Climate Change in **Wainwright**, Alaska

Strategies for Community Health

ANTHC Center for Climate and Health

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Wainwright Traditional Council

City of Wainwright

Alaska Native Tribal Health Consortium

United States Environmental Protection Agency

Achieving wellness through awareness and adaptation

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INTRODUCTION

Climate change refers to change over time due to natural variability or as a result of human activity (IPCC, 2008). Today the term is mostly used to describe global changes caused by the burning of fossil fuels and the warming effect caused by the transfer of enormous quantities of carbon dioxide from the earth to the air. But global climate change also has local implications and communities are seeking adaptive strategies that encourage wellness and sustainability. The environment on the North Slope of Alaska is characterized by permafrost and ice. The wildlife, vegetation and people have specially adapted to live in an environment that is mostly cold and frozen. But because of warming, the environment is rapidly changing and a new Arctic is emerging, characterized by thawing land, open water and a longer warm season. For residents of the North Slope this means new challenges in building and maintaining infrastructure, for providing local services, collecting food and water, and safely navigating the land and seascape. It also means new opportunities for subsistence, land use, transportation, commerce and development. Understanding local effects is the first step in finding a healthy course through the changes and challenges ahead.

This climate change health assessment project was initiated in 2013 by the North Slope Borough, Health Impact Assessment (HIA) program with a grant from the National Petroleum Reserve-Alaska. The project is in collaboration with the Alaska Native Tribal Health Consortium (ANTHC), Center for Climate and Health, and participating local governments. ANTHC performed an assessment in 2009 in Point Hope with funding from the U.S. Indian Health Service. Under the current project, baseline information on climate change vulnerabilities was compiled for all of the communities in the North Slope Borough, but with a special focus on Wainwright, Nuiqsut, Atqusuk and Barrow. A

Wainwright is an Iñupiat whaling community.
Mike Brubaker, 2013.

This Climate Change Health Assessment was performed based on requests from tribal health representatives and from local and regional leadership. Information about local climate, environment, and health conditions was gathered with the help of local and regional government, universities, industry, and state and federal agencies.

project team was established to perform on-site visits and to coordinate with local and regional experts. The team included Heather Dingman from North Slope Borough and Jake Bell and Mike Brubaker from ANTHC. Site visits were performed in Wainwright in June 2013 and in April 2014. The onsite survey and report preparation was based on guidance from the village council, city council and the project team. Information sources include observations of local residents, reports from government agencies, and scientific findings gathered from published sources.

Understanding local impact of climate change is important for assessing negative and positive effects, and developing appropriate adaptation strategies. In Wainwright, residents report changes to the weather, seasons, land and seascape, plants, wildlife and infrastructure, with important implications for public health. Wainwright is a coastal community, vulnerable to thawing of permafrost and erosion at the water's edge and to the melting of sea ice and changing sea conditions. Residents harvest the majority of their food at sea. Changes on both the land and sea are unprecedented and residents are challenged to develop knowledge that will allow them to continue traditional practices. Climate change in Wainwright raises new concerns about food and water security, safety and mental health related to the stress of adapting to a new climate and changing environment.

Figure 1.
North Slope Borough.

This report includes observations, experience and knowledge shared by a wide range of local experts. Predictions and projections on future conditions such as climate, flooding, and erosion are based on available information and limited by the quality of current scientific data and the uncertainties inherent in models. Research and model development is ongoing in Alaska and new information will be available in the near future.

COMMUNITY

Proud Inupiat whalers. Wainwright is a traditional Inupiat community located on a finger of land bordered by the Chukchi Sea and Wainwright Lagoon, north of the Kuk River estuary. The village is located on a hill that slopes down to a small bluff and a sandy beach. Inland the landscape is largely flat and treeless, characterized by tundra vegetation and dotted by small lakes. The population in 2010 was 546 residents, making it the third largest community in the North Slope Borough behind Barrow and Point Hope. Inupiat people have lived in this area for thousands of years. The abundance of the whale harvest allowed for large, permanent communities, in contrast to the semi-nomadic lifestyle of other coastal and inland areas. Here the lifestyle and subsistence practices were tailored to the Arctic marine environment: spring hunting off the sea ice in places the whales passed, and where frozen ground allowed for long term storage of meat and maktak. The result was a culture based on cooperation and sharing and traditions which endure to this day.

In the 1800s the village here was called "Olgoonik". In 1826, Capt. F. W. Beechey named Wainwright Lagoon for one of his officers. The present village which acquired its name from Wainwright Lagoon, was established in 1904. The site was reportedly chosen by the captain of the ship delivering school construction materials, because sea-ice conditions were favorable

Beachfront: homes on bluff in Wainwright.
Photo by Mike Brubaker, 2013.

This report aims to help the citizens of Wainwright make informed decisions on climate change impacts and develop community relevant adaptation strategies.

Figure 2. Google view of Wainwright and region.

for landing. A post office was established in 1916, and a city was formed in 1962 (NSB 2009). Subsistence continues as a central aspect of the community and people are actively engaged through the year in the work of collecting natural resources from the land and sea. Caribou and moose are hunted and bowhead and beluga whale. Ice seal (bearded, ribbon, ringed, spotted), birds and fish are staples of the diet along with wild plants and berries. People are employed in the hotel, restaurants, stores, school, clinic, local government and local services.

Air travel provides the only year-round access to Wainwright. A gravel airstrip is owned and operated by the North Slope Borough. Recent subsidence issues related to permafrost thaw have caused temporary interruptions to air service due to damage to the airstrip (Robert Shears). Marine and land transportation provide seasonal access, and ice change means that the season for shipping is growing longer. Snow machines are used for local transportation in the winter and ATVs in the summer. During the spring whale hunt, umiat or traditional skin covered boats are paddled by the whaling crews. Small outboard driven skiffs are used in the ice free months, and dragged over ice to open water for hunting.

In 2010, 35% of Wainwright adults and 54% of children had "good to excellent" general health.

"I think all native people need to come together to talk about whats happening to the climate."

Rossman Peetok

Most heads-of-households (59%) were physically active at least five days a week. Wainwright is a "dry" village meaning that the possession of alcohol is banned. Despite this, most households (51%) felt that the community had "often" been hurt by drugs or alcohol, during the past year. Most adults (55%) smoked tobacco as did 21% of children between the age 14 and 18. The prevalence of breathing problems such as asthma or chronic cough among children was low. Most heads of households (57%) drink two or more sodas daily.

Food security is an issue in Wainwright. Most households (96%) were not able to get enough store bought food to meet their needs. Thirty-six percent were unable to get enough subsistence foods which are nutritious and protective against the development of chronic disease. Thirty percent of households reported that at times they did not have enough food to eat. Wainwright has a piped water and sewer system, the water coming from a tundra lake located a few miles outside of town. As of 2010 94% of households had running water, up from 74% in 1998. Line breaks caused by rapid thawing of permafrost is a new factor effecting water service to much of the community (NSB 2012).

John Hopson Jr. stands at the opening to his ice cellar.
Mike Brubaker, 2013.

"We may be altering the permafrost in a critical time in history, by putting infrastructure into the ground while it is changing."

Gordon Brower
NSB Planning Department

Wainwright from the air.
Mike Brubaker, 2013.

"It freezes later now. This Elder used to go home on snow machine by late June, now it's open water."

John Hopson Jr.

ECOSYSTEM

Observed change: *increases in temperature, precipitation, and weather variability;*
Community impacts: *changes in seasons, travel conditions, landscape, plants and wildlife;*
Health concerns: *injuries, mental health, changes to harvest, diet and nutrition, sanitation;*
Adaptations: *enhance systems for self-sufficiency and emergency prepardness for emerging risks.*

A system in change. Wainwright is located within the Beaufort Coastal Plain, a treeless region that covers the entire coastal zone bordering the Arctic Ocean. The region is characterized by year round cold, winds, permafrost and (for much of the year) proximity to sea ice. Seen from above the tundra appears as a pattern of geometric shapes formed by repeated ground freeze and thaw. The vegetation is predominately tundra plants and small shrubs, but small willow trees are now beginning to appear along the rivers.

Thousands of shallow lakes provide habitat for waterfowl, and there are also shorebirds, song birds and snowy owls. Ravens are sometimes seen here and may be extending their range north. The tundra lakes provide a source of community water for Wainwright and for other North Slope communities. Seen from the air, the lakes form their own unique patterns. Like natural wind vanes they align with the prevailing wind direction, resembling honey comb or cut marble. Thawing and runoff causes erosion along slopes, riverbanks and bluffs. For the tundra lakes, thawing can change shorelines, in some cases growing larger with runoff, or becoming smaller as they drain and dry.

Summer grass at a coastal camp.
Mike Brubaker, 2013.

"I started to measure the grass. It used to be short, then a decade would go by and it would double, another decade go by and it would double."

Rossman Peetok

Young men playing on the ice.
Mike Brubaker, 2013.

The rivers on the coastal plain meander through the flatlands where flooding or erosion has opened new channels. They flow north towards the Arctic Ocean and serve as important conduits of ecosystem change. Thawing soil allows for shrubs and other plants with deep root systems to compete with the shallow rooted tundra plants. Shrubs capture windblown snow in winter insulating and protecting their roots from frost. The rivers are rich with fish including Arctic char, Dolly Varden, grayling and a variety of white fish. Climate related challenges for fish include, early snowmelt, lower late season water levels and higher temperatures. Turbidity and habitat change are also concerns as thaw-related bank erosion increases sediment deposits, and beveling as cut banks collapse and fill river beds. Sediments deposited from the banks are transferred downstream, shallowing the river and limiting travel by boat.

The sea ice becomes a virtual extension of the coastal plain in winter providing access for polar bears and men, to travel and hunt from the ice. Ice seals inhabit the coastal zone along with walrus. Bowhead, beluga and grey whale migrate along the coast in the spring and return south in the fall. Under the water, salmon, sheefish, crab and cod are present and fished at different times of the year. King salmon and silver salmon are emerging as new species in the region, and gradually becoming appreciated as subsistence resources (Craig George). Wainwright residents report sightings of new species including porpoises, sea lions, and birds such as puffins (Donna Nashoalook).

The coastal plain hosts huge herds of caribou in summer when they migrate towards the coast for calving, grazing and to seek relief from insects. In their wake comes a variety of predators and scavengers including wolves, Arctic fox and grizzly bear. Red foxes are coming north and raising concerns about competition with smaller less aggressive Arctic foxes, and the spread of rabies. Climate related threats to caribou include wildfire and freezing rain events that can reduce forage areas, and higher air temperatures that can cause stress. Musk oxen face their own climate related threats, heat stress and coastal storm surge that can trap and drown entire herds. Small mammals in the region include lemmings, ground squirrels and voles. Low snow years such as the winter of 2014 can be hard on these ground dwellers, and predators that depend on them. Along rivers the emergence of small trees invites new wildlife such as moose, porcupine and beaver.

"Traditional knowledge is dying off. Younger guys went out and didn't know it was dangerous and fell through the ice."

John Hopson Jr.

CLIMATE

Observed change: *increases in temperature, precipitation, and weather variability;*
Community impacts: *changes in seasons, travel conditions, weather;*
Health concerns: *injuries, mental health, changes to harvest, diet & nutrition, sanitation, decreased cold injuries;*
Adaptations: *enhance systems for self-sufficiency and emergency prepardness for emerging risks.*

A new arctic climate. The climate is warmer than in the past. The climate in Wainwright is classified as "arctic" with cold dry winters and cool summers. Temperatures have historically ranged from -56 to +80 degrees Fahrenheit. Precipitation is generally light, averaging only about 5 inches annually as rain and about 12 inches as snowfall. Despite low precipitation the land is covered with water, ice and snow in winter, lakes and wetlands in summer. This is because permafrost acts as a barrier and prevents water from dissipating into

Changing climate means new opportunity for boat-based hunting.
Mike Brubaker, 2013.

"We used to have to wait until July to go boating — now we can go in May.

John Hopson Jr.

the ground. This however is changing; as the shallow permafrost diminishes the seasonal thaw zone grows. The Chukchi Sea has traditionally been ice-free from mid-July through September (NSB 2009). However, the ice-free period is increasing and local hunters travel by boat as early as May and as late as November (John Hopson Jr.).

At the National Weather Service station in Barrow, the average annual temperature has increased by 4.9 degrees Fahrenheit (1949-2012). The biggest increase has occurred during the winter, a whopping 7.3 degrees compared with the (still large) increase of 3.2 degrees during the summer (Alaska Climate Research Center). Between 1958 and 1997 the average number of days in August that exceeded 39 degrees was about 1.2, while between 1998 and 2013 the number increased to 5.9 days. In 2003 there were twenty five days above the 39 degree mark (SNAP 2014).

Average monthly temperature and precipitation trend data is available for Wainwright and the models compare temperatures from 1961 to 1990 with projected temperatures from 2010

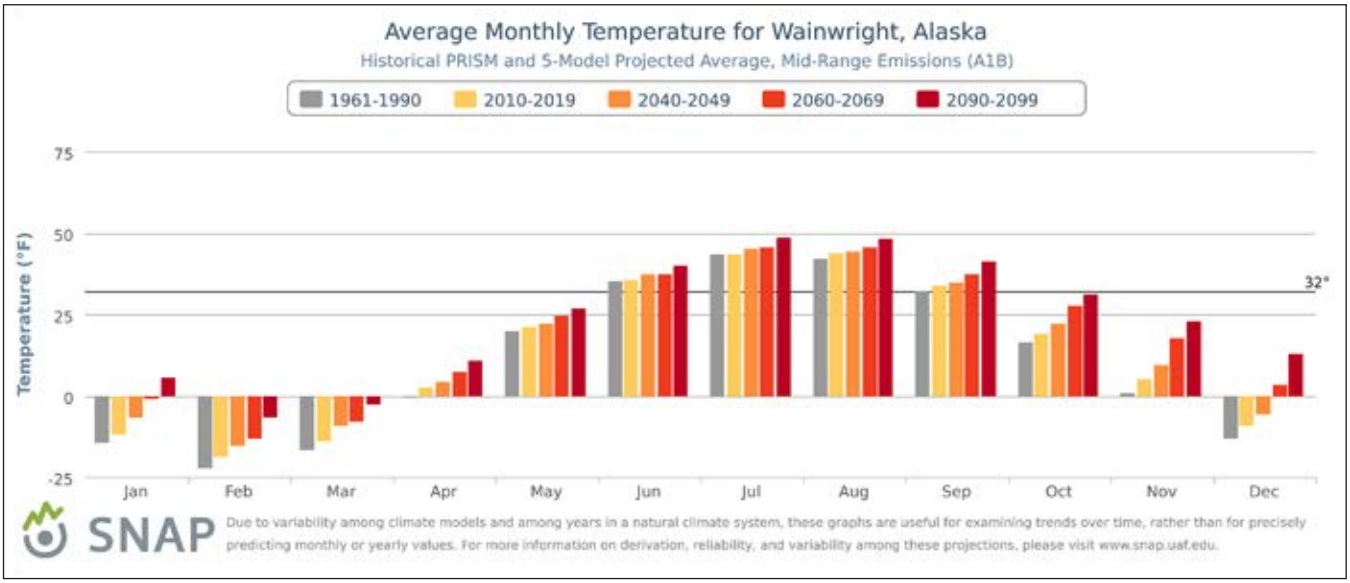


Figure 3. Historic & Projected Average Monthly Temperature, Wainwright, Alaska.
UAF, Scenarios Network for Alaska & Arctic Planning, 2013.

"I remember the year it changed — 1970. That summer was very strange and in the middle lots of snow. From then on each year got different."

Rossman Peetok

to 2019. The projection is that average monthly temperatures will increases in every month (see Figure 3). Precipitation change is projected to occur in eight months, increasing in some and declining in others. Major increases in precipitation are projected for the months of July and August. See Figure 4 (SNAP 2014). Projections for temperature and precipitation extend through the end of the century and generally show increasing temperatures and amounts of precipitation over the long term.

The long-term projections are for continued warming and variations in the timing of freeze-up, break-up, and green-up. Increases in the frequency and intensity of extreme weather are also expected. Precipitation is expected to increase significantly in summer with lesser changes in other seasons. More rain is expected in the shoulder seasons with winter rain also occurring periodically. In the winter of 2013-2014 the limited winter snow resulted in interruptions and delays for snow travel. Benefits of a warmer milder arctic climate include a longer season for water travel, for gardening, for making community water, and for performing maintenance and construction.

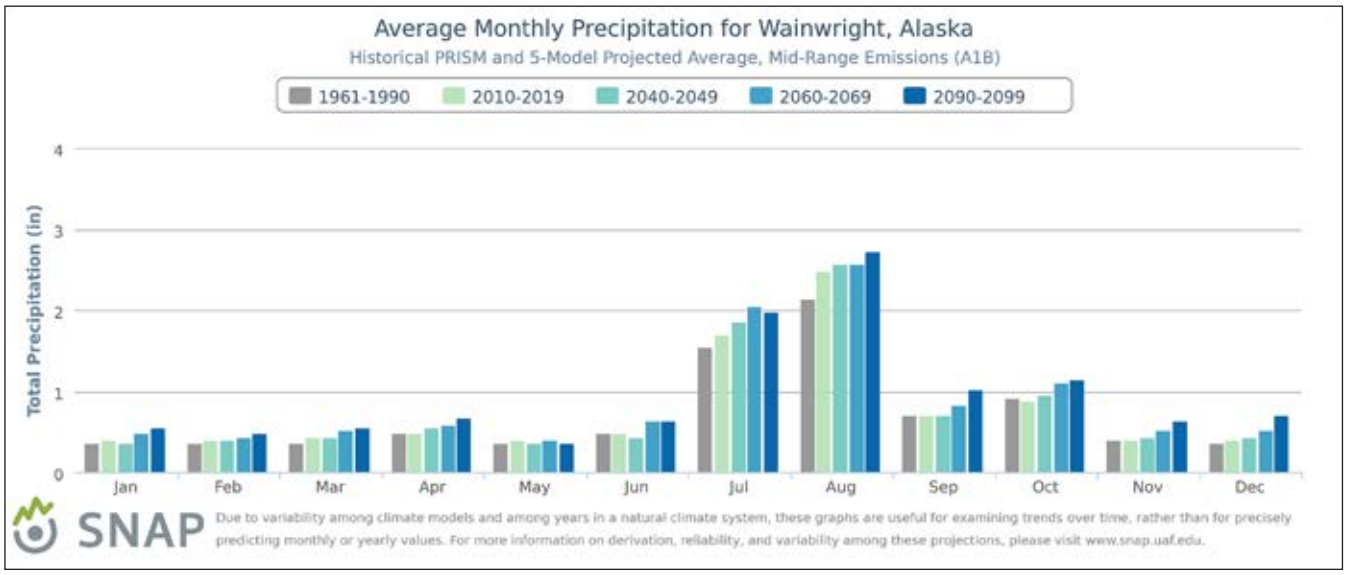


Figure 4. Historic & Projected Average Monthly Precipitation, Wainwright, Alaska.
UAF, Scenarios Network for Alaska & Arctic Planning, 2013.

"When I was growing up (hunting geese) I would wear snowpants and sweaters; now I wear t-shirt only, there are even bugs out!"

Michael Agnasagga

Summer ice conditions in Wainwright.
Mike Brubaker, June 2013.

WEATHER

Changes: *more lightning, less extreme cold, more extreme heat, more intense storms*
Impacts: *wildfire, thawing, erosion, loss of infrastructure*
Health Effects: *respiratory illness related to wildfire smoke, increased potential for heat injury, mental stress*
Adaptations: *enhance disaster preparedness and planning*

Going to extremes. Some types of extreme weather are increasing. Wainwright is vulnerable to a wide range of extreme weather events. With climate change the frequency of some types such as extreme cold, heavy snow, ivus and ice jams, may decrease. Other events such as storm surge, coastal storm, ice storms and thunderstorms may increase. This section considers four types of extreme weather that are likely to increase with climate change: thunderstorms, coastal storms, ice storms and wind storms.

In August 2004 residents reported at least three thunder storms near Wainwright, far greater than in any time in memory (NSB 2009). A major concern related to thunderstorms is lightening and the potential for wildfire. Wildfires have occasionally occurred in the past, but in recent years the combination of warm weather, dry tundra and increased lightning have increased wildfire frequency. The potential for a longer snow-free season suggests that the length of the fire season will also increase.

The wind plays an important role on the coastal plane.
Jake Bell, 2014.

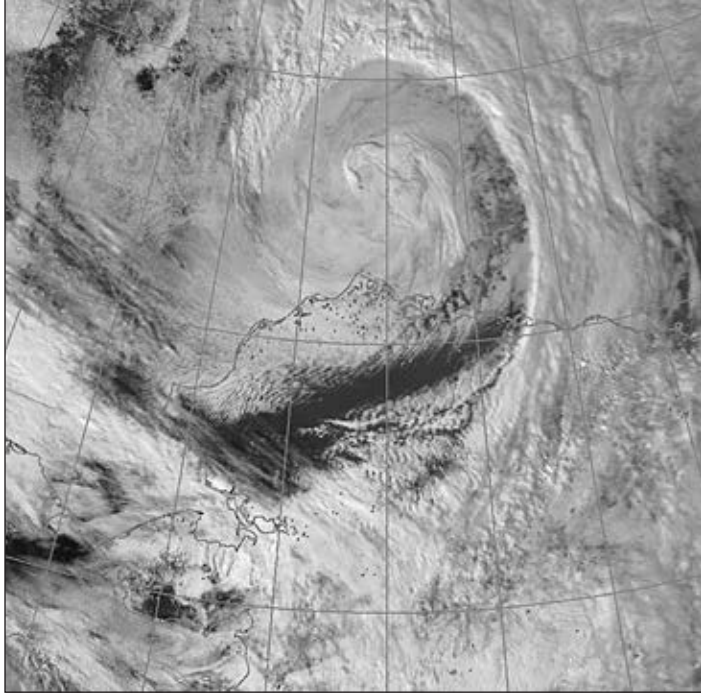
Coastal storms occur regularly and their impact is determined by storm intensity, wind direction and ice conditions. Sea ice, slush ice and shore ice all help to dampen wave energy. Chukchi storms can drive sea ice inland in an event called an ivu. With less sea ice, the potential for ivu may decline, but storms during the ice-free

"We had east wind all winter — then come spring — nothing but west wind. We're not used to seeing this."

John Hopson Jr.

season can be just as damaging. Winds crossing the Chukchi for hundreds of miles raise waves and sea level, once waves strike the coast they increase permafrost thaw and erosion and send waves surging for miles upriver (Gordon Brower). Even in winter Wainwright can experience substantial surge events. On March 10, 1963 a 12 foot storm surge flooded half the community.

Ice storms are caused by freezing rain or ocean spray. The combination of delayed sea ice, high winds and sea spray caused a disaster with power and water failures in Savoonga in January of 2011. This has occasionally also caused ice formation on power lines in Wainwright. However with warmer air temperatures and delayed freeze up, the potential for ice storms may increase in coming years.



Satellite image of the hurricane like structure August 2000 storm. *National Weather Service.*

Wind Storms occur frequently in Wainwright with wind gusts reaching over 70 miles per hour. Elders report that west winds are most problematic (NSB 2009). Residents report changes in wind conditions including intensity and wind direction. Changes in prevailing winds have caused problems with furnace exhaust systems in homes, and interrupted spring whaling due to persistent on-shore winds and the lack of leads developing in the ice pack.

Discussion: Some types of extreme weather may be increasing. These can cause loss of life, injury, mental stress and damage to infrastructure. Consideration of emerging threats is critical for adapting to climate change. Current flood maps are based on a twelve foot event that occurred in 1963, although larger events have occurred in the region since. A variety of climate-driven factors including declines in sea ice, erosion, subsidence and sea level rise will contribute to a higher flood risk. Better planning information is needed and Wainwright is encouraged to review flood hazard maps to ensure they are appropriate to emerging threats and new environmental conditions. Developing comprehensive hazard risk scenarios are helpful to understand potential threat levels. Developing living hazard plans that can be updated regularly is recommended. Also recommended is greater coordination between community and emergency planners to ensure that new infrastructure considers projected conditions during the intended design life and takes into account new understanding about environmental conditions today and for the future.

"In 2009 we declared a disaster in Wainwright because of erosion."

Frederick Brower
NSB Risk Division

LAND

Changes: *thawing, erosion, wildfire, lake, river and vegetation change*
Impacts: *loss of land to erosion, shallow rivers, fewer lakes*
Health Effects: *food and water insecurity, respiratory problems related to wildfires, travel safety*
Adaptations: *alternative water sources, fire management, observer network*

A fragile landscape. As early as the 1970s residents began noticing landscape changes in Wainwright. Grasses were growing more rapidly and the size of shrubs was increasing. More recently, Akpik (cloudberries) began appearing in harvestable amounts, whereas the local abundance was quite limited in the past. (Rossman Peetok; Linda Lee). Shrub and tree growth has been associated with range expansion of moose and porcupine in the Arctic, but also with decreasing habitat for tundra berries. Beaver were reported for the first time in Kivalina and Point Hope over the past decade and as recently as 2011 in the Wainwright area (Robert Shears). Warming conditions can affect air quality and consequently respiratory health due to increases in pollen, dust, and smoke.

Warm temperatures have resulted in dry tundra conditions, lightning and wildfires. A lightning storm caused a wildfire near Wainwright in the summer of 1993. The fire took two weeks to extinguish despite the combined efforts of local and state firefighters (NSB 2009). Between 1950 and 2007, the number of wildfires increased significantly in Northern Alaska (Joly et al., 2009), the result of warmer and drier summer conditions, more frequent lightning strikes, an increase in woody plants, and tinder dry conditions on the tundra (Duffy et al. 2005). In 2007, the largest tundra fire on record occurred on the North Slope, burning over 240,000 acres in a single season. The Wainwright All Hazards Mitigation Plan limits the fire season to the months of June through September because of snow cover. With warming however, the length of the fire season can be expected to grow.

Frequent leveling of foundations is necessary.
Mike Brubaker, 2013.

"The tundra used to be hard, now it is spongy just like the carpet inside your house."

Rossman Peetok

The location of Wainwright in an area designated as continuous permafrost suggests ground that is not vulnerable to thawing. As stated in the All Hazards Mitigation Plan, "Issues or hazards relating to ground heave or thawing pose almost no hazard to the community of Wainwright" (NSB 2009). In the last few years however, the situation has changed and today permafrost thaw has altered the landscape dramatically. Inland river banks are showing signs of erosion. Permafrost thaw and rapid erosion is associated with shallow rivers and navigation problems. Land slumps are altering the size of the channels and sedimentation is increasing boating hazards (Mike Agnasagga). High tides driven by less sea ice and increased wind fetch have periodically improved boat access in some rivers. In some areas, hunting cabins have been moved back from eroding banks (Raymond Negovanna).

A drying lake near Wainwright.
Mike Brubaker, 2013.

Lake change is also occurring. The season for snow and ice travel is shorter. People traveling over ice during traditionally safe periods have gone through the ice (John Hopson Jr.). Permafrost thaw beneath lakes has resulted in methane seeps, lake drying and draining. Inland camps have seen freeze-up delayed from mid-September to early October (Donna Nashoalook). In the summer, warmer temps have even made the lagoon behind Wainwright warm enough for swimming.

Discussion: As risk of wildfire increases, so should local capacity for response, training, equipment and resources. Potable community water is expensive and currently limited due to water line breaks. Water from tundra lakes offers a fire fighting alternative with the proper equipment. Respiratory problems will occur downwind of wildfires and plans for moving vulnerable individuals should be integrated into emergency plans. With potential for new vectors for waterborne illness, clinical staff should be watchful for giardiasis in residents who use untreated water sources. Health educators can raise awareness about effective water treatment equipment. A local observer program can help connect residents and local government with technical resources related to landscape changes and new environmental impacts.

Permafrost thaw and rapid erosion is associated with shallow rivers and navigation problems.

COAST

Changes: *thawing, erosion, increased storm impact, sea level rise*
Impacts: *loss of land, infrastructure, cultural sites and ice (food) cellars.*
Health Effects: *food insecurity, mental health, safety*
Adaptations: *phased relocation away from shore, shore protection, adaptive engineering*

An encroaching sea. Accelerated coastal erosion has occurred over the last three decades. This is due in part to changes in sea ice. In the late 1970s and early 1980s ocean freeze-up began to move from September and October to sometimes November or even later. Because sea ice and shore ice provide protection against ocean waves, the longer ice-free season increases vulnerability to erosion and storm impact. It is estimated over 100 feet of land was lost during this period (Moses Nayakik). In the 1990s, erosion, likely exacerbated by permafrost thaw, resulted in the relocation of houses (Rose Panik) and as many as twelve ice cellars were lost (Raymond Aguvluk). Also lost were areas of culturally and historic importance such as traditional homes and burial sites. To assist in protection of Wainwright's coast a 770 foot rock seawall, has recently been constructed. The seawall has a projected 50-year lifespan (Robert Shears) and replaces previous efforts including stacked "supersacks" that were lost to recent fall and winter storms (Mike Agnasagga).

Wainwright revetment wall.
Mike Brubaker, 2013.

Another important coastal issue is sea level rise. This is caused by the melting of glaciers and polar ice caps and expanding volume of sea water. Sea level rise will increase vulnerability to erosion and flooding. It may also result in benefits such as increased inland access as tidal influence expands up the rivers. Hunters have reported traveling further on a high tide than ever in the past, up

"The borough just completed a 770 foot rock revetment wall in Wainwright. It has a 50 year projected life span."

Matt Dunn
NSB Planning Department

Collapsing bluff in Wainwright.
Mike Brubaker, 2013.

to 50 miles upstream (Mike Agnasagga; Donna Nashoalook). This may be related to changes in sea ice conditions and high water caused by increased wind generated fetch. But trend changes in average sea level are difficult to predict because of the lack of measuring stations and the complex thaw, erosion and land sinking forces at play. For 24 years sea level has been measured in Prudhoe Bay. But another 4 or 5 years of data is needed in order to get reasonable estimates of sea level change (Laura Rear McLaughlin, NOAA).

Discussion: Due to projections for continued warming, it is expected that the natural protection provided by cold climate (freeze, sea ice, permafrost), are expected to diminish resulting in increasing coastal vulnerability to water, wind and wave erosion. Wainwright and the North Slope Borough continue to work on coast protection; without which immediate retreat from the ocean bluff would be necessary. Despite these efforts, on-going land change will continue to present challenges in the coastal zone. Sea level rise will add to overall community vulnerability. Coordination with the borough, academic institutions and government agencies is recommended to understand sea level, permafrost thaw, erosion and other relevant coastal measures and to provide city and borough planners with the best available information. As stated in the Wainwright All Hazards Mitigation Plan, "a long-range plan for the potential relocation of community infrastructure (water lines, sewer lines, roads) currently threatened by coastal erosion" is recommended. Additionally, protection or relocation is recommended to prevent loss of sacred sites and remains to coastal erosion.

Hunters have reported traveling further on a high tide than ever in the past, up to 50 miles upstream.

SEA

Changes: *less old ice, wind regimes, longer ice free season, algal blooms, new marine life*
Impacts: *shorter ice hunting season, and lack of traditional knowledge for new conditions*
Health Effects: *concerns over food security and travel safety*
Adaptations: *ice travel caution, increased boat-based hunting, environmental observation systems*

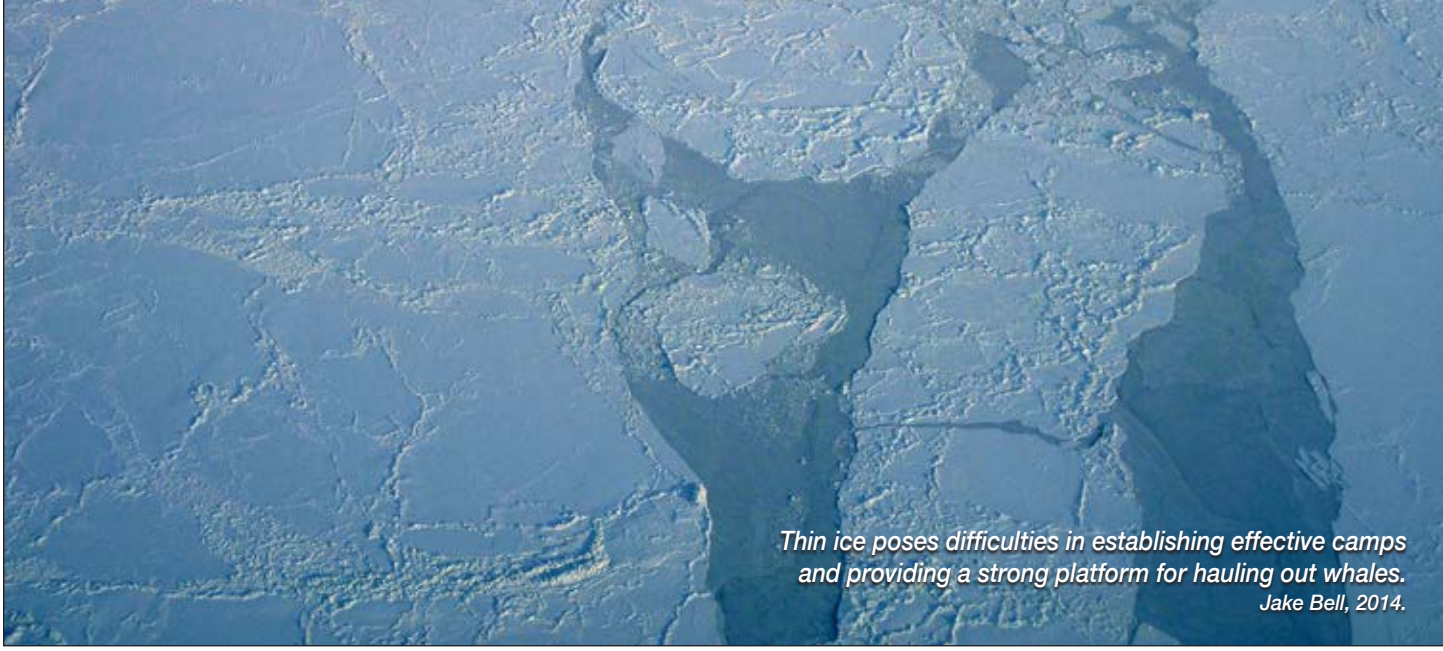
Vanishing ice, turbulent waters. Starting in the 1980s Wainwright hunters began noticing changes in sea ice and discussing the possibility of applying new hunting methods to adapt to the new ice conditions (Ronnie Morales). Over the years the ice has continued to change and retreat, challenging traditional knowledge systems as hunters encounter conditions that are unseasonable or unprecedented. Compounding the problem of thinning ice are changes in 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. The grounded ice provides a platform from which to hunt, haul out whales, and for travel to and from home. Recently however, the winds have come from the Northwest and South (Johnny Adams) or have been "all over the compass" (Robert Shears). This winter, November and December ice building were lost to winds that blew all of the ice out to sea (Mike Agnasagga).

Traditionally Wainwright would hunt whales during the spring, working off the ice shelf and using skin boats. A pre-negotiated number of whale strikes from the International Whaling Commission served as a regulatory limit to help manage whale harvest. But in recent years, wind and poor ice conditions have conspired to prevent hunting, sometimes for weeks. In 2008 with unused harpoon strikes and open water, Wainwright hunters left the ice behind and began fall hunting for bowhead whale. In 2010 they harvested their first fall whale (MaggieTagarook), probably the first since the Yankee whaling days (Craig George). To do this the hunters adapted their traditional techniques; not just the time of hunting

Working on the Ice.
Quinugan Roddy.

"When I was a kid we used to go out [on the sea ice] 9 or 10 miles, now we just go out 3 or 4 miles."

Michael Agnasagga



Thin ice poses difficulties in establishing effective camps and providing a strong platform for hauling out whales.
Jake Bell, 2014.

but also gear type and larger boats that could go further and handle ocean swell generated by miles of ice-free seas. By adding sea-based hunting Wainwright has increased their hunting season and their ability to adapt to changing sea conditions.

The marine life is also changing in the Chukchi Sea with uncertain implications for the Inupiat. One concern is that physical and chemical changes to temperature, salinity and acidification may stress marine species, cause illness, change range or availability for harvest. In the summer of 2009 an unprecedented algal bloom resembling an oil spill was observed by hunters from Wainwright and Barrow. The bloom extended for over 90 miles (Gordon Brower). Dead birds were found floating in the bloom. An outbreak of unusual illness in ice seals and walrus in 2011 resulted in an unusually high number of sick and dead animals. Although a number of potential causes for the illness have been dispelled, a cause has not yet been determined, and it is possible that a combination of different factors is at play. Positive changes in the marine biology have also been described. The increases in silver and king salmon may enhance fishing opportunities for Wainwright and other North Slope communities.

Discussion: The loss of sea ice and changes in the prevailing winds have presented a variety of complex challenges for ice based hunting and have led to the adoption of new hunting methods in Wainwright. Hunters are adapting to changing sea conditions in order to continue the subsistence lifestyle. Ice and sea safety continue to be a concern and the North Slope Borough is a model in Alaska for development of practices that encourage safety and better systems for search and rescue. The adoption by Wainwright hunters of fall whaling demonstrates the resilience of the Inupiat in the face of a rapidly changing sea.

"Few years ago you could go to the ice edge and its there, its ready. Now you have to search for it."

John Hopson Jr.

SUBSISTENCE

Changes: *harvest seasons, environmental conditions, wildlife health and behavior, new species*
Impacts: *concerns over food safety, adaptation to climate change*
Health Effects: *nutrition, mental health, food security*
Adaptations: *development of alternative practices to preserve subsistence*

Leaving the ice behind. Dependence on wild foods makes Wainwright particularly vulnerable to climate change. Wainwright harvests many types of wild foods. The most important are marine mammals. One survey found that over 240,000 pounds of marine mammals were harvested annually (ADFG 1989). This includes bowhead and beluga whale, three types of ice seal and walrus (Bacon et al. 2009). Second is large land mammals (~83,000 lbs.) mostly caribou and then non-salmon fish (~16,000 lbs.) such as grayling. Over a dozen birds, four types of salmon and four types of wild berry are a smaller but important part of the harvest.

Decreases in sea ice are improving conditions for bowhead and likely other marine mammals. More ice-free days means more wind-driven nutrients and more light penetrating in the water (Craig George). The long term affect however, may not be so positive. Rapid environmental change can be stressful on wildlife including marine mammals and increase the risk for disease. Walrus are adjusting forage areas and relocating to coastal haul-outs. Walrus and seals were afflicted with an illness in 2011 causing hair loss, open sores and sometimes death. Climate change remains on the list of potential contributing factors. Some of these new diseases

Drying seal meat.
Mike Brubaker, 2013.

"We've started seeing puffins, porpoises and sea lions up here."

Donna Nashoalook

Blueberries
ANTHC archives.

Sheefish
Mike Brubaker, 2013.

Canada Goose
Mike Brubaker, 2013.

are potentially "zoonotic", meaning they can be passed on to people. An effective prevention is wearing gloves during processing of food, practicing good food preparation hygiene and cooking foods for individuals vulnerable to infection due to illness, on-going treatment for chronic diseases, or pregnancy.

For land mammals, changes in range and timing of migrations are occurring. Conditions for moose may improve with more shrub vegetation for browse. Extreme events such as storm surge have resulted in die-offs of musk oxen. Hunters report caribou being absent in traditional hunting grounds or arriving during the fall rut, thus limiting animals available for harvest (Gordon Brower, Donna Nashoalook). The Northwest Arctic caribou herd is down about 27% since 2011. Moose population has also declined by 50 to 75 percent. Factors affecting moose and caribou include both climate and non-climate factors: decreased food resources, loss of forage areas to wildfire and winter thaw and rain events, seasonal change, poor nutrition and increasing predation. Emerging issues for land mammals may include ticks that are now being reported in central and southern Alaska (Kimberly Beckmen, ADFG).

"The bowhead whales are doing well, because the amount of ice free area where they can feed has increased ten times."

Craig George
NSB Wildlife Department

Spring whaling then.
Barrow - Charles Wohlforth, ©2002

Climate change also has other impacts on subsistence. Late freeze-up can delay ice fishing. Warm water can affect timing of spawning, stream preference and fish health. An outbreak of fungus in white fish was documented near Nuiqsut in 2013. Warm conditions can encourage new waterfowl illness such as avian cholera. Wild berries are very sensitive to temperature and precipitation. Subsistence benefits include new species of fish such as King Salmon. In 1989 only four were harvested in Wainwright. Today King Salmon is emerging as an important North Slope subsistence resource (Craig George, NSB).

Starting in the 1980s Wainwright hunters began noticing changes in sea ice and discussing the possibility of applying new hunting methods to adapt to the new ice conditions.

Spring whaling now.
Barrow - Mike Brubaker, 2013.

Discussion: In the new Arctic, subsistence resources will join or in some cases be challenged by new and different species. Time of hunting will be altered and hunters will need to be flexible in order to accommodate current conditions, rather than historical seasons. Changes to the sea and land conditions will require new methods of travel, and hunters will need to watch for new hazards and extreme weather. New practices will be necessary for food storage and for food preparation. Environmental change can increase risk for wildlife and human diseases. Monitoring is important for disease detection and adopting appropriate prevention methods. Sustaining the whaling culture is central to identity, culture, health, and community sustainability. As demonstrated by the recent successful harvest of fall whale, the innovative and adaptive nature of Wainwright's people will serve them well in the challenges that lay ahead.

"The first fall whale in Wainwright occurred recently. That was the first fall whale in memory. It may have been the first since the Yankee whaling days."

Craig George
NSB Wildlife Department

ICE CELLARS

Changes: *warming, erosion, permafrost thaw,*
Impacts: *eroding and thawing, flooding caused by water line breaks, changes is food quality, spoilage*
Health Effects: *nutrition, food insecurity, food safety, food borne illness, injury*
Adaptations: *development of alternative locations or practices to store food, adaptive cellar systems*

Preserving an Inupiat tradition. Ice cellars, a traditional method of storing whale meat and blubber are used in Wainwright, as well as Kivalina, Point Hope, Point Lay, Barrow, Nuiqsut, and Kaktovik. The traditional cellars offer convenience, ample space, and an economical method for refrigeration. But across the North Slope, problems with preservation and storage of subsistence foods have been documented. Overly wet or warm conditions can prevent proper drying of fish and seal. Problems associated with permafrost thaw and erosion can ruin food and ice stored in cellars as a source of drinking water. In Wainwright, there are ice cellars that continue to function effectively. But there are also cellars that are in trouble.

Entrance to an ice cellar in summer.
Mike Brubaker, 2013.

"The father said 'go north to make the cellar.' The son did and made a good cellar."

Marjorie Angashuk

Moses Nayakik's supply of freshwater ice for drinking stored in his ice cellar.
Jake Bell, 2014.

Some have been lost to erosion. Others are operating on the margins of safety, vulnerable to further warming. Understanding the construction, operation, status and challenges faced by ice cellars is important for food security.

In April 2014 an inventory was made of all ice cellars in Wainwright. A total of 34 cellars were recorded, 15 in use and 19 abandoned (City of Wainwright). Several other cellars are gone, having been lost completely to erosion over the last three decades (Raymond Aguvluk). Many of the abandoned cellars are located along the shore. Yet others were found well back from the shoreline. Some having been impacted by water and sewer line breaks, another casualty of thawing permafrost. In one instance, a cellar was flooded with contaminated water, resulting in food loss and ultimately the total abandonment of the cellar (City of Wainwright Staff; Rossman Peetok; Traditional Council).

"My son just had his head cut by a piece of falling ice in a new cellar."

Ronnie Morales

Thawing is not only raising concerns about food security, but also about the risk of injury from structural failure. Injuries have occurred from falling ice, from slips and falls caused by icy entrances, and in one incidence, a roof collapse that completely buried a man. Fortunately he was quickly dug out by his companions (Ronnie Morales; Mike Agnasagga). There are also cellars in good conditions without any signs of thaw. One such cellar is located along the shore, reinforced by the new seawall (Moses Nayakik). The fact that some cellars continue to function effectively is due in part to the condition of the subsurface environment, the location of cellars, and diligent care by owners. Food insecurity is an important issue in Wainwright. Thirty percent of households at times did not have enough food to eat (NSB 2012). Thirty-six percent of surveyed residents reported that they were unable to get enough subsistence food. Loss of adequate storage affects food security and also raises concerns about foodborne illnesses.

Discussion: To improve food security in Wainwright, problems with ice cellars must be addressed. Actions may include: 1) improving the storage environment in existing cellars, 2) establishing new cellars at a location with a better environment, or 3) developing alternative method for storage. Since many of the cellars are still in use, the priority is on finding ways to prevent them from thawing and to develop storage for community members who are without. The city and corporation is planning to use high elevation areas for new ice cellars (Cheryl Tagarook). Understanding conditions inside cellars and the factors that affect them is critical for determining the adaptation options. Identification of local cellars that produce meat and maktak that is safe and tastes good is very important. Monitoring these cellars is recommended, to record environmental conditions (humidity, temperature etc.), and how they change throughout the food storage season. This is necessary to replicate conditions for new cellars, or in engineered storage facilities. Immediate actions are needed to address cellar safety issues and prevent serious injury or death. Development of best practices guidance for ice cellars (structural, confined space, air quality, slips and falls) is recommended. The failure of sewer lines is another issue that must be resolved to prevent the failure of additional cellar and contamination of stored food and water (ice) resources.

Maktak, boxed in an ice cellar.
Mike Brubaker, 2013.

"He dug out a new ice cellar to the north of town last year and it caved in on him."

Michael Agnasagga

Erosion has resulted in abandonment of some ice cellars.
Mike Brubaker, 2013.

INFRASTRUCTURE

Changes: *flooding, erosion, permafrost thaw, subsidence*
Impacts: *pipeline failures, sinking foundations, damage to airport*
Health Effects: *water insecurity, water borne illness, mental health, safety*
Adaptations: *adaptive engineering and maintenance practices, phased relocation*

A slow moving disaster. Building and maintaining infrastructure in Wainwright is challenging, because of the extremes of the Arctic environment. Today there are new challenges in an environment that is warming and undergoing rapid change. As recently as 2009, thawing permafrost was not thought to be a significant threat for Wainwright because of continuous permafrost (NSB 2009). However, recent infrastructure problems including sinking foundations, damage to the airstrip, and failure of water and sanitation infrastructure have been associated with thawing soil.

The water and sewer system in Wainwright was installed between 1998 and 2000 and consists of pipes buried under gravel "road prism" throughout town. The pipes emerge from the main lines to make connections with each household or facility (Robert Shears; William Bodfish). Most of these connections are fitted with heat trace, an electrically heated pipe connection. This is necessary as many of these juncture rises above ground into the Arctic air. Thawing is thought to be occurring because of a combination of climate-related warming, heating from the pipe system itself, and flooding caused by breaks in the water and waste water lines. Unfortunately, permafrost thaw and above ground melt-water has eroded the original grades of the underground pipeline corridors causing pipes to slump, belly-out and break. Leaking water flows down grade through the gravel causing additional erosion, pipe breaks, and flooding.

A leaking junction between the main water line and a house.
Jake Bell, 2014.

"We closed the clinic because our staff needed to wash their hands before they see patients, and people with digestive problems needed to use the bathrooms."

Geraldine "Bummie" Ningeok,
on the 2014 water system failure

A water storage tank in Wainwright damaged by permafrost thaw.
Jake Bell, 2014.

Similarly, the foundations of many houses are subsiding, breaking the angle of connection of the house pipes with the main lines, shorting out heat trace and causing flooding. A similar subsidence problem damaged one of the main water tanks, despite its installation with thermo-siphons rendering it useable only in temporary situations (William Bodfish). The Water Utility staff tracks leaks in pipes, electrical issues with heat trace, and frozen water and sewer lines. The winter of 2013-2014 has been particularly challenging with 49 pipe leaks since September. The clinic has occasionally been closed because of the loss of water service (Geraldine Ningeok). The water utility staff had dealt with so many leaks over the winter that water reserves were critically low and staff were making emergency water hauls from the lake with trucks (the pipeline from the lake was still frozen) so that water could be treated at the water plant. Consequently, Wainwright was put on a water conservation notice.

Discussion: The condition of permafrost in Wainwright appears to have reached a tipping point as evidenced by the multitude of thaw-related problems that have developed over the past few years. Interruptions to air service and to water service have occurred as well as the frequent closure of the community health clinic. With flooding to some ice cellars, food systems have also been disrupted. The North Slope Borough is actively addressing these problems, fixing damaged infrastructure, applying new construction methods, and new practices such as aggressively removing snow during winter to encourage ground freeze. Regular monitoring of infrastructure for change including foundations is recommended along with monitoring of critical resources such as the community water source lake. Subsurface monitoring of permafrost conditions can help to evaluate how permafrost is performing and identify vulnerable areas.

"The communities were set up as direct bury pipe systems in the 1980s and 1990s. We thought that the permafrost was stable. That did not turn out to be accurate."

Matt Dunn
NSB Planning Department

SUMMARY

The climate is becoming warmer with an increase in average annual air temperature. Temperatures have increased in every month of the year except July. More extreme warm days are expected.

Warming has resulted in decreases in snow and ice. This is affecting conditions for travel on rivers, lakes and on the sea. Poor ice conditions are preventing some types of subsistence activities.

Warmer weather is providing opportunities for new outdoor activities. Children have been playing more frequently in warm lagoon waters.

The climate is becoming wetter with a longer period when rain can occur. The amount of precipitation has increased in seven months. Winter rain events are expected to occur more frequently.

Extreme weather is increasing, including thunderstorms. Lightening and wildfires are also increasing with related risks: poor air quality, infrastructure damage and loss of caribou forage areas.

The season for hunting on the sea ice is becoming shorter. The season for open water travel is however, becoming longer and hunters are adapting with new equipment and methods.

Sea conditions are becoming more challenging and dangerous for navigation. This resulting from sea ice loss, increased effect of wind fetch and resulting increase in wave size.

Higher water is increasing river access. Residents report the ability to sometimes travel further upriver for hunting than ever before, expanding and improving access to subsistence use areas.

Erosion is causing loss of the shoreline and historical sites. Ice cellars, burial grounds and homes have been lost. Armoring the shore is protecting homes that would otherwise need to be relocated.

"My concern is the social aspect, that we can't get traditional foods, cost of food is too high to eat healthy and it affects us, how we feel."

Ronnie Morales

Thawing, flooding and erosion are resulting in the damage and disruption of critical infrastructure. A tipping point has occurred accelerating damage to transportation, water and food systems.

Thawing is resulting in water and sanitation failures. This interrupts water and clinical services and may increase risk of infectious disease.

Sea level rise will increase flood risk. Sea level trend data is needed through tide stations and scenarios to look at combined effect of thawing, erosion, ice change and sea level rise.

Community members are concerned about food security. Changes are affecting subsistence, including the abundance, availability, timing, and quality of food resources.

Climate change has resulted in poor conditions for food preservation. Residents report that unseasonable weather has resulted in poor conditions for drying fish and seal and other foods.

Ice cellars are vulnerable to erosion, thawing and collapse. Structural failures have resulted in injuries and lose of storage raises concerns about food security.

There are more opportunities now to hunt fall whale. Hunters are adapting to the difficult spring ice conditions and lack of fall ice by participating in a fall whale hunt.

Climate models project continued rapid change. Residents should expect that some plants and wildlife will be stressed during a period of rapid environmental change, but that new resources and opportunities will emerge that can benefit Wainwright.

Change will bring new challenges including natural disasters. As climate and environmental conditions are changing so also are the risks for disasters. Updating Wainwright's all hazards mitigation plan is recommended to address climate change related threats.

"With the changing conditions we'll keep on learning. Go out hunting earlier, stay out later, than our Elders used to."

John Hopson Jr.

CONCLUSION

Public health considers climate change based on effects to mental health, injury, disease, and food and water safety and security. In Wainwright, residents report rapid erosion along the coastline and in the town caused by warming temperatures, decreased sea ice, increased wave and storm impact and runoff. Erosion is resulting in the loss of critical infrastructure including homes and ice cellars and raising concerns about food security. Permafrost thaw is another contributing factor to erosion, and also causing the damage and disruption to the community water and waste water system. The frequency of broken underground lines has increased in recent years due to thaw driven stressors.

Potential health effects include increased risk of illness related to disruptions in basic services and loss of traditional food storage facilities from erosion, thawing and flooding. Subsistence practices are adapting to changes in environment, seasons, and harvest conditions. The season for ice-based hunting activities is decreasing, while water based hunting is growing. Another effect is potential for injury related to new land and sea based hazards. Injury related to slips and falls in icy conditions and collapsing walls and ceilings in ice cellars. Poor ice is dangerous to travel and work on. Less sea ice means bigger waves and increasing hazards for sea travel. These conditions increase stress for hunters and their families which can negatively affect mental health.

Positive examples of adaptation include more time hunting whale from the water and efforts by the borough public works to develop new design and maintenance strategies for water and sanitation infrastructure. Benefits of climate change include new subsistence resources, warmer water for swimming in the lagoon, and a longer season for making community water and for maintaining infrastructure.

This report raises awareness about current, emerging, and potential future impacts of climate change. It is hoped that this will help Wainwright make informed planning decisions, find community appropriate development strategies, and pursue a safe, healthy, and sustainable future.

For more information, contact the Center for Climate and Health by E-mail at akaclimate@anthc.org or by phone (907) 729-2464.

"Adaptation is the key to merging our traditional knowledge with western systems. Just as our ancestors and leaders have done for time immemorial."

Ronnie Morales

Figure 5. Climate Change Health Assessment Findings, Wainwright, Alaska				
Topic	**Observed Change**	**Community Impacts**	**Health Concerns**	**Adaptations**
Ecosystem *a system in change*	Once characterized by freezing, now increasingly by thawing and melting	Broad implications for natural, built and social systems; northern migration of biota.	Keeping community systems working. Affordability of adaptations.	Engineer for new and emerging environmental conditions.
Climate *a new arctic climate*	Redefined - increases in temperature; changes in precipitation.	Broad implications for natural, built and social systems; adapting to warmer conditions.	Positive and negative; heat and cold injury. New travel, structural hazards; food and water security.	Adopted practices from traditional knowledge and from warmer regions. Innovations for local services, systems.
Weather *going to extremes*	Increase in thunder, ice storms and storm surge. More extreme warm less extreme cold.	More wildfire hazard; need for related protection systems, longer storm season.	Potential for poor air quality from smoke; increased risk of unseasonable or extreme weather.	New water sources for fighting wildfire. Increased caution stressed by elders related to travel and hunting conditions.
Land *a fragile landscape*	River and lake change. Drying and increased sediment in rivers. More shrubs and less tundra vegetation. New species.	Challenges with river travel. Decreasing lake habitat for water resource and wildlife. Risk of disease from new wildlife (e.g. giardiasis)	Risk of injury related to accident or falls through ice. Reduced water resources for community use. Risk of waterborne illness from encroaching species.	Changes in seasonal use and types of equipment. Advisories related to travel conditions. Use of personal water filters to treat drinking water from traditional sources.
Coast *an encroaching sea*	Shore thawing and erosion. Loss of ice cellars and cultural sites.	Loss of land and related historical artifacts as well as food system infrastructure.	Behavioral health related to loss of community and history. Food security related to decreased storage.	Construction of sea wall and new ice cellars. Planning for storm events and sea level rise; phased relocation as necessary.
Sea *vanishing ice, turbulent waters*	Thinning and retreating ice. Shorter ice season, New marine life.	Increased risk of sea ice related accidents. Poor conditions for ice related subsistence.	Injury or death from accidents on the ice, loss of equipment for subsistence, mental stress related to loss and risk; food security.	Adaptive hunting practices including increased water based hunting and reduced ice based hunting.
Subsistence *leaving the ice behind*	Changing sea and land practices and seasons. New challenges and opportunities for harvest.	Longer potential hunting season for whale. New equipment needs and increased potential for harvest interruption.	Changing subsistence related injury risks with new practices. Food security concerns related to harvest, and wildlife health.	Adaptive subsistence methods, increased flexibility as far as seasonal practices, monitor food condition; prevent exposure to wildlife diseases.
Ice Cellars *preserving an Inupiat tradition*	Thawing, structural failure, erosion, flooding	Abandonment of some cellars, new cellars, loss of food and ice storage.	Food and water borne illness. Food security, injury from collapsing cellars.	Monitor cellars for safety problems, study idea conditions baseline for future storage systems.
Infrastructure *a slow motion disaster*	Erosion, subsidence (sinking), thawing, flooding.	Foundation and structural damage, loss of services from water and sewer line breaks and flooding of homes, ice cellars.	Potential risk for food and waterborne illness. Loss of health -critical infrastructure and services. Closure of clinic.	Adaptive engineering including new strategies for water and sewer system. Management of snow to protect permafrost; construction of sea wall.

Aerial view of tundra.
Mike Brubaker, 2013.

APPENDIX A

Community and Regional Contributors

Anecdotal data was collected on observations and experiences from local experts in health, wildlife, weather, subsistence, education, sanitation, local governance, law enforcement, and emergency services.

Name	Position	Association
Marjorie Angashuk	Member	NSB Fire Department
Johnny Adams	Vice President	Barrow Volunteer Search & Rescue
Michael Agnasagga	Maintenance	Wainwright City Office
Raymond Aguvluk	Board / Council Member	City of Wainwright / ICAS Board
Rene Aguvluk	Rep. / Clinic Secretary	NSB Health Department
Ciara Ahvakana	Board / Council Member	ICAS Board
Judy Anashugak	Board / Council Member	ICAS Board
Justis Anashugak	Resident	NA
William Bodfish	Water Utility Systems	NSB
Vesta Bodfish	Maintenance/Custodian	Borough Clinic
Gordon Brower	Deputy Director	NSB Planning Department
Frederick Brower	Manager	NSB Risk Management Division
Sara Coburn	Veterinarian	NSB Veterinary Clinic
Matt Dunn	CIP Technical Coordinator	NSB Planning Department
Craig George	Senior Wildlife Biologist	NSB Wildlife Department.
John Hopson Jr.	Mayor	City of Wainwright
Ronnie Morales	ICAS Village Liaison	Wainwright Traditional Council
Donna Nashoalook	Staff	Wainwright Traditional Council
Abel Nashookpuk	Resident	NA
Phoebe M. Negovanna	Resident	NA
Raymond Negovanna	Base Operator	Wainwright Search and Rescue
Moses Nayakik	Elder	NA
Geraldine Ningeok	Community Health Aide	CHAP
Rose Panik	Deputy Clerk	Wainwright City Office
Fred Parady	Community Planner	NSB Planning Department
Rossman Peetok	Elder	NA
Helen Peetok	Elder	NA

Name	Position	Association
Qinugan Roddy	Natural Resource Manager	Inupiat Community Arctic Slope
Allison Segevan	Community Health Aide II	CHAP
Steve Segevan	President	OC
Robert Shears	Planner	NSB Planning Department
Raphaela Stimmelmayr	Biologist /Veterinarian	NSB Wildlife Department
Shannon Tazruk	Resident	NA
Cheryl Tagarook	Manager/City Clerk	Wainwright City Office
Maggie Tagarook	Council Member	Wainwright Traditional Council
Bill Tracey Sr.	Fire Chief/Director	NSB Fire Department
Ken Ungudruk	Water Operator	NSB

Kids standing on a whale.
Courtesy of Sophia Segevan.

APPENDIX B

Climate and Health Web Resources

Topic	Resource	Location
Climate / Health Study	Center for Climate and Health	www.anthc.org/chs/ces/climate/links.cfm
Community Profile	State of Alaska Community Database	www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm
Community Profile	NSB Wainwright Community Profile	www.north-slope.org/assets/images/uploads/WainwrightVillageProfile06.pdf
Regional Climate Data	Alaska Climate Research Center, UAF	climate.gi.alaska.edu/Climate/Location/TimeSeries/KingSalmon.html
Temperature Charts	Scenario Network for Alaska Planning	www.snap.uaf.edu/charts.php
Precipitation Charts	Scenario Network for Alaska Planning	www.snap.uaf.edu/charts.php
Extreme precipitation	NOAA Atlas 12	hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_ak.html
Weather Spotters	NWS Extreme Weather Spotter	www.weather.gov/skywarn/
Precipitation Monitor	Collaborative Snow, Rain, Hail Program	www.cocorahs.org/
Erosion Data	USACE Community Report, 2009	www.poa.usace.army.mil/AKE/Home.html
Flood Data	USACE Flood Hazard Database	66.223.166.160/usace_disclaimer.html
Coastal Observations	National Weather Service	www.nws.noaa.gov/om/coop/index.htm
Season Observations	USGS Phenology Network	www.usanpn.org/
Local Observers	LEO Network - ANTHC	www.anthc.org/chs/ces/climate/leo/
Regional Health Profile	North Slope Borough	
Regional Climate Studies	Landscape Conservation Cooperative	www.arcus.org/arctic-alaska-lcc
Harvest Summary Data	Alaska Department of Fish and Game	www.adfg.alaska.gov/sb/CSIS/index.cfm?ADFG=commInfo.Summary&CommID=364&Year=1989

APPENDIX C

Abbreviations

AACD	Alaska Association of Conservation Districts
ACCAP	Alaska Center for Climate Assessment and Policy
ACRC	Alaska Climate Research Center
ANTHC	Alaska Native Tribal Health Consortium
ADF&G	Alaska Department of Fish and Game
ADEC	Alaska Department of Environmental Conservation
CAHM	Climate and Health Measure
CCH	Center for Climate and Health
CCHA	Community Climate and Health Assessment
CCHRC	Cold Climate Housing Research Center
CDC	Centers for Disease Control
CIP	Capital Improvement Project
CSIS	Community Subsistence Information System
CVI	Climate Vulnerability Index
DHSS	Department of Health and Social Services
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
GIS	Geographic Information System
HIA	Health Impact Assessment
HVA	Hazard Vulnerability Assessment
IPCC	Intergovernmental Panel on Climate Change
LEO	Local Environmental Observer
NOAA	National Oceanographic and Atmospheric Administration
NPRA	National Petroleum Reserve - Alaska
NPS	National Park Service
NWS	National Weather Service
NSB	North Slope Borough
SNAP	Scenarios Network for Alaska & Arctic Planning
UAA	University of Alaska, Anchorage
UAF	University of Alaska, Fairbanks
UIC	Ukpeagvik Inupiat Corporation
USFWS	United States Fish & Wildlife Service
USG	U.S. Geological Service

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Looking up from inside a Wainwright ice cellar.
Jake Bell, 2014.

Driving an ATV along the beach in Wainwright.
Mike Brubaker, 2013.

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North Slope Borough
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The Alaska Climate Research Center
The Scenarios Network for Alaska & Arctic Planning
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The State of Alaska Department of Community, Commerce, and Economic Development
The State of Alaska Department of Health and Social Services
The State of Alaska Department of Fish and Game
The State of Alaska Division of Homeland Security and Emergency Management
The State of Alaska Department of Environmental Conservation
The National Oceanographic and Atmospheric Administration
The National Weather Service
The U.S. Geological Survey
The U.S. Army Corps of Engineers
The Environmental Protection Agency
The U.S. Fish & Wildlife Service

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