

CLIMATE

in the Bering Strait Region



Center for Climate and Health

Observations and Lessons from Seven Communities



Written by

Mike Brubaker – Alaska Native Tribal Health Consortium

Kevin Zweifel - Norton Sound Health Corporation

Jennifer Demir - Norton Sound Health Corporation

Anahma Shannon – Kawerak, Inc.

Artwork – Khulan Bazarvaani

Design – Rich Design

Edited by – Birchbark Publishing

Technical Advisors

Mike Sloan – Nome Eskimo Community

Amos Brown -Native Village of White Mountain

Eric Morris -Native Village of White Mountain

Carol Oliver – Chinik Eskimo Community, Golovin

Toby Anungazuk Jr. - Chinik Eskimo Community, Golovin

Michelle Snowball – Native Village of St. Michael

Darlene Chiskok – Native Village of St. Michael

Aida Cheemuk - Native Village of St. Michael

Victoria Rotongan – Native Village of Unalakleet

Kendra Lee – Teller Traditional Council

Allen Atchak Sr. – Stebbins Community Association

Sharon Nayokpuk – Native Village of Shishmaref

Fred Eningowuk – Native Village of Shishmaref

Karen Murphy – U.S. Fish and Wildlife Service

Lori Verbrugge – U.S. Fish and Wildlife Service

Jacob Bell – Alaska Native Tribal Health Consortium

Jennifer Williamson – Alaska Native Tribal Health Consortium

James Berner M.D. – Alaska Native Tribal Health Consortium

John Warren PE – Alaska Native Tribal Health Consortium

Mike Black – Alaska Native Tribal Health Consortium

Gay Sheffield – UAF Marine Advisory Program Sea Grant

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Aida Cheemuk and Michelle Snowball inspect an erosion feature in St. Michael.



Fireweed, Tukaiyuk (local plant) and fishing gear in Golovin.



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Introduction

The Bering Strait region has long been characterized by permafrost and ice, an environment that was mostly cold and frozen. Human habitation in the region dates back some 10,000 years from the time of Beringia. While the ice ages covered most of North America with glaciers, Beringia was a vast grassland; a temperate refuge in an otherwise frozen north.

As the climate slowly warmed and glaciers retreated, the Bering Land Bridge provided a pathway for plants, wildlife and people to pass from Asia into North America. The people who reside in the Bering Strait today have lived in this region for at least 4,000 years. They include Inupiaq, Arctic coastal people who reside on the Seward Peninsula, King Island and the Diomed Islands. There are also Central Yup'ik living mostly south of Unalakleet, and Siberian Yupik on St. Lawrence Island.



*Tending to a grave site affected by erosion in St. Michael.
Photo courtesy of Michelle Snowball.*

Another great climate event is underway causing relocation of people and migration of new plants and animals to Alaska. The environment is rapidly changing and global warming brings impacts to all forms of life. This report is about the effects of a changing climate on the human environment and changes to communities and peoples' lives.

The best measures of change are the observations of people who live and work here, travel the trails, watch the weather, and harvest food from the land and sea. By listening, we learn the nature of



Local observations were discussed at the community meeting in White Mountain.

the changes that are occurring, and gain insight into the causes and specific implications to people and the adaptations that are being developed and used every day.

People of the Bering Strait are excellent observers of environmental change because of their local knowledge and expertise about the weather, wildlife, natural environment and resources. During this

project, residents shared their knowledge on why these changes are important and how change affects people's lives.

Observations were recorded in public meetings and interviews. This information has been interpreted through the lens of public health in order to determine potential health connections and the effects on the communities.

Communities

There are sixteen communities in the Bering Strait region, most are small with populations of less than 1,000. Nome, with approximately 3,600 people, is the regional hub and location of the hospital and college.

Most communities are located along the Bering Sea coast, but there are also island communities like Diomedede, Gambell, King Island, Savoonga, Stebbins and St. Michael. Shishmaref, furthest north, is just below the Arctic Circle, located on a barrier island. There is also the river community of White Mountain.

All of the communities practice subsistence and depend on the harvest of wild resources from the land and sea. Most are remote and lack access to a linking road system. In winter, communities are typically connected through a network of staked trails. Water

sources are varied but include lakes, rivers, snowmelt and groundwater.

Each community is unique, with different economies, infrastructure, services and sources for food and water. All are very expensive to live in due to remoteness, the high cost of fuel and transportation, the extreme environment, and small populations. Communities are challenged not only in adapting to a new climate, but in finding efficient and affordable systems that will encourage sustainability.



View of White Mountain from the Fish River.

The Bering Strait divides North America from Asia, and the Bering Sea from the Chukchi Sea. It was named for Vitus Bering, the Danish explorer who as a Russian officer explored the area in the early 1700s.

In Alaska, the Bering Strait also refers to a region encompassing the Seward Peninsula and Norton Sound. It is a vast area, approximately 22,000 square miles and includes diverse landscapes -rocky shores and sand beaches, low lying barrier islands, tundra, grasslands and wetlands. There are also highlands of willow and alder, treeless mountains of rock and tundra, and rivers lined with cottonwood and spruce forest.

The region is rich in history from the mammoth hunters at the beginnings of the human age, to miners, fishermen, and the enduring caribou and sea mammal cultures which make up the Bering Strait peoples of today.

Seven communities in the Bering Strait region were included in this report.



*“In my own lifetime, I have seen the coast erode 30-50 feet.
I remember the village had a street all the way down
the beach. Now the buildings want to collapse.”*

— Tom Punguk, Golovin

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View of the old town in Golovin.



GOLOVIN is a coastal community located on a point between Golovnin Bay and Golovnin Lagoon. Surrounded by water on three sides, it is a good place to fish, hunt seal and birds, and harvest shellfish. In the hills behind the village, people hunt moose and caribou, and find excellent berry picking. The water comes from a stream and is piped to most homes.

Golovin was named for Captain Vasili Golovnin, an officer of the Russian Navy. But there is also an older name - “Chinik” for the settlement that pre-dates the Russian period. It is the name still used today by the tribal government. In 1887, a church and school were established, and the Dexter Trading Post a few years later. Golovin became an important supply point for area mining operations.

Today there are approximately 170 people in Golovin. The area is vulnerable to coastal storms, ivus (ice surges), and flooding. The community is increasingly looking east toward the bluff and higher land for development, and actively pursuing funding for a rock revetment wall to protect the town center. Erosion is a concern for coastal areas, riverbanks, the old dumpsite and historic grave sites.



An Iditarod musher on bare, snowless ground in March, 2014.
Photo courtesy of Toby Anungazuk Jr..



Boys playing basketball on the wooden court.

SHISHMAREF is located on a barrier island along the Chukchi Sea. For centuries, it has been an important hunting and fishing site. In 1816, Otto Von Kotzebue named the inlet “Shishmarev,” after a member of his crew. The original name is Kigiktaq.

In 1900, Shishmaref became an important supply center after gold was discovered. Today, Shishmaref has a subsistence economy and residents actively harvest food including oogruk (bearded seal), seal, walrus, tomcod, smelt and salmon, caribou, moose, wild plants and berries. The water source is a snow melt pond and residents go to a washeteria to buy treated water. Some people collect ice and rain water for drinking. There is no piped system so residents rely on five-gallon “honey buckets” for sewage disposal.

Shishmaref is vulnerable to storm surges, ivus (ice surges) and flooding. This has increased in recent years due to changing ice and ice season. It is one of Alaska’s priority communities for erosion control. A rock revetment wall has been constructed, but the airstrip, dump, sewage lagoon, bay side of town, subsistence camps, and some grave sites all remain unprotected. There is high risk for flooding and pollution from waste sites.

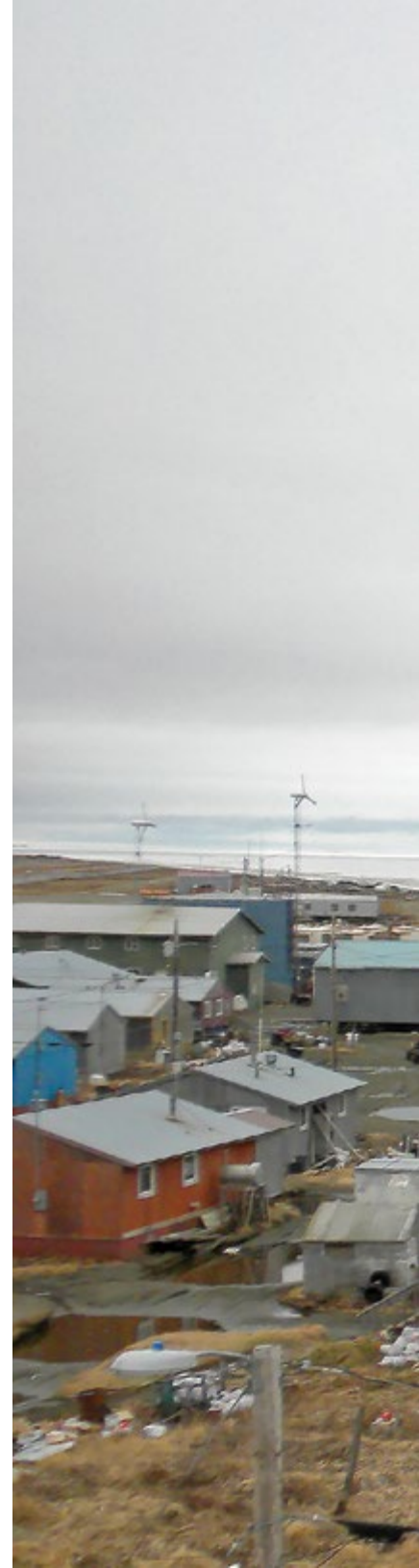
Hunters speak about new subsistence challenges including diminishing sea ice and a shorter ice season. Food security is another priority because of changes in harvest and concerns about the health of oogruk, seals and other wildlife.



Subsistence harvest of oogruk (bearded seal).



Less sea ice means a longer boating season.



*“Usually we are butchering seals on the ice,
but this year it is too rotten. Travel on the ice
has changed, too. It is dangerous.”*

— Ben Kokeok, Shishmaref



*“Over the years property has been destroyed by erosion.
Camps fell in the bay. We’ve moved some up on the bank.”*

— Shirley Martin, St. Michael





ST. MICHAEL is located on the east side of St. Michael Island. For almost 200 years it was a supply hub because of its protected harbor and access to the Yukon River. The waterfront is scattered with remnants of history, rusting sternwheelers, and sparkling beach glass.

In 1833, the Russian-America Company established Redoubt St. Michael near the Native village of Taciq. It was a fortified trading post and the northernmost Russian settlement in Alaska. Fort St. Michael, a U.S. military post, was established in 1897 and as many as 10,000 people lived here during the gold rush. Today, St. Michael has a population of about 475, mostly of Yup'ik descent. Seal, oogrük, beluga, moose, herring, trout, tomcod, salmon, black fish, white fish, geese, cranes, swans, ducks, a variety of berries and plants are important foods. Reindeer are managed locally and provide food and income. Water is piped from a volcanic lake in the interior of the island.

In recent years, St. Michael has experienced flooding related to changes in the ice conditions and storm events. Erosion has undermined the revetment wall protecting the old airstrip and has exposed grave sites in the village. Erosion has also resulted in the loss of shoreline and of infrastructure including homes.



*A St. Michael house threatened by erosion.
Photo courtesy of Michelle Snowball.*

STEBBINS is a coastal community located eight miles west of St. Michael by road on the same island. Stebbins is on the beach between two rocky bluffs that separate the Bering Sea from wetlands and the island's interior. Relocation to higher ground is an option as there is road access to land above the flood zone.

The name Stebbins was first recorded in 1900. Prior to that the village was known as "Tapraq." Stebbins today has a population of about 590, largely people of Yup'ik descent. Seal, beluga, moose, reindeer, fish, and berries

are important staples. Drinking water comes from a volcanic lake in the interior of the island.

Stebbins is vulnerable to flooding from fall and winter storms and sea level rise. Damage to infrastructure and pollution from flood events are priority issues.



Reindeer are an important resource for Stebbins.



*“We are concerned about sea level. With strong west winds,
our whole village can be below sea level.”*

— Nancy Raymond, Stebbins



*“The storm last fall has made part of the point an island.
People can’t fish from the point like they used to.”*

— Kendra Lee, Teller





TELLER is located on a sand spit between Port Clarence and Grantley Harbor. It is connected to Nome by a 64-mile gravel road, and is across the bay from the community of Brevig Mission which is accessible by boat. Formally established in 1900, Teller was named for Senator and Secretary of State, Henry Moore Teller. It quickly grew into a trading center with a population of about 5,000.



Today Teller has a population of about 250, including many residents originally from the village of Mary's Igloo. Seal, beluga, fish, reindeer and a variety of plants and berries are important food resources. The community gets water from Coyote Creek, a mountain stream. Residents haul water from a washeteria and honey buckets are used for sewage disposal.

Teller is vulnerable to flooding from ocean storms. A storm in 2013 damaged the sea wall and eroded the shore right to the edge of the graveyard. This same storm also dredged a second channel through the spit used to access Brevig Mission. Permafrost thaw is a contributing factor to the erosion problem. Without prevention measures, the graveyard will fall onto the beach in a matter of years. New homes are located on the hill, out of the flood zone, but most of the infrastructure is located on the spit.



Girls walking through erosion-threatened grave sites.

UNALAKLEET is located at the mouth of the Unalakleet River where there is evidence of human occupation for more than 2,000 years. Unalakleet, which in Yupik means “from the southern side,” has long been a trade center for the Kaltag Portage, a winter travel route to the Yukon River. The Russian-American Company built a post here in the 1830s.

Today with a population of almost 700, it is the second largest community in the Norton Sound area. People live a traditional subsistence lifestyle with fish, seal, caribou, moose, and bear as important food resources. Water comes from a small mountain-fed stream and is piped along the coast to the community. A wind farm supplements the local diesel power system. There are several stores, a restaurant and coffee house, school, clinic and a paved runway with direct flights to Anchorage.

Unalakleet is also vulnerable to storm surge and flooding. In 2013, storms caused serious erosion and damage to the water line. A rock revetment wall was built and relocation of the community water supply is being planned. New construction is occurring on the hillside above the flood zone.



Boats along the Unalakleet River.



Wind offsets diesel costs and reduces carbon footprint.



“The water line runs four miles from Powers Creek. It is old and vulnerable to thaw and erosion from winter storms.”

— Victoria Kotongan, Unalakleet



“Growing up, the river used to always freeze by the first week in October. Now it does not freeze until November.”

— Rita Buck, White Mountain





WHITE MOUNTAIN is located on the east bank of the Fish River, near the head of Golovnin Lagoon. It is one of the few upriver communities in the region and is located in an area characterized by mountains and spruce forest.

Historically, this was an Inupiat fish camp called Nutchirviq. White Mountain grew during the gold rush of 1900 and a warehouse was built by Charles Lane for his claim in the Council District. After the Spanish flu epidemic, White Mountain had an orphanage, then in 1926, an industrial school.

Today White Mountain is a subsistence community with a population of about 200. Fish, caribou and moose are important foods, and residents hunt seal downriver in Golovnin Bay. Water comes from a well and there is piped water and sewer service.

Residents in White Mountain describe changes such as altered timing of the seasons, unusual weather conditions, rain in the winter, and greater intensity and duration of rain events in other seasons. Changes in the harvest of subsistence resources, spruce bark beetle, and bank erosion are also important topics.



Firewood from beetle kill spruce.



*White Mountain in winter.
Photo courtesy of Traditional Council.*

Changing Climate

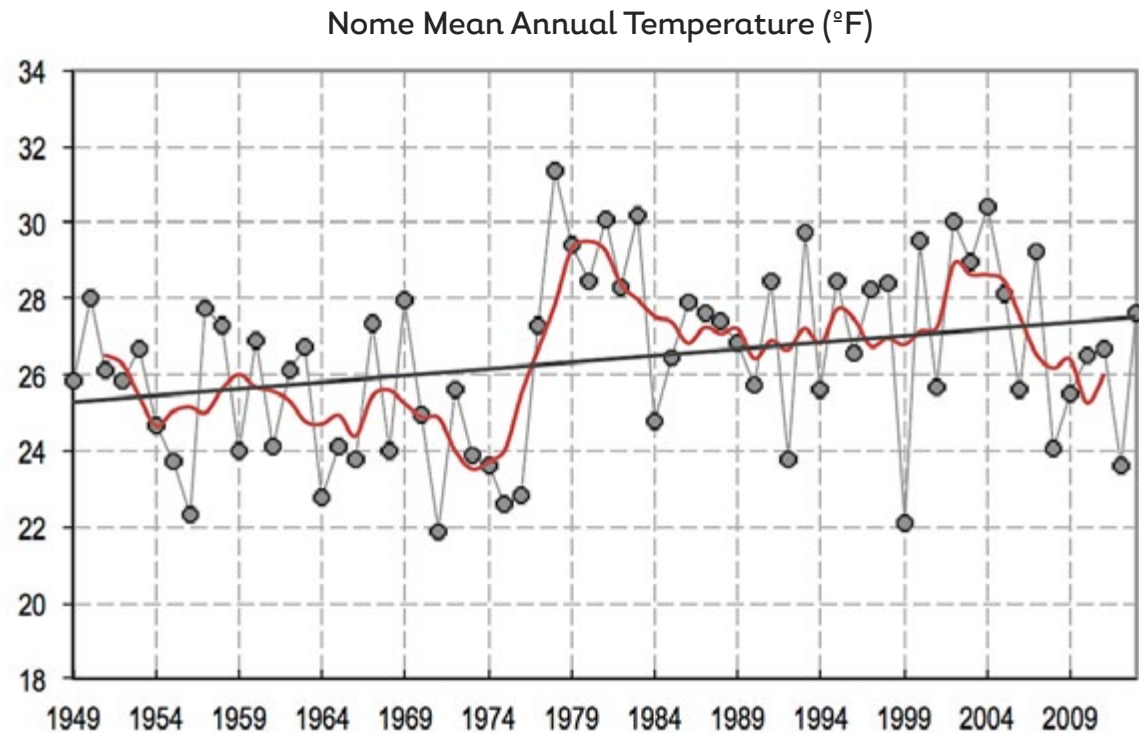
“Winter used to be winter. Freeze up happened in October. Guaranteed. Before break up the bay ice froze to four or five feet thick. That is the way it was, we lived with that weather.”

— Tom Punguk, Golovin

“Climate” is a term used to describe long-term conditions, as opposed to day to day weather. But describing climate is becoming more difficult because conditions are rapidly changing.

A wide range of effects are being observed; not only temperature and precipitation but also the timing of seasons, land and water conditions, and the frequency, type and intensity of weather. To understand the new climate, a discussion about the traditional climate is necessary.

The longest weather records are from Nome where the National Weather Service operates a station. January temperatures have historically ranged from -3°F to 11°F. July temperatures typically ranged from 44°F to 65°F. Average annual precipitation was 18 inches with 56 inches of snowfall. Temperatures can be colder during the winter further inland, and warmer during the summer.



*Nome average annual temperatures have been increasing since the 1940s.
Alaska Climate Research Center UAF*

Climate models developed by the UAF Scenario Network for Alaska and Arctic Planning (SNAP) provide temperature and precipitation trends based on past weather records and project future conditions through 2099. Nome's mean average annual temperature has increased by 2.6 degrees over the past 60 years. Comparing two periods, 1960–1990, and 2010–2012, the average temperature in Nome has increased in every month. Precipitation has increased in 10 months of the year.

Storms

Alaska coastal villages are located in the very best places for harvesting, preparing, and storing local, Native foods. Because of their proximity to the ocean, Shishmaref, Teller, St. Michael, Stebbins, Golovin and other coastal communities are vulnerable to storms and flooding.

Historically, freezing temperatures have helped to temper the power of coastal storms. Sea ice buffered wind swell, and ice protected the shoreline. Today, the ice season is much shorter and thawing shorelines are increasingly vulnerable to storms and other drivers of erosion.

In November 2011, an extra tropical cyclone with hurricane force winds resulted in one of the most powerful storms on record.

A storm surge of over eight feet caused widespread damage to approximately 37 communities on the coast. In Nome, breaking waves flooded a sewer and water treatment plant and 165,000 gallons of raw wastewater was discharged into the small harbor. In Golovin, the ocean flooded most of the community.



2014 summer view of Golovin from similar perspective as storm photo on opposite page.

“There have been more frequent and more severe fall storm surges. They call them 100-year storms, but we have had three or four in the past ten years.”

— Jack Fagerstrom, Golovin



Changing Environment

“There is erosion along the trail to Camp Kitchavik and it appears to be getting larger. There is an odor of noxious gases being released — it smells like sulfur.”

— Carol Oliver, Golovin



Land Change

One of the most important climate change impacts in the Bering Strait Region is thawing permafrost. A landscape once frozen and resilient is now thawing and more fragile. Related impacts include accelerated erosion of rivers and shorelines, draining of lakes, sink holes, and land slumps.

Maps developed by UAF, Geophysical Institute show soil temperature at a depth of one meter. Blue indicates permafrost-sustaining temperatures and red shows conditions that are too warm. By comparing maps from two periods, 1980–1989 and 2000–2009, we see the soil temperature change occurring across Alaska. Thawing permafrost was observed in all seven communities.

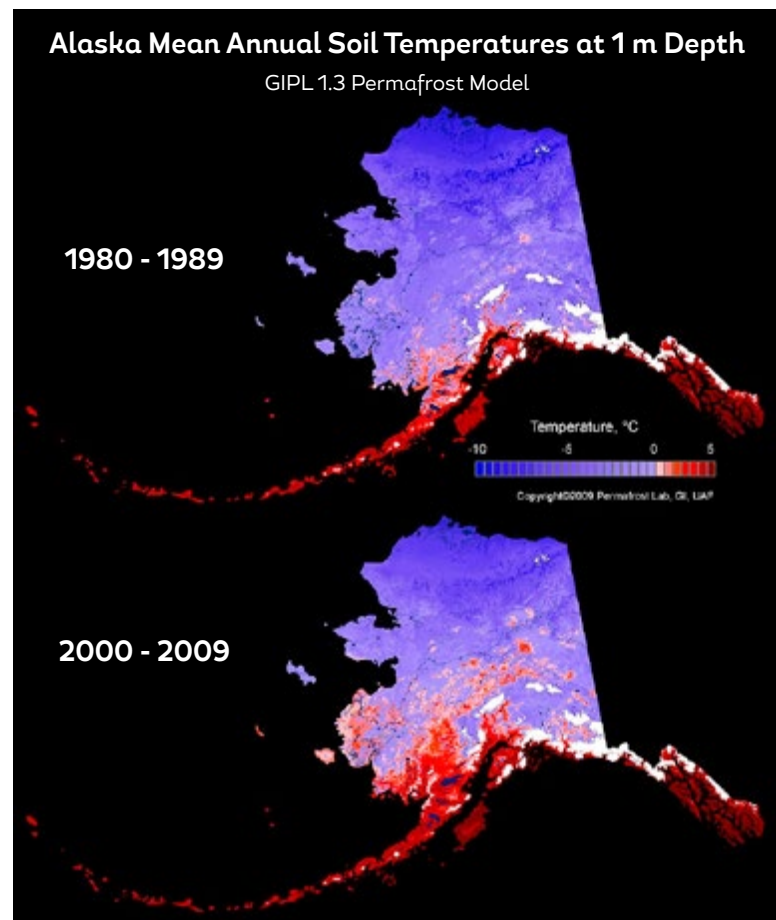


Thawing permafrost and an ice wedge are exposed below the tundra.

Opposite: Erosion feature on trail to Camp Kitchavik near Golovin.

“When picking berries I saw a place where the ice is just melting. You can see ice, mud and a big room full of water.”

—Thomas Cheemuk, Sr., St. Michael



Source: Scenarios Network for Alaska and Arctic Planning (SNAP) and the Geophysical Institute of the University of Alaska, Fairbanks.

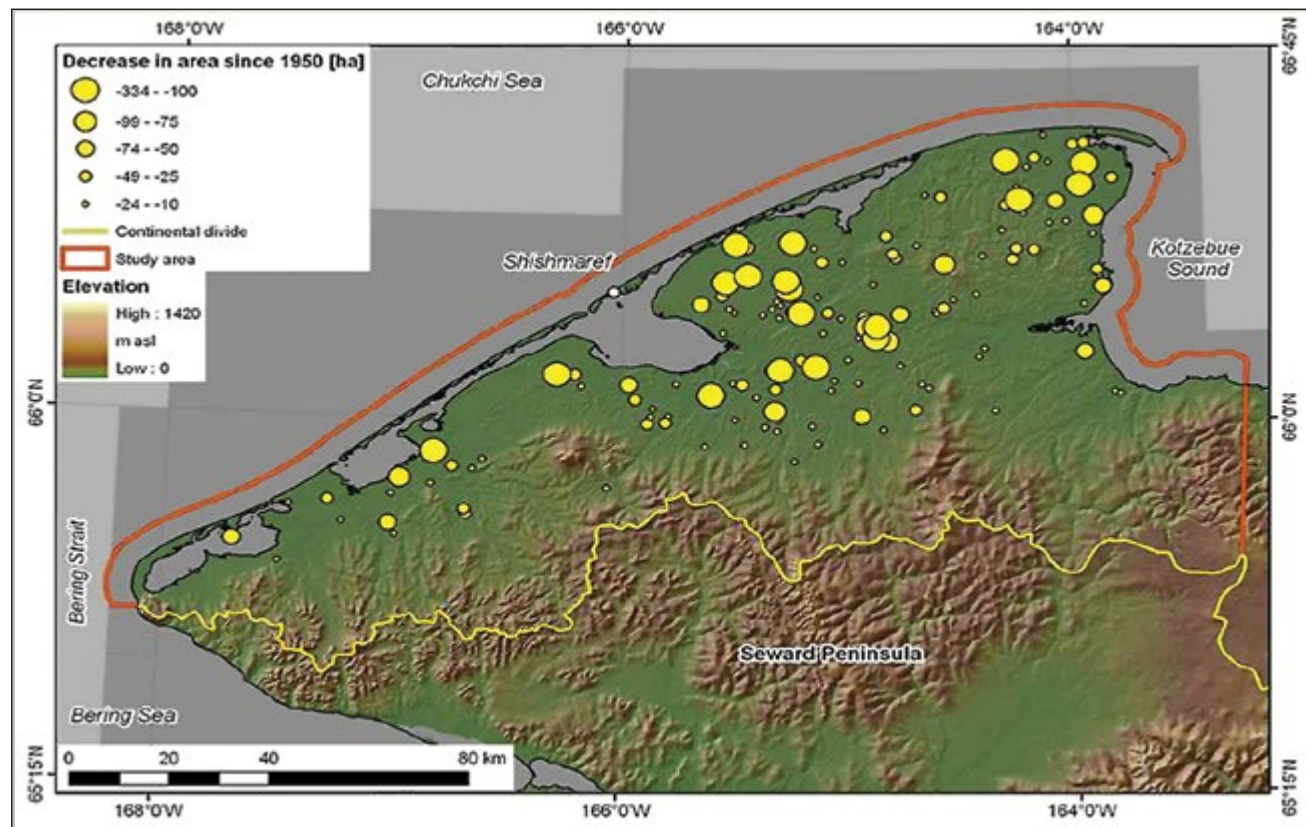
**“Even the lakes are drying up. They used to be full of water.
We used to go up there and pick the greens in the lake.
The place is dry now.”**

— Florence Doyle, Golovin

Lake Change

The Bering Strait region has thousands of small lakes which provide habitat for fish and birds. Reservoirs and lakes supply drinking water for some communities. Increases in water temperature have resulted in algal blooms raising new questions about water quality for fish and wildlife. As temperatures increase, monitoring water levels and water quality is recommended.

Seasonal changes are also occurring, including the timing of breakup and freeze-up. A longer warm season provides more time for operators to make water and for performing maintenance. With less snow pack or a warm, dry summer, shallow lakes dry out and, in some cases, disappear entirely. This means less lake habitat and an increase in grasslands. Thawing permafrost beneath lakes can result in draining as the thaw zones increase. On the Northern Seward Peninsula, lake area has decreased by 20% since 1950.



Researchers from the Alfred Wegener Institute and UAF Geophysical Institute used infrared satellite photos of lakes on the Northern Seward Peninsula to show the decrease in lake size since 1950. Warmer, longer summers have dried out some lakes and others have drained as the permafrost beneath thaws.

Map courtesy of Guido Grosse, Alfred Wegener Institute.

River Change

Rivers are travel corridors for fish and wildlife, and for people who travel by boat in the summer and snowmachine in winter. Today, many rivers in the north are becoming wider, more shallow, and muddier, as a result of permafrost thaw. Residents report changes in the time of breakup and freeze-up, in water depth, in the condition of river banks, and in water quality.

The erosion season for rivers has historically occurred mostly in the spring, related to ice

scouring, snow melt and bank slumping following thaw. Permafrost thaw makes for a longer erosion season and results in episodes when large amounts of bank enter the river. The increased erosion affects sediment load, turbidity, water quality and fish habitat.

Drying of tributaries raises concerns about fish migration. Hunters report that shallow conditions have in some instances prevented access to harvest areas. High tides that surge further up river may result in periodic improvements for inland access. Monitoring of river level and conditions will assist in understanding these changes.



Eroding river bank outside Golovin.

“Across from our family camp there is a bank that is sunk way in. There is a lot of erosion. The water is not as clear as it used to be.”

— Irene Aukongak Golovin



Vegetation Change

Warming soil conditions are changing vegetation and species. In some areas, shrubs have been reported growing taller while tundra plants with shallow root systems retreat.

Rapid growth of willows has been reported. Willows collect snow which provides insulation and encourages root growth. The emergence of new animal species like porcupine in some areas may be an indication of changing vegetation in river corridors. Increases in the beaver population have been reported near Golovin, Shishmaref and White Mountain.

Residents also describe the emergence of new types of plants they have not seen before. These changes raise questions about impacts on local vegetation and food harvest. Potential benefits include increasing browse area for moose. Problems include declining harvest areas for berries. Concerns raised about pest problems including spruce bark beetle near White Mountain. Beetle infestations have been associated with stressed forests related to warming and drought. Increased wildfire risk is a concern, while abundance of firewood has been a benefit of such change.

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“The trees are getting pretty dry. We have more beetles than we can handle.”

—Philip Brown, White Mountain

Coastal Change

In 2008, the Army Corps of Engineers completed an erosion survey of 128 communities across Alaska. Most had river erosion, but 17% were affected by coastal erosion. Five communities in the Bering Strait Region were included on a list of 22 “priority action communities” including Golovin, St. Michael, Shaktoolik, Shishmaref, and Unalakleet. All of these are coastal communities. In October 1997, a severe storm in Shishmaref eroded more than 30 feet of the north shore, requiring 14 homes and the National Guard Armory to be relocated. Five additional homes were relocated in 2002. Other storms have continued to erode the shoreline at an average of three to five feet per year. In the Fall of 2013, the north shore lost another 60 feet, damaging the road and forcing subsistence camps to relocate. High water in the absence of storms is also changing the coast as thawing soils are easily eroded.

“We have moved all the drying racks back this spring. We lost over 60 feet of beach just since last year.”

—Ben Kokeok, Shishmaref



Huge blocks of tundra and turf remain after the underlying permafrost thaws away in Shishmaref.

Sea Change

Sea ice in the Bering and Chukchi seas continues to change, diminish, and retreat. Compounding the problem are changes in the wind conditions. The right wind is crucial for ice-based hunting. A sustained west wind will “ground” ice and cause it to build into large, stable, stacked sheets attached to the sea floor. In the springtime, an east wind will blow and create a “lead” or passage of open water on the ocean side of shorefast ice. In recent years, wind and poor ice conditions have at times delayed or prevented hunting.

Changes in ocean temperature, salinity and pH (acidification) may stress marine species, cause illness, and change range or availability of species for harvest. Changes in the timing and type of algae can affect the marine food chain and introduce harmful algal blooms, such as those which cause paralytic shellfish poisoning (PSP). No cases of PSP have yet been reported in the region. Monitoring is recommended to provide early detection of emerging food safety concerns.



Poor ice conditions and open water makes travel conditions difficult.

***“People fall through the ice
because it is no good, or thin.
They go out and the ice is fine,
when they come back it is rotten.”***

— Gwen Nayokpuk, Shishmaref

Ice Change

Residents rely upon local and traditional knowledge to read ice conditions. Climate change has brought new and increasing hazards. Ice conditions on land and at sea are less predictable and the length of the ice season has been decreasing. Permafrost thaw has caused methane seeps which can affect ice formation and result in thin spots under lake and river ice.

Communities report increases in incidents of people falling through the ice. Especially alarming are those events involving elders who are the most knowledgeable about ice conditions. Falls through ice result in injuries, loss of equipment, and drowning. Travel on poor ice is stressful for hunters and for travelers. Education about safety in changing ice conditions is important. Kawerak, Inc. has written a handbook about travel on sea ice, sharing knowledge from many elders in the region.



Going out to the pack ice.
Photo courtesy of Gay Sheffield.

“They used to camp near the ice edge but now it’s scary and unpredictable. We have a lot of springs now where unless you really know what you are doing, you might get stuck.”

—Bobbi Andrews, St. Michael



Changing Communities

“Storms and thawing are causing a lot of changes.
Graves by the north beach are eroding and sliding down hill.”

— Michelle Snowball, St. Michael

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Thawing and storms have eroded the coast in St. Michael where sternwheelers were stored after the gold rush era of the early 1900s.

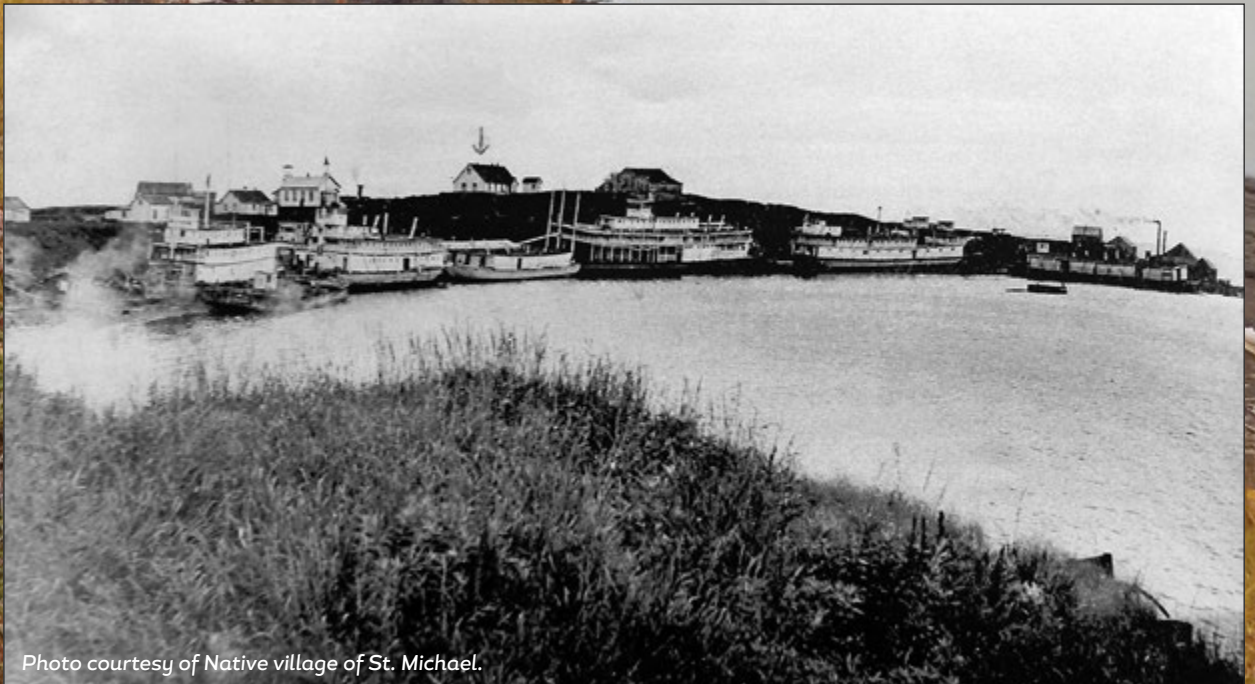


Photo courtesy of Native village of St. Michael.

Burial Sites

Graves in the Bering Strait Region are often located on a bluff with a view of the ocean. As the ground thaws and shorelines erode, coastal communities have watched as the beach moves closer to these sites.

In St. Michael, boxes of remains have already been collected from an eroding bank, leaving the tribal council with the task of finding appropriate methods for moving and reburying the remains. Concerns over infectious disease have been expressed related to remains from past epidemics.

During this survey, eroding and threatened grave sites were recorded in Shishmaref, Golovin, Teller, and St. Michael. Development of regional guidance on culturally appropriate and sanitary methods for grave relocation is recommended.

“When we get a west wind, we get erosion on the Port Clarence side of Teller. It is eroding the bluff and the grave sites.”

—Lilly Okbaok, Teller



The eroding coastline threatens burial sites in Teller.

Subsistence

Throughout the region, many impacts on subsistence were recorded, raising concerns about food security to new opportunities for food harvest. Berries are climate sensitive and harvest variability is related to changes in growing season, precipitation and temperature. Residents report increased variability between good and poor harvest years.

Food preservation is also climate sensitive, and many communities related how wet conditions have interfered with food drying. Hunters reported caribou being absent or arriving during the fall rut. Late freeze-up has interfered with ice fishing and travel. Warmer conditions can affect wildlife health, and recent outbreaks of avian cholera and seal illness are still unexplained.

In the new climate, endemic species are being replaced by new species. The timing of harvest is altered and hunters need to be more flexible to accommodate current conditions, rather than traditional seasons. Changes to the sea and land require new methods of travel, and caution about new hazards, and extreme and unseasonable weather. New practices may also

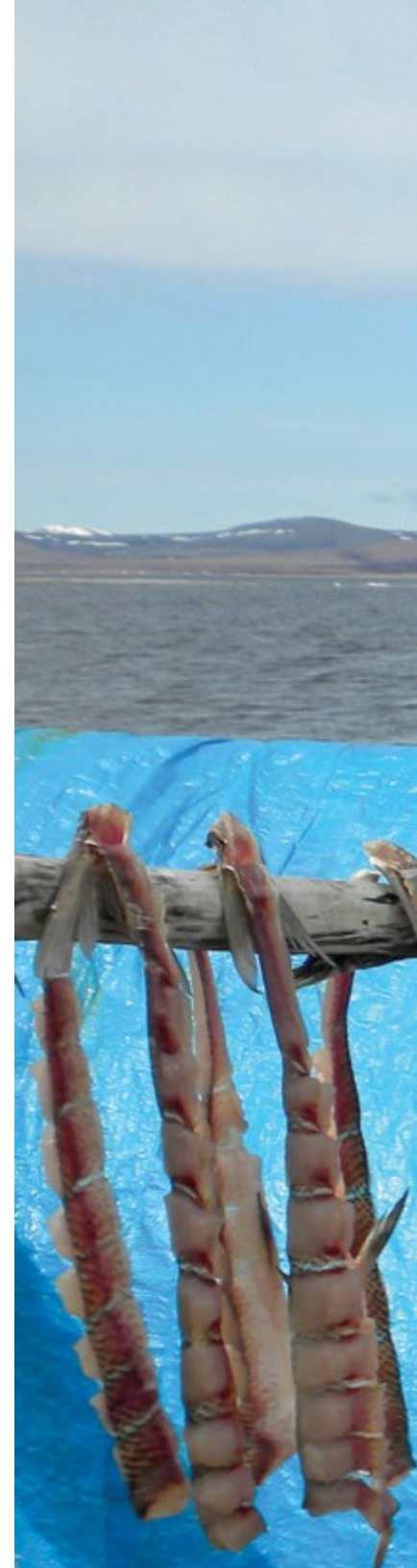
be necessary for food preparation and storage. Sharing observations of changes and adaptations related to subsistence, and monitoring the health of important food resource species is recommended.



Anahma and Shyloah Shannon butcher a caribou near Nome.
Photo courtesy of Chris Shannon.



Ice fishing for sheefish.



*“We only have two weeks each summer of good drying weather.
Then it will rain. We have lost harvest because of that.”*

— Kendra Lee, Teller



Waste

In low lying coastal communities, the landfills and sewage lagoons are especially vulnerable to storm surge and erosion. Three communities with vulnerable waste sites are Shishmaref, St. Michael, and Stebbins.

In Stebbins, storm surge flooding has caused the sewage lagoon to flood, washing waste across the community and onto important harvest areas. Residents are concerned about contamination and the implications for food safety and sanitation.

In Shishmaref, the sewage lagoon and the landfill are at imminent risk of being flooded by erosion or a storm surge. Unless protected, relocated or eliminated, the sewage lagoon and dump will release thousands of pounds of waste into the environment. A waste management plan is needed for these communities.

“It use to be that only the west winds in the fall would take our land. Now all of the winds take our land.”

—Bill Nayokpuk, Shishmaref



Water

Erosion, permafrost thaw, flooding and storm surge are all contributing to diminished water quality, and the damage and disruption of water systems.

In a 2010 State of Alaska study, 25 communities were found likely to experience water impacts from climate change. Seven Bering Strait communities were on the list including Brevig Mission, Diomedes, Golovin, St. Michael, Stebbins, Teller and Wales.

During the course of this project, damaged water lines and disruptions were found to have occurred since 2010 in Shishmaref, Unalakleet and St. Michael. Concerns about changing source water quality were expressed in Shishmaref and Golovin. Developing plans to address emerging problems related to community water systems is recommended.

“The river looks like a cup of coffee. I wonder about how water quality affects the salmon.”

— Toby Anungazuk, Jr., Golovin



Toby Anungazuk, Jr. inspects water conditions at Golovin a water intake.



Inspecting camp damage after an ivu (ice surge) in Kitchavik.
Photo courtesy of Toby Anungazuk Jr.

Same camp in summer.



Subsistence Camps

In November 2011, Toby Anungazuk Jr., made his way to the subsistence camp located about five miles overland from Golovin. He wanted to survey any damage from the recent super storm that flooded Golovin. Toby posted the following message to the Local Environmental Observer (LEO) Network:

“November 16, 2011. The huge November storm that struck Western Alaska caused damage to several subsistence camps at the mouth of the Kitchavik River north of Golovin. Sea ice went up on the shore several hundred feet and destroyed four of eight subsistence fishing camps. The other four were damaged.”

In the months that followed, FEMA provided assistance to Golovin to recover from the storm. However, subsistence camps do not qualify for federal disaster assistance, and some residents faced financial hardships and uncertainty about how to gather food in the storm’s aftermath. The development of assistance programs for subsistence disruption is recommended.

“Sea ice went up on the shore several hundred feet and destroyed four of eight subsistence fishing camps.”

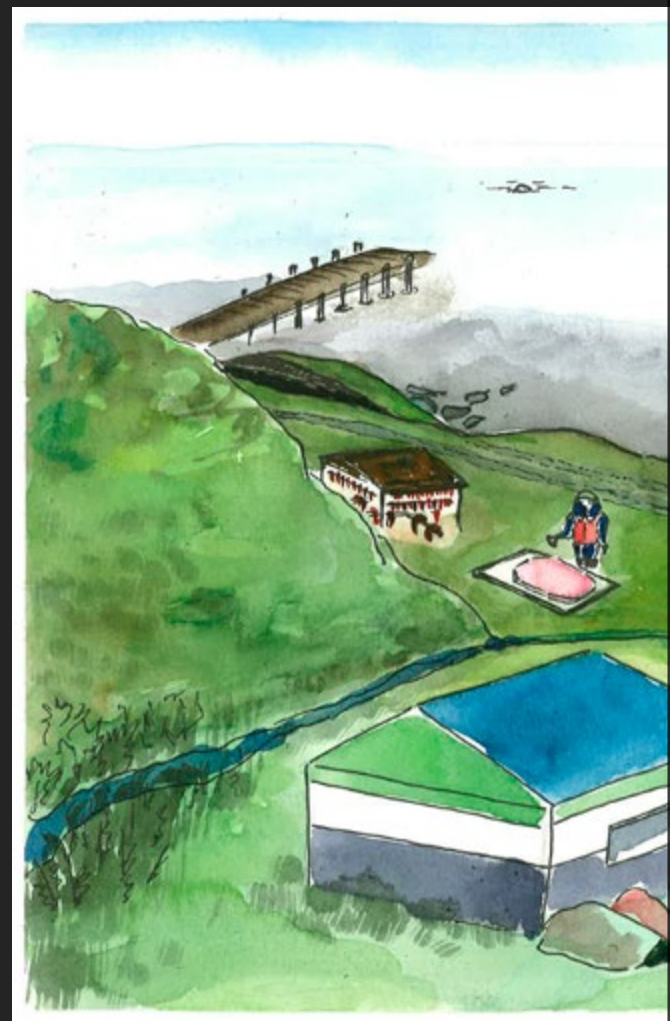
— LEO Network Post
Toby Anungazuk Jr., Golovin

“A lot of the changes that are happening have always been happening, but with global warming they are speeding up. I remember when the tug boat used to go to White Mountain. Now they must wait for a high tide.”

— Tom Punguk, Golovin



The present challenge is helping communities



As long as humans have been in the Bering Strait Region they have adapted to a changing environment. Today the environment is changing at an unprecedented rate. The following sections describe actions on the local level, as well as regional strategies

move toward a more safe and sustainable future.



Illustrations by Khulan Bazarvaani

that are models for adaptation, and planning efforts to help inform future decisions. The challenge today is to find effective and affordable ways to reduce vulnerabilities and help communities toward a safe and sustainable future.

Adapting to Change

“We are the people who are resilient and are surviving. We also need to look to our greatest resources, the children who are coming behind us. It helps me to speak for our future.”

— Dwayne Lincoln, Golovin

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Homes are now being built above the flood zone in Golovin.

Moving Out of Harm's Way

Many coastal communities are already at risk from flooding. Erosion, subsidence, ice change and sea level rise are expected to increase risk in coming years. Stebbins, Teller and Golovin are among the communities that have high ground outside of the flood zone, where evacuation and relocation of homes is possible.

In Golovin, there are several homes built up on the hill and community leaders are now beginning new construction on these higher lands. The tribal council office, community center, and the new water treatment facility are all being constructed out of the floodplain. Phased relocation, moving infrastructure to higher ground, is encouraged when possible. High priority infrastructure for relocation include tank farms, power plants, landfills and sewage lagoons.

“Water came right up to the front step and waves were hitting in the back. Everyone helped each other out. Now during a storm we have someone stay up all night to let everyone know if they have to move up the hill.”

—Carol Oliver, Golovin



In Golovin, the new water treatment facility is being constructed on higher ground out of the flood zone.

***“The sea wall is working good,
but it does not protect everything.
It does not protect the dump, the
road or the washateria.”***

—Jimmy Seetomona, Shishmaref

Protecting Communities

Phased relocation to higher ground and ongoing erosion protection is a priority for low-lying areas in coastal communities including Golovin, St. Michael Shishmaref, Stebbins, Teller and Unalakleet.

In Shishmaref, rock quarried at Cape Nome has been barged north and a new revetment wall prevents erosion, protects infrastructure, and provides community members with peace of mind during the storm season. Other areas of Shishmaref are without protection, and community leaders feel challenged to find resources to protect their community.

Protecting the Land

The combination of warming temperature and damaged tundra can be enough to begin a thawing and erosion process that is unstoppable. Measures that encourage protection of the tundra are more important than ever.

In Golovin, the combination of warming temperatures, ATV traffic, and runoff have created huge erosion ravines that grow larger with each year. As a mitigation effort, geotextile mats have been installed along the ATV route to Kitchavik Creek. Use of these mats is protecting the tundra and helping to prevent more erosion problems in the future.



Florence Doyle of Golovin rides her ATV over the geotextile road installed to protect vegetation and prevent thawing.

Monitoring Food

Climate change raises new concerns about the safety of traditional foods and water supplies. Thawing permafrost, erosion, and extreme weather events provide new pathways for pollutants, both in storage facilities and in the environment. Stress to animals caused by environmental change and migration of new pathogens (germs) are emerging as concerns for wildlife and, in some cases, human health.

Examples include the expansion and increase of giardia-carrying beaver into northern rivers which can become a waterborne diarrheal illness in people. It also includes potential for cases of paralytic shellfish poisoning and other harmful algae related illnesses. Programs to help monitor conditions in traditional foods, and water sources are important in order to understand risks and to develop culturally appropriate methods to prevent illness and encourage continued use of subsistence resources.

**“There are a lot of sick animals.
Last month they could not
take one because of something
on the liver.”**

— Nancy Kokeok, Shishmaref

Oogruk (bearded seal) being
harvested in Shishmaref.



Monitoring Water

Environmental change to lakes and streams was described in White Mountain, Shishmaref, St. Michael and Golovin. One important adaptation is the development of water monitoring programs. The Bering Strait/Norton Sound Watershed Alliance (BSNSWA) was formed in 2014 to promote healthy watersheds, resiliency to environmental change and responsible economic development.

For the past four years, the Native Village of White Mountain has gathered water quality data from nearby rivers and streams. They have been working with the University of Alaska Fairbanks to archive the GIS data and continue to mentor other programs in the region. The Nome Eskimo Community began their water quality monitoring program in 2014.



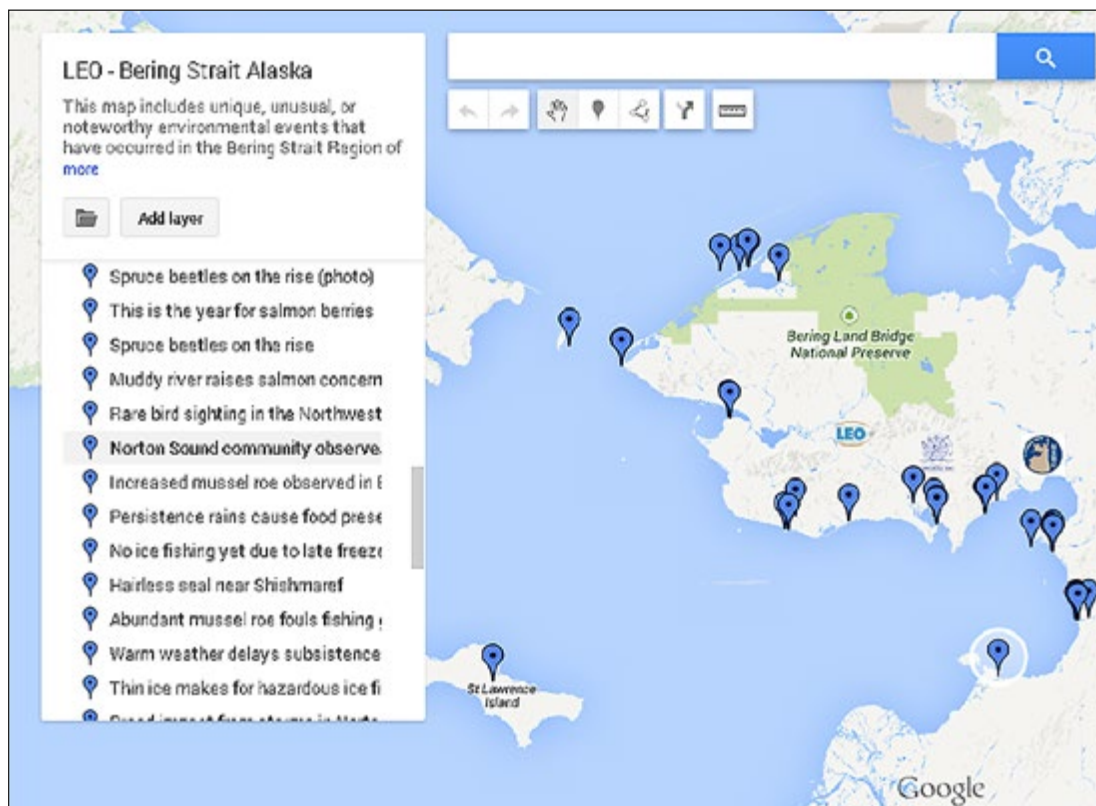
Water quality monitoring credential courses through UAF-NWC.
Photos courtesy of Mike Sloan

Sharing Observations

Sharing observations about environmental change and connecting with technical resources are two objectives behind the Local Environmental Observer (LEO) Network. Observations about unusual and extreme environmental events are posted to public Google maps. Many posts are related to climate change including erosion, ice conditions, landscape

change, unusual wildlife and impacts from extreme weather.

Observations are shared with technical experts at agencies and academic institutions. There are LEO Network members in fourteen communities in the Bering Strait Region.



LEO Network map of observations posted in the Bering Strait Region.



Victoria Kotongan points out storm damage in Unalakleet.

Recording Change

Time-lapse cameras are being used to record seasonal events such as freeze-up or break-up, episodic events such as winter storms, and gradual change such as the thawing river banks.



Image from the time-lapse camera shows low snow levels in 2013.

Some communities are using time-lapse cameras to create photo records of environmental conditions throughout the year, short videos documenting the year in time lapse.

Cameras have been installed in Golovin, Shishmaref, St. Michael, Teller, Unalakleet and Nome as part of the LEO Network Community Camera Project.

Michelle Snowball and Aida Cheemuk show the time-lapse camera in St. Michael.



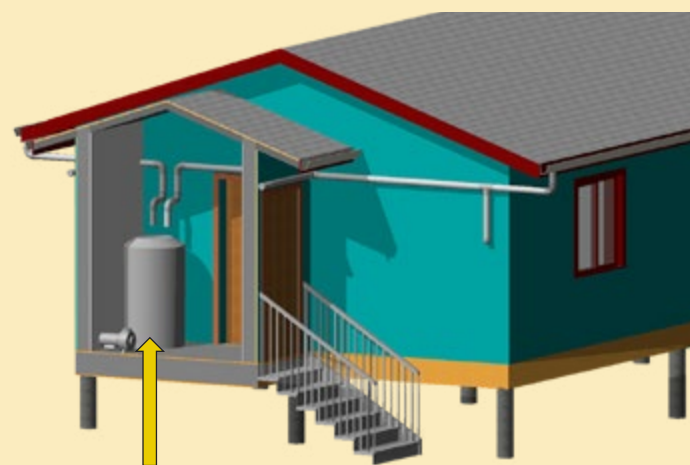
Addressing the Waste Problem

Some landfills and sewage lagoons are vulnerable to flooding and pose a pollution threat. Residents are exploring ways to get rid of the waste stream entirely.

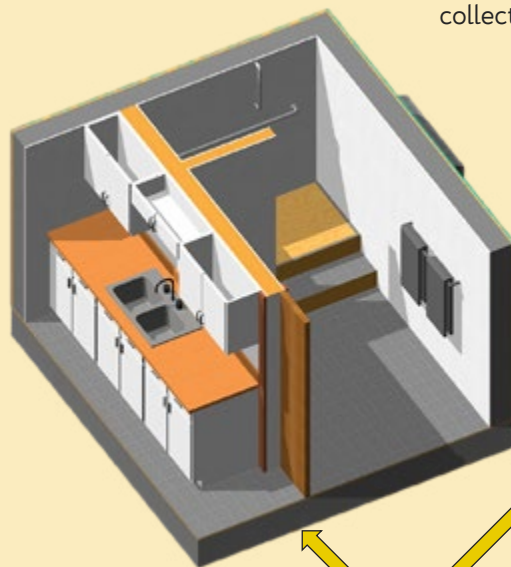
Sewage in some homes must be collected in five-gallon honey buckets and carefully transferred outside for pickup. Once outside, leaking of the waste is a common problem. Shishmaref is exploring rainwater, grey water, and separating toilet systems.

For homes with these kinds of systems, the result would be elimination of the honey bucket, no liquid waste to the sewage lagoon, and reduced plastic and cardboard waste.

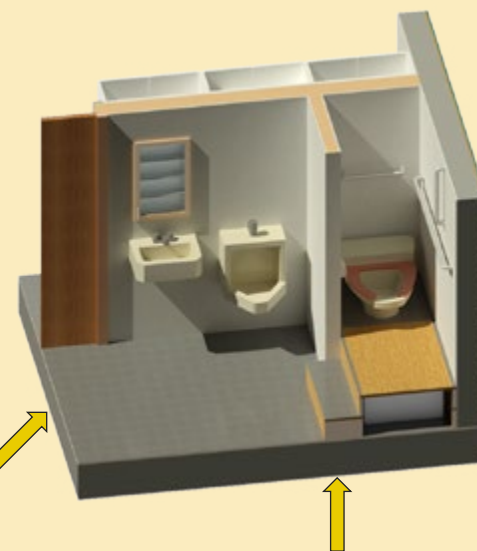
Some homes in the region have no running water. This in-home water system is designed to eliminate honey bucket waste and increase available water for washing.



Tanks for rainwater collection.



Sinks with running water.
Grey water goes to leach field.



Urinal and separating toilet
replaces honey bucket.

Renderings courtesy of
Alaska Native Tribal Health Consortium

Planning for Climate Change

Shaktoolik is a community of 250 people located on a sand spit bordered by the Tagoomenik River and Norton Sound. Along with Golovin, St. Michael, Shishmaref, and Unalakleet, Shaktoolik is on the Army Corps of Engineers list of priority communities for addressing erosion. With funding from Sea Grant, an adaptation planning process was performed in 2014 with a focus on erosion and flooding.

Outcomes from the planning process include recommendation for developing a vegetated berm to protect the shoreline, a storm surge mound to provide refuge in times of high water, storm shelters

“We should be conscious of how we develop projects like infrastructure. We really need to think ahead. The more prepared we are the better off we will be.”

—Shirley Martin, St. Michael

and relocation of the community fuel tank farm. The Shaktoolik planning process provides a model for community engagement on addressing storm threats in Western Alaska.



Workers build an earthen berm to help prevent flooding.
Photo courtesy of Terry Johnson.

Take-home Lessons

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- **National Weather Service records show an increase in average annual temperature since the 1940s.** Residents report warmer summers and winters, winter rains, less snow accumulation and more extreme rain events.
- **Permafrost thaw, erosion and sea ice change are increasing community vulnerability to storm surge and flooding.** Communities should revisit emergency plans regularly to evaluate new and emerging threats and to develop climate appropriate strategies.
- **Permafrost thaw is impacting critical infrastructure.** Monitoring systems are recommended to provide early detection and to prevent structural damage. Systems that allow for regular adjustments, accommodate thawing soils, or prevent thawing such as through active cooling systems are of increasing importance.
- **Lack of adequate snow and ice has created transportation failures interrupting travel between communities and subsistence harvest areas.** Unusual weather conditions are undermining traditional knowledge systems for safe travel.
- **Floods, erosion and other threats sensitive to climate change, pose a risk to infrastructure and to safety.** Having access to emergency plans, shelters and resources that are appropriate for new and emerging risks is a public health priority.
- **The Army Corps of Engineers is planning for three or more feet of sea level rise by 2100.** Revetment walls and berms can help protect infrastructure in the near term. However, long term solutions will require some communities to move above the flood zone.
- **High costs will impede community-scale relocation efforts.** Phased relocation is, however, much more affordable and practical. As old infrastructure is replaced, local governments can capitalize on the opportunity to construct new infrastructure in better locations.
- **Historically, village sites were selected based on proximity to harvest areas, transportation routes, and barge landing.** In addition to enhancing climate resilience, selection of new sites should consider the opportunity of optimizing conditions for alternative energy infrastructure.

- **Community plans should consider the challenges as well as emerging opportunities for increasing resilience, efficiency, and sustainability.** Acquiring locally relevant information and projections about climate, soils, sea level, and water and food resources can support decision making.
- **Community leaders are encouraged to integrate climate change projections into their engineering designs for new infrastructure.** Developers need to clearly detail how new infrastructure will accommodate current and future climate and environmental conditions. Convening a regional group to develop adaptation plans for infrastructure is recommended. Each new project should be approached as an opportunity to move towards a more climate resilient future.
- **Critical infrastructure including storage tanks, sewage lagoons, landfills, power plants, air strips and clinics are located in areas highly vulnerable to flooding.** Preventing spills that could cause environmental pollution should be a top priority.
- **Waste stream reduction is one approach for addressing the pollution threat posed by landfills and sewage lagoons in the flood zone, as well as addressing sanitation deficiencies.** In-home water and sewer systems using separating or

composting toilets can reduce sewage waste and can be moved with homes if relocated.

- **Changes to lakes, rivers, tundra, forests, sea ice, ocean and wildlife were widely discussed along with the many complex related impacts.** Understanding landscape and biological changes are important for attaining healthy communities. Participation in observation and monitoring programs is encouraged to detect and measure changes and to help provide input for community-appropriate adaptations.
- **Developing an active dialogue within local government is integral to the process of planning and adaptation.** Most Bering Strait communities have tribal environmental managers funded by EPA, who can work on climate change education, adaptation and management. An active role in educating local leaders, developing plans and implementing adaptations is recommended.
- **Climate change is having a wide range of impacts on Bering Strait communities.** Some communities need immediate attention to prevent catastrophic losses to infrastructure. All communities need good information so that they can develop appropriate plans and continue the process of becoming more climate resilient.

“The climate change has changed our way of life. How we travel, what we eat, how we take care of our food. It is human nature to adapt to changes, and we are doing our best to do this.”

— Tom Punguk - Golovin





In the Bering Strait Region, a new climate is emerging characterized by thawing, open water and a longer warm season. These are signs of global change caused by the burning of fossil fuels and transfer of enormous quantities of carbon dioxide from the land to the air. The changes affect all life. Bering Strait communities are awakening to a new climate future and are seeking adaptive strategies that encourage wellness and sustainability.

Conclusion

In response to this, the science community is developing systems to measure, improve understanding, and help predict the future. Agencies are finding efficient and effective ways to develop policy and use resources. Industry and communities are challenged to protect infrastructure and to continue to safely provide services, and carry out traditional practices.

Evidence of climate change impacts has been recorded in each of the seven communities that participated in this project. Examples of negative health effects include loss of critical infrastructure such as water distribution systems from erosion and flooding, food insecurity related to poor harvest, spoiling of food or low confidence in the safety of food, increases in risk of injury related to working and traveling in an uncertain or dangerous environment, and mental stress related to difficult or frightening conditions and uncertainty about the future. Positive health effects include longer warm seasons for collecting and treating community water and performing critical maintenance, new food opportunities related to emerging wild food sources and a longer season for growing food and other warm weather activities.

For residents of the region, the new climate means new challenges in building and maintaining infrastructure, for providing local services, collecting food and water, and safely navigating the land and waters. It also means new opportunities for subsistence, land use, transportation, commerce and development. Understanding the local impact of climate change is important for assessing negative and positive effects, and developing appropriate adaptation strategies. Through this project we have learned from the observations and knowledge of Bering Strait residents. We hope this report will help the region to pursue healthy ways to adapt in the future.

Community Participants

*Thank you to community participants for all your help
and for sharing your knowledge.*

Golovin

Carol Oliver
Toby Anungazuk, Jr.
Jack Fagerstrom
Peter Olson
Joe Dexter
Wayne Henry, Sr.
Tom Punguk
Marilyn Dexter
Irene Aukongak
Andy Fagerstrom
Florence Doyle
Julia Randall
Duane Lincoln
Bobby Amarok
Kathy Punguk
Mary Willoya
Frank Amaktoolik
Dora Davis
Virginia Amarok
Ruth Peterson
Sharon Lock
Crystal Fagerstrom
Annette Aukongak
Marilyn Moore

Shishmaref

Richard Kuzuguk
Sharon Nayokpuk
Jimmy Seetomona
Archie Kiyutelluk
Percy Nayokpuk
Glenn Nayokpuk
Stanley Tocktoo
Howard Weyiouanna Sr.
William Paul Jones Sr.
Thomas Ahgupuk
Arthur Sheldon
Ben Rokeok
Gwen Nayokpuk
Donna Barr
Nancy Rokeok
Karla Nayokpuk
Alice Shultze
Johnson Eningowuk
Lillian Kiyutelluk
Steven Kiyutelluk
Bill Nayokpuk
Susie Nayokpuk

St. Michael

Aida Cheemuk
Michelle Snowball
Virginia Washington
Bobbi Ann Andrews
Elmer Cheemuk
Alma Snowball
Helen Laws
Thomas Cheemuk, Sr.
Elmer Cheemuk
Shirley Martin
Randy Blachik
James Heath
Elsie Cheemuk
Dorothy Lockwood
John Lockwood
Norbert Otten
Francine Otten
Tommy Cheemuk Jr.
Frank Myomick
Emily Lockwood
Susie Tom
Bibiana Billingsley
Darren Billingsley
Darlene Chiskok

Stebbins

Ron Kirk
Jerome Pete
Nancy Raymond
Anna Nashoanak

Teller

Dolly Rugzruk
Lilly Okbaok
Kendra Lee

Unalakleet

Jacob Ivanoff
Merlin Johnson
Jolene Nanouk
Doug Katchatag
Frank Katchatag
Victoria Kotongan
Waylon Koutchak
Jobina Ivanoff

White Mountain

Eric Morris
Shawn Takak
Dorothy Barr
Ira Pederson
Howard Lincoln
Peter Buck
Joey Simon
Phillip Brown
Willa Ashenfelter
Rita Buck
June Lincoln
Amos Brown
Colin Lincoln



Aerial view of St. Michael.



Driftwood left by storms on the beach near Unalakleet.



We would like to express our appreciation to our partners in the tribal governments and tribal organizations in the Bering Strait Region for making this project possible.

