Scenarios for Energy and Resource Development on the North Slope and Adjacent Seas

Research and Monitoring Prioritization for the NSSI

Erosion | Coastal and riverine

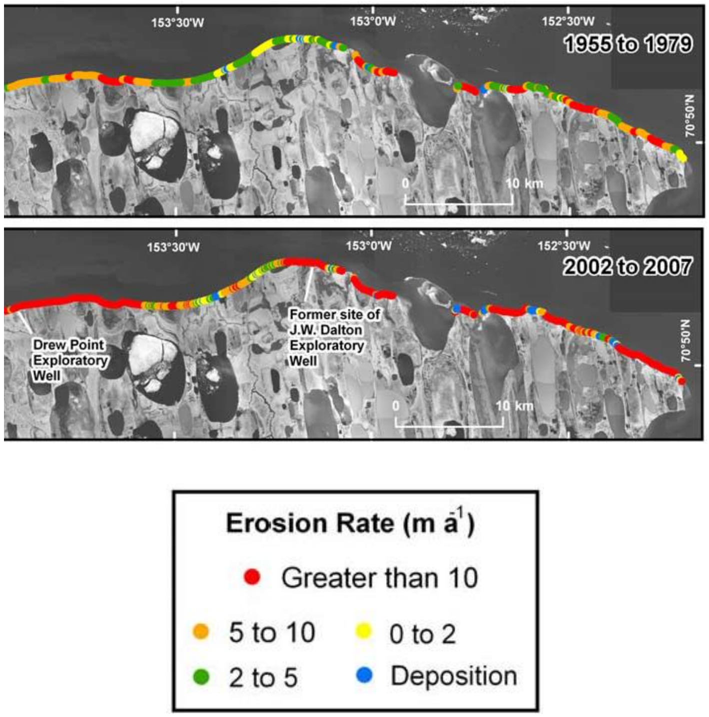

Figure 1. Changing erosion rates along the Beaufort Sea
Source: Jones et al. 2009 (1)

Summary

The coasts along the U.S. Beaufort and Chukchi Seas consist of bluffs, barrier islands with lagoon systems, bays and inlets, deltas and drained lake basins. Collectively they make up rich habitat and also a challenging landscape for coastal construction and ocean access. Coastal erosion rates have been increasing in some locations on the North Slope over the last decade. Climate change related effects on erosion include changes in sea ice and permafrost. It is difficult to accurately project future coastlines given the high variability in erosion rates and processes driving erosion among sites.

Erosion may act as a driver affecting the stability of building foundations, roads, and critical infrastructure for transportation, communication and energy generation. It may also impact housing, and archaeological and paleontological sites. The rate and severity of erosion also acts as driver for the construction of shore-protection structures and the associated erosion mitigation or relocation costs.

Overview

While measurements of erosion rates have been calculated in local areas recent studies have improved assessments of erosion rates throughout the Chukchi and Beaufort coasts (1,2,3). Sea ice helps to buffer the wave and storm-driven effects of erosion, but an increasing seasonally ice-free period leaves coasts more vulnerable to erosion. Most coastal erosion occurs during the seasonally ice-free period. Wind, waves, surface water and air temperature, sea level and storm events affect coastal erosion patterns. Rivers and streams affect erosion through permafrost degradation, and channeling runoff from snowmelt, but also affect sediment deposition.

Factors affecting erosion

Physical features: The presence of sea ice, beaches, coastal orientation and barrier islands can affect coastal erosion rates. Barrier islands are also dynamic features with the ability to migrate over time.

Sediment type: Fine grained muds erode more quickly than coarser sediments. On the Beaufort coast sediments are coarser in the east, and erosion rates generally increase from east to west along the Beaufort coast. The Chukchi coast may have lower erosion rates as a result of coastal orientation, geomorphology and ice content.

Vegetation: The presence of coastal vegetation helps to stabilize sand dominated coasts. Peat and shrubs also help to stabilize areas and reduce river erosion.

Ground ice: The presence of permafrost, particularly ice wedges, influences erosion rates. Wave-impacts and greater thermal and mechanical erosion create niches at the base of bluffs, while permafrost thaw destabilizes bluffs, allowing portions of bluffs to break off. Erosion along lakes and rivers further inland are also strongly affected by stream sinuosity, hydrologic events, ice scouring during break-up, and permafrost thaw that subsequently influences thermokarst formation.

Storms: Large storms have been responsible for some of the largest erosion events observed along the Arctic coast. For example, some places in Barrow experienced up to 35 feet of lateral bluff erosion from a 1963 storm. Storms increase water levels and storm surge but also increase erosion impacts from wind, waves, and ice-gouging. Storms can also cause rapid changes to the size and location of barrier islands.

Figure 2. Projected changes in coastline position for Kivalina. *New erosion mitigation structures may have changed projected shoreline estimates. Source: US Army Corps Engineers Alaska Baseline Erosion Assessment

Trends

Rates of erosion differ along the coast and can vary greatly. However the average erosion rates can be used to describe general trends of loss over time. Mean erosion rates of 1.4 m/yr from Icy Cape to the Canadian border was calculated between 1947 and 2007 (3). Mean rates along the Beaufort coast are 2 m/yr and can be as high as 19 m/ yr. Erosion patterns have become more similar along parts of the Beaufort coast and may become less dependent on shoreline type or ground ice content (1). On small segments of the Alaskan Beaufort coast there is evidence of a doubling of average coastal erosion rates (4).

In Prudhoe Bay average coastal erosion rates of 1.5 m/yr have been recorded primarily related to thermal erosion. Erosion rates along coastal permafrost bluffs (from 6.8 to 19 m/yr) may continue to increase, particularly as the duration of the ice-free season gets longer, temperature increases, and sea level rises (2).

In the Northwest Arctic Borough, erosion rates in Kotzebue Sound showed stabilization or slight accretion from 1980-2003. However future erosion rates of 0.16 to 0.24 m/yr (from 2000 – 2049) is projected if sea level rise continues as projected (5). Current erosion rates along the Chukchi Coast are around 0.1 m/yr and can be as high as 5.8 m/yr (5).

Uncertainties

The unique characteristics of coastal sites make it difficult to project how erosion processes will affect the coastlines. Assessments of erosion based on historical coastlines provide some idea of areas more vulnerable to erosion but cannot be used to project future erosion patterns with great certainty. Changes in hydrology and runoff patterns that affect river flow may also affect uncertainties in riverine erosion. Modeled projections of erosion may make assumptions to account for uncertainties in the timing and magnitude of storms (including effects of wind direction and fetch), projections of sea level rise, and the duration of a seasonally ice-free ocean.

The construction of infrastructure can also either enhance or reduce erosion at local scales. However the exact effect on erosion rates may not be known until studies are conducted after the structure has been built.

Driver interactions

Resource development
Increasing coastal erosion threatens building foundations, bridges and other critical infrastructure. Former drill sites and gravel pads have been lost from eroding coasts. Erosion can also affect the stability of roads and runways making some roads vulnerable to flooding during storms. In addition to surface structures, buried pipelines can become exposed through erosion of overlying sediments. Mitigation efforts to reduce erosion may include building artificial berms and seawalls and offshore dredging for beach renourishment.

Interaction with other drivers
Coastal and migratory birds and fish use beaches, tidal marshes, mud flats and wetlands as breeding, feeding and nesting habitat. Erosion threatens the size and location of available habitat and may make some areas more vulnerable to salt water intrusion. Coastal vegetation will change as salt water intrusion, protection from storms, and sediment geomorphology changes. Coastal communities may need to be relocated as erosion threatens the safety and stability of housing, schools and supporting infrastructure. Culturally important sites also risk being lost to coastal erosion.

Figure 3. Portion of Continuously Updated Shoreline Product area. Source: NOAA National Geodetic Survey

Monitoring efforts

Erosion rates have been more intensely studied in the Beaufort compared to the Chukchi Sea. Given the high impact that erosion can have on coastal communities the US Geological Survey, US Army Corps of Engineers and the Alaska Department of Natural Resources monitor coastal hazards including the potential impacts of coastal erosion. The NOAA National Geodetic Survey also includes some areas in its coastal monitoring program that aims to keep an up to date inventory of the coastline.

References

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