The sensitivity of Canada's Yukon Coastal Plain to a warming climate

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Introduction

Climate changes in the Arctic will have profound impacts on the permafrost coastline of Canada's Beaufort Sea. In addition to warmer air and sea temperatures contributing to erosion, coasts will experience higher sea levels and increased storminess, and they will be exposed to these conditions for longer periods due to an increase in the length of the open water season. This study examines what makes one region of this coastline -- the Yukon Coastal Plain -- especially susceptible to change and the importance of monitoring that change.

Figure 1. The Yukon Coastal Plain is about 250 km long and forms a narrow band of dissected and hilly tundra along the southern Beaufort Sea. It is located within the zone of continuous permafrost which is at least 300 m deep. The mean annual air temperature is approximately -11°C.

Surficial materials

Although the western section of the Yukon Coastal Plain remained unglaciated, a lobe of the Laurentide ice sheet covered most of the eastern part in the early Wisconsin. As a result, the coastal plain consists of a variety of unconsolidated surficial materials, including marine and alluvial deposits, glacial outwash plains and fans, rolling and push moraines, and fine-grained lacustrine sediments (Rampton 1982). Beaches are generally narrow and are backed by coastal bluffs up to 90 m high. Bodies of massive ground ice and large ice wedges are common in the region, especially in the fine-grained sediments (Harry et al. 1985, 1988; Pollard and Dallimore 1988).

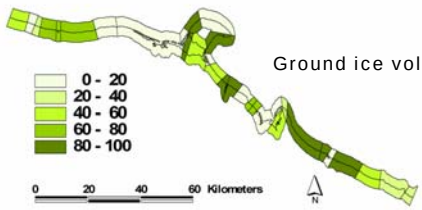

Figure 2. To determine the sensitivity of the Beaufort Sea coast to storm impacts and the effects of changing climate, it is essential to have some estimate of the ice content of coastal cliffs and shorelines. Determinations of ground ice volumes were made following Pollard and Couture (2000) and are highly dependent on surficial materials. Ice contents are lowest in marine deposits in bars and spits, especially in the west, but average 74.0% by volume in lacustrine deposits and 77.4% in morainic material.

Environmental forcings

The primary forcings on permafrost coastal systems are relative sea level (RSL), storminess, and the duration and extent of the open water season (Figure 3). The Yukon Coastal Plain is considered to be in a submergent area (Forbes 1980) so increased sea levels due to oceanic thermal expansion will be magnified, contributing to its sensitivity to erosion (Shaw et al. 1998). Lambert (1995) suggested an increase n the frequency of storms under a warming climate and Solomon et al. (1994) have shown there to a strong correlation between storm intensity and coastal erosion along the Beaufort Sea.

Figure 3. The coast of the Beaufort Sea is micro-tidal, so waves play a stronger role in coastal change. This is particularly true during the open water season, when sea ice does not dampen wave development. Currently, break up begins in June and lasts until early October. Under climate change, the duration of open water is expected to increase by 60 to 150 days (McGillvray et al. 1993).

Impact on humans

The Yukon Coastal Plain is important to aboriginal communities for economic, historical and cultural reasons. The significance of the area is underlined by the fact that most of the coastal plain has been designated as either a national park or a territorial one. The oil and gas industry are also active in the region. Human activities and wildlife may be seriously impacted by changing coastal conditions.

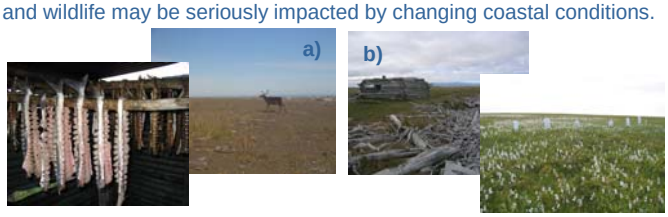

Figure 4. a) Hunting, fishing and trapping are economic mainstays for many aboriginal communities along the coast. These activities also form a backbone of their culture. **b)** Numerous historical and archeological sites exist along the coastal plain. Many of these have already been or are in danger of being washed away by erosion.

Erosion modelling

Thermo-mechanical erosion models such as the one developed by Kobayashi et al. (1999) are being combined with a block failure model to account for changes to coastal morphology. This approach, combined with wave energy modelling, will be used to predict future erosion under changing environmental conditions.

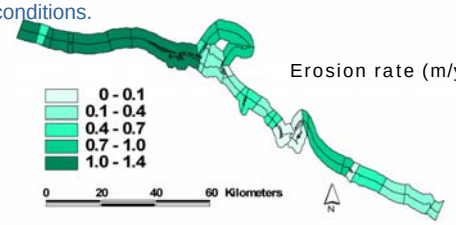

Figure 5. The average erosion rates shown here are derived from the Arctic Coastal Dynamics database and were compiled from a number of sources. Rates vary depending on exposure to storm winds, as well as coastal lithology and morphology. In some cases, recession can be as much as 18.2 m/yr (Harper 1990).

Recommendations

It is proposed that Canada's Yukon Coastal Plain be established as a future Arctic coastal monitoring site. Selection criteria for such sites, to be determined by the wider coastal research community, will ultimately dictate its suitability either as a primary or a secondary site. However, a number of reasons are shown for considering this region:

1) Its unconsolidated and ice-rich nature make it vulnerable to a warming climate
2) A good baseline of observational data is already established from both the scientific and aboriginal communities
3) Its distance from the Mackenzie River Delta which influences coastal processes further to the east
4) There are likely to be changes in environmental forcing variables
5) Monitoring coastal changes would be of benefit to communities and industry

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