Laying the Foundation for Resilient Coastal Communities

Case Studies – Port Heiden and Goodnews Bay, Alaska

Authors: Richard Buzard[1], Chris Maio[1], Jacquelyn Overbeck[2], Erica Lujan[3], Sue Flensburg[4], Davin Holen[5], and Gabriel Dunham[5]
Editor: Paula Dobbyn, Designer: Dawn Montano

1. Arctic Coastal Geoscience Lab, University of Alaska Fairbanks
2. Coastal Hazard Program, Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources
3. Alaska Native Tribal Health Consortium
4. Bristol Bay Native Association
5. Alaska Sea Grant, University of Alaska Fairbanks

INTRODUCTION

During the past century, average temperatures in Alaska have increased by 3° F in summer and as much as 6° F in winter (NAST, 2000; Karl et al., 2009). This rate is twice the national average and is predicted to continue to increase by another 1° to 7° F by 2100. In Western Alaska, this warming is resulting in decreased duration and extent of sea ice, and thawing of permafrost. These environmental changes have negative impacts on coastal villages, including damage to infrastructure and ecosystems, hindering transportation routes, and increasing variability of subsistence resources. Reductions in sea ice extent and thickness leave the coast exposed to fall and winter storms leading to coastal erosion and storm-driven flooding. These coastal hazards pose serious threats to many coastal communities in Alaska, yet data are lacking for much of the state that would allow for risks to be quantified and effective mitigation and adaptation strategies are lacking for much of the state.

Spotlight:

What's a coastal hazard?

Coastal hazards are natural and human-made events that threaten the health of coastal ecosystems and communities (NOAA, 2018). Some of the prominent hazards facing Alaska's coastal communities include shoreline erosion, storm-driven flooding, permafrost thaw, tsunamis, and ice push. Most coastal hazards result from natural ocean processes and only become "hazards" after human-built villages and cities along the coastline are threatened (Kinsman and Gould, 2014).

In Western Alaska, Bering Sea storms (extratropical cyclones) can result in severe erosion, flooding, and damage to critical infrastructure. As local stakeholders grapple with how to respond to mounting coastal hazards, many are asking what steps are needed to build and sustain resilient coastal communities. Unfortunately, there is a common misconception that all communities face similar risks and that a "cookie-cutter" approach will work for addressing these issues. Though some general similarities exist, each community faces a unique combination of many local and regional factors. These include environmental parameters like geographic location, underlying geology, and historical trends, as well as societal and technological factors. Despite these differences, the first step toward a solution is to gather baseline data about the hazards and then work to accurately assess risks. Coastal hazards occur over different spatial and temporal scales. Therefore, baseline data that identify long-term (i.e. sea level rise, changing ocean processes) and short-term (i.e. wave attack or flooding) vulnerabilities must both be collected to accurately plan for and respond to coastal hazards.

Purpose: The purpose of this brochure is to identify some of the first steps toward building and sustaining resilient coastal communities. Lessons learned during two research projects taking place in Port Heiden and Goodnews Bay serve as case studies to demonstrate some of the necessary steps to move toward resiliency. The information presented provides a developing framework toward building the capacity of Alaska's coastal and riverine communities to make informed decisions regarding coastal hazards. It is also intended to promote a long-term, mutually beneficial relationship between local communities and regional scientists.

Spotlight:

What does coastal resilience mean?

Resilient coastal communities plan for and take deliberate action to reduce risks from coastal hazards, accelerate recovery from disaster events, and adapt to changing conditions (NOAA, 2018).

Resilience can be considered a way of thinking that not only serves to buffer against disturbance but also promotes the activities that lead to long-term sustainability and development (Folke, 2006).

The act of being resilient is not stagnant but requires a constant diligence toward identifying and confronting ongoing and future risks.

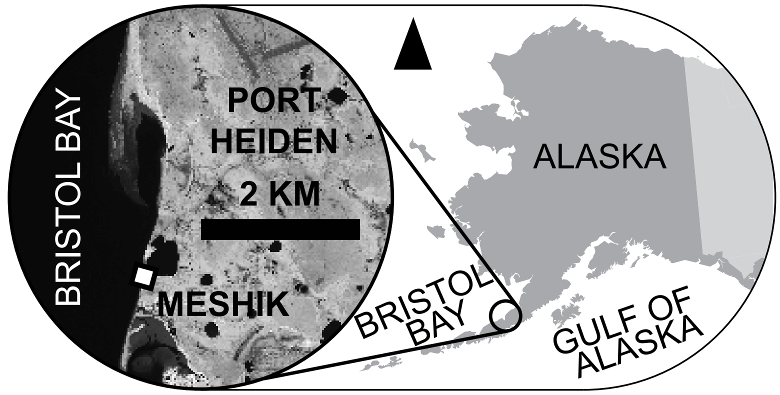
FIELD LESSONS

Southwest Alaska's coastline is one of the most understudied regions in the United States, and is a place that is highly vulnerable to ongoing and future climate change. There is a critical need for workflows and methods that can help build and sustain resilient coastal communities in this remote region. Results from two ongoing studies carried out within the Native Villages of Goodnews Bay and Port Heiden are presented here. The two locations are very different in terms of their geology, geographic location and history, but they share many similarities. For example, both were forced to relocate in the past in response to storm-driven flooding and erosion. These case studies provide valuable lessons for other villages along Alaska's shorelines (both riverine and coastal) currently struggling to effectively respond to a rapidly changing environment.

Aerial image of Goodnews Bay

Case Study 1: Native Village of Port Heiden

Community Snapshot



Population: 102

Primary Governance: Tribal Council

Cultural Heritage: Alutiiq

Economy: Subsistence, commercial fishing, military cleanup

Geology: Built on volcanic sediments (pumice) deposited during the Aniakchak volcanic eruption approximately 3,500 years ago.

Geography: Port Heiden is located on the northern side of the Alaska Peninsula.

Background

Facing decades of erosion, the residents of Meshik (sometimes called Port Heiden's "old village site") were proactive problem solvers and began to adapt to coastal changes by moving to Port Heiden, 2 km inland, in the early 1980s (Kinsman and Gould, 2014). During WWII, over 2,000 military personnel were stationed in Port Heiden's Fort Morrow, leading to the development of a road system, airport, school, and other military and civilian infrastructure. After the military closed the base and radar site in 1978, many contaminants were left behind. The Formerly Used Defense Sites (FUDS) and municipal wastes in Meshik have presented numerous challenges and left a legacy of cleanup efforts that have not kept pace with the rapid erosion. Out of necessity, important infrastructure such as the barge landing are still located along the crumbling shoreline and are thus threatened by erosion (Kinsman and Gould, 2014). In addition, the village lost access to a safe harbor after a road narrowly passing between a lake and the ocean eroded.

> *"Christiansen had a house right over there but it got eroded, all washed away."*
>
> — Nefuti Orloff, resident

Our work

Along the eroding coastal bluffs fronting Goldfish Lake, we installed community-based erosion monitoring sites to be maintained by local tribal staff. Time-lapse photos and ground measurements collected at these sites allow us to quantify the amount of erosion every hour of a storm event. During installation of the sites, GPS and aerial drone survey data were collected to provide a baseline from which local tribe staff could measure erosion (Figure 1). After site installation, a local environmental coordinator refreshed the camera SD memory cards and used a measuring tape to take stake-to-bluff measurements of erosion. The resulting data show the amount of erosion from single storm events, as compared to past surveys that were conducted every 10 to 20 years. Measurements made using the time-lapse photography and collected by the local environmental coordinators are closely aligned, showing the accuracy of this method and the capacity of the locally trained staff (Figure 2).

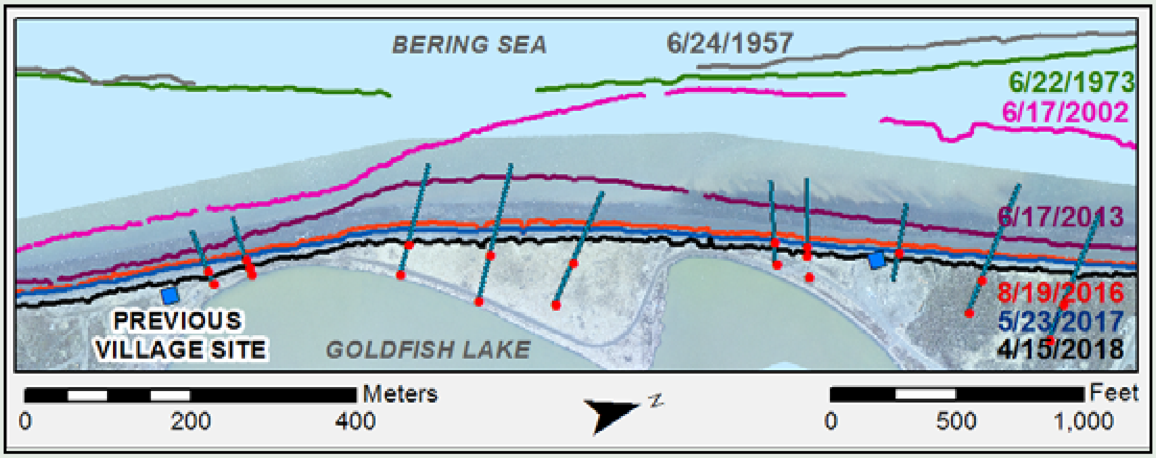


Figure 1.
Map showing community profile locations in blue in the area fronting Goldfish Lake. Historic and contemporary shorelines measured from aerial imagery are also shown. Time-lapse cameras (blue boxes) take pictures every hour. In recent decades, the shoreline has consistently eroded at rates around 40 ft per year, some of the fastest rates in the world.

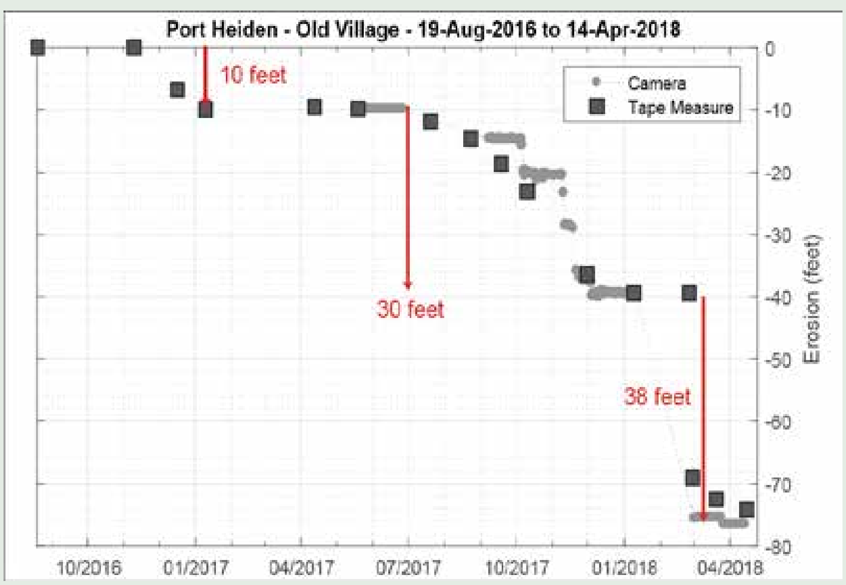


Figure 2.
Bluff erosion measurements from August 2016 to February 2018 taken from time-lapse camera images (circles) and direct tape measurements by citizen-scientist community members (squares).

What we learned

Port Heiden's coastal geography is changing rapidly due to bluff erosion. The road between the ocean and Goldfish Lake is expected to erode entirely and erosion will likely breach the road during the fall of 2018. Erosion is driven by individual storms, which have ample fetch for wave development since nearby Chistiakof Island eroded and welded to the northern coast in the 1970s. Erosion is exacerbated by the weak sediment structure of the bluff, but tends to halt during the winter when the groundwater in the bluff freezes and an ice berm forms on the upper beach, protecting the bluff from waves. Recent warming trends in the region and the increase in open water days linked to declines in sea ice has dramatically accelerated erosion rates in the Bering Sea region.

How does it tie to resilience?

With funding from the Bureau of Indian Affairs, Port Heiden is in the process of developing an environmental vulnerability assessment and adaptation plan with support from the Bristol Bay Native Association (BBNA) and the Alaska Native Tribal Health Consortium (ANTHC). During an initial meeting in an adaptation planning process with ANTHC, Port Heiden residents said that coastal erosion has been the most substantial change the community has experienced in recent memory. However, residents have been proactively confronting coastal change for over 40 years, first by moving primary village infrastructure in the early 1980's. Rapid coastal changes continue to make it difficult to maintain access to a safe harbor and barge landing site. In years past, commercial fishers from Port Heiden launched their boats in a protected lagoon near the Old Meshik village site. The access beach/road have almost entirely eroded and the waves make launching the fishing boats more dangerous, risking damage to the boat and injury to the fisherman at the onset of the season.

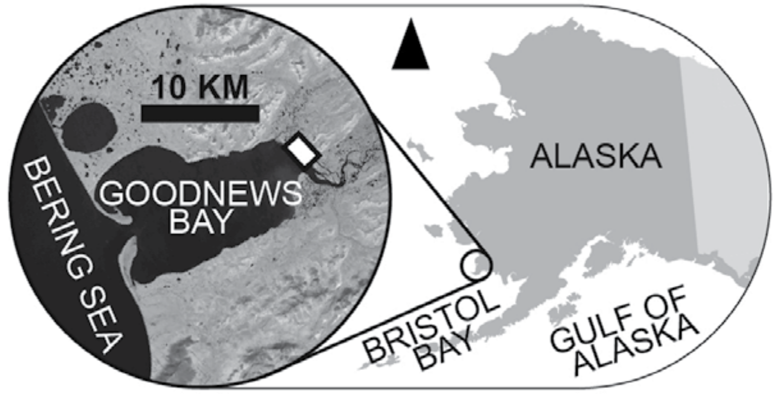
In addition, local accounts suggest there are still unmarked military and municipal contaminates that continually erode from the bluffs and require cleanup. The Port Heiden Environmental Program has developed excellent capacity to re-use and recycle materials. One of two 250,000-fuel storage tanks salvaged from the old village site has been moved and repurposed as the community recycling facility. The facility collects and processes old utility wires and appliances, and it crushes aluminum, in preparation for shipment to a recycling facility. The Environmental Program employs community members for cleanup and recycling jobs, and helps build valuable skills among youth.

During the adaptation planning process, residents named the construction of a safe boat harbor a community priority. This community-based approach to erosion monitoring has resulted in valuable datasets that directly relate to this community adaptation objective. These datasets are also used in proposals to request more funds for confronting identified risks. The environmental program secured funding to continue the monitoring project, maintaining this new connection between residents and scientists so that all parties can continue to develop an understanding of this rapidly changing coastline. Port Heiden is currently working with the Environmentally Threatened Communities Grant Center at ANTHC to fund a feasibility study for the construction of a new safe harbor.

Scott Anderson from Port Heiden assists with GPS survey.

Case Study 2: Native Village of Goodnews Bay

Community Snapshot



Population: 243

Primary Governance: Tribal council and municipality

Cultural Heritage: Yupik

Economy: Subsistence, commercial fishing and guiding

Geology: Built on glacially derived sediments including till. Basalt and serpentinite quarries from Rocky Mountain provide road and boat launch gravel, and bluff armor rock.

Geography: Goodnews Bay is a shallow semi-enclosed lagoon protected from the open waters of Kuskokwim Bay by two barrier beaches. The village sits at the mouth of the Goodnews River and is impacted by both coastal and riverine processes.

Background

"We didn't want to move but the ice and tide made us."

— Maggie Scholtz, Village Elder

Historically, the village of Mumtrak (now called Goodnews Bay) was located seasonally along the low-lying spit adjacent to the Goodnews River but moved to higher ground in the 1920s after flooding and erosion became a frequent issue. The current village site has experienced periodic damage from storm-driven flooding and erosion, especially during the Bering Sea Storm of 2011. In response, the village has armored its eroding bluffs with rock and gravel and migrated the village footprint up the adjoining slope and out of harm's way.

What we did

We produced a high-resolution topographic map, orthorectified aerial imagery (imagery corrected to the earth's surface) (Figure 3), a historical shoreline change assessment, and a flood hazard assessment. We also installed a time-lapse camera. Work was conducted in direct coordination with the tribal environmental program, including the collection of photographs during storm events to document flooding. We engaged with local students at the Rocky Mountain School through school field trips to introduce them to coastal processes and how to measure beach changes using low-cost methods. A community meeting was held at the school to discuss project results and gain local environmental knowledge regarding past storm impacts. Most importantly, we returned to the village on an annual basis over a 3-year period building mutual trust and relationships with local stakeholders. These relationships enabled us to more effectively carry out research tasks and interact with residents to collect local environmental knowledge regarding past storms. The work is also contributing toward new efforts to acquire sustainable grant funding sources for the continuation of this partnership.

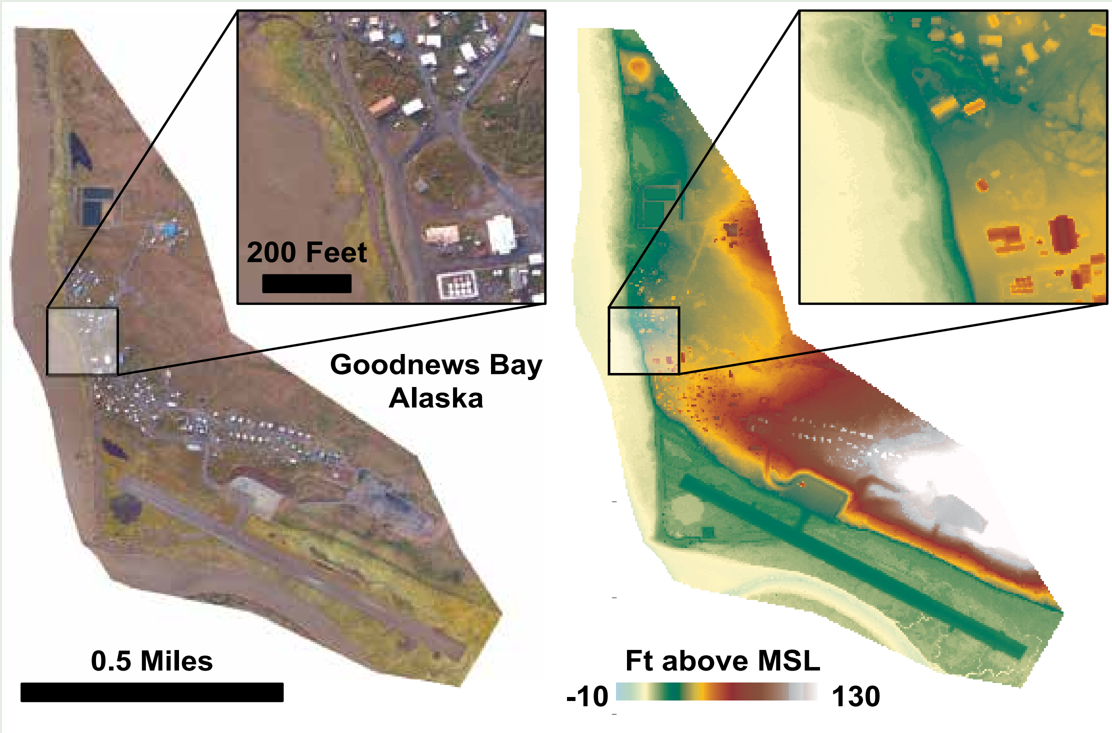


Figure 3.
Aerial imagery of Goodnews Bay (top; A) collected for this project is very high resolution (each pixel is 8.1 centimeters in width). This is coupled with a 16-centimeter digital surface model (bottom; B), which can be used for a number of research purposes including storm surge modeling.

What we learned

Goodnews Bay has a long history of flooding and erosion, but most of its mitigation has been effective. Because significant erosion only occurs during very large storms, village residents have been able to keep up by placing gravel and armor rock along the portion of the village containing the fuel storage facility. The village has a local gravel source that is commonly used to repair damages from erosion and flooding, so the costs are minimized. Storm-surge flooding – the hazard that drove their relocation nearly a century ago – continues to be problematic for the village. A Bering Sea cyclone in 2011 destroyed one home and several boats and completely inundated the runway, which had to be rebuilt. A storm of similar magnitude had caused even more damage in 1979. The newly extended runway remains at risk of flooding, but as in many coastal communities, it is not feasible to build a runway outside of the low-lying area. Similarly, the sewage lagoon is at risk of being damaged by large storms, although such an event has not occurred to date.

How does it tie to resiliency?

Goodnews Bay experiences frequent flooding from storm surge, which has caused damage to local infrastructure, loss of property, and risk to public safety. The 2011 Bering Sea Storm destroyed many boats, an expensive and essential tool for subsistence activities in and around the community (Figure 4). During the storm, ice flow from the Goodnews River was transported onto the shoreline by waves. The village responded by migrating inland and uphill, and new houses have been constructed well above the maximum possible storm surge flood height making them safe from future coastal hazards. Still, through the assessment of coastal change and past flood elevations two areas of the village have been identified as vulnerable to future erosion and flooding including a small creek with several houses along its banks (Figure 4). Accurate forecasts of flood elevations can give the community some time to relocate their property to higher ground and avoid significant financial losses. With improved facilitation between tribal staff and environmental modelers, local observations of flooding are now contributing to improving forecasts of storm events. Beyond this improvement, continued communication and dialogue between the village and coastal scientists will help Goodnews Bay stay connected and informed, boosting the village's capacity to expand its monitoring efforts and make informed decisions regarding the mitigation of future coastal hazards.

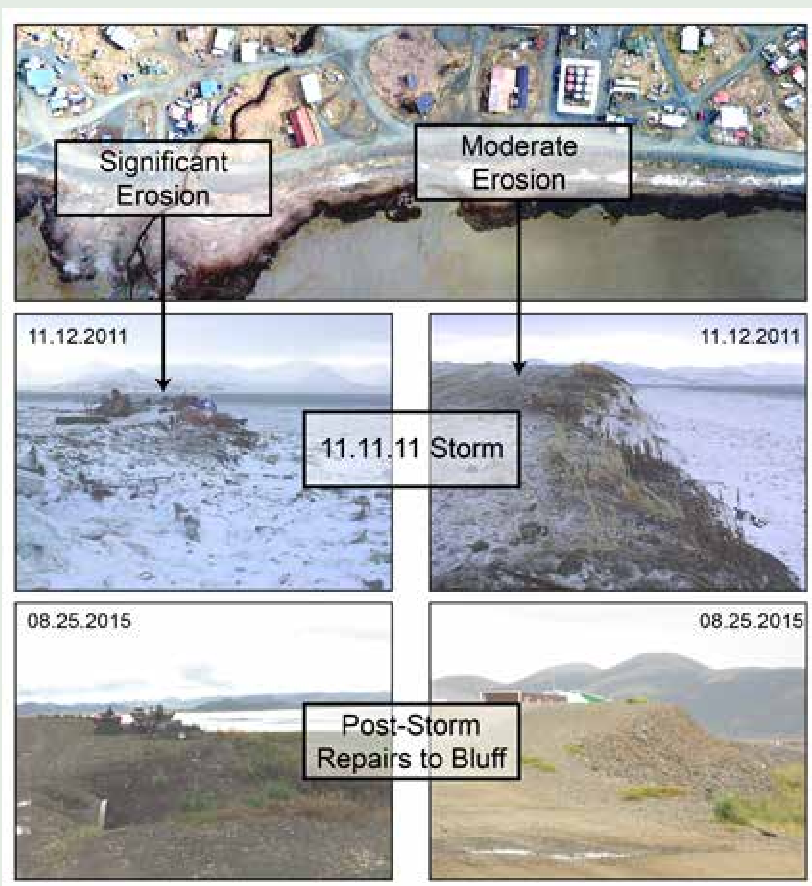


Figure 4. Bluff erosion hot spots as determined by the shoreline change analysis (from Buzard, 2017). Top photos show damage after 2011 storm (courtesy of Alice Julius). The creek area (left) has steadily eroded over the study period and is projected to continue eroding. In other areas the re-armoring of the bluff has kept up with erosion. Note that the 2011 storm left the bluff at an uncharacteristically steep angle (top right) compared to the angle after it was re-armored with rocks and gravel (middle right).

STEPS IN SUPPORTING RESILIENT COASTAL COMMUNITIES – LESSONS LEARNED

Through the two case studies, three key factors have been identified as critical to contributing toward and sustaining resilient coastal communities. These include the need to build partnerships between local and regional stakeholders that support direct community engagement; development of baseline data sets, assessment of historical shoreline trends and establishment of local monitoring programs; and applicable data products that support informed decision-making. These combined tasks help to lay the foundation for resilient communities.

1. Building sustainable partnerships and supporting environmental coordinators to develop direct community engagement

Engagement and buy-in between local and regional stakeholders is one of the most challenging yet important components of building resilient communities and serves as the stepping stone for all other tasks. Through the work in Southwest Alaska, we found that it was essential to partner with local tribal and city councils, tribal environmental coordinators, K-12 school staff and students (Figure 5), other scientists and regional Native health and environmental organizations. Direct engagement between these parties resulted in motivated and highly capable local residents getting involved in the collection of scientific data. We've found that success in monitoring programs is directly related to the actions of one or two committed individuals within the community who tirelessly works to assist in the establishment of monitoring sites, carry out repeat measurements and site maintenance, and regularly communicate with scientists. The leadership and drive of these individuals is by far the most significant factor in whether a program will produce meaningful results. Through the leadership and logistical support of these individuals we hosted several community meetings that facilitated the discussion of local knowledge regarding long-term environmental trends and past coastal hazard impacts. These partnerships are necessary for the establishment and maintenance of coastal monitoring sites, and empower local leaders with measurements and understanding of ongoing changes in their community.

2. Development of baseline data sets and assessment of historical shoreline change rates

One of the major challenges in coastal hazard assessments in Western Alaska is the scarcity of baseline data. It is important to understand whether the area changes often (such as Port Heiden), or infrequently (Goodnews Bay), in order to identify when deviations from the normal coastal processes occur. This begins by documenting the state of the shoreline with great certainty (such as the GPS position of the shoreline, or the topography of the beach), so that it may be compared to future data sets to see how it has changed. A second survey using the same methods must take place during subsequent visits to verify whether changes are occurring, but the majority of future data sets are collected by local monitors. To compare these trends to the past, shorelines are measured within a GIS using historical aerial imagery. During all of these steps, local knowledge of recent and past coastal changes is critical to both identify areas of interest and verify changes observed in imagery. The development of baseline data sets requires:

1. A minimum of two fieldwork campaigns at each location with annual repeat visits and surveys.
2. The acquisition, processing, and analysis of historical and contemporary aerial imagery

Figure 5. Rocky Mountain School (Goodnews Bay) high school students and local environmental coordinator, Alice Julius, assist with data collection. A) Students are taught about GPS systems in preparation for a topographic survey. B & C) High school students are trained by Alice Julius to collect coastal profile measurements using the simple Emery rod method.

3. The establishment of sustained local monitoring programs that provide accurate, time-sensitive data.

3. Applicable data sets that are tailored for local needs, enable informed decision-making, and promote a close working relationship between scientists and local stakeholders

A key component in supporting resilient communities is to produce research products that are accessible and useable to local stakeholders. This means that from the beginning of any project it is essential to have discussions between scientists and local stakeholders to clearly identify what the objectives are and what the local community needs for data products. For example, if flooding is a primary concern, as it is in Goodnews Bay, an elevation map showing past flood levels which clearly shows vulnerable infrastructure is very applicable (Figure 6). The media in which the data product is delivered is also important as many coastal villages have limited internet connectivity, and data intensive online maps and videos are not readily accessible. In these cases, it's often most useful to provide laminated hard copies or digital PDF copies of maps and topographic models that can be viewed without the internet.

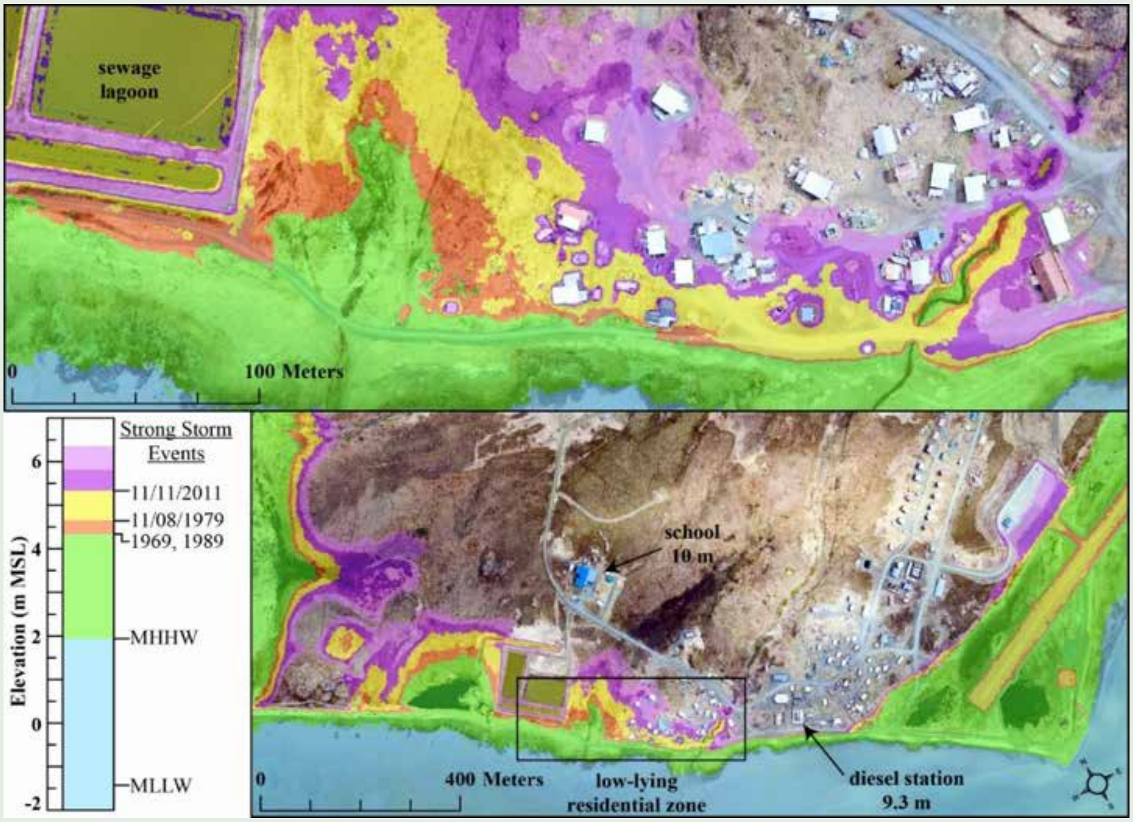


Figure 6. Map of horizontal extent of estimated total water level of strong storms in Goodnews Bay (from Buzard, 2017). All structures in the yellow zone were flooded during the 2011 storm. Purple zones are displayed to visualize extent of a hypothetical storm reaching up to 1 meter above the 2011 storm.

SUMMARY

- Erosion and storm-driven flooding are coastal hazards that pose serious threats to many villages in Alaska, yet information is lacking that would allow for risks to be accurately assessed, planned for, and managed.
- Resilient coastal villages plan for and take deliberate action to reduce risks from coastal hazards, spring back from disaster events, and effectively adapt to changing conditions.
- Erosion rates in Port Heiden are some of the highest in the world, directly impacting access to a safe harbor and subsistence resources.
- Residents of Port Heiden have been proactively confronting coastal change for over 40 years, initially moving their village inland in the early 1980's, and by current action to monitor erosion rates and develop a mitigation and adaptation plan.

- Goodnews Bay experiences moderate erosion and flooding from severe storms such as in November 2011, which led to loss of property and damage to important infrastructure.
- Residents of Goodnews Bay have participated in a coastal resiliency assessment, taken steps to document flooding and erosion damage, and continue to build mutually beneficial relationships with scientists.
- Three key factors have been identified as critical to building and sustaining resilient coastal communities including:
    - Partnerships between local and regional stakeholders and individual community coordinators that support direct community engagement and communication.
    - Development of baseline data sets, assessment of historical coastal trends, and establishment of local monitoring programs
    - Custom-tailored data products that support informed decision-making and promote further community participation and research.

Alice Julius cleans fish along the Goodnews River.

FUNDING SUPPORT AND ACKNOWLEDGEMENTS

Funding for this work was provided by generous funding support from Alaska Sea Grant, the Bristol Bay Native Association, the Bureau of Indian Affairs, the State of Alaska's Coastal Hazard Program, and the University of Alaska Fairbanks. This publication is the result of research sponsored by Alaska Sea Grant with funds from the National Oceanic and Atmospheric Administration Office of Sea Grant, Department of Commerce, under grant no. NA14OAR4170079 (project no. R/127-01), and from the University of Alaska with funds appropriated by the state.

We also want to thank all of the community members that have been involved in these efforts from Port Heiden and Goodnews Bay including the local tribal councils; George Bright, Sr.; Ruth Bright; Willie Ayojiak; Nefuti Orloff; Alice Julius; Peter Julius; Roxanne River; Scott Anderson; Jaclyn Christensen; Wayne Schouten; Sherri Carmichael; Shannon Wilson; Sally Benedict; the teachers and students of the Rocky Mountain School; and all others too numerous to mention. Special thanks to Sea Grant's Paula Dobbyn, Dawn Montano, and Sue Keller for their assistance producing this publication.

A very special thanks to Michele Frandsen who's tireless efforts and keen management made these projects and many more possible.

BIBLIOGRAPHY

Buzard, R.M., 2017. *Spatiotemporal patterns of bluff erosion at Goodnews Bay, Alaska*. Masters Thesis, University of Alaska Fairbanks.

Bronen, R., and Chapin, S. (2013). Adaptive governance and institutional strategies for climate-induced community relocations in Alaska. Proceedings of the National Academy of Sciences. 110(23): 9320-9325. doi: 10.1073/pnas.1210508110

Folke, C (2006). "Resilience: The emergence of a perspective for social-ecological systems analyses". Global Environmental Change. 16: 253–267. doi:10.1016/j.gloenvcha.2006.04.002.

Holling, C.S. (1973). "Resilience and stability of ecological systems". Annual Review of Ecology and Systematics. 4: 1–23. doi:10.1146/annurev.es.04.110173.000245.

Karl, T. R., et al. (eds) (2009). Global Climate Change Impacts in the United States. Cambridge University Press, New York.

Kinsman, N.E. and Gould, A., 2014. *Contemporary Shoreline Retreat Rates at Meshik in Port Heiden, Alaska*. State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys.

National Assessment Synthesis Team (NAST). 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Report for the US Global Change Research Program. Cambridge University Press, Cambridge, UK.

INTERESTED IN STARTING A COMMUNITY BASED MONITORING PROGRAM IN YOUR VILLAGE?

CONTACT US!

Jaci Overbeck
Coastal Hazards Program Manager
Alaska Department of Natural Resources
Division of Geological & Geophysical Surveys
Office: 907-451-5026
3651 Penland Pkwy
Anchorage, AK 99508
jacquelyn.overbeck@alaska.gov

Chris Maio
Assistant Professor of Coastal Geography
Department of Geosciences
University of Alaska Fairbanks
907-474-5651
PO Box 755780
Fairbanks, AK 99775
cvmaio@alaska.edu

Rich Buzard
Graduate Student, Sandia National Lab Intern,
NOAA Coastal Fellow
Department of Geosciences
University of Alaska Fairbanks
(425)-248-1380
rmbuzard@alaska.edu

November 2018