

# Coastal Geoscience Research Program

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## Introduction

Nova Scotia's coasts are dictated by its complex bedrock framework, which provides the structural control for modern headlands and basins. This inherited topography was modified during the Quaternary by successive glacial and interglacial cycles, most notably the most recent Wisconsinan glaciation (75 -11ka). As ice sheets retreated approximately 11,500 years ago, they left behind a paraglacial landscape dominated by glaciofluvial deposits, tills, and drumlin fields in Nova Scotia (Piper & Pe-Piper, 2022). These landforms serve as the primary sediment reservoirs for the province's modern littoral systems.

The transition from a glaciated to drowned coastline is the result of complex post-glacial relative sea-level (RSL) dynamics. While global eustatic levels rose due to melting ice, Atlantic Canada experienced the collapse of the peripheral glacial bulge, leading to ongoing crustal subsidence and isostatic rebound (Koohzare et al., 2005; Shaw et al., 2002). As a result of this post-glacial transgression coupled with anthropogenic climate change, regional sea levels continue to rise by roughly 32 cm per century, forcing shorelines landward and accelerating the erosion of vulnerable bedrock and Quaternary bluffs (Forbes et al., 2009).

Managing these evolving risks requires a process-driven geomorphology perspective that views the coast as a series of semi-contained littoral cells. Within these cells, the erosion of glacial landforms, such as the glaciofluvial bluffs at Framboise or the till-capped cliffs at Five Islands, acts as a critical source of sediment. This material is then transported and deposited to form sediment sinks like beaches and dunes, which provide natural protection for the inland environment.

The Mi'kmaq have witnessed climatic and landscape transformations over generations in Atlantic Canada, providing invaluable long-term records of landscape transformation. For example, Mi'kmaw oral histories describing the catastrophic saltwater inundation of the historically freshwater Minas Basin have been corroborated by modern geoscience (Bleakney and Davis, 1983; Piper and Pi-Piper, 2022; Shaw et al., 2002). This knowledge supports a comprehensive approach to coastal research which integrates oceanographic and atmospheric factors, sediment transport and deposition, and seasonality and ephemeral events such as storms to understand controls over erosion. In many ways, understanding our past is the key to securing the present and future of our coasts.

## Coastal Monitoring Program

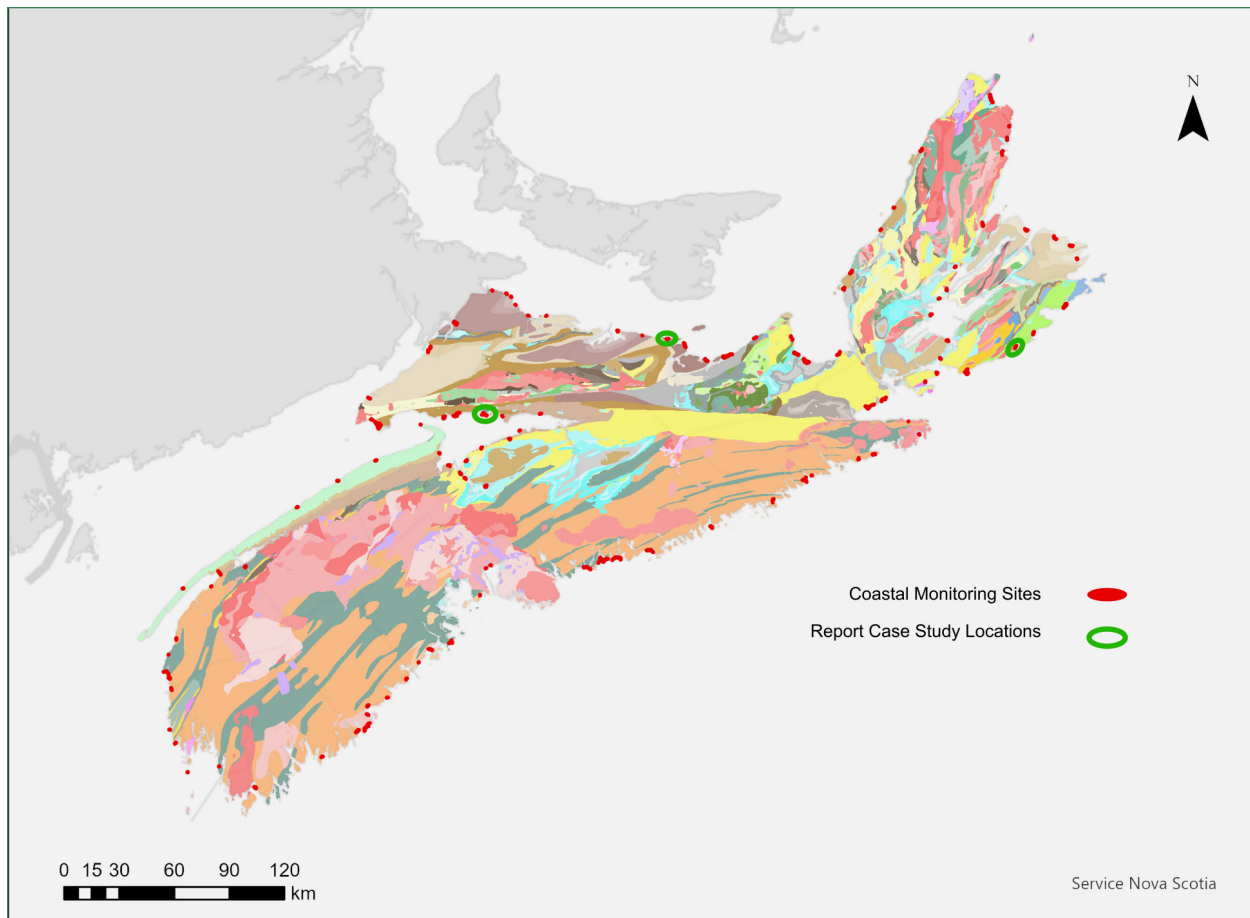
Initiated in 2019, the Coastal Monitoring Program (CMP) is now in its sixth year of monitoring. The core objective is to improve our understanding of Nova Scotia's coastal dynamics and the geohazards associated with changing coastal environments.

The program has 124 active monitoring sites across the province, selected based on their geological setting, geomorphology, cultural significance, and alignment with community priorities (Figure 2). By building upon existing expertise and fostering collaborative research, the CMP is designed to inform climate adaptation strategies for the public, communities, government, NGOs, and industry.

Key outputs of the coastal monitoring program include:

- **Hazard Mapping:** Identifying risks related to erosion, slope stability, and geological vulnerabilities.
- **Public Transparency:** An interactive, publicly accessible map is currently being built to present updated coastal data to stakeholders and decision-makers.
- **Targeted Reporting:** Developing case studies and reports on zones of particular interest with interpretations from the DNR geoscience team.

Ultimately, the insights and data generated by the coastal monitoring program will provide the foundational data to support future provincial coastal policies, technical guidelines, and best management practices for protecting infrastructure.



**Figure 2.** The location of all provincial coastal monitoring sites and case studies discussed in this report including, Framboise - Morrisons Beach, Five Islands Provincial Park, and Waterside Provincial Park with a bedrock basemap.

## Methods

Coastal monitoring combines survey-grade Real-time Kinematic (RTK) receivers with RTK-equipped RPAS commonly known as a drone. RPAS missions utilize a grid pattern with a 75% nadir (bird's eye view) overlap and supplemental oblique imagery. To ensure georeferencing accuracy, ground control points (GCPs) are surveyed via a GNSS RTK receiver before each flight. Since 2024, the program has integrated RPAS-mounted LiDAR to penetrate dense vegetation and map the underlying geomorphology, a critical addition for defining landforms in heavily vegetated areas, providing greater insight into coastal bluff evolution and higher quality datasets.

Aerial imagery and GPS data are processed using Pix4D and DJI Terra photogrammetry software. Key outputs include: Orthomosaics, 3D Point Clouds, Digital Surface Models (DSMs), and Digital Elevation Models (DEMs). The resulting data maintains a high precision Ground Sampling Distance (GSD) of 1–3 cm/pixel, depending on flight altitude and equipment.

By comparing multi-year datasets (e.g., 2019 vs. 2025) in ArcGIS Pro or Global Mapper, cut/fill and surface difference analyses are conducted. This allows DNR geoscientists to quantify volumetric changes and interpret the sediment transport dynamics within each specific site and littoral cell.

## Current Research Highlights

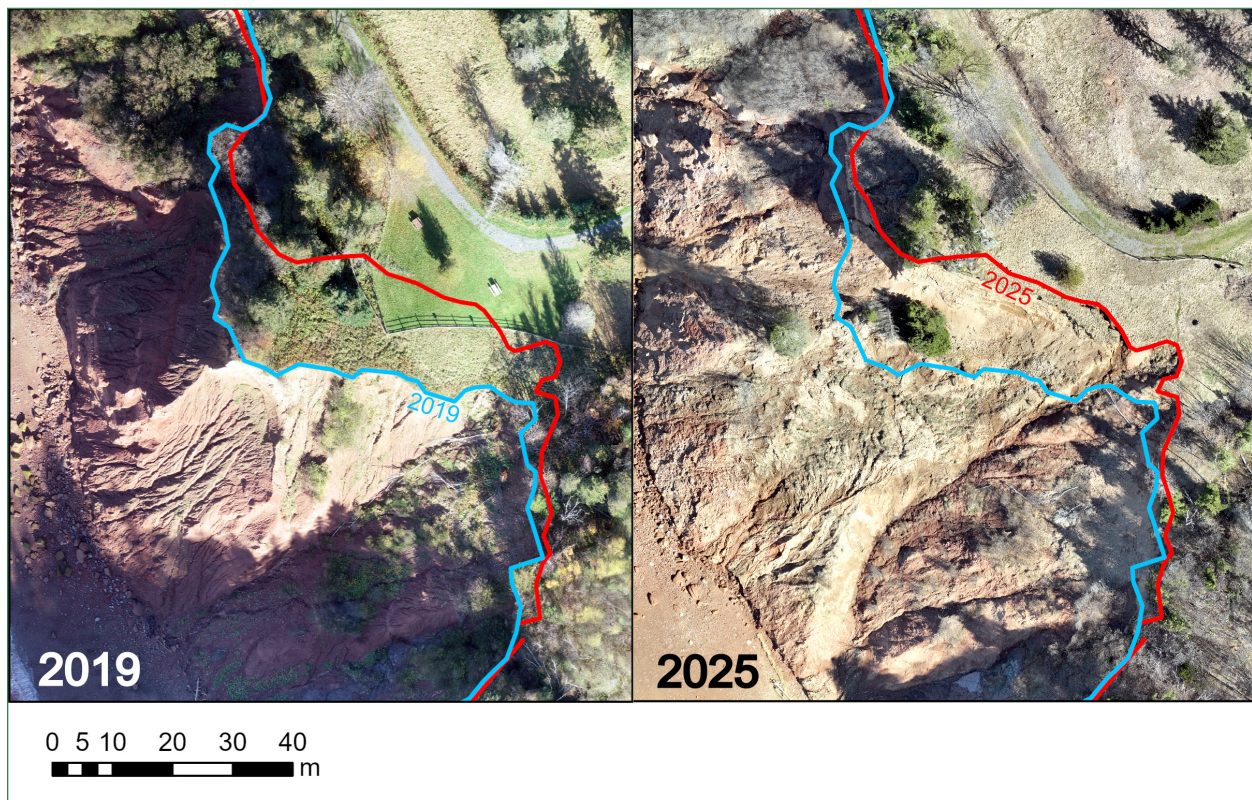
In 2025, a total of 65 coastal monitoring sites were surveyed, with LiDAR surveys successfully completed at 26 locations and photogrammetry at the other 39 sites. Combined, these sites cover approximately 66 km<sup>2</sup> of coastal land, an area roughly equivalent to 3.5 times the size of the Halifax Peninsula. Within this dataset, three notable sites were selected as case studies for this report from our 2025 analysis: Framboise – Morrison’s Beach in Cape Breton, Five Islands Provincial Park, and Waterside Beach Provincial Park, with future longform reports coming for additional sites.

### Framboise – Morrison’s Beach, Cape Breton

A peninsula located at Morrison’s Beach in Framboise, Cape Breton, constrains the beach and its littoral cell. The promontory consists of a fine- to medium-grained sand with glaciofluvial origin. The material is very susceptible to both wave action and aeolian erosion. The bluff crown has shown a landward recession of up to 9 m since the first DNR CMP survey was conducted in 2020. A mass failure occurred between the 2024 and 2025 surveys, leading to approximately 1,575 m<sup>3</sup> of material lost within one year. The high volume of sediment produced from the erosion of this bluff feeds into the local littoral cell, forming the sandy Morrison’s Beach we see today. As storms increase, and the sediment source is reduced, the depositional and erosional environment of the whole cell will change, thus impacting longshore drift both locally and further afield.

## Five Islands Provincial Park

On the shores of the Minas Basin in the Bay of Fundy, Five Islands is a popular hiking and camping destination known for its dramatic landscapes and macrotidal environment. Bluffs formed from glaciofluvial sediment and till make up the western border of the park, while the southern coast is characterized by 90 m cliffs of Blomidon Formation overlain by North Mountain Basalt, reaching a head at the basalt promontory known as “the Old Wife”. Erosion is relatively consistent along the south side of the park with an average rate of 0.4 m/year, calculated using georeferenced air photos dating back to 1964. The rate of erosion along the loose sediment glaciofluvial and till side of the park varies greatly, dominated by mass failure events. The most significant area of erosion is located directly north of the Old Wife, where consistent mass failures has resulted in a 23.5 m setback at the bluff crown and approximately 16,000 m<sup>3</sup> of sediment lost between 2019 and 2025 (Figure 3).

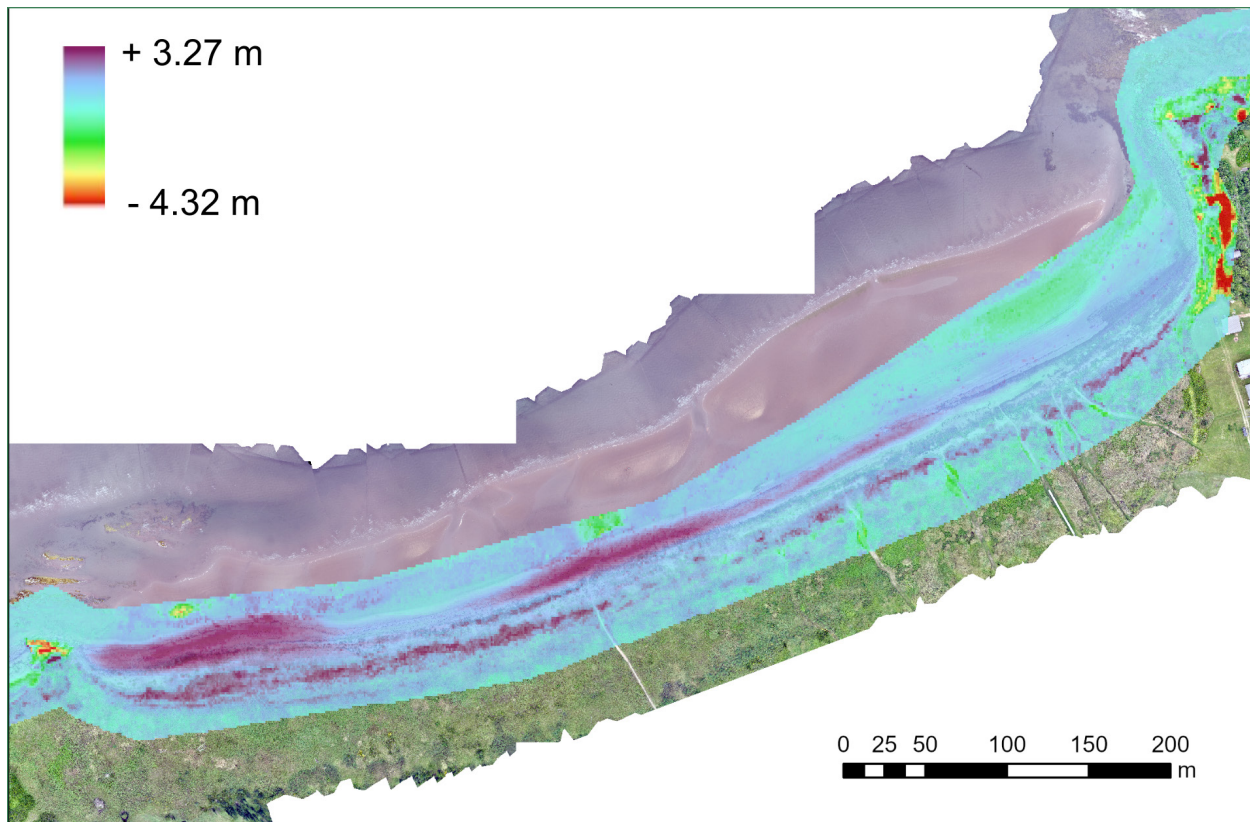


**Figure 3.** Nadir images of mass failure at Five Islands Provincial Park in 2019 (left) and 2025 (right) with bluff edge indicated for each year. Frequent landslides has resulted in over 20 m of setback in 6 years.

These failures are driven by a combination of factors. The base of the cliff, made up of siltstones and sandstones of the McCoy Brook Formation, is undercut by wave action at high tide. Meanwhile, the overlying Quaternary sediment is easily eroded, evident by rills formed from runoff and groundwater seepage, plus a fault in the bedrock creates a plane of weakness. Given these conditions, this section will continue to experience rapid erosion through rockfalls and rotational landslides.

### **Waterside Beach Provincial Park**

Waterside Beach is constrained by headlands, divided in the middle by a bedrock outcrop overlain by a bluff of poorly sorted sandy to gravelly unconsolidated sediment. For this case study, only the littoral cell consisting of the eastern side of the beach was analyzed. Between 2019 and 2025, the shoreline of the beach advanced as much as 16 m with an elevation gain of up to 3 m in the foreshore (Figure 4). Additionally, 3D models created from the photogrammetry surveys show seaward dune migration averaging 1.3 m/year. The beach is primarily fed by sediment eroded from the bluffs at the headland and in the centre of the beach. Bathymetric maps show an anticline in the exposed bedrock of the seafloor offshore Waterside, while provincial bedrock geology maps provide further evidence this site sits at the hinge of a fold axis. This structure creates a trap for sediment transported shoreward, further feeding the beach and allowing sediment to accumulate. of 0.4 m/year, calculated using georeferenced air photos dating back to 1964. The rate of erosion along the loose sediment glaciofluvial and till side of the park varies greatly, dominated by mass failure events. The most significant area of erosion is located directly north of the Old Wife, where consistent mass failures has resulted in a 23.5 m setback at the bluff crown and approximately 16,000 m<sup>3</sup> of sediment lost between 2019 and 2025.



**Figure 4.** Nadir image of Waterside Beach Provincial Park with surface difference layer. The surface difference shown is between 2019 and 2025, with red representing erosion (sediment loss) and purple representing accretion (sediment gain).

## Outreach

In 2025, the Coastal Program geoscientists supported science communication by delivering 15 outreach presentations to a broad spectrum of stakeholders across Nova Scotia. These engagements facilitated an exchange of geoscience data and interpretations between DNR and government, academic, and community partners. A notable takeaway from these outreach events included DNR geoscientists providing technical expertise to researchers and coastal stakeholders to develop accessible geoscience projects and frameworks, including the implementation of 'CoastReach', community-based monitoring stations, across Nova Scotia. The team participated in high-profile public forums, including the Museum of Industry Climate Conversation Series and Parks Canada and Waterfront Baddeck community sessions. Presentations were delivered to the Climate Change Task Force, Parks Canada staff, and local community

members in a Demystifying Climate Adaptation event, focusing on translating complex geomorphological data into actionable adaptation strategies.

Outreach efforts in 2025 also extended into multi-disciplinary and global geoscience leadership. Solidifying Nova Scotia's position as a global leader in coastal geoscience, the historic Thinkers Lodge in Pugwash convened its second international summit, where DNR geoscientists joined a leading cohort of researchers from across Canada and as far afield as Australia to advance collaborative discourse on coastal dynamics and erosion mitigation.

## Future Work

To ensure the 2025 field data is accessible and transparent, the program is developing an ESRI Experience Builder platform. This interactive interface will host site-specific StoryMaps, allowing the public, policymakers, and stakeholders to visualize coastal changes and interpretations with geospatial data across all monitoring sites in Nova Scotia.

Monitoring will resume in Spring 2026, with a dual focus on closing data gaps by prioritizing sites not surveyed during the 2025 season and prioritizing stakeholders by addressing specific areas of concern identified by communities and government partners. Coastal geoscience outreach will also continue to be a core priority for our team in 2026.

Furthermore, the coastal monitoring program is building toward a comprehensive land-to-sea monitoring framework. Future efforts will move beyond surface geomorphology to include sub-surface and underwater mapping that will integrate bathymetry and stratigraphic interpretations to provide a more thorough holistic understanding of the littoral system. By linking onshore erosion with offshore sediment transport, the CMP aims to create high-resolution models for shoreline migration and long-term geohazard potential. Ultimately, this multidisciplinary approach will provide the technical foundation for evidence-based provincial coastal policies and infrastructure protection guidelines.

## Acknowledgements

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Finally, we would like to acknowledge the support and collaboration of our colleagues and partners, whose efforts have been instrumental in advancing coastal research and fostering collaborations.

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