QIK'RTAQ ALUTIIT "SUUMACIRPET"

KODIAK TRIBAL CLIMATE ADAPTATION PLAN

Prepared by the Kodiak Area Native Association

Updated October 2024

This project was funded by the Bureau of Indian Affairs Tribal Climate Resilience Program
and by the
Alaska Center for Climate Assessment and Policy

Cover Art Designed and Illustrated by Alyssa “Uswi” Madrid of Uswi Designs

ACKNOWLEDGEMENTS

We would like to acknowledge that this document was written, and the information included was gathered, on the ancient homeland and traditional territory of the Alutiiq/Sugpiaq people. For generations, the Alutiiq people have lived, hunted, fished, gathered, and cultivated this land, nurturing a deep connection to its natural beauty and numerous resources. We recognize the importance of honoring and respecting Indigenous Knowledges, culture, and the history of the Alutiiq people who have stewarded this land for generations. As you read, please help us honor the families and Tribal members still connected to this land; their heritage and culture continue to enrich our communities. **A special acknowledgement goes to the Kodiak Tribes and the communities of Kodiak for their participation in creating this document.**

We acknowledge the individuals and organizations who guided the development of this plan:

The Kodiak Tribal Climate Adaptation Plan Steering Committee:

Amy Peterson, Koniag

Fred Shanagin, Native Village of Ouzinkie

Anastasia Shugak, Alutiiq Tribe of Old Harbor

Matt Van Daele, Sun'aq Tribe of Kodiak

Elijah Jackson, Native Village of Ouzinkie

Who provided all of the ideas, feedback, and insight as to what this plan should be.

Teresa Carlson, Native Village of Larsen Bay and her mother, Barbara Hochmuth

For sharing special stories and valuable knowledge.

Thank you to the Alaska Climate Adaption specialists and experts who shared resources, expertise, and knowledge:

Ray Paddock, Tlingit & Haida Tribe

Liz Borneman, Sitka Tribe of Alaska

Davin Holen, Alaska Sea Grant

The Alutiiq Museum

KANA Elder Services

CAMA'I & QUYANAA

EXECUTIVE SUMMARY

This booklet's purpose is to serve as a Climate Adaptation Plan for the ten Tribes located in the Kodiak Archipelago. These Tribes are facing serious impacts and threats to their traditional way of life due to a rapidly changing climate. In this plan you will find the documentation of climate hazards for the Kodiak Tribes, the assessment of vulnerabilities of key concern, a brief introduction to observed climate change in the region, and an introduction to ongoing and desired monitoring efforts. At the end of the document you will find an outline of resources that have been identified as being key focus areas to begin adaptation efforts that will be most achievable and impactful.

This booklet is a story of Kodiak Tribes: their way of living, the impacts they are facing amidst a changing climate, and the proposed next steps to healthy, thriving, and resilient communities.

PROJECT BACKGROUND AND DESCRIPTION

In April of 2021, with the support of the Kodiak Tribes, the Kodiak Area Native Association (KANA) applied for the Bureau of Indian Affairs, Tribal Climate Resilience Funds to develop a regional climate adaptation plan and adaptation plan template. Adapting to the impacts of climate change is a key priority of all Tribes in the region. In October of 2019, a resilience workshop, Adapt Kodiak,[1] brought together Kodiak Tribal members, residents, local governments and business representatives to discuss the challenges facing Kodiak Island. The event aimed at starting a conversation about climate change and resiliency in the region and identified associated vulnerabilities. The goal of this project was to build from those efforts by creating a climate adaptation plan that would document climate hazards and concerns, assess vulnerabilities of key concern identified by Tribal members, outline existing climate change reports and monitoring efforts, and review ways to reduce climate-related risks.

Key priorities of this project proposal included: an adaptation plan focused on Traditional Ecological Knowledge, led by Kodiak Tribal members via a steering committee, and designed to be a useful and dynamic tool for all Kodiak Tribes.

[1] Holen, D. (2019). Adapt Kodiak: A Coastal Resilience Workshop Report.

Climate Change Conferences, Workshops, and Trainings

Below is a list of conferences, workshops, and trainings that were attended in preparation for the creation of the climate adaptation plan:

- Climate Camp – Seward
- National Tribal and Indigenous Climate Conference, Institute for Tribal Environmental Professionals
- Alaska Climate Adaptation Community of Practice
- Food Safety after an Oil Spill, Nuka Research
- Indigenous Food Sovereignty and Observing Arctic Change, Molly Tankersley
- Emergency Preparedness Training
- Alaska Forum on the Environment
- Approaches to Adapting to Alaska's Rapidly Warming Climate, Alaska Wildlife Alliance
- ComFish Alaska, Kodiak Chamber of Commerce
- Ocean Acidification Impact on Commercial Fisheries
- Embracing Elders Webinar
- Alaska Fish Consumption Rate Presentation, EPA Region 10 Water Division
- Tribal Disaster Debris and Resilience Planning Training, U.S. EPA
- Food Sovereignty – Healthier Foods, Cultural Practices and Food Security, U.S. EPA
- Alaska Tribal Conference on Environmental Management, Alaska Native Tribal Health Consortium
- National Tribal and Indigenous climate conference

Research, Outreach, and Data Organization

This plan was developed to elevate Traditional Ecological Knowledge, focusing on storytelling, culture, and the experience of Tribal members on the Kodiak Archipelago. Upon the start of this project, a Tribal Steering Committee was formed with representation of the Sun'aq Tribe of Kodiak, the Alutiiq Tribe of Old Harbor, the Native Village of Ouzinkie, the Native Village of Port Lions, the Native Village of Larsen Bay, the Native Village of Afognak, and the Tangirnaq Native Village. Members of this committee played a key role in gathering local observations and knowledge, as well as assisting with the development of the Kodiak Tribal Climate Adaptation Planning Workshop. This was a two-day workshop that brought in Tribal members to learn, share, engage, and discuss climate change in the Kodiak Region. During the event, a traditional foods potluck was held to invite additional community members to participate in providing feedback to the climate adaptation plan and share their observations of change in the region. Additionally, the steering committee asked for Tribal member input and observations in regards to subsistence resources and harvesting changes.

Trips with the Elder Services Department at KANA also provided an opportunity to sit one on one with Elders in the villages to gather information and traditional knowledge. Throughout this plan you will also see culture and language pieces that were sourced from the Alutiiq Museum in Kodiak and western science-based graphs and data from organizations like the Alaska Center for Climate Assessment and Policy, community data from the Comprehensive Economic Development Strategies Plan, and data that has been collected by Tribal members from the Kodiak region.

QIK'RTAQ (KODIAK ISLAND)

BACKGROUND & HISTORY

QIK'RTAQ, UNIGKUAQ | KODIAK ISLAND, ORIGIN STORY

Qikertalillriit | They Made Kodiak

"A raven brought light to the Earth from the spirit world. At the same time, a bladder descended, holding a man and a woman. At first this pair of people enlarged the bladder by blowing and then by stretching their hands and feet; this built the mountains. The man scattered hair on the mountains creating trees and forests where wild animals sprung up and increased. The woman urinated, producing the sea and spit into ditches and holes, forming the rivers and lakes. The woman pulled out one of her teeth and gave it to the man whom made a knife from it. He cut trees with the knife and threw the chips into the river. These wood chips became fish of different kinds. At last, the pair had children. One day their firstborn, a son, was playing with a stone and suddenly the stone became Kodiak Island. On this Island a man and a dog woman were placed. The island was set afloat on the ocean and arrived at its current location. The man and dog woman had children and the Kodiak people are their descendants."[2]

[2] Transcribed from the *Alutiiq Museum Podcast*, Sarah Harrington shares the creation legend that was originally told by an unidentified Alutiiq person to Uri Lisiansky in 1805.

Photo credit, Hallie Brown

WESTERN SCIENCE OF LAND FORMATION

The majority of Kodiak Island is classified as uplands, with elevations exceeding 5,000 feet (1,500 meters) along its eastern coast. The northern portion of the Archipelago is dominated by Sitka spruce forests. Valleys and lower slopes are blanketed with sand and gravel deposits from glaciers. The southwestern portion of the island remained unscathed by glaciation and predominantly features lush tundra. The plant life in this area exhibits notable distinctions from the flora found elsewhere on the island. [3]

KODIAK GEOGRAPHY

The Kodiak Archipelago is situated on the western side of the Gulf of Alaska. The Kodiak Archipelago and a portion of the Alaska Peninsula are within the Kodiak Island Borough, or Koniag Region. The City of Kodiak, the main port of entry to the Borough and its surrounding area, is 252 air miles southwest of Anchorage (a one-hour flight), accessible only by plane or boat.

The Borough encompasses a 29,000 square mile area, which includes approximately 6,500 square miles of land, including lakes and rivers, approximately 23,000 square miles of coastal waters, and 5,500 miles of shoreline. The Archipelago contains 162 named islands and nearly 1,500 unnamed islands, accounting for approximately 74% of the total Borough land area. The Kodiak Archipelago consists primarily of mountainous terrain. Koniag, Kodiak's tallest peak, reaches 4,500 meters. With the exception of the lowlands and broad valleys of the southwestern portion of Kodiak Island, the Archipelago coastline is predominantly rocky and rugged.

Kodiak Island, covering 3,588 square miles, is the largest island in the Archipelago, and is the second largest island in the United States, behind only the Big Island of Hawaii. The north and east sides of Kodiak Island are heavily forested. Wetlands, grasslands, and brush dominate the Island's south end. Commercial stands of timber, primarily Sitka spruce, exist on the north end of Kodiak Island, as well as Afognak and Shuyak Islands. Kodiak Island has numerous deep, ice-free bays that provide sheltered anchorage for boats. The southwestern two-thirds of the island, like much of the Kodiak Archipelago, is part of the Kodiak National Wildlife Refuge.

[3] https://www.britannica.com/place/Kodiak-Island

Kodiak Island is home to eight communities: The City of Kodiak, and the remote communities of Akhiok, Karluk, Larsen Bay, Old Harbor, Ouzinkie, Port Lions, and Chiniak. Within these eight communities, Kodiak Island is home to ten federally recognized Tribes. There are no roads connecting the hub city of Kodiak with the outlying villages, with the exception of Chiniak. Village residents rely on transportation by boat or air for travel in and out of their communities. The Alaska Marine Highway is a vital link between mainland Alaska, the Kodiak road system, and three communities (Port Lions, Ouzinkie, and Old Harbor) that receive service.

Figure 1. Map of the Kodiak Archipelago with seven Tribal communities indicated by blue dots.

The climate of Kodiak Island is characterized by moderately heavy precipitation and cool temperatures with frequent clouds, fog, and high winds. Inclement weather often restricts travel. High winds and freeze-thaw periods are frequent during the winter, with storm winds produced in the Gulf of Alaska sustaining wind speeds up to 75 knots. Kodiak's climate, however hostile, is favorable for over 300 species of plants, many of which were used by inhabitants for food, medicine, and shelter. The deep fjords of Kodiak Island provide abundant habitat for fish and marine mammals. Herring, halibut, Dungeness and Tanner crab, Pacific cod,

and five species of salmon are all found in Kodiak Island waters, providing commercial, subsistence, and sport fishing resources.[4]

KINKUT ALUTIIT | WHO ARE THE ALUTIIQ?

The Alutiiq/Sugpiaq people have a remarkable history filled with rich culture, drastic changes to climate and livelihood, and resiliency and adaptation. It is estimated that the first inhabitants of Kodiak arrived over 7,500 years ago in skin sewn boats to make landfall upon the 180-mile-long, glacial carved island during what is known as the Ocean Bay Tradition. This way of living coincided with a warmer, drier climate, and Alutiiq people survived by hunting marine mammals, such as **wiinaq** (sea lions), **isuwiq** (harbor seals), and **arhnaq** (sea otters), fishing for **amutaq** (cod) with bone hooks, and digging for **mamaayaq** (clams). [5]

Alutiiq history is generally split into three different time periods which mark different cultural traditions: The Ocean Bay Tradition, Kachemak Tradition, and Koniag Tradition (Table 1). The Kachemak Tradition, beginning approximately 4,000 years ago, signified a switch from the heavy reliance on marine mammal resources to harvesting **igallut** (salmon) and **amutaq** (cod) with a **kugyaq** (net). This period also included processing methods like smoking fish and trading with Alaskan mainlanders. The last period, occurring some 800 years ago and known as the Koniag Tradition, consisted of a reliance predominantly on fishing. This fishing specifically targeted large quantities of **igallut** (salmon) to support the growing population.[6] At the end of this period, preceding the colonization of Kodiak by Russians, Alutiiq populations on Kodiak Island were estimated around 8,000 people with approximately 30-40 large villages scattered throughout the Archipelago.[7]

Cuumillapet | Ancestors: Culture through Time	
5500 BC to 2000 BC	Ocean Bay Tradition
2000 BC to AD 1100	Kachemak Tradition
AD 1100 to AD 1763	Koniag Tradition
AD 1763 to AD 1867	Russian
AD 1867 to PRESENT	American

Table 1. Cultures in the Kodiak Archipelago from 5500 BC to present.[8]

[4] Alaska Department of Fish & Game
[5] https://koc.alaska.edu/about/community/
[6] https://alutiiqmuseum.org/learn/the-alutiiq-sugpiaq-people/history
[7] https://alutiiqmuseum.org/learn/the-alutiiq-sugpiaq-people/history
[8] https://alutiiqmuseum.org/images/stories/education/Traditions/Ancestors2022.pdf

Today, the Kodiak Archipelago is home to ten federally recognized Tribes, seven of which reside in six remote areas only accessible by boat or air. The Alutiiq Tribe of Old Harbor, Kaguyak Village, Native Village of Akhiok, Karluk IRA Traditional Tribal Council, Native Village of Larsen Bay, Native Village of Ouzinkie, and Native Village of Port Lions are located in the six remote villages of Kodiak (Figure 1). The remaining three tribes, the Native Village of Afognak, the Sun'aq Tribe of Kodiak, and the Tangirnaq Native Village are based within the City of Kodiak.

A History of Resilience

Around 900 years ago, the Alutiiq people demonstrated their remarkable resilience as they faced significant climatic changes on Kodiak Island and their surrounding waters. This involved a shift from relying on small sea mammals to depending on salmon and whales for sustenance and trade. Perhaps the most profound transformations began in the 1780s, when Russian fur traders established their presence in the region, imposing new societal, economic, and religious practices. Another major transition occurred in 1867 when the United States acquired Alaska, introducing modern industry and Western-style market economics. This shift led to the suppression of the Alutiiq language, and rapid diminishment of traditional subsistence activities and ways of life.[9]

The Alutiiq people demonstrated remarkable resilience in the face of the devastating 1964 earthquake and tsunami that struck the Kodiak region. This catastrophic 9.2 magnitude earthquake, the most powerful earthquake ever recorded in Alaska, unleashed widespread destruction and triggered massive tidal waves that decimated coastal communities.[10] Despite the overwhelming loss and destruction, the Alutiiq people displayed immense strength and solidarity. They came together to rebuild their homes, villages, and lives, drawing upon their traditional knowledge of the land and the sea to adapt and recover. Their resilience was a testament to their deep connection to their cultural heritage and the enduring spirit that has defined the Alutiiq people throughout their history, allowing them to rise from the ashes and rebuild their communities in the face of such adversity.[11]

After the tsunami, Afognak Village residents, with over half of their structures seriously damaged or destroyed, made the difficult decision to relocate to Settler's Cove,

[9] https://alutiiqmuseum.org/images/stories/education/Traditions/Ancestors2022.pdf
[10] Seismicity of the United States, 1568-1989 (Revised), by Carl W. Stover and Jerry L. Coffman, U.S. Geological Survey Professional Paper 1527, United States Government Printing Office, Washington: 1993.
[11] http://alutiiqeducation.org/html/calendar/events/1964-tsunami.php

establishing Port Lions. Kaguyak was nearly completely leveled, including the newly constructed church, with just three homes left standing. Residents of Kaguyak relocated to nearby Akhiok after realizing rebuilding was not possible.

ALLAKAQ NUNA (DIFFERENT LAND)

KODIAK'S CHANGING CLIMATE

"My Elders said that when the green reaches the tops of the tallest mountains, that is when we will begin to see the most intense changes to the Island." [12]

Teresa Carlson first noticed grass reaching the tops of the tallest mountains surrounding Larsen Bay in the summer of 2022.

[12] *Gathered Local Traditional Ecological Knowledge*, Teresa Carlson, Native Village of Larsen Bay

Photo credit, Hallie Brown

KODIAK'S CHANGING CLIMATE

Like many places, the Kodiak Archipelago has seen multiple periods of a naturally changing climate. Upon what is thought of as the initial arrival of the Alutiiq people approximately 7,500 years ago, the climate is believed to have been warmer and drier than today. About 900 years ago, the Kodiak Archipelago saw a significant change: much cooler temperatures with bouts of rain storms and higher intensity weather. Today, Kodiak's climate is considered a maritime or oceanic climate, a climate predominantly influenced by its proximity to the sea." [13]

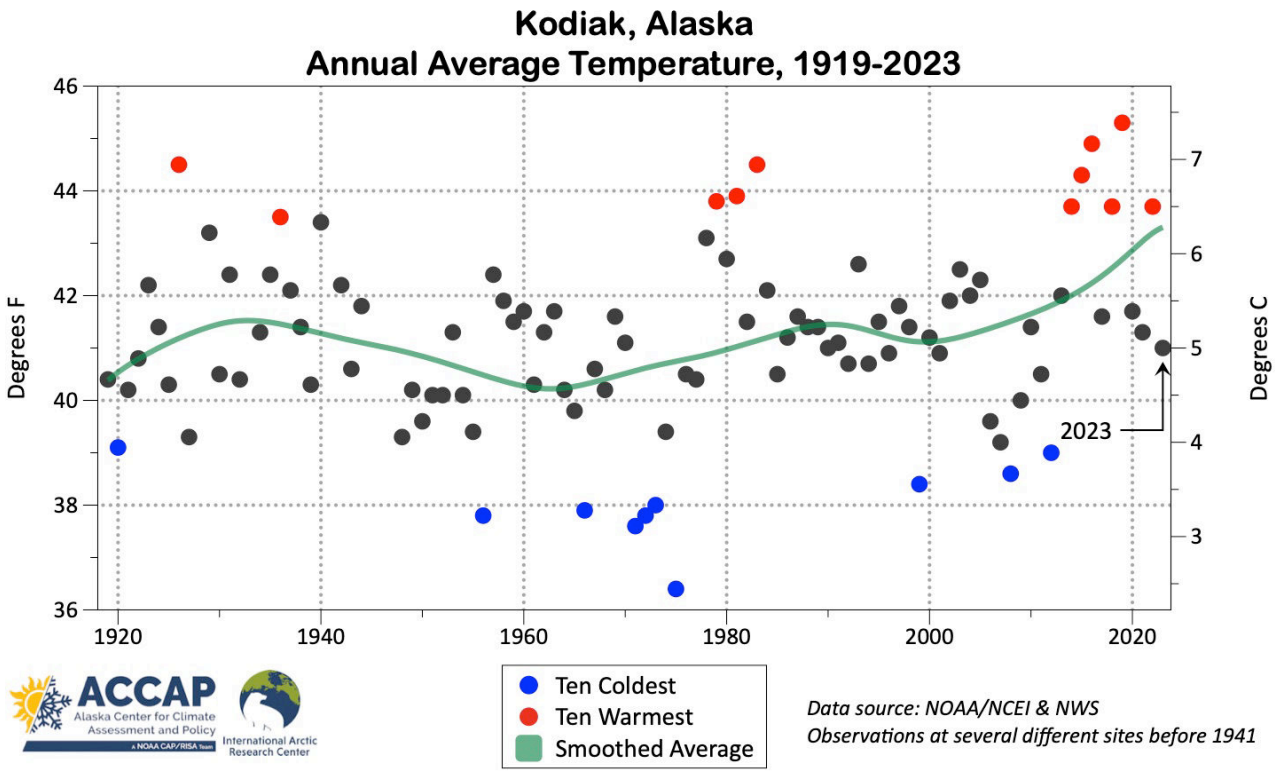

Figure 2. Annual average temperature (°C and °F) at the Kodiak Airport (and other sites before 1941) between 1919 and 2023. Blue and red dots correspond with the ten coldest and warmest years, respectively. The green line represents the smoothed average. [14]

[13] https://alutiiqmuseum.org/images/stories/education/Traditions/Ancestors2022.pdf
[14] Alaska Center for Climate Assessment and Policy

TEMPERATURE

Similar to numerous maritime communities in Alaska, Kodiak experiences relatively mild temperatures year-round (Figure 2). The warm season spans approximately four months, from June to September, boasting an average daily temperature of 58° F. August is the warmest month, reaching an average high of 61° F. Winter temperatures set in from November to April, with an average daily high of 41° F. January marks the coldest month of the year, with temperatures ranging from 28° F to 36° F.[15] Kodiak temperature trends seem to be shifting seasonally (see Changing Seasonality, below).

Over the last 50 years, the average temperature has increased by 3.3° F in Kodiak (Figure 3). Climate change is amplified in the Arctic, and therefore Alaska is experiencing warming at a much higher rate than much of the globe. At two to three times the global average, this increased rate of warming is largely due to a rapid loss of sea ice in the Alaskan Arctic and changes in energy circulation (atmospheric and oceanic) in northern latitudes.[16] Most of the climate change impacts felt in Alaska can be linked to rising temperatures.

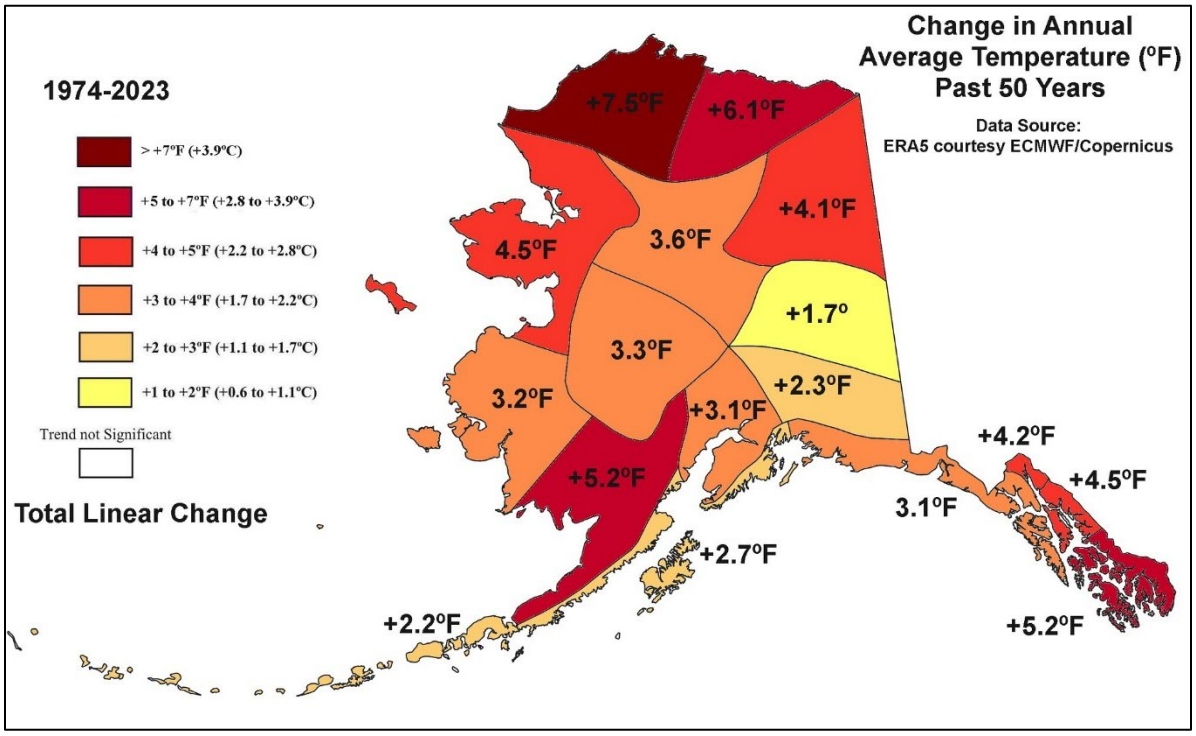

Figure 3. Change in annual average temperature across Alaska in the last 50 years. Kodiak temperatures have increased 2.7°F (1.5 °C) since 1974.[17]

[15] https://weatherspark.com/y/200/Average-Weather-in-Kodiak-Alaska-United-States-Year-Round
[16] Previdi, M., Smith, K. L., & Polvani, L. M. (2021). Arctic amplification of climate change: a review of underlying mechanisms. *Environmental Research Letters*, *16*(9), 093003.
[17] Alaska Center for Climate Assessment and Policy

PRECIPITATION

> *"I recall a time not that long ago when Kodiak had warm, sunny summer months with little rainfall."*[18]

> *"The last time [I] recall heavy snowfall in Larsen Bay was in the late 70s; the snow would be piled up to the tops of the windows."*[19]

The Kodiak Archipelago experiences substantial levels of precipitation, and is considered a temperate rainforest. The annual mean precipitation observed in Kodiak is approximately 78-98 inches. Due to its relatively mild winter temperatures, Kodiak does not see exceptionally high levels of snowfall; the average annual snowfall is 68 inches. Many Kodiak residents can recall a time when most of Kodiak's precipitation was observed in the winter months, as snowfall rather than rain. Summer months were filled with more sunshine and less precipitation than is experienced today (Figure 4). As the Kodiak climate changes, annual precipitation patterns are also changing. Over the past 50 years, it is estimated that Kodiak's annual precipitation has increased by 2% (Figure 4).

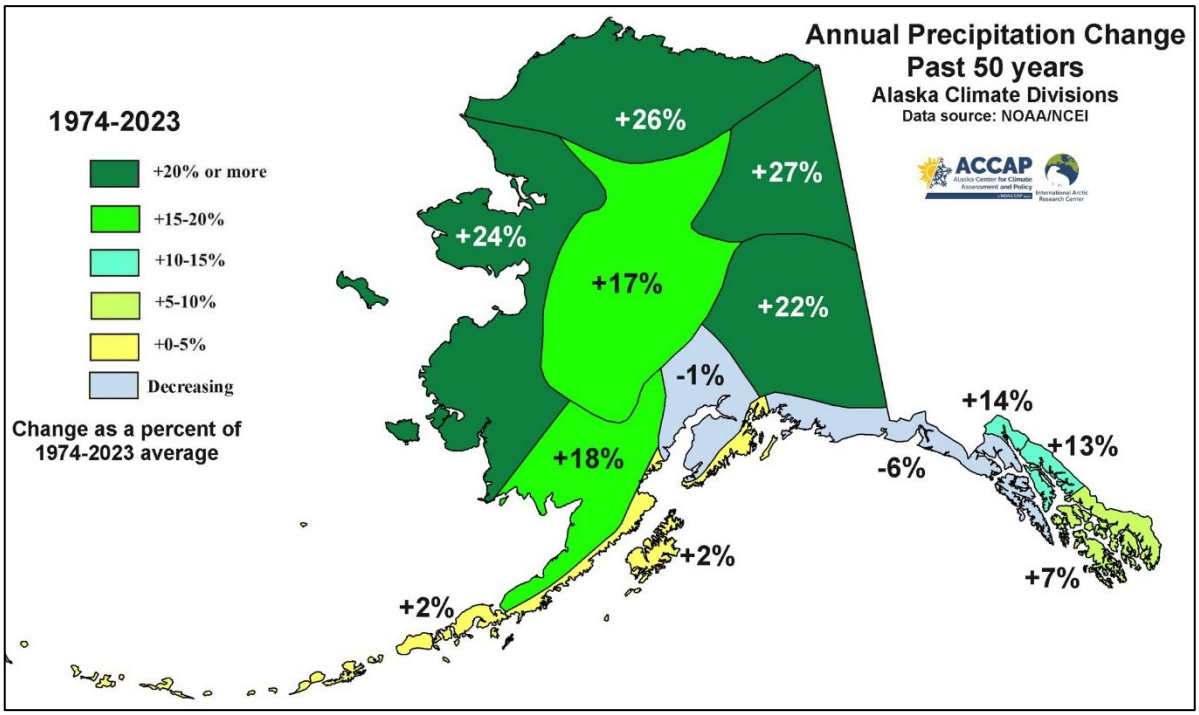

Figure 4. Average increase in annual precipitation across Alaska in the last 50 years. [20]

[18] *Gathered Local Traditional Ecological Knowledge,* Unidentified Kodiak Community Member
[19] *Gathered Local Traditional Ecological Knowledge*, Teresa Carlson, Native Village of Larsen Bay
[20] Alaska Center for Climate Assessment and Policy

Ocean Acidification

Ocean acidification is a chemical process caused by the absorption of human-generated carbon dioxide into the ocean. This increase in dissolved carbon dioxide makes seawater more acidic. Dissolved carbon dioxide concentrations in the ocean naturally vary seasonally (Figure 5). With summer comes increased daylight hours. This increase in sunlight drives phytoplankton productivity, therefore absorbing carbon dioxide and lowering seawater acidity. In the winter months, the lack of sunlight and colder temperatures lead to higher carbon dioxide absorption. Additionally, cold water absorbs more gas. Because the waters surrounding Kodiak are so cold, it is expected that Kodiak, and Alaska as a whole, will feel the impacts of ocean acidification earlier than other coastal regions of the world. [21]

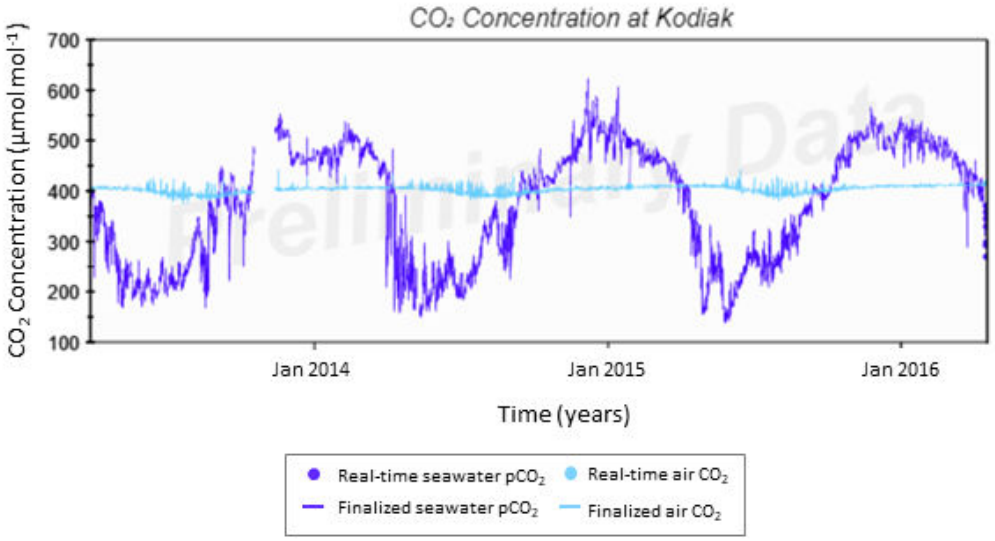

Figure 5. CO_2 concentration of air and seawater collected from 2013-2016 during an Ocean Acidification Mooring Project in Chiniak Bay, Kodiak. The light blue line indicates the concentration of CO_2 in the air, and the dark blue line indicates the concentration of CO_2 in the seawater. [22]

In 2013, a consortium of entities and researchers began gathering baseline data on ocean acidification in the Kodiak region. The data was collected by a mooring buoy located off the shores of Kodiak, in Chiniak Bay. Consecutive real-time readings began in 2013 but ended in 2016 due to a lack of funding. This ended the mooring program, but about a year later, in 2017, the National Oceanic Atmospheric Administration (NOAA) received a Burke-o-lator; an instrument that analyzes ocean chemistry in real time. Kodiak is home to one of four installments in Alaska collecting continuous ocean chemistry data (Figure 6). The

[21] Alaska Ocean Acidification Network
[22] Mooring buoy data collected by the National Oceanic and Atmospheric Association

Burke-o-lator also analyzes discrete samples; ideally a seawater sample can be collected anywhere on the Archipelago, and later be analyzed in the lab to uncover clues about the ocean chemistry when the sample was collected.

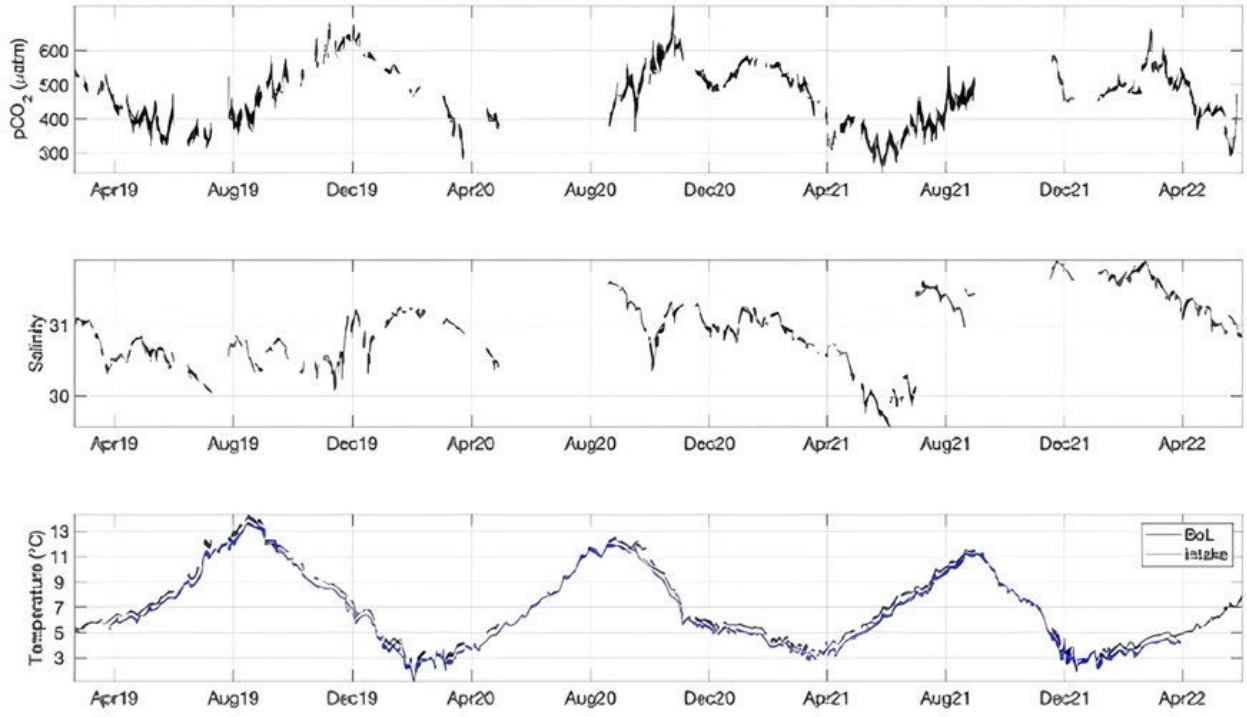

Figure 6. Continuous seawater monitoring data of dissolved CO_2 (top panel: pCO_2 µatm), salinity (middle panel: ppt), and temperature (bottom panel: °C) measured on the NOAA Burke-o-lator from April 2019 to April 2022. Seawater temperature was also measured upon intake (blue line). [23]

In 2018, NOAA and KANA teamed up to develop a Kodiak Ocean Acidification Monitoring project in the region. Four Tribes, the Native Village of Larsen Bay, the Alutiiq Tribe of Old Harbor, the Native Village of Port Lions, and the Native Village of Ouzinkie, volunteered to begin sampling in their remote communities. This project followed similar protocols to other remote discrete ocean acidification testing taking place in Sitka, Alaska. Due to NOAA budget cuts and COVID, discrete sampling was stopped in 2022. KANA is now working with new a Partner, the Alutiiq Pride Marine Institute, and sampling restarted in these four remote communities in July 2024.

The collection of these data plays a crucial role in predicting and quantifying the potential impacts of ocean acidification (and increasing seawater temperatures) in areas

23 Cohen, J. 2024. *In prep:* Report for Tribal Samplers and the Kodiak Area Native Association on Community Ocean Acidification Monitoring, 1-16.

around Kodiak's remote communities. More ocean acidification data is being collected by entities across the state, but these data do not give community specific ocean chemistry insights like the discrete samples collected in Kodiak. This discrete collection enables researchers to establish the typical trends in the waters surrounding Kodiak and to monitor changes as these communities deal with the effects of climate change.

Harmful Algal Blooms

The Kodiak Archipelago has been identified as a "hot spot" for harmful algal blooms (HABs). Although limited data has been collected in the region, the perfect nutrient rich conditions exist for algae to thrive.[24] With guidance from Kodiak Tribes, local expert Julie Matweyou, and the Sitka Tribe Lab, KANA began monitoring harmful algal genera in 2019, developing new HAB baseline data for the Kodiak region (Figure 7). Since then, KANA has identified the presence of three genera of phytoplankton that pose a threat to human and marine mammal health: *Alexandrium, Dinophysis*, and *Pseudo-nitzchia.*

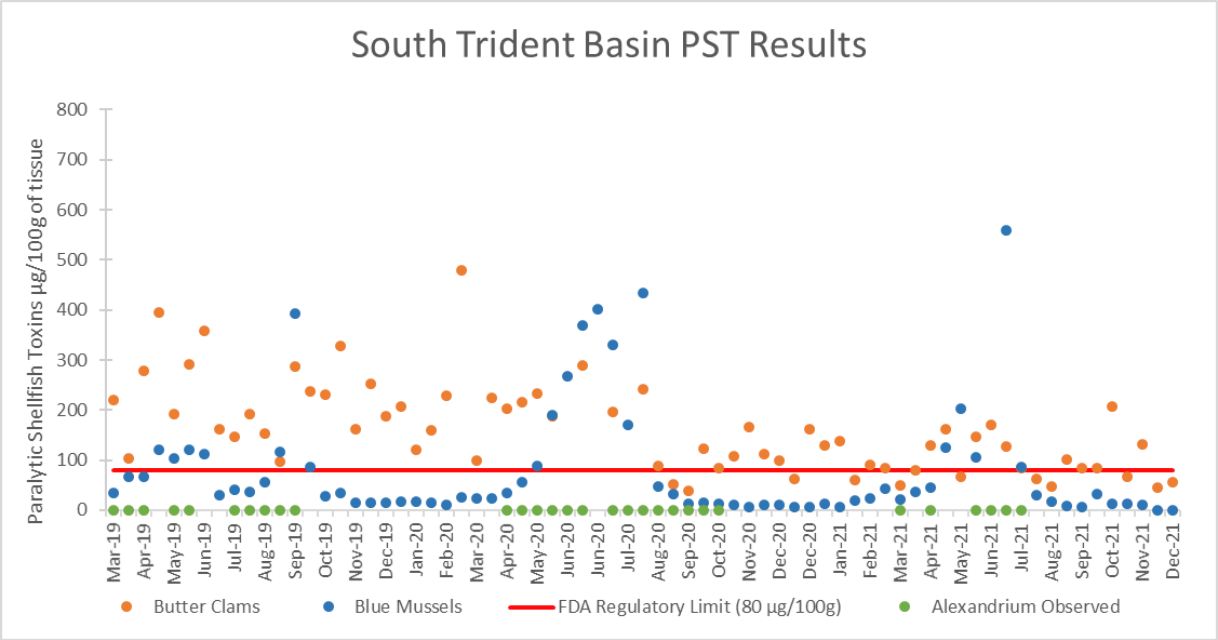

Figure 7. Paralytic shellfish toxins (PSTs) measured in butter clam and blue mussel tissue from South Trident Basin in Kodiak. Green dots represent dates when *Alexandrium* was present in the water column. The red line indicated the FDA regulatory limit for consuming shellfish. Data were collected by the Kodiak Area Native Association from 2019-2021.

[24] Kibler, S. R., Litaker, R. W., Matweyou, J. A., Hardison, D. R., Wright, B. A., & Tester, P. A. (2022). Paralytic shellfish poisoning toxins in butter clams (Saxidomus gigantea) from the Kodiak Archipelago, Alaska. *Harmful algae*, *111*, 102165.

Of particular concern are the presence of *Alexandrium* and *Psuedo-nitzschia*. *Alexandirum* produces saxitoxin, a neurotoxin responsible for paralytic shellfish poisoning.[25] *Psuedo-nitzschia* produces domic acid, a toxin that causes amnesic shellfish poisoning.[26]

Continuous monitoring of HABs and shellfish testing will continue to address environmental trends that pose a threat to human health and subsistence resources by Native and non-Native Alaskans. Despite the numerous algal blooms and subsistence harvesting activities that continue today on Kodiak, there are no advisory efforts in place. Therefore, KANA works with local tribes, radio stations, and local scientists to increase awareness and knowledge of HABs and puts out advisories when shellfish toxin levels test above the regulatory limits.

CHANGING SEASONS

"My Elders shared that eventually we will see two winters and two summers [in Kodiak]."[27]

The Alaskan growing season is brief. Only May through September, this window to grow food is shorter than any other region in the United States. Due to Kodiak's mild maritime climate, however, we see a slightly extended season compared to the rest of the state. As temperatures continue to rise, it is projected that Kodiak's growing season will expand (Figure 8).

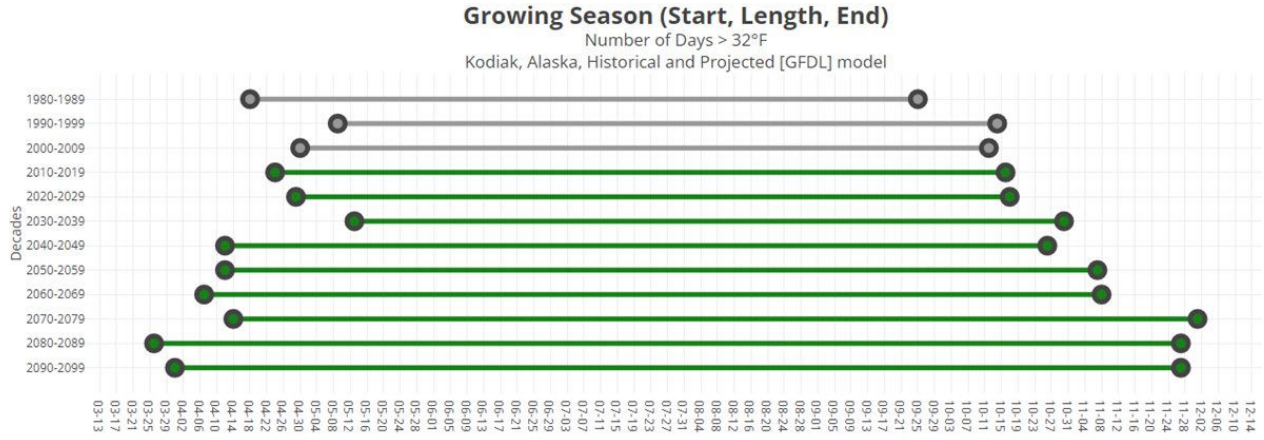

Figure 8. Observed and predicted growing seasons by decade from 1980-2099 in Kodiak, Alaska. Growing seasons are defined by number of days above 32°F. Grey horizontal lines represent past growing seasons. Green horizontal lines represent predicted future growing seasons.[28]

[25] Etheridge, S. M. (2010). Paralytic shellfish poisoning: seafood safety and human health perspectives. *Toxicon*, *56*(2), 108-122.
[26] Bates, S. S., Hubbard, K. A., Lundholm, N., Montresor, M., & Leaw, C. P. (2018). Pseudo-nitzschia, Nitzschia, and domoic acid: New research since 2011. *Harmful Algae*, *79*, 3-43.
[27] *Gathered Local Traditional Ecological Knowledge,* Teresa Carlson, Native Village of Larsen Bay
[28] https://snap.uaf.edu/tools/gardenhelper/

Recent local agriculture movements reflect these expanded growing seasons. There has been an increase in hydroponic and micro-farming on the archipelago. Four of the six Kodiak villages have high tunnels and raised bed farms that provide their village community with vegetables. There are a few micro-farms in Kodiak that supplement the city with local greens, root vegetables, preserves, goat dairy, baked goods, and poultry. Kodiak is also home to the only Goat Dairy farm, providing the community with assorted goat dairy products. By building and expanding local agriculture effort, perhaps the island's resiliency will increase and Kodiak will become less dependent on outsourced foods.

HUMAN HEALTH & WELLNESS

Changing conditions to our environment and ecosystems are currently, and will continue to impact the health of our residents (Figure 9). As mentioned above, Kodiak's climate is getting warmer and wetter (Figures 3 and 4). These conditions may increase mold and extend allergy seasons which will directly impact groups with allergies, asthma, autoimmune disorders, and other respiratory diseases.

Access to our nutrient rich subsistence resources, such as salmon, venison, and berries will likely be impacted by shifting growing seasons and habitat changes. Changing ecological conditions such as ocean chemistry and increasing water temperatures also create unpredictable stressors for the salmon and marine life that locals rely on for year-round sustenance.[29]

Wildfire risk may also increase with climate change, with warmer temperatures and decreased seasonal snow cover.[30] Wildfires are a natural ecological process in forests and tundra ecosystems, yet as the climate warms they may burn more frequently, longer, and more intensely. A warmer climate also creates a more hospitable place for vectors such as non-native mosquitoes and ticks. These vectors may carry pathogens that cause vector-borne diseases.[31]

[29] https://adaptalaska.org/wp-content/uploads/2019-Anchorage-Climate-Action-Plan_ADOPTED.pdf
[30] Partain, J. L., and Coauthors, 2016: An assessment of the role of anthropogenic climate change in the Alaska fire season of 2015 [in "Explaining Extremes of 2015 from a Climate Perspective"]. Bull. Amer. Meteor. Soc., 97 (12), S14–S18.
[31] Caminade, C., McIntyre, K. M., & Jones, A. E. (2019). Impact of recent and future climate change on vector-borne diseases. *Annals of the New York Academy of Sciences*, *1436*(1), 157-173.

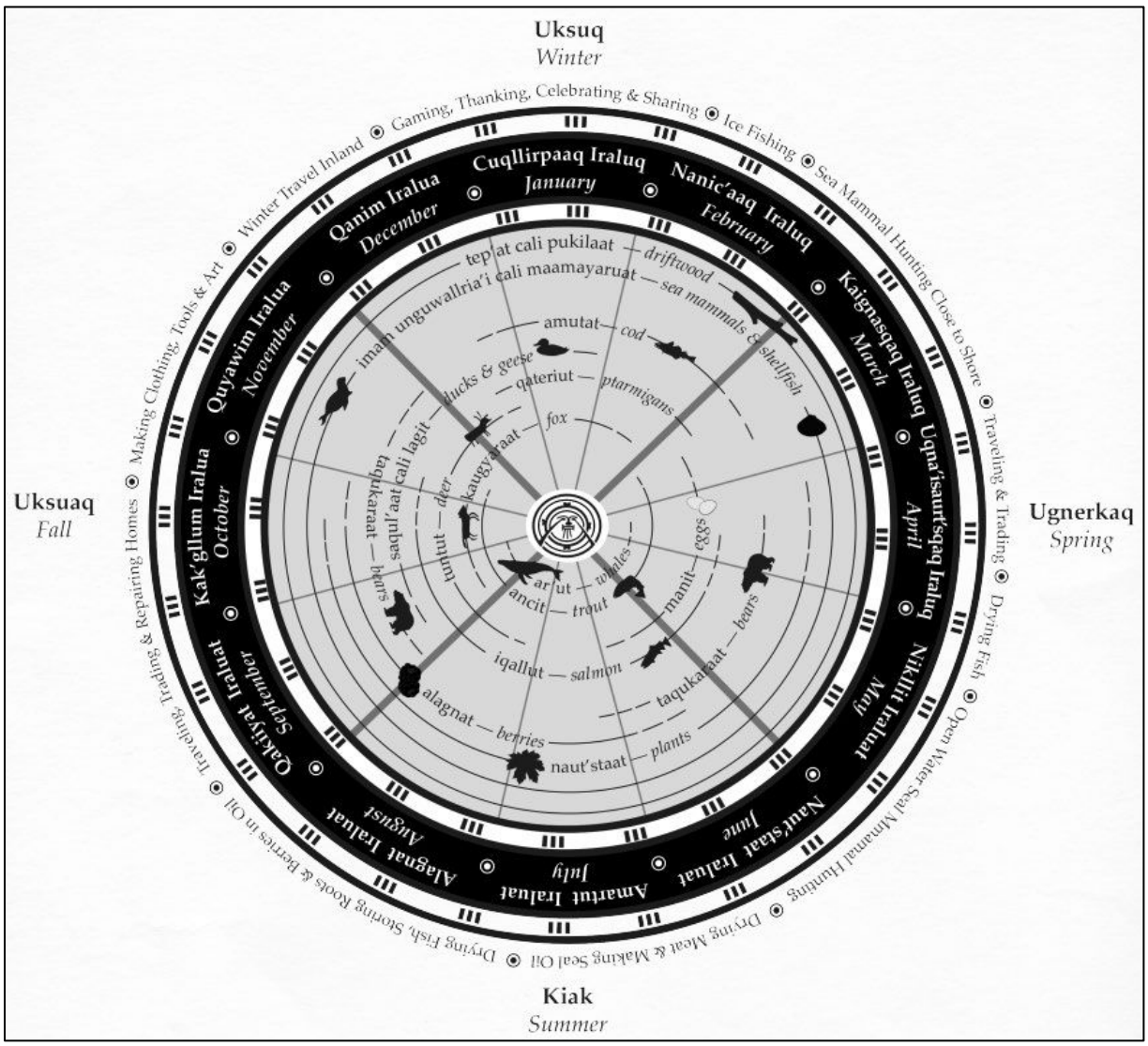

Figure 9. The Alutiiq cycle of life in the community of Karluk, located on the southwest shores of the Kodiak Archipelago.[32]

[32] Alutiiq Museum, Alisha Drabek

ADAPTATION STRATEGIES

Photo credit, Hallie Brown

ADAPTATION STRATEGIES IN KODIAK

The strategies outlined below reflect the Kodiak Tribes' deep-rooted connection to the land and their commitment to taking a holistic approach to climate adaptation. Rather than isolating or prioritizing individual resources, the Tribes recognize that all elements of the environment are interconnected. This worldview, central to Indigenous knowledge, emphasizes that changes in one area of the ecosystem inevitably affect the whole. Therefore, the Tribes have chosen to organize adaptation strategies into broad categories that address climate concerns in an integrated and systemic manner, reflecting the belief that the health of the environment, the community, and cultural practices are all interconnected.

This holistic approach ensures that the solutions put forth are sustainable and reflect the values of reciprocity and respect for the natural world. By not prioritizing one resource over another, the Kodiak Tribes aim to maintain balance and harmony within the environment, recognizing that everything, plants, animals, water, air, and people, is part of a larger, interconnected system. This method also honors traditional knowledge, which has been passed down for generations and teaches that caring for the environment as a whole is essential for the continued health and survival of the community.

Through this framework, the Tribes are better positioned to adapt to the complexities of climate change, ensuring that their cultural values, subsistence practices, and environmental stewardship continue to thrive in the face of new challenges. By taking a holistic and interconnected approach, the Kodiak Tribes are able to address climate impacts in ways that preserve the integrity of their environment, culture, and community for future generations.

KANA has worked with the ten regional Tribal communities to identify these following adaptation strategies, but more exist than can be detailed. The adaptation strategies are currently broken down into five categories: monitoring, cultural revitalization, education and outreach, restoration and conservation, and further capacity building. This is a living document; we are in the process of changing this plan from species specific adaptation strategies to broader categories that do not prioritize species of higher noted concern to community members. These strategies need more consideration for future work, funding, and support. As priorities and concerns shift, we will update these adaptation strategies to fit the needs of the Kodiak Tribes. Following the adaptation strategies are four focus areas of particular interest where we can implement the adaptation strategies listed. These include: shellfish, salmon, berry patches, and medicine.

Monitoring

1. Monitor for changing ocean chemistry and ocean acidification at or near important or traditional shellfish harvesting beaches.
2. Monitor for HABs and paralytic shellfish toxins at or near shellfish harvesting beaches.
3. Conduct shellfish biomass surveys at traditional harvesting beaches.
4. Continued and expanded monitoring of important salmon spawning rivers, lakes, and streams for environmental changes and contaminants.
5. Initiate citizen science monitoring programs to track the changes to berry patches and berry yield across the Kodiak Archipelago.

Cultural Revitalization

1. Implement clam gardens in Kodiak villages.
2. Language revitalization
3. Cultural Tourism
4. Teaching and documentation of traditional medicinal plants

Education and Outreach

1. Teach and implement sustainable harvesting methodologies.
2. More research and understanding into what medicinal plants exist in Kodiak, what their habitats are, and how the plant population can be better supported.

Restoration and Conservation

1. The eradication of the invasive Signal Crayfish in Buskin Lake. [33]
2. The management of invasive plant and wildlife areas that are overtaking previously healthy berry patches.

Further Capacity Building

1. Co-management of marine mammals with Kodiak Tribes and agencies like U.S. Fish and Wildlife Service and the National Marine Fisheries Service.
2. The co-management of salmon rivers with federal, state, and local regulatory agencies and Kodiak Tribes.
3. Improved land access and resources to increase accessibility of important cultural and subsistence areas.
4. Hydroponic farms and greenhouses that can cultivate traditional, medicinal plants.

[33] https://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=884

MAMAAYARUAT | SHELLFISH

Many species of shellfish are harvested year-round; for this section, we will focus specifically on cockles, razor clams, surf clams, littlenecks, butter clams, and blue mussels. These are the most commonly harvested bi-valves in the Kodiak Archipelago.

Despite being able to harvest year-round, many restrict this harvest to winter months or, *"months containing the letter r"* to reduce the risk of paralytic shellfish poisoning, this knowledge being passed down from generation to generation. Research and monitoring has started to paint a different picture, however, suggesting the presence of high levels of paralytic shellfish toxins earlier into the spring and later into the winter. It is of great concern that with projected warming conditions, shellfish will become increasingly unsafe to eat.

Many residents no longer harvest shellfish out of fear of paralytic shellfish poisoning. Historically, Kodiak has been known as a "hotspot" for paralytic shellfish poisoning, and unfortunately many communities have discontinued harvesting bi-valves due to the deaths of friends and family as a result of consuming toxin-containing shellfish. This discontinuation of shellfish harvesting is a tremendous loss of food source, but it is also damaging to the human, cultural, and spiritual health of Kodiak Tribal members.

Observed Changes:

1. A population decline, along with smaller or younger shellfish requires harvesting greater quantities.
2. A shorter harvesting season due to HABs, and increased risk of paralytic shellfish poisoning.

Community Concerns:

1. Shellfish are being over-harvested and the shellfish available for harvest are smaller.
2. A change in ocean chemistry (ocean acidification, or a decrease in seawater pH) causes shellfish difficulty to grow.
3. HABs are occurring earlier in the spring and later in the fall.
4. Warmer ocean temperatures create favorable conditions for HABs.
5. A rise in the sea otter population which could have significant ecological impacts, influencing the balance of marine ecosystems, specifically in regards to shellfish.

Proposed Adaptation Strategies:

6. Co-management of marine mammals with Kodiak Tribes and agencies like U.S. Fish and Wildlife Service and the National Marine Fisheries Service.
7. Monitor for changing ocean chemistry and ocean acidification at or near shellfish harvesting beaches.
8. Monitor for HABs and paralytic shellfish toxins at or near shellfish harvesting beaches.
9. Conduct shellfish biomass surveys at traditional harvesting beaches.
10. Implement sea gardens, including clam gardens, in Kodiak Villages.
11. Teach and implement sustainable harvesting methodologies.

Helpful Resources:

1. The Alutiiq Museum's mission is to "preserve and share the heritage and living culture of the Alutiiq people" and they have many programs focused on Alutiiq cultural revitalization, and education. They also have a network of talented Alutiiq artists. Working with an organization like the Alutiiq Museum to preserve the knowledge of sea otter harvesting and work with their network of traditional Alutiiq artists on sea otter crafts and wares.
2. Chugach Regional Resources Commission currently has a marine mammal management program and is actively working on the co-management of marine mammals in their region. This would be a great organization to connect with on the establishment of a program of this caliber.
3. There are many organizations and Tribes in the State of Alaska that are working on ocean acidification monitoring (Alaska Ocean Observing System). While there is currently some monitoring of ocean acidification taking place by KANA and Kodiak Tribes, a large and consistent network is challenging. Additional funding is needed to continue this program.
4. Continuing to monitor for HABs in the Kodiak Archipelago will be vital to the safe consumption of shellfish. KANA monitors multiple beaches on the Kodiak Road System as part of the Alaska Harmful Algal Bloom Network. Finding funding to continue and expand this network to the villages in Kodiak consistently would be the next step so that Tribal members can receive the necessary equipment and training to monitor in their community.

5. Many communities are unsure of the shellfish populations at their traditional harvesting beaches; conducting biomass surveys on a yearly basis would allow population tracking in the face of climate change. KANA has worked in the past with Sitka Tribe of Alaska and Sun'aq Tribe of Kodiak to run these surveys at beaches on the Kodiak Road System.
6. Many Tribes in the Pacific Northwest are working on rebuilding or introducing sea gardens at appropriate beaches to provide a location of a healthy and sustainable shellfish population while reviving an important cultural practice.[34] The Indigenous Aquaculture Collaborative is working with Tribes to provide technical expertise on how to implement Sea Gardens in their community.

IGALLUT | SALMON

The Kodiak Archipelago is home to some of the most pristine salmon fisheries in the world; Tribal members rely on salmon for both income through commercial fishing, and subsistence to carry them through the winter months.

Tribes and communities on the island have noticed a decline in salmon returns to Kodiak rivers, along with changes in the timing of returns.[35][36] Changes in the quality, size, and texture of the salmon have also been observed. Research is being conducted on the effects of warming rivers on salmon spawning and the potential risk of paralytic shellfish toxins in many fish, including salmon, a better understanding of how climate change will impact salmon populations is necessary.

Observed Changes:

1. A decline in salmon returns to Kodiak rivers.
2. The quality and size of salmon harvested in Kodiak waters is decreasing.
3. The timing of salmon returns is changing across species.

Community Concerns:

1. Climate change and increased river temperatures are impacting ecosystem health and impacting adult salmon ability to spawn and juvenile salmon ability to survive.

[34] Groesbeck, A. S., Rowell, K., Lepofsky, D., & Salomon, A. K. (2014). Ancient clam gardens increased shellfish production: adaptive strategies from the past can inform food security today. *PloS one*, *9*(3), e91235.
[35] https://www.kmxt.org/news/2023-06-16/low-sockeye-numbers-prompt-buskin-closure
[36] https://www.kmxt.org/news/2024-07-30/adf-g-commissioner-concerned-about-historically-low-king-salmon-in-kodiak-island-river

2. Warming waters and an increase in HABs could increase the risk of paralytic shellfish toxins in salmon.
3. Invasive Signal Crayfish are damaging salmon habitat and consuming salmon eggs in the Buskin River.

Proposed Adaptation Strategies:

1. Continued and expanded monitoring of important spawning rivers and streams for a change in environmental parameters and salmon populations.
2. The co-management of rivers with federal, state, and local regulatory agencies and Kodiak Tribes.
3. The eradication of Signal Crayfish in Buskin Lake.

Helpful Resources:

1. The U.S. Fish and Wildlife Service, in partnership with Kodiak Tribes and other entities, began a water-temperature monitoring network in the Kodiak Archipelago in 2014. This network monitored 27 stream sites and 25 lake sites. Every year a data report was released, often connecting increasing river temperatures to changed salmon behavior. The project lost funding but could be continued through other organizations and Tribes through additional funding sources. Additionally, this monitoring could be extended to other Tribally important salmon spawning rivers, lakes, and streams.
2. Giving Tribes the ability to co-manage fisheries with state and federal agencies is going to be essential for the future success of not just salmon, but the environment in general. Tribal members have been stewards of this land for thousands of years and their knowledge, experience, and observations must be considered when it comes to the management of these resources. Other states and agencies like the Washington Department of Fish and Wildlife have begun to successfully co-manage fisheries with the Tribes and could be a model for co-management of Kodiak fisheries.[37] There are also a variety of training opportunities and workshops like the Congressional Climate Camp that can better equip Tribes and communities to understand climate policy and review the legislative process, along with key areas and opportunities for climate mitigation and adaptation policy.

[37] https://wdfw.wa.gov/fishing/tribal/co-management#:~:text=Washington's%20salmon%2C%20steelhead%2C%20and%20other,federal%20government%20in%20the%201850s.

3. The eradication of Signal Crayfish in the Buskin Lake could be a great next step to improve the habitat of Kodiak Salmon. While the source of the signal crayfish to the Buskin is unknown, the invasive thrives in the Buskin. The signal crayfish feed on salmon eggs and additionally become more active in warmer water temperatures, creating a climate change concern. The Sun'aq Tribe of Kodiak in partnership with Kodiak Soil and Water Conservation District has established a program to eradicate signal crayfish from the Buskin, but more research is needed to understand the best methods of eradication and the full scope of their impact to the watershed. [38]

NUNAKUTAQ | BERRY PATCH

Many types of berries can be found on the Kodiak Archipelago. Commonly harvested berries include the salmonberry, blueberry, cloudberry, watermelon berry, low bush cranberry (lingonberry), and high bush cranberry.

In recent years, community members have reported that berry patches, across species, are disappearing or producing a lower yield of berries that also look much different than they used to (specifically the salmonberry). Observations also note that the time of year when berries ripen seems to change each summer, and is no longer reliable for harvest.

Observed Changes:

1. Berry patches are diminishing and becoming more and more inaccessible and/or sparse.
2. Berry bushes are producing a lower yield of berries and the ripe berries are of a lower quality.
3. There is a shift in the growing season, especially salmonberries, making it unpredictable when and if berries will be available.

Community Concerns:

1. The changing climate (increased average temperature, precipitation, and change in seasonality) may be impacting berry bush growth.
2. Lower-density salmon runs are depleting salmonberry patches of vital nutrients and produce a lower yield or quality of fruit. [39]

[38] https://sunaq.org/signal-crayfish/
[39] Siemens, L. D., Dennert, A. M., Obrist, D. S., & Reynolds, J. D. (2020). Spawning salmon density influences fruit production of salmonberry (Rubus spectabilis). *Ecosphere*, *11*(11), e03282.

3. The overgrowth of invasive and non-invasive plants, like alder, is limiting available space for berry patches.

Proposed Adaptation Strategies:

1. Citizen Science monitoring programs to track the changes to berry patches and berry yield across the Kodiak Archipelago.
2. Improved land access and resources to support the ability to reach inaccessible areas.
3. The management of other plants and wildlife areas that are overtaking healthy berry patches.

Helpful Resources:

1. More research and observations are required to conclude that berry bushes are diminishing in Kodiak. While a full-blown monitoring project might be most useful, it would require time, funding, and collaboration. Perhaps a better first step is to encourage the use of citizen-science monitoring programs like the Local Environmental Observer Network (LEO Network).[40]
2. Additional land access could be a way to help individuals who rely on this resource to continue to harvest a sustainable amount of fruit. This could mean increased access to commercially owned land or additional community resources like skiffs or off-road vehicles to reach areas not possible to access by foot.
3. Funding for a program to manage plants and wildlife areas would allow communities to manage some of those plants that are overtaking areas where berry patches are prominent. Programs like the Alaska Environmental Quality Incentives Program could be a funding resource that would support this strategy.

SUNGCAUTET | MEDICINE

When it comes to subsistence harvesting in Kodiak, people often think about fish, marine mammals, and terrestrial wildlife. Plants, however, provide subsistence and medicine. Medicinal plants are an important aspect of Alutiiq culture that should be highlighted when considering the effects of climate change.

Like other plants referenced in this adaptation plan, the concern for medicinal plants centers on their abundance and seasonal availability. Medicinal plants are no longer found in

[40] https://www.leonetwork.org/

places where they have been harvested for generations. While this may be linked to a changing climate, more research and observations are needed. A abundance of traditional knowledge about these medicinal plants is held closely by tribal members and Elders. Finding ways in which to better understand and help mitigate the impacts of climate change on medicinal plants should be approached cautiously and respectfully.

Observed Changes:

1. Medicinal plants are harder to find; they are not present in traditional locations or quantities.

Community Concerns:

1. The changing climate (increased average temperature, precipitation, and change in seasonality) may be affecting medicinal plants' ability to grow.

Proposed Adaptation Strategies:

1. Hydroponic farms and greenhouses that can cultivate traditional, medicinal plants.
2. More research and understanding about the medicinal plants in Kodiak, their what habitats need they have for survival.

Helpful Resources:

1. The Kodiak Archipelago Leadership Institute[41] is a non-profit that works with rural communities on agriculture, maricultural, and hydroponics, and may be able to assist efforts to grow and cultivate medicinal plants.
2. The USDA has funding for an Agriculture and Food Research Initiative[42] that includes research into "Plant Health and Production" and "Agriculture Economics and Rural Communities" which could fund efforts to research the medicinal plant populations in rural communities.

[41] https://www.kodiakleadershipinstitute.org/
[42] https://www.nifa.usda.gov/grants/programs/agriculture-food-research-initiative

CONCLUSION

Based on the information gathered, in order to adapt to a rapidly changing climate and increase coastal resiliency, further research, funding, and capacity will be crucial. Local observations and monitoring efforts will also be needed to help inform further adaptation strategies and needs. This Climate Adaptation plan is a living document and will continue to evolve and change just as the berries, salmon, and people that have shown remarkable resiliency through time across the Kodiak Archipelago.