Central Council of the Tlingit & Haida Indian Tribes of Alaska

CLIMATE CHANGE ADAPTATION PLAN

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ACKNOWLEDGEMENTS

Gunalchéesh / Háw'aa (Thank You)

Sitka Tribe of Alaska

Jamestown S'Klallam Tribe

Institute for Tribal Environmental Professionals (ITEP) Northern Arizona University

Swinomish Indian Tribal Community

Tulalip Tribes

USDA-USFS Pacific Northwest (PNW) Research Station

USGS Alaska Climate Science Center

Geophysical Institute Alaska Climate Research Center UAF

North Pacific Landscape Conservation Cooperative

U.S. Fish & Wildlife Service

Southeast Alaska Fish Habitat Partnership (SEAKFHP)

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Tribal Climate Change Project University of Oregon

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SECTION I. THE TRIBE'S HISTORY OF ADAPTABILITY AND RESILIENCE

The Central Council of the Tlingit and Haida Indian Tribes of Alaska (Tlingit & Haida) is a federally recognized Indian Tribe that serves 20 villages and communities stretching over 43,000 square miles within the Alaska Panhandle. The Tlingit & Haida citizenship is among the largest, most isolated, and most geographically dispersed of Native or Tribal populations nationwide. The region encompasses a 525-mile strip of coastline and interior waterways, bordered by Canada on the north, south, and east, with the Gulf of Alaska on the west.

The area of Southeast Alaska known as the "Panhandle" or the "Alexander Archipelago" is one of the few temperate rain forests in the world. It consists of many islands which comprise the Alexander Archipelago, and a thin strip of mainland running from Dixon Entrance to Icy Bay. Southeast Alaska stretches from approximately 54 degrees north latitude at the southern tip of Prince of Wales Island to 60 degrees north latitude near Yakutat, Alaska. The many sounds, channels, straights, fjords, narrows, bays, coves and natural harbors create a maze of waterways between the islands and the mainland.

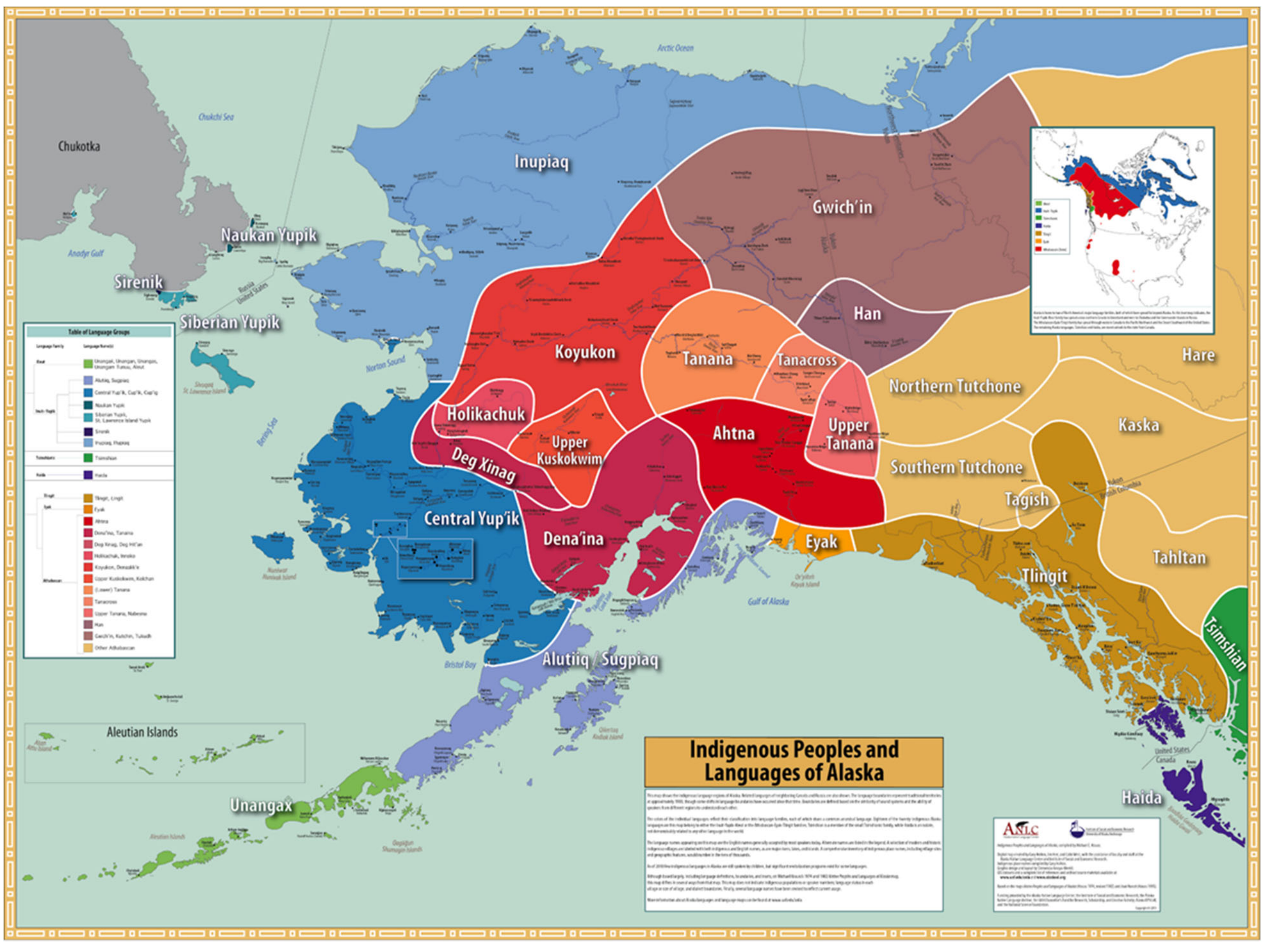

Figure 1: Tlingit and Haida Ancestral Land and Waters – Yellow dotted-lined box. (Source UAF)

Southeast Alaska, our ancestral lands and waters, is a region that is experiencing changes in the climate and weather patterns, yet there is currently little data available on the extent of climate change effects.

SECTION I. THE TRIBE'S HISTORY OF ADAPTABILITY AND RESILIENCE

Tlingit & Haida began to seek information and studies on climate change in Southeast Alaska to fully understand its impacts to our tribal citizens and our way of life. In a national technical report on climate change, there were only two pages on Southeast Alaska and climate change impacts. In addition, Tlingit & Haida requested information on Southeast climate change from local scientists, the University of Alaska, U.S. Geological Survey, and the U.S. Forest Service; and it was determined that there is currently little information specific to the Southeast Alaska region. However, what is known is that climate change is having adverse impacts on our customary and traditional hunting, fishing, and gathering ("subsistence") resources. Rising average global temperatures, rising sea level, increases in ocean acidification, and the increased frequency and severity of storms have brought the effects of climate change to the forefront. Water quality in Alaska has been of concern for some time now. Climate change is believed to have an adverse effect in our salmon streams, causing the waters to warm and effecting salmon eggs and fry. Climate change also has an impact on the influx of invasive plant species.

Southeast Alaska climate change impacts differ from those of the rest of the state. Northern Alaska and the interior are faced with massive sea level rising and erosion, and melting permafrost. Southeast impacts focus mainly on the ability to harvest traditional subsistence foods and resources. Being located on the coast, climate change impacts on marine resources are a main concern for SEATOR (Southeast Alaska Tribal Ocean Research) Tribes. Fish and shellfish species are an important cultural and traditional food item that is being affected both directly and indirectly from changing ocean temperatures and chemistry due to climate change. Increased harmful algal bloom (HAB) events, although not harmful to the shellfish themselves, pose a severe health concern to those who harvest them. Ocean acidification limits the ability for shell formation at critical stages in the lifecycle, and can cause huge impacts to local shellfish stocks and other fish species. Salmon species rely on specific ocean, stream, and estuary conditions that promote healthy returning stocks. With a change in ocean chemistry and temperature, valuable subsistence resources will be difficult to access and potentially cause human health concerns. Climate change also has negative traditional and cultural impacts on terrestrial resources such as black-tail deer, yellow cedar, and other subsistence plants.

Most of the Alaska based climate change trainings and conferences focus on northern Alaska issues and seldom address southeast Alaska. In December 2015, Tlingit & Haida and Sitka Tribe of Alaska (STA) initiated the help and support from the Institute for Tribal Environmental Professionals (ITEP) to develop a specific workshop focused on southeast Alaska issues the SEATOR and Southeast Alaska tribes were facing. The workshop was well attended and the Tribes were able to develop a list of priorities through a vulnerability assessment through the consideration of both climate impacts variables and related environmental stressors that could potentially have the greatest negative impact on the community's resilience and subsistence way of life. The Tribes spent several days working together to prepare for developing a climate change adaptation plan (CAP) and collaborated with other Washington State Tribes that have already gone through the process. The SEATOR and Southeast Alaska tribes are relying on the high capacity and dedication of Tlingit & Haida and Sitka Tribe of Alaska to develop a template and southeast "prototype" CAP.

Tlingit & Haida has worked to determine what changing climate conditions will occur in southeast Alaska and potentially affect all southeast Tribes; and prioritized each area of concern with a ranking based off of vulnerability and importance to the citizens and culture alike.

SECTION I. THE TRIBE'S HISTORY OF ADAPTABILITY AND RESILIENCE

The following document is an effort in the next step; where a matrix was developed to determine what areas have the highest probability of impact and what monitoring or mitigation plans could be put in place to address those impacts.

All areas of concern fall under the subsistence and cultural resources that the Tribes depend on. Since time immemorial, subsistence has constituted an essential component to Alaska Native culture. The opportunity for subsistence uses by rural residents of Alaska is essential to a healthy physical, economic, traditional, and cultural existence. Southeast Alaska Natives are reaffirming their culture every time a subsistence species is harvested, consumed or otherwise used by tribal citizens. Tribal communities are being affected by climate change on a number of different scales depending on individuals' wealth, status, and gender. The subsistence practices provide for the social, cultural, spiritual, and economic wellbeing and survival of the Alaska Native community.

Taking action now to evaluate the impacts of climate change will help the Southeast Alaska Tribes prepare for and increase their resilience to climate and weather related events. Because of the conscious conservation efforts of our ancestors, our people are still benefiting from an abundance of natural resources. In the face of climate change, and for our descendants, we shall be unremitting as the "Stewards of the Air, Land and Sea." Planning for the future will allow the tribes to benefit from emerging opportunities, protect against undesired impacts, and ensure that they continue to achieve their missions.

Mission of the Central Council of the Tlingit & Haida Indian Tribes of Alaska:

"Preserve our sovereignty, enhance our economic and cultural resources, and promote self-sufficiency and self-governance for our citizens."

A. Temperature Changes – Increasing Temperatures

1. Observed Changes
   A. Average annual air and ocean temperatures have increased over the last century and are projected to continue to increase.
   B. Higher average temperatures will generate more extreme heat events and increased heat stress for plants, animals, infrastructure, and humans.

The temperature of 2016 was the warmest by a large margin, 1.5°F warmer than the previous record holder 2014 (See Figure 2). While 1.5°F is not a large deviation for a single station on a monthly basis, it is a very large value for an area as large as Alaska and for a whole year. This can be also deduced from the previous four maxima, which lie all within 1°F of each other. Furthermore, the three last consecutive years have been the warmest, most likely caused by the strong El Nino and global warming. [1]

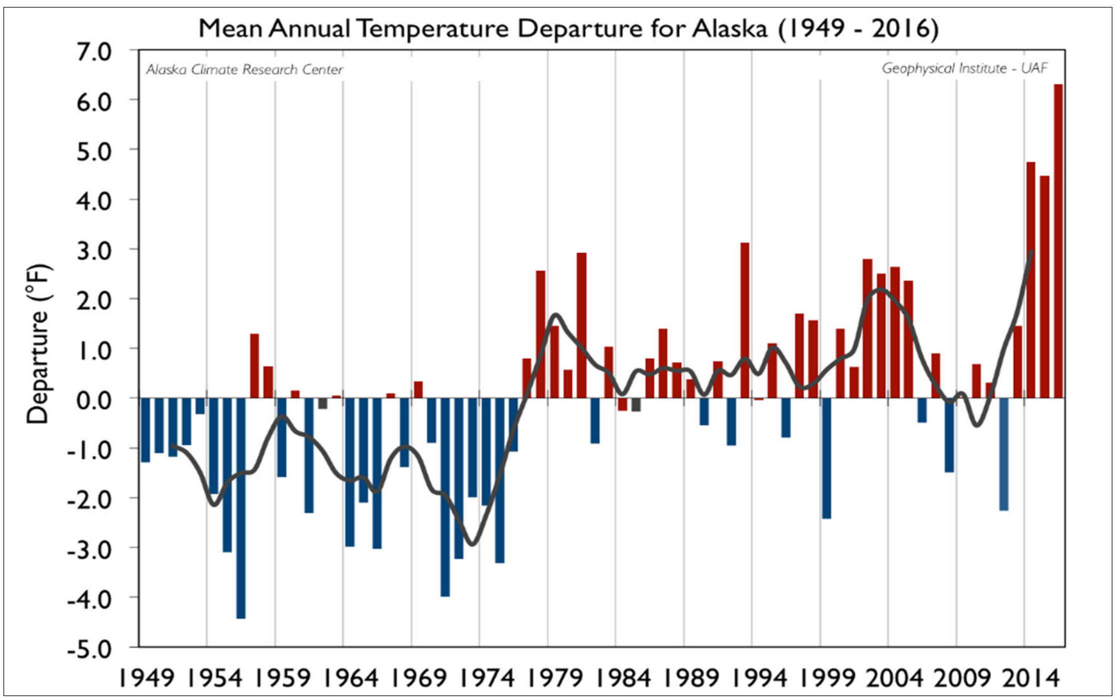

Figure 2: Mean Annual Temperature Departure for Alaska. The year is shown on the horizontal axis (x-axis) increasing from 1949 on the left to 2016 in the right. Temperature Departures for Alaska are shown on the left vertical axis (y-axis) and are represented by the blue and red bars on the graph. (Source: The Alaska Climate Research Center).

Rising global average temperature is associated with widespread changes in weather patterns. Scientific studies indicate that extreme weather events such as heat waves and large storms are likely to become more frequent or more intense with human-induced climate change (EPA).[2] Higher average temperatures are associated with warmer summers and more extreme heat events. Extremely high temperatures and low temperatures occurred almost equally across the United States during the 1940s and 1950s. Now, extreme high temperatures are occurring almost twice as frequently as extremely low temperatures.

The increases in temperature that have been observed are part of a global pattern of change that is driven primarily by human activity. Research into the increasing atmospheric concentrations of greenhouse gases since the industrial revolution (mid 1800s) has convinced scientists and others that human produced greenhouse gas (GHG) emissions are the main driver of current and future climate change (See Figure 3). The carbon isotope combinations of these GHGs are the telltale sign that this current increase in carbon dioxide (CO_2) is man-made (Read more about Carbon and its Anthropocentric Fingerprint in Section II-B). This is in contrast to slower, longer time scale, climate changes in the Earth's history that have been driven by complex non-human events such as solar output, distance of the Earth from the sun, ocean circulation, and composition of the atmosphere (NCA3).[3] The burning of fossil fuels releases GHG primarily CO_2 into the atmosphere. These gasses act like a blanket around the earth trapping in heat and warming the planet. The more GHG present in the atmosphere, the thicker the "blanket" and the higher the overall temperature.

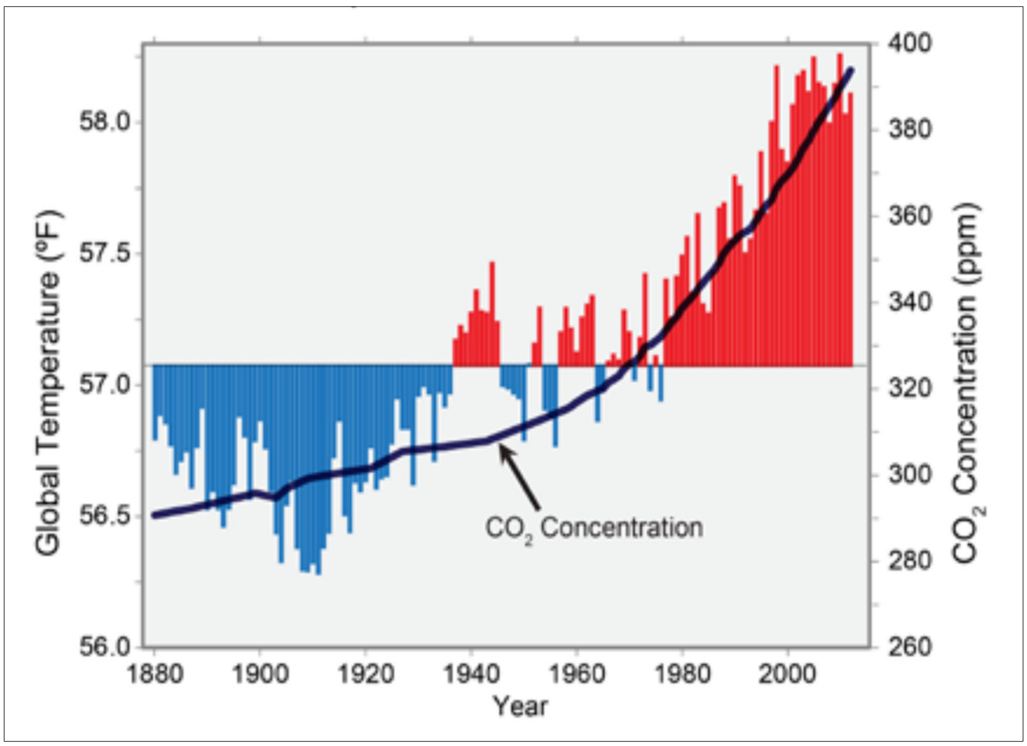

Figure 3. Global annual average temperature (as measured over both land and oceans) has increased by more than 1.5°F (0.8°C) since 1880 (through 2012). Red bars show temperatures above the long-term average, and blue bars indicate temperatures below the long-term average. The black line shows atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). While there is a clear long-term global warming trend, some years do not show a temperature increase relative to the previous year, and some years show greater changes than others. These year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and volcanic eruptions. (Source: NCA3)

2. Projections of Future Changes and Climate Exposure

Researchers use computers to model, or project, the potential impact scenarios of these GHG emissions. Using the conservative scenario of a lower increase of GHGs, or Mid-Range Emissions model (A1B) from the Intergovernmental Panel on Climate Change (IPCC), this A1B model still projects global GHG emissions to continue to increase throughout the century (See Figure 4). This A1B scenario incorporates future projections of population, economic productivity, technology development, and other factors.

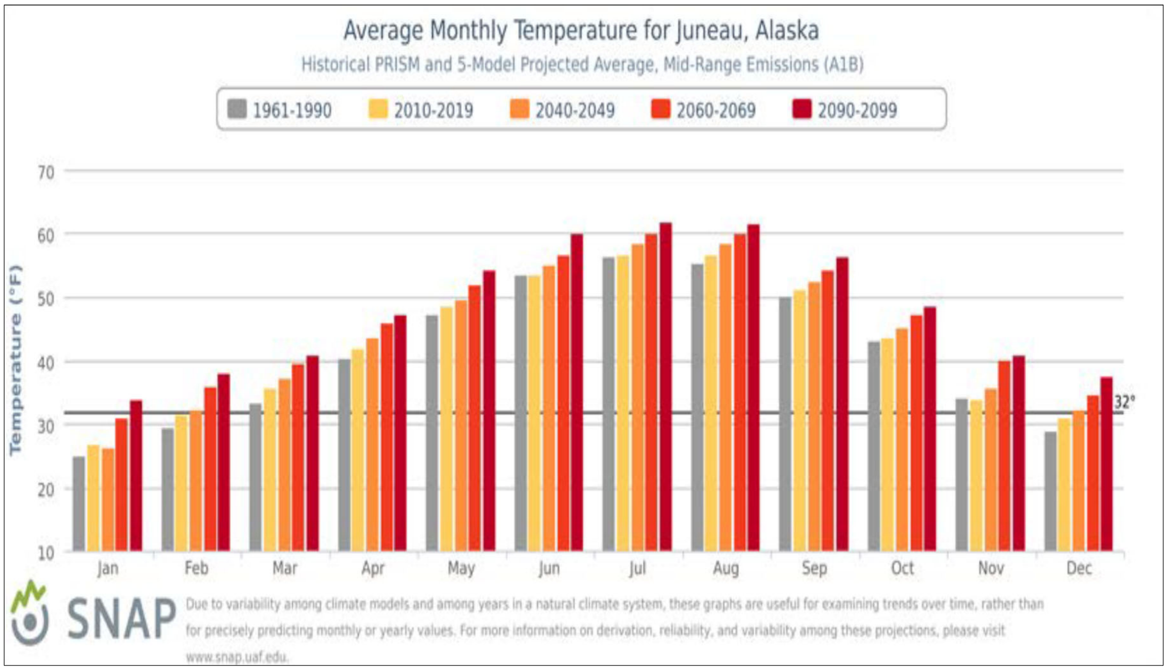

Figure 4: Average Monthly Temperature for Juneau, Alaska Historical and Projected Average using the Mid-Range Emissions A1B Model. Months and Years, designated by their corresponding color, are shown on the horizontal axis (x-axis) from 1961 to 2099. Temperature (°F) is shown on the left vertical axis (y-axis) represented by the bars with the corresponding color representing the time period. (Source: University of Alaska, Fairbanks)

All climate change projections, including mid-range scenarios incorporating a leveling of GHG's, show temperatures continuing to increase throughout the coming decades. Other projections, with increasing GHG levels, correlate higher emissions to even higher temperatures.

B. Isotopes of the Carbon Atom and the Fossil Fuel Fingerprint

1. Carbon Isotopes
   - The different Isotopes of the Carbon atom.
   - Most lifeforms prefer the lighter mass carbon, also known as carbon-12 isotope.

The carbon atom has 6 positively charged protons and 6 negatively charged electrons, with a varying number of neutrally charged neutrons. Adding the number of protons and neutrons together gives the isotope of the atom. The most abundant isotope of carbon, carbon-12 (^{12}C), has 6 protons and 6 neutrons and is 98.93% of the carbon on Earth. Carbon-13 (^{13}C) has 7 neutrons and is 1.07%, and carbon-14 has 8 neutrons and is 0.0000000001% of the carbon found on Earth.[4] The remaining carbon isotopes have such short half-lives (<30ns. to <20min.) that they are only studied in laboratory environments.

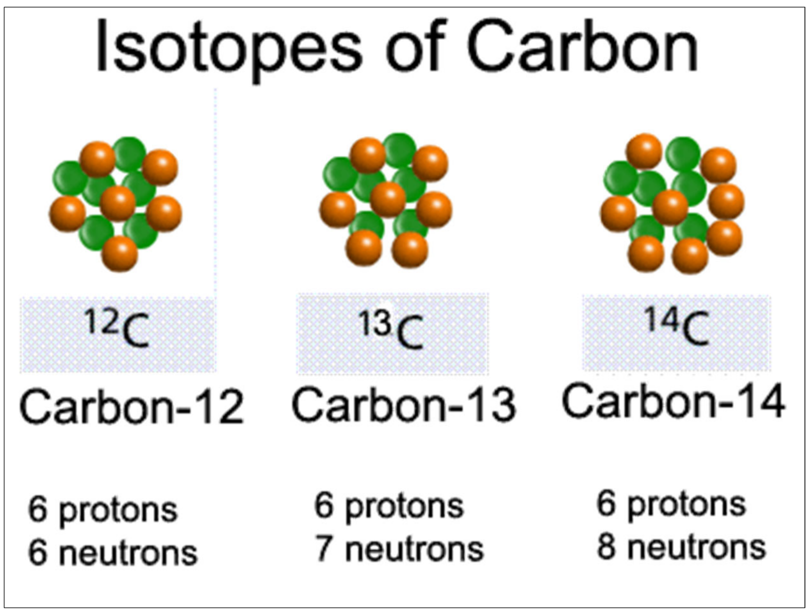

Figure 5: The Isotopes of Carbon and the configuration of protons and neutrons. (Source: Socratic.org)

Carbon atoms continuously cycle through living and nonliving matter. Most plant life, including phytoplankton, discriminate against ^{13}C and prefer the lighter ^{12}C isotope. [5] Carbon-13 atoms are slightly heavier in mass and require more energy in the photosynthetic reaction. Plants prefer the lighter Carbon isotope, absorbed from the CO_2 in the atmosphere, to make for a more efficient photosynthesis process.

2. The Mesozoic Era, the Paleozoic Era - Carboniferous period
   - Fossil fuels came from ancient plant life.
   - Lifeforms left their signature preferring the carbon-12 isotope.

The Mesozoic Era (252 to 66 million years ago) of geologic time saw the Earth's oceans teaming with vast amounts of plant life, or phytoplankton. In the Mesozoic Era's warm and shallow oceans large numbers of dead organic matter would fall to the ocean floor, eventually mix and then be covered by inorganic matter. Over geologic time these immense stores of carbon-12 transformed into pockets of petroleum.

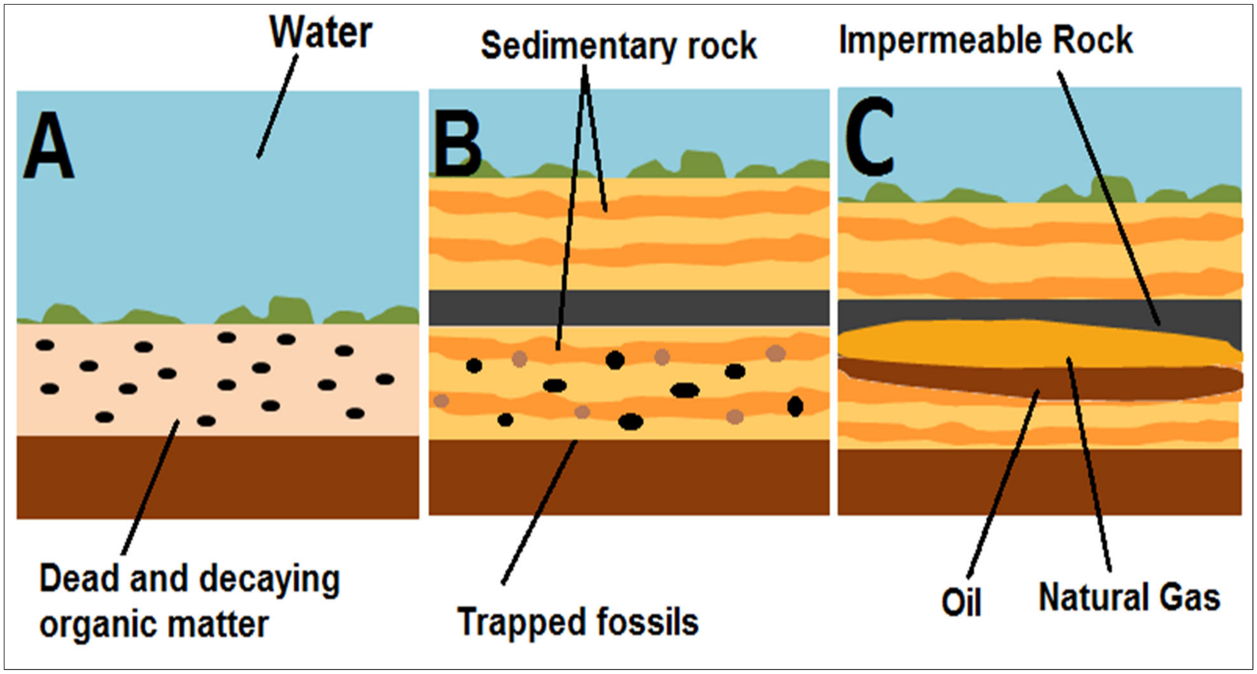

Figure 6: The process of oil and natural gas formation over geologic time. (Source: Energy Education)

The Carboniferous period (358 to 298 million years ago), within the Paleozoic Era, created vast amounts of terrestrial plant life, specifically immense trees. So much of this organic matter was living and dying that not all of the matter could fully decay. Deposited in much the same way as ocean fossil fuels this terrestrial plant matter formed the majority of the Earth's coal-beds; hence the name Carboniferous aka "carbon or coal bearing."

With the Earth's biomass preferring the lighter ^{12}C atom this isotope became the dominate form of carbon trapped in these fossil beds. Pressure, temperature, and geologic time would eventually turn all these Sun energized ^{12}C stores and deposits into the fossil fuels that we use in the modern era.

3. CO_2 and Carbon-12 Increases, the Isotopic Anthropocentric Fingerprint
   - Since the last ice age the ratio of ^{12}C to ^{13}C has remained relatively constant.
   - Since 1850 CO_2 and ^{12}C have increased in the atmosphere and oceans.
   - This increase in ^{12}C is the proof that Climate Change is anthropocentric

Using dendrochronology (tree rings) and ice-core samples researchers have shown that the atmospheric ratio of ^{12}C to ^{13}C has been relatively constant since the last ice-age (11,700 years ago). However, researchers discovered that the ratio of the ^{12}C to ^{13}C isotope in atmospheric CO_2 began changing drastically around 1850. This change coincides with the immense growth in coal consumption and other fossil fuels caused by the Industrial Revolution. [6]

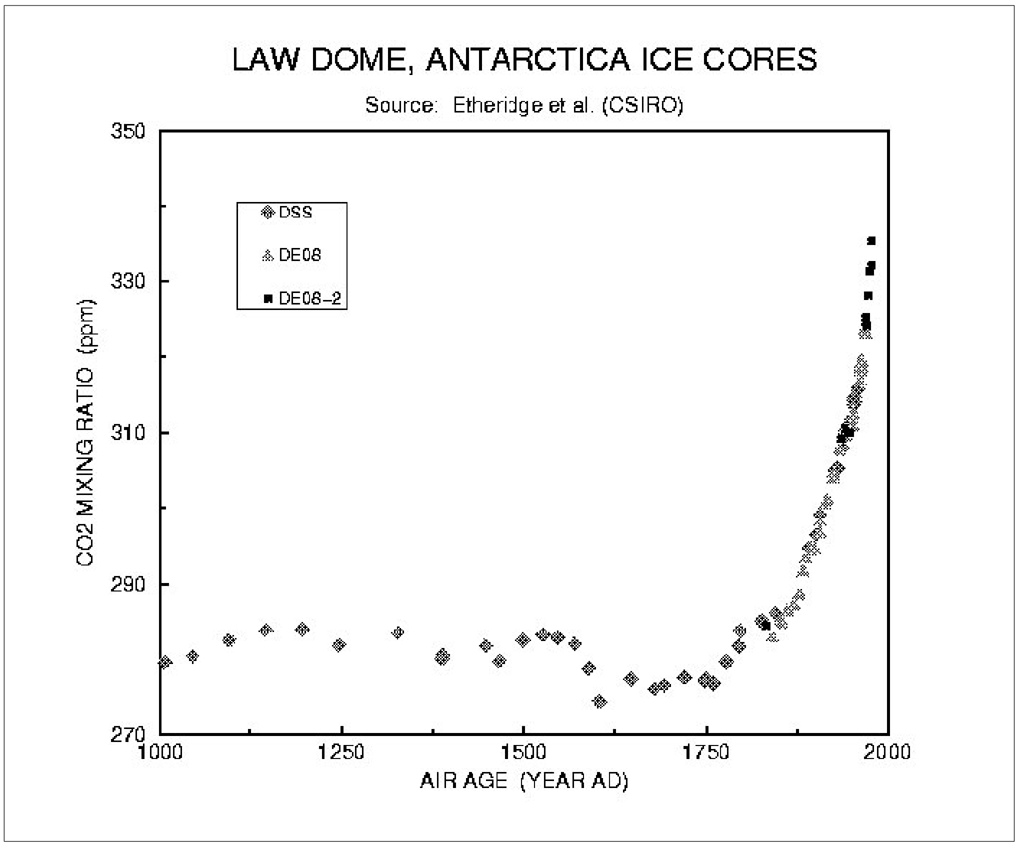

Figure 7: Atmospheric CO_2 Parts per million (ppm) analyzed from Antarctic ice cores. (Source: Etheridge et al. via CDIAC)

Even in the early days of the Industrial Revolution the air pollution caused by so many great industrial factories gave rise to the first large-scale environmental laws; Britain's Alkali Acts in 1863. The change in the ratio of ^{12}C to ^{13}C coincides with the increase of atmospheric CO_2 caused by the increased emissions of CO_2 from the Industrial Revolution. [7] Evidence suggests that the anthropocentric fingerprint of climate change is observed in the increasing ^{12}C isotopes in the atmospheric ratio of CO_2 emissions that have been discovered to have begun with the industrial revolution.

C. Precipitation Pattern Changes

1. Observed Changes – More Rain, Less Snow

Between 1940 and 2005 annual precipitation in Juneau increased by 2.6 inches to over 10 inches. These trends indicate that the Juneau area is shifting toward a warmer and wetter climate regime. In northern Southeast Alaska, mean winter temperature began exceeding 0° C in the mid-1980's resulting in a reduction of total annual snowfall from 109 inches to 93 inches, despite higher total precipitation. [8]

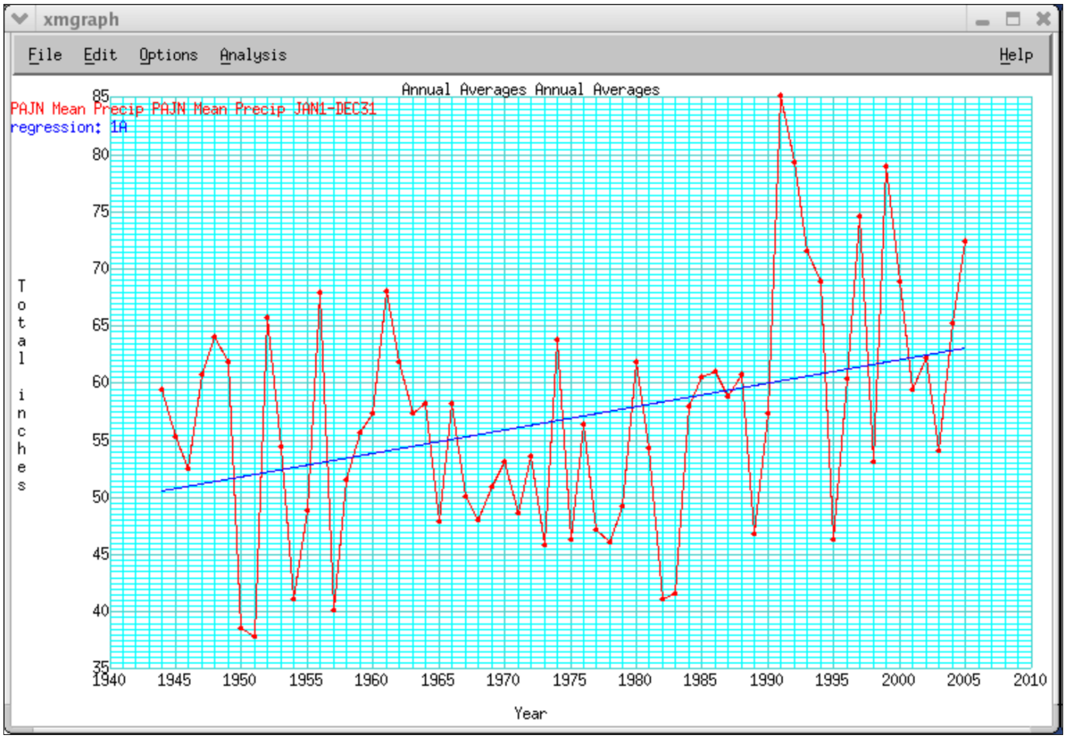

Figure 8. Annual precipitation at Juneau International Airport 1943-2005 (red) and its regression line (blue) showing the best-fit relationship with precipitation over time. The regression line indicates a wetter trend overall. (Source: National Weather Service, Juneau)

Even though our region will have an increase of precipitation, due to rising temperatures, there will be less snow cover. Snow cover is a "blanket" that protects fragile Cedar roots from damaging freezing temperatures, during the spring melt it provides salmon spawning streams with a clean, cool, and abundant water supply. A smaller snow pack equates to a lower spring melt. Paradoxically, however, increased precipitation in the form of extreme rain events is a major factor in river and stream scour. These extreme increased flow events scour river and stream beds potentially causing damage to sensitive salmon spawning grounds.

2. Model Projections of Change and Exposure

Using the A1B projection scenario temperatures and precipitation are expected to increase across Southeast Alaska throughout the next century (See Figure 9). Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat trapping gases emitted globally, and how sensitive the Earth's climate is to those emissions.

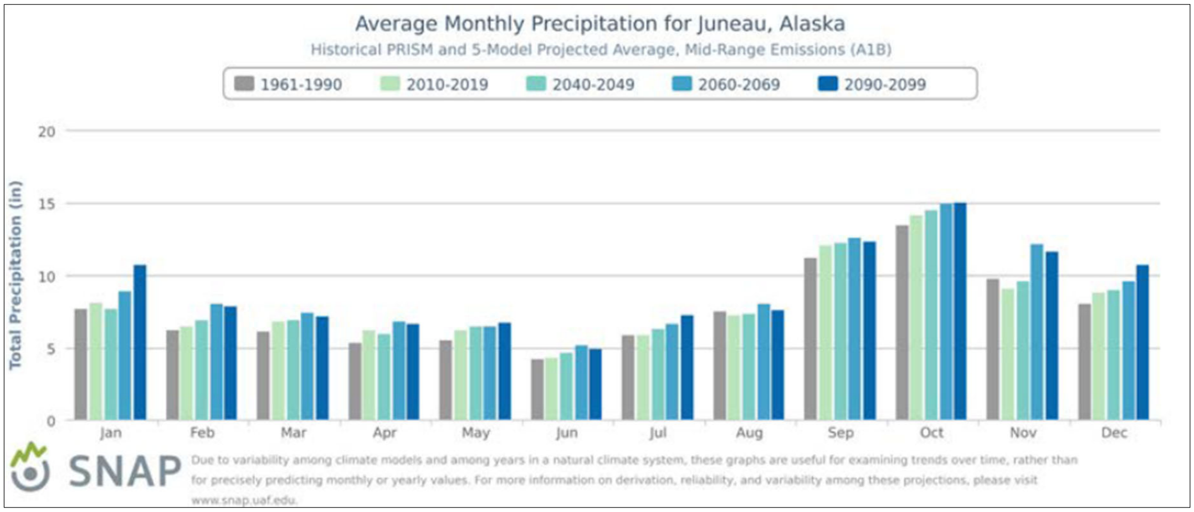

Figure 9: Average Monthly Precipitation for Juneau, Alaska Historical and Projected Average using the Mid-Range Emissions A1B Model. Months and Years, designated by their corresponding color, are shown on the horizontal axis (x-axis) from 1961 to 2099. Temperature (°F) is shown on the left vertical axis (y-axis) represented by the bars with the corresponding color representing the time period. (Source: University of AK, Fairbanks)

Take away: The Southeast Alaska climate will continue to shift from an abundant snowpack environment to a less snowpack and more rainfall scenario. This shift in climate will have serious negative consequences for salmon spawning ecosystems.

D. Post-Glacial Isostatic Adjustment and Shore Zone Changes

1. Observed Changes and Projections

Ice fields and glaciers in the coastal mountains of Southeast Alaska have undergone rapid thinning over the last 100–200 years. The increase in temperature has had a dramatic effect on Southeast Alaska's glaciers and the land masses that surround these areas (See Figure 10). A rapid retreat of glaciers and ever increasing ice thinning rates have a significant effect on the Southeast Alaskan region regarding Climate Change; the land masses are rising.

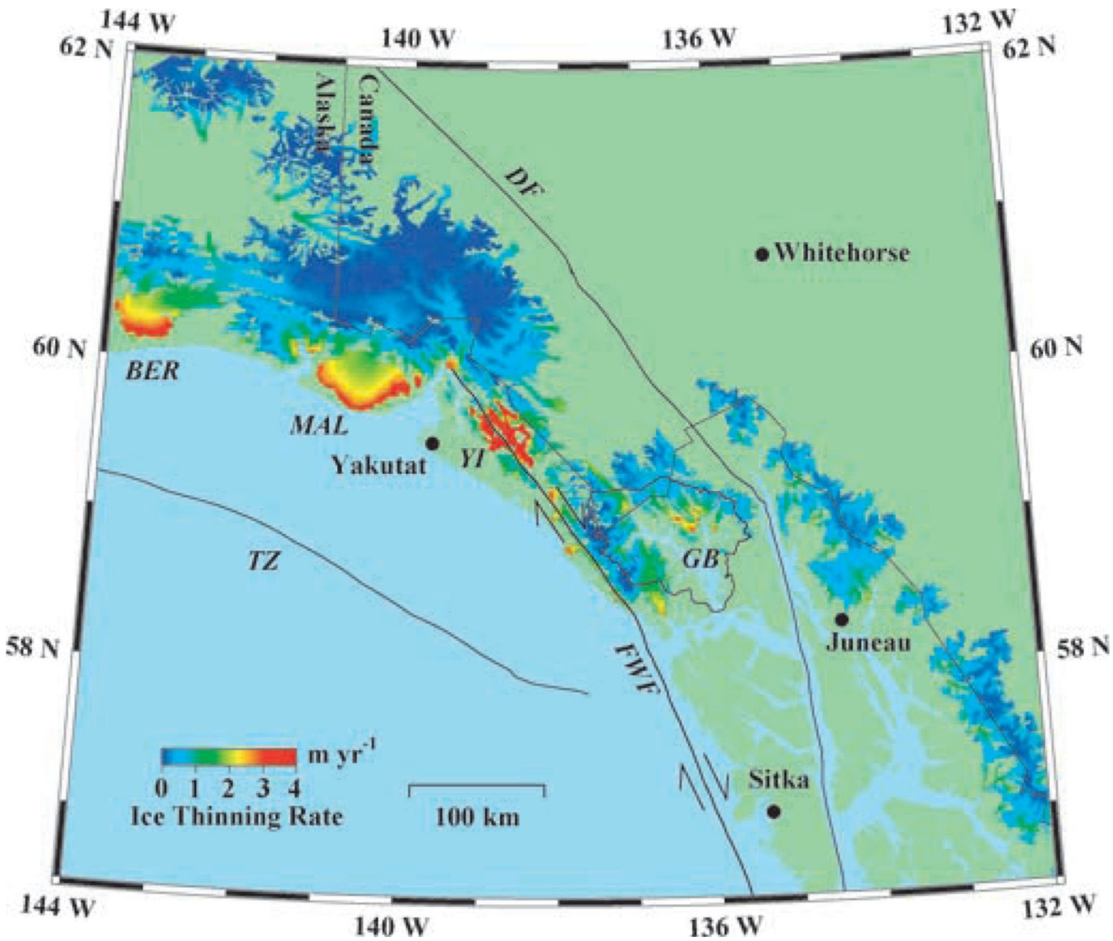

Figure 10: Location map, showing cities, faults (FWF, Fairweather Fault; DF, Denali Fault; TZ, Transition Zone Fault), Alaska Canadian border, and present-day ice thinning rates from Arendt et al. (2002). The black outline surrounding Glacier Bay (GB) outlines the extent of the icefield that filled Glacier Bay 250 years ago. (Source: Oxford Academic Journals)

Isostatic Adjustment, sometimes referred as Post-Glacial Rebound, caused by rapidly retreating glaciers has caused landmass and shoreline uplift that, in some areas, is out pacing sea-level increases. Researches have documented these Isostatic Adjustments using Global Positioning System (GPS) surveys, Tide gauge measurements, and raised shoreline studies (See Figure 11).

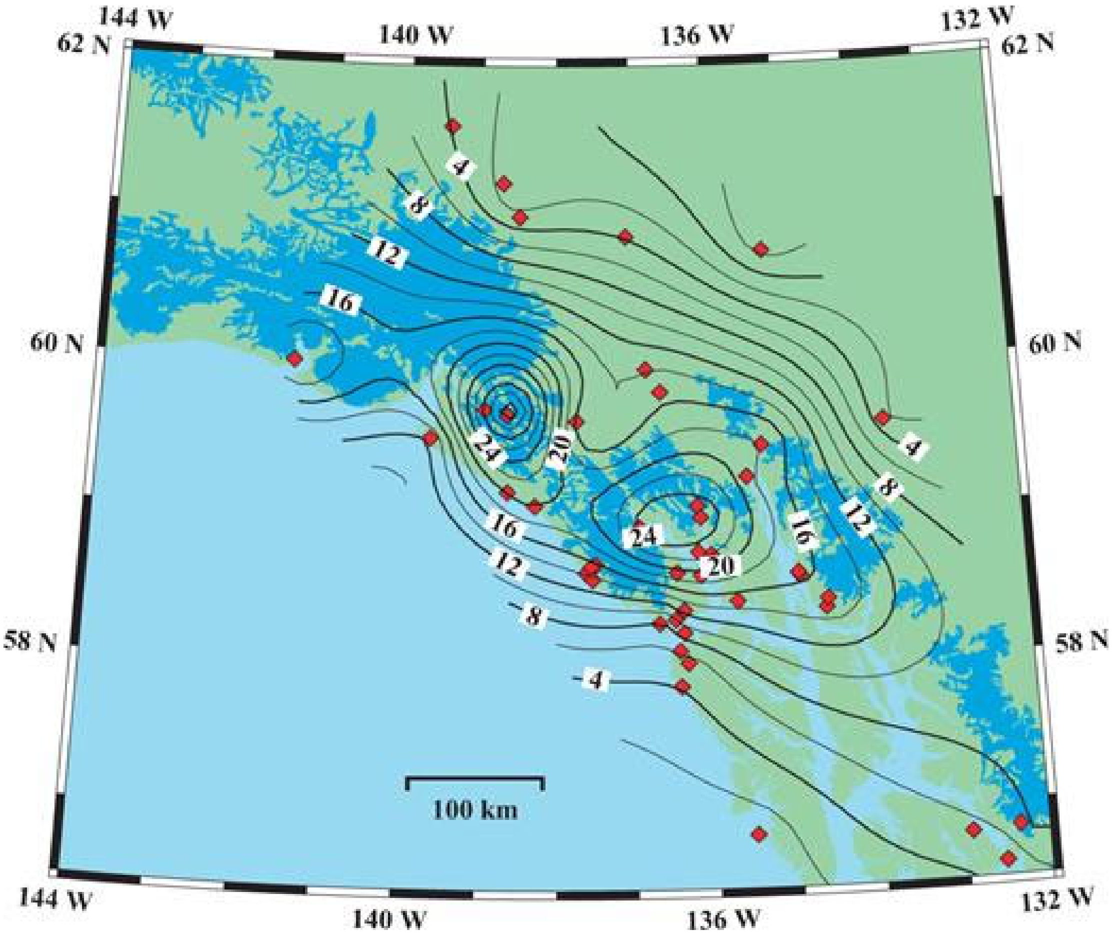

Figure 11. GPS uplift rates. Contour interval is 2 mm yr−1. Red diamonds indicate GPS sites. Glaciers and ice fields are shown in light blue. (Source: Oxford Academic Journals)

Accreted (rising) lands have been a significant concern for the Mendenhall Refuge located in Juneau, Alaska. [9] Rising land masses will have negative consequences on traditional lands including shellfish and Ell grass beds and salmon spawning streams. The data suggests that this Isostatic adjustment will continue for 700 to 800 years as a result of ice already lost. Researches are beginning to discover that additional tidewater glacial melt is also contributing to ocean acidification. [10]

Take away: Decreasing ice mass in Southeast Alaska will increase the isostatic adjustment (post glacier rebound) of Southeast Alaska effecting salmon and shellfish ecosystems.

E. Ocean Acidification and Temperature Increase

1. Observed Changes

Ocean Acidification (OA) is affecting the oceans globally, including coastal estuaries and waterways. About 1/3rd of anthropocentric generated CO_2 is absorbed by the ocean. This increase of CO_2 in the oceans has lowered the pH and created a more acidic seawater. It has been estimated that the ocean is 30% more acidic today that it was 300 years ago.[11] These rising CO_2 levels of the world's oceans have been correlated with rising CO_2 levels in the atmosphere (See Figure 12).

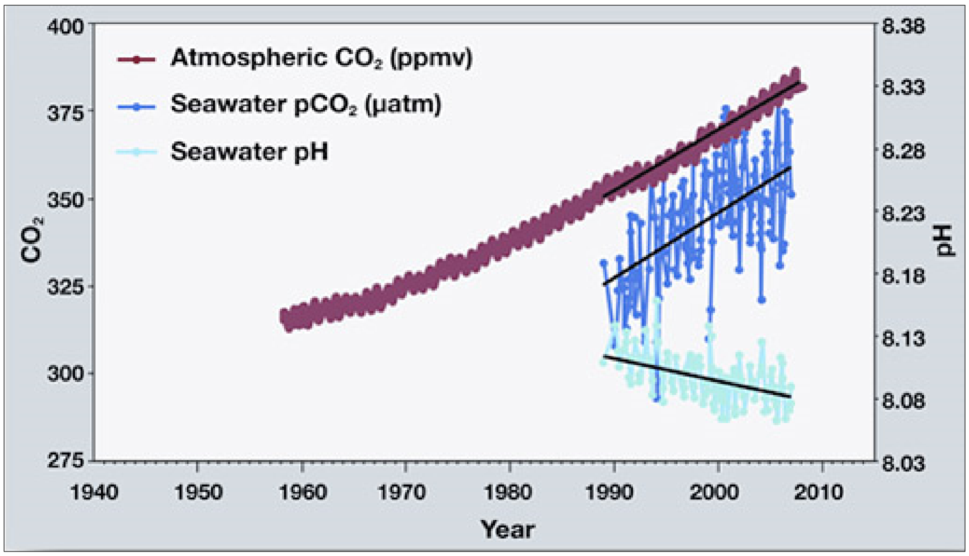

Figure 12: This graph illustrates the correlation between rising levels of CO_2 in the atmosphere at the Mauna Loa observatory off Hawaii with rising CO_2 levels in the ocean. As more CO_2 accumulates in the ocean, the pH of the ocean decreases. (Source: Alaska Ocean Observing System)

While much is unknown about the biological effects of OA, it is critical for Alaskans, who are so dependent on the ocean, to better comprehend these changes. Alaskans need to understand how ocean acidification impacts the ocean food web, the fish and fishery responses to OA, and, for fishery policy makers, how to add OA as a subset to management scenarios and decisions. Alaska is expected to experience the effects of ocean acidification faster and more seriously than lower latitudes, waters in Alaska are both 'cold and old': cooler water temperatures and global circulation patterns mean that Alaska waters naturally hold more CO_2 year round. Ocean acidification causes an increase in hydrogen ions, which in turn decreases the abundance of carbonate ions. Carbonate ions are an integral part of calcifying or shell making for organisms such as crab, oysters, clams, cockles, and certain kinds of plankton. The current rate of OA is faster than any time on record; 10 times faster than the last major acidification event 55 million years ago. [12]

2. Model Projections

Researchers at the Intergovernmental Panel on Climate Change (IPCC) have created another projection model called the Representative Concentration Pathway (RCP). Low emission projections are the RCP 2.6, with the current unchanged high CO_2 emissions labeled RCP 8.5. In the graph below (See Figure 13) it shows historical change from the 1850's up to current times. Projections into the future are the blue line using the low emissions RCP 2.6 model, and the current emissions model RCP 8.5 in red. Future projections of ocean acidification and the lowering of pH chemistry show, even with low CO_2 emissions, lower pH levels and a greater acidification of the world's oceans. [13]

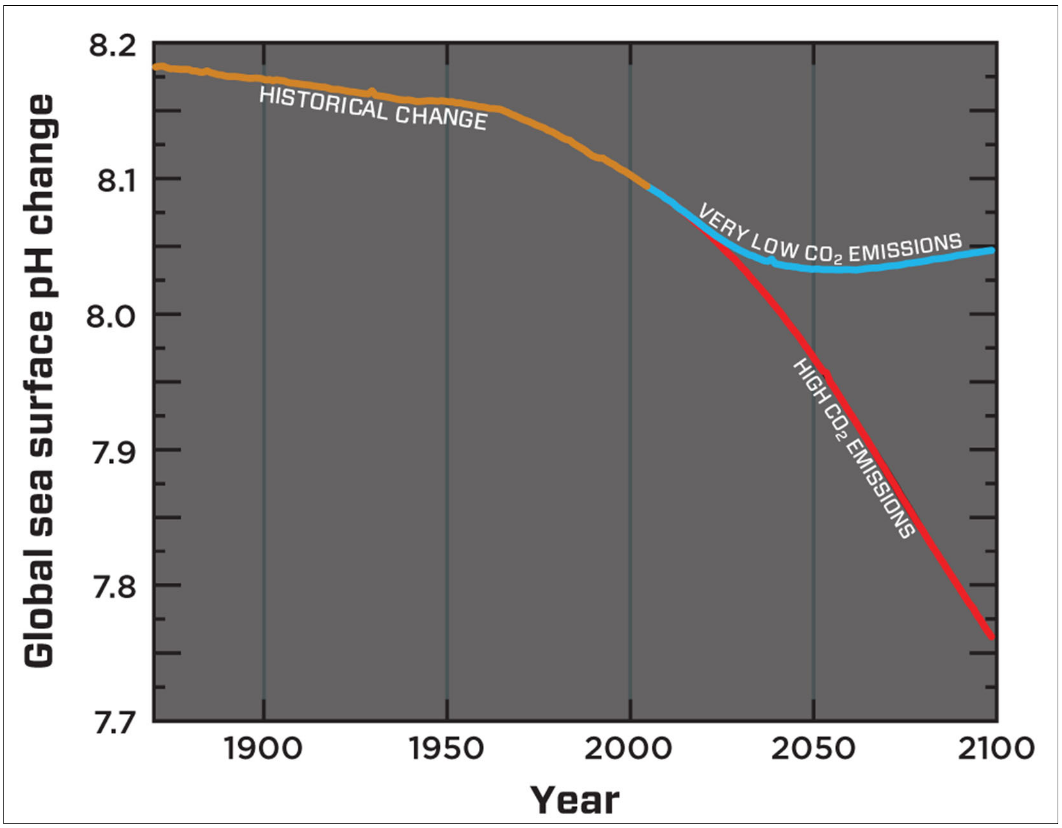

Figure 13: Modelled global sea-surface pH from 1870 to 2100. The blue line reflects estimated pH change resulting from very low CO_2 emissions to the atmosphere (IPCC Representative Concentration Pathway, RCP* 2.6). The red line reflects pH from high CO_2 emissions (the current emissions trajectory, RCP* 8.5).

Take away: As ocean temperatures and ocean acidification increase marine resources will continue to decline.

F. Forest Habitat Changes

1. Observed Changes

Yellow-cedar decline is a leading example of climate change on a forest tree species. Fine-root freezing, a major factor in cedar mortality, is understood to be caused by two factors: less snow cover and more precipitation. Snow cover acts as a blanket protecting to the cedar root systems by preventing frost damage, and more precipitation creates a wet-soil condition that limits nutrient cycling and root depth. In turn these condition affect canopy cover and standing biomass which negatively impact soil temperatures. [14] Canopy cover protects cedar by creating cooler shady areas on warmer days, and by trapping naturally earth radiating heat on cooler days. Cedar's optimum soil (or edaphic) niche is a narrow window easily influenced by temperature, drainage, and competing tree species (See Figure 14).

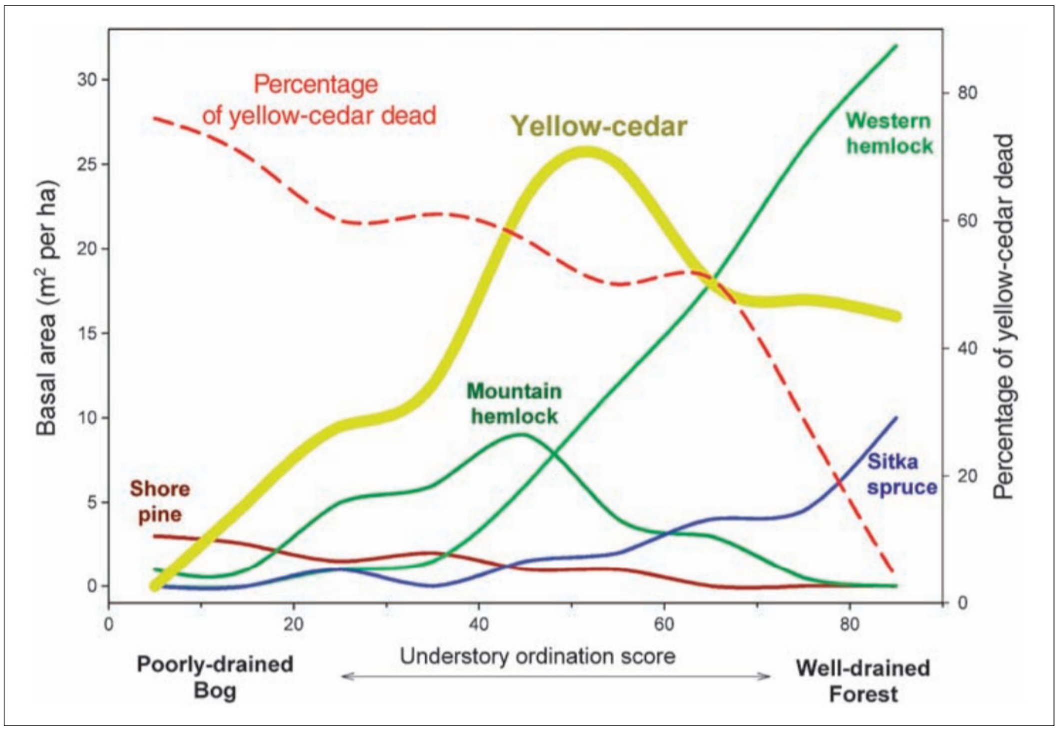

Figure 14. Yellow-cedar's optimum edaphic niche and the occurrence of yellow-cedar mortality along the soil-drainage gradient. The abundance (live basal area) of yellow-cedar and competing tree species was determined by splining the midpoint values from nine intervals along a range of soil-drainage levels indicated by understory plant composition expressed with ordination scores. (Source: BioScience)

Take away: Cedar conservation and restoration strategies must acknowledge the dynamic nature of our climate, active forest-management, and favoring conditions for niche expansion. The lessons learned from the initial work on high-value species, like Yellow-cedar, may inform future efforts on a wider variety of other forest species.

G. Invasive and Recolonizing Species

1. Invasive Aquatic Species

Nonnative or recolonizing species become invasive in an environment when the natural predators, diseases, or other biological or ecological mechanisms that kept the species in check within its former habitat are missing in this new environment. Lacking this eco-biological balance, the invading species effectively changes the biodiversity and possibly the ecology of a locale. This can often cause millions of dollars in damage to local economies. Approximately 50,000 nonnative species have been introduced to the United States as a result of human movements, commerce, and trade.

Invasive species can change ecosystems by altering habitat composition, increasing wildfire risk, competing with native species for food and territory, changing existing predator/prey relationships, reducing productivity, or otherwise disrupting natural habitat functions. In doing so, invasive species pose one of the greatest threats to biological diversity. [15] Many scientists agree that climate change will alter destination habitat and increase vulnerability to invasion because of resource scarcity and increased competition among native fauna and flora. [16]

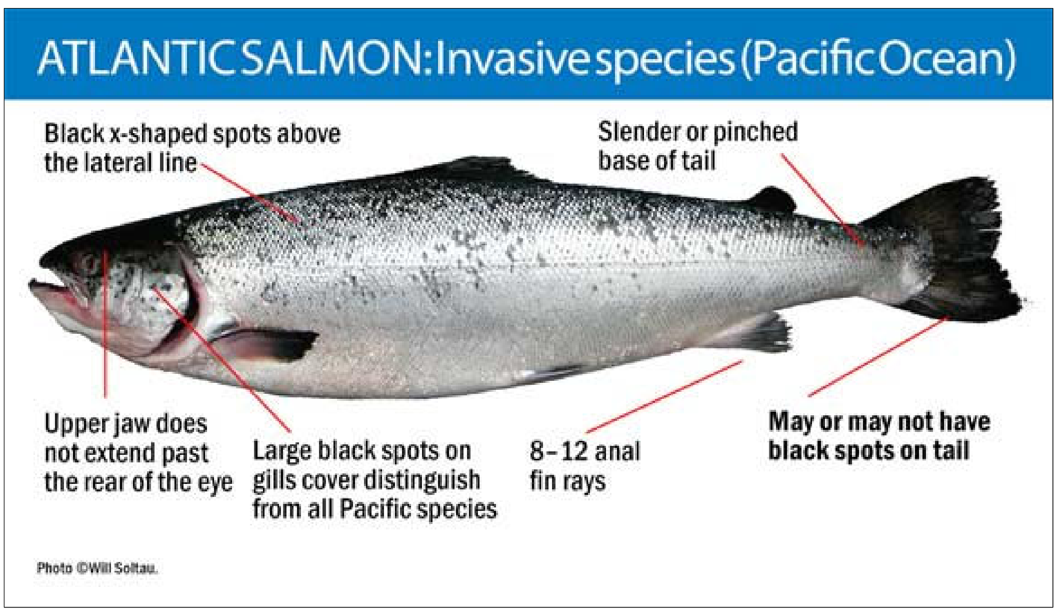

Figure 15: Alaska Department of Fish and Game, Invasive Species – Atlantic salmon

Atlantic salmon often escape fish-farming net pens off the coasts of British Columbia and Washington State. These large and overpopulated net pens are treated for disease and parasites; therefore, treated fish may not show signs of pathogens but could be carriers. Atlantic salmon have been documented spawning in streams in British Columbia. [17] Researchers have observed that juvenile Atlantic salmon are more aggressive than their Pacific counterparts and that this characteristic could enable them to outcompete Pacific salmon for food, spawning habitat, and other resources.

2. Recolonizing Aquatic Species

Alaska Sea Grant conducted research called "The Southern Southeast Alaska Sea Otter Project," which investigated the impacts of sea otter recolonization on four commercially important species and their associated fisheries (Dungeness crab, geoduck clams, sea cucumbers and red sea urchins). Sea otter population growth, and predation on commercially important shellfish species, are of increasing concern to commercial fishermen in southeast Alaska. At a recent Alaska Board of Fisheries meeting, seven of sixteen Dungeness crab proposals represented attempts to close specific areas to commercial or sport fishing for shellfish species, as a response to predation by sea otters. [18]

Figure 16: Sea Otter Eating Crab. Photo Credit: Jacqueline Deely

3. Invasive Plant Species

Non-native invasive plants displace native vegetation, degrade wildlife habitat, and negatively affect human health, the economy, and the environment. Factors such as geographic isolation and harsh winters have protected Alaska from large-scale invasive plant infestations in the past. Recently, however, some of the most harmful noxious weeds of the lower 48 states have begun to grow and spread in Alaska. [19]

Figure 17: Foliage of Japanese Knotweed *Fallopia japonica.*

One of the more natural resource damaging invasive species is Japanese knotweed. *Fallopia japonica* forms monocultures that reduce plant species diversity by shading native vegetation. It clogs waterways and lowers the quality of habitat for wildlife and fish. It reduces the food supply for juvenile salmon in the spring. Japanese knotweed hybridizes with giant knotweed. [20]

For invasive species already living in Southeast Alaska, there are many factors that could cause a dramatic spike in their proliferation. “They seem to go through a phase where they remain in a low concentration, kind of dormant, and then all of a sudden something happens, whether it be warming of the ocean, or whatever it happens to be. And then they all of a sudden they explode everywhere.” [21]

Take away: Meaningful mitigation and adaptation strategies need to be created to address the problem that invasive species present to traditional subsistence users in Southeast Alaska.

H. Human Health

1. Indigenous People – The Hardest Hit by Climate Change

Climate change impacts to human health stem from a wide range of sources (e.g., heat waves, flooding, wildfire, infectious disease) that affect the social and environmental determinants of health common to all humans, including clean air, safe drinking water, sufficient food, and secure shelter (WHO 2014). [22]

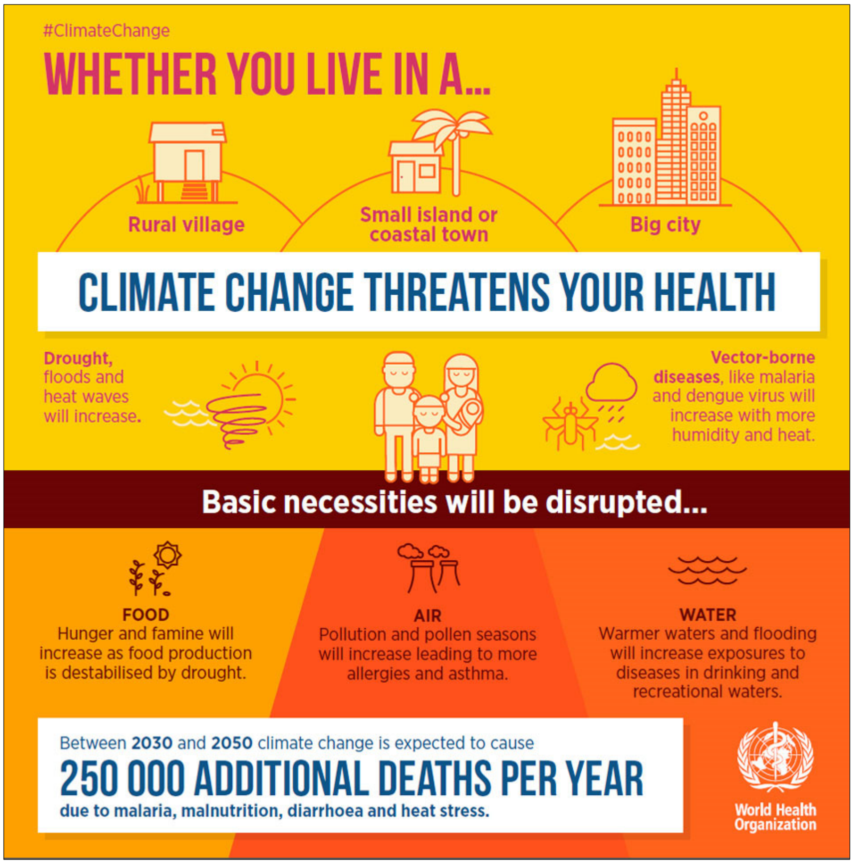

Figure 18: World Health Organization (WHO). 2014. Health Topics: Climate Change.

"Indigenous peoples have contributed the least to world greenhouse gas emissions and have the smallest ecological footprints on Earth. Yet they suffer the worst impacts not only of climate change, but also from some of the international mitigation measures being taken," according to organizers of a United Nations University co-hosted meeting April 3 in Darwin, Australia. [23]

The "FAO (Food and Agriculture Organization of the United Nations) is well aware that indigenous peoples are among the hardest hit by climate change because of the impact climatic variability has in their livelihoods and food security," -Mr. Yon Fernandez de Larrinoa, FAO Indigenous Peoples' Focal Point during the 15th Session of the Permanent Forum on Indigenous Issues (UNPFII) at the UN Headquarters on May 11, 2016. [24]

Climate change has impacted human health directly (e.g. extreme weather) and indirectly through intermediate environmental factors (e.g. air quality, and subsistence harvest timing fluctuations). "Alaska tribes are particularly impacted by climate change because of their location in a biozone that is extremely sensitive to warming and because the current legal system deprives them of direct control over their land and natural resources. While Alaska tribes have benefitted from the assistance of government entities, environmental groups, and Native Corporations, none of these completely shares the tribes' interest in subsistence protection or faces the same kind of threat to its well-being from climate change." [25]

Areas impacted by Climate Change and Human Health possible outcomes:

- Environment: Lowered indoor air quality from increased Black Mold contributed by more precipitation, higher temperatures, expansion of invasive species
- Subsistence: Less Salmon, Hooligan, Herring, Shellfish, and berry harvests
- Cultural: Loss of livelihood, increased Yellow Cedar Mortality, fluctuating seasonal patterns

Figure 19: Our People today and tomorrow

Take away: Indigenous and rural populations are harder impacted by the effects of Climate Change.

A. Climate Change Conferences and Workshops

Attended:
Tulalip Tribes and Swinomish Indian Tribal Community – *Climate Change Adaptation Planning*, Affiliated tribes of Northwest Indians – *Tribes & Frist Nations Climate Summit*, Department of the Interior - Bureau of Indian Affairs - *Providers Conference*, Central Council Tlingit & Haida Indian Tribes of Alaska – *Southeast Environmental Conference*, Institute for Tribal Environmental Professionals (ITEP) Northern Arizona University – *Introduction to Climate Change Adaptation Planning*, U.S. Forest Service - *Developing Adaption Actions for Aquatic Resources of the Tongass National Forest*, Sitka Tribe of Alaska Environmental Research Lab - Southeast Alaska Tribal Ocean Research (SEATOR) – *Southeast Alaska Tribal Toxins (SEATT) Workshop.*

B. Research, Outreach, & Data Organizations

USDA-USFS Pacific Northwest (PNW) Research Station, USGS Alaska Climate Science Center, North Pacific Landscape Conservation Cooperative, National Climate Assessment 2014, Alaska Center for Climate Assessment and Policy, International Arctic Research Center UAF, Scenarios Network for Alaska + Arctic Planning (SNAP), Sustainable Southeast Partnership, Tribal Climate Change Project University of Oregon, U.S. Climate Resilience Toolkit NOAA, GEOS Institute, Alaska Sea Grant, Adapt Alaska, Alaska Climate Adaptation Science Center

C. Vulnerability Rankings

Climate vulnerability depends on exposure, sensitivity, and adaptive capacity (as shown in Figure 20). **Climate exposure** is the extent and magnitude of a climate or weather event. **Sensitivity** is the degree to which that area of concern is susceptible to a climate impact. **Adaptive capacity** is the ability of the area of concern to adjust to or respond to the changing conditions. Thus, it is critical not only to consider climate impacts themselves, but also how the areas of concern are likely to respond to those impacts. Through the consideration of both climate impact variables and related environmental stressors, sensitivity and adaptive capacity of each of the key areas of concern have been identified.

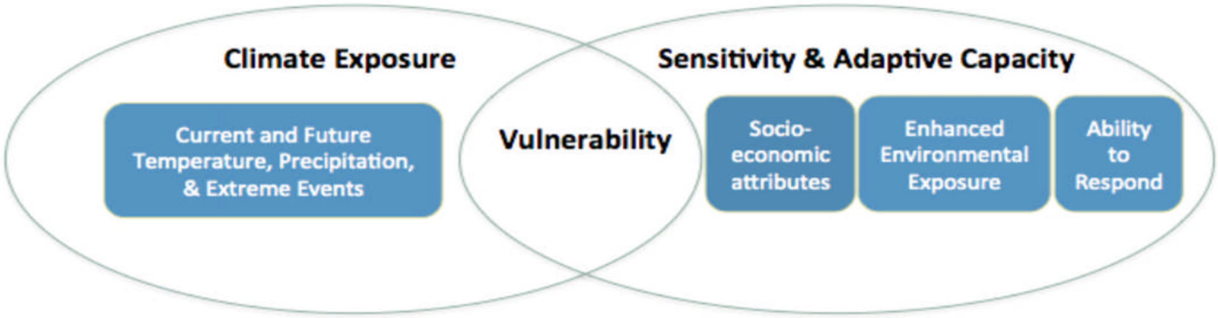

Figure 20: Climate Vulnerability depends on climate exposure, sensitivity, and adaptive capacity.

Each key area of concern has been assigned a sensitivity ranking and an adaptive capacity ranking (Table 1). The **sensitivity rankings** range from **S0-** *System will not be affected by the climate impact* to **S4-** *System will be greatly affected by the climate impact*. The **adaptive capacity** rankings range from **AC0-** *System is not able to accommodate or adjust to the climate impact* to **AC4**- *System is able to accommodate or adjust to the climate impact in a beneficial way*.

Table 1: Sensitivity and adaptive capacity levels and descriptions.

Sensitivity Levels	
S0	System will not be affected by the climate impact
S1	System will be minimally affected by the climate impact
S2	System will be somewhat affected by the climate impact
S3	System will be largely affected by the climate impact
S4	System will be greatly affected by the climate impact

Adaptive Capacity Levels	
AC0	System is not able to accommodate or adjust to the impact
AC1	System is minimally able to accommodate or adjust to the impact
AC2	System is somewhat able to accommodate or adjust to the impact
AC3	System is mostly able to accommodate or adjust to impact
AC4	System is able to accommodate or adjust to impact in beneficial way

The key areas of concern were then placed in a vulnerability matrix to determine the relative vulnerability rankings between areas of concern. Those that are the most vulnerable have the highest sensitivity and the lowest adaptive capacity. Those that were the least vulnerable have lower sensitivity and higher adaptive capacity. All key areas of concern are shown in Figure 21.

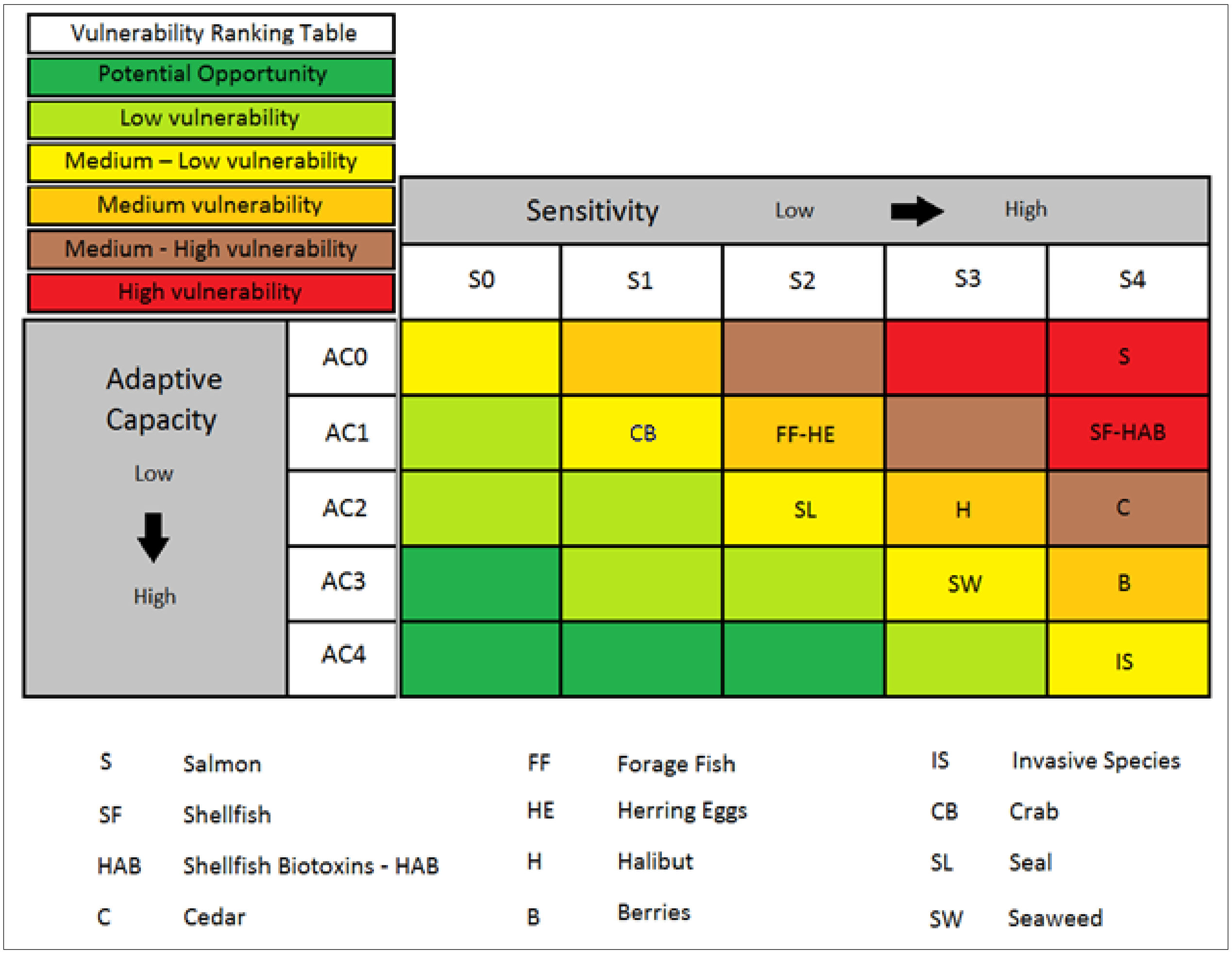

Figure 21: Climate Vulnerability Rankings for Key Areas of Concern. Rankings are based on sensitivity and adaptive capacity.

D. Prioritizing Key Ares of Concern

Benefiting from the similarities of landscapes and ecosystems, and from the exceptional research and energy invested in the creation of the document, the Jamestown S'Klallam (JSK) Tribe's *Climate Vulnerability Assessment and Adaptation Plan* was used as a template for the creation of *Tlingit & Haida's Climate Change Adaptation Plan and Template*. Below are some of the criteria, used in both the JSK and Tlingit & Haida (T&H) adaptation plans, for prioritization of key areas of concern.

Magnitude of Impacts: Reflection of the scale and intensity of a climate impact
Timing of Impacts: Reflection of when the climate impact is likely to occur
Persistence and Reversibility: How persistence or irreversible the impacts are
Likelihood of Impacts: How likely it is for the impact to occur
Distributional Nature of Impacts: Indication of how widely the community may be impacted
Importance of System at Risk: Measure of the cultural, economic, social value of the system
Potential for Adaptation: Availability of actions to prepare for or respond to the impacts.

The following prioritization of key areas of concern represents at the time the best data available, therefore because this is considered a living document, these key concerns areas are adjustable. These grouped areas of prioritization have emerged as the most important measure for tribal planning:

Very High Priority Areas of Concern

- Salmon
- Shellfish
- Shellfish Biotoxins - HAB
- Cedar

High Priority Areas of Concern

- Forage Fish
- Herring Eggs
- Halibut
- Berries

Medium Priority Areas of Concern

- Invasive Species
- Crab
- Seal
- Seaweed

Very High Priority Areas of Concern are those areas sharing high community value, with a large magnitude of expected impacts, persistence, hazardous timing, and limited potential for adaptation. Most of these areas of concern rank particular high in cultural importance. Salmon, shellfish, and cedar lead this category due to their cultural, social, and economic value and the limited tribal control over their adaptive capacity.

High Priority Areas of Concern include important cultural, economic, and subsistence resources. However, the timing of severe climate impacts to these areas of concern is likely many years in the future, so the need for immediate preparation is limited.

Medium Priority Areas of Concern include invasive plants and animals that are encroaching on our ecosystem, and important cultural and economic resources with a generally high potential for adaptation.

A. Group One: Extremely High Priority Areas of Concern

1. Salmon [High Vulnerability – Very High Priority]

a. Why Salmon are Important

Salmon is an iconic cultural resource for the Tlingit & Haida tribes. Traditionally, salmon provided the foundation for almost all aspects of cultural life for the Tlingit & Haida people and was an important trade good with the more interior Athabascan tribes. Salmon continues to represent an important tribal cultural connection to the waters of the Tlingit & Haida ancestral homeland and also provide a valuable economic and nutritional resource for our people.

Traditional foods, such as Salmon, provide a nutrient-rich and culturally important component of the modern diet, along with their harvesting and processing activities being associated with a more active lifestyle. [26] Such diets and lifestyles provide food packed with essential fatty acids, antioxidants, and protein and are associated with prevention and mitigation of chronic diseases such as diabetes, heart disease, and cancer. [27] Local fishing is a top contributor to physical activities among our tribal citizens.

Tribal Citizens' commercial and subsistence harvest varies depending on year, salmon-type, and fisheries management. For example, in 2018 fishing for King salmon was restricted by the Alaska Department of Fish and Game (AKDFG). In the Juneau area restrictions were activated on the Taku River. Below is an excerpt from the March 2018 Alaska Department of Fish and Game Emergency Order:

"Taku River king salmon production is low at this time. The 2018 preseason forecast for Taku River king salmon is 4,700. This forecast indicates the escapement goal range (19,000-36,000) will not be met. In addition, forecasts for other Southeast Alaska wild king salmon stocks are also below goal as the majority of the Southeast Alaska wild king salmon stocks continue to experience poor productivity. At the Alaska Board of Fisheries January 2018 meeting in Sitka, the board adopted the *Chilkat River and King Salmon River King Salmon Stock Status and Action Plan* which specifies how the department will manage fisheries to reduce harvest of these two wild king salmon stocks. These actions are being taken as part of a region wide effort to reduce harvest of these two wild king salmon and increase spawning escapement for future productions. Management actions are being taken across all Southeast Alaska fisheries, including sport, commercial, personal use, and subsistence, to reduce harvest of wild king salmon." [28]

These AKDFG Emergency Order restrictions were also activated in the Haines/Skagway, Petersburg/Wrangell, and Ketchikan areas in 2018.

b. Potential Impacts of Climate Change

Especially when focusing on salmonid species, it can be difficult to unravel the multiple stressors affecting riverine, coastal, and ocean survival rates and ultimately harvest. Some environmental conditions are due to changing climate conditions while others are due to increases in populations, land use changes, pollutions, and other stressors. There are, however, some key climate related concerns.

Important stream systems in Southeast and throughout Alaska are trending towards more transient (mixed rain/snow) and less winter snowpack dominated watersheds. Increased winter rain and smaller snowpack lead to more intense winter flooding events and streambed scouring, along with altered timing of river flow, all are salmon-sensitive aspects of the hydrological cycle.

Increasing stream temperatures are having significant effects on salmon in Alaska. Salmon are particularly vulnerable to temperature while in freshwater. They may suffer reduced survival of eggs and fry, reduced growth rates due to increased respiration and metabolism, premature smolting causing decreased ocean survival due to small size or lack of synchronicity with plankton blooms, greater vulnerability to pollution, and great risk to predation and disease. [29]

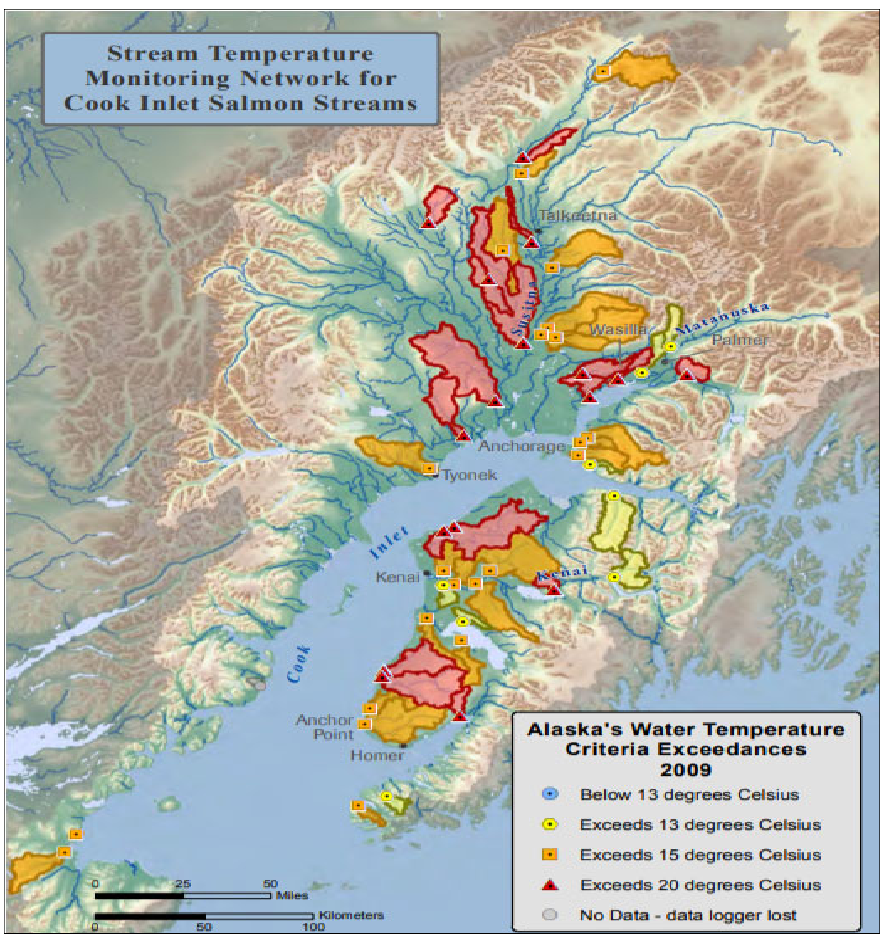

Figure 22: Stream temperatures monitored in the Cook Inlet basin, Alaska. Nearly all exceeded maximum tolerance levels for salmon at least part of the summer. Source: Sea Grant Alaska 2016

c. Actions to Increase Resilience

The environmental changes described above do not happen in isolation. As summer flows decrease, there will be less water, warmer temperatures, and increased evapotranspiration. Lower flow rates will mean that the water stays in the streams and rivers longer and has higher water temperatures that will add stress to salmon returning to these rivers and streams. To address these threats, The Central Council of the Tlingit & Haida Indian Tribes of Alaska should pursue, to the extent appropriate, the following:

Table 2: Resilience Strategies for Salmon. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Salmon	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Reduce other stressor to salmon habitats, including: development, sedimentation and pollution of streams, changes in streamside vegetation, erosion due to land-use practices such as road building and clear cutting.	Medium	Moderate	Low	Immediate -to-Medium Term	Yes (surrounding communities, Federal, State, private land owners)
Replace or remove barriers to fish passage.	High	Low	Medium	Immediate -to-Medium Term	Yes on State and Federal Land.
Restore stream and streamside habitats (including planting native trees and removing invasive vegetation) and enhance instream survivability, likely in partnership.	High	Hard due to non-tribal land	Medium	Medium to Long Term	Yes (Forest Service, National Park Service, Private land owners.
Ensure sustainable harvesting of salmon. This includes ensuring that a diversity of species are caught via monitoring programs (to the extent possible given curent population levels) as opposed to unevenly catching one species.	Low	Moderate	Medium	Immediate	Yes (surrounding communities, Federal, State, private industry)
Managing hatchery programs to minimize harm done to wild stocks.	Low	Easy	High	Immediate	Yes

While the Tribe undertakes many natural resource programs that strive to protect salmon, it is highly likely that climate change will make existing management practices less effective. To address the new and enhanced stressors salmon are likely to face due to climate change, it is recommended that the Tribe continue to work in collaboration with the diverse group of stakeholders relevant to salmon habitat to continue to reduce as many of the existing stressors to salmon (i.e., habitat fragmentation, changes in streamside vegetation, sedimentation and pollution of streams), to best enhance their capacity to adapt to climate impacts. This includes working to restore stream habitats, ensure sustainable harvesting of existing stocks, and enhancing the ability of the salmon to reach their spawning grounds. Should it become necessary to reduce the salmon harvest due to threatened salmon populations, the Tribe may wish to convene a working group to investigate the potential risk to community health and wellness from this diminished cultural, dietary, and economic resource.

2. Shellfish [High Vulnerability – Very High Priority]

a. Why Shellfish are Important

Old proverb; "*when the tide goes out, the table is set*."

Shellfish have been in integral part of tribal life for the Tlingit & Haida people throughout their history. Tribal Citizens continue to participate in the subsistence harvest of Pacific Littleneck Clams (*Protothaca staminea*), Butter Clam (*Saxidomus gigantean*), Pacific razor clam (*Siliqua patula*), Cockle (*Clinocardium nuttalli*), Blue Mussel (*Mytilus edulis*), Geoduck (*Panopea abrupta*) and many more. These provide high quality sources of protein and nutrients, are readily available, and intimately connect Tribal Citizens to their cultural heritage. Additionally, local clam-digging is considered a top contributor to physical activity among Tribal Citizens. There are few financial barriers to personal harvest of shellfish, making them the most easily accessed and well-distributed subsistence resource among Tribal Citizens.

There are shellfish harvest beaches throughout Southeast Alaska, although some beaches see more consistent use for subsistence harvest. Traditional foods, such as shellfish, provide a nutrient-rich and culturally important component of the modern diet, along with their harvesting and processing activities being associated with a less sedentary lifestyle. Such diets and lifestyles provide food packed with essential fatty acids, antioxidants, and protein and are associated with prevention and mitigation of chronic diseases such as diabetes, heart disease, and cancer. [30]

b. Potential Impacts of Climate Change

Shellfish in Southeast Alaska face serious threats from changing climate conditions. The concerns come primarily from changing habitat conditions due to warming water temperatures, increasing ocean acidity, and isostatic adjustment. Rising temperatures will favor more heat tolerant shellfish species, increase overall suffering from thermal stress, and decreased burrowing activity. [31] As studied under laboratory conditions, shellfish generally exhibit negative response to conditions of elevated CO_2 and reduced pH, in effect being forced to exert more energy to build their shells and prosper. [32, 33] Higher air temperatures during low-tide events have the potential to add additional stress to these species.

Alaska's coastal waters are especially susceptible to ocean acidification compared to lower latitude oceans. First, cold water can absorb more CO_2 than warm water, so our cold northern waters tend to be naturally high in CO_2. This means that Alaska and other high latitude areas will likely see the effects of ocean acidification sooner than areas farther south. Additionally, natural factors such as high productivity, glacial melt, and upwelling increase the potential for regions around Alaska to be vulnerable to ocean acidification. [34]

c. Actions to Increase Resilience

Efforts to assist shellfish in becoming more resilient to climate change primarily focus on continued sampling of shellfish, with testing conducted at the Southeast Alaska Tribal Ocean Research (SEATOR) Sitka Tribe of Alaska Environmental Research Lab (STAERL), and the monitoring of Harmful Algal Blooms reducing or eliminating existing stressors, thereby increasing overall adaptive capacity and reliance. To help achieve this goal, Tlingit & Haida should, to the extent appropriate, undertake the following:

Table 3: Resilience Strategies for Shellfish. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Shellfish	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Continue to sample and monitor shellfish biotoxins to increase public health, and improve local shellfish knowledge and data.	Medium	Moderate	High	Immediate -to- Long Term	Yes (surrounding communities and Tribes, SEATOR)
Ensure sustainable havesting of shellfish	Low	Moderate	High	Immediate	Yes (with State and Tribes)
Rebuild stocks (i.e., restoration)	Medium	Moderate	Medium	Medium-Term	Yes State
Propagation and restocking of populations in areas where natural reproduciton of native bivalves is limited. If this is pursued, ensure replaced stocks are indigenous to the area.	Medium	Easy	Medium	Immediate	Yes State
Transplanting adult clams and oysters (assisted migration) from remnant populations into areas that are more suitable for reproductive success.	Medium	Moderate	Medium	Immediate	Yes State

3. Shellfish Biotoxins – HAB [High Vulnerability – Very High Priority]

a. Why Shellfish Biotoxins and Harmful Algal Bloom (monitoring) are Important

Harmful Algal Blooms (HAB) have been increasing in frequency, intensity, and duration around the world. [35] These toxins rarely harm the shellfish, but in high concentrations can harm humans and other animals that consume the shellfish. Much warmer than normal water and air temperatures continued along the Alaskan coastal areas in recent years, as part of the continuing increase in average global temperatures, and the specific result of an unusually persistent high pressure ridge that first developed in 2013 on the USA and Canadian west coasts. The result was an anomalous area that came to be known as the "blob" – a large area in the Gulf of Alaska and Bering Sea where marine waters were as much as 12° C above normal. This passed the pivotal temperatures of 6° C-16° C for the growth of a number of harmful algal species including *Pseudo-nitzschia* and *Alexandrium*. [36] As discussed earlier, shellfish harvesting is important for the Tribe from a nutritional and cultural standpoint. The Tribe tests year round for shellfish biotoxins and works closely with SEATOR.org to post toxin information online.

b. Potential Impacts of Climate Change

There are many environmental and human factors that affect the occurrence of HABs, making it difficult to determine the exact climate related contribution to their increasing frequency. [37] Sea surface temperatures greater than 55.4 °F (13°C) have been found to promote HABs and make PSP more likely. As the climate warms and air temperatures increase, waters temperatures will also rise. The expansion of the seasonality and potentially the range of HABs will increase the likelihood of human exposure to toxic shellfish in new or unaccustomed months and locations. It is also possible that the areas will see the emergence of new or different types of algal blooms of biotoxins.

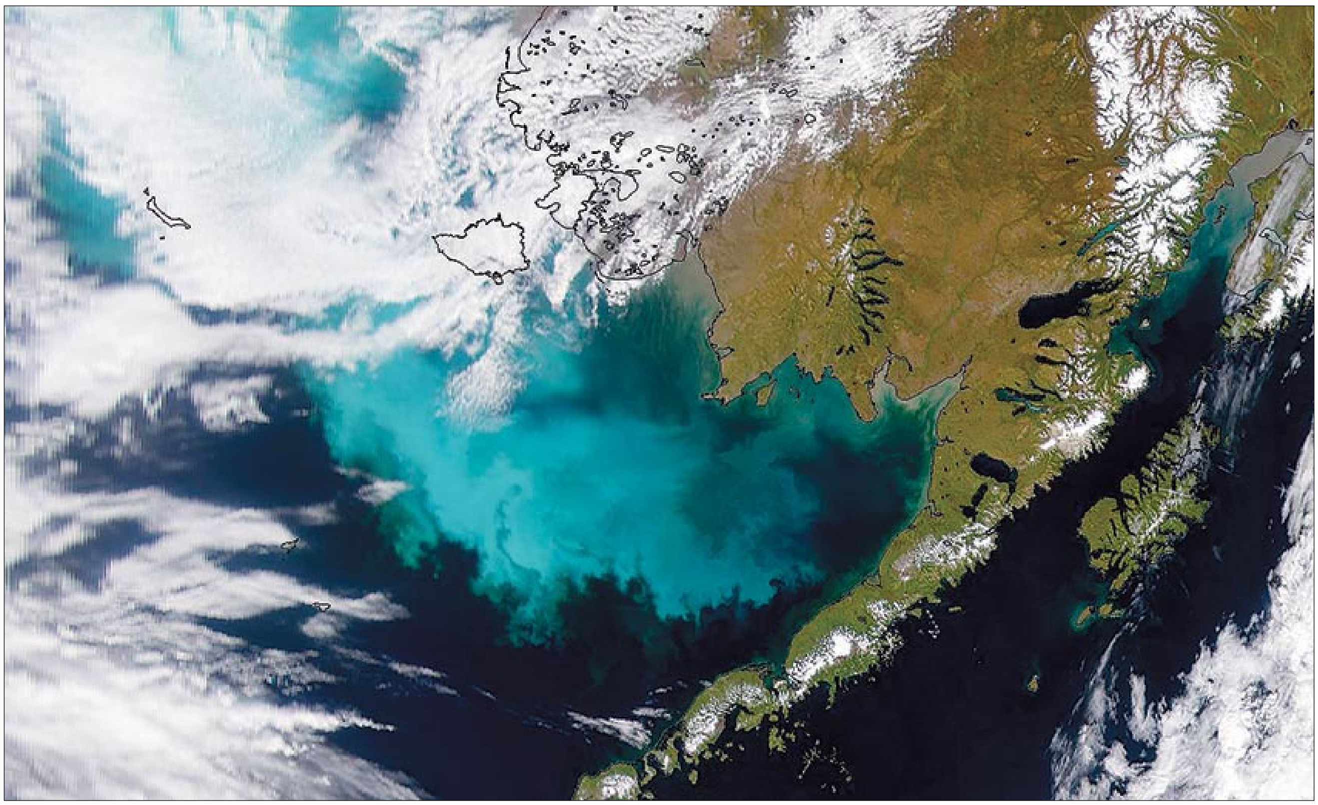

Figure 23: Satellite image of Bering Sea algal bloom. Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE.

c. Actions to Increase Resilience

Although it is difficult to make exact projections of how HABs events will be altered by a changing climate and other environmental conditions, the potential concerns for human health and the cultural heritage associated with shellfish harvest make planning a necessity.

The following strategies could be used to decrease risk of exposure to shellfish biotoxins in the tribal community:

Table 4: Resilience Strategies for Shellfish Biotoxins. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Shellfish Biotoxins	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Continuation and extension of monitoring program. This includes working with the research community to identify or develop environmental predictors of harmful algal blooms.	Low	Easy	High	Immediate	Yes (surrounding communities and Tribes, SEATOR)
Enhance online alert system, develop a procedure for posting of notices on beaches, contact newspaper.	Medium	Moderate	Medium	Immediate to Medium-Term	Yes (with State and Tribes)
Revisit public health response to biotoxin events and improve notification procedures.	Low	Easy	Medium	Immediate	Yes (Tribe, Community, State)

Many harvesters contact the Tribe for updates on the current monitoring results before they undertake harvesting activities. The Tribe does not have jurisdiction over all shellfish beds in the area, but it could consider a leadership role in strategies for public alerts to ensure that shifts in timing and location of HAB risk are better understood and communicated. It may also be worth investing in furthering partnerships to enhance monitoring and testing for current and future potential shellfish biotoxins.

4. Cedar [High Vulnerability – Very High Priority]

a. Why Cedar is Important

For hundreds of years, the ocean and the forest have provided life sustaining resources for the Tlingit and Haida people of Southeast Alaska. Using red and yellow cedar trees they made their homes, canoes, clothing, tools, dishes, baskets and monument poles. Today, Tlingit and Haida people continue these traditions, holding deep respect for the cedar and the gifts that it provides to sustain and enrich peoples' lives. [38]

Figure 24: Surviving western and mountain hemlock at Goose Cove, Peril Strait, Alaska appear as green trees among the numerous dead yellow-cedar trees, illustrating a successional shift in tree species in response to yellow-cedar decline.

b. Potential Impacts of Climate Change

In Southeast Alaska changing conditions are creating a less snow-pack / more rain scenario, and this creates significant impacts on cedar mortality. "For example, Alaska yellow-cedar (*Callitropsis nootkatensis*) decline appears to be closely related to changes in transient snow—reduced snow packs affect soil insulation, causing fine root damage and mortality in areas with poor drainage." [39] Climate model scenario results "…projected an overall regional increase in mean annual temperature (MAT) and mean annual precipitation (MAP), and a decrease in annual precipitation as snow (PAS)." [40]

c. Actions to Increase Resilience

The Tribe should consider, to the extent appropriate, the following:

Table 5: Resilience strategies for Cedar. This table provides a select list of key actions to increase resilience of local cedar populations and a number of criteria to be used in the evaluation, prioritization, and selections of strategies.

Cedar	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Conservation and active management in occupied suitable habitat.	Medium	Moderate	Moderate	Immediate -to-Long Term	Yes, Federal, State, Tribes
Asssisted Migration. Dispersal of red and yellow cedar to new habitat areas with suitable climates.	Medium	Moderate	Medium	Immediate -to-Long Term	Yes, Federal, State, Tribes
Create a monitoring and reporting system to track how red and yellow cedar abundance and yields are changing. Partner with traditional harvesters to gather on-the-ground observations.	Low	Easy	High	Immediate	No

B. Group Two: High Priority Areas of Concern

1. Forage Fish and Herring Eggs [Medium Vulnerability – High Priority]

a. Why Forage Fish and Herring Eggs are Important

Two species of forage fish that have been culturally and economically important to the Tribes are Eulachon and Herring. Eulachon (aka "hooligan") is a small member of the smelt family and has always been prized by our tribal people. Rendered into mineral and vitamin rich oil, it was used for seasoning, preserving and trade, and prevented many illnesses. Herring, and especially their eggs, have always been culturally significant; in springtime a hemlock bough would be put down on a known spawning beach during low tide and later would be collected covered in herring eggs. The collection and sharing of herring eggs has been celebrated annually since time immemorial.

b. Potential Impacts of Climate Change

In addition to our people losing access to this natural and cultural resource due to the effects of climate change, the ecosystem is greatly affected by the decline of forage fish. "The decline of these species is considered to be a potential cause of dramatic declines in populations of Steller sea lions, fur seals, and seabirds during the past 20 years." [41] The southern distinct population segment (DPS), Eulachon that spawn in rivers south of the Nass River in British Columbia to the Mad River in California, is listed as threatened under the Endangered Species Act. "Global warming may also pose a threat to the species by reducing the availability of their prey; zooplankton and phytoplankton. In addition, the recovery of populations of predator species, such as humpback whales, may impact herring populations." [42]

c. Actions to Increase Resilience

Due to conflicting reports on Forage Fish resiliency between local and state reporting agencies the following strategies could be used to increase the resilience of Forage Fish in Southeast Alaska:

Table 6: Resilience strategies for Forage Fish.

Forage Fish	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Active participation with the Southeast Alaska subsistence Regional Advisory Council	Low	Moderate	Moderate	Immediate -to-Long Term	Yes, Federal, State, Tribes
Active participation with the Alaska Board of Fisheries	Low	Moderate	Moderate	Immediate -to-Long Term	Yes, Federal, State, Tribes
Continued monitoring of forage fish populations, utilizing Federal, State, Tribal, and Local Knowledge	Low	Moderate	Moderate	Immediate -to-Long Term	Yes, Federal, State, Tribes

2. Halibut [Medium Vulnerability – High Priority]

a. Why Halibut is Important

Subsistence fishing for halibut has a long history in Southeast, as evidenced by the carved halibut hooks used by Native people for centuries. In 2003, a formal subsistence halibut fishery was authorized by the federal government, and an estimated 3,000 Southeast subsistence fishermen landed approximately 628,000 lb (285,455 kg) of halibut. [43]

b. Potential Impacts of Climate Change

“Despite their reputation as a large and long-lived fish, the size-at-age of halibut has experienced significant declines in recent decades. For instance, the average weight of a 20-year-old halibut has declined from more than 120 pounds in 1988 to less than 45 pounds in 2013. Observed reductions in halibut size-at-age could be the result of more competition among halibut or between halibut and growing populations of arrowtooth flounder, changes in prey composition or availability, response to climate variability, such as increased ocean temperatures that may have affected metabolic processes including respiration rates, or genetic selection by fisheries that prefer larger fish, leaving stunted ones to reproduce.” [44]

c. Actions to Increase Resilience

The Pacific halibut stock is managed under the Pacific Halibut treaty between Canada and the United States. The International Pacific Halibut Commission (IPHC) is responsible for assessing the status of the stocks and setting harvest strategies and catch limits that provide for optimum yield. Within the United States, the North Pacific Fishery Management Council (NPFMC) is responsible for allocating the halibut resource among users and user groups fishing off Alaska. The National Marine Fisheries Service (NMFS) is responsible for developing, implementing, and enforcing regulations pertaining to management of halibut fisheries in U.S. waters. The State of Alaska participates in management through the ADF&G Commissioner’s seat on the North Pacific Fishery Management Council.

Table 7: Resilience strategies for Halibut

Halibut	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Mitigate impacts of commercial fishing and size-at-age selection bias.	Low	Hard	Moderate	Immediate -to-Long Term	Yes, IPHC, NPFMC, Federal, State, Tribes
Increase active participation in International, Federal, and State management.	Low	Moderate	Moderate	Immediate -to-Long Term	No, but would be beneficial
Continued and improved monitoring of Halibut populations and sizes.	Low	Moderate	Moderate	Immediate -to-Long Term	Yes, IPHC, NPFMC, Federal, State, Tribes

3. Berries [Medium Vulnerability – High Priority]

a. Why Berries are Important

Wild berries are a valued traditional food in Southeast Alaska. Of the many wild berries found in Southeast Alaska salmonberry (*R. spectabilis*) and high-bush blueberry (*V. ovalifolium* and *V. alaskensis*) are considered very important. Phytochemicals in wild berries may contribute to the prevention of vascular disease, cancer and cognitive decline, making berry consumption important to community health in rural areas. [45]

b. Potential Impacts of Climate Change

Research on wild berries in Alaska is relatively recent, only a few decades of data has been collected so far. However, researcher's, "observations suggest that there have been changes in the productivity of some wild berries in the past decade, resulting in greater uncertainty among communities regarding the security of berry harvests. Monitoring and experimental studies are needed to determine how environmental change may affect berry abundance. [46]

c. Actions to Increase Resilience

Due to a lack of historical data and monitoring of wild berries the following strategies could be used to increase the resilience of wild berries in Southeast Alaska:

Table 8: Resilience strategies for Wild Berries

Berries	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Monitoring and experimental studies are needed to determine how environmental change may affect wild berry abundance	High	Moderate	Moderate	Immediate -to-Long Term	Yes, Federal, State, Tribes
Community outreach programs discussing wild berry abundance, variability, and traditions.	Low	Moderate	Moderate	Immediate -to-Long Term	None

C. Group Three: Medium Priority Areas of Concern

1. Invasive Species [Medium Vulnerability – Medium Priority]

a. Why Invasive Species are Important

Southeast Alaska has been invaded by a number of harmful invasive plants and animals. There are examples of species reintroductions that have been cause for harm. Invasive alien species are plants, animals, or other organisms that are introduced to a given area outside their original range and cause harm in their new home. Because they have no natural enemies to limit their reproduction, they usually spread rampantly. Invasive alien species are recognized as one of the leading threats to biodiversity and impose enormous costs to agriculture, forestry, fisheries, and other human enterprises, as well as to human health. [47]

b. Potential Impacts of Climate Change

Japanese Knotweed is an invasive weed that damages stream banks, limits flow, and degrades salmon spawning grounds. Atlantic Salmon compete with native steelhead, cutthroat trout, Dolly Varden, and coho salmon. And the reintroduction of sea otters into more interior waters has caused havoc on shellfish populations. Climate change has the potential of increasing the damage caused these invasive species.

c. Actions to Increase Resilience

To address these threats, The Central Council of the Tlingit & Haida Indian Tribes of Alaska should pursue, to the extent appropriate, the following:

Table 9: Resilience strategies for Invasive Species

Invasive Species	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Assist the tribe in becoming an active voice to cut the unintentional introduction of aquatic invaders by overseeing federal standard setting on the discharge of ballast water in the United States.	High	Hard	Moderate	Long Term	Yes, Federal, State, Tribes
Conduct local research on invasive species in the area.	Medium	Moderate	Moderate	Immediate -to- Long Term	Yes, Local

2. Crab [Medium Vulnerability – Medium Priority]

a. Why Crab are Important

Since time immemorial our people have been harvesters of crab. Several species of crabs were eaten by the people who had access to them, so much so that there is another saying: "*in Tlingit Aaní you have to be an idiot to starve.*"

b. Potential Impacts of Climate Change

The effects of Climate Change have already been seen: "stocks of red king crab, Tanner, and snow crab currently are in a prolonged period of decline. Scientists believe that crab stocks respond to surface and subsurface seawater temperature, vertical mixing, currents, atmospheric pressure, and subtle variations in sea level." [48]

c. Actions to Increase Resilience

To address these threats, The Central Council of the Tlingit & Haida Indian Tribes of Alaska should pursue, to the extent appropriate, the following:

Table 10: Resilience strategies for Crab

Crab	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Become a more active voice for tribal concerns in the Alaska Board of Fisheries (BOF).	Low	Moderate	Moderate	Long Term	Yes, Federal, State, Tribes
Conduct local research on impacts of climate change on crab.	High	Hard	Moderate	Long Term	Yes, Local

3. Seal [Medium Vulnerability – Medium Priority]

a. Why Seal are Important

Harbor seals play a crucial role in the culture and diet of Alaska Natives; the annual subsistence harvest of harbor seals in Alaska is about 1800 to 2900 animals, with fewer seals harvested in recent years. Traditional use of seal has a long history in Southeast Alaska. Seal has been used for food, oil, grease, and for the clothing and tools. Seal oil / grease is a high valued storage medium.

b. Potential Impacts of Climate Change

Harbor seals are listed as an Alaska Species of Special Concern. A Species of Special Concern is any species or subspecies of fish or wildlife or population of mammal or bird native to Alaska that has entered a long-term decline in abundance or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance. Dramatic declines in harbor seal numbers have been documented in Alaska, including a decline from approximately 11,000 seals to 1,000 seals during 1976-1988 on Tugidak Island near Kodiak a site previously considered to host one of the largest concentrations of harbor seals in the world. [49]

c. Actions to Increase Resilience

To address these threats, The Central Council of the Tlingit & Haida Indian Tribes of Alaska should pursue, to the extent appropriate, the following:

Table 11: Resilience strategies for Seal

Seal	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Become an active voice at the NOAA Fisheries Alaska Regional Office for the National Marine Fisheries Service (NMFS).	Low	Moderate	Moderate	Immediate to Long Term	Yes, Federal, State, Tribes
Conduct local research on seal populations and climate change impacts.	High	Hard	Moderate	Long Term	Yes, Federal, State, Tribes

4. Seaweed [Medium Vulnerability – Medium Priority]

a. Why Seaweed is Important

Several seaweeds are important to the Tlingit and Haida people. Black seaweed (*Porphyra*), ribbon seaweed (*Palmaria*), bull kelp (*Nereocystis*), and giant kelp (*Macrocystis*) continue to be harvested by our people. Seaweeds have various minerals, vitamins, carbohydrates, and sometimes protein. They are very low in fat and are approximately 80-90% water. [50]

b. Potential Impacts of Climate Change

Research has been conducted using seaweed to fight ocean acidification and carbon pollution. "The University of Washington will be working with the Bainbridge Island-based Puget Sound Restoration Fund to see whether growing seaweed could help combat ocean acidification in Puget Sound waters. Like plants on land, kelps and other seaweeds naturally take up carbon dioxide. Puget Sound waters are already high in carbon dioxide and are projected to become more so in the future. Seaweeds, which are naturally abundant in Puget Sound, could help address this growing problem. The team proposes to cultivate seaweed at a demonstration site in north Hood Canal, assess the project's effect on the acidity of nearby water, and harvest the resulting crop to test marketable products such as plant fertilizer, food and biofuels. [51]

c. Actions to Increase Resilience

To address these threats, The Central Council of the Tlingit & Haida Indian Tribes of Alaska should pursue, to the extent appropriate, the following:

Table 12: Resilience strategies for Seaweed

Seaweed	Cost	Ease of Implementation	Political/Community Support	Timing of Action	Partnerships Required
Work with SEATOR to investigate seaweed as a tool to fight ocean acidification in Southeast Alaska	Low	Moderate	Moderate	Immediate to Long Term	Yes, Federal, State, Tribes
Conduct local research and monitoring on local seaweeds	Low	Hard	Moderate	Long Term	Yes, Tribe

D. Next Steps

The Tribal government and Tribal Citizens are well poised to successfully prepare for changing climate conditions in Southeast Alaska. The ongoing efforts by Environmental Departments and other organizations have created a foundation that can be used to move from planning to action. The Tlingit & Haida people have been responding and adapting to a changing climate for thousands of years. Preparing for continued and accelerated change is not something new, but a continuation of the holistic natural resource and culturally driven approach that has kept the Tlingit & Haida people a vibrant and growing community.

Four key next steps have been identified to help the Tribe move forward with building preparedness for climate change. They are:

1. Prioritizing adaptation strategies for implementation and identify individuals or departments responsible for implementation;
2. Building community support for climate preparedness;
3. Incorporating climate preparedness into the Tribal Government operations and policies and;
4. Collaborating with surrounding communities during the Southeast Alaska Environmental Conference.

Step One: Prioritizing adaptation strategies for implementation and identifying individuals or departments responsible for implementation.

To maintain the momentum established through this process, the Tribe should start by prioritizing the adaptation actions identified and identify two or three actions for immediate implementation. In prioritizing actions, the Tribe should consider which actions will provide immediate value, which actions are likely to secure public support, which actions can be financed (either through existing budgets or with external support), and which actions are likely to provide the greatest social, cultural, economic, and environmental value to the Tribe. As part of this process, the Tribe should identify the individuals or departments that are responsible for implementing each action and assign a timeline by which each action will be completed. Actions can be grouped it three categories: actions for immediate implementation within the next year; actions to implement in the medium term (2-5 years); and actions for implementation in the future (i.e., 6+ years).

It is also worth noting that a number of additional funding sources are available to help the Tribe implement prioritized adaptation actions. The Tribe is encouraged to leverage the work they have done and the information summarized in this report to secure additional funding such as grants through federal agencies and private foundations. Moreover, having a vulnerability assessment and a list of prioritized adaptation actions will likely enhance the Tribe’s chances of securing additional funding as it demonstrates the Tribe’s foresight and readiness to act.

Step Two: Building community support for climate preparedness.

Building community support, particularly with Tribal Citizens, is a key component of the long-term engagement necessary to support tribal actions to enhance climate resilience. Building community support is listed as the second step in the process but, in reality, this will be an ongoing effort that requires continual emphasis. Utilizing the results from Step One (Prioritizing Adaption Actions) can be an effective way to begin engaging citizens, departments, and surrounding communities in climate preparedness. Moreover, some of the discrete actions listed in this report will likely require addition funding and allocating that funding requires political support. This support starts with understanding how climate change will affect the resources and assets that the Tribe values and why taking these actions will help protect those assets.

There are many ways to engage the tribal community as a whole. The overviews of selected key areas of concern provided in this report provide a starting point for that engagement. These short, graphically rich, documents are designed to help broaden the conversation throughout the tribal community and provide a non-technical summary of the issue and the potential actions to increase resilience. Additionally, the Tribe should consider integrating climate change discussions into existing outreach efforts working to ensure that supporting material are provided at appropriate community events.

Step Three: Incorporating climate preparedness into tribal government operations & policy.

For many communities there is a gap between the identification of actions to increase climate resilience and the implementation or operationalization of those actions. Simply asking project sponsors or project managers to consider and prepare for climate change is not sufficient. The Tribal Government should work to develop specific guidance for how to integrate a set of key climate variables into the project approval process. For example, depending on the project lifespan, the Tribe could require that new buildings be built with carbon footprint reducing techniques and materials.

Step Four: Collaborating with surrounding communities, and other key stakeholders to monitor key changes in climate likely to affect the Tribe.

Because the magnitude of effects from climate change will very locally, the Tribe should partner with state, federal, academic, private, and nonprofit entities that currently monitor how social, economic, and natural systems are shifting. For example, the Tribe has already established collaborations with many federal, state, local, and academic organizations. Preparing for, or adapting to, the impacts of climate change is not an outcome, but a process. While this report incorporated the best available science to date, there will likely be highly applicable scientific findings and discoveries over the next few years and decades. In order to be responsive to that new information, it is important to set-up a dynamic process that can incorporate relevant data as it becomes available.

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