

¹Tribal Response to Climate Change and the Evolving Ecosystem of Hood Canal: Learning from the Past to Plan for the Future*

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The people looked at the wonderful new gifts that the stupid little girl had brought for the people of the future. After a while assH3'qap said, "No...No...the most important gift that I brought for the people is to "Pay attention!"

-Traditional Twana Story-

Abstract

Hood Canal is a fjord forming the western arm of Puget Sound, Washington. Climate change has had a major influence on Hood Canal and the original indigenous people. Currently another major climactic shift is taking place in the region. Humans are forced to respond to changes in the ecosystem they inhabit. This case explores the relationship of paleo, archaic and modern native people to the past and present evolving ecosystem of Hood Canal. Cultural and economic adaptation will require utilizing political tools to try and reduce the impacts to the environment as well as recognizing new natural resource based economic opportunities.

Formation of Hood Canal

Today the Hood Canal basin lies at the western edge of the Puget Lowlands on the eastside of the Olympic Mountains, in Washington State (Figure 1).



Figure 1. Hood Canal.

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The landscape consists of small areas of flat glacial till plains and the steep terrain of the Olympics Mountains, which rise immediately to the west. Several tributaries drain from the mountains into the waterway, the largest of which is the Skokomish River located at the southern elbow of the canal. It is here that the ancestors of the Twana people now known as the Skokomish tribe reside. Over the last 13,000 years the landscape of the Puget Sound Lowlands evolved from grassy tundra, to a patchy alpine boreal forest and finally to a climax temperate rainforest. The development of the closed temperate rainforest riverine environment and its relation to salmon production facilitated a cultural shift of the archaic people that lived in the region.

The modern Hood Canal environment has a unique climate because it is located at the boundary of two geographically different regions. At the southern end of the canal lowland area, plains are dissected by low-gradient streams with a wet winter and dry summer climate. The Olympic Mountains create a pronounced rain shadow over northern lowland portions of the basin. Average rainfall ranges from 255 cm per year at the Skokomish river to 75 cm per year at the northern end of the basin (Mass, 2008). In addition, the bathymetry² and morphology³ of the waterway makes it highly susceptible to environmental change.

The formation of this landscape between the Cascade and Olympic mountains was the result of dynamic ice flows over the earth's crust for many millions of years. During the Pleistocene Epoch (2.0 million to 10,000 years before present), large ice masses the size of continents advanced into the Puget Sound Lowland during glacial periods and then retreated during interglacial periods. These massive ice sheets and warmer periods left behind glacial sediment deposits. Evidence suggests the area that is now the Puget Sound lowlands was glaciated at least six times during the Pleistocene. Over tens of thousands of years glacial sediment deposition processes established the topography of the region. However, the modern landscape scoured within this topography is primarily the result of the Vashon glaciation which occurred between 15,000 and 20,000 years ago (Shipman, 2008). During the last glacial expansion of this period the outer reaches of the Cordilleran Ice Sheet expanded southward from British Columbia into northwestern Washington. When it reached the Olympic Mountains it was separated into two lobes. The Juan de Fuca lobe stretched westward while the Puget lobe flowed in between the Olympic and Cascade mountain ranges (Shipman, 2008) (Figure 2).

² The shape of the bottom of a water body as described by the information derived from depth measurements.

³ The form and structure of a geologic feature.



Figure 2. The Puget Lobe of the Cordilleran Ice Sheet (Adapted from Porter, 1998).

Over the next several thousand years these lobes advanced and retreated. Radiocarbon dating of materials contained in the sediments of lowland lakes suggest that the last recession began 16,500 years ago and retreated at a rate of 500 meters per year exposing the majority of the Hood Canal region about 800 years after the retreat began (Porter, 1998). Water from melting ice flowing south beneath the glacier as it retreated scoured the major troughs that define Hood Canal and the rest of Puget Sound today. What was left behind after the final glacial recession however was a landscape that was quite different than the climax spruce and hemlock temperate rain forests described 500 years ago when European explorers first arrived in the area. Sea levels at the end of the final glacial retreat were 140 feet higher (Swanson, 2003). Over the next several thousand years the biota of the landscape would evolve and the mega flora and fauna including people and their culture would be altered by the changing climate.

Climate Change and Paleohistoric Colonization

Climate plays a fundamental role in determining the geographic distributions and biophysical characteristics of ecosystems. Climate change can therefore have profound effects on the animals and plants therein. Changes in plant reproduction timing, shifts in large animal ranges, migration patterns and the interactions between co-dependant species can be disrupted. Geophysical processes can be disrupted as well. Stable temperature and chemical regimes of large water bodies can be increased or decreased and the atmospheric chemistry altered. These geophysical and biophysical changes to the ecosystem impact the people that live there. In most cases these changes occur over many hundreds of generations and are adjusted for gradually by the effected residents. Sometimes the environmental changes can be rapid, coming in the form of large disturbances and require dynamic responses to the new environment. Environmental changes in the ecosystems where people reside are often overlooked when considering the human condition over time. Environmental changes are fundamental to determining who the people that inhabited the land around Hood Canal were thousands of years ago, and who they are today. The native people's adaptations to their natural surroundings defined their culture. (Howard, 1989). Just as we study changes in flora to better understand localized post glacial changes in climate, tracking the human response can reveal a more overarching understanding of climactic influences on ecosystems.

The archaeological evidence to describe the evolutionary response to climate of paleo (10,000 – 7,000 BP) and archaic (7,000 – 3,000 BP) cultures of Hood Canal and the Puget Lowlands is scarce. The mild humid environment of the Pacific Northwest is not an effective environment for preserving the past. Organic material is quickly incorporated into the surrounding environment via rapid decomposition in most cases. Animal data are virtually nonexistent for archaeological sites older than 3,000 years (Bryan, 1957). The most informative evidence comes from wet site archeology and Shellmiddens. Wet site archeology is the study of fragments of wood and fiber preserved in wet soils. These sites are continuing to provide important information about the people living in the region 3,000 to 5,000 years ago. The oldest of these sites located on Queen Charlotte island in British Columbia is over 9,000 years old (Foster, 2004). More common sites that provide clues to the daily lives of Native Americans are shell middens. Midden meaning "refuse heap" are areas that were formed gradually over long periods of time. Made up largely of shell refuse, they can also enhance preservation of other materials like bone. Although middens provide a wealth of information about the people who made them, the oldest shellmidden site in the Northwest is less than 3,000 years old (Stein, 2008). The only paleo site in the Hood Canal region is known as the Manis Mastodon site. It is an unusual preservation of a Mastodon with some evidence of paleo peoples (Prentiss et al, 2003).

Many scholars believe that the earliest migrations to the New World started in Asia, and then traveled across Siberia to the Americas over the Bering Land Bridge. They also believe there was a series of migrations over many thousands of years that may have included coastal peoples migrating from the south as well (Rogers, 1991). The paucity of archeological data and the lack of extensive study of Hood Canal and the Puget Sound lowlands has left a large void in the prehistoric record. Continuing exploration has begun to provide additional details to the story of when and how paleo peoples arrived in the Puget Sound region. It is possible that Clovis people may have arrived earlier than previously thought (Citation) In addition some experts have proposed that the Pacific coast may have provided an additional pathway into the region as many as 8,000 years ago. However, for the most part a simple narrative still describes ancient peoples arrival into the region, and details describing northwest cultures older than 3000 years ago are simplistic at best.

The simple story involves evidence from a few prominent archeological sites scattered throughout the Pacific Northwest and is described in the following manner. Paleo peoples (paleo meaning ancient) entered the Pacific Northwest sporadically the earliest around 15,000 years ago (Citation). Several archeological sites in the Puget Lowlands indicate paleo peoples were in the region in significant numbers about 10,000 to 12,000 years ago. These people were known as Clovis people and were nomadic big game hunters. They were named Clovis for the style of spear point common among them. Clovis culture has been documented across North America (Butler, 1961). In 1977 a 12,000 year old mastodon skeleton was found near Hood Canal with a spear point embedded in a rib. This site called the Manis Mastodon site is one of only a few sites with anthropologic association older than 10,000 years in the Pacific Northwest. Whether or not people inhabited the Hood Canal region this long ago though is debated as there is a possibility that the animal may have migrated into the region with the point already lodged in the rib (Barton, 2002).

As the large mammals began to disappear a new group called archaic people or Cordilleran inhabited the region. They had developed better tools that allowed the hunters to kill the smaller, faster ungulates (different types of deer species) for food. A variety of paleo and archaic archeological sites indicate there may have been several groups of these people in the Northwest simultaneously. Based on limited archaeological evidence, their populations were sparse and widely scattered. Environmental evidence suggests climate, volcanic eruptions, and catastrophic floods made their livelihood in the area a challenge. Four thousand years ago their populations began increasing and about 2,000 years ago, two distinct cultural groups, the Coastal and Plateau peoples, emerged. Like today, the Cascade Mountains delineated the cultures (Butler, 1961).

This story, however, gives us very little insight into cultural adaptations to the dynamic evolving environment of the period. Volcanic activity was more regular than today, sea levels were dropping, and, as the glaciers receded, a boggy tundra type landscape was evolving into a thick conifer dominated rainforest. Recent investigations into the paleo and archaic histories of the people of the Puget Sound region have begun to provide us with a better understanding of how these people were shaped by the changing climate.

Evidence of Clovis culture has been uncovered in several areas in the Puget Lowlands. However none of these sites have been dated beyond 12,000 thousand years ago and evidence of the culture persists for only about a thousand years. The persistence of the Clovis culture in the area is brief and may be the result of the changing climates impact on their primary food source, large land mammals (Butler, 1961).

The next cultural assemblage revealed by archeological evidence is referred to as the Old Cordilleran. It is unclear as to whether these people's ancestors were from the Clovis culture or whether they migrated into the region with technology that was better suited to killing the new smaller fauna that dominated the landscape, thereby out-competing and displacing Clovis people. The extent of their duration in the area is imprecise but commonly considered to be between 4 and 7,000 years. Archeological evidence of these people does not reveal large assemblages of tools, animal material or other materials used for everyday life that would be left behind if the people had inhabited a single area for a long period of time. It is therefore believed that these people were nomadic (Butler, 1961).

The basic economy of the Cordilleran people was essentially oriented toward hunting of land mammals, particularly deer. A few river resources were probably used such as fish and freshwater mussels but these were not a dominant source of food. The economy of the Old Cordilleran Culture remained tied to the land for several thousand years (Butler, 1961).

Gradual Environmental Shift

There are two primary elements that allowed archaic people to survive the ecological shifts brought on by the changing climate. The first element is that the change was gradual enough to allow for environmental and cultural adaptations. The second was that

the environmental adaptations included abundant resources. Not only were these natural resources that would become important to the economy of the people allowed to adapt to the changing climate but the people had time to change their culture enabling them to utilize the new environmental resources.

By identifying pollen found in sediment cores samples taken from the bottom of lakes throughout the Puget Lowlands and correlating the pollen to carbon dating methods scientists have been able to detail a timeline for the post glacial advance of the temperate forests in the Northwest. As far back as 13,000 years ago *patchy Pinus* woodlands covered an extensive portion of the coastal Pacific Northwest (Brown, 2002). These forests were primarily open spaces interspersed with tundra grasses, perfect for large grazing animals. As the temperatures warmed *pinus* density increased and the large mammals hunted by Clovis people disappeared. This is known as the early Holocene dry interval and occurred 10,000 – 8,000 years before present. This warming period correlates very well with the disappearance of Clovis culture (Lambert, 2008).

For the next 5,000 years significant cooling took place, during this interval a noticeable change in forest composition occurred. Cool, moist conditions began to dominate the Olympic Peninsula region. alder, Douglas fir, and bracken fern decreased throughout this period. Simultaneous with these declines, pollen diagrams from the Manis Mastodon site near Quilcene, indicate that hemlock, spruce and cedar begin to become prominent (Bergland & Mar, 1988). Over the next 3,000 years the climate and ecology of the modern regional environment took shape. A flow of Pacific maritime air onto the western Olympic Peninsula with high humidity, and abundant precipitation dominated the weather regime (Maunder, 1968). The effect of the changing climate associated with the beginning the late Holocene period as far as the Cordilleran people are concerned is that it marks the onset of fully closed forests.

Being dependant on grassy open spaces these environmental shifts would have greatly reduced the carrying capacity for deer and elk, the primary food source for the Cordilleran people. It would also have decreased the availability of edible plants. The scarcity of large game would have made winter season mobility a regular occurrence as people followed herds to suitable grazing areas. It has been hypothesized that these people may have covered larger areas more frequently due to the smaller herds on the winter ranges. The Late Cordilleran people are also considered to have utilized fire to maintain vegetation and preserve prairies. This cultural practice may have provided some relief from the climatically induced changes in plant diversity (Butler, 1961). However, in contrast to the Puget Lowlands and the western Peninsula, the mountains along the east side of the Olympic range drop steeply into to the adjacent Hood Canal region. Therefore prairie lowlands are limited by rivers that have small areas of low gradient reaches. Moving southward along the western side of Hood Canal, there is virtually no coastal plain until one reaches the Skokomish river at the southern end of the Canal. It is possible that an overall reduction in the productivity of terrestrial ecosystems resulting from forest closure could have necessitated increasing reliance upon anadromous fish (Salmon) and other marine resources.

The relationship of salmon production to large trees in and around the streams they resided is the second element that allowed the Old Cordilleran culture of the Hood Canal region to enter what is known as the The Charles (4000-3000 B.P.), Larcono Beach (3000-2400 B.P.) and Marpole phases (2400-1400 BP). This 3000 year cultural period leading up to Euro-American introduction into the area marks the beginning of significant population growth, a high level of cultural complexity, and sedentary residence of the native peoples of Hood Canal.

A Resource Shift to Salmon and Shellfish

The study of biogeography investigates how animals are distributed spatially and temporally by past and present events. The biogeography of salmon is essential to the story of adaptation to changing climate of the past and present native peoples of the Hood Canal region. Certainly when the Puget Sound area was covered by glacier salmon habitat would have been non-existent. It is not clear how salmon recolonized the region or how long it took. Several hypotheses have been offered. The most widely accepted theory is that salmon emigrated from the ice-free areas of the Columbia River, Chehalis River, and Coastal areas, the majority utilizing the glacial outflow through the Chehalis drainage (Figure 3) (McPhail, 1986).

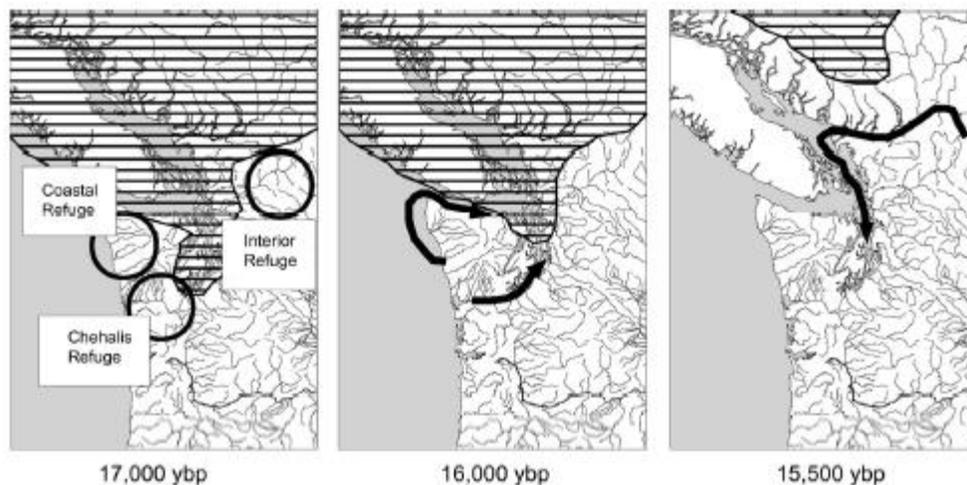


Figure 3. Salmon colonization into Puget Sound region (from McPhail, 1986)

In addition to salmon it is believed that the majority of fish immigrating into the newly formed Puget Sound came from the ocean because the majority of marine life in the region has a high salinity tolerance. (McPhail, 1986).

Certainly the environment that salmon recolonized was difficult to survive in. Sea levels were in flux and river channels were highly energetic areas filled with geomorphic disturbances such as volcanic lahars, glacial calving and flooding. Because of salmon's reproductive strategy producing a much larger number of offspring than is expected to survive to reproductive age, the species was able to maintain a viable population as the environment and climate evolved to more favorable conditions. The growth of the forest along the river banks helped transform watersheds into salmon friendly places. The trees

provided bank stabilization and when recruited into the river caused channel braiding and scoured deep pools. These changes to the rivers morphology would have reduced the overall energetics of the rivers, increasing the survival of salmon eggs deposited into the gravel and providing refuge for juveniles. With the closing of the forest about 5,000 years ago the heavily forested watersheds of Hood Canal and the rest of Puget Sound had evolved into a perfect environment for salmon production.

As salmon production increased and ungulate populations declined as a result of the newly formed climax forests, people began to shift their location to coastal environments. Here the people now known as S'Klallum began to take up semi-permanent residences along the south shore of the Strait of Juan de Fuca to the mouth of Hood Canal. In concert the Twana people began to use the western side and southern extremity of Hood Canal. Here these tribes were able to more readily utilize the natural resources the coastal areas were beginning to provide (Duer, 1999). In addition to salmon another primary food source was shellfish. The protected waters of Hood Canal provided perfect conditions for the production of shellfish.

In the Hood Canal and Puget Sound region true estuarine conditions occur because of the fiord-like nature of the basin. The result is a longer annual period of high productivity. This productivity is the result of the upward transport of nitrates from tidal energy. These nutrients in Hood Canal are concentrated further by the morphology of the basin. At the mid-point of the fjord a shallow shelf exists providing a partial barrier to outgoing tides. A result of the high level of nutrients phytoplankton and other nuston densities are very high. When this nutrient rich environment is combined with the sandy glacial deposition transported to the Sound from river down-cutting through glacial till, just as forests made the ecology of watersheds perfect for salmon, the ecology of Hood Canal evolved into a perfect environment for shellfish. Littleneck clams, butter clams, horse clams, geoducks, basket cockles and Olympic oysters were abundant (Gunther, 1927)

Ecosystem response to climate change does not always result in the evolution of an environment suited for producing an abundance of food resources. The Sahara desert was once a tropical rainforest. However in the case of the Hood Canal region the symbiotic nature of the evolutionary response of environmental elements to climate change eventually created a bounty of natural resources that the people who inhabited the area were able to utilize. In fact, this period (2500 years ago to the present) is widely believed, when wealth is measured by leisure time, to have supported one of the wealthiest cultures in the history of humanity. Large sedentary communities were able to form without the need for agriculture.

Pre Euro-American Settlement Natural Resource Utilization

Traditional Salish stories of S'Klallum and Twana embody the environmental evolutionary ecology of the people. Stories of the people emerging from clams and a tree teaching a girl how to use Cedar bark for clothing seem to parallel how the resources of the closed forest system became an integral part of their everyday lives.⁴

⁴ See Traditional Twana story in teaching notes.

The ethnography of the people living around the Hood Canal region was documented in the early 19th century (Gunther, 1927; Elmendorf, 1960). This historic documentation in concert with oral evidence from tribal members provides some insight into the 3,000 year old culture of the people residing in the Hood Canal region. Two areas of the Hood Canal region correspond to the areas occupied by the two major Tribes. The northwestern region of Puget Sound, as far south as the mouth of the Hood Canal were occupied by the S'Klallam Tribe; and the western side of the Hood Canal was occupied by the Twana, now known as the Skokomish (Elmendorf, 1960).

S'Klallam

In 1927 Gunther recorded many S'Klallam villages located along the shores of the northern most extent of Hood Canal at the mouths of rivers and creeks. Subsistence was oriented towards salmon. Gunther reported that villages were always located at river mouths near fishing grounds; still most people found it necessary to move several times each year to follow the various runs of salmon or to gather vegetable products." (Gunther, 1927). Most groups occupied a series of seasonal camps from January or February through October and spent only two or three months in the winter villages. The groups that moved were composed of a number of families or frequently a whole village (Gunther, 1927).

In the late summer, the people of S'Klallam villages made a trip to Hood Canal for dog salmon (chum). Huckleberries were picked in conjunction with dog salmon fishing. The Dowewallips and Hamma Hamma rivers were primary Hood Canal tributaries that were utilized but the Union and Tahuya rivers were also fished, both located within Skokomish territory at the south end of Hood Canal (Swindell, 1942).

Gunther had the impression that plant resources were somewhat more important to the S'Klallam than to most other Peninsula groups. As a result of the rainshadow in the eastern S'Kallam territory, edible plant resources were abundant. Fern root, camas, tiger lily, berries, nuts and other greens were harvested in openings in the forest. Compared to fishing and collecting, hunting by the S'Klallam is described as least important economically and mostly done at sea. Both land mammal and sea mammal hunting was done by specific tribal members trained for only those hunts. Each village had their own whaler or deer and elk hunter (Gunther, 1927).

Twana/Skokomish

The Twana occupied the majority of the Hood Canal basin. It is estimated that there were about 1,000 Twana in the 1850's and about half of these occupied the valley of the Skokomish River (Elmendorf 1960). A total of 15 original winter villages were documented in the early 19th century. The majority located upriver on the Skokomish, the largest river draining into the Hood Canal. As with the S'Klallam the other villages were located on saltwater but always near the mouths of rivers or creeks. About eight months

was spent traveling around the Hood Canal region fishing hunting and plant collecting, occasionally returning to the winter villages to store their bounty.

Twana food resources utilized were fish, sea mammals, molluscs, waterfowl, deer and elk, and vegetable products. Salmon and shellfish are identified as the most important food resource for all Twana and the fishery took place in the River rather than in the Canal. The Skokomish River had habitat that provided for all the major species of salmon. However the majority of tributaries flowing into Hood Canal from the west side quickly rise from the Canal into the Olympic Mountains. These high gradient river systems provide only short stretches for salmon spawning thus the systems are more suited for Pink and Chum salmon which spawn in the lower part of rivers and migrate to sea immediately after hatching. As for shellfish the most important species were considered littleneck clams, butter clams, basket cockles, horse clams, oysters and geoducks.

Marine fish were also taken by the Twana. Marine mammals, porpoises and, very rarely, whales and sea lions were hunted on occasion. Elk and deer were also hunted during the fall in the Olympic Mountains. Plant resources utilized included fern roots, camas, various roots and berries, acorns, hazelnuts, and pinenuts. Camas, berries and "wild carrots" were collected in "burnt-over areas" south of the Skokomish river (Elmendorf, 1960).

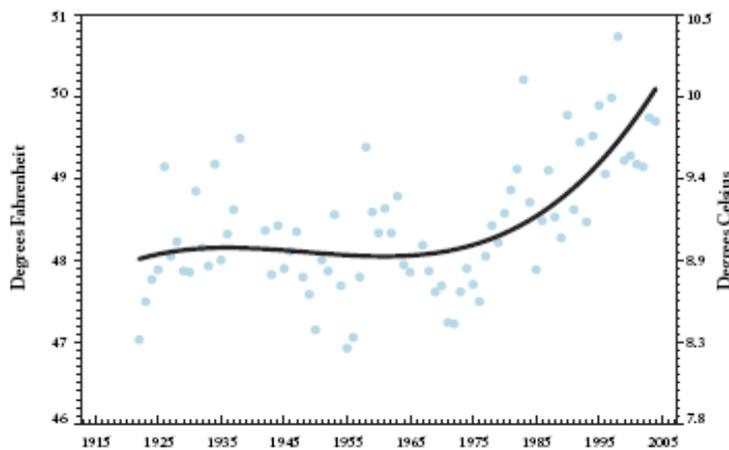
Modern Climate Change: Ecosystem Impacts and Tribal Response

As shown, the historical record indicates that prior to Euro-American settlement the landscape of the Hood Canal region was productive enough to sustain permanent winter communities of Twana and S'Kallam people. The arrival of Euro-Americans around Hood Canal in the 1850's began a new period of alternative land use techniques by a different culture. These techniques resulted in significant alteration to the landscape leading to habitat degradation and causing a decrease in production of natural resources. These modern land use practices continue today and prevent natural regeneration of the landscape and the natural resources it produced.

The waterway of Hood Canal is particularly susceptible to physical and chemical changes in its environment. The bathymetry and shape of the waterway makes the exchange of water from in and outgoing tides reduced. Hood Canal has a shallow lip of 160 feet near the mouth creating a long, deep and narrow bowl resulting in the slowest water circulation of all the Puget Sound sub-basins. This slow rate of incoming and outgoing tidal exchange causes the southern end of the canal to become especially susceptible to low dissolved oxygen (DO) As a result DO in the waters of Hood Canal have become a problem.⁵

⁵ See case by Cole, S. R., Indian Fishing Practices and Dissolved Oxygen in Hood Canal.

Climate change is happening and is exacerbating the DO problem as well as causing the water to become more acidic. Over the last 100 years the Puget Sound region warmed at a rate greater than the global trend. The global average annual temperature increased over 2.3 degrees Fahrenheit during the 20th century while every climate record in the Puget Sound region showed a warming trend of over 2.7 degrees Fahrenheit since the 1950's. Climate models predict the warming to continue. The Hood Canal region is expected to warm by another 2 degrees by 2050 (Snover, 2005). This additional warming is predicted to accelerate environmental impacts because now the aquatic habitat is warming as well (Figure 3) (Snover, 2005). Aquatic ecosystems like Hood Canal that are sensitive to both temperature and precipitation trends are going to be altered by a 21st century climate; a climate which will be quite different than what the plants and animals have adapted to over the last several thousand years.



Sea Surface Temperature

Figure 3. Sea surface temperatures taken in the Strait of Georgia (taken from Snover, 2005)

As a result of warming temperatures the negative impacts of altered habitat in Hood Canal are already being seen. Hood Canal has supported a high diversity of life within and around its waters. Fluctuations in climate and sea level play a role in determining the viability of this diversity by their influence on tidal circulation and water chemistry. Although past research has focused on how land use impacts have been increasing the low DO in Hood Canal, recent research indicates climate change is making a contribution to the problem as well. Low DO dead zones have been found in recent years off the coast of Washington and Oregon. Water from these areas eventually makes its way into Puget Sound increasing the magnitude of low DO events in estuaries prone to drops in DO concentrations (Chan et al, 2008).

Reduced snowpack in the mountains, another result of climate change, in turn reduces streamflow and freshwater input into the Canal. The reduction of freshwater into the system decreases the effectiveness of mechanisms that impact circulation of tidal water in and out of the basin.

Finally carbon dioxide concentrations, one of the primary gases responsible for global warming, are increasing in the canal. Not only are higher concentrations being brought in from the ocean but concentrations are increasing from chemical processes that create the low DO environment in the canal (Joy, 2010). Low DO is created by larger than normal blooms of planktonic organisms. The magnitude of these blooms can be increased by warmer water temperatures. When the plankton die they sink to the bottom of the Canal where they begin to decompose. The decomposition process called eutrophication removes oxygen from the water while releasing additional carbon dioxide which gets absorbed in the water column.

High concentrations of carbon dioxide in the waterway are also increasing the acidity of the water. As a result shellfish production is reduced as the soft shells of juvenile clams and oysters are corroded by the acidic water (Joy, 2010).

Modern day climate changes negative impacts on shellfish and salmon could be very significant. Shellfish survival is being compromised by the increasing acidity of the water. A major commercial shellfish company has been forced to supplement its production using alternative facilities in Hawaii (EPOCA, 2010). Salmon are vulnerable to changes brought about by climate change as well. However because of the diversity of habitats salmon utilize, assessing climate changes impact on their survival is difficult. Increases in precipitation and decreases in snow pack, one of the outcomes of climate change, may already be impacting freshwater salmon survival. By increasing flood events in the winter and decreasing spring flows from reduced snowmelt runoff, juvenile salmon production is decreased. Currently one of the primary salmon species, chum salmon, once harvested in great numbers by the Twana and S'Klallam tribes is listed as threatened by the Endangered Species Act (NMFS, 1999). Climate change impacts will make recovery of this species even more difficult.

Finally the changing climate will bring rising sea levels which will decrease the amount of estuarine beach habitat as well as altering significantly other canal aquatic habitats (Mote et al, 2008).

Proactive Management

The general picture of climate change for Hood Canal is increased winter flooding and decreased summer and fall stream flows. In combination with elevated sea levels and summertime stream and estuary temperatures the new environment could be taxing for the current organisms dependent on the past instream and estuarine habitat of Hood Canal. The local tribes have an economic and cultural interest in the natural resources produced by Hood Canal. Land use practices such as forestry, agriculture, hydroelectric projects and urbanization have already had severe impacts on natural resource production in the region. How will the tribes respond to the economic and cultural impacts resulting from the additional stresses these resources are incurring as a result of climate change?

To date the majority of Pacific Northwest Tribal response has been primarily policy oriented. ⁶The Swinomish Tribe created a Climate Change Initiative and an accompanying Climate Change Proclamation. These documents recognized the challenges climate change will bring and committed the tribal government to respond. Additional Pacific Northwest Tribal responses have mirrored recommendations put forth in the *Climate Change and Pacific Rim Indigenous Nations report* by the Northwest Indian Applied Research Institute which were to: gather information, secure sources of water, secure food sources, prepare for impacts on plants and animals, develop relationships with local communities, make political alliances with tribal and non tribal governments and educate tribal members especially youth (NIARI, 2006) (Grossman, 2008). These documents are important for getting climate change on the map and into the Tribe's social framework. Now a focus on adaptive management strategies is needed.

Adaptation to climate change will require an adjustment by people and the environment to expected climatic effects. These environmental effects can be degrading or create beneficial opportunities. Current adaptation to climate change outcomes is stuck in the descriptive phase. Conditions are changing such that proactive adaptation is needed. Tribal governments need to implement proactive responses now. These responses need to create, implement and meet management strategies. Habitats need to be surveyed and assessed in a way that anticipates ecosystem adaptation to climate related stresses. Key areas can be diagnosed by exploring the magnitude of the potential impacts, the timing of impacts, the permanence of the impacts, and the overall importance of the habitat at risk. The adaptive capacity of a particular habitat or region to the effects of climate variability and change is important when considering areas that have potential natural resource benefits. It is possible that ecological adaptations will create new natural resource opportunities in some areas.

Hood Canal tribes' culture is at risk from climate change. The effectiveness of a predicted ecological adaptation that boosts cultural survival should be measured against economic potential and natural resource management goals. The knowledge to perform this difficult task is still present in the culture of the people whose ancestors have already experienced the need to shift natural resource based economic opportunity to survive. This traditional ecological knowledge base or ancestral environmental stewardship can be a fundamental tool in guiding the tribe's adaptation strategies to the changing ecosystem.

However compared to the last several thousand years the challenge of this climate shift is that it is happening rapidly. It is predicted that in the next 50 years or so the land that makes up the Skokomish delta in the photograph below will become an intertidal salt marsh (Figure 4) (Mote et al, 2008).

⁶ See Case by Robinson, S. and Alesko, M., A global issue poses particular challenges to indigenous peoples everywhere. How can tribes respond locally?



The Skokomish River delta (Wikimedia)

Figure 4. Mouth of the Skokomish River.

According to the Climate Impacts Group of the University of Washington a sea level rise of this magnitude could result in a loss of nearly 40% of estuarine beaches in Hood Canal, habitat that shellfish depend on (Table 1) (Mote, 2008). However the table also indicates that salt marsh habitat could increase by over 100%.

Table 18. Projections of Habitat Changes for Site 8 [A1B Max for 2050, 2100 and 1.5 Meters for 2100]							
	Area of Habitat Type in Hectares (Acres)				Percentage Change (Relative to Totals for This Site)		
	Initial Condition	2050 (+0.28 meters/11.2 inches)	2100 (+0.69 meters/27.3 inches)	2100 (+ 1.5 meters/59.1 inches)	2050 (+0.28 meters/11.2 inches)	2100 (+0.69 meters/27.3 inches)	2100 (+ 1.5 meters/59.1 inches)
Undeveloped Dry Land	40,510 (100,102)	40,169 (99,260)	40,125 (99,151)	40,084 (99,050)	1% loss	1% loss	1% loss
Developed	961 (2,375)	961 (2,375)	961 (2,375)	961 (2,375)	No change	No change	No change
Swamp	1,399 (3,457)	1,447 (3,576)	1,447 (3,576)	1,447 (3,576)	3% expansion	3% expansion	3% expansion
Inland Fresh Marsh	293 (724)	294 (726)	293 (724)	284 (702)	<1% expansion	No change	3% loss
Tidal Fresh Marsh	14 (35)	14 (35)	14 (35)	14 (35)	No change	No change	No change
Transitional Marsh	0 (0)	80 (198)	55 (136)	75 (185)	NA	NA	NA
Saltmarsh	131 (324)	280 (692)	198 (489)	195 (482)	114% expansion	49% expansion	48% expansion
Estuarine Beach	558 (1,379)	379 (937)	365 (902)	344 (850)	32% loss	34% loss	38% loss
Tidal Flat	0 (0)	55 (136)	92 (227)	87 (215)	NA	NA	NA
Ocean Beach	0 (0)	0 (0)	0 (0)	0 (0)	NA	NA	NA
Inland Open Water	793 (1,960)	839 (2,073)	837 (2,068)	835 (2,063)	6% expansion	6% expansion	5% expansion
Estuarine Open Water	9,199 (22,731)	9,342 (23,085)	9,473 (23,408)	9,537 (23,566)	2% expansion	3% expansion	4% expansion
Open Ocean	0 (0)	0 (0)	0 (0)	0 (0)	NA	NA	NA
Brackish Marsh	164 (405)	162 (400)	162 (400)	161 (398)	1% loss	1% loss	2% loss
Inland Shore	3 (7)	3 (7)	3 (7)	3 (7)	No change	No change	No change
Tidal Swamp	37 (91)	37 (91)	37 (91)	36 (89)	<1% loss	<1% loss	3% loss
Riverine Tidal	41 (101)	41 (101)	41 (101)	39 (96)	No change	No change	4% loss

Table 1. Sea level rise impacts on a variety of aquatic habitats in Hood Canal (Mote, 2008).

Could the increase in salt marsh habitat provide an opportunity for an alternative or expanded natural resource economy? How could an effective adaptation strategy allow for an expanded salt marsh ecosystem to provide a potential new natural resource base. What other opportunities might evolve? The overall impact of climate change is hard to project because of incomplete knowledge of the relative importance of potentially competing influences. Can traditional ecological knowledge play an important role in recognizing opportunity and implementing effective adaptation strategies? Will it provide an opportunity for the Hood Canal tribes to adapt as their ancestors did from the forest to the coast, from deer and elk to salmon and shellfish.

References

- Baker, G. R. (1983) *Holocene vegetation history of the Western United States, In Late-Quaternary Environments of the United States: The Holocene*, edited by H. E. Wright, Jr.; University of Minnesota Press, Minneapolis.
- Barton, M. (2002) *Prehistoric America: A Journey through the Ice Age and Beyond*, Yale University Press
- Bergland, E. O. & Marr J (1988) *Prehistoric Life on the Olympic Peninsula: The First Inhabitants of Great American Wilderness*. Pacific Northwest National Parks and Forests Association
- Brown, K.J, & Hebda R.J (2002) Origin, development, and dynamics of coastal temperate conifer rainforests of southern Vancouver Island, *Canada. Can. J. For. Res. Vol. 32, 2002.*
- Bryan, L. A., (1957) Results and interpretations of recent archaeological research in western Washington with circum-boreal implications. *Davidson Journal of Anthropology, Vol.3, No. 1.*
- Butler, R. (1961) The Old Cordilleran Culture in the Pacific Northwest. *American Antiquity 27(3):435-437.*
- Chan F., J., Lubchenco, A.B.J., Kirincich, A., Weeks, H., Peterson, W.T., Menge, B.A. (2008) Emergence of Anoxia in the California Current Large Marine Ecosystem, *Science, 15 February 2008: Vol. 319. no. 5865, p. 920*
- Chasan, D.J. (1981) *The water link—A history of Puget Sound as a resource*: Seattle, Wash., University of Washington Press.
- Daniel G. G., J. S. McLachlan, B. B.Linda, K. A. Young (2001). *Postglacial history of subalpine forests, Olympic Peninsula, Washington, USA*. *The Holocene 11,2*: pp. 177–188.
- Deur, D., (1999) *Salmon, sedentism, and cultivation: toward an environmental prehistory of the northwest coast*, in Hirtt, P. and Goble, D., eds., *Northwest lands and peoples—An environmental history anthology*: Seattle, Wash., University of Washington Press, p. 119–144.
- Elmendorf, W. W. (1960) *The structure of Twana Culture, Research Studies 27(3) Supplement*, Pullman: Washington State University.

- EPOCA, (2010) Local oysters affected by acidic water; corrosive water threatens Hood Canal Retrieved 6/21/2011
<http://oceanacidification.wordpress.com/2010/07/28/local-oysters-affected-by-acidic-water-corrosive-water-threatens-hood-canal/>
- EPA, (2008) Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources. Jill S. Baron, U.S. Geological Survey and Colorado State University Linda A. Joyce, U.S.D.A. Forest Service Peter Kareiva, The Nature Conservancy Brian D. Keller, National Oceanic and Atmospheric Administration Margaret Palmer, University of Maryland Charles Peterson, University of North Carolina J. Michael Scott, U.S. Geological Survey and University of Idaho, Retrieved 6/21/2011
<http://www.climatescience.gov/Library/sap/sap4-4/default.php>.
- Federal Register. (1999)a. Vol. 64, No. 56, March 24, 1999, p. 14308.
- Foster, R. and D. Croes 2004 Joint Tribal/College Wet Site Investigations:
 In, *Journal of Wetland Archaeology*, 4, 2004, 125–137
- Grossman, Z., (2008) Indigenous Nations' Response to Climate Change. *American Indian Culture and Research Journal* 32:3 5-27.
- Gunther, E. (1927) "Klallam Ethnography." *University of Washington Publication in Anthropology*. Volume 1, Number 5. Pages 171 to 314.
- Howard, C. M. (1989) *Contemporary Cultural Anthropology*. 3rd ed. Scott, Foresman and Company, Glenview, Illinois.
- Joy, L. (2010) Scientists Find Rising Carbon Dioxide and 'Acidified' Waters in Puget Sound. Retrieved 6/21/2011
http://www.noaanews.noaa.gov/stories2010/20100712_pugetsound.html
- Kenneth L. Petersen, K. L., P. J. Mehringer, Jr., C. E. Gustafson., (1983) Late-glacial Vegetation and Climate at the Manis Mastodon site, Olympic Peninsula, Washington *Quaternary Research Volume 20, Issue 2, September, pg. 215-231*
- Loren G. D. (1995) *Volcanism, Climate Change, and Prehistoric Cultural Succession in Southern Washington and North-Central Idaho* A THESIS
 submitted to Oregon State University; pp227
- Mass, C., (2008) *The weather of the Pacific Northwest: Seattle, Wash.*, University of Washington Press.
- Maunder, W.J.(1968). Effect of Significant Climatic Factors on Agricultural Production and Incomes. *Mon. Wea. Rev.*, 96, 39-46.

- McPhail, J.D. (1997) The origin and speciation of *Oncorhynchus* revisited. In D. J. Stouder, P.A. Bisson, and R.J. Naiman (eds.) *Pacific Salmon and Their Ecosystems: Status and Future Options*. Chapman and Hall, New York. pp. 29-38.
- Mote P., P.A. Petersen, S. Reeder, H. Shipman, and L. W. Binder, (2008). Sea-level Rise and Coastal Habitats in the Pacific Northwest. An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon. A report by the University of Washington Climate Impacts Group and the Washington Department of Ecology. pp.11.
- NIARI, (2006) *Climate Change and Pacific Rim Indigenous Nations Report*. The Evergreen State College, Olympia Wa. Pp 81.
- NMFS. (1999) *Status Review of Chum Salmon* Protected Species Branch, Natl. Mar. Fish. Serv, 525 NE Oregon St., Suite. 500, Portland, OR, 97232. 83p.
- Porter S.C., Swanson T.W. (1998) Radiocarbon Age Constraints on Rates of Advance and Retreat of the Puget Lobe of the Cordilleran Ice Sheet during the Last Glaciation *Quaternary Research* 50, 205–213 (1998)
- Prentiss, W.C., Chatters J.C. (2003) *The Evolution of Collector Systems of the Pacific Northwest Hunter*. *Gatherers of the North Pacific Rim* 63: 49-80
- Rogers, A. L. A. Rogers, R. S. Hoffmann, L. D. Martin Native. (1991) American Biological Diversity and the Biogeographic Influence of Ice Age Refugia *Journal of Biogeography* Vol. 18, No. 6, pp. 623-630
- Shipman, H. (2008) *A Geomorphic Classification of Puget Sound Nearshore Landforms*. Puget Sound Nearshore Partnership Report No. 2008-01. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.
- Swindell S., (1942) *Tulee v. State of Washington*, 315 U.S. 681, 62 S.Ct. 862, 86 L.Ed. 1115 (1942)
- Snover, A. K., Mote, P. W. Whitely B.L., Hamlet, A.F., Mantua, N. J (2005) *Uncertain Future: Climate Change and its Effects on Puget Sound*. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle).
- Stein, K. J., (2008) Geoarchaeology and Archaeostratigraphy View from a Northwest Coast Shell Midden. *Case Studies in Environmental Archaeology*

Interdisciplinary Contributions to Archaeology, 2008, Part II, 61-80, DOI: 10.1007/978-0-387-71303-8_4

Quinn, T., (2009) *An Environmental and Historical Overview of the Puget Sound Ecosystem. Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop*; pg. 11- 18

Appendix 1

Traditional Twana Story

assH3'qap.wps

There was one little girl who never paid attention to anything that was being said by the elders. She was always talking when she was supposed to be listening. When the other children tried to be attentive to the teachings she would poke them or cause disruptions in some other way. She did this so much that everyone called her “assH3'qap” (as sha kop); which means stupid or foolish. They called her by this name so much that everyone began to accept it as her real name.

Time passed all too suddenly for assH3'qap, for she knew it...it was time for her to go into the wilderness on her spirit quest. Early one morning her grandmother woke her up and told her, “It is time for you to go into the wilderness and find sk3'lalitut, your spirit power. Do not come home until you find it...and bring a gift to benefit those who are yet to come. With that, assH3'qap was hastily escorted to the foot of the mountain. She was quickly left alone by her grandmother.

Now, for the first time in her life she was truly alone, no one to pester, no instructions to ignore, no one to call her “assH3'qap”. Still at first she did not worry, it was early in the day, she was warm and nothing looked scary. Not yet that is...assH3'qap began to wander about, here and there. Night was fast approaching. The temperature fell. In the increasing darkness of nightfall she could hear sounds, strange sounds. There was no one to huddle up to for warmth. There was nothing to eat. There was no one to talk to. She was all alone in the wilderness. Alone...and she didn't know what she was supposed to do. She had never listened...she knew it all already or there were other things to do or she didn't have the time. Now the time of endless excuses was finished. Indeed she was assH3'qap. If only she had listened, she would know what to do.

It was dark. It was cold. assH3'qap was lonely. There were scary unseen things making noises in the darkness. Finally, exhausted from fear of the unknown terrors that lurked in the darkness, she fell into a cold restless sleep. Morning came. It was much better now. It wasn't scary anymore. But she was hungry, thirsty and scratched up from wandering naked through the dense brush in the dark. For three more nights she went through the same ordeal. Each day she was more hungry, more exhausted and more lonely. On the fourth night she found a hollow in the ground at the base of a huge cedar tree. It offered some degree of protection from the night wind. She wept through the night...pausing now and then to say, “Why was I so assH3'qap?” “Why didn't I pay attention?”

Very early, on the morning of the fifth day, just before dawn, she heard a tiny voice asking, “Why are you crying little girl?” She stopped her sobbing and looked around. She could see no one. Then she heard it again. “Why are you crying little girl?” It was coming from above her. She strained to see up in the limbs of the big cedar tree and saw a little bird. It was the one who was talking to her. She replied, “I'm crying because I'm so “assH3'qap”. I knew that I would be sent out here to find “something” but I never listened. Now, I don't know what I'm supposed to look for. The little girl admonished assH3'qap, “Pay attention! Pay attention!” The little girl watched as the little bird made a nest. She watched what it was using and how it was putting it together. She took some flexible grasses and after a number of attempts she had made a crude little container somewhat like the little birds nest. She realized that she could put things in this crude little container and carry them in it. “I'll call it a basket”, she exclaimed joyfully. People will be able to carry more things than with just their hands. It will be my gift for the people of the future.

assH3'qap wandered around the mountain side, putting berries, and other items in her new basket. Night fell. She tried to sleep but she was cold and she ached where she was scratched up. She cried through the night. In the early morning, just before dawn, she heard a voice asking, "Why are you crying little girl?" She told her story, and how she was gifted with the skill of basket making. And said, "I know that I should be thankful for what I have received, but my skin is sore from being scratched. I'm assH3'qap and don't know how to protect it." The voice said, "Pay attention!" The little girl looked up, and it was the cedar tree talking to her. She could see where some bark had come loose. The wind had worked it back and forth until it was flexible. "Use my skin", said the great cedar as the bark dropped down to the little girl. She took the softened bark and with plant fibers she wove it into a dress. The dress protected her bare skin from the harshness of the environment. The girl was happy now because she had two gifts, a basket and a garment. She continued her journey around the mountain.

It was colder now than before. Night fell again. This time it was very cold. There was no one to huddle next to for warmth. Aching with cold she once again wept through the night. Just before dawn she heard a voice asking, "Why are you crying little girl?" She said, "I know I should be thankful because I have received two gifts already, but I'm so cold I ache." "Pay attention!" the voice said. "Take this mountain goat wool that has tangled in my branches," said the bush. The little girl took it. She held it against herself and felt how warm it became where it covered her. She put the wool in her basket and walked on. She came to a stream and sat down to rest.

The girl took the warm goat from her basket and wondered aloud to herself, "I wish I knew how to fix wool so that it would stay together and I could make it into a garment without it falling apart, but I'm so assH3'qap." A voice said, "Pay attention!" It was the flowing stream that was speaking to her. She looked into the stream and saw how the flowing stream had twisted some fibers into string. She did this with the wool and it stayed together; she wove it into a blanket. She wrapped it around herself, it was warm and she felt good. Now I have three gifts she exclaimed to herself. She took some cedar bark and twisted it too; with this she made a trump-line to secure her basket to her so that she didn't have to carry it with her hands. Now I have four gifts she sighed to herself.

The girl looked at the stream again. There were fish in the stream. She realized how hungry her people were at times. She exclaimed to herself, "If I wasn't so assH3'qap, I could find a way for my people to catch those fish". A tiny voice said, "Pay attention!" It was a spider who was talking. The little girl watched as it wove a web in the crotch of a branch. She took a limb and bent it in a circle. Then she twisted more fiber into string and constructed a web on this hoop. "My people will use this to dip fish out of the water", she said. assH3'qap decided that it was time to return back to her people now. Wearing her new cedar dress, wrapped in her warm wool blanket, basket strapped to her for head and carrying a dip net, she made her way down the mountain towards the home of her people.

It was the beginning of a new day. The children were playing at that place where the people lived. They saw a strange thing approaching the place where they stayed. They ran to where the adult people were gathered. "There is something very strange approaching us" they exclaimed breathlessly. The people went to see. And true enough a strange thing was approaching. It wasn't naked like they were. It was covered with wondrous things. As it got closer they saw that it was the girl "assH3'qap". They all rushed to see her. As they reached out to feel and touch the wonderful mysterious things that assH3'qap was wearing and carrying, they asked, "What is the most important gift that you have brought for the people?"

assH3'qap replied:

“It is the basket that will allow us to carry many things”. Then she said, “No...it is the strap that the basket hangs from. It frees our hands for other purposes”. Then she said, “No...it is the clothing that the cedar tree gave me. It will protect our skin from the elements”. Then she said, “No...it is the goat wool that the bush gave me to make a blanket. A blanket will protect the people from the cold”. Then she said, “No...it is the net that the spider showed me how to make, so the people can catch fish”.

The people looked at the wonderful new gifts that the stupid little girl had brought for the people of the future. After a while assH3'qap said, “No...No...the most important gift that I brought for the people is to “Pay attention!”. Yes the gift of paying attention. You see...from the beginning of time all these things were here. The birds were making their basket nests. The cedar tree was offering its bark for clothing when it fell from the tree in soft shredded pieces. The mountain goats have always brushed off their shedding wool onto the bushes, where the birds gathered it to put a warm lining in their nest. The stream had always twisted fibers with its current. The spider has always wove its web right where we all could see. All these gifts have always been here, only no one paid attention. They have been overlooked since the beginning of time, until “I paid attention”.

The people gave assH3'qap a new name. They called her sQulalchi (She who is a skilled weaver). Since that time her gift has remained the most important one to mankind, “Pay attention!”

© **Bruce subiyay Miller** Bruce (subiyay) Miller was an artist, teacher, historian, storyteller and spiritual leader from the Skokomish Indian Reservation, near Shelton, Washington. He played a key role in conserving and sustaining the **Twana** language and culture of the Skokomish people. Growing up he absorbed language and culture from family members, and he dedicated his life to the preservation and teaching of Twana stories, ceremonies, healing practices, dance, and arts. He also revived and maintained the knowledge of traditional uses of plants for healing, ceremony, and food. Bruce was a skilled basket weaver and carver, speaks and teacher of the Twana language, and he led the revival of a number of traditional Twana spiritual and ceremonial practices including the **winter longhouse** ceremonies and the first elk ceremony. Often described as the Skokomish Tribe's Renaissance man, Bruce worked as a playwright, actor, teacher and counselor around the world, but his most important role was that of a teacher of the Twana tradition and culture. *The National Endowment for the Arts honored his life's work in 2004 with a National Heritage Fellowship and the First People's Fund awarded him the 2005 Community Spirit Award.*