T7.1 MODIFYING FORCES

The coast is a place of constant change. Winds, waves, tides and ice are continually at work, eroding, transporting and depositing the rock, gravel, sand and mud of the shore (see Plate T7.1.1). On the Atlantic Coast (Region 800), waves are the most important environmental agent of change, while in the Bay of Fundy (Regions 600 and 700), tides, and the currents generated by them, are of greater significance. Sea-level rise can also contribute to morphological changes on the coast. Organisms can influence the modifying effects of the physical forces.

TOPOGRAPHY

Landforms that result from these forces depend very much on the bedrock geology, unconsolidated surficial materials remaining from the last glaciation, and sea-level changes in the post-glacial period. For purposes of this description, bedrock can be grouped into resistant and unresistant types. Resistant rocks dominate the Atlantic Coast, except in southern Cape Breton Island, the Bay of Fundy coast west of Cape Split (District 720) and the Antigonish–western Cape Breton Island section of the Gulf of St. Lawrence (Districts 220, 310).

Beaches and marshes in these areas are derived exclusively from reworked surficial sediments, including eroded drumlins, glacial outwash and marine deposits. These beaches and marshes are therefore of limited extent and size. Unconsolidated bedrock outcrops in the Northumberland Strait (District 520), southern Cape Breton Island (Districts 530, 870) and the upper reaches of the Bay of Fundy (District 620) are sources of relatively abundant coastal sediment. Surficial deposits also tend to be more plentiful in these areas. As a direct result, the largest beaches and marshes are found on these coasts.

In the late 1970s, winter storm waves were breaking down the primary sand dune at Rissers Beach, Lunenburg County (Unit 832). Deterioration of the jetty at the west end of the beach by the river was found to be the root cause. The jetty had functioned to support the beach in a configuration which faced the direction of greatest wave energy. When the jetty developed gaps, sand washed into the river at an increasing rate, leaving the beach sand-starved and eroding. The beach was restored by repairing the jetty, in-filling the breaks in the dune with Christmas trees as sand traps, and planting beach grass to help hold the sand in place.

WAVES

Ocean swells from the south and east dominate the Atlantic Coast. This high-energy environment is more pronounced in winter. In the fall, remnants of hurricanes often cross the province and its coastal waters from the southwest. Significant wave height occurring for a 12-hour period once a year varies from 6 m in the Gulf of Maine to 8 m off Halifax and Cape Breton Island.[1]

Waves due to offshore winds have no erosive effect on the shoreline, but even off Halifax (which experiences predominantly northwest and northerly offshore winds in the winter) easterly storm-wind events produce onshore waves which rework exposed glacial deposits along the Atlantic Coast at Hartlen Point (Unit 833) at a rate of 2 m annually. Waves along the Eastern Shore are responsible for reworking sediments varying in size from sand particles to cobbles.[2]

The Atlantic Coast is also exposed to long ocean swells originating from storms at great distance. Swells from the open ocean are not very significant in the Bay of Fundy, nor in the Gulf of St. Lawrence.

Summer winds from the southwest and especially winter winds from the northwest generate waves in the Bay of Fundy. These have combined with the tides to erode wave-cut platforms on west-facing coasts. In the Gulf of St. Lawrence, northeast storm winds generate waves of sufficient energy to erode unresistant bedrock outcrops at 1 m annually.

A noticeable seasonal cycle in wave energy is observed in the Atlantic Ocean, Bay of Fundy and Gulf of St. Lawrence (although the Gulf is protected by ice from December to April). The increased winter wave energy, especially in storm episodes, combs down beaches, removing sand and gravel offshore and destroying the characteristic series of parallel offshore bars. Persistent, but gentler, onshore winds in the summer move the same material shorewards, rebuilding the beaches and bars.

TIDES

With the rapid increase in tidal range and height within the Bay of Fundy, stronger tidal currents are established and the capacity to move sediments increases. Large tides have ranges of 5.1 m at Yarmouth (District 920), 9.3 m at Digby (District 720), 12.6 m at Advocate (District 710) and 16.0 m at Burntcoat Head in Minas Basin (District 620). Currents have been reported in excess of 5 m/s in the Minas Channel.

River estuaries in the Bay are virtually dry at low tide. Stronger currents generated by the flood tide carry fine sediment into these estuaries, which the weaker ebb-tidal currents are unable to remove. This is the origin of sediments which have built, and are building, the marshes at the heads of Chignecto and Cobequid bays. The strongest currents in the main channels carry and deposit sand, forming gigantic sand bodies characterized by sand waves. Particularly conspicuous sand bodies are found in the Avon estuary off Hantsport (Unit 511a), and off Economy Point and in Cobequid Bay west of the Shubenacadie estuary (Unit 913a). This sand is exposed only at low tide.

Tidal range is only 1–2 m in the Northumberland Strait, and at certain times only one tide occurs (see T6.1). In summer, the low tide occurs during the day, exposing beaches and sand bars to the sun's radiation. The incoming tide is warmed as it moves over these sand flats, raising water temperatures to the highest values achieved in Nova Scotia. In winter, the reverse situation occurs: the sand flats are exposed at night and the incoming tidal water is chilled, greatly aggravating the ice conditions.

Tidal ranges of large tides increase westward on the Atlantic Coast from a large tide of 1.4 m at Ingonish (Unit 522b) to 1.95 m at the Guysborough (District 860) and 2.1 m at Halifax (Unit 833). Narrow entrances restrict the tidal influence in Bras d'Or Lake (Unit 916). However, strong tidal currents and barometric tides result in the mixing of fresh and salt water. The largest tidal-current velocities are generated within inlet throats and estuarine tidal channels, and here provide the mechanism for landward transport of sand- and mud-sized sediments into embayments.[2]

ICE

Only in the Gulf of St. Lawrence does sea ice cover large areas of water. Shore ice begins forming in December and by late January covers much of the Northumberland Strait. Not until late March or April does this ice break up and move through the Cabot Strait to the Atlantic. The ice cover is moved by strong winds and, in piling up on windward shores, protects the coast from wave attack, although the ice itself may "raft" material from beaches and marshes. During break-up, strong currents moving ice along the Atlantic coast of Cape Breton Island cause ice scour, removing sediments, vegetation and animals southwards and offshore.

Ice forms in the Upper Bay of Fundy (Unit 913a) from December to April. Drift ice moves with the strong current and transports material which becomes frozen into the flows but may strand with the ebb tide.

Ice forming on mud flats in the Bay of Fundy may protect the coast from erosion by waves and tidal currents. However, the mud flats themselves are heavily scoured by ice, which causes erosion and mortality of benthic organisms.

Local ice forms in bays on the Atlantic Coast but does not produce major changes in coastal landforms.

SEA-LEVEL RISE

All coastlines in Nova Scotia are changing. Rising sea level over the last 15,000 years (see T3.3) has caused the coast to retreat inland, flooding the lower reaches of river valleys, eroding unresistant bedrock and unconsolidated materials to create marine platforms, raising marsh levels, and pushing beaches landwards.

Tide-gauging records for Nova Scotia indicate that the relative sea level has been rising over the past century. Records at Halifax show an average 35-cm rise since 1896. The projected relative rise by 2070 is one metre per century.[3]

The impact of accelerating sea-level rise on the coast of Nova Scotia is extrapolated from evidence of post-glacial coastal changes and from observations of coastline retreat over the last century. Past and current sea-level changes have contributed to the erosion of bedrock shorelines and bluffs, beach retreat and subsequent sediment increase in sheltered inlets and estuaries.

Coastal dunes on Sable Island (District 890) are constantly being reworked, and increased sea-level rise is expected to accelerate this process.[3] The cyclic phases of progradation, stability and retreat, resulting from sea-level changes, waves and tides, have been changing the shoreline of Nova Scotia since the last glacial retreat. If the predictions on sea-level change in the future are right, these processes will continue to modify the coast, possibly at an accelerated rate.[3]

BIOLOGICAL COMPONENT

Biological communities have a significant impact on the form and development of the coastline. When salt-marsh grasses and Eel Grass colonize muddy shores, they reduce the wave and current action, leading to the deposition of sediment and the building of more extensive muddy environments. Kelp beds can have a similarly moderating effect in areas exposed to high waves.

Growth of thin films of unicellular algae on the surface of muds can make them more resistent to erosion by slowing the rate of change over what would occur in the absence of organisms. Some sea-bottom invertebrates, such as the amphipod *Ampelisca* and the polychaete *Clymenella torquata*, build tubes out of sediment, and the combined effect can stabilize the sediment. Organisms that feed on sediment sometimes make the bottom more stable by depositing feces, which are more compact and stable than the sediment was before it was ingested.

Rock-boring organisms, such as the clams *Zirphaea crispata* and *Petricola pholadiformis*, tunnel in soft rocks in shallow water and help to break them apart. The shells of clams in some coastal environments form a distinctive feature, and the crushed remains of shells and the skeletons of barnacles can form a distinctive type of sediment called shell hash.

CULTURAL FACTORS

Agricultural and forestry practices have led to significant loads of sediment entering the ocean and resulting in pronounced coastline change, usually in sheltered coastal estuaries. Humans have also had an impact by excavating or in-filling marine areas (the former Halifax City Dump) and by dyking practices begun by the Acadians and continued to the present. The construction of causeways, breakwaters and jetties alters the normal pattern of water movement and sediments transported by water and can create or destroy coastal features such as beaches and tidal marshes (see T12.9).

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Associated Topics

T3.3 Glaciation, Deglaciation and Sea-level Changes, T6.1 Ocean Currents, T6.3 Coastal Aquatic Environments, T6.4 Estuaries, T7.2 Coastal Environments, T7.3 Coastal Landforms, T10.9 Algae, T11.17 Marine Invertebrates, T12.7 The Coast and Resources

Associated Habitats

H2 Coastal

References

1 Walker, R.E. (1976) Wave Statistics for the North Atlantic—1970. Bedford Institute of Oceanography, Dartmouth, N.S. (*Data Series* BI-D-76-3).
2 Boyd, R., A.J. Bowen and R.K. Hall (1987) "An evolutionary model for transgressive sedimentation on the Eastern Shore of Nova Scotia." In *Glaciated Coasts*, edited by D.M. Fitzgerald and P.S. Rosen. Academic Press, San Diego.
3 Shaw, J., R.B. Taylor and D.L. Forbes (1991) "Impact of accelerated sea level rise on the coast of Nova Scotia, Canada." In *The Climate of Nova Scotia; Proceedings from a Symposium, November 19, 1991*. Atmospheric Environment Service, Environment Canada, Dartmouth, N.S.

Additional Reading

• Forbes, D.L., and R.B. Taylor (1987) "Coarse-grained Beach Sedimentation under Paraglacial Conditions, Canadian Atlantic Coast." In *Glaciated Coasts*, edited by D.M. Fitzgerald and P.S. Rosen. Academic Press, San Diego.

Plate T7.1.1: Eroding drumlin at Lawrencetown Head, Halifax County (Unit 833). The till is eroded and sand transported and deposited in the sand beach/dune system of Conrod Island in the distance. Photo: D. Davis

