

Mapping and Monitoring Coastal Erosion in Nova Scotia

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Introduction

The 2015 research activities of the Mapping and Monitoring Coastal Erosion (MMCE) program focused on two projects that began in late 2013 (Nixon, 2014; Nixon, 2015a, b): (1) coastal characterization and erosion potential in Cape Breton, Pictou and Halifax counties and (2) barrier evolution in the Bras d'Or Lakes under past, present and future sea-level rise. The broad aim of the Nova Scotia Department of Natural Resources MMCE program is to build a foundation of physical coastal knowledge via field research, and to develop maps, databases and tools to assist coastal managers, land-use planners and property owners. Such knowledge includes a thorough understanding of the geology and geomorphology of Nova Scotia's coastline, and the important geomorphic and environmental processes operating in the coastal zone (both past and present). In combination with the latest climate change projections, predictions can be made of future coastal erosion and rates of inland migration of shorelines.

Project 1: Coastal Characterization and Erosion Potential

Background

Coastal erosion is a problem in many parts of Nova Scotia, where it creates risks to public safety and damages property and infrastructure (e.g. Dunham, 2014; Finck, 2007, 2011, 2014; Taylor, 2014; Taylor *et al.*, 2013). Accelerating rates of relative sea-level (RSL) rise (James *et al.*, 2014) and other impacts of climate change, including the ongoing reduction of winter sea ice in the Gulf of St. Lawrence (Senneville *et al.*, 2013) and projected

increases in temperature and precipitation (Ouranos, 2010), indicate that coastal erosion and inland migration of shorelines will have an increasingly adverse impact on people and property in these areas.

Coastal Characterization and Mapping

Three inaugural study regions were selected for coastal characterization, erosion monitoring and risk analysis in Nova Scotia, based on several factors. These factors included natural resistance to erosion (or lack thereof, based on regional geological and physiographical characteristics), settlement patterns, infrastructure on or near the coast, social, cultural, and environmental assets, available data (especially lidar surveys), and input from municipalities and communities. The three regions selected were northern Cape Breton County, the northwestern shore of Pictou County, and eastern St. Margarets Bay, Halifax County (1, 2 and 3, respectively, on Fig. 1).

Within each of these larger regions, one or more representative coastal cells were selected for detailed characterization, mapping and monitoring. A coastal cell is defined as a coastal compartment (usually separated by two headlands in Nova Scotia) that contains a complete cycle of sedimentation, including sources, transport paths and sinks (see Nixon, 2015a for a more comprehensive description). Most of the field work in Cape Breton and Pictou counties was conducted in 2014, while field work in St. Margarets Bay was completed in 2015. One coastal cell, which encompasses Cleveland Beach Provincial Park (Fig. 2), was selected for mapping in northern St. Margarets Bay. The form and materials of the backshore, foreshore and nearshore zones of the coastline at Cleveland Beach Provincial Park were described, photographed and mapped during three site visits in the spring and summer of 2015. These

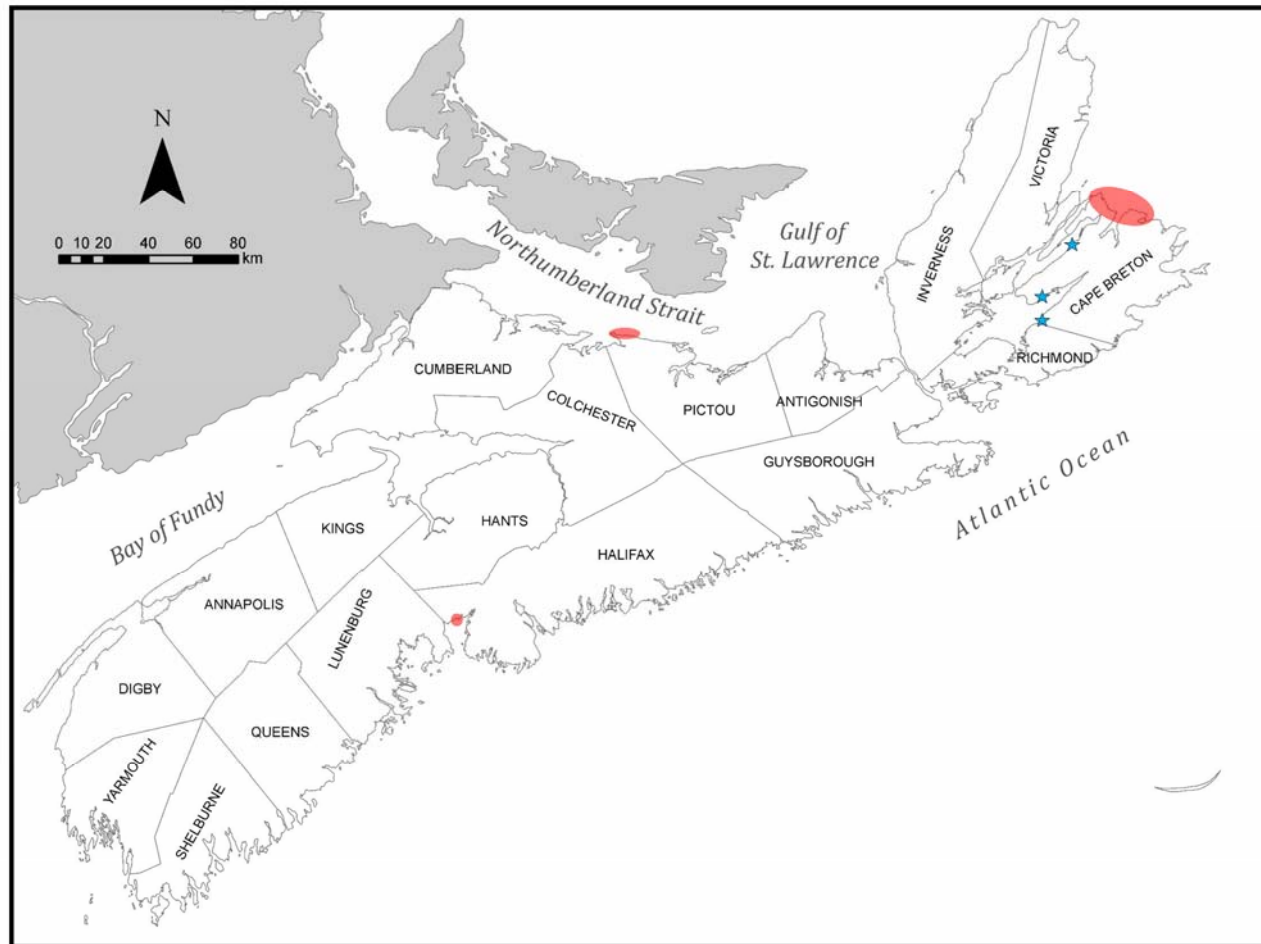


Figure 1. Map of the counties of Nova Scotia showing the locations of study areas for Project 1 (red polygons) and the three barachois ponds studied in Project 2 (blue stars).

data were analyzed together with previous, complementary coastal mapping of the adjacent coastal zone to the west (P. W. Finck, unpublished data).

Much of the remainder of 2015 was devoted to researching and developing methods for mapping on a line in ArcMap. This technique, known as linear referencing, is a method of spatial referencing, in which the locations of features are described in terms of measurements along a linear element (the backshore, foreshore and nearshore coastlines in this case), from a defined starting point. Other 2015 activities included designing the structure of the coastal characterization tables and geodatabases for the backshore, foreshore and nearshore coastlines, transcribing field notes and entering the data into the geodatabases, sorting, organizing and selecting georeferenced

photographs, and creating coastal zone maps for each of the coastal cells in ArcMap (e.g. Fig. 3).

Coastal Erosion Monitoring

The GNSS (Global Navigation Satellite System) survey data collected in 2014 and 2015 were used to calculate slope values for the foreshore zones within each of the coastal cells, and were also added to new, erosion-themed geodatabases in ArcMap (where all future GNSS surveys will be stored). The GNSS data consist of high-precision geographic surveys (i.e. 1-10 cm accuracy in x, y and z dimensions) of cliff-top edges, beach profiles, and erosion control point sites (to be used to aid future monitoring) within each of the mapped coastal cells (Nixon, 2015a). The GNSS data were also used to determine historical rates of coastal change by comparing GNSS data and/or



Figure 2. Cleveland Beach Provincial Park shoreline in St. Margarets Bay, Halifax County. Red line is the GNSS survey, which followed the vegetation line and/or greatest break in slope, separating the beach from the leading edge of coastal erosion. Yellow x symbols show locations of the two erosion control point markers for Cleveland Beach Provincial Park (to be installed at a

recent (≤ 5 years old) lidar imagery to orthorectified aerial photographs taken in the 1930s and 1940s (Fig. 4).

Two sites were surveyed for erosion control points in 2014 and 2015 at Cleveland Beach Provincial Park. At these sites holes were drilled into two large boulders for the future installation of two erosion control point markers (DeMont, 2015; Fig. 2).

Future Directions

Work planned for 2016 includes the selection of new field sites for detailed mapping and monitoring (summer and fall 2016) and the completion of a DNR Open File Report (winter 2016). The Open File Report will contain maps and descriptions of all six coastal cells distributed across Cape Breton,

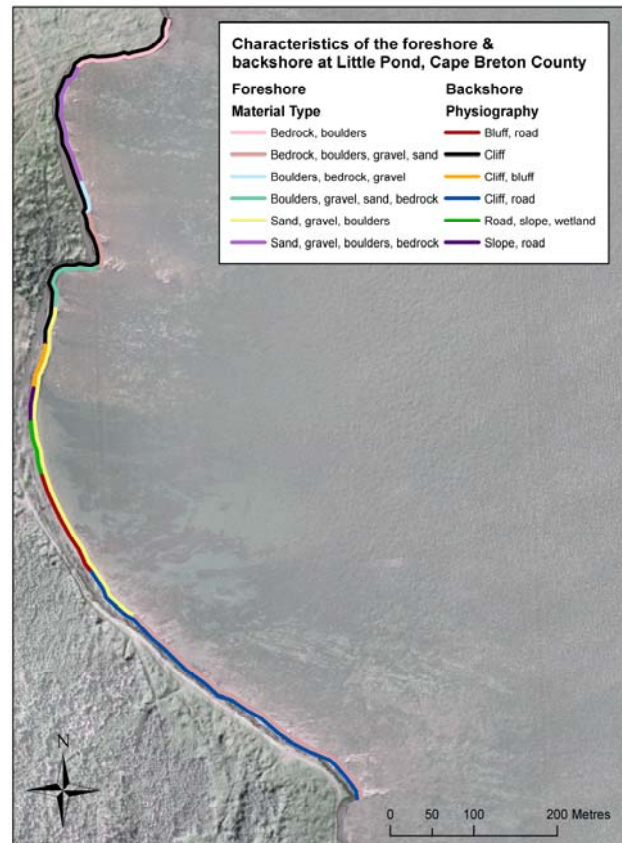


Figure 3. Coastal characterization of an individual coastal cell at Little Pond, Cape Breton County. The innermost colour-coded line paralleling the coast represents the physiography of the backshore, while the outer (more seaward) colour-coded line represents the composition of the sediments and other materials that make up the foreshore. There are seven different attribute categories describing the form and materials of both the backshore and foreshore that can be turned on or off, depending on the map-user's needs.

Pictou and Halifax counties, and also include an analysis of their vulnerability to future erosion.

Project 2: Barrier Evolution in the Bras d'Or Lakes

Background

Barrier beaches enclosing small ponds and lagoons (known in Atlantic Canada as 'barachois') constitute ~12% of the Bras d'Or Lakes shoreline in Cape Breton, Nova Scotia (Taylor and Shaw, 2002). Many of these barriers have been developed into harbours, roads and recreational areas. Well preserved, drowned (≤ 25 m below mean sea level)

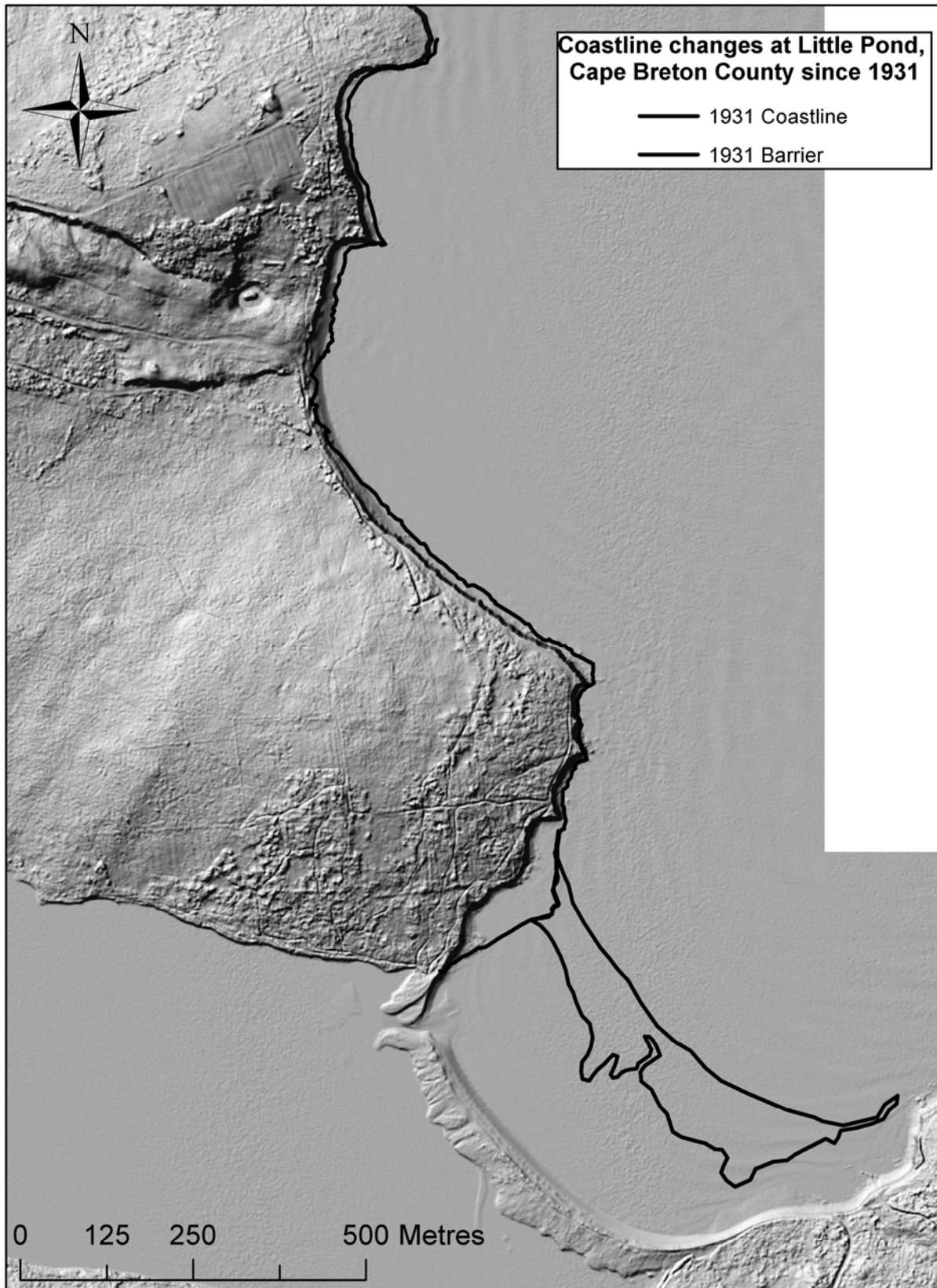


Figure 4. Shoreline changes at Little Pond, Cape Breton County, since 1931. The black line was traced along the coastline on an orthorectified aerial photo of this area from 1931 and displayed against lidar imagery from 2010. Note the concentration of erosion on the coastal cliffs at the northern end of the barrier beach (likely due to migration of the barrier, approximately 30 m toward the southwest since 1931).

early-mid Holocene coastal landforms in the Bras d'Or Lakes, including spits, tombolos and barrier islands (Shaw et al., 2006), may be an indication of things to come for the modern barriers, especially given the projected relative sea-level (RSL) rise for this region over the next 100 years (~62–140 cm by 2100 at Baddeck, N. S., relative to 1986–2005; James et al., 2014).

A basic understanding of the age of the barachois, including the nature of the sediments underlying them and the morphodynamics of their barriers (i.e. how quickly they evolve from growing or stable phases to landward-migrating or submerging phases), is required to provide baseline data with which modern and future coastal dynamics may be compared and with which vulnerability to sea-level rise and coastal erosion can be characterized. Field work for this study included acoustic mapping of the sediments beneath the ponds in 2013 (i.e. shallow seismic and sidescan sonar; Nixon, 2014) and the recovery of six sediment cores in 2014: two from each of the three barachois.

Progress in 2015

Approximately two months in early 2015 were devoted to completing the final sampling and laboratory analyses of sediment cores that were recovered (in 2014) from the two coastal ponds and one lagoon in the Bras d'Or Lakes (Nixon, 2014; Nixon 2015b). Radiocarbon dates on organic matter sampled from the cores and sent for analysis to the University of Laval and the Keck Carbon Cycle Accelerator Mass Spectrometry facility (University of California, Irvine) were delivered in April 2015. A cursory examination of the radiocarbon dates indicates that approximately 3 m of sediment (mostly silt and clay) were deposited in Amaguadees Pond over the past ~3600 years, yielding an average annual sedimentation rate of ~0.85 mm/yr. Further analyses of basal sediments in the Amaguadees Pond cores are required to determine whether or not the pond (and therefore the barrier) is older than 3600 years. In Irish Vale lagoon, the average sedimentation rate has been 0.32 mm/yr for the past ~2500 years. Radiocarbon dated wood (~2500 years old) from the very base of the fine-grained pond/lagoon sediments (which lie above a poorly sorted diamict) indicates that the

barrier enclosing Irish Vale lagoon (formerly Irish Vale pond prior to breakdown of the barrier; Nixon, 2014; Nixon 2015b), has been in existence for ~2500 years. A basal date on wood from Campbells Pond, which did not bottom out on non-pond sediments (i.e. till or bedrock), indicates that sediments accumulated at an average rate of ~0.6 mm/year for the past 1000 years, but the pond itself may have been in existence for much longer.

The sediment cores were also sampled at a high resolution (every 1–5 cm) for X-Ray Fluorescence (XRF) analysis to characterize elemental variability in the pond sediments through time using the DNR portable XRF spectrometer. The unsampled (archived) halves of each of the split sediment cores were also scanned for X-ray, spectral reflectance and magnetic susceptibility at the Geological Survey of Canada (Atlantic) core scanning facility in April 2015. Results from X-ray, spectral reflectance and magnetic susceptibility will be used to characterize changes in grain size and concentration of organic matter in the sediments and to facilitate the identification of sedimentary structures, such as varves.

Future Directions

A full analysis of the sediment cores of the Bras d'Or Lakes barachois, together with results from the acoustic mapping of the seafloor and subsurface (Nixon, 2014) will be presented in a research paper that is currently in preparation. The Bras d'Or Lakes may be a good candidate for future coastal mapping, characterizing and monitoring (see Project 1, above) depending on the conclusions of this study regarding the dynamics of the barriers and vulnerability of the barachois ponds and their inner shorelines to future sea-level rise and erosion.

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