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Effect of Erosion in Alaskan Coastal Villages

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Alaska has warmed twice as fast as the global average during the past half-century and temperatures are projected to rise up by 1.5-5° F by 2030 and 5-18° F by 2100. Less sea ice covers the Arctic Ocean today than at any time in recent history. At the same time, the land itself is also affected by temperature increases. Permanently frozen subsoil, or permafrost, keeps the land intact and habitable along the northwestern Alaskan coast, is also melting. These environmental changes are resulting in accelerated rates of erosion and flooding that damage or destroy infrastructure and threaten communities throughout coastal regions in Alaska. Since 2003, federal and state governments have documented these climate change impacts on Alaskan communities and the need for immediate action to protect populations. State and federal government agencies are struggling to respond to the enormous new needs of these communities. Despite spending millions of dollars, the traditional methods of erosion control and flood protection have not been able to protect some communities. For several Alaskan Native communities, permanent protection measures are not a feasible possibility and community relocation is the only long term solution that can protect them from accelerating climate change impacts. This paper presents a brief overview of climate change in Alaska, examines the impact of climate change on Alaska Native rural villages, and analyzes the state, federal and community responses.

Key Words: Coastal Erosion, Permafrost Thawing, Climate Change, Community Response

Introduction

The disastrous consequences of global warming forecasted by scientists are now being seen in Alaska. Alaska's 6,600-mile coastline has been subjected to decades of severe erosion. Alaska's northern coastline is frozen-ice for most of the year. The ice season usually lasts from November to April on most of the Bering Sea coast, longer along the Chukchi Sea coast and still longer on the Beaufort Sea coast, where it usually lasts 9 to 10 months (Bronen, 2013). The northern coastline of Alaska experiences some of the highest erosion rates in the world during its ice-free months. The high coastal erosion rates generally are caused by seasonal storm surges, the thawing of permafrost, and movement of ice chunks breaking along the shoreline. In particular, mean erosion rates along the Beaufort coast are estimated at about 6.5 ft/yr and can be as high as 62 ft/yr (Gibb et al., 2011). Other geologic forces such as earthquakes, landslides and land subsidence have also contributed to the state's erosion problems.

The changing environment is the principal cause for displacement of Alaska Native villages (USACE, 2009). Erosion is a natural process, however, it becomes a problem when it damages or destroys something of value. In the past, communities could move away from areas affected by erosion because they did not depend on built infrastructure. The construction of public facilities such as power plants, schools, health clinics, and airports tie communities to the land and limits their ability to move (USACE, 2009). Therefore solutions have been put in place to try and mitigate these issues. This paper includes descriptions of the nature and extent of coastal erosion hazards, the role the federal & state governments have played in reducing erosion losses. A brief historic perspective of government efforts to protect communities and long term solutions currently being investigated are discussed. For summary purposes these issues can be addressed in the three 'Key Issues' below:

Key Issue 1: What are the physical causes for coastal erosion in small villages of Alaska? How does permafrost thaw influence erosion?
Key Issue 2: What significant efforts have been made to mitigate erosion in Alaska Coastal Village? How have government agencies and community organizations attempted to address the problem?
Key Issue 3: What long term solutions have been proposed or are currently put in place?

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Methodology

This section is a description of issues that were identified, of assumptions that were made and how researchers analyzed each 'Key Issue'. For many, climate change seems to be the key issue at the center of Alaskan erosion issues. Therefore, issues concerning what was the causing erosion in these communities and how it correlates to climate change were examined. Research data includes, a history of different types of erosion protection measures that have been used and put in place in individual communities as well as government efforts, as presented in official reports and by previous researchers. Much of the emphasis was on erosion protection efforts by U.S. Army Corps of Engineers (USACE) since data for these projects was readily available. Communities did some research on relocation efforts since it appeared to be the only permanent solution for some of the communities. Not much research was included on legislation and laws governing erosion protection assistance since it is not the main focus of this paper. Much of the research data came from reports and studies done by government entities such as the USACE and Government Accountability Office (GAO), newspaper and journal articles, project data information from USACE, and several online websites on climate change.

Results and Analysis

Causes of Coastal Erosion

In the past few decades, average temperature in the Arctic has risen at almost twice the rate as the rest of the world (Hassol, 2004). Widespread melting of glaciers, sea ice and rising permafrost temperatures present more evidence of strong arctic warming. These changes in the Arctic provide an early indication of the significance of global warming. Flooding and erosion threaten the existence of a significant number of Alaska Coastal Native communities. Rapid climate changes are occurring faster than many have predicted, as reported in the United States National Climate Assessment - Alaska Technical Report (Markon et al., 2012).

Decreasing Arctic sea ice extent and warmer temperatures are having detrimental effects on many Alaska Native coastal communities. Rising global temperatures have caused a decrease in the extent and thickness of Arctic sea ice. Summer sea ice in the region shrank by nearly 40 percent between 1978 and 2007 (Reiss, 2010). Coastal communities located in northwestern Alaska depend on the Arctic sea ice to protect them from the storms that originate in the Bering and Chukchi Seas. These storms can cause hurricane-strength damage on the coast due to wave action and storm surges. The seas are traditionally frozen from early November to mid-May. The ice creates a protective barrier to storm surges that cause flooding and erosion. However, decreased Arctic sea ice along with warming temperatures have caused a delay in the freezing of the Bering and Chukchi Seas. This delay in freezing of the Arctic seas prevents the ice from forming and exposes many coastal communities to the flooding and erosion caused by storms that originate in the Bering and Chukchi Seas and occur primarily between August and early December (Shulski and Wendler, 2007).

Permanently frozen subsoil also known as permafrost, keeps the land intact and habitable along the northwestern Alaskan coast, but this frozen subsoil is melting due to temperature increases, causing infrastructure, including water and sewage systems, to sink into the earth and alters their structural integrity. The land itself is also affected by temperature increases (GAO, 2009). It has been reported that the temperature of the top layer of permafrost has increased by up to three degrees Celsius since the 1980s (Markon et al., 2012).

Erosion accelerated by decreased sea ice extent and thawing permafrost, is causing some Alaska Native villages to seek relocation of their communities. Historically, communities could move away from areas affected by erosion because they did not depend on built infrastructure. However, as discussed earlier, the construction of permananet public facilities such as power plants, schools, health clinics, and airports, ties communities to the land and limits their ability to move (USACE 2009). It has been recognized that some communities need to relocate in their entirety because there is no higher ground close to the community and since all of the land on which the community is located is exposed to flooding and erosion. This paper examines a few of the most threatened communities. The phenomenon of erosion facing Alaska Native communities is well-documented. Several communities, including those which are now most threatened by erosion, began documenting the impact of erosion on their community in the 1980s in order to develop a long-term strategy for protection in place (Cox, 2007).

Efforts to Manage Erosion

In general, most communities have been resourceful in determining for temporary measures since they are the first ones to respond to erosion issues. However, several communities have reached out externally to state and federal agencies for assistance and to try to develop long-term solutions. In less severe situations, communities often take action themselves to slow the erosion, using whatever materials are immediately available. Sandbags, large oil drums, old construction equipment, abandoned cars and broken-down heavy machinery have been used to slow erosion. However, some coastal communities have limited heavy construction equipment that can be used to push sand up from low-tide areas to help secure a bluff. Some have used armor stone or other construction materials that have been stockpiled at the community as a means of temporary relief from erosion.

From as far back as the early 1900s until very recently, USACE has led federal shoreline protection and erosion control projects. USACE first began carrying out its mission in 1824, but it did not become responsible for shoreline protection until the early twentieth century. It has been reported that flooding and erosion affect 184 of 213 (or about 86 percent) Alaska Native villages to some extent (GAO, 2009). Of those villages, 31 were identified as imminently threatened by flooding and erosion. Below summarizes erosion control efforts in the following four communities: Bethel, Shishmaref, Kivalina, and Unalakleet. These four communities were chosen due to the author's personal knowledge of each of them and due to the recent USACE efforts in each of these communities to combat erosion related problems.

Bethel Bank Erosion

Bethel is located on the north bank of the Kuskokwim River and about 400 air miles west of Anchorage, with a population of just over six thousand people. Bethel is the major educational, economic, social, and cultural community in the Southwest Alaska Region. The village's main port is the only one on the western Alaska coast for oceangoing ships and serves as the supply center for villages in the Yukon-Kuskokwim Delta. For the last 40 years the riverbank adjacent to the community has been seriously eroded. Bethel experiences periodic flooding, mostly because of ice jams during the spring breakup of the Kuskokwim River. In 1985 The City of Bethel constructed 4,000 linear feet of bulkhead to protect the riverbank. A storm in May of the same year endangered the bulkheads, requiring USACE to move ahead with an emergency bank protection project to save them.

In 1995, the spring ice breakup caused such severe erosion that the governor of Alaska declared a state of emergency. A cove 350 feet long and 200 feet inland was created by a scour and endangered several existing structures. In response to the 1995 emergency, USACE placed rock along 600 linear feet of the riverbank and dock (USACE, 2006). In response to this, USACE also began an 8,200-foot bank stabilization seawall project that cost $24 million and was completed in 1997. This project included stabilization of the riverbank from the existing petroleum dock at the downstream end to the Bethel city dock at the upstream end. Although Bethel is not in imminent danger, it has experienced serious erosion and has undertaken various infrastructure-specific activities to resolve this problem. This includes a project to repair the seawall by placing more rock, and by replacing a steel tieback system, and placing steel wale on the inland side of the pipe piles. The project will reinforce the seawall an additional 1200 feet so that it protects the entrance to Bethel's small boat harbor. Phase 1 of the project extension, placement of rip rap at the toe of the existing bulkhead was completed in September 2007 (USACE, 2014a).

Shishmaref Coastal Erosion

Shishmaref (SHISH-muh-reff) is village located on Sarichef Island in the Chukchi Sea, just north of the Bering Strait and five miles from the mainland. The village is surrounded by the 2.6 million-acre Bering Land Bridge National Reserve. The population was 563 at the 2010 census. Shishmaref may seem to some as a poster child for the negative impacts of global warming. The effects of climate change in Shishmaref are sometimes seen as the most dramatic in the world. Rising temperatures have resulted in a reduction in the sea ice which serves to protect the island from storm surges. At the same time, the permafrost that the village is built on has also begun to melt, making the shore even more vulnerable to erosion. In recent years the shore has been receding at an average rate of up to 10 feet per year. Even though several barricades have been put up to protect the village, the shore has continued to erode at an alarming rate. All efforts to arrest the erosion have been unsuccessful for other than short periods of time. Several homes, the

town's water system and other infrastructure are being undermined by the erosion, causing several structures to collapse and fall into the sea. ("Alaska Village Erosion Technical Assistance Program," n.d.)

In recent years the Bureau of Indian Affairs (BIA), the City of Shishmaref, and the US Army Corps of Engineers have invested in shoreline protection along the community of Shishmaref. In 2004, the BIA installed 200 feet of shoreline protection along the shoreline near the Native store. In 2005, the Corps installed (Phase 1 Rock Revetment project) 230 feet of protection, connecting to the BIA project, extending to the east to protect the Shishmaref School. Also in 2005, the community of Shishmaref installed about 250 feet of protection extending to the east from the Corps project. In 2007, the Corps installed another 700 feet of protection (USACE, 2014b).

In 2009-10, a rock-wall barrier was constructed for protection along significant portions of the coast fronting the community. However, approximately one-third of the community, including the airport, residential structures and community infrastructure, remain exposed. In 2009, the USACE report stated that severe damage to community is expected by 2019 (USACE, 2009)

Kivalina Coastal Erosion

Kivalina (kiv-uh-LEE-nuh) is a city and village in Northwest Arctic Borough, Alaska. The population was 377 at the 2000 census and 374 as of the 2010 census. Kivalina is located on the southern tip of a 7.5 mile long barrier island located between the Chukchi Sea and a lagoon at the mouth of the Kivalina River. It lies 130 km 81 miles northwest of Kotzebue. It is the only village in the region where people hunt the bowhead whale. The original village was located at the north end of the Kivalina Lagoon but was relocated due to severe sea wave erosion during storms. The island on which the village lies is threatened by rising sea levels and coastal erosion. As of 2013, it is predicted that the island will be inundated by 2025("Kivalina, Alaska," n.d.). Kivalina has not historically seen significant erosion. The Kivalina spit has seen cyclic erosion and accretion, with modest accretion on the Chukchi Sea side more prevalent during the 30-year period of 1970 to 2000. The higher energy storms that could result in significant erosion occur during the winter months when the Chukchi Sea is frozen. This has resulted in natural erosion protection in the past. However, with global climate change the period of open water is increasing and the Chukchi Sea is less likely to be frozen when damaging winter storms occur. Winter storms occurring in October and November of 2004 - 2007 have resulted in significant erosion that is now threatening both the school and the Alaska Village Electric Cooperative (AVEC) tank farm. This erosion has resulted in the loss of some teacher housing and the school and community laundromat drain fields (USACE, 2006).

The significant winter storms of 2004-05 caused erosion of up to 70 to 80 feet of uplands behind the school. The bank line was within 25 feet of the main school structure. Erosion in the vicinity of the AVEC tank farm was similar, with only 5 feet of uplands remaining between the nearest tanks and the bank line. This resulted in emergency erosion protection projects being pursued by both the state and federal governments. In 2008, the village of Kivalina sued 24 fossil fuel companies for the destruction of its homeland, claiming they suffered monetary damages from the energy industry for the destruction of the island by flooding and erosion caused by climate change. The suit was dismissed by the United States district court on September 30, 2009, on the grounds that regulating greenhouse emissions was a political rather than a legal issue and one that needed to be resolved by the US Congress and the administration rather than by courts. The village appealed the decision but lost its federal court case in 2013. The last project completed by USACE was in 2009 and included the construction of 1200ft of rock revetment as well as additional placement of sand fill for temporary erosion protection on the beach (USACE, 2014c). Currently Kivalina has had nine erosion control projects completed from 1992 to 2009 and some of them mostly dealing with community relocation.

Unalakleet Erosion Control

Unalakleet (EW-nə-lə-kleet) is a city located on the Norton Sound at the mouth of the Unalakleet River, 148 miles southeast of Nome and 395 miles northwest of Anchorage. At the 2010 census the population was 688. Unalakleet is known in the region and around Alaska for its salmon and king crab harvests; the residents rely heavily on Caribou, Ptarmigan, Oogruk (Bearded Seal) and various other salmon species. Unalakleet is also known for its aesthetic value, as it resides right next to the Bering Sea, immediately next to a large, clean river (Unalakleet River) and has trees, tundra, and hills behind it. Unalakleet has long been a major trade center between the Athabascans who lived in the interior of Alaska and the Inupiat who lived on the coast. The Russian-American Company built a trading post here

at Unalakleet in the 1830s. Sami reindeer herders from Lapland were brought to Unalakleet to teach sound herding practices in 1898. In 1901, the United States Army Signal Corps built a 605-mile (974 km) telegraph line from St. Michael that passed through Unalakleet ("Unalakleet, Alaska," n.d.). Unalakleet suffers from erosion on both the ocean side (Norton Sound) and from the Unalakleet River. The erosion rate on the Norton Sound side averages 1 foot per year, and occurs when storm surge attacks the spit washing away beach material. The rate of erosion from the Unalakleet River is more severe and averages two feet per year (USACE, 2014d).

At current erosion rates the fish processing plant and some residences at the mouth of the Unalakleet River could be lost within 2 to 10 years. The community's water line running along Norton Sound could also be lost, as well as some parts of the airport. Over time, erosion is expected to continue to capture some residences, roads, and utilities but the community as a whole will not be destroyed. In 2000, the Natural Resource Conservation Service (NRCS) constructed 1,400 feet of gabions (wire baskets filled with rock) beginning at the upstream end of the fish processing plant on the Unalakleet River and extending around the end of the spit approximately 1,000 feet with a cost of about $1.3 million. A late November storm in 2003 caused severe damage to the gabions. The State of Alaska signed a disaster declaration for this area and the community is applied for funding to repair the gabions. The estimated remaining life of the gabions ranges between 2 and 10 years. Failure would cause site specific damage to structures and facilities, but, as mentioned, complete loss of the community is not expected.

The existing bank protection at Unalakleet is in need of major repair or replacement. The gabion structure has been ruptured in places, spilling the rock core out where it can easily be washed away even during good weather conditions. The Corps is developing a project to remedy the erosion in this location through the construction of a riprap revetment with an estimated cost of about $30 million (USACE, 2006). Some housing is be expected to be lost if the bank protection is not be repaired or replaced. These losses would be limited in nature to areas directly adjacent to gabion wall failure. Various site specific roads, electric and telephone lines, and water and sewer lines in the community are subject to loss, though the infrastructure as a whole is not are expected to be destroyed.

Changes in USACE Authority

The history of the USACE's involvement in shoreline protection reflects the general evolution of federal coastal erosion policies from in situ structural protection like seawalls, jetties, breakwaters, dredging, and rock revetment to a more flexible range of approaches, including soft engineering approaches like sand scraping, beach replenishment, dune stabilization, and retreat and relocation

The Corps' authority to construct solutions for erosion control in Alaska has been modified by the repeal of Section 117 of the 2005 Energy and Water Development Appropriations Act in March 2009. Previously Section 117 had allowed projects constructed under that authority to be funded at full Federal expense, and did not require that those projects be justified by using the traditional benefit-cost ratio test. Under Section 117, the Corps was able to initiate the construction in Kivalina, Newtok, Shishmaref, and Unalakleet. In other words, erosion protection measures were previously fully federal funded. After the repeal of Section 117 these communities are required to cost-share with the government on these projects. Now, because of the repeal of Section 117, it is unknown whether these projects will be completed as planned. An example of this issue is the rock wall in Shishmaref. The rock wall was originally planned to be nearly twice as long as it is, but money is now only available if the village can fund 35% of the cost needed to build it. It is unlikely that a village with a population of 563 people, who largely hunt seals for food and harvest ice for water would have millions of dollars to fund such a project. As of now, the Corps has several cost-shared programs that communities can utilize for assistance. Section 14 of the U.S. Flood Control Act of 1946 allows the Corps to plan, design, and construct erosion control projects that protect public infrastructure. Section 103 of the U.S. River and Harbor Act 1962 is used for protection against storm waves and hurricanes (USACE, 2009).

Relocation

As previously discussed, 31 villages were recognized as imminently threatened due to erosion. According to federal, state, and village officials, at least 12 of these communities have decided to relocate, in part or entirely, or to explore relocation options. The villages of Kivalina and Shishmaref will likely need to move all at once and as soon as possible, since they continue to suffer flooding and erosion and have limited emergency evacuation options.

The city of Kivalina hopes to relocate to a new site 7.5 miles from the present site. Studies of alternate sites are ongoing (Zarembo, 2007). According to a 2009 U.S. Army Corps of Engineers study, the estimated cost of relocation runs between $95 and $125 million, with the current location likely to stay above water only for about 10 to 15 years. However, more recent estimates have been reported to run as high as $400 million (Abate, 2010).

In 2002 the city of Shishmaref formed what is called 'The Shishmaref Erosion and Relocation Coalition' which created a strategic plan for relocation and the village has been seeking funds and support to move forward with relocation since. An Army Corps of Engineers study in 2004 estimated that relocating Shishmaref to the Alaska mainland would cost $180 million (Gregg, 2010).

Community relocation may be the only solution that can protect residents from the damaging effects of flooding and erosion on a significant number of Alaska Native communities. But while several villages have tried to move, they've found that the reality of doing so is much more complicated. A 2009 U.S. Government Accountability Office report recognized that no government agency has the authority to relocate communities, no governmental organization exists that can address the strategic planning needs of relocation, and no funding is specifically designated for relocation. As a result, none of the 12 villages identified have been able to relocate (GAO, 2009).

Conclusions

Flooding and erosion threaten the habitability of a significant number of Alaskan native communities. Community relocation may be the only adaptation strategy that can protect community residents. It has been recognized that no government agency has the authority to relocate communities, no governmental organization exists that can address the planning needs of relocation, and no funding is specifically designated for relocation (GAO, 2009). Even with their communities in imminent danger, none of the villages identified have yet been able to relocate. The relocation challenges faced by Kivalina and Shishmaref exemplify the need to create a governance structure which can better respond to the needs of communities. In the meantime, Government agencies are spending millions of dollars to construct erosion protection infrastructure, which only have an anticipated lifespan of ten years, sometimes 15 to 25 years if they are properly maintained. However, there is some growing concern that such protective measures may reduce the urgency among and slow the momentum toward relocation by creating a false sense of safety at the existing villages that need to relocate and thus prolonging their stay in dangerous conditions. Lessons have to be learned to guide communities and government agencies to transition from protection in place to community relocation before a community becomes uninhabitable because of climate change. Federal and state agencies, along with elected officials, must explore the budgetary constraints of current laws and propose solutions to safeguard Alaskan communities affected by erosion related problems due to climate change.

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