Monitoring Event-driven Erosion in Wainwright, Alaska

The importance of high-resolution data for capturing change on the Arctic Coast.

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October 27, 2023

In July of 2023 the Alaska Division of Geological & Geophysical Surveys (DGGS) traveled to Wainwright, Alaska, to conduct a flood risk assessment; what we encountered was a community with an entirely different priority.

Flooding was not the greatest concern for the people we spoke with; instead, they want the sea to stop eating away their land.

Why do these data matter?

Coastal communities in Alaska are becoming increasingly more vulnerable to erosion associated with flooding, permafrost degradation, and amplified storm impacts (Berman and Schmidt, 2019; Irrgang and others, 2022). The impacts of this increased risk are not constrained to land loss alone but may also include reduced or impeded access to cultural, social, health, and economic resources (Brubaker and others, 2014; Hauser and others, 2021; Markon and others, 2018). Historical shoreline datasets have made it possible to quantify the rate of shoreline change due to erosion over the last several decades (Buzard and others, 2021a; Overbeck and Buzard, 2020). However, collecting these data at regular intervals to better track changes is often difficult, especially in remote locations like the northern coast of Alaska.

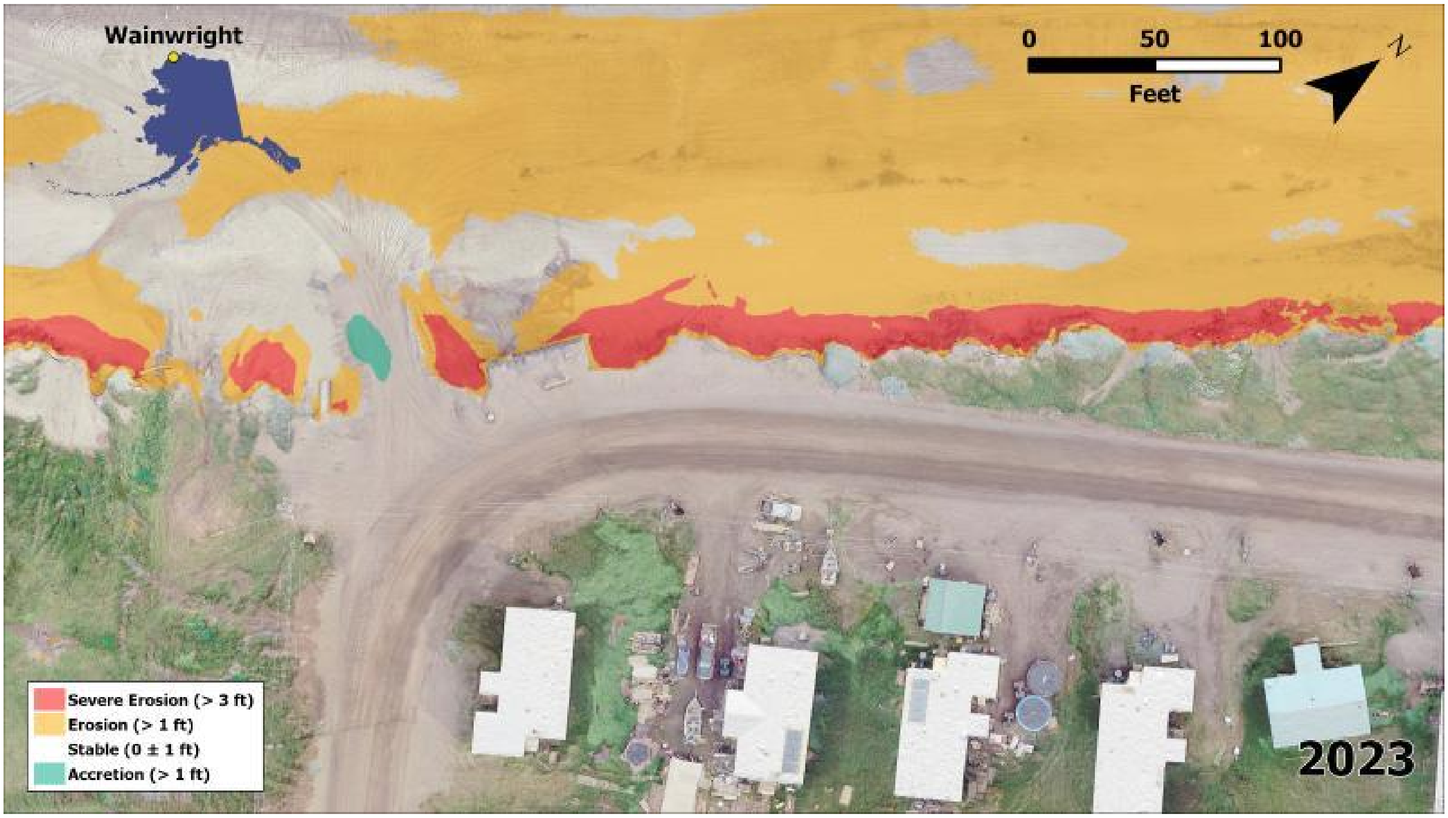
The Alaska Division of Geological & Geophysical Surveys (DGGS) collected coastline data in Wainwright, Alaska, before and after a significant storm event that occurred in October 2022 (NCEI, 2023). These data make it possible to quantify the amount of erosion that was caused by this singular storm and highlight the utility of regular monitoring efforts. The data also demonstrate the efficacy of the community's erosion mitigation measures. Digital surface models (DSMs) created from unmanned aerial vehicle (UAV) surveys collected in 2021 (Buzard and others, 2021b) and 2023 are used to map erosion and calculate volumetric land loss. This information, along with local knowledge, may provide valuable insight for communities and funding agencies as they identify and apply appropriate mitigative measures to protect their coastlines.

Climate change isn't a far off, abstract issue in Wainwright. During our visit, locals shared with us their observations of the shifting environment. These changes extend well beyond just the erosion along the beach bluffs.

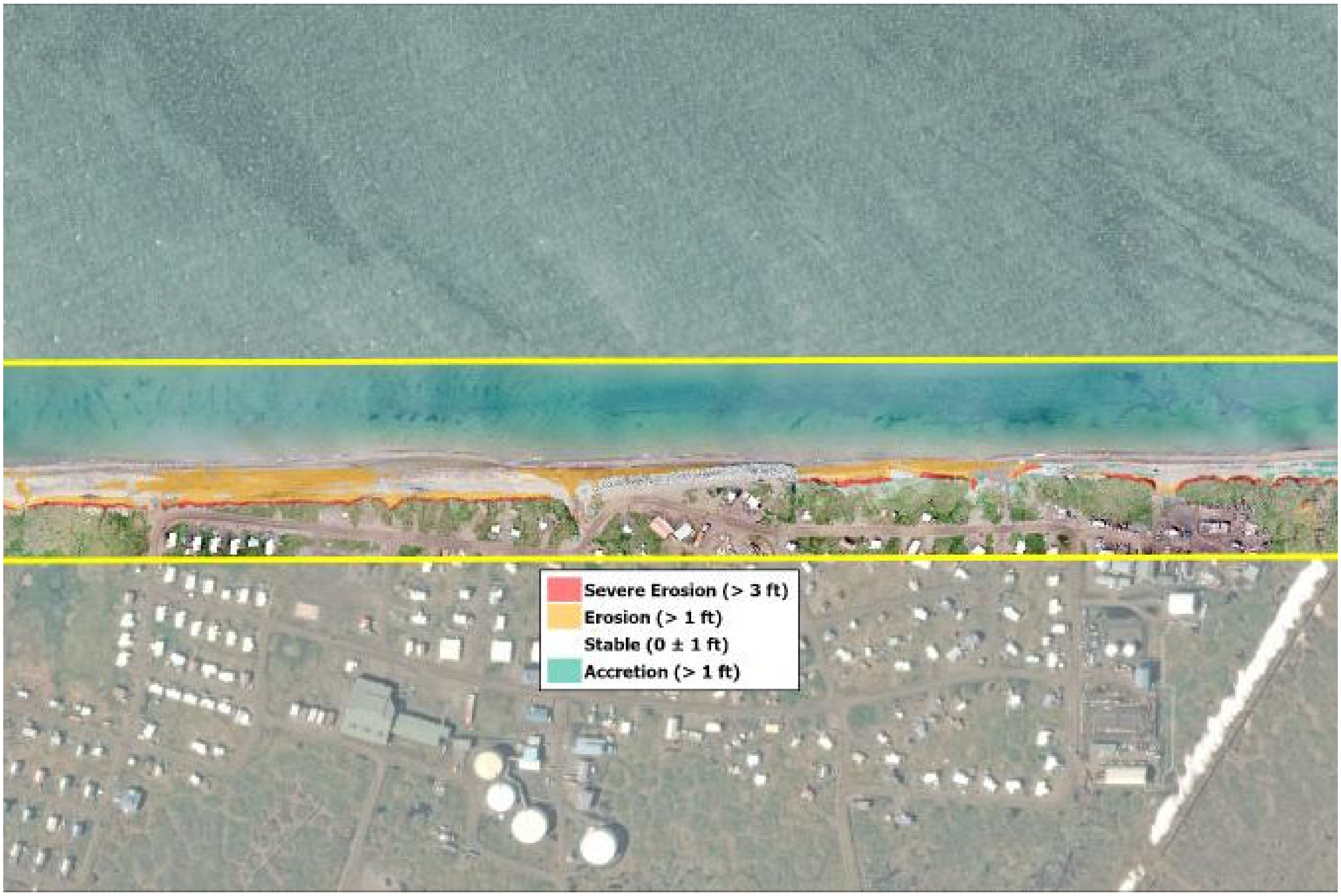
An elder stopped to chat with us, noting that the sea ice is receding more and more each year. The longer the water stays free of ice, the more difficult it becomes to maintain subsistence hunting, a proud cultural tradition and economic necessity in Wainwright.

What can these data tell us?

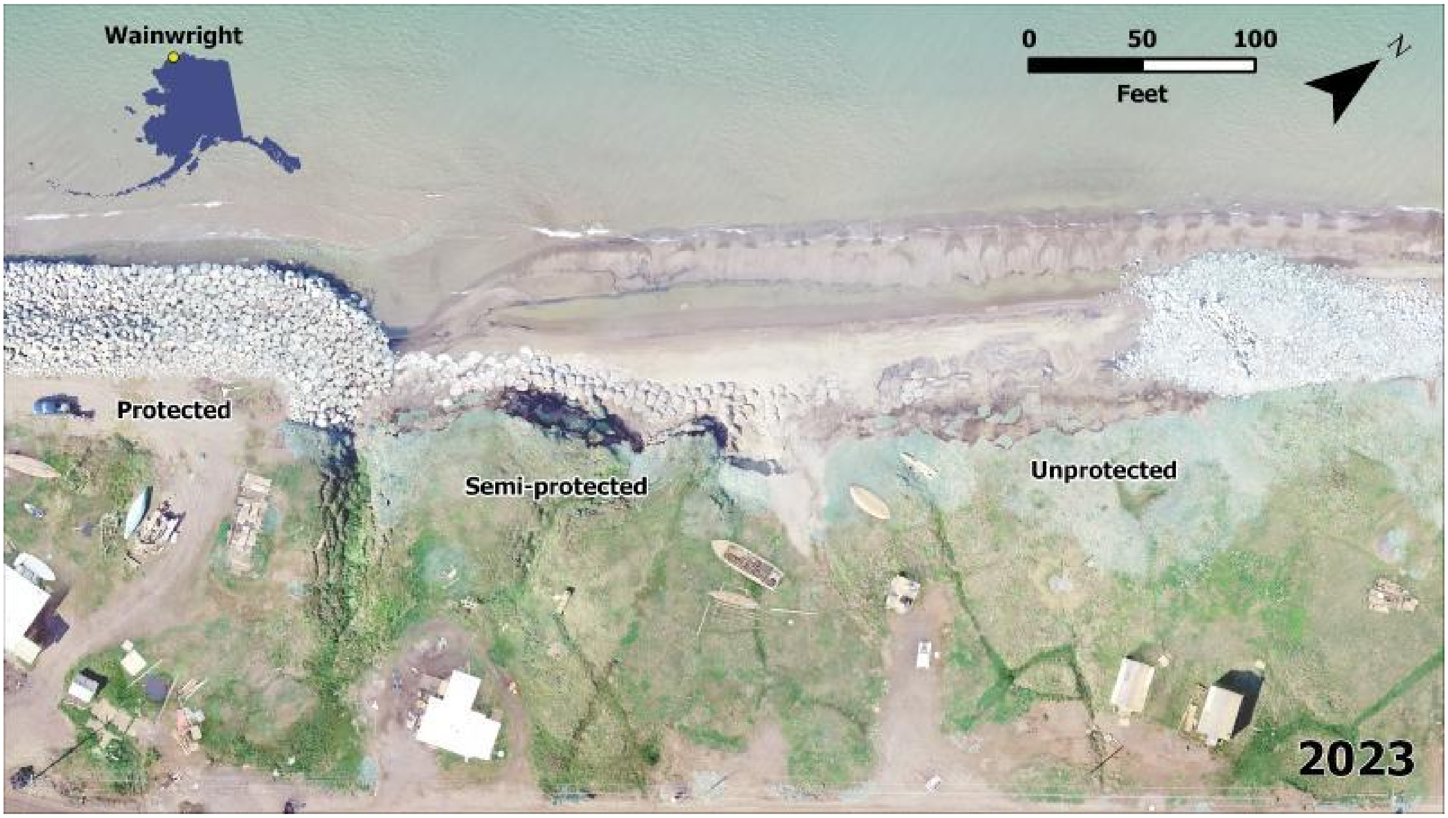
Repeat high-resolution aerial imagery is useful for visually assessing change. Comparing 2021 and 2023 imagery of the beach and bluffs at the southern end of Wainwright shows dramatic change caused by the October 2022 storm. From this imagery it is evident that erosion is encroaching on roads and other infrastructure, and impacting access to the beach. Subsistence hunting and fishing off the northern coast are vital to the culture, economy, and health of Wainwright's citizens (Brubaker and others, 2014).



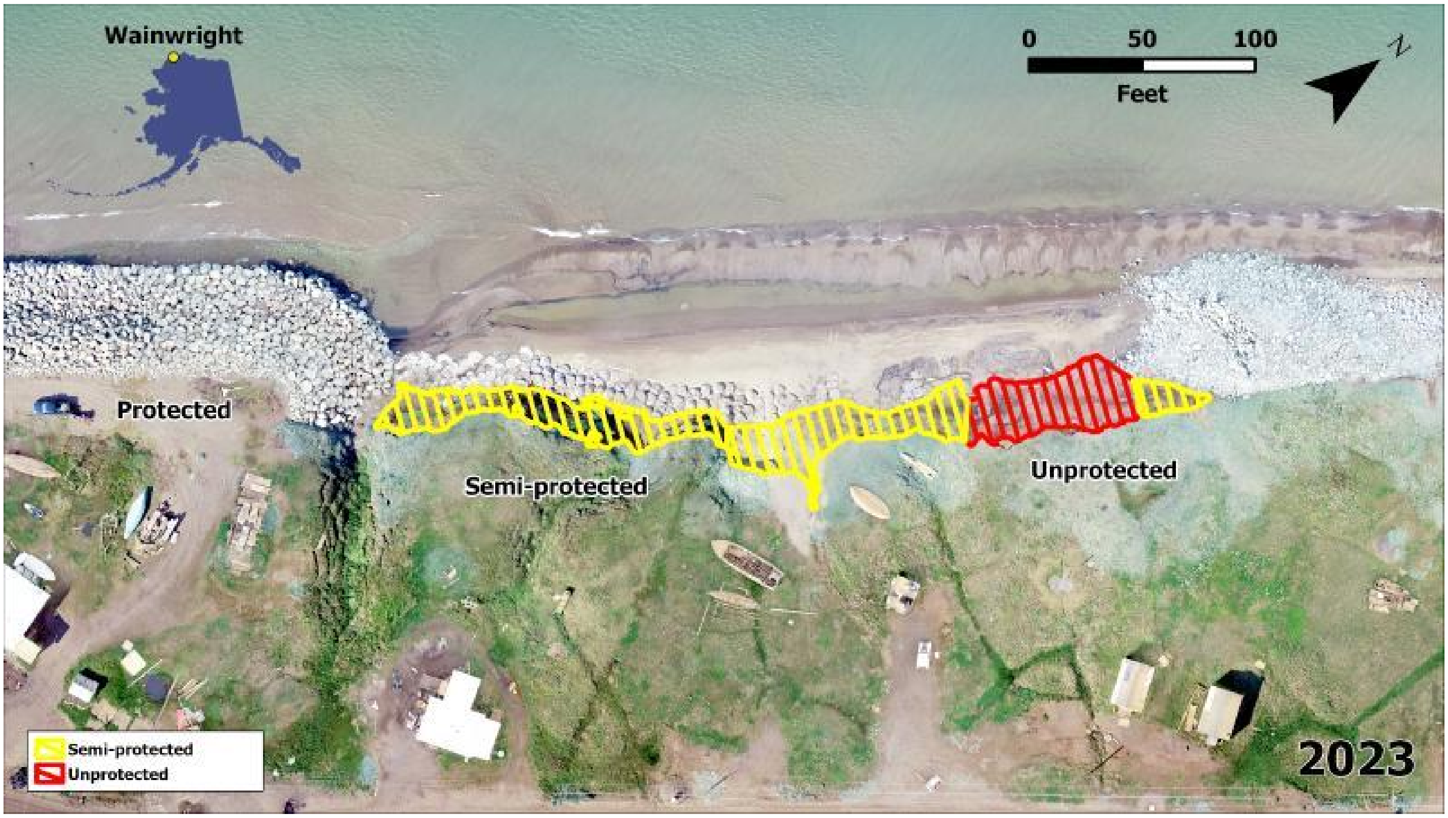
Difference maps generated from repeat high-resolution elevation data can be used for volumetric analysis. These data can reveal more subtle changes that are not easily identified in aerial imagery, such as beach erosion and accretion. Additionally, these three-dimensional products can more accurately account for total material loss, something that cannot be assessed using linear erosion models alone.



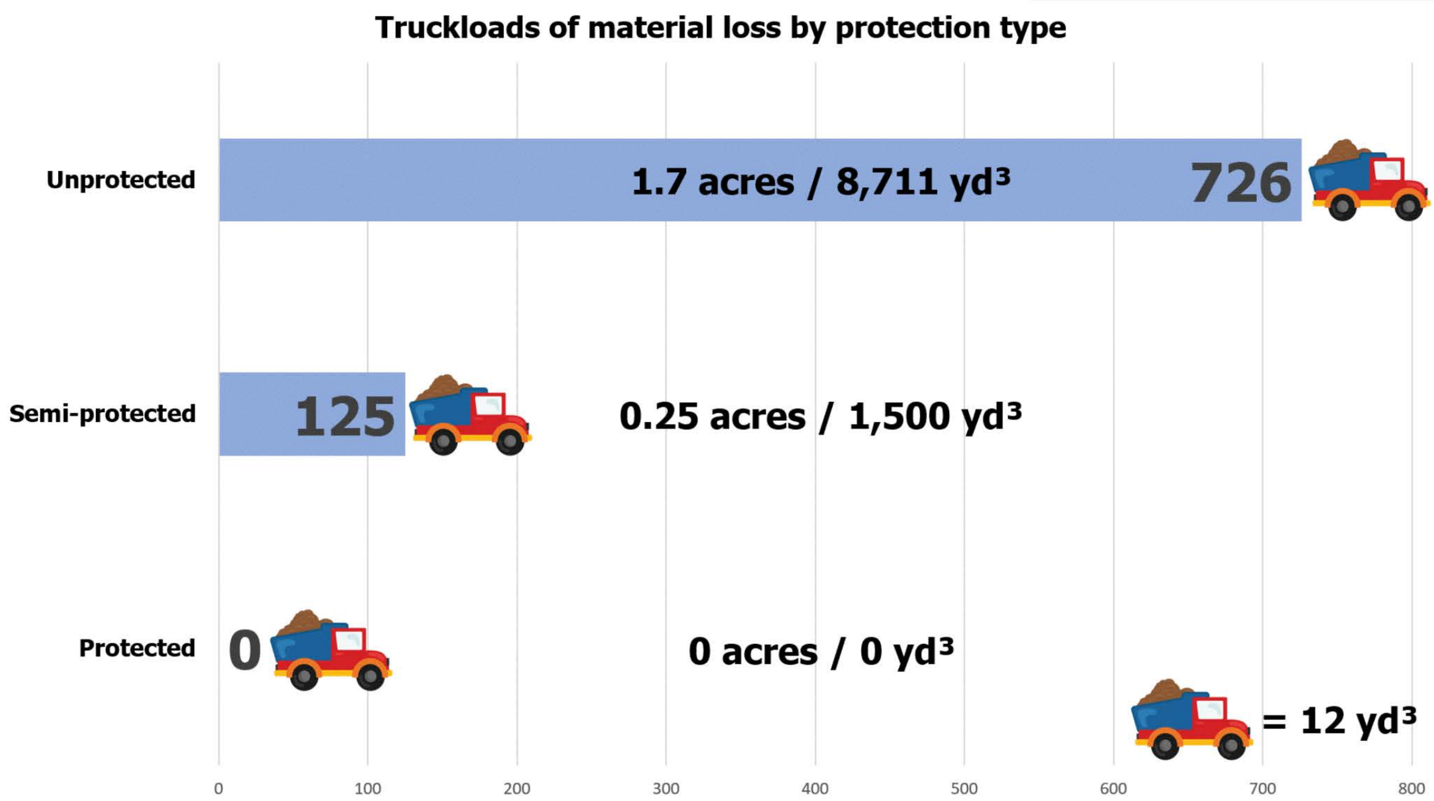
DGGS conducted a preliminary volumetric comparison of the 2021 and 2023 DSMs to estimate total land loss within a 1.1-mile-long section of the coastline. The different bluff faces were grouped by level of erosion mitigation: protected, semi-protected, and unprotected. Protected bluffs are fronted by permanent, engineered structures (i.e., rock revetments). Semi-protected bluffs are defended by temporary or transitory protections like sandbags or small armor rock deposits. Unprotected bluffs are fully exposed without any erosion protection measures in place.



Areas of protection, semi-protection, and no protection were visually identified by DGGS to allow each level of erosion mitigation to be analyzed separately. A cut-fill analysis was then run against the 2021 and 2023 DSM for each area.



For the initial analysis DGGS focused on bluff erosion only, though beach erosion and accretion are also evident within the data and will be included in future work. DGGS eliminated man-made structures and placed materials from the volumetric comparison because these may have been replenished or otherwise altered between data collections.



Engineered protections cover approximately 0.14 miles of the 1.1-mile-long study area, with semi-protected bluffs accounting for roughly 0.25 miles, and unprotected bluffs making up the remaining 0.71 miles.

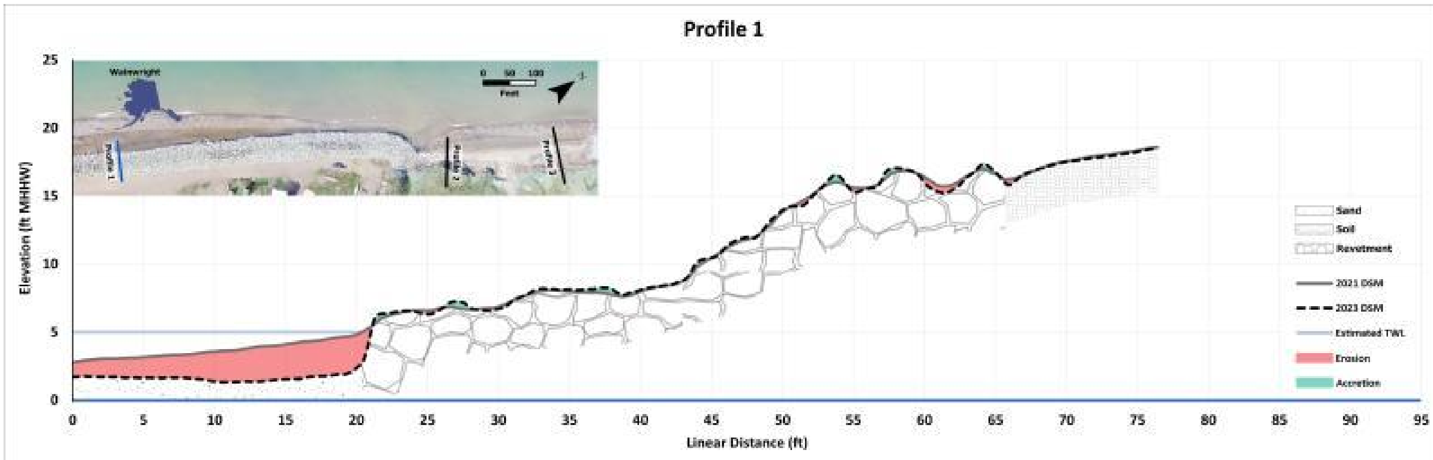
A short stretch of boulder revetment composed of massive blocks of granite covers less than a quarter of Wainwright's coastline and appears to be holding up well. The unprotected bluffs to the north and south of this seawall stand in stark contrast.

We asked about flooding, but our gracious hosts shook their heads and, pointing to the failing bluff

face, told us about the collapsing ground and how much was lost last year.

How can we use these data?

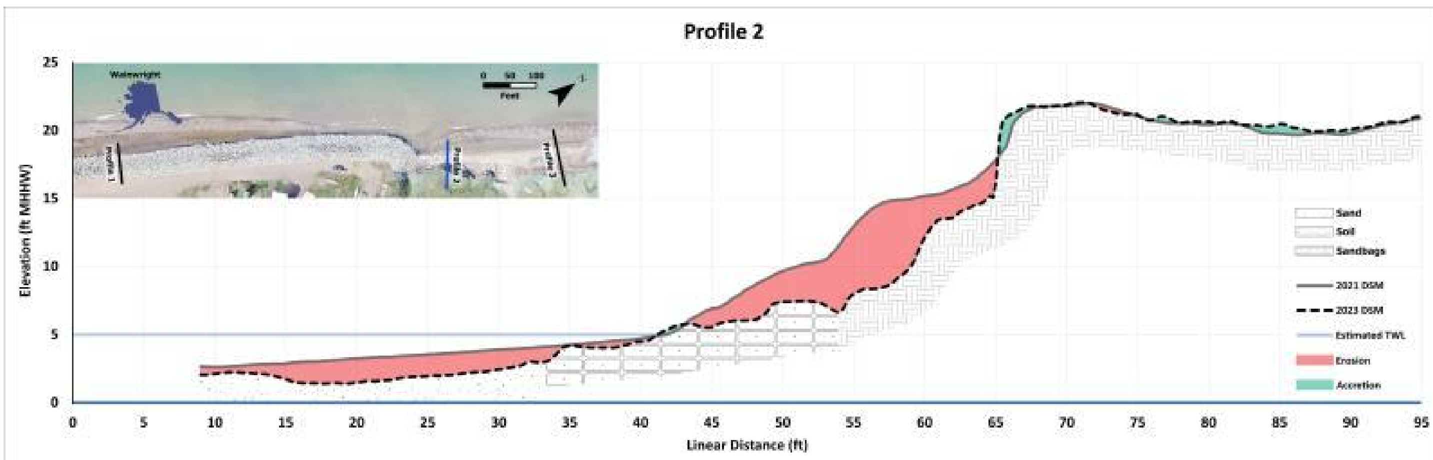
Wainwright's coast, with its varying levels of erosion mitigation, can provide insight into storm impacts for areas of protected, semi-protected, and unprotected coastline. DGGS created elevation profile cross sections from the 2021 and 2023 DSMs at locations illustrative of each of these protection levels. No peak water level was reported for Wainwright during the October 2022 storm event, so a rudimentary estimation of the total water level (TWL) was derived from the average reported peak water level in Point Lay, "approximately 6 feet above normal high tide line," and Utqiagvik, "around 4 feet above the normal high tide line" (NCEI, 2023).



Protected Coastline

Oblique imagery of the rock revetment protection in Wainwright, Alaska (DGGS, 2023)

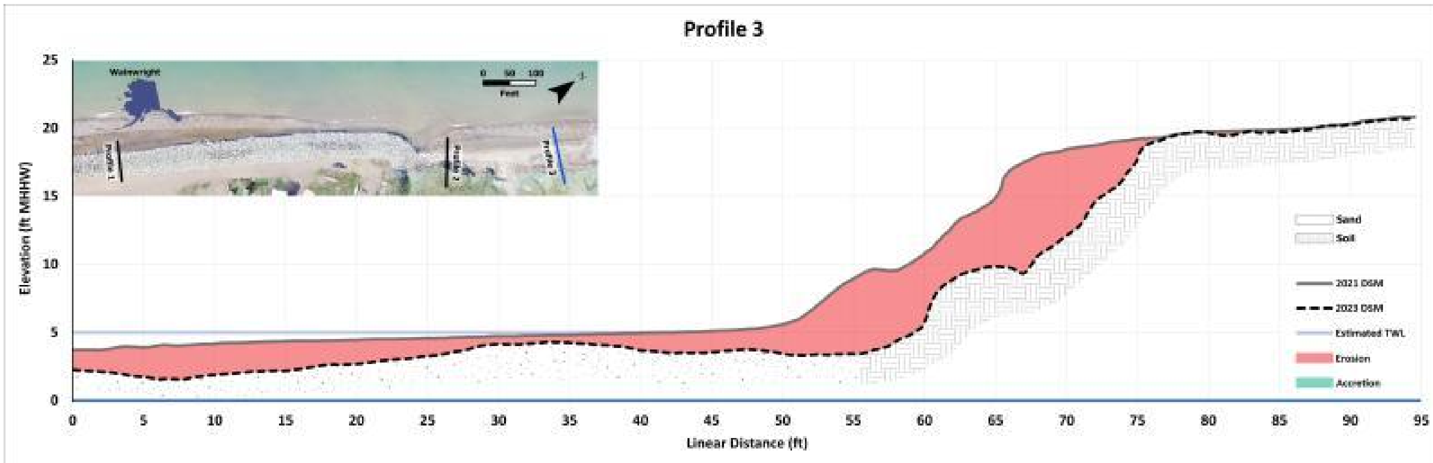
Protected coasts are engineered to mitigate erosion and reduce damage from flooding or wave impacts (USACE, 2008). The purpose of revetments like the one employed in Wainwright, is to prevent landward erosion by dissipating wave energy (Dean and Dalrymple, 2002). This elevation profile highlights that the revetment remained relatively unchanged between 2021 and 2023, but significant beach erosion has taken place at the seaward toe of the structure.



Semi-protected Coastline

Oblique imagery of sandbag semi-protection in Wainwright, Alaska (DGGS, 2023)

Semi-protected coasts may consist of less permanent mitigation measures like sandbags, gabions, or smaller armor rock such as riprap. While these solutions can be more environmentally friendly, might make use of locally available materials, and may have more affordable upfront costs, they often require maintenance and replenishment (Liew and others, 2022). Whether permanent or transitory, the primary purpose of any protection measure is to attenuate, halt, or deflect incoming waves before they reach the bluff face (Dean and Dalrymple, 2002). This elevation profile across a section of Wainwright's coast protected by sandbags shows beach erosion that extends up the seaward slope of the bluff, removing a large amount of material below the bluff edge, which did not experience retreat between 2021 and 2023. The now steeper, non-vegetated slope of the bluff here is likely less stable and therefore more susceptible to erosion.



Unprotected Coastline

Oblique imagery of an unprotected bluff in Wainwright, Alaska (DGGS, 2023)

Unprotected bluffs are subject to the full force of incoming waves, leaving them especially vulnerable to event-driven erosion. Areas without protection are prone to faster rates of erosion than protected portions of the bluff (Buzard and others, 2021a). Such unprotected areas in Wainwright experienced significant erosion between 2021 and 2023, which included retreat of the bluff edge.

Everyone we met in Wainwright told us about the thawing permafrost, the sinking ground, and the encroaching waves. It seemed to be on everyone's minds.

An elder directed our attention to the scarps and overhangs that make up the exposed bluff edge, telling us it used to be at least twenty feet further out before the October 2022 storm.

What can these data do?

High-resolution data, in both the spatial and temporal dimensions, are a critical asset for monitoring change on the community scale. In order to assess event-specific impacts, it is necessary to collect data at a frequency consistent with storm event occurrence. Throughout rural Alaska, it is particularly challenging to gather the requisite datasets within the short pre- and post-storm timeframe, making regularized data acquisition schedules extremely important. Furthermore, documenting the efficacy of coastal protections can inform planners on how best to implement protective measures to enhance their coastal resilience.

These data not only help establish a record of event-driven erosion and its repercussions, but they can also be a tool for advocacy and land conservation; they can tell the story of our changing environment in concrete terms and lend hard numbers to the concerns of those impacted. DGGS is making these preliminary results available to the community of Wainwright, the North Slope Borough, and other interested parties in the hopes that they may be of use immediately, but plans for continued analysis of the data collected in 2021 and 2023 are ongoing with a goal of setting these data in a broader context.

These data and their implications highlight the urgent need for investment, research, and assistance in Wainwright and other Arctic communities. Further work is needed all along the northwestern coast of Alaska to investigate how climate change is affecting the interface between the sea and the land in underserved portions of the Arctic. Sea ice extents, changing weather patterns, permafrost degradation, and sea level rise are only a few of the confounding factors that may be contributing to erosion in this and similar locations.

Without action, the sea may not stop at just taking bites out of the land, it may swallow up traditions, homes, communities, an entire way of life.

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Acknowledgements

We thank the Native Village and City of Wainwright, Alaska, for supporting the creation of these data products, made possible as part of the State of Alaska-funded Arctic Strategic Transportation and Resources (ASTAR) Capital Improvement Project. The Alaska Division of Geological & Geophysical Surveys' work for this project supports a collaborative effort between the North Slope Borough and the Alaska Department of Natural Resources to strengthen community infrastructure and facilitate access to Arctic resources while enhancing the quality of life and economic opportunities for North Slope communities. It also provides valuable information for land-use management and planning decisions. The views and conclusions contained in this story are those of the authors and should not be interpreted as representing the opinions or

policies of the Alaska Division of Geological & Geophysical Surveys, Alaska Department of Natural Resources, the North Slope Borough, or the State of Alaska.

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