

**Climate Change Implications for the Quileute and Hoh Tribes of
Washington: A Multidisciplinary Approach to Assessing Climatic
Disruptions to Coastal Indigenous Communities**

By

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A Thesis: Essay of Distinction
Submitted in partial fulfillment
of the requirements for the degree
Master of Environmental Studies
The Evergreen State College
March 2009

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ABSTRACT

Climate Change Implications for Quileute and Hoh Tribes of Coastal Washington: A Multidisciplinary Approach to Assessing Climatic Disruptions to Coastal Indigenous Communities

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Native peoples are the world's early warning system that climate change is affecting human communities. Climate disruptions are impacting hardest on their place-based rights and way of life. On the northern coast of Washington State, Traditional Ecological Knowledge gathered through in-depth interviews strongly suggests climate change is impacting the reservations of the Quileute and Hoh peoples. Both Nations live on low-lying coastline, bordered on three sides by the Olympic National Park, and are susceptible to sea-level rise, extreme storm surge events, and shoreline erosion. Quileute and Hoh peoples are already experiencing and responding to increased winter storms and flooding associated with increased precipitation coinciding with high tide at both the Quillayute and Hoh River mouths. They have little high land to relocate out of the river flood or ocean surge zones. In response, both tribes are requesting higher land within the Olympic National Park for village relocation. Species range shifts in the ocean are becoming more common with the arrival of new warm water species. Declines have been exhibited in traditional resources in the terrestrial, freshwater and marine environments along with an increase in invasive species, hypoxia and domoic acid events. In response, domoic acid is frequently tested to ensure traditional foods gathered are safe. The Quileute obtained a fair weather fisheries agreement with the State to help stabilize their subsistence economy during the winter storm season. Emergency radios and satellite phones are available to all residents on the isolated Hoh Reservation. Intertribal cooperation is increasingly relied on in order to maintain traditional practices. Traditional Ecological Knowledge is a critical resource for understanding and responding to the environmental changes already occurring on the coast. Other coastal communities will be forced to respond to similar impacts and should look to these tribes as a model.

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ACKNOWLEDGMENTS

I am tremendously thankful for the entire Quileute and Hoh Nations for making me feel part of their communities. I truly felt honored to be a guest at DeAnna Hobson's home on the Quileute Reservation during the entire duration of the project. I will forever be indebted to her and her family for opening their door and making me feel like part of the family. To the Quileute and Hoh Tribal Councils I share my greatest appreciation for approving and supporting the project, and me throughout the study. To the Quileute Natural Resources office thank you so much for providing me with an office space. To the Quileute and Hoh Natural Resources offices thank you for the support and the many resources you provided me. A special thank you to Bonita Cleveland who invited me to dance on many occasions; it was an honor I will never forget! In addition, thank you to my readers, Zoltan Grossman, Linda Moon Stumpff, and James Jaime for all of your support, guidance, and encouragement along the way. A final thank you goes out to my family for always believing in me.

CHAPTER 1 – INTRODUCTION

Climate Change and Native Peoples

Native peoples are the world's early warning system that climate change is affecting human communities. Climate change is impacting hardest on their place-based rights and way of life. From villages in Alaska suffering from unstable ground associated with melting permafrost and ice, to Pacific Islanders becoming the first climate change refugees due to sea-level rise inundating small island nations; Native people are experiencing the first major effects of global climate change.

Peoples living in the Northern latitude regions are experiencing unprecedented warming that is changing the traditional livelihoods of many Native communities. The Inuit of Canada, Alaska, Siberia and Greenland are dealing with drastic changes in their environments and are working together to find ways to quickly adapt.

For the Inuit, warming is likely to disrupt or even destroy their hunting and food-sharing culture as reduced sea ice causes the animals (on which they depend) to decline, become less accessible, and possibly become extinct (Corel, 2005; NIARI, 2006). One way the Inuit people are trying to cope with the changing environment, is by changing their hunting patterns by adjusting their "seasonal calendar" (Fenge, 2001), by shortening the season for ice fishing and using all-terrain vehicles when there is not enough snow to support snowmobiles (Riedlinger, 2001). In

the summer, seals are hunted by boat on the open water due to the lack of ice floes (Riedlinger, 2001).

Pacific Islanders too are feeling the impacts of climate change. For example, the small nation of Tuvalu is experiencing seawater intrusion into their small atoll land base.

There are islands themselves disappearing...so that's surely a sign that there's something changing around here. – Loto Pasefika (Horner, 2004)

Traditional foods are suffering from increased salinization of the soil due to sea-level rise. Native crops such as the taro and yam are dying off. More droughts and tropical cyclones are causing extensive damage to the landscape, making the small atolls progressively less habitable for Tuvaluans (Horner, 2004). Neighboring countries such as New Zealand are beginning to accept Tuvaluans as climate change refugees (Horner, 2004). In a speech to the United Nations the Prime Minister of Tuvalu summed up the feelings of many Indigenous communities who are experiencing the first major impacts of climate change.

We live in constant fear of the adverse impacts of climate change. For a coral atoll nation, sea level rise and more severe weather events loom as a growing threat to our entire population. The threat is real and serious, and is of no difference to a slow and insidious form of terrorism against us. – Saufatu Sopoanga, Prime Minister of Tuvalu (Sopoanga, 2003)

Washington Coastal Tribes

Like Pacific Islanders, Washington tribes are limited to sovereign land bases, essentially fixed political islands within a landscape without space to migrate away from climate change impacts, such as sea-level rise.

In the West Coast States, tribes limited to small land bases on the coastline are most at risk. In Washington State, the Shoalwater Bay, Quinault, Hoh, Quileute, Makah, Skokomish, Lower Elwha Klallam, Jamestown S’Klallam, Port Gamble S’Klallam, Squaxin Island, Suquamish, Tulalip, Swinomish, and Lummi are all coastal dwelling people that will have to respond to increased storm surges, warming seas, and sea-level rise (See Figure 1). Many other tribes in Washington are located on rivers only a short distance from the coast. One reservation in particular that has been experiencing increased river and rainfall induced flooding, especially during the last two winters (2008-09), is the Confederated Tribes of Chehalis.

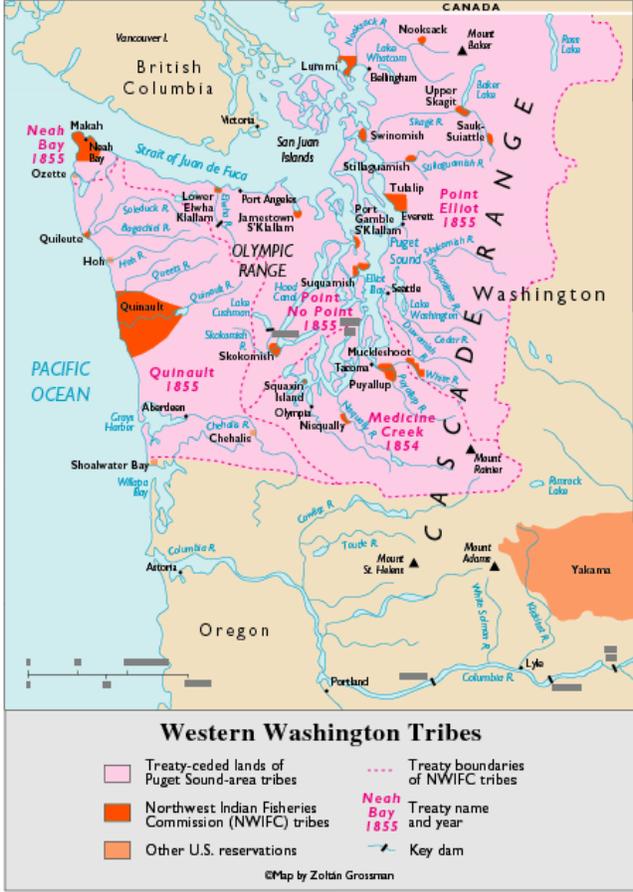


Figure 1 – Map of Western Washington Tribes. All of the reservations are located on waterways (Courtesy of Zoltan Grossman).

Tribes with exceptionally small reservations are at even more risk. The Shoalwater, Hoh and Quileute reservations on the outer coast of Washington all have only one square mile or less (Shoalwater 335 acres), and therefore have very little land for retreating from increased storm surges and sea-level rise.

The effects that marine and terrestrial ecosystem disruptions will have on tribes' way of life will disproportionately affect the viability of these low-lying reservations along the Washington coastline, making it difficult to maintain traditional and non-traditional place-based practices. This is especially true for the Quileute and Hoh tribes, whose reservations are low-lying coastal land bordered on three sides by the Olympic National Park (Figure 2-6). Not only are their reservation lands close to sea level, but their subsistence economies rely on the availability of natural resources such as fisheries.

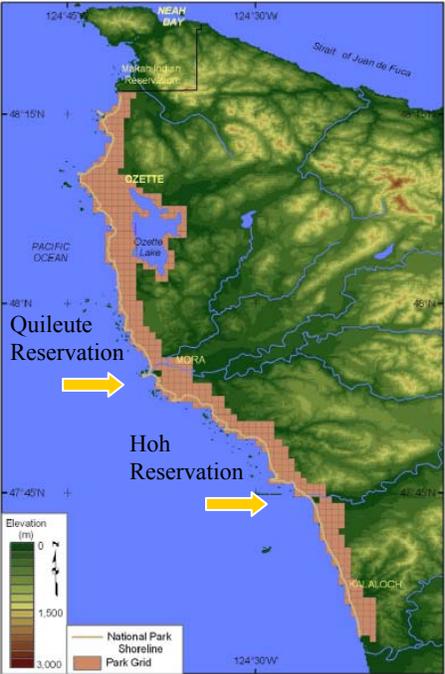


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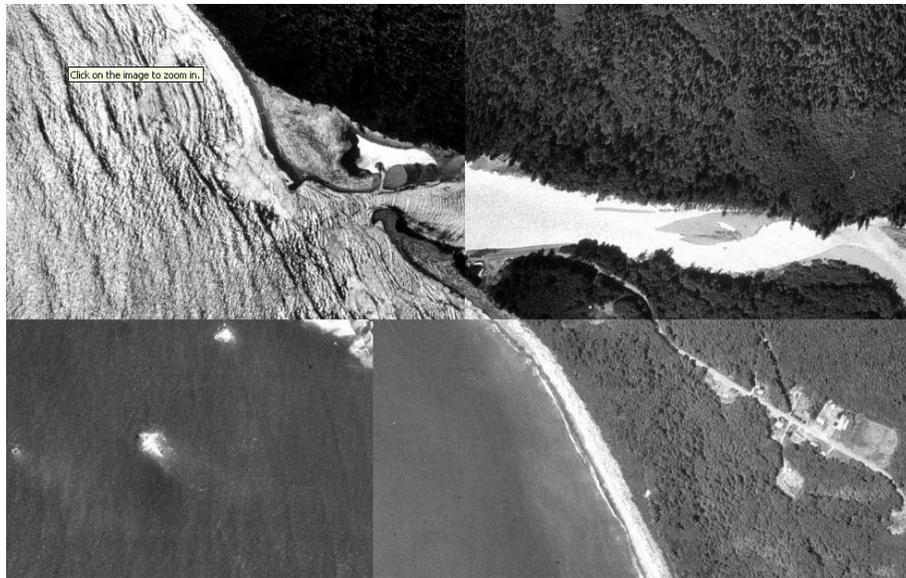


Figure 5 – Hoh Reservation aerial map from 1994 shows the low-lying village along the ocean and the Hoh River (TerraServer USA, 2009)

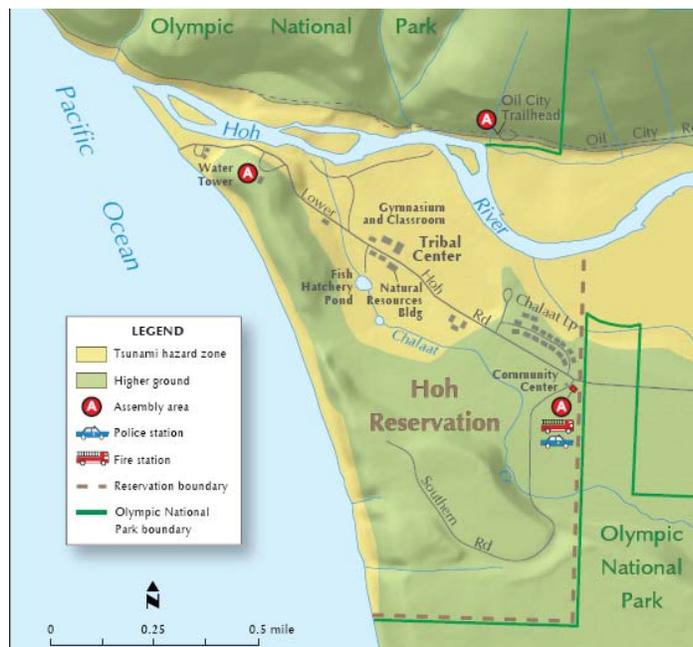


Figure 6 – Hoh Reservation tsunami inundation map. All major government structures are within the tsunami risk zone (DNR, 2007a).

Global climate change may be the greatest challenge for Washington tribes since the arrival of European-American settlers. This challenge is occurring due to global phenomena, much of it distant from our shores. The ice caps are rapidly melting with increasing global temperatures. Scientists have predicted that sea-level will rise with the melting of the polar ice and the thermal expansion of the ocean in warmer temperatures. Not only will sea level rise, but marine life is in jeopardy as the water warms above natural levels, putting communities that depend on the intricate marine ecosystem at risk. The impacts of this global climate change will hit hardest on those living in coastal regions.

Native peoples of Washington coast have an intimate connection to the land and ocean, and have adapted to previous environmental and social changes from the receding glaciers of the last ice age to European American colonization. Yet they may be facing unprecedented disruptions to their coastal way of life due to climate change. It is important to document current changes being felt by the Hoh and Quileute peoples so that their intimate knowledge of the coastal landscape can be shared with other communities that will soon experience the changes from global warming. Their responses could help serve as a model for communities to begin to mitigate and adapt to the changes to come.

Quileute Tribe

The Quileute people have lived in the coastal rainforest of the Olympic Peninsula for thousands of years. The Quileute and the Hoh

tribes (along with the former Chemakum tribe¹ of the Port Townsend area) are linguistically unrelated to any other tribes in the world. Quileute and Hoh people are the last to carry the Quileute language from what is called the Chimakuan language family, descended from a unique language of their ancestors.

Life for the Quileute people has not always been peaceful. With their traditional land base, legal rights and culture impacted by European colonization, the Quileute people have long fought for their traditional rights on the land and sea. Historically, the people of the Quileute Tribe used a land base of 900 square miles from the coast to the Olympic Mountain Range (Morganroth III, 2008; Pettitt, 1950). Chris Morganroth III (2008) noted that they shared camps with other coastal tribes, moving with the seasonal weather cycles from the coast to inland areas.

For the past 100 years or so, since reservations were set up, we were not allowed to migrate anymore. We used to move with the weather...moving to different camps with the season from the ocean to further inland. We were not nomads, but rather we moved with the weather to the best camps. There were nine tribes on the Olympic Peninsula; many had communal homes called longhouses. The Quileute people had several villages that were kept open by fire. – Chris Morganroth, Quileute Elder

During early negotiations with Governor Issac Stevens of Washington Territory and President James Buchanan, the Quileute signed the Treaty of Quinault River in 1855, followed by the Treaty of Olympia the following year (Buchanan, 1855 & 1856) that resulted in giving up large tracts of lands with a guarantee of continued access to the traditional fishing grounds “that had long sustained their people” (Ralston, 2008).

Yet their negotiations with the State did not leave them with their “usual and accustomed places” to fish, but instead forced them to move south to a reservation located on the traditional land of the Quinault people, their “traditional enemy” (Ralston, 2008). The Quinault Reservation was an attempt by the United States government to consolidate a land base for “the different tribes and bands of the Quinaielt and Quillchute Indians,” eventually for the Southwest Washington tribes too after their treaty talks collapsed (Buchanan, 1855 & 1856). The Quinault Reservation is approximately 115 miles south of La Push on the current road system. Many Quileute people walked to the Quinault Reservation never to return to their homeland, while some grew homesick and returned to La Push.

After 33 years of waiting, the Quileute finally gained a land base recognized by the United States. On February 22, 1889, President Benjamin Harrison created a separate reservation for the Quileute people, a one-square mile of coastal land bordered by the Quileute River and the Pacific Ocean. Currently, their land base is limited to 814-acre reservation, the original reservation with the addition of some private land holdings, which is much still reduced from their traditional 900-square mile territory. The Quileute Reservation is currently home to approximately 450 members of the Quileute Tribe with an additional 256 members living off the reservation (Ralston, 2008).

Following United State’s recognition of their sovereignty, the Quileute (along with the Hoh Tribe) had another challenge with the

creation of the Olympic National Park in 1938, and the addition of coastal lands in 1953 that directly border both reservations (ONPS, 2008). The National Park Service has a preservation mission that does not always include Indigenous people, making negotiations for resources especially difficult. As a result with the Park as their new neighbor, obtaining traditional land resources has become more challenging because actions must be dealt with on the federal level.

After the historic Boldt Decision of 1974 the Quileute and Hoh people, along with other coastal and inland tribes of the Pacific Northwest, re-established their treaty-backed fishing and hunting rights. Now the Quileute people have recognized rights to fish in their “usual and accustomed” fishing areas within the Quillayute River watershed. They also reestablished ocean fishing rights that spans 200 miles from shore from Sand Point near Lake Ozette and south to the Queets River mouth (Moon, 2008).

The Quileute people have always been intimately connected to the coastal land and sea. They were historically known for their accomplished seal and whale hunting. Their recognized sovereign land is primarily coastal lowland, which is highly susceptible to flooding during winter storms and lies within a high-risk tsunami zone (Figures 2-3).

The 1964 Alaskan earthquake of magnitude 9.2 was the largest earthquake ever recorded in North America. It triggered a tsunami that hit the Alaska, B.C., Washington, Oregon, and California coastlines. This is a

very vivid memory for many people still living on the Washington coast. In La Push boats were damaged, but fortunately no lives were lost. Out of fear of tsunamis, and of increased flooding during winter months, the tribe is currently bidding for higher ground. Following a major storm that hit the Quileute Reservation in December 2006 that pushed huge drift wood up to the school playground and the January 2006 tsunami that hit South and Southeast Asia, the children of La Push held a mock funeral to protest their dangerous school location in the lower village (Kowal, 2006). This dramatized a very real and dangerous situation that the Quileute Tribe faces not only out of fear of a tsunami, but also of the impacts of climate change and sea-level rise. Nearly half of the current reservation land base is in the river flood zone, making the options slim for moving any of the lower village to safety within the designated reservation.

If a tsunami warning were issued for the coast, people would have just minutes to travel nearly a mile down the only road out of the reservation. – James Jaime, Executive Director Quileute Tribe (Crawford, 2004)

Currently, the school along with the entire lower village organizes tsunami drills where everyone must evacuate up to the highest part of the reservation where the current high school sits, the A-Ka-Lat. In 2004 the Quileute community successfully evacuated everyone (~250 people) from the lower village within nine minutes, within the amount of time tribal leaders believe is successful in avoiding loss of life (Crawford, 2004).

Hoh Tribe

By an Executive Order of President Grover Cleveland on September 11, 1893, four years after the Quileute Reservation was recognized, the Hoh Tribe was granted a small, one square-mile reservation along their traditional lands of the Hoh River (Wray, 2002). The reservation is 443 acres bordered by the ocean, the Hoh River, and the Olympic National Park. The tribe has approximately “186 registered Hoh tribal members, 94 of whom live on the reservation” (Wray, 2002). Of the 443 acres, 90 percent of the land is in the 100-year flood plain that seems to be flooding more frequently in recent years (Berry, 2008; M. Riebe, 2008). In addition, 100 percent of the 443 acres is within a high-risk tsunami zone (Berry, 2008; M. Riebe, 2008)(Figure 5-6).

The Hoh River watershed is made up of numerous tributaries—some small and some quite large. The Hoh River, or Cha’laK’at’sit (Southern River) flows from Mount Olympus down to the Pacific Ocean. It flows from the mountain tops and descends 7,000 feet in a 50-mile stretch before it reaches the ocean (Powell, 1999). It is known as the “southern river” because it was traditionally the southernmost river in Quileute-speaking country (Powell, 1999). Historically, the Hoh village was characterized by a “busy waterway with 7 settlements along its course and a resident population of 110 or more” (Powell, 1999). There was always seasonal movement (before the reservation was established) to hunting and gathering grounds and camps along the river. Jay Powell

notes, “the entire watershed was utilized in traditional times. The Old Peoples’ cognitive maps of the river were dotted with place names, the boundaries of hunting grounds, and the sites associated with mythic narratives, spiritual beliefs, ritual sites, burial locales, tribal historic events, and favorite foraging spots” (Powell, 1999).

To this day the Hoh Tribe makes its livelihood primarily from fishing, with some individuals also selling traditional crafts such as cedar woven baskets, cedar dugout canoes and other carvings (Hoh Tribe, 2008). Both the Quileute and Hoh people still gather much of their resources from the tidelands for razor and butter clams, boots (chitons) and slippers (mussels) and the forest for cedar, grass and berry harvests.

Purpose of Study

With the understanding of current climate change impacts and those predicted for the Pacific Northwest, this project examines specific examples on the local scale. The coastal reservations of the Quileute Tribe in La Push and the Hoh Tribe at the mouth of the Hoh River in coastal Western Washington are where the project takes root. The project attempts to document current impacts that the tribes are experiencing, through an interview process that relies on the Traditional Ecological Knowledge (TEK) that these communities, like many Indigenous communities, still possess. TEK is aligned with Western scientific findings and predictions. Even in the absence of this alignment, the process documents environmental changes being felt by the Quileute and

Hoh communities and the responses these communities are already taking to adapt to the environmental changes. TEK is important to environmental studies because it can be “used to understand and predict environmental events upon which the livelihood or even survival of the individual depends” (Huntington, 2000). The purpose of this study is to provide an inventory of the changes being felt by the Quileute and Hoh communities and to help share responses for other coastal communities to use as a guide. Native and non-Native communities can use this study approach to help document environmental changes in their own communities to shape community adaptation planning. This project also tries to breakdown the disciplinary barriers that often alienate TEK and promote interdisciplinary discussions.

CHAPTER 2 – LITERATURE REVIEW

Numerous reports of a changing climate have come from the scientific community, but those to first feel the changes are those who have lived within a landscape for thousands of years— Indigenous First Nations.

On one hand, Indigenous peoples are on the frontline of climate change the first to feel its effects, with subsistence economies and cultures that are the most vulnerable to climate catastrophes. On the other hand, Indigenous people can also be viewed as the most historically adaptable and resilient, because of our traditional ecological knowledge and community ties. (NIARI, 2006)

This literature review will cover case studies on Native communities around the world to highlight the importance of using Traditional

Ecological Knowledge. This section will also cover specific reports on climate change from Native American communities and what methods have been employed to try to overcome some of the looming impacts of climate change.

TEK is a knowledge base that holds and immeasurable amount of value that can greatly add to the understanding of the environment. Historically TEK “has been marginalized by disciplinary boundaries that accord to science, the study of nature and to social science, the study of human societies” (Neis et al., 1999), though it can greatly add to many, if not all, disciplines. There is no universally accepted definition of TEK. A commonly cited definition is “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationships of living beings with one another and their environment” (Berkes et al., 2000).

Cajete provides a working definition:

...Indigenous science is that body of traditional environmental and cultural knowledge that is unique to a group of people and that has served to sustain those people through generations of living within a distinct bio-region. This is founded on a body of practical environmental knowledge learned and transformed through generations through a form of environmental and cultural education unique to them. Indigenous science may also be termed “traditional environmental knowledge” (TEK), since a large proportion of this knowledge served to sustain Indigenous communities and ensure their survival within the environmental contexts in which they were situated. (Cajete, 2000)

This working definition can also be used for traditional ecological knowledge, which can also be termed “Indigenous science.”

Climate change has spurred a new green era. Across the globe, businesses are cashing in on selling and marketing themselves as ‘green.’ Much attention has been spent on research into how climate change will affect economies, health and politics, but “rarely does its impact on minorities and Indigenous groups get a mention, even though they are among the worst affected” (Baird, 2008). TEK, from Native and Indigenous groups, highlights place-based changes occurring throughout the world that can inform Western scientists on the varying degrees of change already occurring.

Though TEK and impacts on minority and Indigenous groups are not mentioned in current climate science, it does not mean that TEK has never been successfully used across disciplinary boundaries. The following case studies will provide examples of how TEK has been used in understanding complex environmental problems.

TEK Case Studies Around the World

Cod fisheries in the north Atlantic have been in decline over the past century. To better understand the fishery, Neis (1999) documented TEK from the peoples of Newfoundland and used their knowledge to enrich the western scientific knowledge of fisheries science. The outcome of the study provided the researchers with, “invaluable information not only on fishing strategies and marine ecosystems, but also on fishers’ and the industry response to the combined effects of resource decline and related policy initiatives.” The researchers felt that TEK could be used in

fisheries management in “at least four areas”: defining management goals and values, allocation of resources, development of ecological concepts and fisheries permitting (Neis et al., 1999).

In another case study in Micronesia (Johannes, 1981), the Palauan people provided an astonishing amount of knowledge on the marine ecosystem. Johannes stated that he was told of “months and lunar periods as well as the precise locations of spawning aggregations of some fifty-five species of food fish in a tiny archipelago...that was more than twice as many species of fish exhibiting lunar spawning,” then had ever “been described in the scientific literature for the entire world (Johannes, 1981).”

These two examples highlight the importance and the vast knowledge that TEK can bring to natural sciences, especially in marine ecosystems, but TEK is not limited to improving resource management and fishery sciences. The acceptance and incorporation of TEK in a variety of discourses, such as physics (Capra, 1975) and ecology (Lovelock, 1979), can move investigators from reductionist thought, to human (Brunée, 1989) and animal rights and welfare (D'Amato & S.K. Chopra, 1991). TEK is changing the way people think about the environment around us. As Doubleday explains, “Perhaps the environmental crisis which so many have cast in terms of overpopulation or pollution or global change is really a crisis in the way we think” (Doubleday, 1993).

TEK and Climate Change Case Studies

Drought generated famine in African countries, flooding in Bangladesh, and melting ice in the Arctic region are all environmental impacts that are putting traditional and subsistence livelihoods at stake. Not only are these communities and places important for the world to learn about, but their responses to climate change may help others who may not live as closely to the land. Through TEK, Indigenous and Native peoples have been historically adaptable to their surrounding environments, and offer vast knowledge to non-Native communities. As carriers of TEK (that has been passed down from generation to generation), Native peoples possess some of the most important tools for adapting to global climate change, yet these very tools are being confronted with the unprecedented rapid changes.

In the East African country of Uganda, changes in rain patterns are disproportionately affecting farmers living in Karamoja Province. Food stock and cattle are severely affected by declines in rainfall during key months.

Climate change in the future is going to affect Karamoja very badly. It used to be that we had rain for six months and it was dry for six months. It is now eight months of drought and only four months with rain...even this rain is spread out and not continuous – Michael Kuskus, Karamoja, Uganda (Baird, 2008).

A group led by Michael Kuskus, of the Karamoja Agro-Pastoral Development Programme, have been active in getting farmers to diversify as an adaptive response to changing rainfall patterns (Baird, 2008). In

order to avoid severe economic depression and starvation, from cattle loss due to drought, farmers are encouraged to sell cattle when food is plentiful and save the profit to buy food supplies during severe droughts (Baird, 2008). People are also encouraged to join together for group loans that can be used to purchase food supplies when droughts are severe (Baird, 2008). However, this response can only last so long before droughts cause the land to become uninhabitable. People are already moving to nearby cities as a result of food shortages.

This is going to have a huge negative impact on us and affect our lifestyle drastically. More people will move away and our communities will be splintered, traditions lost. How much more of this will we be able to take? – Michael Kuskus, Karamoja, Uganda (Baird, 2008).

In Bangladesh climate change is impacting coastal areas, as sea-level rise causes people to retreat from the encroachment of the ocean. Gathering and fishing grounds that were present just 45 years ago have been eroded away beneath the ocean waves (Baird, 2008).

My family had water-buffaloes and they used to graze on the wetland, but now there are fewer of those animals as the grazing land is lost under the waves – U-Sa-Chi-Master, Bay of Bengal, Bangladesh (Baird, 2008).

These challenges are difficult to meet because there is little that will stop the ocean's forces, which will only worsen with rising sea level.

In the Northern Hemisphere, the Inuit people of the Arctic are struggling with melting ice and permafrost that is forever changing their traditional landscape. In response, Inuit people (who have contributed very little to the problem of global climate change) have filed a petition

against the United States with the Inter-American Commission on Human Rights (Watt-Cloutier, 2005). Inuit people feel that the effects of global warming in the Arctic “constitute violations of Inuit human rights, for which the United States is responsible”(Watt-Cloutier, 2005). The 174-page petition states specific environmental, social, economic and cultural impacts global warming is having on the Inuit people.

In addition to the petition, the small Inupiat village of Kivalina in northern Alaska has sued 24 companies for contributing to global climate change. Of the companies included, 8 are oil companies (including the ExxonMobil Corporation), 14 power companies and one coal company (Ben-Yosef, 2008). The lawsuit was filed in federal court stating that these companies disproportionately contributed to a warming climate in the Arctic region.

Warming temperatures are contributing to later ice formation that used to occur by October to help protect the coastal Kivalina Village from winter storms (Ben-Yosef, 2008). Now, sea ice is not forming until December or later and it is melting much earlier (Ben-Yosef, 2008). With accelerated erosion the people of Kivalina are requesting the companies pay for the relocation of their village, which is estimated at \$400 million (Ben-Yosef, 2008). This is an example of responses Native peoples are taking to help protect their livelihoods in a rapidly changing environment.

Climate Change and Native Americans

Within the United States, Native Americans are also struggling with the impacts of climate change on their reservations and “usual and accustomed” places where treaty rights are practiced (in treaty ceded territories). When many American Indian Tribes signed treaties with the United States the phrase “as long as the rivers run” was used (NIARI, 2006). This phrase implied an understanding that natural resources from traditional grounds would continue to provide for Native peoples (NIARI, 2006). Now within a changing climate, the NIARI report (2006) points out that this statement holds less ground for all people today.

Native Americans face an even larger obstacle for responding to climate change— a limited sovereign land base. Limited to reservations and specified treaty lands for gathering resources, Native peoples, within the United States, may face hard times when essential food sources become unavailable within their designated areas due to the changing climate. With species shifting to cooler regions (both northward in latitude and higher in elevation), traditional gathering and hunting areas may no longer be suitable environments for obtaining subsistence foods, culturally important resources, or the maintenance of a resource dependent subsistence economies. Tribes, dependent on treaty-designated fishing zones in lakes and rivers may suffer from fish kills due to warmer water temperatures, increases in invasive species, salt water intrusion, lower oxygen levels and flows (Glick et al., 2007). Those dependent on ocean

resources may be impacted by species shifts, lower oxygen levels, warmer temperatures, ocean acidification, increases in invasive species, and sea-level rise.

Unlike other citizens, the Tribes are tied to their homelands in a unique relationship to their lands and to the United States. Their identity is deeply rooted to their lands- the place from which they emerged, where their ancestors dwell, about which their stories and language refer, and to which they have continuing spiritual and collective obligations. Because of their unique political history, their recognized prior rights and treaty rights only apply to their reservations and usual and accustomed lands. Moving from these lands to adapt to large-scale environmental decline would cut them off from their origins, from the places of their collective memory, and the rights to self-determination the Tribes possess as peoples. – Terry Williams and Preston Hardison (NIARI, 2006).

Due to the actual and predicted changes, many tribes across the United States have begun taking action to protect resources and traditions that have sustained their people for thousands of years. Conferences specific to climate change impacts on Native Americans have been increasing in number across the nation. Tribes such as the Cocopah (2006), Umatilla (2008), and Squaxin Island (2008), have already begun hosting climate change gatherings to share TEK of changes being seen from nation to nation and on successful adaptive strategies. In the Pacific Northwest, the annual Gathering of Coast Salish Peoples (from Western Washington Tribes and British Columbia First Nations) have made climate change impacts and planning for coastal Native communities one of their top priorities (Lekanof, 2008).

In the Southwest of the United States, climate change is expected to create water shortages. Tribes of the Southwestern area are beginning

to look at TEK to conserve water in agriculture. The ancient Hohokam peoples (the ancestors of the Pima and Tono O’odham (Papago) tribes of Arizona (Cajete, 2000)) practiced water conservation through canalization, impoundments, diversions and in-situ storage, such as “pebble-mulch fields and grid gardens that stored rain and snow fall for the growing season” (Watson, 2000). These technologies are now being studied through a NASA-funded program that is investigating future methods of conserving water in a changing climate (Watson, 2000).

The Swinomish Tribe of Washington State has already pinpointed some of the impacts they will face. The Swinomish Reservation is in the upper Puget Sound region and is at risk to increased flooding and inundation due to sea-level rise.

Some of the Impacts Facing the Swinomish Tribe

- More frequent flooding damage from storm/tidal surge events
- Salt water intrusion and habitat loss
- Species relocation/migration
- Possible loss of access routes where diking is insufficient in preventing inundation
- Disruption of surface transport and emergency services due to inundation
- Spread of contaminants carried by inundation waters
- Fishery/habitat impacts; stream flows & temperature
- Increased shoreline erosion

(O'Hara, 2008)

Using TEK, the tribe has responded by creating a planning guide for short-term adaptation and long-term mitigation with the University of Washington’s Climate Impact Group (CIG). The guide explores responses

such as relocating structures that are in at-risk locations, intergovernmental coordination, establishing funding support, and including climate change impacts into all future planning. The Swinomish have partnered with local climate change experts, county and city officials, and local utility companies to coordinate local solutions to climate change impacts in the Skagit River Basin.

The Paiute Tribe of the Pyramid Lake Indian Reservation, in northern Nevada has also been experiencing changes in their Great Basin environment and has begun taking adaptive approaches. In the Great Basin, the ecosystem depends on snow pack in the mountains to maintain stream flows and Pyramid Lake levels for productive riparian habitat. Warmer temperatures have caused the snow pack to recede in elevation, putting riparian ecosystems at risk (Mosley, 2008). As a result, the Paiute people have witnessed lower lake levels than ever before, an increase in invasive plant and animal species, loss of native plants, dewatering of lakes, seeps, springs and wetlands, poorer water and air quality conditions, and lower crop yields (Mosley, 2008). With drying lake beds, such as the Salton Sea, air quality has increased asthma and respiratory problems in the area (Mosley, 2008). In response, the tribe has come up with an adaptive management plan based on TEK of the local environment.

Paiute Adaptive Management Plan

- Remove non-native plants that compete with native plants for water, soil nutrients and space
- Plant native drought tolerant plants to replace non-native plant species
- Purchase water rights and dedicate them for in-stream flows to protect biological integrity and habitat, improve water quality and provide flows for spawning fish
- Work with upstream stakeholders to develop a watershed plan for using and managing water to protect regional beneficial uses (Pyramid Lake Paiute worked since 1992 to develop the “Truckee River Operating Agreement” with all the major stakeholders within the Truckee River watershed basin).

(Mosley, 2008)

The Paiute people are coming together to try to protect their traditional lands and livelihood by implementing a water resource plan that emphasizes maintaining flows on an ecosystem level by including all the major stakeholders.

The Paiute and Swinomish tribes represent just two examples of the types of climate change impacts facing Native American communities. Both tribes are actively planning and responding to current and future climate-induced changes to their homelands. The tribes possess TEK that allows them to know what types of changes, even subtle ones, are affecting their local environments and how to best approach them. Native peoples should be look to in this time of change, for their TEK of the local environment and their history of adaptation.

CHAPTER 3 BACKGROUND

Climate change (also referred to as global warming, global climate change and global climatic disruption) is a term used to describe human-

induced changes to the global environment, as a result of increased atmospheric greenhouse gases (GHGs). The primary source of GHGs come from the increased combustion of fossil fuels since the industrialization era (1750) that have resulted in higher levels of, carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), atmospheric concentrations of carbon dioxide and methane in 2005 far exceeded the 'natural' levels exhibited in ice cores for the last 650,000 years (IPCC, 2007a). These gases act as heat absorbers that are causing the earth to heat up through a greenhouse effect (IPCC, 2007b) (Figure 7).

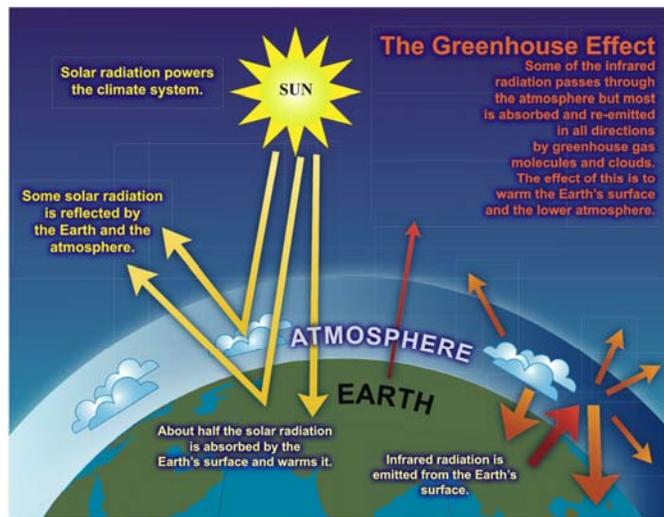


Figure 7 – Greenhouse effect caused by the accumulation of greenhouse gases such as carbon dioxide, nitrous oxides, sulfur oxides and methane (IPCC, 2008).

These findings have led to numerous studies on the global and local impacts of climate change on the earth's natural systems. The IPCC is a Nobel prize-winning, worldwide renowned source for climate change data. The IPCC is made up of hundreds of scientists from countries around the

world that devote themselves to compiling bi-annual reports. These reports focus on the “the causes of climate change, its potential environmental and socio-economic consequences and the adaptation and mitigation options to respond to it” (IPCC, 2008). In its most recent report published in 2007, IPCC calls for immediate action stating that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.” These current changes have been observed (IPCC, 2007a):

- Sea level has risen 3.1 mm every year from 1993 to 2003 and since 1975 occurrences of more extreme high sea levels have increased (Figure 8)
- Terrestrial ecosystems responding with earlier onset of spring events and migration of flora and fauna to northern latitudes and higher elevations
- Poleward and upward elevation shifts in plant and animal ranges
- Ocean acidification from uptake of carbon since 1750 has decreased pH by 0.1 units
- From 1995-2006 eleven of the twelve years rank among the twelve warmest years in global surface temperatures since 1850 (Figure 8)
- Marine and freshwater systems have exhibited shifts in algal and fish species ranges and abundances associated with increased water temperatures, ice cover, salinity, oxygen levels and circulation.

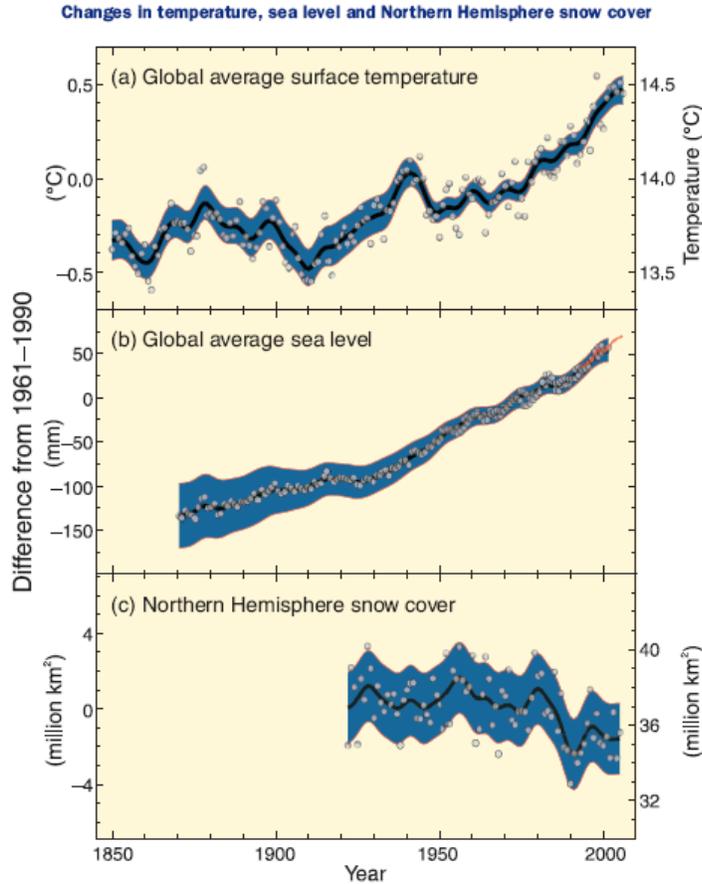


Figure 8 – Global environmental changes associated with climate change. Land surface temperature has been steadily increasing since Industrial Era began. Sea level is rising in response to melting arctic regions and thermal expansion of the ocean waters. In addition, snow cover has been declining in the Northern hemisphere (IPCC, 2007a).

Regional Climate Change Impacts

Along with global predictions of climate change, the University of Washington’s Climate Impacts Group (CIG) provides local and regional data specific to the Pacific Northwest (PNW). The CIG predicts that the PNW will have “warmer, wetter winters, and warmer summers, with streamflow increasing in fall and winter, and decreasing in summer” (Canning, 2001). In addition to sea level rise, the CIG has predicted an increase in erosion and landslides associated with increased winter

rainfall, flooding and ocean storm surges. Natural climatic cycles in the PNW are predicted to be enhanced by anthropogenic climate change, such as the increased rainfall seen during La Niña years.

Increased Storm Damage and Flooding

The Pacific Northwest weather is a highly complex system that has many divergent factors, making studying climate change difficult. The region's weather is dominated by two main systems, the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation (ENSO) cycles. The PDO cycle operates on a 40-60 year time scale, whereas ENSO operates on a 2-3 year time scale, both of which naturally influence the PNW's warm and cool phases (CIG, 2008). Mantua et al. (1997), correlated that cold PDO (when aligned with a La Niña year) is associated with good salmon runs. "Recently, however, these decadal cycles have broken down: in late 1998, the PDO entered a cold phase that lasted only four years followed by a warm phase of three years from 2002 to 2005" (NOAA, 2008c) (Figure 9).

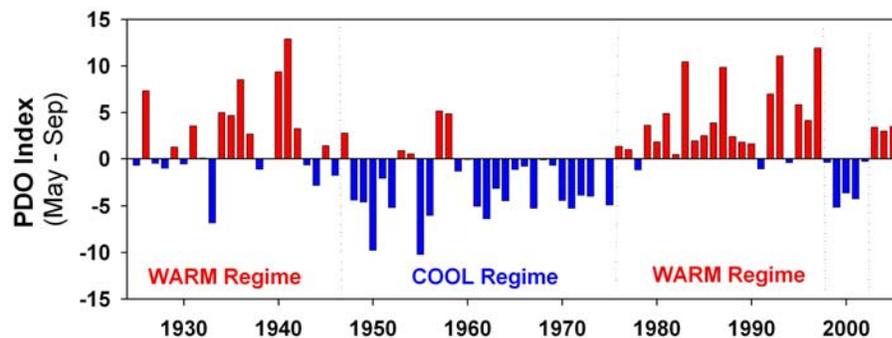


Figure 9 – Pacific Decadal Oscillation (PDO) cycles from 1925-2006. Red bars are positive or warm years and blue bars are negative or cool years (NOAA, 2008c).

Sea level rise caused by climate change in combination with natural climatic changes such as El Niño, known to temporally increase sea level in the Pacific Northwest (Komar, 1986) could create greater impacts from winter storm surges during El Niño years. As Komar (1992) later notes, during the 1982-83 El Niño the monthly mean water level at Newport, Oregon was 32 cm above monthly mean sea level, and up to 19 cm above maximum monthly mean sea level. During the El Niño of 1997-98 wave heights along the Washington coast exceeded normal levels, in Grays Harbor they were almost 1 meter above normal in December and January, and 1.5 meters in February (Kaminsky et al., 1998). Thus an El Niño in combination with a winter storms, can cause more damage to PNW coastal environments, especially those along major river mouths (Canning, 2001). When the water rises in the ocean at high tide and meets with a river at flood stage, an extreme flooding event results (Canning, 2001).²

The combination of La Niña and climate change will also heighten problems associated with increased winter rainfall and sea level rise. According to Canning (2001) increased winter rainfall along with a La Niña year like those seen in 1998-99 will result in:

- A greater frequency and magnitude of landslides, especially in locales where topography and vegetation has been disturbed by land development and land use practices.
- An increased frequency and duration of river-mouth flooding, especially when river flood flows arrive at the coast coincident with high tide.

These impacts will likely affect the Quileute and Hoh tribes who both have lands bordering major river mouths and whose watersheds have been logged in the past and continue to be logged under new regulations that can include riparian buffer zones. Coastal communities such as the Quileute and Hoh are looking at specific impacts to their local coastline.

Specific impacts for PNW coasts include (CIG, 2008):

- Sea level rise (associated with El Niño events) increase risk of coastal erosion
- Increased winter precipitation (associated with La Niña events) increase the risk of coastal riverine flooding and of landslides
- Southeasterly winter storms (associated with El Niño events) increase risk of coastal erosion
- Co-occurrence of all these conditions increases the likelihood of large, damaging coastal erosion and flooding events

Decreased River Flow

Along with heavier rainfall events, climate change will result in lower-than-average snow pack and increased water temperatures. Higher water temperatures in the Pacific Ocean are likely to “exacerbate the impact of excess nutrient runoff into coastal waters, enhancing harmful algal blooms (HABS) and hypoxia events” (Glick et al., 2007). Higher terrestrial and water temperatures will also continue to facilitate invasive species and diseases to spread into regions where colder temperatures used to limit their expansion (IPCC, 2007a). Thus far the Pacific Northwest in the 20th century has already experienced the following changes (CIG, 2008):

- Temperature has increased on average 1.5 F between 1920 to 2003, the warmest period on record was the 1990s
- Daily minimum temperatures on the rise, rising faster than the maximum daily temperature through the mid-20th century
- Precipitation has increased annually by 14% during 1930 to 1995
- Snow water equivalent for April 1st is on the decline in almost all recorded sites from 1950 to the year 2000. Low to mid level elevations exhibiting the highest decline
- Timing of peak runoff has shifted up to 20 days earlier for many rivers in the PNW

With these changes and those to come, people may choose to respond to climate change through mitigation and adaptation. In this context, mitigation would be to respond by lowering the negative effects of climate change through some action, while adaptation would be to respond to the effects of climate change by creating or doing something that would work within the changed environment (either proactively or responsively).

Project Location

The project is centered on the Quileute Nation’s Reservation on the coast of Washington State in the village of La Push, and the Hoh Nation’s Reservation at the mouth of the Hoh River. Both tribes have been ceded one square mile reservations, much of which are within river channel migration zones (CMZ) of the Quillayute and Hoh Rivers.

The Quileute Reservation has a lower village comprised of family homes, preschool through middle school facilities, Natural Resource Office, Tribal Office, Personal Office, Marina, Health Services, Riverside Restaurant, High Tide Seafood Company, Community Center, United States Coast Guard station and Oceanside Resort and Campground—all

just above current sea level. The upper village has two housing areas, a clinic, police station, Head Start Preschool and the Quileute Tribal High School or A-Ka-Lat Center all of which are may still be susceptible to large tsunami waves. In addition to being in a low-lying area, the United States Geological Survey reports that the coastline of the Quileute Reservation is in a high-risk area for erosion (Figure 10-11).

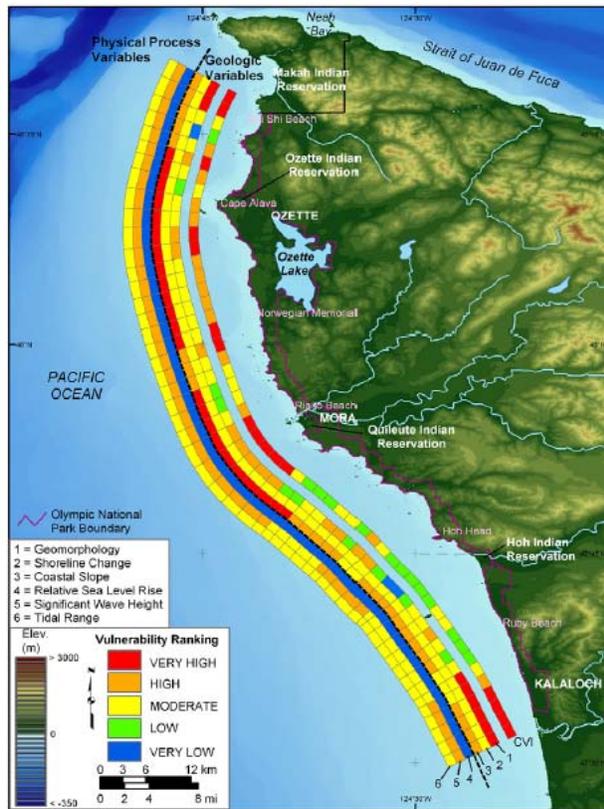


Figure 10 – Coastal erosion along the northern Washington coastline. Moderate to high risk erosion potential for Quileute Reservation and low erosion potential for the Hoh Reservation according to a USGS Report (Pendleton et al., 2004).



Figure 11 – Images depicting the Quileute and Hoh coastlines’ vulnerability to erosion. Figure 7 shows the diverse geomorphology and the Quillayute River mouth. Figure 8 is Rialto Beach, just north of the Quileute reservation that is highly vulnerable. Figure 5 is Hoh Head, just north of the Hoh Reservation that has a rocky cliff with very low vulnerability (Pendleton et al., 2004).

The Quillayute watershed is fed by rainfall, snowfields, and glacial lakes (Hook, 2004; Moon, 2008)(Figure 13). Since the Quillayute River is not fed directly by glacial water, it is already more susceptible to warmer temperatures (Hook, 2004) and lower flows in the crucial summer and fall months, when Chinook and chum salmon return to the river system. In addition to susceptibility to lower flows, the Quillayute sub-basin has an alarming problem with invasive plant species, which does not bode well for salmon habitat (Hook, 2004).

Like La Push, the Hoh Reservation also has lower and upper villages. The lowermost village of the Hoh Reservation has been

abandoned since the mouth of the river changed and flooding increased in the 1970's (Sampson, 2008). Family homes were moved to higher elevations on the reservation (where now some families still reside), in addition to newer buildings that house the Hoh Tribal office, Hoh Natural Resources and Community Center, all of which are in high-risk zones for tsunamis and Hoh River channel migration (Figure 6). Additional housing, community gardens, police station and fire station are located in the highest portion of the existing one-square mile reservation. The Hoh Reservation sits along the mouth of the Hoh River, 90 percent of which is within the historic flood plain and 100 percent within tsunami risk zone (Berry, 2008; M. Riebe, 2008). The Hoh Head coastline just north of the reservation is considered low risk for erosion by U.S. Geologic Survey (USGS), but the reservation coastline itself was not surveyed (Figures 7-8)(Pendleton et al., 2004). However, important cultural sights along the Washington coastline, identified by the USGS researchers are at risk from erosion (Figure 12)(Pendleton et al., 2004).

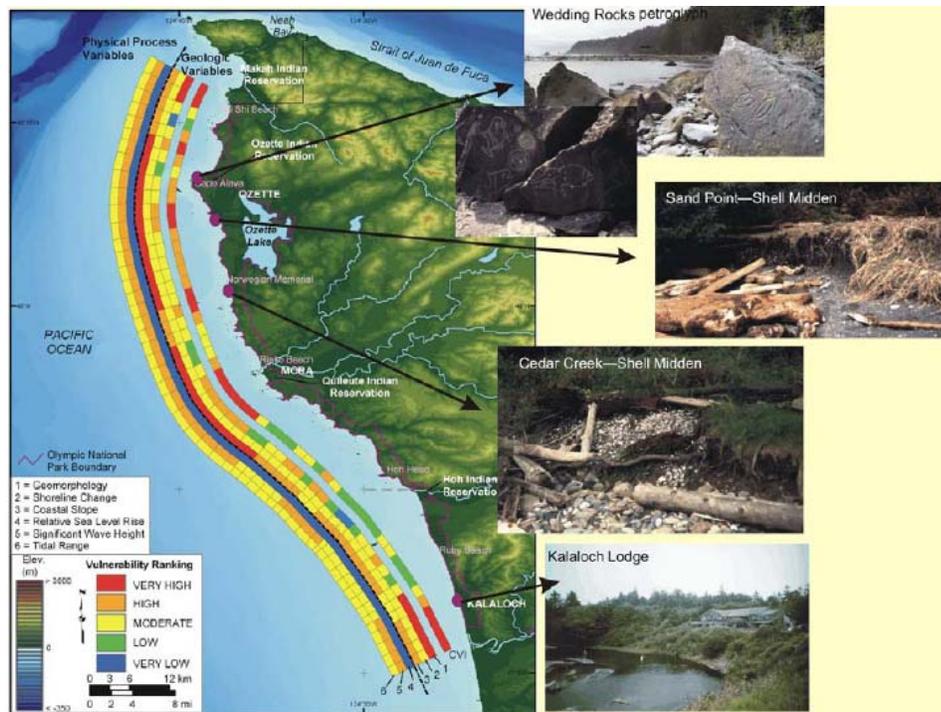


Figure 12 – Cultural resources subject to erosion with sea-level rise along the Washington coastline (Pendleton et al., 2004).

The Hoh River Basin drainage encompasses approximately 299 square miles of land, and only 35% of the watershed is outside Olympic National Park boundaries. This portion is from the mouth of the river to Mile 29.6 (Golder Associates, 2005) (Figure 13). The Hoh River watershed receives an astounding average of 150 inches of rain annually (whereas the city of Seattle receives an average of 36 inches annually). This heavy rainfall helps maintain the river’s flow, along with glacier and snow pack run-off that feeds the river system with cool water during the summer months (Golder Associates, 2005).

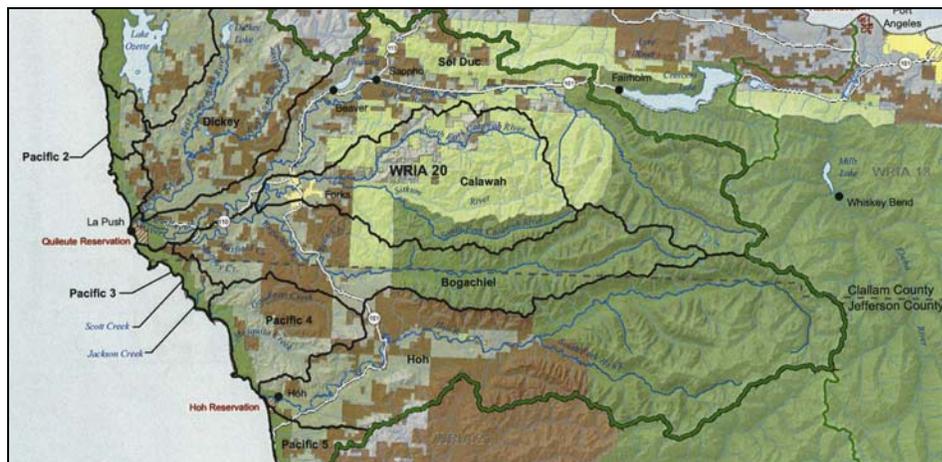
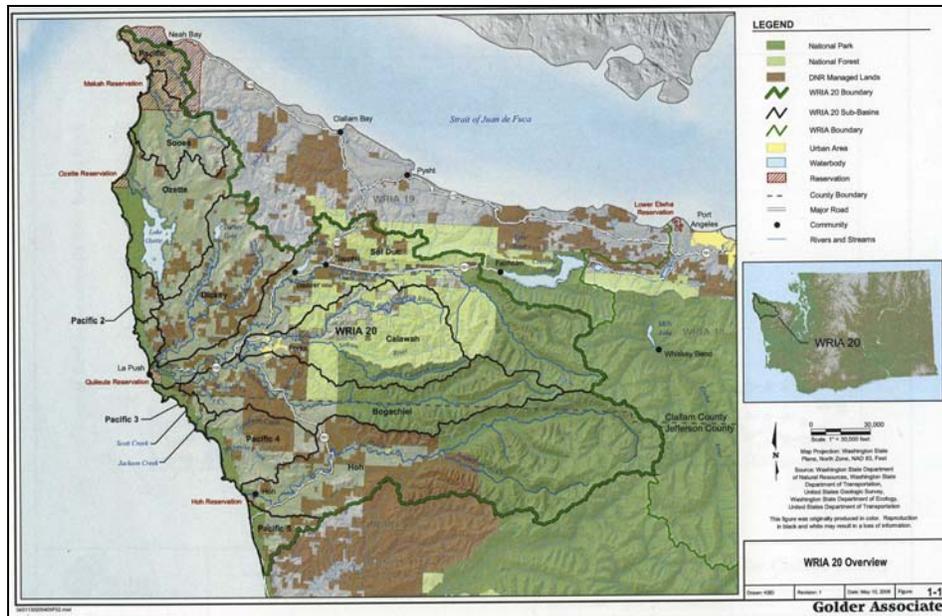


Figure 13 – Hoh and Quillayute River watersheds. Hoh River watershed is primarily surrounded by National Park lands (65%). The Quillayute River watershed is primarily bordered by private and National Forest lands (Golder Associates, 2005).

Flow Impacts on Local River Systems

The Hoh and Quileute communities are dependent on the seasonal returns of salmon species for their subsistence economy and to maintain their ancestral cultural connection to the land. Global climate change poses a threat for both the welfare of the people and the salmon.

As a result of local climate shifts, several low-flow years have been recorded for both the Quillayute and Hoh Rivers. The Hoh experienced extreme low flow events in 1987 and 2002 that “impaired the passage at River Mile 3.0 of salmon returning for spawning” (Golder Associates, 2005). A single year’s impact will be felt in subsequent years when those hatched salmon were supposed to return to the river. “The frequency of such low flows is anticipated to increase under predicted global warming conditions, and may present a significant challenge to the continuing viability of salmonid runs” (Golder Associates, 2005). Golder Associates pointed out that “extrapolation of past hydrologic trends points to an elevated frequency and duration of these low flow occurrences, increasing the possibility of detrimental impacts to Hoh River fisheries.”

Low flow impacts to salmon runs can include shallow water at the river mouth (creating a barrier to salmon entrance) and an increase in predation. Without a strong freshet (water flow from rainfall or snow melt) salmon may not get the signal to move upstream, and fish passage from the river mainstem to tributaries may be limited due to shallow depth. Salmon rearing may be affected without adequate flow and depth to provide cool water temperatures for egg and alevin development. Outmigration of juveniles may also be affected by lower flows and water depth (Golder Associates, 2005). Spring Chinook salmon, the most economically prized run in the Hoh River basin, are most at risk of redd

(nest of eggs in gravel) dewatering or isolation because of their late summer spawning time (Golder Associates, 2005).

The timing of flow rates is also crucial to salmon productivity in any watershed. Low flows during egg incubation in the river can be fatal and early or late freshets may not be timed with the arrival of migrating salmon causing increased stress of spawners. Thus changes in the timing of these cycles (due to global climate change), may be extremely detrimental to the successful reproduction of salmon.

The Hoh watershed is made up of steep terrain, with thin soils and shallow bedrock that do not allow for much water retention. As a result, water moves quickly through the system in extreme storm events (Golder Associates, 2005). This pattern results in high peaks of river flow that can scour out salmon redds in the river mainstem. Rainfall is predicted to increase in the PNW, while precipitation as snowfall will decline with warmer temperatures (CIG, 2008). Rainfall on top of snow pack and glaciers will increase high flow events with the melting of those water reserves. In recent years, such as a November 2006 event, flows reached a peak of 60,700 cubic feet per second (cfs), causing flash flood events, bank erosion and severe scouring of the river bed (USGS, 2007). Annual peak flows in the Hoh River basin do not have a significant correlation ($R_2 = .10$) with time, but may in years to come, with precipitation increasing in the form of rainfall versus snow in the winter months (Figure

14). High flow rates may also be an indicator that more extreme storm events are occurring now compared to 40 years ago (Figure 14).³

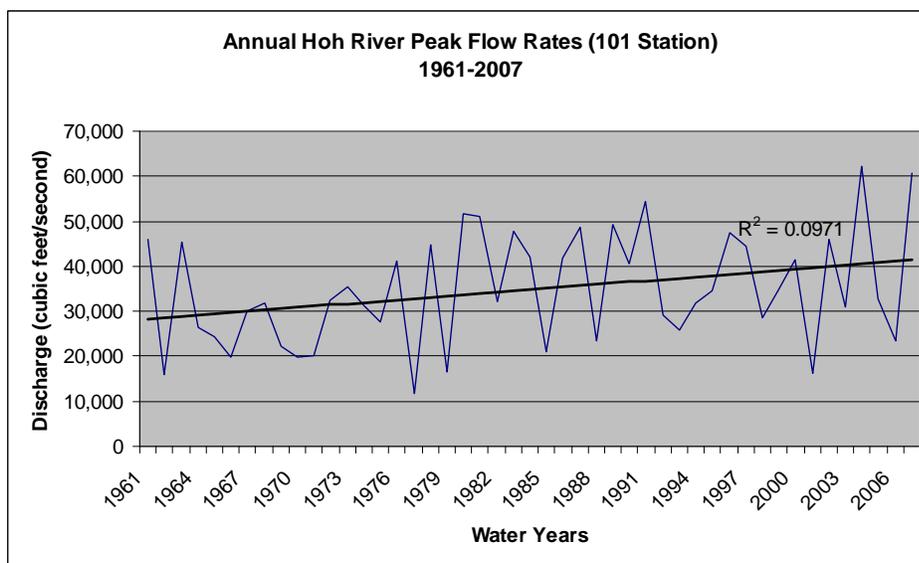


Figure 14 – Annual high flow rates of the Hoh River from 1961-2007 in water years. Peak high flows appear to be increasing over time, but they are not statistically significant ($R^2 = 0.10$) (USGS, 2007).

In addition, low groundwater retention makes the system more dependent on snow pack and glacier melt during the low-flow months of summer and fall (Golder Associates, 2005). The glaciers (Hoh, Blue and White Glaciers) that feed the Hoh River during crucial summer and early fall months have receded over the past century (Heusser, ; Peterson, 2008). Mountain ranges that are much higher than the Olympic Mountains (Mount Olympus highest peak is 7,980 feet) are feeling the impacts of a warmer climate with glaciers retreating, which could mean detrimental impacts for ecosystems dependent on Mount Olympus for seasonal runoff.

CHAPTER 4 – METHODOLOGY

The goal for this project was to emphasize the need for Traditional Ecological Knowledge (TEK) in understanding environmental challenges, specifically climate change. In order to bridge disciplinary boundaries, natural science research was woven into the project to make the point that different knowledge bases can effectively be used together. TEK provides the earliest warnings of ecological changes, while Western scientific research projects must often wait years for funding, publication, and review. TEK is crucial in understanding the current crisis of climate change in a timely framework, since we no longer have years to meet the challenges. This project strives to have a holistic approach without compromising the detail of changes being felt on the coast. The scope of the project was narrowed to two specific areas on the coast, the Quileute and Hoh reservations. Climate change is a global problem and no specific environmental change can easily be attributed directly or solely to it. This project is not about proving a theory or hypothesis, but rather recording changes being seen and experienced in the local environment—changes that may eventually be verified as linked to climate change.

Study Design and Objectives

The study was designed with a multidisciplinary approach in order to bring new information on climate change impacts to the coastal communities of the Quileute and Hoh Nations. The objectives for the project were to document the changes being seen on the coast using TEK,

and the responses both communities have taken, are taking, and are considering taking. The final objective of the project was to compile the changes and responses into a form that can be used as a model by other Native communities and non-Native coastal communities.

This project also attempts to identify some of the challenges that climate change impacts are bringing to the tribal nations throughout the United States. Reservation boundaries enclose islands of sovereign lands and treaties delineate ceded territories, both defended by Native nations, but in an era of shifting species and intensified storms, these geographical limits can make it more difficult for Native Americans to maintain practices of their ancestors while responding to the vast impacts of climate change.

Documenting Process

Information was gathered from in-depth interviews from the Hoh and Quileute communities, which was conducted in a two-part process. The first part consisted of semi-structured exploratory interviews of key elders, community members and natural resource persons from the Quileute and Hoh Nations that were completed to document Traditional Ecological Knowledge (TEK) on environmental changes. In addition, interviews of surrounding community members and non-Native natural resource personnel were completed to collect Local Ecological Knowledge (LEK). Both interview processes concentrated on changes to the marine and terrestrial environments.

TEK from these interviews is based on information passed down through oral tradition and knowledge that is shared among families, experienced harvesters, and resource users. TEK is a knowledge base that is significant to indigenous peoples around the world and it “represents experience acquired over thousands of years of direct human contact with the environment” (Berkes, 1993). TEK among the Quileute and Hoh tribes is an especially unique knowledge base because the northern coast of the Olympic Peninsula is relatively uninhabited. Aside from the Quileute, Hoh and Makah reservations, the rest of the northern coastline lies within the Olympic National Park boundaries (Figure 2).

LEK was gathered from interviews of key informants from the surrounding area of the Olympic Peninsula. LEK is a knowledge base that has a shorter timescale and held by people who do not have historical origins from the area, but have made observations within their life-time and/or passed down through several generations of their family and are shared among resource users. The LEK interviews also focused on noticeable landscape and or resource changes on the Olympic Peninsula within the surrounding area of the Quileute and Hoh reservations. Most LEK was gathered from personnel in the Quileute and Hoh Natural Resources offices.

Traditional Ecological Knowledge, as a resource, can be used to understand changes in the natural environment, as discussed in the literature review section of this thesis. LEK is also an important resource

for information on the natural environment from non-Indigenous people of a particular area. LEK is defined by Charnley et al. (2007) as “knowledge, practices, and beliefs regarding ecological relationships that are gained through extensive personal observation of and interaction with local ecosystems, and shared among local resource users.”

The second part of interviews covered the land requests by both tribal nations from the National Park Service. In order to document the importance of the land requests, active tribal members were interviewed. Both the Hoh and Quileute are requesting additional land from the Olympic National Park for relocation in response to low-lying land that is easily flooded, subject to sea-level rise and within severe tsunami zone. Within the Quileute Tribe some also attribute the land request as being a reclamation of land that rightfully belongs to the tribe (also see Results Section).⁴ Documenting the requests for higher ground is an important response to climate change and was tied into the interviews on present and future climate-induced changes to natural resources.

Participants were not randomly selected, but instead key people were identified by the Tribal Councils, the Tribal Natural Resources offices, and the Hoh and Quileute communities. In addition, each interviewee was asked for recommendations on other interview candidates. Non-Native interviewees were identified by tribal members as key information holders because of their close connection to a particular resource, the tribe, and/or long-time residency in the area. This process is

commonly termed chain referrals. The process was completed once suggested participants were already interviewed.

If suggested persons declined an interview they were not asked repeatedly, instead their names were dropped from the list of referrals. This was done so that no person felt pressured to participate in the project if they did not feel inclined to do so. Everyone who was interviewed received a letter about the project, detailing the goals and objectives. In addition, as required by The Evergreen State College's Human Subjects Review Policy, a consent form was signed by all participants identified in the project. This process helps protect the rights of the individual being interviewed. Some information was also gathered from community members during social events. If a release contract was not signed under those circumstances, their identity was kept confidential. None of the interviewees requested their name remain confidential.

Interviews were analyzed by transcribing, coding and compiling similar environmental statements to find consistency among elders and resource users on a local scale. To find a connection to global climate change, the findings were also compared to the current impact predictions natural scientists are making on regional scales. Though the TEK gathered can stand on its own as significant knowledge on environmental change, it was aligned with natural science research to help bolster the importance of interdisciplinary discussion. The natural science research of the Intergovernmental Panel on Climate Change, Washington Department

of Ecology, University of Washington Climate Impacts Group, United States Geologic Survey, and ethnographic archives of the tribes were used to broaden the disciplinary scope of the project. Archival ethnographic data was used to compare the current condition of the reservations' natural environment to conditions in the past.

The interview transcriptions were coded for responses that both tribes are taking to address the environmental changes impacting their livelihoods. A model of community assessment and adaptation to these changes was created from the community responses, to help other communities facing similar climate change impacts on the Pacific Northwest coast begin to plan.

CHAPTER 5 – RESULTS

Changes on the Coast

Many of the findings are hard to directly attribute to climate change, though they may very well be directly caused by the increasingly variable climate. However, the tribal knowledge of and responses to environmental changes as a whole, are unique and have value for other coastal communities, where the impacts from climate change will be felt stronger in the future. The changes observed by the Quileute and Hoh communities have been broken down into six main categories: Storms, Fisheries, Diseases and Pests, Population Changes, Gathering, and Land Acquisitions. By categorizing the impacts it helps clarify the extent to which effects of environmental changes are being observed and addressed.

No attempts were made to prove or disprove the perceptions of the Quileute and Hoh tribes, but rather observations were aligned with western science predictions as a way to document changes being observed.

Within the main categories, additional responses were inserted from LEK perspectives of the non-Native community. Many of these perspectives are from the staff of the Quileute and Hoh Natural Resources Offices. To closes the Results Section, responses that individuals and or the communities have taken, will be taken, or are considering to take are summarized. Climate change is on the minds of many tribal members, even if they have not yet responded to the challenge.

I think it just better not warm up too fast. There certainly has been weird weather though. I see a lot of changes. – Margaret Black, Quileute Elder

Storms

Many people on the Quileute Reservation report that storms are increasing in intensity and frequency during the winter season (Black III, 2008; Black, 2008; Conlow, 2008; Hobson, 2008; Jackson, 2008; Loudon, 2008; Moon, 2008; Morganroth III, 2008; E. Penn, 2008; Penn Jr., 2008; Ratcliff, 2008; M. Schumack, 2008). Simply put the “weather is changing” on the coast (Penn Jr., 2008). They report that these changes in storm patterns have only begun to intensify in the last few years, when ‘superstorms’ have hit the area with fierce winds and violent rains. In 2006, a superstorm event hit the area with extreme wind force and wave surges that particularly affected the Tribal School in the lower village.

Waves threw giant driftwood up to the elementary and middle school playgrounds (Hobson, 2008; Loudon, 2008; Penn Jr., 2008). DeAnna Hobson said that it was the first time in her lifetime that had happened (Hobson, 2008). Winds came in from the north and the south during the storm. Quileute elders commented extensively on recent storms:

Storms have increased in intensity, trees are falling over, and water comes over the roadway. – Chris Morganroth, III Quileute Elder

For the past 2 to 3 years we've seen an increase in storms...four years ago there was a superstorm that almost took the school away. The lower village was evacuated for the day. Strong winds and currents were coming in from the northwest. There was also high water. The break wall was broken right out front of the school and near DeAnna's house. – Chris Penn Jr. (Giggs), Quileute Elder

The ocean almost broke through there with big storms [in front of school]. The waves, they get so big that they come crashing through there, knocking everything around. Last year or the year before it was all flooded through there [lowermost school building K-8th grades] – Beverly Loudon, Quileute Elder

More storms are occurring now, not only in the Gulf but here too. – Roger Jackson, Quileute Elder

Short of reviving the seasonal migrations of their ancestors, the Quileute and the Hoh must endure the increasing storms without retreating inland (Morganroth III, 2008). This is a tough situation to face, because both tribes recognize that the storms are eroding away their recognized sovereign lands, both literally and figuratively.

How are we going to save what land base we have left, because you can't create more land? – Marie Riebe, Hoh

On the Hoh Reservation storms are also increasing, which is seen in increased flooding events. In the 1970's the lowermost village on the ocean was abandoned due to flooding and erosion from the changing river mouth. Now the lowest village is farther inland from the ocean waves, though still within the tsunami and river flood zones. Testimony from Hoh elders indicate storms are increasing in strength.

More trees are falling. They [storms] pack more wallop now than they ever did. It just costs more money to have these terrible storms, that's what it amounts too. – Viola Riebe, Hoh Elder

Local people in the surrounding area also believe that the storms have increased within the last few years (Dickerson, 2008; B. Johnson, 2008; Lien, 2008; Northcut, 2008).

For crab fishermen, increased winter storms mean little hope of getting out of the narrow La Push Harbor. Economically, increases in winter storm activity affect the fishermen's livelihood (Northcut, 2008).

I think just about the last 2 or 3 years it has almost been unfishable. We had 5 days that were 17' or greater [swells] then we had one day with a 33' combined swell and there's a lot of days where you'll have the 40-knot winds. For us it disrupts the crab fishery for the most part. And for right now it is our biggest fishery out in the ocean. That's become the 'bread and butter' of our fishery. It's crucial [economically], that [crab fishery] makes or breaks the fishermen for the year. – Kris Northcut, Harvest Management Biologist for the Quileute Tribe

For Darby, a non-Native commercial fisherman who has fished from La Push for 40 years stated that “the last two years has been spooky, scary weather” (Dickerson, 2008). The Hoh Tribe also would have a hard time

getting out to sea for fishing, because they would leave from La Push, but currently the Hoh Tribe is not ocean fishing.

In response to increased storm activity, the Quileute Tribe negotiated a 'Fair Weather Agreement' with Washington State, allowing the Quileute fishermen equal access to fishing grounds with extended days when the weather is unremitting. Fishermen from the north or the south of La Push have easier access out of their ports, so this helps the Quileute catch their quota.

In the last 2 seasons there have been very violent storms that have stayed non-stop in the region for 30 days or greater, so we negotiated a 20-day guaranteed fair weather agreement...
– Mel Moon, Quileute Natural Resources Director

For many tribal fishermen the new agreement brings them hope of maintaining their income if the crab is abundant.

In the summertime, thunderstorms are reported to be declining (J. Penn, 2008). This report came late in the project after most interviews were complete, so no one was asked specifically about summer thunderstorms. However, this is an important observation that should not go unnoticed.

I guess the thing I'm worried about most is the loss of thunder [storms]. I remember having them a lot when I was a boy, my dad would tell me it was thunderbird and whale fighting again. We used to have 20-30 thunderstorms a summer, this year [2008] we had 2. – John Penn, Quileute

More people should be interviewed about thunderstorms, because it does play an important role in oral history and signals change in summer weather fronts.

Wind

The elders say the winds are changing on the Quileute Reservation (Black, 2008; Jackson, 2008; Loudon, 2008; Morganroth III, 2008; E. Penn, 2008; Penn Jr., 2008; M. Schumack, 2008). There was not a consistent report that winds are growing stronger, but the consensus is that the winds are changing. Winds are arriving at different times of year when they are not expected, and the wind directions are changing (Jackson, 2008). Many of the elders are afraid that the winds will be coming from a different direction in the future, bringing in more storms (Jackson, 2008; Morganroth III, 2008).

Some believe that the winds hitting La Push have increased in severity (Black III, 2008; Black, 2008; Hobson, 2008; Loudon, 2008; Morganroth III, 2008; E. Penn, 2008; Penn Jr., 2008; M. Schumack, 2008). Chris Morganroth spoke of water funnels and extreme winds that have ripped roofs off homes.

We've had water funnels [waterspouts], a couple of them right off Cake Rock. A tornado [funnel cloud] that was 60' and 12' wide picked up a trailer and tore it off the foundation [near the point past High Tides Seafood Company] and moved up to Earl Penn's house and ripped the roof off...this happened in the early 60's...[I've] never heard of anything [like waterspouts or funnel clouds] historically that happened here. – Chris Morganroth III, Quileute Elder

More recent storms have also ripped through La Push, taking roofing off some homes (Loudon, 2008).

Precipitation

The Quileute Reservation receives roughly 118.33 inches of rain annually. This report comes from the closest weather data of Forks, Washington (dating back to 1907), which is just 15.5 miles inland from the coast (King, 2008). The Hoh Reservation on average receives roughly 160 inches of rainfall annually (ONPS, 2008). The Hoh River runs through the temperate rainforest of the Olympic Mountains and receives considerably more rain in its watershed.

In recent years more rainfall has been reportedly falling in the Quileute and Hoh territories. It may be that more precipitation is falling in the form of rainfall than snowfall, increasing the river flows and flooding in the winter months. The late Pearl Conlow looked back at her childhood and recalled walking to her uncle's house for get-togethers during the winter months.

I guess I just didn't notice it [rain] when I was small, when I was younger. There didn't seem to be as much rain, because a lot of our winters were spent in get-together.
– Pearl Conlow, late Quileute Elder

Many people on the Quileute Reservation agree that there is more rain falling now than there ever has been (Black III, 2008; Black, 2008; Conlow, 2008; Hobson, 2008; Loudon, 2008; Matson, 2008; Morganroth III, 2008; Penn-Charles, 2008; E. Penn, 2008; Penn Jr., 2008).

Rains have increased during the months of November through February. Seven-to ten-day floods have made the river breach its banks and cause flooding in the lower village. – DeAnna Hobson, Quileute

The river is changing with increased rainfall.
– Chris Morganroth III, Quileute

In fact, the records kept by Jerry King in Forks indicate that the highest annual rainfall since 1907 occurred in 1997, with 162.14 inches. This was followed by 160 inches in 1999 (King, 2008). Even in water years (October 1 to September 30 of the next calendar year, used by weather stations) these high rainfall years span an El Niño (1997-98) and La Niña (1998-2000) episodes, which indicates they may not be due to these ‘normal’ climatic cycles (NOAA, 2008a).

Timing of rainfall

The timing of rainfall is very important for many natural cycles, but for the Quileute and Hoh people, timing is everything for productive salmon runs. In recent years the timing of rainfall has not been consistent (Anonymous 1, 2008b; Leitka, 2008; Morganroth III, 2008; Penn-Charles, 2008).

Really it's a change in the weather. Before it used to be, when August would come it would rain so hard...that's when the run of the salmon would come in. Now that's changing and we don't get rain until later on, so the run is changing its cycle in time.
– Mary Leitka, Hoh

Salmon waiting for fall freshets at the river's mouth have to spawn in the mainstem of the river where water levels are adequately flowing. Mainstem spawning has been followed by heavy rains, which arrive during the crucial egg incubation period. The high flows are devastating to salmon eggs because they scour out gravel beds. (See more on changes in river flow in subsequent High Flow and Flooding Sections.)

Snowfall

Precipitation as snowfall has declined on the coast. Winters are now milder in temperature with fewer robust cold fronts (Anonymous 2, 2008a; Conlow, 2008; Jackson, 2008; Wallerstedt, 2008) to keep snow on the ground for more than a day. On both the Quileute and Hoh reservations, people indicated that there has not been snowfall in recent years like there used to be (Black, 2008; Jackson, 2008; Matson, 2008; E. Penn, 2008; Sampson, 2008; Wallerstedt, 2008). If snow does fall, it only lasts for a day or so before it melts.

We used to look forward to the snow, because we had all four seasons then. We haven't had that for a long time. Winters are mild it seems like they're not hard like they used to be, they're not real cold like they used to be. – Bertha Wallerstedt, Quileute Elder

*Well there seems to be a lot of difference now. It seems to be a lot warmer now then it used to be.
– Pearl Conlow, late Quileute Elder*

...in the 70s we had 3 to 4 feet of snow on the beaches, now we don't even get any snow in the winter time. – Gene Sampson, Hoh

However, following the completion of the interviews a snow storm hit Washington State. During December 2008 a cold front hit Washington coast bringing snowfall to the Quileute and Hoh reservations. The total for the month of December was 18 inches (King, 2008). This was the first major snow to hit the area since the 1970's (Sampson, 2008). The total snowfall for 2008 was 31 inches, just under the 1964 record high of 36 inches (King, 2008). In many Washington cities' snow records were broken for the amount of snow to hit in a one month period (Hill, 2008).

Despite this recent snowfall, the overall trend is that snowfall on the coast is in decline.

Bertha and others on the Quileute Reservation also commented on the excitement and expectation of winter icicles that her and her siblings used to look forward to in the winter months (Jackson, 2008; Matson, 2008; Wallerstedt, 2008).

We don't have the big icicles like we used to have, we used to be able to reach out from our bedroom window and pull great big icicles off the roof and we haven't had that in years... and I miss it. That was really a great part of growing up,... the big icicles. The icicles [now]...they're small and they don't stay...what we used to have they were big and they were hard and they stayed for days and days. – Bertha Wallerstedt, Quileute Elder

In the 1940s George Pettit interviewed many people at La Push to get a feel of the old days, including their comments about the weather. He documented his conversations with the Quileute people in the book, The Quileute of La Push 1775-1945. One of his interviews included a conversation with Morton Penn. Morton spoke of a famine that occurred during the winter of 1840 when his grandmother was still a young lady. La Push and the surrounding areas were snowed in for most of the winter; with 'deep' snow pushing out many of the elk and deer herds. Morton stated that people then started putting up more food to survive longer winters, but no such winter had yet occurred again. "Morton wonders whether the climate of the area is growing milder" (Pettitt, 1950). Morton may have been on to something, considering that the snowfall levels have steadily declined since the 1940s.

During a conversation with a Quileute fisherman, snow pack was mentioned on Mount Olympus. It is used as a guide for fisherman at sea finding their way back to port.

Back in the days when I skippered boats and I had the crew watch when we'd come in from offshore all you could see was the Olympics, so I'd tell them see the snow, see the snow, head for the snow, and now I say head for the mountains, because all you see is the mountains except for a snow cone on the very top, new pinnacles are sticking up...noticing that offshore now is seeing the difference...in the summer when were fishing and now we look up there and see bare spots all over...pinnacles are sticking up, stuff that you didn't normally realize was there.

– Roy Black III, Quileute

On the Hoh Reservation snowfall has not been what it used to. As one interviewee pointed out, the reservation used to receive 5 feet of snow, but high levels no longer fall in the winter months (Sampson, 2008).

...my parents would talk about the abundance of everything...that was because they were getting regular [events] they got 5 feet of snow every year...– Gene Sampson, Hoh

The regularity of these events, and the flooding that used to follow, are no longer predictable on the Hoh Reservation.

Local Ecological Knowledge also indicated that snowfall around both reservations (B. Johnson, 2008) and in the Olympic Mountains has not been what it used to be (Peterson, 2008). Gary Peterson, the owner of 6th Peak Outdoor Adventures and Store in the Hoh River Valley, stated that the snowfall is not even close to the amount he experienced as a kid.

...it's been a long time since we've had serious snow. Here in the mid-1960s you could step across the [tops of the] fences here and there really hasn't been anything like that...– Gary Peterson

Gary goes on to state that precipitation as rainfall is not on the decline in the Hoh Valley.

...although precipitation [as rain] there hasn't been a whole lot of change in it. I mean the record year was 1997 or '98 with 197 inches of rain at the [Olympic National Park] Visitor's Center.
– Gary Peterson

These responses align with predictions by CIG (and others in the scientific community), that the amount of precipitation falling as snowfall will decline in association with a warming climate, and there is evidence in the Cascade Mountains that it is already happening (CIG, 2008).

High Flow and Flooding

In fact, precipitation as rainfall is only supposed to increase with the onset of a warmer wetter climate in the Pacific Northwest (CIG, 2008). There is evidence that this may already be occurring in the Hoh and Quillayute River systems. Increased river flow and flooding has, in recent years, profoundly affected both the Hoh and Quileute communities, so both tribes are seeking higher land out of the Channel Migration Zone (CMZ).

During the December 3, 2007 rainstorm, high flows occurred in both the Quillayute and Hoh Rivers. The high flows adversely affected the Chinook salmon runs that had recently spawned in the river.

Right before the storm, we had active spawning throughout the Quillayute River system, and the kind of flows we saw with this storm will certainly reduce egg survival because the high water scoured eggs out of the gravel. – Roger Lien, Fisheries Biologist Quileute Tribe (Preston, 2007)

Flows on the Hoh River reached more than 60,000 cubic feet per second (USGS, 2007). The same impacts likely affected Hoh River Chinook.

The former fisheries biologist for the Hoh Tribe stated his concern about increasing severity of floods in the Hoh River system.

That storm hit two weeks after peak fall Chinook spawning on the Hoh. Most of the eggs were in the gravel. Fortunately, salmon produce a lot of eggs and that trait helps Chinook survive flood events. However, the frequency and severity of these floods continues to increase and we're concerned about how that affects survival. – Tyler Jurasin, Fisheries Biologist Hoh Tribe (Preston, 2007)

The same extreme flooding of the Hoh also occurred in 2006 (Preston, 2007) and in October 2003 (USGS, 2007).

On the Quileute Reservation, flooding has been increasing from both high water levels of the Quillayute River and from an increase in ocean storm surge events.

Year before [2006-'07 winter] it flooded and the waves came in up there at Lonesome Creek [Store, in lower Quileute village] and they came all the way up to the cabins over here, it was unusually high, high water. – Bertha Wallerstedt, Quileute Elder

The lower village is extremely susceptible to flooding after heavy rains that cause the river to breach its banks, coinciding with a high tide and wind-driven waves. The river seems to most often overflow into a slough at Thunder Road (Conlow, 2008; Hobson, 2008; Loudon, 2008; E. Penn, 2008; Wallerstedt, 2008; Williams, 2008). The water goes down Thunder Road and flows, like a river in front of the Tribal Center, Community Center and around neighboring homes. This is not necessarily a new occurrence (Conlow, 2008; E. Penn, 2008), but its frequency has increased

(Black III, 2008; Hobson, 2008; Ratcliff, 2008; J. Schumack, 2008; Wallerstedt, 2008; Williams, 2008). Long-time residents of the area also believe that flooding has increased in La Push (Dickerson, 2008; Payne, 2008)

With four rivers—the Sol Duc, Dickey, Bogachiel and Calawah—feeding into the Quillayute River, increased rainfall and flow exacerbates erosion along the river’s edge. DeAnna Hobson lives on the Quillayute River and watches it rise every winter as the rains come, observing the floods first-hand. She stated that “millions of board feet” have been coming down the river annually, making it too dangerous to capture logs as they come downriver because of the high flow—a practice that used to be common (Hobson, 2008; Ratcliff, 2008). The trees that come downriver were clearly not old snags that had fallen into the river, but rather live trees swept downstream from extreme bank erosion. During the winter, many mounds of debris can be found on the beach, with nearly every inch of the river covered in downed trees. In 2004 the Bogachiel River flooded over La Push Road (Highway 110) cutting off La Push. During the flood “people were in distress up river...getting rescued by boat (Hobson, 2008).” Flooding from the Bogachiel River across the La Push Road near Three Rivers has become more frequent, cutting off La Push almost every winter (Hobson, 2008; Morganroth III, 2008; Penn-Charles, 2008). When the roadway is blocked by high waters, the only

access route the Quileute people have is through logging roads (Davis, 2008).

Heavy rains and past logging practices are usually the reported cause of the increased flow and flooding of the Quillayute River (Black III, 2008; Hobson, 2008; Morganroth III, 2008; Penn-Charles, 2008; J. Schumack, 2008; Williams, 2008).

The logging caused more runoff that straightened out the river's path so it no longer bends and winds down to the mouth. – Chris Morganroth III, Quileute Elder

Frank Geyer, the Quileute Timber Fish and Wildlife Biologist, stated that changes in logging practices have allowed woody debris to remain in river, such as beaver dams have started to allow the rivers to flood in new areas. Overall, flooding has increased in certain areas and there is no way to know the exact changes that are causing the observed impacts.

Without the meandering of the river bed to slow down the river's flow, and with an increase in rainfall, flooding is occurring with less predictability. River flooding on both lower reservations was always been a problem, according to the elders, but today with no opportunity to move seasonally inland from the river the tribes suffer more from the blunt impacts of flooding. The floods are also less predictable than they used to be. An elder stated that the flood waters have begun to rise and fall rapidly with the onset of more extreme rainfall events (Jackson, 2008).

The heavy rains have saturated the soil to the point that trees are falling over with even the slightest gusts of wind.

Rainfall has increased. The soil has become soft or saturated so much that any little wind blows over huge trees...two or more people around. – Miss Ann Penn-Charles, Quileute

Cedar logs were traditionally captured along the Quillayute River during the winter months, so that the roots of the cedar tree could be harvested and used to weave traditional burden baskets. Elder weavers recall gathering the roots with their grandmothers when they were young, but now flooding has taken away all of the banks to which they used to drag the logs onto (Morganroth, 2008; M. Schumack, 2008).

On the Hoh Reservation, conditions of increased flooding have become unbearable. During November 2006 a severe storm hit the Hoh Reservation that caused the river to crest over its banks and flood into the village and into the septic system.

Our septic system backed up and toilets became fountains! – Marie Riebe, Hoh

No help was received from the county government, so the U.S. Congressman Norm Dicks was called and the National Guard arrived three hours later, bringing food and supplies to the Hoh villages (M. Riebe, 2008). During this particular storm the Hoh River flow peaked at 60,700 cubic feet per second on November 6th, which further exacerbated the flooding and erosion on the Hoh Reservation (USGS, 2007).

Alexis Berry, the Executive Director of the Hoh Tribe, said that tribal members have told her that the Hoh River floods used to be on a 10-year cycle but the frequency has increased and they are now occurring

every year. Everyone that was interviewed responded similarly

(Anonymous 1, 2008a; M. Riebe, 2008; V. Riebe, 2008; Sampson, 2008)

It's flooding more then when I was a little girl. We always have high water when it rains in the fall time. – Viola Riebe, Hoh Elder

Yeah and its all running right down the road you can't even see the road...it was probably 2 feet of water on it... – Hoh
(Anonymous 1, 2008a)

The predictability of these flooding events has also been lost. The river may rise and fall with little warning, whereas before heavy snowfall precede flooding events (Sampson, 2008).

... they [elders] knew when to go and to get out... now it could be like this here now [it was a hot summer day] and tomorrow we could be floating...not even anyone can predict what it does anymore ...the bad thing about it is that we don't know when it's going to change because it used to happen around November that was the framework we expected to get ready to sand bag... last couple of years...all of sudden when no one's ready...[so] they finally walled off around the tribal center, because in the front there it was knee deep inside the tribal center...
– Gene Sampson, Hoh

The LEK gathered from the Hoh Natural Resource personnel also reported that flooding has been occurring more frequently (Allison, 2008; Gilbertson, 2008). In some areas of forest habitat restoration, flooding has decimated some of the tribe's progress. Steve Allison, the Director of the Hoh Natural Resources Department, stated that the 4,000 trees planted in an area called Schmidt Bar on Hoh River Trust land were lost in the last two winters (November '06 and December '07).

I mean we lost 40 acres there alone and we planted probably 4,000 trees in there. – Steve Allison, Hoh Natural Resource Director

During the November 2006 storm the “river came up 18’ and went down 10’ in one 24-hour period” (Allison, 2008). This is similar to the statement by elder Roger Jackson on the Quileute Reservation where floodwaters are rising and falling more rapidly than ever before.

Flooding on the Hoh Reservation is not a new occurrence but, similar to the community in La Push, people are reporting that it is occurring more frequently than in the past. The lower village of the Hoh Reservation has already relocated once because of flooding near the river mouth. According to interviewees, the last family to occupy the lowermost village on the oceanfront left in the 1970’s.

Folks lived down in the lower village until the 1970s when fighting the river became too much. – Gene Sampson, Hoh

*No one lives down there anymore. They moved up over the hill and then up over the hill. They’re having to move from there because that’s ... major flooding every year.
– Viola Riebe, Hoh Elder*

Permanent sand bags now line most homes and facilities in what is now the lowermost village. The tribal office and community center has been repeatedly flooded in recent years and now has a permanent berm around its perimeter, built with eight feet of imported soil (Sampson, 2008).

In response to the extreme flooding events, the Hoh Tribe is pushing to get certified by FEMA so that the tribe can in the future apply for grants (M. Riebe, 2008). The tribe is currently in the National Incident Management System (NIMS) process to get staff trained for natural

disasters. There are three people already trained, but overall the tribe aims to have 26 people trained—including all members of the Tribal Council, Fire Department, and all Program Directors (M. Riebe, 2008). The tribe is taking this very seriously so that they can be prepared for the next event. FEMA has already supplied the tribe with two satellite phones, emergency radios for every home, and a defibrillator for every building.

We need to be ready...not wonder who has it or where is it?
– Marie Riebe, Hoh

In addition, the Washington State Emergency Management, under Washington State's Military Department is going to install an emergency siren on the reservation (M. Riebe, 2008). Everyone has an emergency radio in their home, but if the radios are not on there is no forewarning of a tsunami.

Fisheries

In both the Hoh and Quillayute River systems, the number one factor that has been shown to influence the Maximum Sustainable Harvest (MSH) of salmon is the summer low flows (Northcut, 2008). Successful spawning of the summer salmon runs are reduced by low flow events during key summer months, impacting the success of the salmon runs in the Quillayute River.

They went through and figured out...it was the MSH at summer low flows that... controls the number of salmon we can produce. – Kris Northcut, Quileute Natural Resources

This knowledge is extremely important when looking toward the future impacts that climate change is projected to have: warmer temperatures,

less runoff from declining snow pack, and changing in timing of rainfall in key summer months. Summer low flows will continue to be a crucial factor in salmon survival.

In the mild winter and spring of 1997-98, regional water supplies were strained in the summer and fall by an early snowmelt (Mote, 1999). The early snowmelt and dry summer created low flows and warmer temperatures in many watersheds, resulting in upriver barriers for migrating salmon (Mote, 1999). In the summer, low flow events can inhibit salmon from finding passage way into smaller tributaries, in response the salmon lay their eggs in the mainstem of the Hoh River (Gilbertson, 2008). According to the Hoh biologist, as a result “many of these Chinook redds [spawning beds]...get excavated by these extreme winter high flows and blown out” (Gilbertson, 2008).

On the Hoh River artificial ‘rip rapping’ has been installed along banks up river to help protect homes and Highway 101. However, the rip rapping has exacerbated the high flow events, by shooting the river through at “a gun barrel-like velocity” (Gilbertson, 2008). Rip rapping up the river is a big concern for the Hoh Tribe, because it can change the way the river naturally moves, and increase river flow at the same time (M. Riebe, 2008; V. Riebe, 2008).

Timing of Runs

One of the most significant runs, the surf smelt, has been seasonally late for the past few years. As part of an annual tradition, the

Hoh and Quileute peoples seine-net for smelt in the rivers and on the ocean shore. Communications take place between all tribes along the coast in order to report the first arrival of the smelt (Penn-Charles, 2008).

Smelt changes are true up and down the coast, because they are gathered from Neah Bay to Queets, wherever the first smelt arrive.
– Miss Ann Penn-Charles, Quileute

Many people look forward to the smelt harvests, a delicacy and subsistence food of both tribes. The smelt were put up in tribal smokehouses to prolong the food source.

For the Quileute people the timing of the smelt runs has been a significant part of an annual Elder's Week celebration. Traditional foods are harvested and prepared for the elders. One of the most prized was the 'stink eggs' fermented from the smelt spawners returning annually to the Quillayute River mouth. Miss Ann of La Push tells of the shift in timing of the smelt run and the effects of this change.

Fish are coming in later and later in the summer. In 2007 beach smelts or night smelts came a month late. Normally they come in May, by Elder's Week that year they came in June. There have not been stink eggs ready for Elder's Week for the past 3-4 years. That would require the smelt to come in early May and be fermented for three weeks before elder's week.
– Miss Ann Penn-Charles, Quileute

For Hoh people, smelting has been part of their livelihood since the beginning of time. Oral history of the tribe tells of a transformation that occurred by the "Changer" K'wati "who went around the world making things as they are today" (Andrade, 1969). At Hoh River he found the "inhabitants of the area were upside down people, who walked on their

hands and handled their smelt dipnets clumsily with their feet. They weren't very good at it, so they were famished and skinny. K'wati set them rightside up and showed them how to operate their nets with their hands" (Andrade, 1969). K'wati then told the ancestors, "You shall use your feet to walk...Go and fish smelt. You shall catch much fish when you fish smelt. Ever since then there is much smelt at Hoh" (Andrade, 1969).

Mary Leitka of the Hoh Tribe stated how important smelt are to the Hoh people.

...you know I think that because of the change and now I see this is probably going to be the worst thing of all to see, and that's our smelts. – Mary Leitka, Hoh Elder

She went on to say that when visiting Sitka, Alaskans reported not seeing the silver smelts return to their area, so in response Mary made arrangements to trade smoked Hoh River smelt for herring eggs.

... so that was going to be our trade and now we can't do it...we'd used to be able to get them on our river and we'd smoke them and now there's none left – Mary Leitka, Hoh Elder

Not only is smelting an important tradition, but smelt is an important subsistence food source for many people in the tribe. Intertribal trading was always a way to share abundances of local foods for something rare, but now it is becoming even more important in maintaining traditional food systems as species shift and or decline in response to climate change.

Gene Sampson talked about the past abundance of the smelt in the summer being so high that "ten years ago you could sit here every day and

you could smell them from here [tribal office], from the beaches...” It was such an important food source that anyone hungry “could walk down and get some.” Times are getting “scary” for people so dependent on the seasonal production of food sources (Sampson, 2008).

Retaining the tradition of seasonal seine-netting for smelt is being lost with unprecedented low annual returns. The Quileute too are seeing a decline in the important resource. Ann Penn-Charles and Eileen Penn report declines that have pretty much bottomed out in the past two years.

They were big river canoes, one full canoe hold about a little over a ton of smelts and we would have to work like crazy to make sure that we threw the salmon smolts back so they wouldn't die. Smelt fishing would be in June and July. – Eileen Penn, Lummi Elder

Surfers at First Beach on the Quileute Reservation also reported seeing declines in the smelt populations that used to be thick along the beach during the summer spawning season. Throughout interviews of Quileute and Hoh tribal members, Natural Resource staff, and local fishermen there is a sense that the seasonal abundance of smelt had been rich, and are now left with few returning (G. Johnson, 2008; Leitka, 2008; Lien, 2008; Penn-Charles, 2008; E. Penn, 2008).

As a response, in Hoh River people are resorting to farmed fish to be put up in their smokehouses as a way to get by in the absence of the annual abundant returns of the smelt.

...smelts we used to smoke now we have to go to our hatcheries to get fish...farmed fish they are doing now just to keep people satisfied you know. We were the smelt capital of the world now it's...very slim pickings. Just a couple of years ago you'd get so

sick of eating them...back in the 70s there'd be smelt...those are the things that you heard...will never ever be gone.
– Gene Sampson, Hoh

Population Changes

In addition to the smelt arriving late, there have been shifts and changes in other species populations. Many of these changes are difficult to directly attribute to climate change, because they may be influenced by a number of factors. Regardless, it is important to document all changes that have been observed.

In 1999, Jay Powell reported that tidal areas around the Hoh River mouth were ‘plentiful’ of skatefish, tomcod, and sturgeon. At that time, fisherman Frank Fisher caught a 14 foot long sturgeon at the river mouth (Powell, 1999). Now sturgeon are very scarce in the Hoh river (Leitka, 2008; Sampson, 2008). Tomcod and flounder have almost disappeared. One interviewee blamed the temperature changes in the river for the loss of sturgeon, flounder and tomcod.

We average 57-degree water, 66 or 64 for four or five years was way unnormal for the temperature of the waters and when that started happening we lost a lot of our sturgeon, our flounders. We used to get the tom cods [we] lost those in the early 80s they moved to La Push...and I don't know what year they lost a lot of theirs, it used to be a regular thing catching them in the boat basin a lot of the kids over there used to catch them and sell them to the long liners as bait, not even the kids can make any money now.
– Gene Sampson, Hoh

The decline is also true for the Quillayute River. Many people reported declines in flounder and tomcod. The tomcods used to be so thick in the Quillayute River that the whole surface of the water was

“caked with them” (Black III, 2008). Seining for smelt used to bring up a lot of perch and flounder but they are not as “plentiful” as they once were (E. Penn, 2008). A commercial fisherman who has fished out of La Push for 22 years also stated that tomcods have declined since his arrival, when they were abundant (G. Johnson, 2008).

Salmon populations are on the decline in both the Quillayute and Hoh River systems. There are many impacts that have threatened salmon populations—from previous over harvests, logging practices, development, etc.—but it is important to take note of the abundance that had been present in both river systems. Mary Leitka from the Hoh Tribe recalled a hike she took with an elder upriver to visit areas that were used for seasonal fish camps. The elder told her that the chum had been so thick “we could walk on their backs” and “now we don’t see them anymore” (Leitka, 2008).

Fortunately for both the Quillayute and Hoh Rivers, the tributary waters are within the Olympic National Park boundaries (verses private timber lands), thus keeping the habitat more or less intact since the Park was designated (Lien, 2008), though the boundary may be contested over for gathering, hunting and fishing rights. However, regardless of the Park’s designation, salmon runs in both river systems are not what they were historically.

In 2008 the salmon runs were “pretty depressed” for the Hoh River, according to the Hoh Natural Resource Director (Allison, 2008).

Everything was “shut off for spring Chinook [the prized run] on June 16th and normally it’s the last week of July, because they’re looking at below escapement levels” (Allison, 2008). The fishery had never been shut down that early in the season, at least since the 1980s when Steve started working for the Hoh Tribe (Allison, 2008). One Hoh tribal fisherman recalls polling up river in the 1960s and getting 40 to 50, 35-pound salmon in a single drift, but today “it’s down to hatchery size which is very, very little” (Sampson, 2008).

In response to lower numbers both tribes are looking at improving riparian habitat. The Quileute have been actively removing invasive Japanese knotweed in the watershed to help improve natural water conductivity (Northcut, 2008). The Hoh Tribe has planted trees to help keep the river temperatures cool in summer months (Allison, 2008). From a fisheries management perspective, if salmon numbers continue to decline, there are few other options other than to hope that “the state will further limit their [fishery] and our fishery” to keep the runs going (Lien, 2008), which occurred in California and Oregon in 2008. Farmed fish has been the option for many (Sampson, 2008).

It affects everybody not just the Natives, but the non-Indians too. It...affects everybody one way or another and it's tough for our people. – Gene Sampson, Hoh

Looking towards the future, from the words of Chris Penn Jr. who testified during the Boldt Treaty case, “resolution for all of these problems...[is]

that we've got to sit down together otherwise we're all sitting on the bank. Our resources come first that's what keeps us alive" (Penn Jr., 2008).

Bird Declines

LEK and TEK of fishermen indicates that tufted puffin at sea are not near the population numbers there once were (G. Johnson, 2008; J. Schumack, 2008).

... there aren't a lot of puffins anymore and there used to be quit a few of those. You don't see those as often anymore...seems rare now, I'm kind of surprised. – John Schumack, Quileute

This is an important note because climate researchers are indicating that ocean warming will affect pelagic bird abundances within the California current system (Veit et al., 1996). Veit et al. (1996) reported that seabird abundance has declined by 40% from 1987 to 1994 within the California current system. This decline coincides with an increasing sea surface temperature. This could mean that other commonly found pelagic birds within the usual and accustomed fishing grounds of the Quileute and Hoh may also decline. With such a broad breath of impacts, pelagic birds in particular were not focused on and may be of interest for future projects.

Quileute elders state that hummingbird numbers are down, especially during the spring and summer of 2008 (Loudon, 2008; Wallerstedt, 2008).

And everyone was talking about they haven't seen as much hummingbirds either, due to the climate change or whatever is happening... making a change on land and sea and everything. – Beverly Loudon, Quileute elder

Another Quileute elder spoke of other common backyard birds returning in low numbers during the spring and summer of 2008 (Wallerstedt, 2008). Birdhouses were empty while birdfeeders remain full of food.

Hypoxia

Ocean dead zones have been recorded along the Pacific coast from La Push south through Oregon. These dead zones are caused by low oxygen levels in the ocean resulting in massive crab and fish kills that wash to shore (Grantham et al., 2004). The recent hypoxia events along the Pacific coast have been called “unprecedented” and “severe” within the California Current System (Grantham et al., 2004). The events are alarming to everyone along the coast who depends on the ocean for their food and economy. Changes in ocean upwelling that bring nutrient rich cold water to the surface may be the cause of these pockets of low oxygen.

According to the IPCC, the occurrence of low oxygen levels may be due to a variety of factors including: “biological activity, changes in the physical transport of oxygen, or by a change in temperature and salinity”(IPCC, 2007b). Ocean upwelling contributes to the physical transport of low oxygen water and nutrients on to the near shore productive continental shelves (Chan et al., 2007; Grantham et al., 2004). Respiration in these productive shelves can further decrease oxygen availability resulting in hypoxic conditions along the shelf (Schwing & Mendelsohn, 1997). Timing of upwelling is dependent on decadal cycles in the Pacific Ocean, such as the ENSO and PDO (NOAA, 2008c). Many

pelagic fish rely on coastal upwelling for their reproductive success. The strength and timing of upwelling is significant in providing the right water column mixing that maintains concentration of food organisms (Cury & C. Roy, 1989).

Seasonal anoxic conditions can become hypoxic with an increase in upwelling that leads to a rise in primary production associated with amplified nutrient availability (Chan et al., 2007). As a result benthic waters can become hypoxic from an increase in decaying biomass settling in shelf waters (Chan et al., 2007). Continental shelf species, such as invertebrates and bottom fish are accustomed to occasional anoxic conditions but cannot adapt to persistent severe anoxic or hypoxic conditions (Childress & Seibel, 1998). As a result, major fish and invertebrate kills can be seen along the Washington and Oregon coasts.

Regional researchers recently made a connection to changes in upwelling patterns and climate change, stating that “delayed early-season upwelling and stronger late-season upwelling are consistent with predictions of the influence of global warming on coastal upwelling regions” (Barth et al., 2007). According to the IPCC (2007) Report, ocean water “freshening [addition of fresh water from Arctic melt] is pronounced in the Pacific,” this may be contributing to changes in upwelling and oxygen transportation being seen in the Pacific (IPCC, 2007b).⁵

The Eastern Pacific Ocean off the western coast of the United States coastal upwelling is wind-driven (Bakun, 1990). As a result

changes in wind direction, strength and timing can also greatly contribute to upwelling that may overall impact marine productivity. TEK mentioned earlier, indicates that changing patterns in wind direction and timing are already being observed along the coast of Washington (see Wind in Results Section).

For the people of La Push and Hoh River these changes have been and are continuing to affect their subsistence food sources and marine resource economies. Hypoxia events have been the priority issue for many First Nation gatherings and will continue to be as they affect the salmon, the life-blood of many Northwest tribes, as well as other resources (Lekanof, 2008).

Crabbing

Crabbing has been particularly vulnerable to hypoxic events up and down the West Coast. Hypoxic events have been primarily occurring during the summer months. A published report on hypoxic conditions off of Newport Beach, Oregon, indicated that the key timeframe for hypoxia is from late summer through September (Figure 15) (NOAA, 2008c).

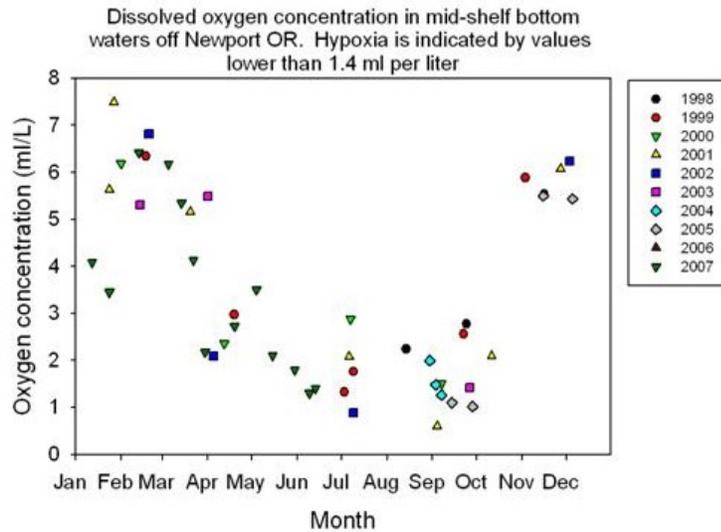


Figure 15 – Hypoxia events occurring off of Newport beach Oregon indicate that they primarily occur during the summer to early fall (NOAA, 2008c).

For the Quileute fishermen, crabbing is very important economically. Fishermen reported that in addition to the crab kills south of La Push and the Hoh River, crab have been slow to ‘harden up’ in the fall. The State requires that the crabs be 23% meat content with hard shells (G. Johnson, 2008), but in the last few years their shells have not hardened on time (Ratcliff, 2008; J. Schumack, 2008). The LEK from the Quileute Tribal Harvest Biologist and a commercial fisherman from La Push, both indicated that the crab has taken longer to harden up over the past couple of years (G. Johnson, 2008; Northcut, 2008).

Some of the [crab] shell condition and meat content for the past couple of years, it’s taken longer for the shell to get harder and the meat content to get to a point where it’s acceptable. In fact one of the years I believe it went all of the way into January before the meat content was ready. So that might be taking longer, because maybe the upwellings that breed the food or something isn’t happening. In the 2004-2005 season, it [shell hardening] didn’t start until week 16 [middle of January] when the crab season

[starts] *for tribe, (October 1st to September)*. – Kris Northcut, Quileute Natural Resources

There was also worry that the water temperatures were too warm and that was causing the delay for the crab.

The crab, kind of a strange cycle for a while... It was taking way too long for them to harden up, the water temperature was just strange, it was warmer then it should have been [last year].
– Steve Ratcliff, Quileute fisherman

Timing of ocean upwelling is key for many species to obtain essential nutrients, and with oceanographic changes in upwelling patterns the results are devastating for ecosystems.

The delay in shell hardening is worrisome if it is indeed related to the timing of ocean nutrient upwelling. Dungeness crabs molt every season and must receive the right nutrients to be able to rebuild their shells for the winter months. Crab shells may be an early sign that something is changing in the oceans.

Domoic Acid

In addition to hypoxic events, domoic acid events have become common along the Washington coastline. Domoic acid is a product of a diatom (algae) species called *Pseudo-nitzschia* that is absorbed by crab and shellfish and is a human health risk if ingested. According to the Quileute Natural Resources office, domoic acid events on the West Coast began showing up in 1991 (Moon, 2008; Northcut, 2008). Previous to the 1990s, domoic acid was only found on the East Coast. Whether facilitated

by ship ballast water and/or warming coastal waters, domoic acid events have become common during the summer months.

For Quileute and Hoh peoples, domoic acid events affect their ability to freely gather shellfish due to adverse health concerns, such as short-term memory loss and other neurological problems (Burkholder, 1998; Moon, 2008). Not only does domoic acid pose a human health risk it can also adversely affect marine mammals and birds who ingest infected shellfish and crab (Gulland, 2000). Frances Gulland's 2000 report to NOAA was the first of its kind to show unusual marine mammal kills associated with domoic acid toxins.

Hoh and Quileute peoples reported that clams are particularly small in size and number on the ocean beaches (Leitka, 2008; V. Riebe, 2008; Sampson, 2008; Wallerstedt, 2008), which may be due to domoic acid events. But with more restricted harvests (due to domoic acid toxicities) there would seem to be more shellfish available. Some studies have indicated that domoic acid from *Pseudo-nitzschia* caused blood cell abnormalities in the Pacific oyster (Jones et al., 1995), so it could be possible that domoic acid may have other physiological affects such as stunting the growth of coastal clams. Hypoxic events and/or disease were often suggested as the problem for shellfish.

I think that warmth is causing a lot of the disease that is getting into our seafood. – Mary Leitka, Hoh Elder

The waters don't have enough oxygen...oxygen is not plentiful. Last year or the year before our ocean floors were filled with dead sea life. Now we can dig clams at Kalaloch and now they are 1 1/2

to 2 inches when before they were 4 inches or bigger. Huge, huge clams. – Viola Riebe, Hoh Elder

What really hurts all the tribes along the coast is the water conditions [domoic acid and hypoxia] in our fishing clams, anything along the coastline is no longer predictable whether we are going to have this or that anymore – Gene Sampson, Hoh

LEK also indicated that changes in the ocean are becoming unpredictable and the extent of the problem is becoming hard to follow.

...You can't just count on the normal trends that were happening in the past. All of those indicators don't hold a lot of weight nowadays because there are just so many different things taking place out in the ocean, certain upwellings aren't taking place, temperatures aren't happening, dissolved oxygen problems...I mean it's...things that weren't happening are happening now, so if your not tracking it closely you could have some serious problems.
– Kris Northcut, Quileute Natural Resources

In response to the increase in domoic acid events along the coast, the Quileute began regular testing at local beaches to ensure shellfish harvests are safe (Davis, 2008; Moon, 2008). The Quileute started a program with the Washington State Department of Ecology to monitor the domoic acid blooms by taking shellfish samples from the beach. The Director of the Quileute Natural Resources stated the tribe's goal and success of the program:

Our goal was to have rapid assay [toxin] tests so that people could know immediately if there was trouble and not to harvest. Now we have a lab that has the capacity to test them. They are day after tests and we post the results the next day. – Mel Moon, Quileute Natural Resources

With rapid testing and the State-operated shellfish hotline, harvesting can continue when levels are safe. Crab meat must also be tested prior to crab season to ensure that domoic acid is not present (G. Johnson, 2008).

In addition to testing, the Quileute have been working with the Northwest Fisheries Science Center (NWFSC) to help map the toxic blooms to find out what is triggering them (Moon, 2008; Northcut, 2008). It appears that nutrients coming out of the Strait of Juan de Fuca, along with upwelling nutrients, create the “ideal conditions for *Pseudo-nitzschia*” to bloom (Moon, 2008). Warming ocean temperatures and changes in ocean upwelling may also be to blame. Many algal blooms have been associated with El Niño events, so this trend towards warm water affinity “has led to the suggestion that global climate change and warming trends may also encourage their growth” (Burkholder, 1998). Shifting in geographic range and increased activity of algal blooms may also be caused by warming trends from global climate change (Epstein et al., 1993).

Along with being involved in the NWFSC, the Hoh and the Quileute are involved in working with the Intertribal Policy Council (IPC) that brings together coastal tribes, NOAA and the Olympic National Coast Marine Sanctuary (OCNMS). As Joe Gilbertson, the Fisheries Management Biologist for the Hoh Tribe, explains:

The coastal tribes have formed the partnership with IPC... to have a consensus and an agreement to move forward in a unified and collective manner with regard to evaluating these physical and biological ...parameters. Partnership with IPC is to get the buoy system running better to record surface temperatures, wind and swell directions, [and] physical parameters. – Joe Gilbertson, Hoh Natural Resources

In 2006, the OCNMS installed monitoring stations along the coastline that will bring new data on hypoxia events by measuring temperature, dissolved oxygen and salinity of the ocean (Figure 16)(OCNMS, 2006). With this knowledge gained through Western Science, combined with TEK, the Quileute and Hoh peoples may be able to start predicting hypoxic and domoic acid events in a changed environment.

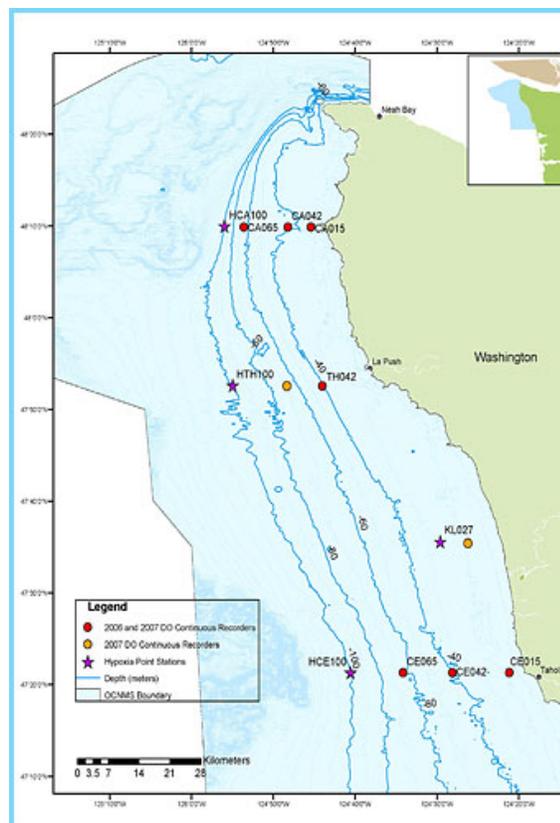


Figure 16 – Olympic Coast National Marine Sanctuary water monitoring buoys (OCNMS, 2006).

Diseases and Pests

Warming temperatures on land and sea enable influxes of invasive and noxious plants, animals and diseases to move into new areas. On the Olympic Peninsula some of these invasions are already beginning to take place. Through interviews with the natural resource staff from both the

Hoh and Quileute tribes, a picture has begun to emerge on the types of issues both nations have begun to face.

Non-native Louse

Pests and diseases are predicted to increase with climate change (CIG, 2008). In addition to the influx of *Pseudo-nitzschia*, a louse has been impacting deer and elk populations around the Olympic Peninsula. Commonly termed ‘hair slip’ the non-native louse (species of lice) has “further pushed the elk population down” (Geyer, 2008). How the louse species was introduced or if it has anything to do with the changing climate is unknown, but noteworthy. Personnel at both the Hoh and Quileute Natural Resources offices mentioned the new problem (Allison, 2008; Geyer, 2008) that, as of yet, has no solution.

Hemorrhagic Disease

In addition, to the louse, a ‘hemorrhagic disease’ was reported by the Director of the Hoh Natural Resources as a new problem for elk populations. According to Allison the wasting disease is an anaerobic bacterium that grows in fields with standing water. The elk come in contact with the bacteria and “it’s like a hemorrhagic disease that is fatal” (Allison, 2008).

They witnessed that down in Clearwater [a tributary of the Queets River]. That’s a function of heavy rains in spring and sunlight that would cause a bloom of the stuff and they would ingest it and it would cause a hemorrhage. – Steve Allison, Hoh Natural Resources

With increased flooding the disease could become more of a health problem for elk populations, which is a subsistence food source for the Quileute and Hoh peoples.

Spruce Weevil

The Sitka spruce weevil (*Pissodes strobe*) has begun taking hold of the spruce trees within the Hoh River watershed. In the mid-1980's the spruce weevil exploded on private timber plantations (Thysell & Steve Allison, 2005). Spruce weevil has been shown to perform better with warmer temperatures (Heppner & Jennifer Turner, 2006) that monoculture plantations provide. It primarily attacks the Sitka spruce because it grows at lower elevation and thus a warmer climate, but Engelmann spruce at higher elevations is also susceptible (Heppner & Jennifer Turner, 2006). A weevil attack to a spruce causes deformed limbs and branching, along with stunted growth and needle drop (Heppner & Jennifer Turner, 2006). This can be devastating to riparian zones, especially in the temperate rainforest where spruce is "a key component of salmon habitat" (Thysell & Steve Allison, 2005).

As a way to control the proliferation of the spruce weevil within the Hoh watershed, the Hoh Tribe has planted around 40,000 alder trees to keep temperatures cool around groves of spruce trees, essentially shading out the weevil (Allison, 2008). This is an environmental control mechanism that avoids the use of chemicals within a riparian area, helping

to keep one of the traditionally predominant riparian trees in the watershed by lowering insect activity (Allison, 2008).

In response to increased pests and diseases, both tribes have continued to focus on the ecosystem level to figure out how best to address species declines, because everything is interconnected.

I think that we need to look at the connection of the food sources and to what is disappearing, because...it's not just the elk and the deer. There's many...things that depend one upon the other, even clear down to the little spiders and bugs, mom used to talk about that. I think it's important that we realize that some how we're going to have to work at protecting many of them.

– Mary Leitka, Hoh Elder

For many reasons it is difficult to identify the best way to control invasive species in a changing environment. Both tribes are doing what they can to protect the native salmon habitat through continued removal of Japanese knotweed and shading out spruce weevil.

Species Range Shifts

Marine and terrestrial species have shifted their ranges in response to the warming climate. Species range shifts were predicted to move to cooler areas to the north and/or to higher elevations as temperatures warm on land and sea. For fish and other marine species, this means that ranges would shift away from their original grounds towards northern latitudes.

“Climate-related changes in fish distribution have been typically characterized as range shifts or displacement away from the center of the home range, as temperatures grew warmer (Perry et al., 2005; Zeidberg & Bruce H. Robison, 2007).”

On the Quileute and Hoh reservations some potential range shifts have already been observed in avian, marine, and terrestrial species.

Bird Species

Brown pelicans (*Pelecanus occidentalis*) are a new visitor to the Washington coastline. According to many interviews with elders (Jackson, 2008; Matson, 2008; Morganroth III, 2008), LEK (Dickerson, 2008; B. Johnson, 2008; G. Johnson, 2008; Payne, 2008), tribal fishermen (Moon, 2008; Ratcliff, 2008; J. Schumack, 2008) and natural resource staff (Geyer, 2008; Northcut, 2008) the brown pelicans are a new arrival to the coast. The consensus arrival time was around the mid-1980s (Moon, 2008; Morganroth III, 2008; Payne, 2008). Now, the brown pelican has begun to stay longer on the coast. They are now arriving during the second or third week in June and departing the last week in October (Geyer, 2008; Moon, 2008; Morganroth III, 2008; Penn Jr., 2008).

The brown pelican's original northern range was limited to California. In the late 1960s, the pelican became a federally listed endangered species after the DDT pesticide crisis that left many birds unable to form eggshells (Wickliffe & J.W. Bickham, 1998). The brown pelicans in particular "are the most sensitive avian species to the effects of DDE," a by-product of DDT (Blus, 2007). In California in particular, the pelicans had the highest level of DDE exposure compared to pelican populations in Louisiana, Florida, South Carolina, North Carolina and Texas (Blus, 2007). The California population seemingly recovered and moved north into Washington, but sources still have the brown pelican's northern range limited to California (Figure 17)(Cornell, 2003). Warming

waters, decline in food, and recovery from DDE may all be factors in their migration northward to the Washington coastline.



Figure 17 – This figure shows the current range of the brown pelican, which lacks inclusion of more recent populations off the coast of Washington State (Cornell, 2003).

Two other bird species were identified through LEK as recent arrivals. The turkey vulture (B. Johnson, 2008) was reported a new arrival to the Quillayute Prairie (just inland from the Quileute Reservation) and the Caspian tern arrived about 20 years ago to La Push (Payne, 2008). These are both worth mentioning; however these arrivals were indicated late in the interview process so no one else was questioned about their arrival.

Ocean species

The Humboldt squid (*Dosidicus gigas*) has started frequenting the waters off the coast of Washington. TEK (Black III, 2008; Moon, 2008; Ratcliff, 2008; J. Schumack, 2008; Williams, 2008) and LEK (Dickerson, 2008; G. Johnson, 2008; Northcut, 2008; Payne, 2008) indicate that the Humboldt squid originally arrived during an El Niño event, but kept returning even during colder La Niña cycles. This coincides with several reports from the scientific community that indeed the Humboldt squid has started expanding its original range away from the warm waters around the equator but, not migrating north of central California (Blumenthal, 2008; Cosgrove, 2004; Zeidberg & Bruce H. Robison, 2007). “This geographic expansion occurred during a period of ocean-scale warming, regional cooling, and the decline of tuna and billfish populations throughout the Pacific” (Sibert et al., 2006; Zeidberg & Bruce H. Robison, 2007). Not only were Humboldt squids not seen in Washington state until recently (5 to 10 years ago according to TEK) they were not observed in California’s Monterey Bay until 1997 (and stayed through the strong El Niño event of 1997-98). They arrived again in great numbers to Monterey Bay during the smaller El Niño event of 2002 and have been year-round residents ever since. Warm waters in the Eastern Pacific Ocean occurred “10-15 months and again by 2-3 months in both 1997 and 2002 arrivals” (Zeidberg & Bruce H. Robison, 2007).

Though the change in the distribution does not follow the ‘normal’ range shifts or displacements, because the Humboldt squid is not leaving its original range but rather expanding north and south, the shift in range into historically colder waters is concerning. Waters may be warming enough to support its habitation.

The fact this is happening in both hemispheres could be a sign it is tied in with global warming. – John Field, NOAA fisheries biologist (Blumenthal, 2008)

Zeidberg and Robison (2007) stated that its range expansion does not strongly correlate with warming sea surface temperatures, but its expansion during El Niño events suggest a strong “warm-water affinity”. However, fishermen in La Push have been seeing an increasing number of squid during La Niña years, as recently as 2008, when ocean waters should be colder.

They’re showing up more than usual, yesterday [Sept. 17, 2008] one of the sport fishermen caught a 5 ½ footer. For the last couple of years, few years actually, there’s been a Humboldt free for all... just enormous size squid... – Steve Ratcliff, Quileute

To still have giant squid present in 2008 during a La Niña cycle indicates some environmental factor is driving the Humboldt squid to the north. Whether climate-induced or not, the Humboldt squid’s presence means something is shifting in the food chain off the Washington coast, with the arrival of a new top predator. The Humboldt squid can be greater than two-meters long and weigh up to 110 pounds (Zeidberg & Bruce H. Robison, 2007). It is a voracious predator that may pose a problem for Washington coast fisheries, especially salmon runs (Blumenthal, 2008).

Sea Turtles

Turtles were also commonly referred to in interviews from LEK and TEK holders. The loggerhead turtle (*Caretta caretta*) was indicated as an unusual sighting by Quileute fishermen (Moon, 2008; J. Schumack, 2008; Williams, 2008) and other local people (Dickerson, 2008; G. Johnson, 2008). Loggerhead turtles migrate from the equator to feeding grounds off the coast of Alaska, and have been shown to be sensitive to warming sea surface temperature (Chaloupka et al., 2008). In response, they are predicted to “shift foraging habitats to cooler and more productive waters” (Chaloupka et al., 2008). This could mean that more loggerhead turtles will be seen in the future off the Washington coast with climatic warming.

In addition to the loggerhead turtle, the leatherback turtle (*Dermochelys coriacea*) has been sighted during El Niño years, which is very rare and unusual according to LEK (G. Johnson, 2008) and TEK (Moon, 2008; Ratcliff, 2008). Leatherback turtles can tolerate wide ranges of water temperatures (NOAA, 2008b) from Southern Hemisphere tropics to the West Coast of Washington state. During the early 1980s leatherback turtles were spotted off of Westport, Washington (Eisenberg, 1983). Leatherback and loggerhead turtles may frequent the waters off of La Push more often during El Niño years, but there is not a clear indication that sightings are unusual, according to NOAA. Both turtles are listed under the U.S. Endangered Species Act so they may also be rare

sightings due to small populations. However, TEK indicates that both turtles were rarely seen. This may signify they are already responding to warmer waters off the coast.

Fish

Increases in warm-water fish such as mackerel, tuna and sardines were reported by fishermen in La Push. During the 1997-98 El Niño event, LEK and TEK reported higher numbers of mackerel that were inhibiting their ability to catch salmon (Black III, 2008; Moon, 2008; Morganroth III, 2008; Northcut, 2008; Williams, 2008). Tuna moving with warm water 10 miles to 40 miles offshore was reported by TEK interviewees as a major change, as opposed to ‘normal’ temperature conditions when tuna are 100 to 500 miles offshore (Black III, 2008; Morganroth III, 2008; Ratcliff, 2008; Sampson, 2008; Williams, 2008). LEK reports also indicated changes in tuna migration coming in earlier in the summer (G. Johnson, 2008) and moving with bands of warm water 10 to 40 miles offshore (Northcut, 2008). Tuna appear to have warm water affinity and may continue to return earlier in the summer if the ocean continues to warm.

Sunfish

The sunfish or common mola (*Mola mola*) were frequently referred to as a new arrival to the coast by Quileute and Hoh fishermen (Black III, 2008; Moon, 2008; Morganroth III, 2008; Ratcliff, 2008; Sampson, 2008; Williams, 2008) and natural resource staff member Kris

Northcut. Sunfish were first seen during strong El Niño years, but have now been present during the colder La Niña cycle.

Then the oddball stuff, sunfish, a lot of that type of stuff is seen more in the last 10 years, there's more of them in the areas that we never used to see them before. – Roy Black, Quileute fisherman

Fishermen took notice of the sunfish because they have the unusual behavior of surfacing in an act that looks as if they are sunning themselves. They are also an exceptionally large species; the largest of the bony fish reaching over 3 meters in length (Cartamil & Christopher G. Lowe, 2004).

Sailfish

Sailfish (*Istiophorus* sp.) also first appeared off the coast during an El Niño cycle (Morganroth III, 2008) around 10 years ago (J. Schumack, 2008). Even during recent La Niña years, sailfish have been present. A sailfish was caught by a Quileute fisherman in 2007 (J. Schumack, 2008).

They are distinct fish that can be seen surfacing with their slender body and long pointed fins, which caught many fishermen off guard when they first appeared.

We didn't even know what it was; these big old fins coming out of the water. – John Schumack, Quileute fisherman

For tribal fishermen, the changes that are being seen are unusual and not necessarily following the ENSO and PDO cycles. As one fishermen put it, “it doesn't take a rocket scientist to figure out what's going on in your industry that those kinds of fish are coming around” (Black III, 2008).

TEK indicates that these new species were not present during the time of their Quileute and Hoh ancestors.

TEK held by Quileute and Hoh fishermen is providing an early warning that impacts are occurring in the present. TEK provides an early warning system for commercial and subsistence fisheries off Washington coast. In the North Sea, scientists have already identified distribution shifts among “nearly two-thirds” of the marine fish species (Perry et al., 2005). The species that have exhibited a range shift were reported to have smaller body sizes and faster life cycles. Perry et al. (2005) stated that this will likely have “profound impacts on commercial fisheries through continued shifts in distribution and alterations in community interactions.”

Communication between Tribal, State and Federal governments is essential in order to safeguard tribal treaty rights and the future of subsistence fishing. Knowledge of change is available and must be used to timely respond to the changes present in the marine ecosystem. We no longer have the luxury to wait for certainty.

Gathering

Many plants were traditionally gathered by the Quileute and Hoh peoples for medicinal, cultural and subsistence purposes. Many foods and materials are still gathered from the forest by the Quileute and Hoh tribes. Some of these resources have seen changes in recent years.

Cedar Bark

Cedar bark is an important resource for tribal basketweavers. It is harvested every year during a very specific time before the bark becomes too pitchy for use. According to some elders, the bark has not been the same for the past few years. Reports of drier bark may indicate warmer summer weather that is changing the cedar trees; usually the inner pith of the bark is very wet (E. Penn, 2008). After the bark is cut from the tree it is stripped and laid out to dry. The timing of the drying process depends on the moisture content of the bark. An elder indicated that the bark is drying out faster now (Morganroth, 2008). In addition, there are no longer old-growth cedar trees available. Agreements with the local logging companies (Geyer, 2008; Morganroth III, 2008; Morganroth, 2008) has allowed some continued seasonal bark peeling, but often the bark is gathered from trees already cut down, so the bark quality is lost (Morganroth, 2008).

As a way to respond to these changes in quantity and quality of bark, a few basketweavers stated that they often purchase bark from gatherings or trade with other tribes (Morganroth, 2008; E. Penn, 2008). This is another example of intertribal cooperation in response to shifting and changing resources.

You have to find the other places they might be, or start trading with other tribes that have the grasses that they travel with to the different pow-wows. Some of them bring bear grasses with them to trade, or if we are at a basket conference they bring their stuff there and trade and sell for the people that don't get to go out...the other option, other places might have the same kind of grass we

used to have, and sometimes there's people from Canada that come down to sell their grasses and their cedar bark...yellow cedar bark is a nice commodity. It's a prized one.

– Eileen Penn, Lummi Elder

Bear Grass

Bear grass was a commonly gathered grass, but it has become less available as the floral industry continues to use it. Illegal harvests are very common on the Olympic Peninsula. During the summer of 2008, a truckload of bear grass was confiscated near Hoodspport. Much of the grass was made available to local tribal weavers. As a result of illegal harvesting, the bear grass is not as tall or as wide as it once was (Loudon, 2008; Morganroth, 2008; E. Penn, 2008; M. Schumack, 2008). Bear grass used to be 4 to 6 feet tall and now is no larger than 2 feet tall (M. Schumack, 2008).

It seems to me that a long time ago they had real nice bear grass; in fact they were a lot longer and a lot wider, back when the men used to pick them. – Marian Schumack, Quileute Elder

Illegal harvesting techniques are often given as the reason for the shorter grass (Loudon, 2008; Morganroth, 2008).

...ruining it just by cutting it not understanding that it's supposed to be pulled instead of cut. Years ago it used to be a lot wider and taller, but because so many people are bothering it now it seems like it's not. – Beverly Loudon, Quileute Elder

There could be other factors, including a changing climate, that are influencing the bear grass' growth. It is likely the biggest impact is coming from illegal harvests.

In order to keep traditional weaving practices alive, some grasses are purchased or traded because they are no longer available in the usual gathering areas. A weaver from the Quileute Tribe stated that she already buys her sweet grass from people in Canada where it still available (Morganroth, 2008). Many people are trying to keep traditions alive with the younger generations even if it means purchasing materials from other tribes.

I try to do right with my children and grandchildren to keep it going [basket weaving] and so both of my daughters they weave and my granddaughter. So I still try to have my children use the natural stuff on there, it's a very few, but it is. – Lela Mae Morganroth, Quileute Elder

Berries

In recent years, some species of berries (such as huckleberries, salmonberries, blackberries, and thimbleberries) have been late to ripen. Berries have also been low in abundance (Loudon, 2008). During the spring and summer of 2008 various berries were reported three weeks to two months late by LEK and TEK harvesters (Anonymous 2, 2008b; Hobson, 2008; Loudon, 2008; Payne, 2008; Penn-Charles, 2008; E. Penn, 2008). Wild strawberries on the beach are normally ready in July or August, but in 2007 they were not ready until the late August, early September (Penn-Charles, 2008). Salmonberries are coming on at different times now, but they used to be ready for Elder's Week in May.

... the harvesting of different foods is affected by the weather.
– Eileen Penn, Lummi Elder

Sprouts or first shoots of the blackberry were also harvested in May and they are increasingly late as well. During Elder's Week the shoots were eaten with the stink eggs, which is considered a delicacy by many (Penn-Charles, 2008).

...affected so much of everything...in Native country it so important because that's what they rely on. – Gene Sampson, Hoh

Huckleberries in the mountains are having “hard cycles” in recent years, they are not on time and are low in abundance (Penn-Charles, 2008; Sampson, 2008). Ba'áts or Indian Celery (*Equisetum* or horsetail) would also come out during March to April, and by June they would be done. These were used to help with springtime allergies, but by June 2008 they had not come out yet.

Springtime used to be so busy; it was the time everything was awakening. – Ann Penn-Charles, Quileute

There was always a feast with the elders at the end of April or middle of May, but in recent years plants are not ready for harvest (Penn-Charles, 2008).

Annual gathering of traditional foods have been affected by the climate. Quileute and Hoh peoples say these are not normal cycles. The months of the Quileute calendar were named by harvest seasons of specific resources (Jaime, 2008b). Unprecedented changes are being exhibited in these temporal cycles. Factors such as logging and land management on the Olympic Peninsula have a role in availability, but

these activities do not necessarily influence the timing of spring events. Overall, TEK indicates that these changes have never been present before.

Responses to Change

Adaptation is a common response for Native peoples because subsistence harvest of natural resources is still part of their lives. Harvesting and gathering practices have adapted to new rules and regulations since European American colonization. Practices have also adapted in more recent times to changes in the timing of fish runs and berry harvests, the declines of important weaving materials and smelt, and the increased occurrence of unpredictable weather and severe storms.

In response, both the Hoh and Quileute tribes are in current negotiations to obtain higher ground from the Olympic National Park. This is in direct response to tsunami, storm surges, and flooding that threatens much of the two reservations. However, this response of higher land can also be seen as an appropriate response to sea-level rise and increased storm surge events caused by climate change. The 2004 tsunami in South and Southeast Asia was a wake-up call for many people living on the world's coastlines, but for the Quileute and Hoh peoples increased flooding and storm surges from severe 'superstorms' have also played a part in their decisions to move important tribal buildings to higher ground. Moving the Tribal School is of utmost importance for many people living on the Quileute Reservation. The recent storm surges of 2004 and 2006 were the first to reach the school grounds, littering large woody debris and

leaving standing water on the play fields (Hobson, 2008; Loudon, 2008; Payne, 2008).

The wind force caused the ocean to come up to the Tribal school. That was the first time in my lifetime that had ever happened.
– DeAnna Hobson, Quileute

There was a superstorm that almost took the school away. The lower village was evacuated for the day. Strong winds and currents were coming in from the NW. There was also high water. The break wall was broken right out front of the school and near Deanna's house. – Chris Penn, Jr. (Giggs), Quileute Elder

Implications for the Future and Long-term Responses

The Quileute and Hoh peoples are looking forward to future generations, which is an essential approach when considering the viability and availability of traditional foods and resources in response to climate change impacts. The tribes are mindful of the threat that climate change poses on their natural resources, and are increasingly aware that the changes have already begun for the present generation. Many tribal members stated they will have to continue to make connections with other tribes in order to obtain and maintain traditional usage of culturally important resources. Many basketweavers are already in the practice of purchasing specific materials from other tribes at gatherings. This allows them to continue the cultural practices of their ancestors; an example of community-based intertribal cooperation (Morganroth, 2008).

Long-term responses for the tribes involve moving the lowermost villages to higher ground. This is no easy undertaking for any community and is a political task for both tribes. The tribes must appeal to the federal

government for land, but this is made even more complicated with the surrounding land designated as National Park.

Moving a village is a big task when you have lots of people involved. – Viola Riebe, Hoh Elder

The Quileute Tribe also has a land zoning issue with the National Park Service, which adds tension to the request. When the Quileute Reservation was created in 1889 the mouth of the Quillayute River was located north of its current location. In 1910 a storm hit the area and “caused the river’s mouth to close and the river to move southward” (Jaime, 2008a). The change in the river mouth left a parcel of land cut off from the Quileute Reservation. Following the storm, a 1916 survey was done that excluded this parcel of land from the Reservation (Jaime, 2008a). This survey is now commonly termed the ‘erroneous survey of 1916’.

In 1953 the coastal Olympic National Park was designated. Unfortunately for the Quileute people, the Park boundaries were drawn from the erroneous 1916 survey, which failed to recognize the original Reservation boundaries of 1889 (Jaime, 2008a). The cut off parcel of land was deemed part of the Olympic National Park and is the current location for the Rialto Beach parking lot. This change in boundaries has added political tension for the tribe’s request for higher ground from the National Park Service.

Presently, the Quileute Tribal Council has drafted up a bill for Congress and is awaiting President Barack Obama to back their request

(Hobson, 2008). The hope is that the political change over will help pass the bill for additional Quileute Trust Land, out of harms way from tsunami, sea-level rise, and increased storm surges.

The Hoh Tribe is also in pursuit of higher ground out of the Hoh River channel migration zone and tsunami danger. U.S. Congressman Norm Dicks along with the Hoh Tribal Council drafted Bill 7073, “The Hoh Indian Tribe Safe Homelands Act” which he introduced during the 2009 congressional legislative session.

The bill is requesting that 260 acres of private land purchased by the Hoh Tribe, along with 160 acres transferred over from the Washington Department of Natural Resources, and 37 acres from the National Park Service, be added as Hoh Trust Land. This addition would provide the tribe with a continuous parcel of land from the ocean to Highway 101, which includes higher ground for village relocation. Councilwomen Marie Riebe reminds us that if this bill passes it will be the second move for the Hoh people. The first move was in the mid-1970s when the lowermost village, along the ocean, was abandoned due to flooding conditions (M. Riebe, 2008).

The Hoh and Quileute tribes’ land requests will provide safe homelands that can be used to respond to rising sea-level and increased storms and flooding. Global sea-level has already risen 18 centimeters (7.1 inches) in the past century (Pendleton et al., 2004) and is projected to rise an additional 48 centimeters (18 inches) by 2100 (IPCC, 2007b). Sea-

level rise will continue to shape policy responses for the Quileute and Hoh Tribal Councils into the future. But for now the tribes are responding to the most imminent dangers of flooding, tsunami, and ocean surge.

Marine Sanctuary

In addition to the land acquisitions with the National Park Service, there is a new entity on the Washington coastline that the Quileute and Hoh tribes are working with to help safeguard marine resources. The Olympic Coast National Marine Sanctuary was established in 1994 to preserve the unique habitats along the coastline from the Canadian border south to Copalis River. The National Marine Sanctuary encompasses the usual and accustomed fishing grounds of the Makah, Quileute, Hoh and Quinault Nations, making it of fundamental importance that all tribes work with the Sanctuary to ensure their resources are protected and preserved for future generations. Mel Moon the Director of Quileute Natural Resources stated the tribal resource concerns with the creation of the Sanctuary.

We were concerned that the MPA [marine protected areas] would create issues with no take zones and wouldn't recognize treaty rights, and would just kind of create a park out there. The Sanctuary and the tribes have not had the greatest relationship, but we finally came to a point where we realized we need to change...we are trying to get a better relationship established through a committee called the Intergovernmental Policy Council, and hopefully we will have a better relationship in the future. We don't see them being able to do a fisheries management [without] staff. [At] this point in time it's really not there.
– Mel Moon, Quileute Natural Resource Director

Though the Marine Sanctuary has caused concern for tribes along the coast, a level of resource protection is also desirable to address declining salmon runs. Partnering with the Olympic Coast National Marine Sanctuary, and having a voice through the Intergovernmental Policy Council (IPC), the Quileute and Hoh tribes (along with the Makah and Quinault Nations) can begin to work together to find answers for changing ocean conditions. Communications through the IPC will hopefully bring collective information from coastal tribes, NOAA, and the State, on the domoic acid and dead-zone events, changes in sea-surface temperatures, and shifting species that have been witnessed along the coast. Their collective responses may shape policies that will safeguard resources for all peoples into the future.

CHAPTER 6 – DISCUSSION & CONCLUSION

Native peoples are the world's early warning system that climate change is affecting human communities. With place-based oral histories of their homelands stretching back centuries, Native Americans hold vital knowledge of ecological change in the United States. For Native communities climate disruptions are impacting hardest on their place-based rights and way of life. On the northern coast of Washington State, Traditional Ecological Knowledge gathered through in-depth interviews strongly suggests climate change is impacting the Quileute and Hoh Reservations. Both tribes live on low-lying coastline, bordered on three

sides by the Olympic National Park, and are susceptible to sea-level rise, extreme storm surge events, and shoreline erosion.

In response, the tribes are requesting higher land within the Olympic National Park for village relocation. Quileute and Hoh peoples are already experiencing and responding to increased winter storms and flooding associated with increased precipitation, coinciding with high tide at both the Quillayute and Hoh River mouths. With little higher ground for relocation out of the river migration or ocean surge zones, the tribal communities must request higher ground in order to preserve their cultural connection to the place of their ancestors.

In the ocean, species range shifts are becoming more common with the arrival of new warm-water species. The most notable are the brown pelican and Humboldt squid, which are consistently arriving along the Washington coastline. TEK of the Quileute and Hoh communities reports that these are new species to the area. As top predators, together the brown pelican and the Humboldt squid pose a threat to the marine food web. The Humboldt squid has been termed a ‘voracious predator’ that may further devastate salmon populations (Blumenthal, 2008).

Declines have been exhibited in traditional resources in the terrestrial, freshwater, and marine environments, along with an increase in invasive species, hypoxia, and domoic acid events. Domoic acid is frequently tested in shellfish to ensure traditional foods gathered are safe. Rapid testing is now available on the Quileute Reservation.

Increased storm severity and flooding prompted the Quileute Natural Resources office to obtain a fair weather fisheries agreement with the State. This agreement will hopefully help stabilize their subsistence economy during winter storm seasons when it is impossible to get out of the narrow harbor.

In response to increased storms and flooding on the Hoh Reservation, emergency radios and satellite phones have become available to all residents on the geographically isolated Reservation.

Intertribal cooperation is increasingly relied upon in order to maintain traditional practices. With declines in bear grass, smelt, tomcod, sturgeon, flounder and other important resources, intertribal communications and trade have become a key way to maintain cultural livelihoods. Tribal members need trade and commerce with their northern neighbors to maintain ties to species that have shifted out of their homelands, and to educate their neighbors about desired or invasive species headed their way.

Traditional Ecological Knowledge is a critical resource for understanding and responding to environmental changes already occurring on the coast. Through this project it is clear that TEK is crucial in understanding environmental changes on natural resources and the ecosystem as a whole. It provides more immediate warning of changes underway, allowing more time to prepare responses.

Future for the Quileute and Hoh Communities

Oral history tells the Quileute and Hoh peoples that they have prepared and survived major environmental changes in the past. Chris Morganroth III goes back in time and tells the story of the ancestors who were warned by the Great Spirit that change was coming for their people. Through this process “Our people prepared for the ice age.”

The Great Spirit told people a long period of ice and snow was to come. People stored food away. Leaders [when food wasn't lasting] prayed food would be available. Thunderbird appeared over them. People were scared. Thunderbird flew out to the ocean and got lost. Two to three weeks later thunderbird came back with whale. It was thundering, and lightening was shooting out of Thunderbird's eyes. Whale was in Thunderbird's mouth [which] it dropped at the feet of the Quileute people. [Whale provided the nourishment to make it through the ice age].

– Chris Morganroth, Quileute Elder

Like their ancestors before them, the Quileute and Hoh peoples see changes happening in their environment and have begun to take action to prepare for the worst.

With the new White House administration there is hope that change is on its way for many Native communities. For the Quileute and Hoh communities this change will hopefully come in the form of higher ground acquisitions. Continued congressional monitoring is important to fully know what is in store for these communities as they prepare for climate change.

Following the anticipated receipt of higher ground, village relocation can begin for the Hoh Tribe; making permanent sand bags a memory. The K-8 Tribal School in the Quileute lower village will finally

have safe grounds without the fear of continued storm surges and tsunami dangers.

Model for Coastal Communities

Native and non-Native coastal communities can begin to understand the impacts that are present in their own communities and the importance Traditional Ecological Knowledge has in documenting and responding to them. The approach of connecting TEK and natural science in this project is transportable to other Indigenous communities.

Information gathering may be easily found through any tribe's natural resources department, which is almost certainly working on issues related to climate change. Within all communities there are groups of people who meet to share information on particular resource gathering and traditions. For example, fishermen meet on a regularly basis to share information on new quotas; during these meetings changes in the environment are often the topic of discussion. Recording the TEK and LEK of fisheries during these meetings will help identify some of the changes being seen and will help resource managers work with governments on appropriate responses and adaptations.

For changes found in the terrestrial environment weaving circles, are a good example that hold vast TEK on traditional resources required for the practice of gathering weaving materials. These groups will be able to identify changes, not only in weaving materials, but also plants, animals and weather cycles that are often experienced when out gathering. For

example, in this thesis project, one weaver in particular spoke candidly about the declines in the amphibian species, such as frogs and salamanders she would often see in the forest (E. Penn, 2008).

Recommendations

Climate change is a global problem that has vast implications for ecosystems around the world, many of which are still unknown. For any research project it is impossible to cover all the angles and questions that could be asked. This final section contains a few suggestions on follow-up projects and studies for the Washington coast and the Quileute and Hoh tribes.

As a follow-up to this project, it is important to continue documenting changes on the coast, such as species range shifts, changes in natural resources, storm surges, and sea-level rise, as well as documenting the continued responses of both the Quileute and Hoh tribes. The Olympic Coast National Marine Sanctuary (OCNMS) has been studying the unique habitats of the Sanctuary, but more needs to be done to ensure that communication about the current and projected climatic changes are included in the Sanctuary's master plan.

The best preparation for the low-lying reservations of the Quileute and Hoh tribes is to continue to pursue higher ground to retreat from sea-level rise and increased storm surges. Storms have already increased in severity and it is likely they will only worsen in time as sea-level rises.

Intertribal cooperation on local and regional scales must continue to be utilized to ensure that traditional practices and foods survive for future generations. More reliance on intertribal cooperation and continuing to form trading partnerships with First Nations across the Canadian border is crucial. Since species range shifts will be moving northward (as well as higher in elevation), sharing knowledge of plants and animals with neighboring communities to the north will need to become a common practice, as groups prepare for change.

Continuing to build and strengthen ties that have long sustained intertribal trading must continue to prepare for adaptation to the unique changes and challenges being felt in each community. This is a time for all levels of tribal governance to make strong efforts to communicate with other Indigenous nations and with their own tribal members, to share plans and advice on adaptive approaches from education to village relocation. There is much to be shared. In the introduction to this thesis I list a few examples of Native communities beginning to adapt, but there are many more.

Preparation and response cannot be limited to tribal government and agencies. Though resources may be available to tribal natural resource staff, adaptive responses must come from all levels of the community to be successful. Response and adaptation is too important to be left up to staff that already have large-scale projects within their job

descriptions. Fortunately for many Native communities, there is still a sense of ‘community’ that can bring everyone together.

Youth is an important part of community response to climate change, as it will continue to affect future generations. Involving youth action is a very powerful force for any community. Youth are already heavily involved in community care and awareness. Committees that join together many age groups, from students to elders, are ideal outlets for developing community and individual focused responses to climate change impacts. This is the time for positive action that will steer people away from despair when it comes to large scale environmental changes.

For the Quileute and Hoh tribes, youth have already been involved in activist roles by peacefully demonstrating the dangerous location of the Tribal School on the Quileute Reservation. This type of youth action can be extended to forming an environmental health club. This club could focus on healthy choices, but also empower youth by involving them in community level planning for environmental changes. Another source for student involvement can be through the student summer employment opportunities, Youth Opportunity Program (YOP) offered to Tribal High School students.

Along with this, the Quileute and the Hoh tribes must continue to strive for inclusion in all discussions regarding the designation of protected areas under the Olympic Coast National Marine Sanctuary (OCNMS). It is of fundamental importance that communications are

strengthened with the Sanctuary to ensure that the distribution of environmental benefits are equal while treaty rights are upheld for all coastal tribes. OCNMS is perceived as threatening to Native livelihoods because additional park-like presence in the ocean (including no-take zones such as Marine Protected Areas) could negatively impact tribal subsistence economies. The uneasiness and fear felt by many tribal members primarily centers on the exclusion of traditional fishery practices, at a time when climate change is increasingly constricting these practices. For the Quileute and Hoh peoples this is especially worrisome since relationships have not always been positive with the National Park Service for accessing land resources. The Sanctuary has begun to show invested interest in hearing all feedback from local communities, but more needs to be done, such as a community forum with the Sanctuary.

Communities around the globe are beginning to come together to plan for adaptation and mitigation strategies on the local level. TEK within the tribal communities already points to changes occurring on the coast. Communities in the Pacific Northwest, such as the Quileute and Hoh tribes have access to a leading climate research team, the Climate Impacts Group (CIG) at the University of Washington. To aid in planning large scale projects (such as village and school relocations), the CIG has a Community Planning Guide. TEK points to specific impacts, such as locations of flooding and storm surge events. The CIG Planning Guide can help coastal communities map environmental impacts and at risk

areas. Community mapping can lead to the development of adaptive response strategies to current and perceived environmental impacts. As a next step, the designated planner in each tribal office can consider incorporating a long-term plan for climate change adaptation. Much of this is currently being done as both tribes make plans for the higher ground acquisitions and the CIG's guide can help make the connection to climate change adaptation and mitigation.

Community forums and conferences on climate change have been the focus of many tribal gatherings throughout the PNW. As a final recommendation, community gatherings on climate change implications, adaptations, and mitigations must be held by Washington coastal tribes. Coastal reservations will see the worst of climate change impacts with sea-level rise, flooding, and increased storms. It is essential that these gatherings are organized for sharing information specific to coastal impacts. TEK holds vast knowledge of previous change and adaptation, and it will provide solutions for coastal tribes facing climate change.

In a final note regarding the tribes' request for higher ground, theirs is a request of environmental justice. The Quileute and Hoh communities must have a "safe and healthy environment" out of harm's way from tsunami, storm surge, and flood zones. This is environmental justice that must be recognized; otherwise the cultures of these peoples will remain at risk of surviving to future generations.

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APPENDICES

1. The Chemakum Tribe is not federally recognized because their numbers were so “reduced that they were absorbed into the S’Klallam, Skokomish and other groups by the 1850’s” (Wray, 2002).
2. Canning (2001) reports that during the 1997-98 El Niño a high water level occurred with 10-15 cm water higher than the high tides predicted for January 2, 1998. As a combination of high winds and high sea level “strong wind-induced waves” caused severe shoreline erosion, a 15 meter retreat, at Point Brown in Ocean Shores, Washington. In addition it caused “widespread wave runup” into primary dunes from Cape Shoalwater to Copalis Head (Canning, 2001).
3. In October 2004 and November 2006 Hoh River flows reached 62,100 and 60,700 cubic feet per second (cfs). These are extreme high flow peaks that are not seen on records dating back to 1961 (Figure 14).
4. In 1910 a storm hit the coast that caused the Quillayute River mouth to shift south. As a result a 10-acre parcel was cut off from the rest of the Quileute Reservation. Following this event an official US government survey was completed by the General Land Office in 1914 and was approved in 1916. The survey had key errors that failed to recognize the 10-acre parcel boundary and it excluded some privately held lands. When the coastline was added to the Olympic National Park in 1953 the erroneous 1916 survey was used to create the new boundaries. This resulted in the incorporation of the 10-acre parcel within the National Park. Subsequently the disputed 10-acres became the parking lot for Rialto Beach (Hobson, 2008; Jaime, 2008a; Ralston, 2008).
5. Freshening is the addition of freshwater into the ocean that causes the ocean’s salinity to lower in concentration, particularly at the ocean surface. Fresh water coming from increased precipitation and melting of land-based ice is suspected to increase ocean freshening in the decades to come (Fedorov et al., 2007).