning in most of the unit. (5)
- Area is developed with approximately 50 % of the riparian vegetation removed. (4)
- Almost no shoreline armoring in the unit in the southern end while the northern end has substantial armoring. (1,4)
- Moderate feeder bluffs located along the North end of the unit. (4)
- Central part of unit has sand spit with emergent marsh. (4)
- The north portion of this unit has been rated an impaired water body due to temperature. (7)

Primary Stressors: Riparian Loss, Shellfish Aquaculture, Shoreline Armoring

Intact Areas:

Reference: Greater Mason County Nearshore Habitat Assessment, Draft 2004.

- Appendix B -

South Puget Sound Marine and Nearshore Water Quality and Toxics Characteristics

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This Appendix first covers overview information and key findings regarding water quality and toxics characteristics and knowledge of South Sound. It then describes natural conditions, and how water quality conditions have changed based on three categories of data and information, 1) the state's Clean Water Act Section 303(d) impaired waters list, 2) an overview of specific water quality parameters important to nearshore and marine ecosystem health, and 3) an overview of toxic contaminants issues. Please refer to the Landscape Summaries section of the recovery plan for sub-area specific water quality and toxics data.

1. Water Quality and Toxics Overview and Key Findings

Because the South Sound is an interconnected ecological system, protection of water quality and sediments is necessary throughout the system. On shorter temporal scales, nutrients or toxics added within one sub-area, for example an inlet, may mostly affect that sub-area. Over longer temporal scales however, nutrients and toxics may move to other sub-areas though abiotic and biotic process. This is a fundamental concept of importance to the long-term protection of South Sound fish and their ecosystem.

Overall, South Sound water quality includes a variable mix of good quality conditions that are important to protect, and negatively affected conditions (conventional water quality parameters as well as toxics contaminants) that are important to restore. The South Sound should be viewed as highly sensitive to pollution due to natural stratification conditions, low flushing rates, and life histories for some South Sound stocks that include extended juvenile development in areas with degraded water quality.

System Models

Importantly, two modeling approaches have been initiated to enable the South Sound to be viewed as a system. The first lays a framework to understand trophic level changes overtime (Preikshot and Beattie 2001). The second focuses on factors related to dissolved oxygen concentrations, water clarity, altered species composition, and formation of algal scums (Albertson et al. 2002). At this time, while useful, both modeling tools are in need of additional data to elucidate questions regarding how the South Sound ecosystem may be changing, and what management measures will be effective for protection of ecosystem function.

Key Findings Include:

- Pollution of Puget Sound waters is a high sensitivity factor for South Sound fish. They may be in contact for long periods with contaminants such as PCBs, or have a likelihood of being effected by other contaminants, or low dissolved oxygen conditions (O'Neill et al. 1998; O'Neill & West, pers. comm. 2004).
- South Sound marine waters have an existing combination of natural and anthropogenic characteristics that affect dissolved oxygen conditions and that can lead to stress and mortality of fish and other aquatic organisms. Ecology marine monitoring data show:
    - Strong stratification of South Sound marine waters makes them sensitive to low dissolved oxygen conditions (Newton et al. 2002).
    - 41% (n_{total} = 17) of South Sound stations recorded low to very low levels of dissolved oxygen between 1990 and 2003 (unpublished Ecology marine monitoring data).
    - High to very high ammonium-N concentrations (likely indicating anthropogenic ammonia sources) were found at 62% (n_{total} = 13) of South Sound monitoring stations, compared to only 31% (n_{total} = 32) of stations in Central and Northern Puget Sound (Newton et al. 2002).
    - Sensitivity to added human-caused nutrients, that could lead to lower dissolved oxygen concentrations was identified in six of the seven South Sound inlet sub-areas (all but Eld Inlet) (Newton et al. 2002).
- A broad spectrum of anthropogenic toxic compounds is found in South Sound waters (CWA Section 303(d) list). It is poorly known what effects these contaminants may be having on South Sound fish. However, pharmaceuticals (including endocrine disruptors), PAHs, pesticides and their additives, and persistent bio-accumulating compounds such as PCBs and PBDEs are examples of toxics groups that can cause a wide variety of effects to salmon, including neurosensory damage, increased oxygen consumption, changed timings for smoltification and migration, reproduction problems, reduced stamina, altered swimming and social interaction, and impaired homing and anti-predator behaviors (Johannessen & Ross 2002).
- Although Central Puget Sound is more broadly contaminated, and has higher PCB levels than Southern Puget Sound (Dutch et al. 2003), coho salmon from the Nisqually River had the highest concentrations of PCBs in Puget Sound. This was followed by Deschutes coho (O'Neill et al. 1998). Northern Puget Sound and Central Puget Sound coho had the lowest and second lowest PCB levels respectively (O'Neill et al. 1998).

- Salmon transfer PCBs to eggs and offspring may start with contamination. In addition, returning salmon are bringing PCBs to disperse in their natal watersheds and streams when they return to spawn (see also Johannessen and Ross 2002).
- Global warming can cause changes to the South Sound marine and nearshore water quality conditions and these changes can profoundly affect salmonid stocks (Preikshot & Beattie 2001).

2. Natural Water Quality Conditions

Historic[1] water quality conditions in South Puget Sound resulted from watershed processes that delivered fresh water and nutrients (organic and inorganic), and episodically at higher flows delivered coarse and fine sediments, and wood (Montgomery et al. 2003). Marine and nearshore processes provided a complex of cycles (e.g., tidal) and inputs (e.g., biological as well as abiotic) that affected the water quality conditions (Prager 2000*).* Water column stratification (Newton et al. 2002), and poor flushing and hence longer water residence characteristics of South Sound waters in comparison to those of Central and Northern Puget Sound (Albertson et al. 2002, Preikshot & Beattie 2001) may have been similar historically to what they are today.

The state water quality code, WAC 173-201A, Section 30-1(c) defines the water quality criteria that apply to Class AA waters of extraordinary quality. These are the most stringent standards, and although they do not take into account naturally high or low conditions they would be expected to most clearly mirror historical conditions. These include[2]:

Dissolved oxygen: Marine – dissolved oxygen shall exceed 7.0 mg/L.
Water temperature: Marine – temperatures shall not exceed 13 C due to human activities.
pH: Marine – pH shall be within the range of 7.0 to 8.5 with a human-caused variation within the range of < 0.2 units.
Toxic, radioactive, or deleterious material concentrations: Toxic, radioactive, or deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department (see WAC 173-201A-040 and 173-201A-050).

Additionally, Newton et al. (2002) use 2 µM of ammonium-N as an example of a high historic nutrient value, and it is therefore useful for comparative purposes.

[1] Historic conditions are considered to be those that occurred largely without anthropogenic influences.
[2] Also included in the standard but not detailed for this report are criteria for fecal coliform organisms, total dissolved gas, turbidity, and aesthetic values.

A more thorough overview of marine water quality standards specific to the South Sound is attached at the end of this Appendix.

3. Current Water Quality Conditions

Clean Water Act Section 303(D) Impaired Waters

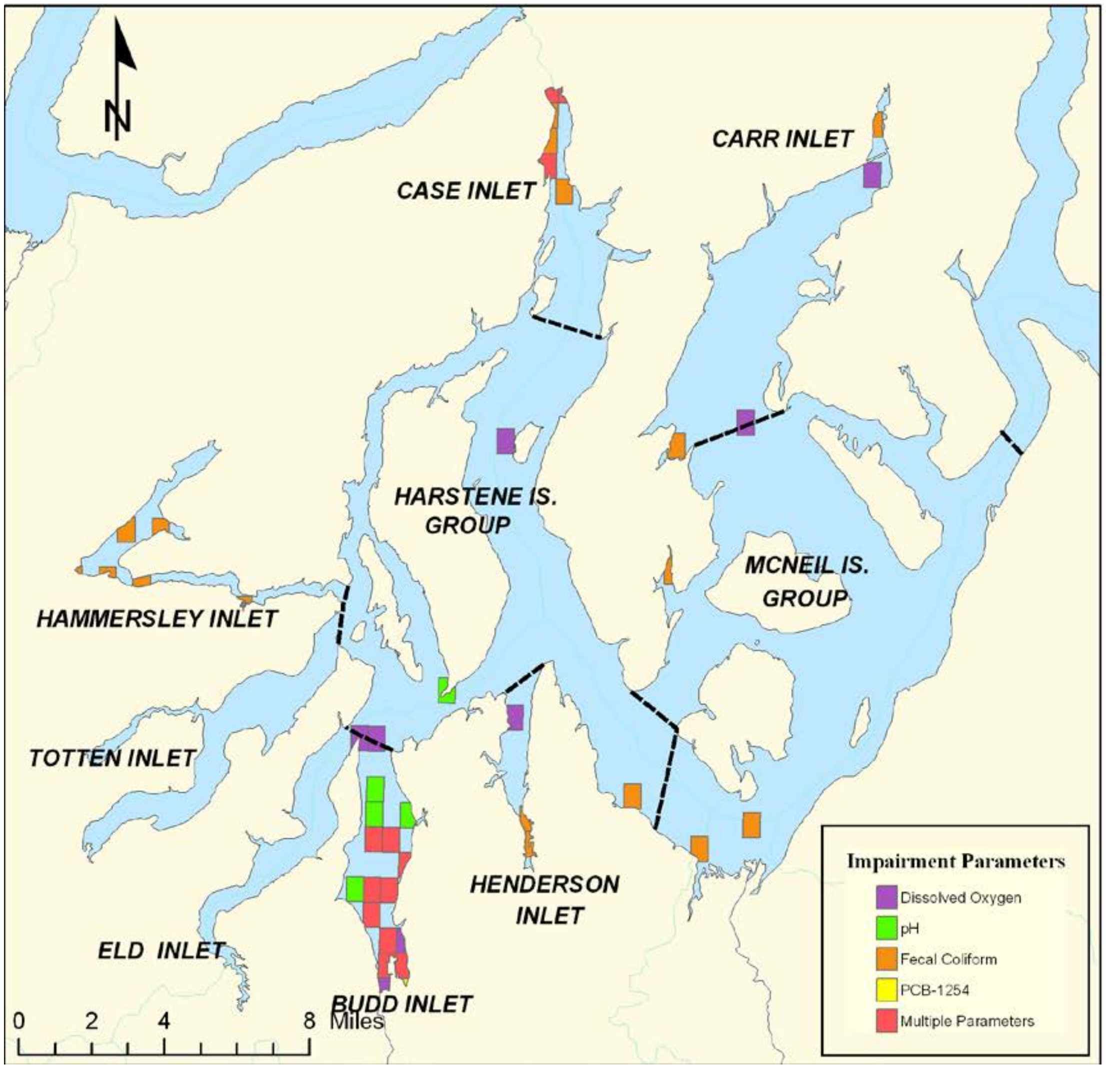
Under the Federal Clean Water Act (CWA) Section 303(d) the state is required to list waters that do not meet the state's water quality standards. The 1998 303(d) list is the most current, adopted list. An updated 2002 list has had public review but will not be finalized until it is further updated and adopted summer of 2005. It will be the official 2004 list. This section of the plan contains an overview of the lists, and listing information specific to landscape sub-areas is found in the Landscape Summaries section of the plan.

<u>1998 CWA Section 303(d) List</u>

An overview map of South Sound marine and nearshore areas and 1998 listed parameters is shown in Figure 1. There are 92 listings occurring at a total of 46 South Sound marine and nearshore locations. Two landscape sub-areas have no listings (Eld and Totten Inlets), whereas Henderson has three locations (each with one parameter), McNeil Island Group has four (each with one parameter), both the Harstene Island Group and Carr Inlet have five (each with one parameter), Hammersley has six locations (each with one parameter), Case has seven locations (some with multiple parameters for a total of 11 listings), and notably, Budd Inlet has 16 listed locations, many of which have multiple listings (58 total listings). Sixty-three percent of all the marine and nearshore listings within the South Sound are found within Budd Inlet. The most frequently listed parameter is fecal coliform (23 listings), followed by dissolved oxygen and pH, both with 17 listings. There is one listing for sediment bioassay, and 34 listings of a variety of chemical contaminants (all within Budd Inlet).

<u>2002 CWA Section 303(d) and Waters of Concern Lists</u>

Because the draft 2002 CWA Section 303(d) list is not finalized, it is possible that some proposed listings will change. However, information in the draft list is informative for salmon recovery. There are extensive additional listings proposed for South Sound marine and nearshore waters. In addition, there are proposals for a list of "waters of concern" where data values indicate concern,



LANDSCAPE AREA	WATERBODY NAME	LISTED PARAMETER	NO. OF LISTINGS
CARR INLET			
	HENDERSON BAY	Dissolved Oxygen	1
	HENDERSON BAY	Fecal Coliform	1
	CARR INLET	Dissolved Oxygen	1
	CARR INLET	Fecal Coliform	2
MCNEIL IS. GROUP			
	NISQUALLY REACH/DRAYTON PASS.	Fecal Coliform	4
HENDERSON INLET			
	HENDERSON INLET	Dissolved Oxygen	1
	HENDERSON INLET	Fecal Coliform	2
BUDD INLET			
	BUDD INLET (INNER)	Dissolved Oxygen	5
	BUDD INLET (INNER)	pH	2
	BUDD INLET (INNER)	Sediment Bioassay(s)	1
	BUDD INLET (INNER)	Chemical Contaminants[a]	34
	BUDD INLET (OUTER)	Dissolved Oxygen	6
	BUDD INLET (OUTER)	pH	10
ELD INLET			0
TOTTEN INLET			0
HAMMERSLEY INLET			
	OAKLAND BAY	Fecal Coliform	4
	SHELTON HARBOR (INNER)	Fecal Coliform	1
	HAMMERSLEY INLET	Fecal Coliform	1
HARSTENE IS. GROUP			
	NISQUALLY REACH/DRAYTON PASS	Fecal Coliform	1
	SQUAXIN, PEALE, AND PICKERING	Dissolved Oxygen	2
	SQUAXIN, PEALE, AND PICKERING	pH	1
	CASE INLET AND DANA PASSAGE	Dissolved Oxygen	1
CASE INLET			
	CASE INLET AND DANA PASSAGE	pH	4
	CASE INLET AND DANA PASSAGE	Fecal Coliform	7
TOTAL LISTINGS =			92

[a]Inner Budd Inlet chemical contaminants are: Bis(2-ethylhexyl) phthala(s), Butylbenzyl phthalate(s), Chrysene(s), Dibenzofuran(s), Fluoranthene(s), Total PCBs, 2-Methylnaphthalene(s), Acenaphthenes(s), Acenaphthylenes(s), Anthracene(s), Benz(a)anthracene(s), Benz(a)anthracene(t), Benzo(a)pyrene(s), Benzo(b)fluorene(t), Benzo(b,k)fluoranthenes(s), Benzo(g,h,i)perylene(s), Benzo(k)fluorene(t), Chromium(s), Chrysene(t), Copper(s), Dibenz(a,h)anthracenes(s), Fluorene(s), Indeno(1,2,3-cd)pyrene(s), Mercury(s), Naphthalene(s), PAHs(s), Phenanthrene(s), Pyrene(s), Zinc(s), PCB-1254(t).

Map by Ecology, April 2004,
SWRO Water Quality Section.

Figure 1. South Sound nearshore and marine 1998 Clean Water Act Section 303(d) listed waterbodies.

but data did not meet 303(d) list criteria. Noteworthy, new 303(d)proposed listings include extensive toxics for the McNeil Island Group, additional 303(d) toxics parameters for Budd Inlet, new toxics listings for the Harstene Island Group, and new dissolved oxygen and one toxic parameter listing for Case Inlet. Tables 1 and 2 provide an overview of the proposed listings.

Table 1. Proposed 2002 new conventional water quality parameter listings by landscape area. (*Final 2002/2004 list is expected to be available summer 2005.*)

Landscape Area	Parameter	Medium	Type of Listing
Carr Inlet			
	pH	Water	303(d)
McNeil Island Grp			
	pH	Water	Water of Concern
Henderson Inlet			
	pH	Water	Water of Concern
Budd Inlet			
	Temperature	Water	303(d)
Eld Inlet			
	Temperature	Water	303(d)
	Dissolved oxygen pH	Water	Water of Concern
Totten Inlet			
	Temperature	Water	303(d)
	Dissolved oxygen pH	Water	Water of Concern
Hammersley Inlet			
	Dissolved oxygen Fecal coliform	Water pH	Water of Concern
Harstene Island Grp	No new parameters		
Case Inlet			
	Dissolved oxygen	Water	303(d)

Conventional Water Quality and Associated Parameters

This section describes the stratification, dissolved oxygen, and nutrient conditions of South Sound waters. Much of this information is derived from Ecology marine monitoring stations (Figure 2).

Stratification

Stratification is the natural layering of water based on its density. Sea water is most dense, and fresh water, such as that entering into the Puget Sound from rivers, is less dense. Stratification can be persistent to intermittent, and can vary
Table 2. Proposed 2002 new toxics water, sediment and tissue quality listings by landscape area. (*Final 2002/2004 list is expected to be available summer 2005.*)

Landscape Area	Parameter	Medium	Type of Listing
Carr Inlet			
	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene 2,4-Dimethylphenol Benzyl alcohol Butylbenzyl phthalate Hexachlorobenzene	Sediment	Water of Concern
	Total PCBs	Tissue	Water of Concern
McNeil Island Grp			
	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene Hexachlorobenzene	Sediment	303(d), also Water of Concern
	Total PCBs	Tissue	303(d), also Water of Concern
	1,4-Dichlorobenzene 2,4-Dimethlyphenol Acenaphthene Benzo(a)anthracene Benzo(g,h,i)perylene Benzyl alcohol Butylbenzyl phthalate Chrysene Dibenz(a,h)anthracene Hexachlorobutadiene Dibenzofuran Fluorene HPAH Indeno(1,2,3-cd)pyrene Phenanthrene	Sediment	Water of Concern
	4,4'-DDE Dieldrin	Tissue	Water of Concern
Henderson Inlet			
	1,2,4-Trichlorobenzene 2,4-Dimethylphenol Benzyl alcohol Hexachlorobenzene	Sediment	Water of Concern

Table 2. Continued.

Budd Inlet			
	1,2,4-Trichlorobenzene 1,2-Dichlorobenzene Hexachlorobenzene 2,4-Dimethylphenol 2-Methylphenol 4-Methylphenol Benzo(k)fluorene Benzyl alcohol	Sediment	303(d) and some parameters additionally with an area(s) proposed for Water of Concern status.
	Total PCBs	Tissue	303(d)
	Butylbenzyl phthalate Cadmium Pentachlorophenol	Sediment	Water of Concern
Eld Inlet	No parameters		
Totten Inlet			
	1,2,4-Trichlorobenzene 2,4-Dimethylphenol Benzyl alcohol Hexachlorobenzene	Sediment	Water of Concern
Hammersley Inlet	No parameters		
Harstene Is Group			
	Bis(2-ethylhexyl)phthalate	Sediment	303(d)
	Total PCBs	Tissue	303(d) and also area(s) with Water of Concern status
	Benzyl alcohol 1,2,4-Trichlorobenzene Hexachlorobenzene	Sediment	Water of Concern
Case Inlet			
	Bis(2-ethylhexyl)phthalate	Sediment	303(d)
	Hexachlorobenzene 2,4-Dimethylphenol Benzyl alcohol	Sediment	Water of Concern

from strong, to weak (Newton et al. 2002). Density stratification influences how readily pollutants will be mixed out, and whether dissolved oxygen conditions will develop or persist "*The stronger the stratification the more likely reduced water quality can develop*" (Newton et al. 2002).

Figure 3, adapted from Newton et al. (2002) displays the stratification of 13 Ecology marine monitoring stations in South Sound, based on data from 1990 to 2000. Of the 13 sites, two are classed as having strong stratification. These are Budd Inlet site BUD002 which has persistent strong stratification, and the other is Hammersley Inlet site OAK004 which has intermittent strong stratification. Most sites, (10) are classified as having infrequent but moderate stratification. These sites are located in Carr, Case, Totten, Eld, and Budd Inlets, and in both the Harstene and McNeil Islands groups. Only one station (DNA001 within the Harstene Island Group) is classified as having weak and infrequent density stratification.

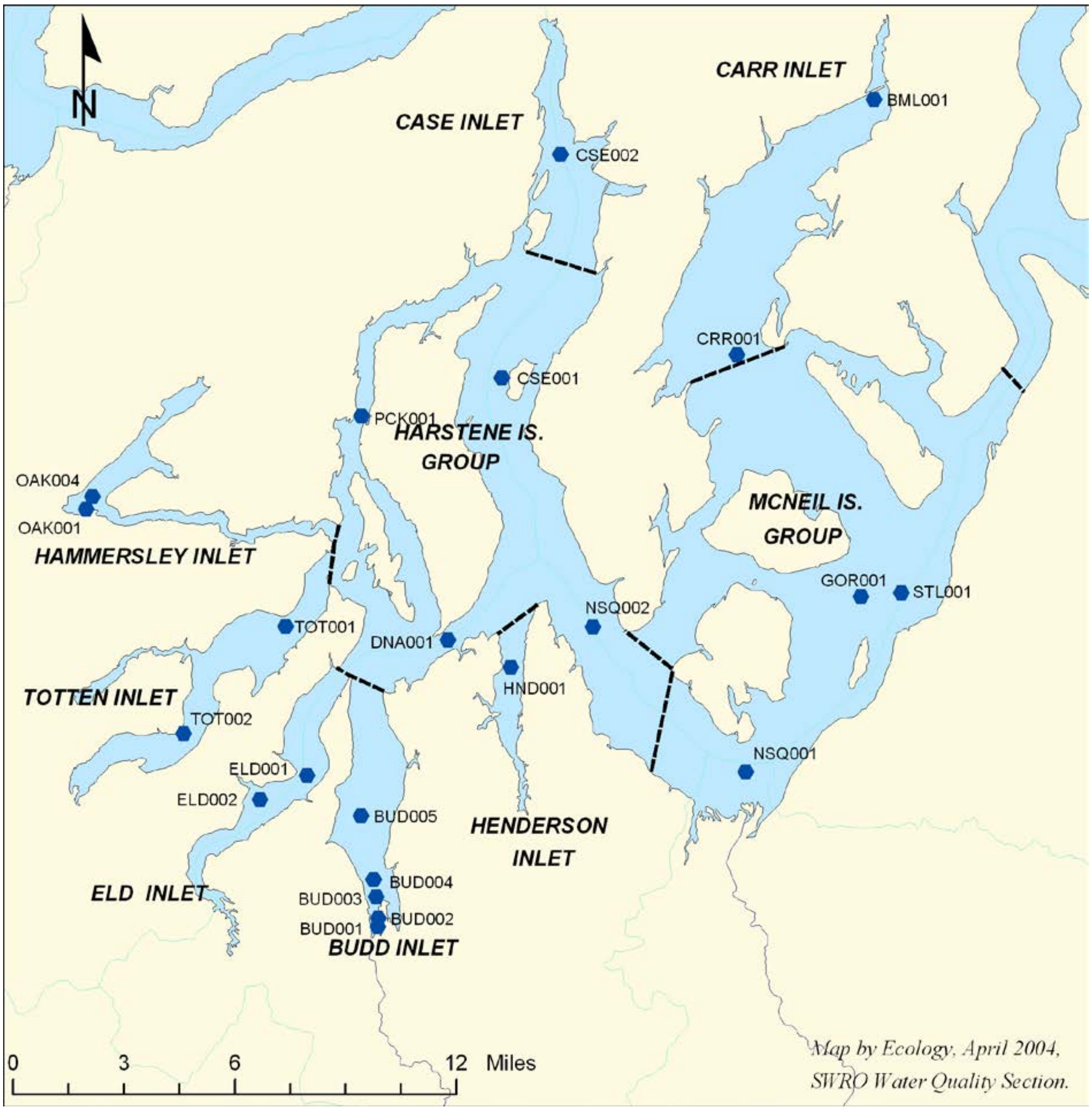
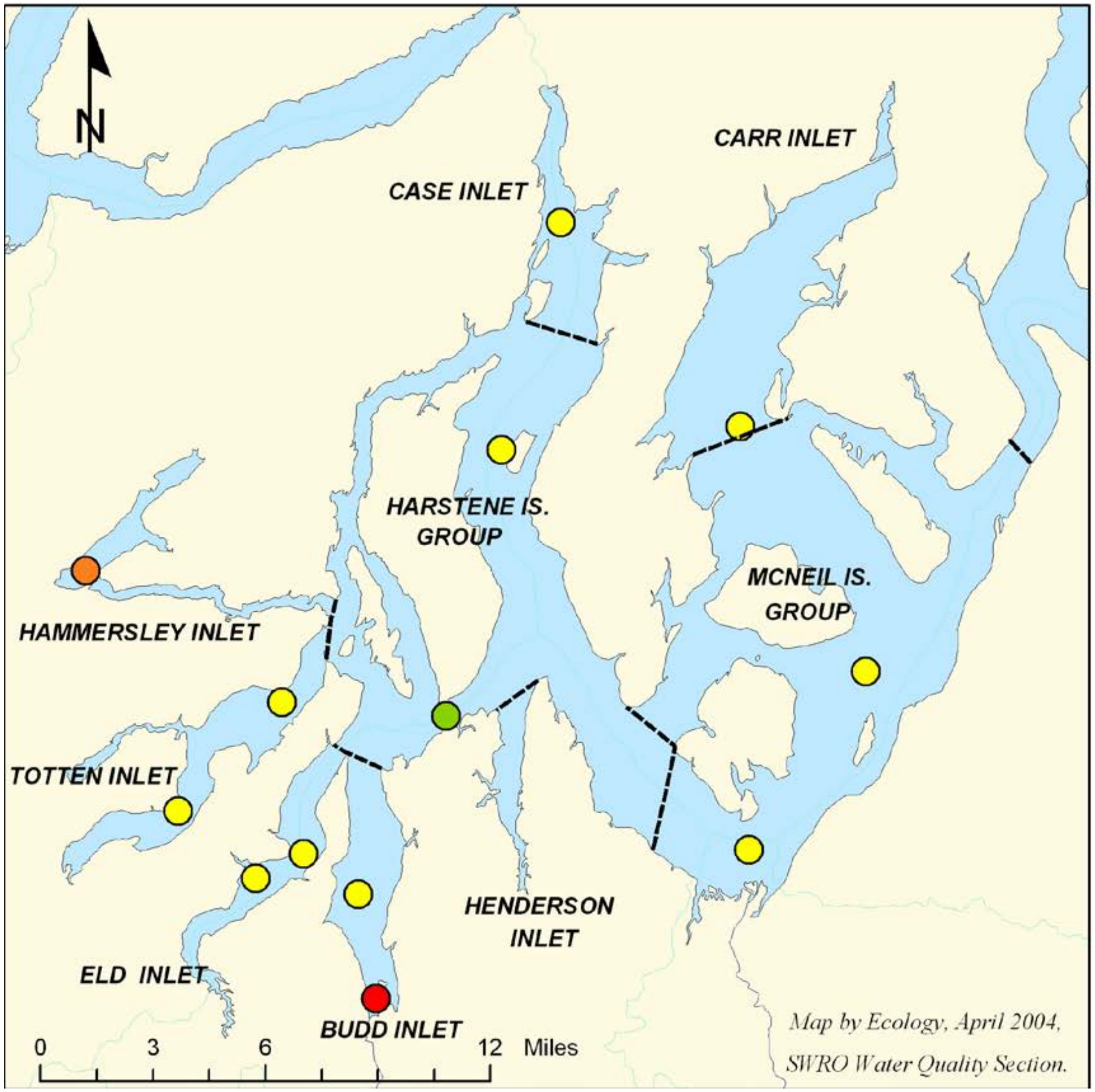


Figure 2. South Sound Department of Ecology marine ambient monitoring stations, shown within the South Sound recovery landscape sub-areas.

Dissolved Oxygen

Dissolved oxygen is required by fish for essential functions (Kramer 1987). Levels of dissolved oxygen <5 mg/L can cause biological stress, and levels <3 mg/L (hypoxia) can cause mortality or other significant effects (Newton et al. 2002). Low dissolved oxygen can be caused by the decomposition of organic material, from either natural or anthropogenic sources, or a combination of both (Newton et al. 2002).



LANDSCAPE ANALYSIS AREA	ECOLOGY STATION NAME	STRATIFICATION INTENSITY[a]	FREQUENCY[b]
CARR INLET			
	CRR001	Moderate	Infrequent
MCNEIL IS. GROUP			
	GOR001	Moderate	Infrequent
	NSQ001	Moderate	Infrequent
HENDERSON INLET			
	No data		
BUDD INLET			
	BUD002	Strong	Persistent
	BUD005	Moderate	Infrequent
ELD INLET			
	ELD001	Moderate	Infrequent
	ELD002	Moderate	Infrequent
TOTTEN INLET			
	TOT001	Moderate	Infrequent
	TOT002	Moderate	Infrequent
HAMMERSLEY INLET			
	OAK004	Strong	Intermittent
HARSTENE IS. GROUP			
	DNA001	Weak	Infrequent
	CSE001	Moderate	Infrequent
CASE INLET			
	CSE002	Moderate	Infrequent

[a]Density stratification intensities are based on the mean change in sigma-*t* as follows: strong is >2.0; moderate is >0.5-2.0; and weak is 0-0.5.

[b]Density stratification frequencies are as follows: infrequent is 0-33% of time; intermittent is >33-67% of time; and, persistent is >67-100% of the time.

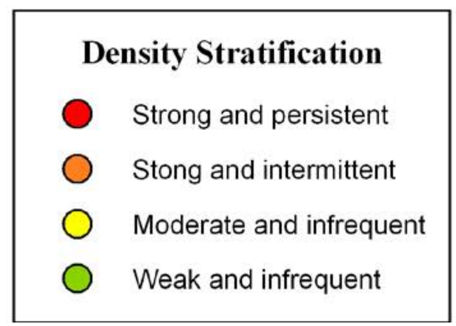


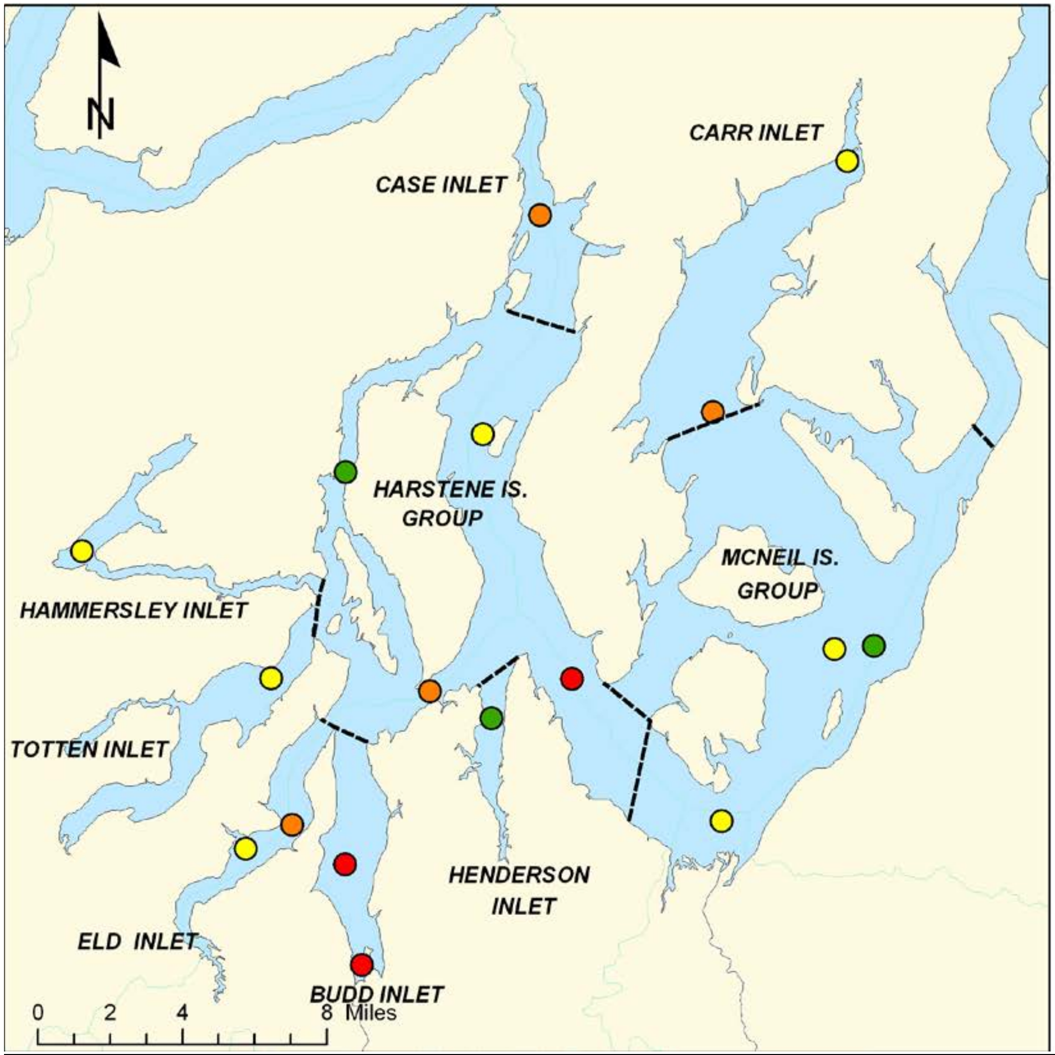
Figure 3. South Sound nearshore and marine density stratification. (*Based on data and analysis in Newton et al. 2002.*)

Determining whether low dissolved oxygen levels are a natural occurrence or are affected by human sources can be difficult. One aspect of this is the input to Puget Sound in late summer of ocean waters with a naturally low dissolved oxygen content of 5 mg/L or less (Newton et al. 2002). Newton et al. (2002) state "*However, because the inflowing upwelled waters have a naturally low DO content that is minimum in late summer (at about 5 mg/L or less), any human activity that decreases the DO concentration will have a more profound water quality impact, since the initial concentration is already about at the limit where some species encounter stress. This is especially important since the timing of the lowest DO concentrations from the oxidation of organic production is also in late summer. A small amount of anthropogenic nutrient input can have a larger effect at this time than it would if the oceanic waters' DO concentrations were higher. Puget Sound is a very unique system in this respect. Human contributions to DO debt must be carefully evaluated.*"

For purposes of this report dissolved oxygen data (utilizing the lowest dissolved oxygen values recorded during years 1990 to 2003) from 17 Ecology South Puget Sound marine ambient monitoring stations were grouped into four categories. These categories are very low (<3.0 mg/L), low (<5.0 mg/L), good (>5.0 mg/L), and excellent (> 6.0 mg/L). The first two categories are based on Newton et al. (2002), and the second two categories reflect the state water quality standards for Class B and A waters, respectively. We have not included a category for >7 mg/L (i.e., the Class AA standard) as no station had a minimum value that exceeded this level.

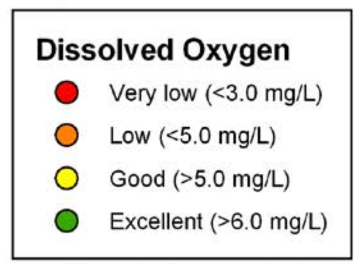
Dissolved oxygen results are shown in Figure 4. Seven of 17 (41%) stations recorded low (four stations) or very low (three stations) levels of dissolved oxygen. There were seven stations with good minimum levels, and three with excellent minimum recorded levels. Landscape sub-areas Henderson, Totten, and Hammersley Inlets, and the McNeil Island Group had no stations with low or very low dissolved oxygen.

The concern about low dissolved oxygen impacts from increasing development in the South Sound led Washington Department of Ecology to initiate development of coupled, three-dimensional hydrodynamic and water quality models of South Sound (Albertson et al. 2002). Phase I has been completed and has confirmed the South Sound's sensitivity to increased nutrients and susceptibility to low dissolved oxygen conditions related to nutrient additions (Albertson et al. 2002). The model results suggest that Carr, Case, and Budd Inlets are potentially the most sensitive to increased nutrient loads. Additional data is necessary to make this model fully functional for elucidating South Sound nutrient and dissolved oxygen relationships.



LANDSCAPE ANALYSIS AREA	ECOLOGY STATION NAME	DO mg/L[a]	DO CATEGORY
CARR INLET			
	BML001	5.7	Good
	CRR001	3.7	Low
MCNEIL IS. GROUP			
	GOR001	5.5	Good
	STL001	6.4	Excellent
	NSQ001	5.8	Good
HENDERSON INLET			
	HND001	6.5	Excellent
BUDD INLET			
	BUD002	2.4	Very low
	BUD005	1.6	Very low
ELD INLET			
	ELD001	4.9	Low
	ELD002	5.9	Good
TOTTEN INLET			
	TOT001	5.9	Good
HAMMERSLEY INLET			
	OAK004	5.4	Good
HARSTENE IS. GROUP			
	NSQ002	2.6	Very low
	DNA001	4.8	Low
	PCK001	7.0	Excellent
	CSE001	5.4	Good
CASE INLET			
	CSE002	4.8	Low

[a]Dissolved oxygen concentrations <3.0 mg/L, e.g., hypoxia, are deleterious to many organisms; concentrations <5.0 mg/L may induce biological stress (Newton et al. 2002).



Map by Ecology, April 2004,
SWRO Water Quality Section.

Figure 4. South Sound nearshore and marine minimum dissolved oxygen values. (*Data from Ecology Marine Monitoring Program for years 1990 to 2003. These are the lowest values measured through the entire water column.*)

Ammonium-N (Ammonia-Based Nitrogen)

Ammonium-N is a by-product of decomposition of organic matter and comes from both natural and anthropogenic sources. Natural sources include degradation of organic nitrogen and denitrification, whereas human sources include degradation of sewage or other inputs (Newton et al. 2002). Ammonium-N is utilized in plankton nutrient cycles; zooplankton excrete ammonium-N (Dugdale & Goering 1967; Valiela 1984), and phytoplankton assimilate this nutrient (Parsons et al. 1984). As such, "*it is rarely observed in substantial quantities in seawater*" (Newton et al. 2002). Elevated levels of Ammonium-N may indicate an anthropogenic ammonia source such as sewage (Newton et al. 2002).

High (>5 µM) and/or very high (>10 µM) ammonium-N concentrations were found at 62% (8 of 13) of South Sound Ecology marine monitoring stations, versus 31% (10 of 32) of stations in Central and Northern Puget Sound (Newton et al. 2002). Two stations in Budd Inlet (BUD002 & BUD005), had very high concentrations. High concentrations were found in Eld Inlet (station ELD002), Totten Inlet (station TOT002), Hammersley Inlet (station OAK004), Harstene Island Group (stations DNA001 & CSE001), and Case Inlet (station CSE002). Figure 5 displays this information.

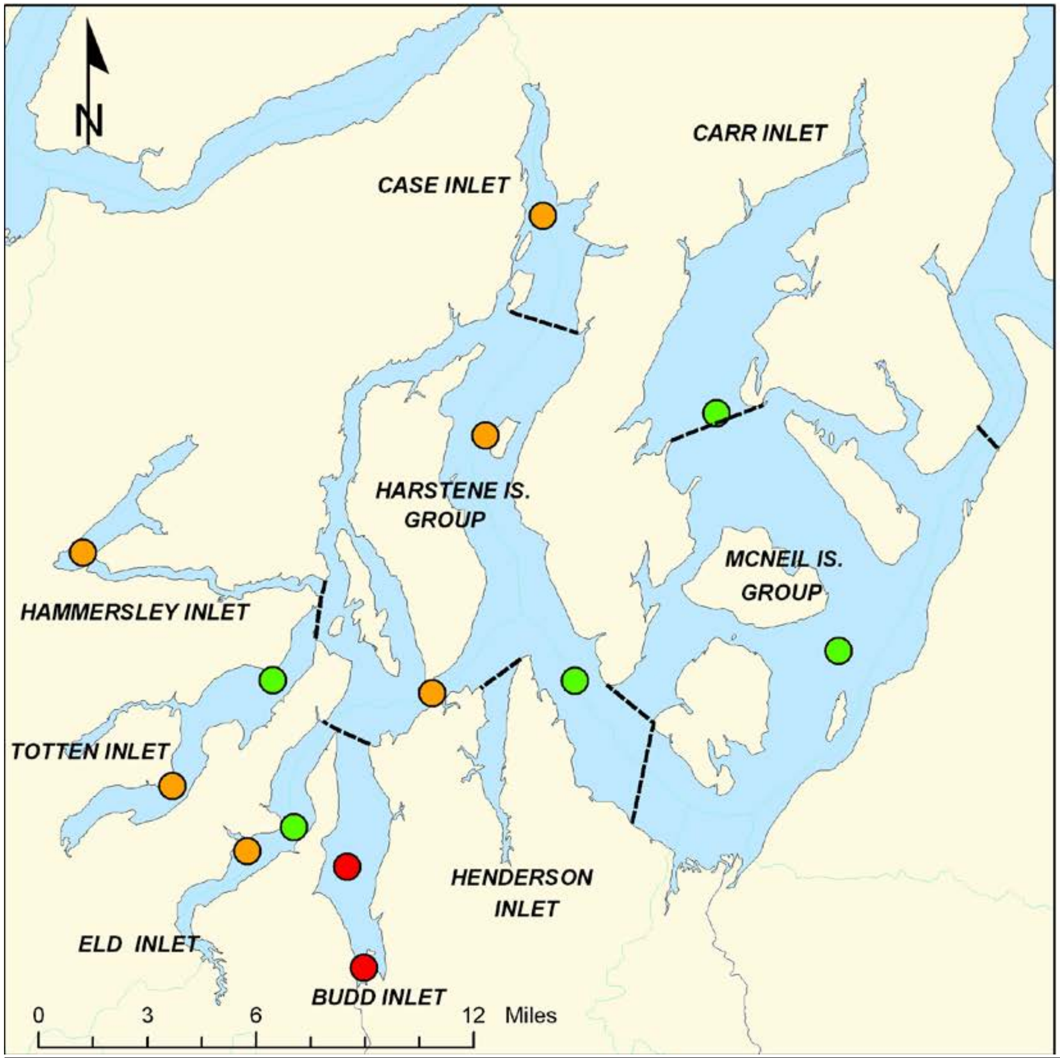
Nitrite

High nitrite concentrations can indicate eutrophication (Newton et al. 2002). South Sound had the majority (ca. 64%, n_{total} = 11) of Puget Sound marine monitoring stations with high nitrite concentrations between October 1997 to December 2000 (South Sound stations: BUD002, BUD005, CRR001, CSE001, CSE002, DNA001, NSQ002) (Newton et al. 2002).

Surface Dissolved Inorganic Nitrogen

Surface dissolved inorganic nitrogen (DIN) is the combined concentration values of nitrate+nitrite-N plus ammonium-N. Low DIN concentrations occurring over extended periods of time (<1 µM for >3 or >5 months) are useful indicators of areas sensitive to human-caused nutrient inputs (Newton et al. 2002). "*Adding nutrients to these locations could result in increased organic production that could subsequently lead to lower DO concentrations*" Newton et al. (2002)

The two island sub-areas did not show sensitivity based on this indicator parameter; however, sensitivity to added nutrients was prominent in the South Sound, with six of the seven inlet sub-areas (all but Eld Inlet) having data that reflected a high or very high sensitivity to human-caused nutrient inputs (see Figure 6) (Newton et al. 2002).



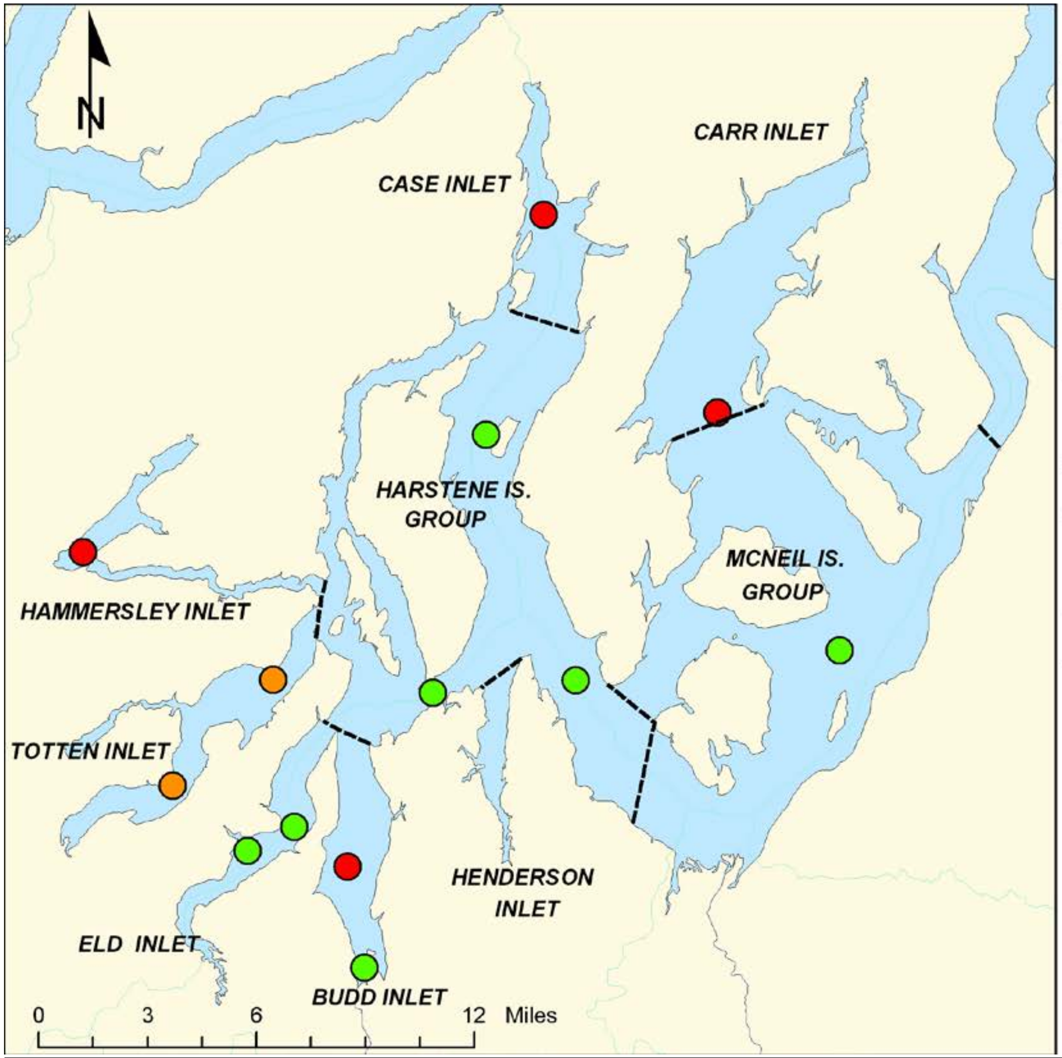
LANDSCAPE ANALYSIS AREA	ECOLOGY STATION NAME	AMMONIUM-N CATEGORY
CARR INLET		
	CRR001	Not high
MCNEIL IS. GROUP		
	GOR001	Not high
HENDERSON INLET		
	No data	
BUDD INLET		
	BUD002	Very high
	BUD005	Very high
ELD INLET		
	ELD001	Not high
	ELD002	High
TOTTEN INLET		
	TOT001	Not high
	TOT002	High
HAMMERSLEY INLET		
	OAK004	High
HARSTENE IS. GROUP		
	NSQ002	Not high
	DNA001	High
	CSE001	High
CASE INLET		
	CSE002	High

Maximum Ammonium-N Concentration

- Not high (max. <or=5 micrograms/M)
- High (max. >5 micrograms/M)
- Very high (max. >10 micrograms/M)

Map by Ecology, April 2004,
SWRO Water Quality Section.

Figure 5. South Sound nearshore and marine ammonium-N maximum concentrations. (*Data is from October 1997 through December 2000. Based on data and analysis in Newton et al. 2002.*)



LANDSCAPE ANALYSIS AREA	ECOLOGY STATION NAME	SENSITIVITY CATEGORY
CARR INLET		
	CRR001	Very high
MCNEIL IS. GROUP		
	GOR001	Not high
HENDERSON INLET		
	No data	
BUDD INLET		
	BUD002	Not high
	BUD005	Very high
ELD INLET		
	ELD001	Not high
	ELD002	Not high
TOTTEN INLET		
	TOT001	High
	TOT002	High
HAMMERSLEY INLET		
	OAK004	Very high
HARSTENE IS. GROUP		
	NSQ002	Not high
	DNA001	Not high
	CSE001	Not high
CASE INLET		
	CSE002	Very high

Sensitivity to Added Nutrients (length of time with <1 microgram/M Dissolved Inorganic Nitrogen)

- Not high (low DIN for 0-2 months)
- High (low DIN for 3-4 months)
- Very high (low DIN for >=5 months)

Map by Ecology, April 2004, SWRO Water Quality Section.

Figure 6. South Sound nearshore and marine sensitivity to added nutrients. (*Data is from October through December 2000. Based on data and analysis in Newton et al. 2002.*)

4. Marine Ecosystem Contaminants

Toxics in nearshore and marine ecosystems include older, persistent contaminants, as well as newer contaminants that have poorly understood effects on salmonids and their ecosystem. Two recent efforts (Johannessen & Ross 2002; EVS Environmental Consultants 2003) have compiled information on the effects of toxics on fish and the marine ecosystems. Johannessen & Ross (2002) investigated the possibility that contaminants were responsible for a change in adult return timing for Fraser River late-run sockeye that has resulted in a change in pre-spawning adult mortality from 10% to over 90% between 1994 and 2001. Johannessen & Ross (2002) state "*Contaminants could be contributing to the disruption of migratory timing through a number of contaminant-related impacts, including a disruption of endocrine processes (e.g. permanent or transitory neurotoxicity or developmental toxicities) or interference with olfactory cues during migration.*"

In a study of importance to Puget Sound chinook, Arkoosh et al. (1998, reported in EVS Environmental Consultants 2003) studied juveniles from the Duwamish estuary (where fish are exposed to PCB, DDT and PAHs), along with juveniles from a hatchery and a non-urban estuary. They tested the fish for immune system effects by exposing the fish to the marine pathogen *Vibrio anguillarum* (Arkoosh et al. 1998). The Duwamish fish incurred higher mortality than the other fish and retained poor immune function for least two months after being removed from the contaminated area (Arkoosh et al. 1998).

<u>Key Concepts for Understanding Toxics Issues and South Sound Fish and Ecosystem Function</u> (*Based primarily on information from Washington Department of Fish and Wildlife Marine Research Scientists Sandra O'Neill and Jim West.*)

- Due to low flushing rates, residency times for contaminants in South Sound are likely to be longer (e.g., see Preikshot & Beattie 2001), and therefore to have bigger ecosystem effects than in the North Sound and Central Sound.
- Hypothesis: fish residence time is related to toxic uptake; greater residence time = greater uptake (O'Neill et al. 1998).
- South Sound fish in comparison to North Sound fish, spend a lot of time in potentially polluted waters and may therefore be in greater contact longer with contaminants such as PCBs, have a greater likelihood of being effected by other contaminants, and be more sensitive because of this (also see O'Neill et al. 1998). They additionally must travel to the sea and back through the more highly polluted Central Sound.
- Salmon that spend more years in the ocean have lower contaminant levels. Based on WDFW research it appears that most PCBs in Puget

Sound salmon are obtained in the Puget Sound, vs. the ocean. Only small amounts of PCBs were found in salmon juveniles in freshwater (e.g., Duwamish salmon).

- South Sound adult salmon (Nisqually and Deschutes) have higher levels of PCBs than those in Central and South Sound.
- Toxics are degraded habitat. Physical habitat may be restored, but contaminants could potentially prevent fish stocks from being restored.
- Food chain issues.
    - o Salmon eat sand lance, smelt, and herring.
    - o English sole and crabs absorb bottom contaminants, and may mobilize these contaminants though their production of eggs and larvae.
    - o The South Sound "Squaxin" herring stock has elevated levels of PCBs above those in Northern Puget Sound. These herring are thought to move within both South and Central Puget Sound. As part of the food chain, they bring contaminants to the South Sound.
    - o Salmon transfer PCBs to eggs and offspring may start with contamination. In addition, returning salmon are bringing PCBs to disperse in their natal watersheds and streams when they return to spawn (see also Johannessen and Ross 2002).

Contaminant Categories, Fish Effects, and South Sound Information

We considered five categories of toxics (legacy toxics, endocrine disruptors and other pharmaceuticals, PAHs, pesticides, and PBDEs) important to the marine ecosystem of South Puget Sound, and thus the recovery and long-term health of its salmonid populations. They, along with a brief overview of effects to fish, and South Sound data are described below. This is not a comprehensive overview of toxics issues but a summary of key issues important to consider for salmon recovery.[1]

1. Legacy Toxics. Polychlorinated biphenols (PCBs) are an example of a legacy toxic of significant concern. PCBs are neurotoxins (i.e., cause damage to the brain)that may cause changes in salmon behavior such as migration timing (Johannessen & Ross 2002). Although PCBs were banned from production three decades ago, they still pose a risk to the aquatic food chain (EVS Environmental Consultants 2003) and are present in Puget Sound fish (salmon, herring, and rockfish). The Central Sound has the highest sediment concentrations of PCBs in Puget Sound (Dutch et al. 2003). Because South Sound fish must travel through Central Sound, and because Central Sound marine waters flow to South Sound,

[1]Readers are encouraged to also refer to Johannessen and Ross (2002), EVS Environmental Consultants (2003), and other literature.

this may represent a substantial pollutant source to South Sound waters and fish (O'Neill & West, pers. comm. 2004).

From 1992 to 1995 O'Neill et al. (1998) studied the PCB concentrations in Puget Sound coho and chinook. Chinook had greater PCB concentrations than coho, and marine area sampled fish had greater concentrations of PCB's than fish from rivers. Nisqually River coho had the highest concentrations of PCBs, followed by coho from the Deschutes; coho from the Skagit and Nooksack rivers had the lowest PCB concentrations. Three of seven hatchery coho from Nisqually had PCB levels ca. two-times higher than wild Nisqually coho. O'Neill et al. (1998) question whether South Sound coho with very high levels of PCBs might have been delayed-release fish that spent more time in South Sound, and therefore had a greater length of time in contact with contaminants.

Spatial trends and concentrations (ppb, dry weight) of PCBs in Puget Sound are shown in Figure 7 (from Dutch et al. 2003). South Sound is among areas with the lowest PCB concentrations (mean = 4.62 ppb), however, 29% (12 of 42) of South Sound sites tested positive for PCB presence. Central Puget Sound has the broadest contamination, with 63% of sites (37 of 47) testing positive for PCBs and the highest mean contamination level within the Puget Sound (mean = 92.46 ppb). The Whidbey Basin had PCBs at 46% of the sample areas and the highest PCB level of the study (100.80 ppb). North Sound and Hood Canal had the lowest overall extent of occurrence and contamination level.

2. Endocrine Disruptors and other Pharmaceuticals. Endocrine related functions include "*development, growth, reproduction, chemical balance (osmoregulation), and chemical messaging…disruption of this system can affect behaviour and the timing and extent of changes in the body such as smoltification*" (reviewed by Johannessen & Ross 2002).

The presence of estrogen mimics (e.g., pharmaceutical products) is correlated with sewage and normal releases from treatment plants (O'Neill & West, pers. comm. 2004). These hormones are believed to affect the hormone system and future fitness levels. In Elliot Bay (Central Puget Sound), English sole males have been found with female estrogen effects (O'Neill & West, pers. comm. 2004). Data specific to South Sound regarding pharmaceuticals in wastewater is not available. A screening study of pharmaceuticals in the Sequim/Dungeness area (Johnson & Carey 2004) is in the developmental stage; similar assessment work tied to fish populations would be useful for South Sound.

3. Polycyclic Aromatic Hydrocarbons (PAHs). These are contaminants from burning, motorized boats, cars, oil spills, and creosote. Once in South Sound water, they may stay because of slow flushing rates (O'Neill & West, pers.

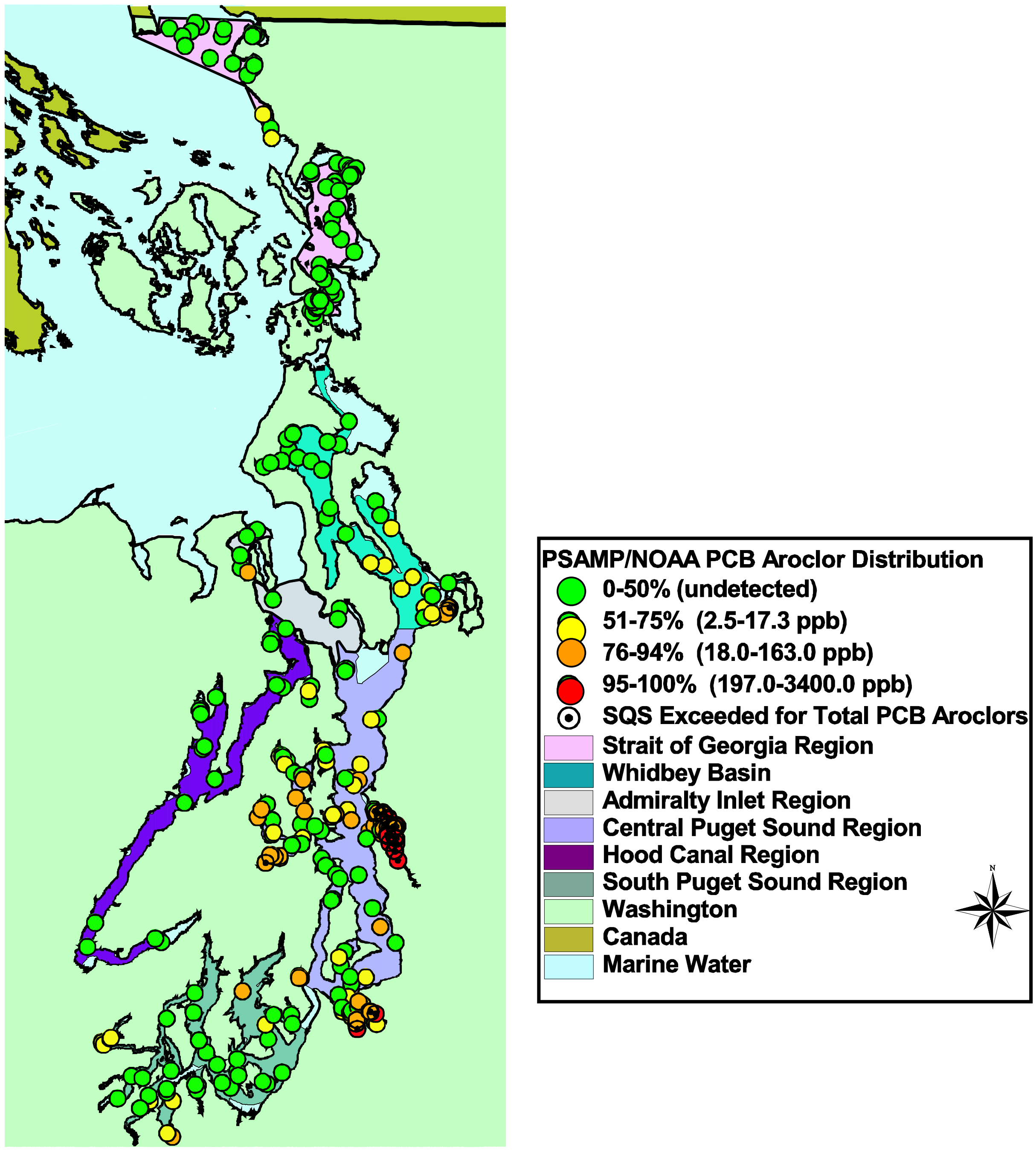


Figure 1. Distribution of total PCB Aroclor concentrations (ppb, dry wt.) in sediments from the 1997-99 PSAMP/NOAA sediment survey, and comparison with Washington State Sediment Quality Standards (SQS) (Ecology, 1995). (Reproduced with permission from Dutch et al. 2003.)

comm. 2004). Effects on salmonids include "*neurosensory damage, increased oxygen consumption, and the impairment of neurotransmission, muscle contraction and osmoregulation*" (Neff 1979).

4. Pesticides (Insecticides and Herbicides) and Additives. Many organophosphate and carbamate pesticides affect nervous system function (Johannessen & Ross 2002). In addition to mortality the effects on fish, (reviewed in Johannessen and Ross 2002) "*can include: reproduction problems, reduced stamina, altered swimming and social interaction, flared opercula, hyperexcitability, and other behaviour changes…*" Additional effects may be related to olfaction (i.e., sense of smell), and could interfere with "*feeding, defence, schooling, reproduction, and migration*" (reviewed in Johannessen & Ross 2002).

Diazinon, triclopyr and the additive nonylphenol are examples of pesticides that may have salmonid impacts. Diazinon, an organophosphate pesticide used for lawns and gardens, is reported as a "*common contaminant in the effluent of wastewater treatment plans in the U.S. and most commonly detected insecticide in urban streams in the U.S.*" (Johannessen & Ross 2002). Sub-lethal effects to salmonids from diazinon can include impaired: homing behavior, female scent acknowledgement by males, and anti-predator behaviors (Johannessen & Ross 2002). A large scale increase in triclopyr use in British Columbia forests between 1994 and 1998 coincides heavy adult pre-spawner mortality for Fraser River late sockeye, but there are no data linking these two events (Johannessen & Ross 2002). The forest pesticide additive nonylphenol, which may cause endocrine disruption, is a possible cause of Atlantic salmon declines (Fairchild et al. 1999).

5. PBDEs (Polybrominated Diphenyl Ethers). PBDEs are persistent, bio-accumulating toxics used as flame retardants in products such as mattresses and carpeting. They have a similar structure to PCBs, and appear to behave similarly (O'Neill & West, pers. comm. 2004). PBDE concentrations in the environment are increasing throughout North America, with contaminants appearing in Great Lakes fish (O'Neill & West, pers. comm. 2004), and in the Canadian Arctic biota in exponentially increasing amounts (Johannessen & Ross 2002).

Global Warming (*A Brief Note*)

Global warming may cause substantial changes in the South Sound ecosystem. Preikshot & Beattie (2001) note "*Changes in primary production and physical oceanographic conditions in SPS caused by global warming, due to the accumulation of greenhouse gases, and inter-decadal climate patterns imply profound disturbances to SPS salmonid stocks.*"

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Attachment to Water Quality Appendix: South Sound Marine Water Quality Standards

The Washington Administrative Code (WAC) that addresses water quality is Chapter 173-201A (1997). The marine and nearshore waters of Carr, Henderson, Totten and Case Inlets, the McNeil Island Group, and waters to the east of Harstene Island are classed as AA (extraordinary waters) in Chapter 173-201A Sections 120 and 140. Marine and nearshore waters in Budd Inlet north of Priest Point Park, Eld Inlet, Hammersley Inlet (but not including inner Shelton Harbor), and the waters to the west of Harstene Island are classed as A (excellent water quality). The marine and nearshore waters of Budd Inlet south of Priest Point Park, and Oakland Bay (inner Shelton Harbor), are classed as B (good water quality).

The water quality standards include three types of criteria that are to be protected and are of importance to salmon and salmon recovery for the South Sound. These are (1) narrative standards, (which include a general water quality characteristics statement, inclusion of wildlife habitat as a characteristic use, and non-specific portions of the standards such as for deleterious material); (2) the numeric criteria (e.g., for water temperature); and, (3) the WAC 173-201A-070 Antidegradation policy. These are further described below. In addition, readers are referred to WAC 173-201A for additional information.

Narative Standards

<u>General Water Quality Characteristics</u>

The general water quality characteristics of waters are (Chapter 173-201A Section 30):

- Class AA "*Water quality of this class shall markedly and uniformly exceed the requirements for all or substantially all uses*."
- Class A "*Water quality of this class shall meet or exceed the requirements for all or substantially all uses.*"
- Class B "*Water quality of this class shall meet or exceed the requirements for most uses."*

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Characteristic Uses

Characteristic uses (i.e. beneficial uses) to be protected are defined in Chapter 173-201A Section 30-1(b) to include the following:

(i) Water supply (domestic, industrial, agricultural), (*Class AA & A only*).
(ii) Stock watering.
(iii) Fish and shellfish – Salmonid migration, rearing, spawning (*Class AA & A only*) and harvesting. Other fish migration, rearing, spawning, and harvesting. Clam, oyster, and mussel rearing, spawning and harvesting (*harvesting Class AA & A only*). Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting.
(iv) Wildlife habitat.
(v) Recreation (primary contact recreation (*secondary contact for Class B)*, sport fishing, boating, and aesthetic enjoyment).
(vi) Commerce and navigation.

Water Quality Criteria (Numeric and Narrative)

Section 30 defines the water quality criteria that apply to Class AA, A and B waters. These include[1]:

- **Dissolved oxygen, Marine:** – dissolved oxygen shall exceed 7.0 mg/L (*Class AA*), 6.0 mg/L (*Class A*), and 5.0 mg/L (*Class B).*[2]
- **Water temperature, Marine:** – temperatures shall not exceed 13.0 C (*Class AA*), 16.0 C (*Class A*), or 19.0 C (*Class B)* due to human activities.[3]
- **pH, Marine:** – pH shall be within the range of 7.0 to 8.5 with a human-caused variation within the range for Class AA waters of <0.2 units, for Class A and B waters of <0.5 units.
- **Toxic, radioactive, or deleterious material concentrations:** Toxic, radioactive, or deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent up those waters, or adversely affect public health, as determined by the department (see WAC 173-201A-040 and 173-201A-050).

[1] Also included but not detailed are criteria for fecal coliform organisms, total dissolved gas, turbidity, and aesthetic values.
[2] See WAC 173-201A Section 30 for additional specifics regarding natural depressed dissolved oxygen conditions and human-caused activities allowances.
[3] See WAC 173-201A Section 30 for additional specifics regarding natural conditions that exceed the temperature standard and human-caused activities allowances.

Anti-degradation Policy

WAC 173-201A-070, the anti-degradation policy states:

(1) Existing beneficial uses shall be maintained and protected and no further degradation which would interfere with or become injurious to existing beneficial uses shall be allowed.

(2) Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria.

(3) Water quality shall be maintained and protected in waters designated as outstanding resource waters in WAC 173-201A-080.

(4) Whenever waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected and pollution of said waters which will reduce the existing quality shall not be allowed, except in those instances where:

- (a) It is clear, after satisfactory public participation and inter-governmental coordination, that overriding considerations of the public interest will be served.
- (b) All wastes and other materials and substances discharged into said waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment by new and existing point sources before discharge. All activities which result in the pollution of waters from nonpoint sources shall be provided with all known, available, and reasonable best management practices.
- (c) When the lowering of water quality in high water quality waters is authorized, the lower water quality shall still be high enough quality to fully support all existing beneficial uses.

(5) Short-term modification of water quality may be permitted as conditioned by WAC 173-201A-110.