SUB-SECTION 4M.6

PUYALLUP TRIBE ALL HAZARD MITIGATION PLAN
CLIMATE CHANGE

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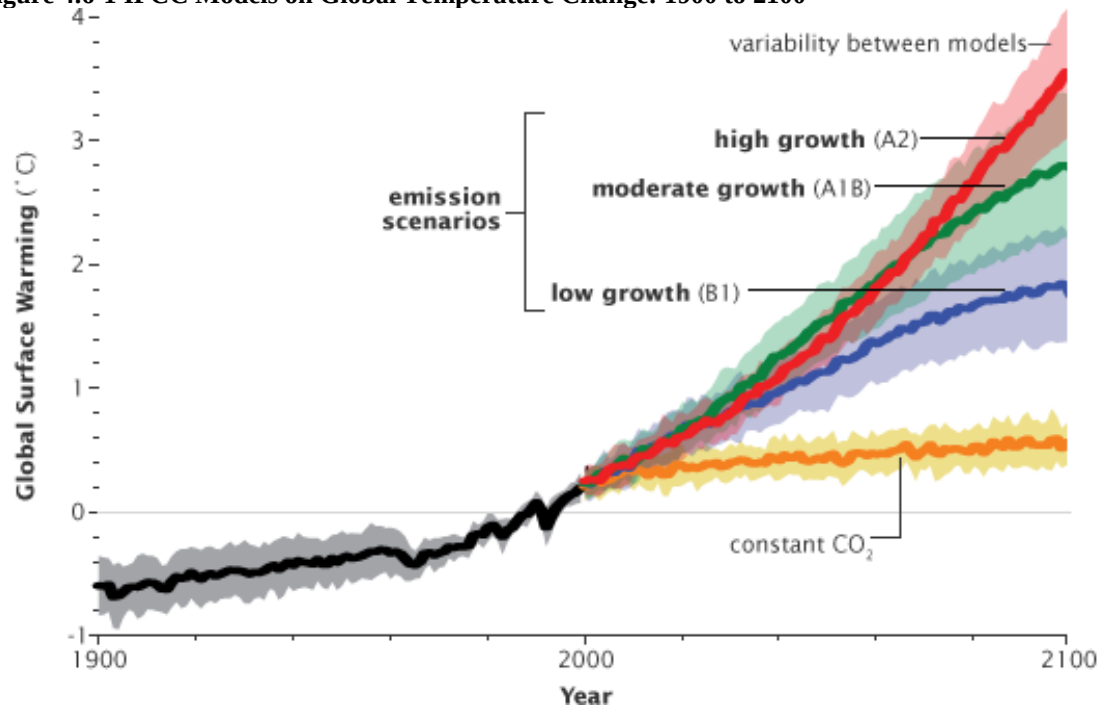
Identification Description

Climate change has received tremendous press recently due to the topic of global warming making it into the mainstream consciousness. Currently the expanding body of empirical data supports the basic premise that the long term average temperature of the earth's atmosphere has been increasing for decades. This trend is continuing, and the scientific community generally agrees that it will continue for the foreseeable future unless dramatic steps are taken on a global scale to decrease the release of greenhouse gases (*Figure 4.6-1 IPCC Models on Global Temperature Change: 1900 to 2100*). This will create dramatic changes in the local environment of Pierce County. Today, questions revolve around the overall increases in local temperatures, precipitation, and wind patterns and their long term effects.

For Pierce County, climate change boils down to a few basic questions which can further be broken down into two categories: natural causes/impacts and human causes/impacts. The questions regarding the natural environment include: How will the temperature change over the next few decades? How will the rain and snowfall patterns change? Will this exacerbate other problems in the environment? What new environmental problems will arise? What are the expected changes in the biological life zones? What will be the effect of sea-level rise on Pierce County's coastline? How will climate change impact the ecology of Puget Sound?

Figure 4.6-1 IPCC Models on Global Temperature Change: 1900 to 2100[1]



The second half asks: How will these changes affect the citizens living here? What changes to the infrastructure will be needed to accommodate the expected environmental changes? What lifestyle changes will be necessary? What are the economic consequences

of property loss, especially to the port/industrial area? How will individuals, business, and government respond to changes in life style required by the changes in the local environment?

Definition

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change encompasses the major influx in temperature, precipitation, or wind patterns.[2] While climate change today is thought of as being synonymous with global warming, in reality global warming is a type of climate change.

From another perspective, climate change is the variation in either regional or global environments over time. In this case time can refer to periods ranging in length from a few decades to other periods covering millions of years.[3]

Today, much of the talk of climate change presupposes a rise in global temperature averages. Over the past 150 years good temperature records have allowed comparisons to be made of global temperatures from year-to-year. This has shown an overall increase of approximately 0.8^{o} C during this period, (see Figure CC-1). Over the next century an increase of 6^{o} C is expected due to the green houses gases already in the earth's atmosphere. An increasing body of scientific evidence implies that the primary impetus driving climate change today, are human activities that increases the amount of atmospheric greenhouse gases.[4]

A number of circumstances can cause climate change including both natural and human causes. These natural factors may be solar cycles, volcanic eruptions, the changing of ocean current patterns, or even something as unusual as a methane release from the ocean floor.[5] Those changes due to human activities are frequently called anthropogenic climate change which pertains to activities that alter the atmospheric composition.[6] For natural causes the United Nations Framework Convention on Climate Change (UNFCCC) uses the term "climate variability" for non-human caused variations.[7]

Types

There are two major classifications: global warming and global cooling.

Global Cooling

A decrease in the average temperature of the earth's atmosphere, especially a sustained decrease sufficient to cause climatic change.

Global Warming

An increase in the average temperature of the earth's atmosphere, especially a sustained increase sufficient to cause climatic change.

Profile

With the primary direction of climate change today being global warming, Washington State, Pierce County and the Planning Area will experience major changes during the next century. The expected further increases in temperature for Washington State are shown in Table 4.6-1. In this table we can see the projected temperature rise broken down by each year. Such increases will continue to dramatically affect the plants, animals, people and economy of Pierce County and the Planning Area. The change in rain and snowfall patterns, life zone migration, and sea-level rise will all create a different County than we have today.

Global warming, by itself, is only part of the overall problem, and is actually the result of a number of factors that are all combined into overall environmental degradation. The increase in greenhouse gases, the primary factor blamed for global temperature increase, comes from many divergent sources. Included in the current list are carbon dioxide from modern industry; the burning of fossil fuels; deforestation and cement manufacture; methane from cattle and other animals including such small animals as termites; and gases such as nitrous oxide, chlorofluorocarbons, and a host of other trace gases.

While the increase of atmospheric carbon dioxide (CO_2) is foremost in peoples' minds when they think of global warming, some of the other gases have a much greater impact on global warming for the quantity released than does CO_2. Methane is 20 to 30 times as effective in its ability to absorb infrared radiation as CO_2, and chlorofluorocarbons, while usually associated with the destruction of the atmospheric ozone layer, are also highly contributive to global warming. A single chlorofluorocarbon molecule is 20,000 times more effective as a greenhouse gas than is a carbon dioxide molecule. While a number of these other gases contribute a significant amount to the increase in global temperatures the main culprit for the foreseeable future, due to the sheer quantities released, will continue to be carbon dioxide.

> "Emissions of CO_2 due to fossil fuel burning are virtually certain to be the dominant influence on the trends in atmospheric CO_2 concentration during the 21st century."[8]

With the advent of the industrial revolution, the quantity of atmospheric CO_2 began to rise. For the 400,000 years prior to the industrial revolution, the atmospheric CO_2 concentrations ranged between 200 and 280 parts per million (ppm). Since the beginning of the industrial revolution, this has increased to today's levels of around 380 ppm and is continuing to increase about one percent per year. By the middle of the 21st century, these levels could reach 500 ppm and by the end of the century, 800 ppm.

Historically there have been many ways that carbon dioxide has been absorbed by the planet. Plant and animal matter that have been buried in great quantities are eventually transformed into coal and oil. Plant material, especially trees, can absorb large quantities of carbon and the ocean acts as a natural carbon sink. The ocean contains approximately 50 times as much carbon as does the atmosphere. At the same time human activity

continues to add more of it at an ever increasing rate. Of all the fossil fuel carbon released to the atmosphere, about 48 percent of it currently ends up in the ocean.[9] This continued absorption of carbon dioxide changes the chemistry of the ocean, and essentially affects all sea life. Computer modeling anticipates that this will increase the acidity of the oceans surface water by a drop of 0.4 pH units.[10] How this will affect the sea life in Puget Sound and Pierce County in particular is still an open question requiring further research.

The pace of some affects of global warming seems to be accelerating. Computer models of climate change from the 1990s appear to be already outdated in their predictions. The slowing of the Ocean Conveyor Belt and the destructiveness of storms appears to be increasing at a rate the models had predicted would happen much later in this century[11].

Table 4.6 -1 Recent and Projected Temperatures for the Pacific Northwest[12]

	1970-99	2020	2040
Annual	47.0° F	48.9 °F	49.9°F
(increase)		*1.9 °F*	*2.9 °F*
Oct. – Mar.	36.1 ° F	37.8 °F	38.6 °F
(increase)		*1.7 ° F*	*2.5 °F*
Apr. – Sept.	57.9 ° F	60.0 °F	61.2 °F
(increase)		*2.1 °F*	*3.3 °F*

Notes: Temperatures are averages across the Pacific NW, and may vary significantly from region to region. The table compares observed temperatures for the 1970-99 periods with changes in temperatures averaged across 30 yr periods centered on the 2020s and 2040s projected by 10 global climate models' two emission scenarios. The future temperatures are the averages calculated from changes projected by those climate models for the specified time periods.

Occurrences

Global climate change has been the norm for essentially the entire life of the planet. It has forced organisms to change with the changing climate either by migrating or evolving to fit the new weather patterns. Those that did not follow either of these paths either died out, or were reduced in their ranges, sometimes forming small insignificant communities perpetually on the verge of extinction.

The last dramatically different climate that we are able to at least get a partial view of is the last ice age. As much as that climate contrasts with ours, we can see only traces of it today. Knowledge of it has gradually evolved through years of research. The covering of much of North America, Europe and parts of Asia with ice, in addition to the linking of the North American continent with Asia, the connecting of Malaysia with Sumatra and Borneo, and Australia with New Guinea, is outside the realm of personal experience. It doesn't influence our day to day thinking.

The most recent lengthy episode for which we have detailed written records is the cooling of the Northern Hemisphere during what is called the "Little Ice Age"[13]. While there were glacial advances, it was not a true ice age in that it did not last long enough for glaciers to significantly increase the percentage of land they covered. During this 500 to 600 year period temperatures dropped from 1-1.5º Celsius.[14] This drop changed disease patterns, caused famine and led to social upheaval in some areas.

In the more recent past, the 25 year temperature decrease from 1940 to 1965, impacted many individuals alive today (See Figure 4.6 -1.) and shows that even with an overall increase in global temperatures there will be periods when the average temperature will drop for extended periods of time.

While there are wide variations from year to year in global temperatures, the overall trend since the beginning of the industrial revolution has been for a gradual increase. The forecasts are for this trend to continue into the indefinite future depending on the continued release of greenhouse gases, volcanic eruptions, etc. How much of a change in temperature we can expect in the future is one of those debatable questions with estimates ranging from a degree or two up to ten or more degrees Celsius. Even with only a one or two degree increase there would be tremendous climatic changes. While a number of them are expected to be detrimental, there should be some positive changes as well. It is estimated that the worldwide temperature today is only three to five degrees Celsius more than it was during the last ice age, so this could easily double over the next century.

Health and Safety of Persons in the Affected Area at the Time of the Incident

The overall impacts from long term climate change are only beginning to be felt throughout Pierce County. Impacts on health would be gradually felt. As the average temperature rises gradually over the next few decades, the incidence of diseases normally associated with warmer climates will increase. There should be a slight decrease in cold related injuries in the winter months and an attendant increase in heat related injuries during the summer months. With both of these, the elderly will be among those affected the most.

Health and Safety of Personnel Responding to the Incident

Unlike other emergencies, climate change will not have personnel responding to it as if it was an immediate emergency. Health related issues for personnel will be similar to those for the general population.

Continuity of Operations and the Delivery of Services

While there will be changes in the environment throughout Pierce County, change will develop slow enough to maintain continuity of operations. It is not expected that climate change by itself will impact the delivery of services on a long term basis. As the climate changes gradually from decade to decade, governmental offices, response organizations and personnel will gradually adapt to fit the new circumstance. Other changes in the

environment, such as population growth, should impact delivery of services more than gradual climate change.

Property, Facilities, and Infrastructure

Impacts to property, facilities and infrastructure could be considerable, depending on a number of factors, especially sea-level rise. Due to the extensive coastline in Pierce County, sea-level rise combined with subsidence in some areas will eventually damage a large number of properties; affect businesses, and damage local infrastructure.

Individuals living along the coast of Puget Sound, especially those with low bank properties will experience the rise in water levels first. Water will encroach into their yards and winter wave action will erode yards, expanding the beach inland. Areas like Salmon Beach, portions of Day Island, Wollochet Bay, Sunset Beach and others will have problems with high tides actually impacting homes directly. In contrast high bank areas could have problems with their hillsides being undercut by wave action leading to an increase in steep bank erosion or landslides, threatening the homes or property above.

Marinas and other businesses, along Ruston Way, portions of Day Island, Gig Harbor, and the Port of Tacoma in many cases will be subject to damage from an increase in sea level combined with wave action. Most of them are currently high enough to avoid damage from winter storms; however their margin of safety disappears due to rising water levels, and in some cases subsidence. In the event of an extreme low tide, the ferry system cannot run and increases the vulnerability of egress and ingress for Pierce County.

Along much of Pierce County's coastline are critical roads and railroad tracks that are essential to the County's transportation system and furthermore functionality. An increase in sea level may require raising these to protect the movement of people and goods. With Pierce County's industrial base located largely within the confines of the Port of Tacoma and adjacent properties, any significant rise in sea level will put portions of it in jeopardy.

The potential is there to flood ports, tidewater industrial areas, river deltas, coastal wetlands and beachfront properties. Some of the homes in areas like Sunset Beach, Day Island and Salmon Beach that are currently just above the high water mark will begin to be flooded during times of high tides. Either land will have to be raised with fill, massive seawalls built or some industry or roads will have to be relocated to higher ground along with homes in the most threatened areas.

In addition to coastal area flooding, wave action could increase the undercutting of high bank areas such as along the Tacoma Narrows. This could undermine homes and other buildings or structures located along these bluff areas. When the combined coastal subsidence and sea-level rise are added to normal winter high tides and storm surge, damage could be extensive to current structures.
Electric generation in Washington is primarily hydroelectric. It relies on a constant supply of water delivered to the dams and generating plants. A decrease in the amount or changes of the timing of streamflow in the winter/spring snowpack will impinge on the

ability of electric generating plants to meet demand. Even further the demand during the summer for air conditioners, refrigeration units etc., when water levels will be at their lowest will exacerbate this problem. If water resources can no longer fill the need for electric generation then there could be an increase in the use of fossil fuels to generate electricity. This will create more air pollution problems. Due to the strain on the energy infrastructure, controlled brownouts will occur as a method to relieve the system. Otherwise blackouts would occur and greatly increase the likelihood of heat-related deaths especially among the elderly, those weakened by disease, and the poor.

The Environment

Continued scientific research today shows major changes on a worldwide scale. They range from gradual sea-level rise to thinning of the arctic ice pack to a change in the amount of ice at mid-latitudes. Changes in the range of insects and the strength of storms are currently forecast for the present and near future.

One of the major problems associated with global warming is the increase in sea-level. Over the past century, the global average sea-level rise has ranged from 1 to 2.5mm/year. In southern Puget Sound, sea-level rise is expected to have the largest global warming rise in the state, about 5mm/year.[15] This is a consequence of rising water levels combined with the gradual subsidence taking place in Pierce County and will change the nature of life along the shorelines. In 2001 research on southern Puget Sound showed the rate of subsidence in the Tacoma area to be 2.4 mm/year.[16] This means that even without any sea-level rise, the land will sink around 9.5 inches over the next century. When we add in the minimum expected sea-level rise of up to 2.5mm/year this could lead to an effective increase of over 19 inches over the next century.

Over the next several years we should begin to see its effects develop on the local scale. The potential is there to flood ports, tidewater industrial areas, river deltas, coastal wetlands and beachfront properties. Some of the homes in areas like Sunset Beach, Day Island and Salmon Beach that are currently just above the high water mark will begin to be flooded during times of high tides. Either land will have to be raised with fill, massive seawalls built or some industry or roads will have to be relocated to higher ground along with homes in the most threatened areas. All of these are extensive and expensive projects.

In addition to coastal area flooding, wave action could increase the undercutting of high bank areas such as along the Tacoma Narrows. This could undermine homes and other buildings or structures located along these bluff areas. When the combined coastal subsidence and sea-level rise are added to normal winter high tides and storm surge, damage could be extensive to current structures.

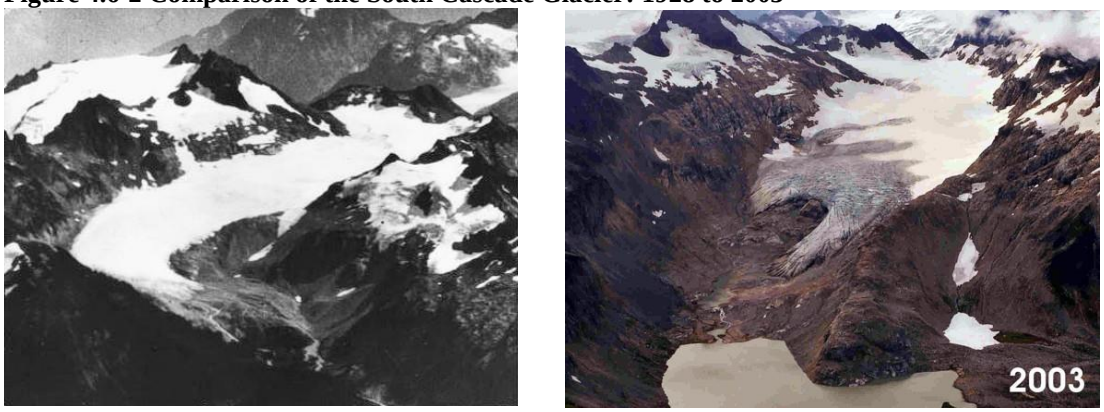
One of the other possible effects that may happen due to a warming trend is the movement of saltwater into the coastal aquifers low lying near tidal zone areas, rendering wells in those areas useless. Others would include the expansion of saltwater marsh areas into areas where they do not currently exist.

Locally in Pierce County we may see a cycle of warmer winters and drier summers. If the snowpack is not accumulating, this will cause a lack of available stream water in the summer. Drier summers means an increase in forest fire danger, more stress on agriculture, water rationing, and the possible destruction of fish runs especially salmon, steelhead, and trout.[17] As the climate gradually changes we can expect an upward movement of lower elevation ecosystems. Those ecosystems, like the sub alpine and alpine that are located near the top of our mountains, may be pushed up by pressure of other species from lower elevations as the weather warms. This could lead to the extinction of many endemic species which have tenuous holds in these environments. Over time it could also lead to the migration of plants and animals endemic to areas further south like Oregon and Northern California moving into the Puget Sound basin.

A decrease in river flows and lake levels especially during the summer months due to the lack of snow in the mountains is already becoming visible in the lack of glacier ice in the Cascades. Ice volumes have decreased dramatically as can be seen in Figure 4.6-2.

The South Cascade Glacier in the North Cascades is one of the glaciers that has been studied for many years and has lost much of its ice volume over the past nearly 80 years; photo on left from 1928 and photo on right from 2003. A lack of permanent ice to feed the rivers when the rest of the snow pack melts in the spring could mean very low water levels in the rivers by the time late summer arrives. This would be offset by the possibility of heavier flows during the fall and winter. The decreased flows during the summer will create warmer rivers that are detrimental to already reduced salmon runs. In addition the heavier flows during the winter could scour many of the river bottoms decreasing salmon habitat.

Figure 4.6-2 Comparison of the South Cascade Glacier: 1928 to 2003[18]



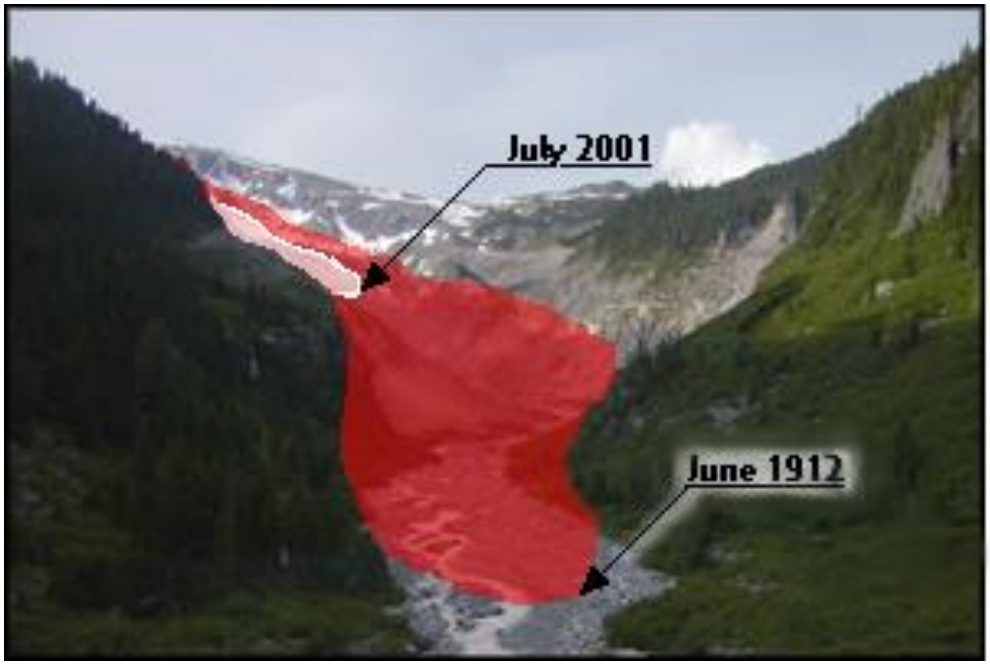
On Mt. Rainier in Pierce County, many of the same issues are confronted with the retreat of its glaciers. Over the past 40 years, due to glacier shrinking of the Paradise and Williwakas Glaciers, the Paradise ice caves, a popular spot for tourists to view the underside of a glacier up close, have disappeared. Other glaciers in the park have also retreated, in some cases long distances up valley. The Nisqually Glacier, shown in Figure 4.6-3, has retreated approximately one mile upstream since 1912 and evidence in the valley shows that the first chronicle mentioning the glacier in 1857 had the ice

considerably further down valley, well below the current bridge across the Nisqually River.

Other environmental changes might include a loss of forest resources due to changing patterns of precipitation and an increase in temperatures during the summers. Forests could be depleted through changing growth patterns due to weather changes, an increase in insect infestations or an increase in forest fires.[20]

A decrease in the amount of winter precipitation locked up as snow in the Cascades means that a higher percentage of our normal precipitation will be available to cause winter flooding in the County. Currently the mountain snowpack acts as a natural water reservoir. As the annual snowpack decreases due to warmer winters the amount of precipitation that normally falls will raise stream and river levels. This could increase Pierce County's flood potential.

Figure 4.6-3 Lower Nisqually Glacier Retreat: 1912 to 2001[21]



Other potential effects include new diseases, that while endemic to warmer climates could migrate to Pierce County; a longer growing season for some crops; and a change in the recreational possibilities available for both residents and visitors.

Economic and Financial Condition

The changing climate will affect nearly every portion of the County's economy. Examples include:

- Energy usage will change. Warmer temperatures will reduce the need for electricity and other energy sources for home heating in the winter, but

increase it during the summer months when air conditioning needs will increase;

- The warmer temperatures with the rising snow levels could decrease the ski season at Crystal Mountain resort;
- Agricultural growing seasons should increase, as should their demand for water;
- New agricultural crops that have been grown in warmer climate zones may be added to the state's agricultural base;
- Agricultural pests found in warmer climates could invade Pierce County and attack crops;
- The increase in forest fires due to dryer summers will increase the cost of fire fighting;
- The lack of a large snowpack will decrease the amount of available water as the summer progresses. This will create a need for more water storage units to handle the increased need in late summer and early fall;
- Increasing health care costs are expected in the areas of heat related illnesses, such as heat stroke, heat associated illnesses such as asthma, and infectious diseases that are associated with warmer weather like West Nile Virus;
- With the potential increase in flooding mentioned above there will be increased costs for responding to, and recovering from, these floods; and,
- The need for more energy efficient solutions to the climate change and global warming issues should increase the options for new business development.

Economic effects will be felt not only as a result to changes in the surface ecosystems, but also to changes in the marine environment. Some fish species that are used to the frequent cold waters of Washington are already close to disappearing, such as Pacific Cod. While overfishing assisted in the decline, scientists point to warmer water as a contributing factor in stifling their recovery.[22] The fishing industry has had a difficult time for many years and the declining local species will continue to cause problems for the foreseeable future. However, at the same time that some species are decreasing, others like ocean sunfish, barracuda, sardines, striped bass and lizard fish are beginning to show up in Washington waters.[23] In order to survive, the fishing industry may need to change some of the species that sustain it, moving from the traditional northwest species to ones that are moving into the area.

Public Confidence in the Jurisdiction's Governance

As the changes in the local environment accumulate over time the public could begin to demand that any problems that arise be mitigated. It may become difficult convincing citizens to accept the costs, including new taxes associated with mitigating the results, preventing damage through controls on land use, or the difficulty of accepting a change of lifestyle that might be required. Frustration could be expressed against local leaders and government agencies.

Resource Directory

Regional

- **Pierce County Department of Emergency Management**
  http://www.co.pierce.wa.us/PC/Abtus/ourorg/dem/abtusdem.htm

- **University of Washington Program on Climate Change**
  Box 355351, OSB 227
  School of Oceanography
  University of Washington
  Seattle, WA 98195-7940
  206-543-6521; Fax 206-543-6393
  http://depts.washington.edu/uwpcc/ourprog/our_program.html

- **Washington State Department of Ecology**
  http://www.ecy.wa.gov/

- **Office of the Washington State Climatologist**
  http://www.climate.washington.edu/events/

- **Climate Impacts Group (CIG)**
  http://www.cses.washington.edu/cig/

- **Mt. Rainier – Glaciers and Glacier Change**
  http://www.nps.gov/archive/mora/ncrd/glacier/

National/International

- **Intergovernmental Panel on Climate Change**
  http://www.ipcc.ch/

- **U.S. Environmental Protection Agency**
  http://www.epa.gov/climatechange/index.html

Endnotes

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[12] Impacts of Climate Change on Washington's Economy: A preliminary Assessment of Risks and Opportunities, November 2006, Washington Economic Steering Committee and the Climate Leadership Initiative Institute for a Sustainable Environment, university of Oregon for WA. Dept. of Ecology and Dept. of Community, Trade and Economic Development, Washington State, P. 17.
[13] While there is some disagreement as to the actual beginning of the "Little Ice Age," ranging from 1150 to 1560, with most scientists putting the beginning at the later number, the end point is commonly agreed to be around 1850. There had been a general cooling of the climate from around 1150 to 1460 and then a warm spell for approximately 100 years, and then from 1560 to 1850 a very cold climate shift. From http://www2.sunysuffolk.edu/mandias/lia/little_ice_age.html, http://www.windows.ucar.edu/tour/link=/earth/climate/little_ice_age.html and others.
[14] The Little Ice Age, Lisa Gardiner, University Corporation for Atmospheric Research, The Regents of the University of Michigan http://www.windows.ucar.edu/tour/link=/earth/climate/little_ice_age.html
[15] Climate Variability, Climate Change, and Sea-level Rise in Puget Sound: Possibilities for the Future, Douglas J. Canning, Washington Department of Ecology and JISAO/SMA Climate Impacts Group, U. of Washington, 2001, p.1-2.
[16] Ibid, page 2.
[17] Mote, P., A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder, 2014: Ch. 21: Northwest. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX
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[23] Ibid.