



Tribal nations will likely be disproportionately impacted by climate change due to their intimate, long-standing relationship with the natural environment and its resources, as well as their reliance on a wide range of natural resources for subsistence and cultural traditions.

Executive Summary

The Port Gamble S'Klallam Tribe has been concerned about climate change and its actual and potential impacts for over a decade, with increasing focus in the last five years. This report, funded primarily by the Bureau of Indian Affairs (BIA) with initial start-up funding from the Environmental Protection Agency (EPA), uses a scientific literature review and interviews with Tribal staff to identify anticipated climate change impacts on local ecosystems, species, human health, cultural resources, and Tribal infrastructure.

The impact assessment focuses on the Port Gamble S'Klallam Tribe's primary traditional use area, which is the central part of their large Usual and Accustomed Area (U&A). The Tribe's primary traditional use area is comprised of the upper half of Hood Canal and all of Admiralty Inlet. Because this chapter draws from existing datasets and literature, the time periods, spatial scale, and scenarios used to generate the information varies. Where available, we have utilized studies that focus on Hood Canal and Admiralty Inlet or on the Puget Sound region. The Tribe's Natural Resources Department prefers to use the high emissions scenario results for its planning, considering this "business as usual" scenario seems to be the most likely given current greenhouse gas emissions trends.

OBSERVED AND PROJECTED CHANGES IN CLIMATE

Observed changes include:¹

- *Temperature:* Air temperatures in the Puget Sound region increased by about +1.3°F between 1895 and 2014. All but six of the years from 1980 to 2014 were warmer than the 20th century average.
- *Precipitation:* There has been no discernible long-term trend in total *annual* precipitation for the Puget Sound region, though spring precipitation is increasing. Most studies find that both the frequency and intensity of heavy precipitation have increased to some degree in Western Washington.

¹ See the following chapters for source information.



- *Snowpack and glaciers:* Glaciers in the Olympic Mountains lost 34% of their area and 20% of their volume between 1980 and 2009. A decrease in spring snowpack has been observed at Hurricane Ridge.
- *Streamflow:* The spring peak in streamflow is occurring earlier in the year for many snowmelt-influenced rivers in the Puget Sound region.
- *Sea level rise:* Sea level at the Seattle tide gauge—which has a longer record than the gauge in Port Townsend—rose by 8.6 inches between 1900 and 2008.
- *Water temperature:* Average water temperatures in Hood Canal increased by approximately 1°F between 1950 and 2009.
- *Ocean acidification:* A combination of increased carbon dioxide in the atmosphere and nutrient runoff have lowered the pH of Hood Canal's deep waters thereby increasing its acidity.

Projected future changes include:

- *Temperature:* Under a high emissions scenario, the average annual temperature is projected to increase by 6°F by mid-century and 9°F by 2100. We expect more extreme heat events and fewer extreme cold events.
- *Precipitation:* Model projections for changes in annual and seasonal precipitation in the Puget Sound region vary. Overall, the region is expected to see wetter winters and drier summers. Extreme precipitation events are likely to become more frequent and more intense.
- *Snowpack and glaciers:* Spring snowpack will continue to decline as more winter precipitation falls as rain and snow melts earlier. We expect that the glaciers in the region will continue to recede.
- *Streamflow:* Not all of the watersheds in the Tribe's primary traditional use area have been modeled to date. Watersheds that currently receive a mix of rain and snow are likely to receive relatively less snow in the future as temperatures rise, resulting in higher winter streamflows and lower summer streamflows. Warmer summer water temperatures are expected.
- *Wildfires:* Climate change is projected to increase the frequency and severity of forest fires in Western Washington, although quantifying the change in fire risk is difficult due to the low frequency of large wildfires in Western Washington.
- *Sea level rise:* High emissions scenarios project a 56-inch increase in sea level in Seattle by 2100 (compared to 2000). Recently, scientists have noted that approaches used for sea level rise studies may have underestimated the contributions from melt in Greenland and Antarctica, suggesting that sea level rise could be higher.
- *Water temperature:* Sea surface temperatures in the region are projected to warm by just over 2°F by the 2040s under a moderate emissions scenario. Warming would be even higher under a high emissions scenario.
- *Ocean acidification:* The pH of Washington's coastal waters is projected to continue decreasing as the atmospheric concentration of carbon dioxide climbs. Specific projections are not available for Hood Canal.

These projected changes may impact the Tribe both directly and indirectly, through consequences to natural resources and human systems. Examples are described below, with more detailed descriptions in the following chapters.



NATURAL RESOURCES

Salmon: Warming stream temperatures can decrease growth rates, change migration timing, amplify vulnerability to disease and predation, and increase mortality. Lower summer streamflows can impede salmon migration. In the winter, heavier rainstorms and resulting high-flow events could cause more damage to deposits of salmon eggs in rivers and streams. As different salmon stocks and species have different life histories and habitats, specific impacts may differ, as described in the Salmon chapter of this report.

Forage fish and critical prey: Forage fish such as the Pacific herring, surf smelt, and Pacific sand lance form a critical link in the marine food web. They may be affected by increased water temperatures, lower dissolved oxygen levels in nearshore habitat, and reductions in suitable habitat due to sea level rise; however, the limited research on lifecycles of specific forage fish species makes it difficult to determine their relative vulnerability with great precision.



Shellfish: Shellfish like clams and oysters are being affected by ocean acidification, which makes calcium carbonate less available for young shellfish and larvae to form their shells. Toxins produced by harmful algal blooms may appear more often, making shellfish dangerous to eat. Higher sea levels can also inundate existing intertidal habitats and reduce the amount of time when Tribal members can access beaches for harvesting. New studies show potential impacts to Dungeness crab.

Forests: Climate change is expected to lead to changes in forest growth and productivity, wildfire risk, insect and disease outbreaks, and, eventually, the geographic distribution of tree species. With its relatively wetter climate, Western Washington has—and will continue to have—a lower wildfire risk than Eastern Washington, but there is likely to be a greater risk in our region than we have observed in the past. There are likely to be more outbreaks of the mountain pine beetle through mid-century as temperatures warm; however, outbreaks may decrease later in the century as climatically suitable habitat declines. As trees weaken in times of drought, they will become increasingly vulnerable to these and other pests and disease. Still, given the long lifespans of trees, forests will likely remain fairly stable for the next 20 to 50 years, despite ongoing changes in climate.



Wetlands: While development and pollution are likely to remain the lead degraders of local wetlands, climate change adds another layer of stress to these systems. The Point Julia salt marsh and wetland, for example, could be inundated by sea level rise. It may also be affected by increased erosion and damage from extreme coastal weather events. Tidal and intertidal wetlands and pocket estuaries play an important role as habitat for salmon and shellfish. As the climate changes, estuarine beaches and tidal swamps are expected to shrink, while some tidal flats and salt marshes may expand.

Birds: Birds' ability to travel easily and find new areas with climates suitable for their needs helps reduce their vulnerability. Species that live in specific thermal niches or have very specialized diets, however, will be less prepared for expected temperature variations or changes in the timing of food availability. The



marbled murrelet, spotted owl, and western grebe have very specialized diets which can increase their vulnerability. Meanwhile, rising sea levels may reduce the extent of foraging habitat available for shorebirds like the brant.

Mammals: An increased wildfire risk in Western Washington's forested landscapes could damage areas that provide critical habitat for elk, deer, and bear. The potential for more frequent or intense drought, as well as changes in the types and prevalence of diseases, can also directly affect animal health and survival. On the other hand, milder winters could have some benefits, including potentially higher survival rates for juvenile elk.

HUMAN SYSTEMS

Infrastructure: The design and location of most Tribal facilities will likely make them able to withstand anticipated climate change impacts. At Point Julia, however, the lower elevation makes boat launches and other nearby facilities more vulnerable to sea level rise. Flooding would be exacerbated during storms or extreme high tides. Sea level rise and increased heavy rainfall events are also expected to speed up existing bluff erosion dynamics. New planned housing lots are all located safely away from low-lying areas and the bluff.

Health and safety: Like other communities in Washington State, the Tribe can expect longer and more frequent summertime heat waves, more wildfires with corresponding reduced air quality, and a longer pollen season. Climate change could also contribute in some places to the spread of some infectious diseases (e.g., fungal infections), contamination of wells, and more cases of shellfish poisoning. Depending on local landscapes, climate change could bring more floods, landslides, and other extreme events. While the Tribe has focused its emergency and safety preparations on earthquake preparedness, some of those measures could also help the community deal with weather-related events.

Cultural resources: Climate change impacts that reduce the abundance of salmon and shellfish could affect Tribal ceremonies and customs. Climate change—and non-climate stressors like development—could also reduce access to and the availability of other traditional foods and gathering materials. Most of the Tribe's archaeological sites are in coastal areas and are therefore exposed to sea level rise and erosion. Within the reservation, the Tribe can take steps to protect these sites; its ability to take action is more limited with regard to culturally significant sites in other parts of the Tribe's primary traditional use area. Climate change may impact the Tribe's cultural health and identity depending on the intensity and significance of climate change impacts. However, Tribal members are experts at resiliency and will adapt to the changing times ahead.

Additional details on each of these resources and systems can be found in the corresponding chapters of this report.

NEXT STEPS

The Tribe's Natural Resources Department will use this impact assessment as the foundation for a participatory vulnerability assessment and adaptation planning process in 2017, engaging a wide range of other Tribal departments to understand the risks and identify ways to proactively adapt. Many of the Tribe's existing programs already contribute to resilience, and these will be even more important in the context of a changing climate. It is likely the Tribe will need to take additional actions given the magnitude and scope of the projected changes. By looking ahead and engaging staff and community members in discussions about what the Tribe can expect and what steps we need and want to take, we can protect our traditions, our community, and our resources for many generations to come.