

Coastal Monitoring Program

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Introduction

The coastal environment is a constantly changing system influenced by many dynamic processes. Understanding the current and past conditions of Nova Scotia's coastlines and the processes that shape them, allows us to develop strategies to protect Nova Scotia's maritime coast; a core element to Nova Scotia's economy and culture.

Nova Scotia has a unique and varied geology that defines the province and its landscape. Glaciers spread over the Maritimes in the early Pleistocene and have advanced and retreated several times. Approximately 18,000 years ago glaciers covered Canada and Nova Scotia, with water locked away in ice sheets, sea levels were more than 100 m below present (Finck, 2006). Glaciers that covered the province as recently as 11,500 years ago sculpted bedrock and deposited sediment that now make up much of our province's coastline today (Piper & Pi-Piper, 2022). As glaciers retreated sea levels rose and due to this, the province has been characterized geomorphologically as a drowned coastline (Fisher et al. 2012). Erosion and land submergence from sea level rise have been occurring throughout the Holocene and exacerbated in the last century by human-induced global warming (Shaw et al. 2002; IPCC, 2023). Sea level rise projections vary throughout the province, with average projections showing a rise of 32 +/- 0.13 cm per century (Forbes et. al. 2009). Rising sea levels and warming oceans lead to increased

storm activity hitting the provinces coastline (IPCC, 2023). Erosion of coastal material pressures shorefaces to retreat landward and in many cases dramatically, as cliffs and bluffs fail catastrophically these geohazards threaten infrastructure and public safety. Previous studies have found sections of coastal headlands on Isle Madame, Nova Scotia eroding 1.53 m annually with other studies showing as much as 5 – 10 m of loss on coastal drumlins and unstable barrier beaches migrating landward as much as 10 m annually (Force, 2013; Taylor, 2007). Geology plays an important role in coastal erosion; however, the whole sediment transport system of a littoral cell must be understood to inform policy and the public on coastal dynamics. A littoral cell is a semi-contained sediment source, transportation, and deposition loop. This includes sediment transport processes in the nearshore and offshore related to longshore drift, tidal ranges, wave action, shoreline hardening (both natural and anthropogenic), and groundwater discharge.

The First Nations Mi'kmaw have witnessed the climate and landscape transform having lived in Atlantic Canada for generations. It is therefore important to approach coastal change with a Two-Eyed Seeing lens, to integrate both Western ways of knowing along with traditional knowledge. Oral stories passed down provide evidence of the once freshwater Minas Basin being catastrophically inundated by sea water that have been corroborated with western geoscience methods (Bleakney & Davis, 1983; Piper & Pi-Piper, 2022; Shaw et al. 2002). Provincial coastal research is looking to learn from traditional knowledge to guide decision making related to coastal protection. In many ways, understanding the

past is the key to understanding the present and future of our coasts.

Coastal Erosion Monitoring Program (CEMP)

The objective of the Coastal Erosion Monitoring Program (CEMP) is to improve our understanding of Nova Scotia's coastal dynamics and the associated geohazards related to coastal environments. CEMP is a continuation of the coastal monitoring program started in 2019 by Natural Resources and Renewables (NRR) Geological Survey Division and will both build upon existing expertise and grow collaborations in the coastal field with internal departments such as Public Works, Environment and Climate Change (ECC) and external groups such as the Geological Survey of Canada (GSC). There are over 110 coastal monitoring sites across the province that have been chosen based on geological setting, geomorphology, and cultural significance (Figure 1). CEMP will inform climate adaptation strategies for stakeholders, including the public,

government, non-government organizations, and industry through mapping of the coastal environment and highlighting the risks and vulnerabilities to coastal infrastructure related to erosion. The intention is to provide transparency to decision makers related to coastal matters and to promote awareness and understanding of the complex coastal environment. CEMP has a wide scope to undertake both regional and local scale coastal dynamics across Nova Scotia's changing coastlines. The key project outputs will include hazard mapping for erosion, slope stability, and geological influences. These data will be presented and updated regularly, primarily through an interactive map that will be available to the public, along with case studies and reports related to zones of particular interest such as mass failure events. New insights and data from this project will provide the foundation for future coastal policies, technical guidelines, and best management practices for protecting coastal infrastructure from coastal erosion.

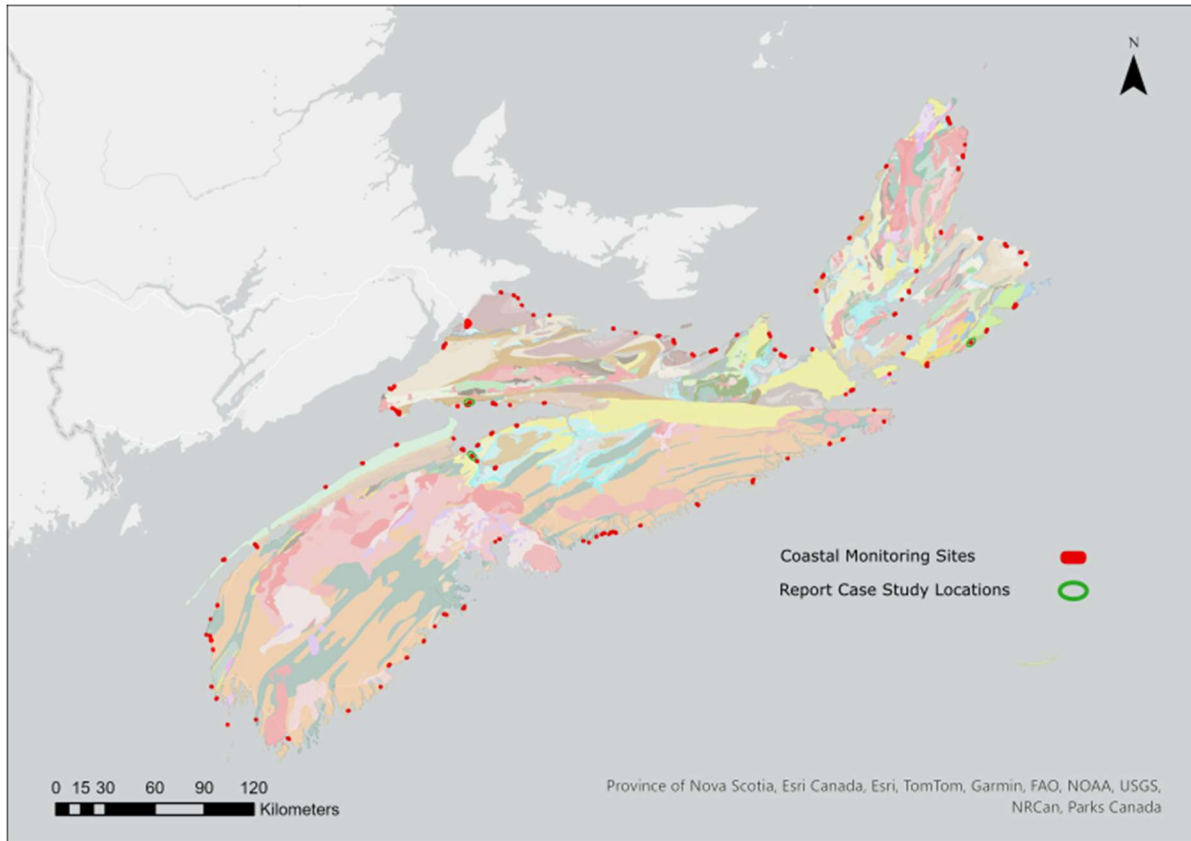


Figure 1. The location of all provincial coastal monitoring sites and case studies discussed in this report including Wasson Bluff, Blue Beach, and Morrison’s Beach with a bedrock basemap (Keppie, 2000)

Methods

Sites are monitored using a survey-grade Real-time Kinematic (RTK) receiver and RTK Remotely Piloted Aircraft System (RPAS). The RPAS is flown in a grid over monitoring sites and collects nadir photos

with a 75% overlap, followed by oblique photos of the shoreline. Prior to a RPAS survey, ground control point targets are surveyed using the RTK receiver, which are then photographed by the RPAS to align photos with the chosen datum (Figure 2).



Figure 2. Summer student (Emma McCarron) surveying a ground control point with a GNSS receiver along the coast of the Bay of Fundy at low tide.

Field data collected from both the RPAS aerial images and receiver GPS locations are processed with PiX4D 4.5.6/4.9.0 and DJI Terra, photogrammetry software that are utilized to produce orthophoto mosaics, 3D point clouds, and Digital Surface Models (DSMs). Ground Sampling Distance (GSD) has an accuracy between 1 – 3 cm/pixel, depending on flight elevation and model of RPAS. Once multiple surveys of one site have been conducted (i.e. a site that was surveyed in 2019 and 2024) these data are then processed in ArcGIS Pro to produce a cut fill and surface difference between two models that can highlight and quantify volume change and surface differences on the coast. These data are then interpreted to

understand sediment transport dynamics and influence on the littoral cell.

United States Geological Survey (USGS) Digital Shoreline Analysis System (DSAS) is used to calculate shoreline migration by producing transects at 1 m intervals along a coastline to produce an average erosion rate of the monitoring site (Himmelstoss et al. 2024). Georeferenced historical air photos are also used to determine historical erosion rates and provide a record of what a site looked like prior to modern development. However, air photos are less accurate due to their resolution and distortion of the camera and cannot wholly be relied upon for erosion rate estimates.

Preliminary Results

Eighty-four monitoring sites covering approximately 105 km of coastline were surveyed during 2024. Three notable sites that have undergone significant coastal erosion were looked at in more detail.

Wasson Bluff, Minas Basin

Volumetric change has been calculated for a rotational failure along Wasson Bluff, located on the north coast of the Minas Basin in a significant fossil rich area part of the Cliffs of Fundy Geopark. A rotational slide is the movement of earth that fails along a curved scarp. The site was surveyed in 2019, 2020, and 2024 and the mass failure event was reported to have occurred in 2022. Comparing models from previous years to after the slide it was determined that over 6,700 m³ of sediment was removed or the equivalent of 63 Halifax Transit Buses with an average retreat of the bluff toe being 15 cm per year from tidal and wave action (link to Wasson Bluff report when released).

Morrisons Beach, Cape Breton

The integration of RPAS surveys and DSAS allows for a detailed analysis of shoreline migration as far back as 1928; when air photos started to be collected by the province. A peninsula located at Morrisons Beach in Cape Breton, constrains Morrisons beach and its littoral cell. The promontory consists of a fine-to medium-grained sand with a glaciofluvial origin. This material is very susceptible to both wave action and aeolian erosion. The bluff crown shows a landward migration of 15.7 m since 1945 with an average erosion rate of 0.21 m annually (Figure 3). This erosion produces high volumes of sediment which feed into the local littoral cell forming the sandy Morrisons Beach we see today. As storms increase, and the sediment source is reduced, the depositional and erosional environment of the whole cell will change; impacting longshore drift both locally and further afield as sediment is starved.



Figure 3. Nadir image of the bluffed peninsula at Morrisons Beach, Framboise, Cape Breton. Migration of the bluff crown landward are annotated with 1945 and 1998 identified from georeferenced aerial images and 2020 and 2024 identified.

Blue Beach, Avon River

During the summer of 2024 a flash flood event occurred in the Annapolis Valley, with over 120 mm falling in less than five hours. Blue Beach located on the Avon River, another significant fossil site in Nova Scotia, saw its gravel berm break from a normally quiescent stream (Figure 4). The stream

became a torrent removing a large section of the natural gravel berm with over 5,500 m³ of material being washed into Avon River. These preliminary results will be disseminated as geohazard reports along with a future erosion map of all sites across the province to inform stakeholders of erosion rates.

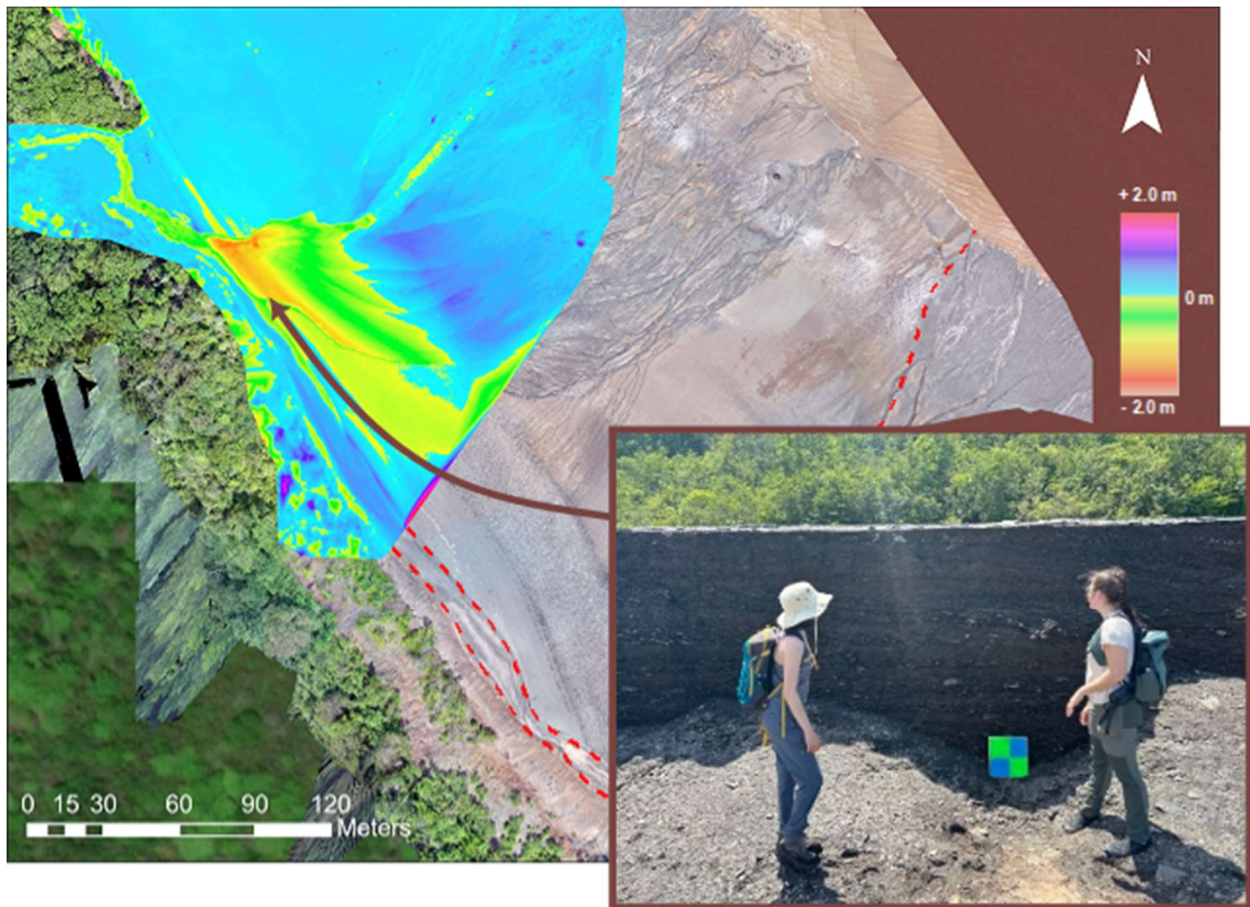


Figure 4. Surface elevation difference of a section on Blue Beach, Nova Scotia comparing change from 2021 to 2024 after a major flash flood event. Two NRR summer students (Émilie Snow and Emma McCarron) inspect the gravel berms scarp.

Future Work

Data collected during the 2024 field season are now being processed and methods to showcase the data to the public in the most accessible and informative way possible are

currently being workshopped. Annual monitoring of sites will continue in spring 2025 with the new utilization of a DJI L2 LiDAR camera to increase the resolution and data available for analysis. Future work

also involves expanding coastal monitoring to gain a more holistic approach including a multidisciplinary view on Nova Scotia's coast by incorporating bathymetry, and stratigraphic interpretations. It is the future goal of CEMP to incorporate coastal littoral systems related to process and sediment characteristics, both onshore and offshore, to further define erosion, shoreline migration, and geohazard potential.

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