WETLANDS

INTRODUCTION

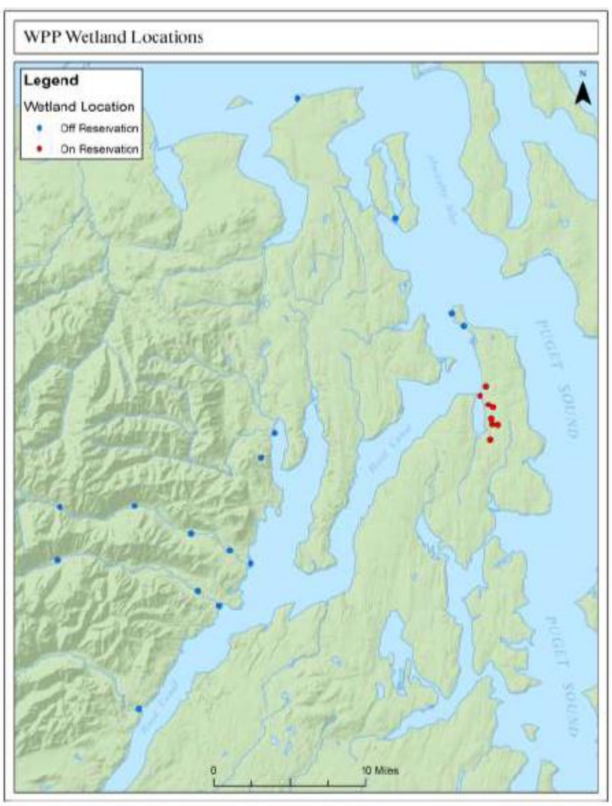
The Port Gamble S'Klallam Tribe places great value on wetlands as a cultural resource. Coastal and inland wetlands provide habitat for species that are important for subsistence, economic, and cultural reasons—including elk, deer, shellfish, and salmon—as well as traditional medicines. Wetlands also protect coastlines from storm damage, help to filter runoff from developed areas, and provide recreational opportunities for wildlife viewing, hunting, and fishing [1].

In 1992, there were 86 acres of palustrine wetlands (inland non-tidal areas like swamps) and 8 acres of salt marsh on the reservation; lands that have received Trust status since then have additional wetlands [2]. Figure 1 maps some of the wetlands that the Tribe considers to be particularly significant. In addition to wetlands on the reservation (see text box), these include wetlands in the upper and lower Dosewallips and Duckabush and associated deltas, as well as the Hamma Hamma delta, Quilcene, Foulweather Bluff, Twin Spits, Kilisut Harbor, and Devil's Lake [2]. Some of the Tribe's wetlands have particular cultural significance, and associated data are therefore carefully protected [2].

Definition: Wetlands are lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.

Federal Geographic Data Committee (FGDC) Standard

Figure 1. Map of preliminary selection of significant wetlands within the Tribe's usual and accustomed areas (2014) [2].



On-reservation wetlands include [2]:

Miller Lake
Middle Creek/Dump Plume
Shipbuilders Creek
Creek behind Reservation Cabins
Wetland on trust land adjacent to Martha John tribs
Wetland at Martha John East WQ monitoring site
Point Julia salt marsh
Other unnamed wetlands

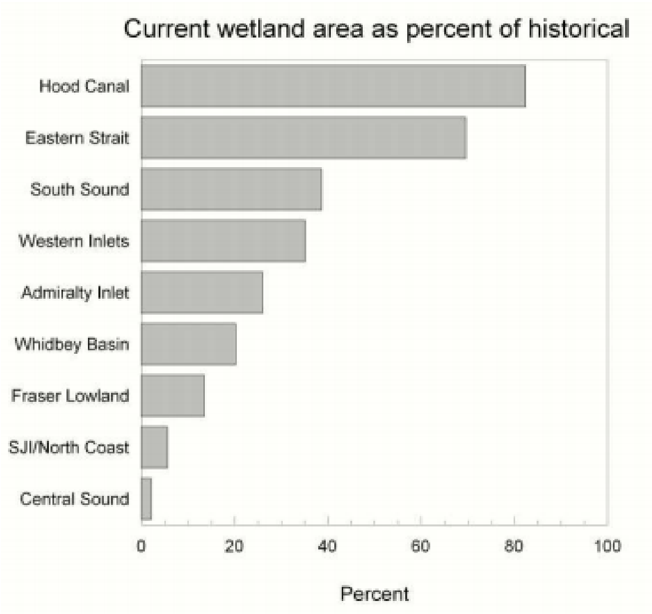
Puget Sound's wetlands have been affected for many years by human activity, such as agricultural expansion, conversion to urban land use, and construction of ports and industrial facilities [2]. A 2006 study found that the most common cause of wetland degradation in Hood Canal and the Strait of Juan de Fuca was fill associated with transportation infrastructure (e.g., railroads) or with residential development [3]. Collins and Sheikh estimated that current tidal wetlands in Puget Sound only cover 17% to 19% of their historical extent; the median size of the remaining wetlands is also smaller than before [4]. The rate of wetland loss across the U.S. has dropped since the late 1990s, due to federal programs and wetland reestablishment projects; however, reestablishment projects have been more successful in upland areas than in coastal areas, perhaps due to costs, competing land use interests, logistical challenges, coastal storms, and sea level rise [1].

Non-climate stresses such as development and pollution are likely to remain the lead degraders of wetlands [5], but climate change adds another layer of stress that puts wetlands at even greater risk. The Port Gamble S'Klallam Tribe has a wetlands program and a Wetland Conservation Program Plan (WCPP) that cover both wetlands on the reservation and those in usual and accustomed areas. The WCPP highlights the importance of considering sea level rise and other climate change projections when making decisions about future wetlands monitoring, assessment, protection, and enhancement [2].

The Point Julia salt marsh and wetland is a priority concern for the Tribe in the context of climate change. This area could be inundated as a result of sea level rise; the Tribe is also anticipating that it could be affected by increased erosion, sedimentation, and damage from extreme coastal weather events. See the Observed and Projected Climate Changes chapter for more information on sea level rise projections. Additional research is being conducted in partnership with the University of Washington in 2017.

Most of the tidal wetlands in Puget Sound have historically been comprised of the estuaries of large rivers, particularly on the eastern side of the Sound. In the past, only 1% of tidal marsh area in Puget Sound was made up of fan-delta estuaries draining the Olympic Mountains to Hood Canal and the Strait of Juan de Fuca through the Hamma Hamma, Duckabush, Dosewallips, Quilcene, Dungeness, and Elwha rivers; these are key parts of the Port Gamble S'Klallam Tribe's usual and accustomed area [4]. However, over time, the north Sound has lost a greater percentage of its historical wetland area than has Hood Canal (see Figure 2) [4]. As a result, the "steep" estuaries of the Olympic Peninsula now make up more—5%—of the region's tide marsh area [4].

Figure 2. Hood Canal has lost proportionally less of its tidal wetland area than other parts of Puget Sound. Source: Collins and Sheikh, DNR 2005 [4].



IMPACTS ON COASTAL WETLANDS

This chapter places special emphasis on coastal wetlands—such as tidal and intertidal wetlands and pocket estuaries—because of their important role as habitat for salmon and shellfish, which are key resources for the Tribe. As the climate changes, coastal wetlands are likely to be affected by sea level rise, changes in precipitation and associated shifts in streamflow and sediment delivery from coastal rivers, and increasing air and sea temperatures. As detailed below, the anticipated consequences include changes in wetland extent, their ability to provide adequate habitat, and, in the end, species composition and abundance.

CHANGES IN EXTENT

Sea Level Rise

As the sea level rises, and more land is inundated, estuarine beaches and tidal swamps are expected to shrink, while some tidal flats and salt marshes are expected to expand. In Puget Sound, estuarine beach area is projected to decrease by 7%, tidal freshwater marsh by 24%, and tidal swamp by 77% between 2000 and 2100, given mid-range sea level rise of 27 inches [6]. At Port Townsend, Admiralty Inlet, and Whidbey Island, specifically, there could be a 72% loss of estuarine beach by 2050; by 2100, an estimated 74% of brackish marsh and 29% of inland fresh marshes could be converted to salt marsh and tide flat [6]. Meanwhile, the tidal flat area could increase by an average of 240% [7]. Under a more extreme sea level rise scenario, USGS scientists found that most coastal wetlands around the world would disappear [8]. Storm surge on top of sea level rise will contribute to increased erosion of shorelines.

Sediment Delivery

Streams bring new sediment to tidal wetlands. With declining snowpack and more intense winter precipitation, more sediment is expected to be brought downriver. It is not currently known whether this increased sediment will be enough to help Puget Sound's tidal wetlands keep up with rising sea levels, however [7]. While a recent study in the Snohomish estuary found that soils in preserved sites without dikes are keeping pace with current estimated sea level rise [9], on average across the U.S., soil accretion will have to occur two to seven times more quickly over this century in order to keep up with rising sea levels [10]. If insufficient sediment arrives, tidal wetlands need to be able to migrate to higher ground in order to survive; armored shorelines, roads, and other development prevent this from happening in many places [8]. Steeper slopes also provide fewer opportunities than shallow slopes and level areas for new wetland creation as the sea level rises [9].

Soil accretion can happen more quickly when there are rootmats and vegetation to help trap sediment, pointing to wetland restoration and planting as useful adaptation strategies [9]. The carbon dioxide fertilization effect may also help with sediment accumulation. Experiments at the Smithsonian's Global Change Research Wetland found that as emissions continue to rise, increased carbon dioxide will speed the creation of new wetland soil because higher carbon dioxide increases the growth of some plant species [11]. Plant root production contributes to organic soil formation, which complements sediments delivered from rivers and the sea [10]. This increased soil creation could help to offset the pace of inundation from rising sea levels in some places.

RESEARCH NEED: Will sediment be delivered from local rivers at a fast enough rate to help wetlands keep up with sea level rise?

SPECIES COMPOSITION

Studies show that while wetland plants can often cope with increases in single stressors, it is much harder for them to adapt to multiple stressors [10]. Climate change adds a number of new threats on top of the development pressures already affecting these ecosystems.

In addition, because wetland plants and animals are located in a transition zone between aquatic and terrestrial environments, they are particularly sensitive to small, permanent changes in conditions [12]. A small drop in water levels, for example, can turn an inland wetland into dry ground, whereas it would have less impact on a lake [13].

Warming sea temperatures will affect coastal ecosystems with shallow water—like tidal wetlands—sooner than deeper ocean waters [14]. Higher water temperatures could affect the composition of plant and animal populations in these areas [6]. If these species have the time and pathways to migrate, and there are alternative habitats available, they may move.

Changes to water salinity and soil salinity induced by ocean acidification and sea level rise may also create conditions that are beyond the tolerance of some plants and invertebrates [15]. In coastal wetlands, sea level rise increases salinity exposure for plants that may, for example, prefer brackish water [12].

WILDLIFE HABITAT

The aforementioned impacts will specifically affect the habitat and survivability of animals that are of particular importance to the Port Gamble S'Klallam Tribe, such as a range of salmon, forage fish, shellfish, and various bird species.

FISH

Salmon rely on coastal marshes and other nearshore ecosystems for feeding and refuge from predation as they move into the ocean life stage (see Figure 3). Different salmon species spend different amounts of time in estuaries before moving on to the open ocean; juvenile Chinook and chum are particularly dependent on estuaries and pocket estuaries [6]. Chinook, pink, and chum fry and fingerlings may stay in these areas for up to 180 days [16]. Estuarine sampling done in North Hood Canal by researchers working with the Port Gamble S'Klallam Tribe found that coho and chum salmon were particularly abundant at tidal creek sites, and chum and pink salmon were most abundant at independent marsh sites [17].

RESEARCH NEED: Are the Tribe's inland wetlands more dependent on receiving water from precipitation, or from groundwater? Those relying on precipitation will be affected more directly by climate change.

Figure 3. Nearshore marine and estuarine habitat use by salmonid species in the Pacific Northwest. Adapted from Glick et al. 2007 citing Williams and Thom 2001 [6].

	Nearshore marine and estuary use		
	Adult residence	Adult and juvenile migration	Juvenile rearing
Chinook	Extensive	Extensive	Extensive
Chum	Little or unknown	Extensive	Extensive
Coho	Some	Extensive	Some
Sockeye	Little or unknown	Extensive	Little or unknown
Pink	Little or unknown	Extensive	Extensive
Source: Williams, G.D. and R.M. Thom. 2001. *Marine and Estuarine Shoreline Modification Issues* (Sequim, WA: Battelle Marine Sciences Laboratory/Pacific Northwest National Laboratory), p. 14.			

Changes in wetland extent will affect salmon directly, through habitat availability, and indirectly, through the food web. Studies in the Gulf of Mexico show that there is a complicated relationship between estuarine-dependent fish species and vegetation loss in intertidal areas: in that region, large areas of wetland have been lost, but fisheries have not suffered greatly [10]. One hypothesis is that this is because in the short term, fragmentation of marshes creates more of the marsh edges that serve as critical habitat [10]. Still, the longer-term effects of continued wetland degradation will ultimately be negative for these fish species. Meanwhile, in Puget Sound, forage fish like herring, surf smelt, and sand lance, which spawn on beaches, are an important food source for salmon [6]. Lost beaches and tidal flats, therefore, will have a cascading effect on salmon through their food chain.

Other climate change impacts on wetlands will also affect salmon. A 1998 literature review found that there were four main reasons cited as being responsible for limiting the residence time of juvenile salmon in estuaries; these included increases in summer water temperature, a lack of preferred prey, extreme river discharge, and increases in antagonistic interactions among juvenile fish when densities increased [18]. Two of these—increases in summer water temperature and extreme high and low river discharge events—are projected to occur as the climate continues to change.

It is worth noting that salmon are not the only fish species likely to be affected by sea level rise and changes in coastal wetlands. Groundfish—including various types of rockfish and sole, as well as Pacific cod and lingcod—also rely on nearshore habitats for juvenile rearing and other uses [6].

See the Salmon chapter and the Forage Fish and Critical Prey chapter for more information.

BIRDS

Birds that rely on coastal or inland wetlands for nesting or migration routes may be affected by changing precipitation and water availability during critical seasons [12]. Shorebirds, for example, often rely on coastal and intertidal flats for feeding in winter and during times of migration [19]; changes in the extent of those flats and the availability of invertebrates will affect the number of shorebirds supported in and near Port Gamble S'Klallam Tribal lands. Studies in other parts of the globe have found reduced numbers of shorebirds corresponding to losses in mudflats [19]. If armoring and development do not prevent wetland migration to shallow upland areas, new habitats could be created, but they may not be created fast enough to avert losses in shorebird populations [19].

Ducks, geese, and seabirds also rely on marshes, beaches, and tidal flats, and on the forage fish that have historically been found in those areas, and are likely to be affected by sea level rise and associated changes in the ecosystems [6].

See the Birds chapter for more information.

SHELLFISH

As the sea level rises, deeper waters threaten to reduce shellfish production. For example, Dungeness crabs use estuaries as nurseries; changes to local estuaries would therefore affect survival and reproduction of crabs [6]. On the other hand, the projected increase in tidal flat area in Puget Sound could be favorable for production. See the Shellfish chapter for more information.

IMPACTS ON INLAND WETLANDS

While this chapter has primarily focused on tidal wetlands and estuaries, the Port Gamble S'Klallam Tribe is also concerned about inland wetlands that are also sensitive to climate change impacts. For example, inland wetlands can be affected by rising air temperatures, which increase evaporation and transpiration rates and can lead to drying that reduces wetland size [5]. Shallow seasonal ponds that provide breeding ground for amphibians may change dramatically or disappear with changing precipitation and increasing air temperatures [20]. Those same changes in hydrology and temperature will also affect species composition in bogs and fens [12]. In addition, riparian wetlands that get inputs from streams will be affected by changes in precipitation and reduced snowmelt at the headwaters [5] and areas that juvenile salmon use for off-channel rearing and flood refuge habitat. Wetland trees may shift in response to rising air temperatures, if climatic conditions do not shift too quickly for them to migrate and re-establish populations in new locations [13]. Studies in

RESEARCH NEED: How do juvenile salmon use various nearshore habitats across Hood Canal? What environmental factors (e.g., salinity) are most important for juvenile salmon? [3]

the Cascades found that climate change would reduce overall water availability for wetlands, increase the frequency of pond drying, and lengthen the summer dry spell [20].

Movement and migration may not be possible; just as shoreline armoring and coastal development prevent the migration of coastal wetlands as the sea level rises, inland wetlands are often constrained by dams, roads, drainage, and other barriers, as well as soil type and topography [13].

LOOKING AHEAD

The Tribe's WCPP includes planned future activities that will help to increase understanding of climate change impacts on local wetlands and build resilience. For example, the Plan includes deploying water level/temperature loggers at five sites to help monitor climate change and related changes in hydrology, sea level, and sediment deposition [2]. Other activities, such as ensuring that appropriate buffers and protections are applied to wetlands during forest practice operations, will also have indirect climate resilience benefits.

The Tribe is also a partner in the Kitsap Forest & Bay Project (KFBP), along with Kitsap County, the Suquamish Tribe, and several NGOs and other organizations and agencies. The project aims to conserve 6,700 acres of forest around Port Gamble Bay, including for the purpose of preserving marine and freshwater habitats [21]. The first phase covered 535 acres along the Port Gamble Shoreline, across the bay from the Port Gamble S'Klallam reservation; this land was protected as a park in early 2014.

These existing and ongoing efforts are critical to address non-climate pressures—such as development and pollution—on wetlands, and will be even more important as climate change places additional stress on local wetlands that provide important habitats for fish, shellfish, and birds.

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