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Barrier Islands, Sand Spits and Dunes in the Southern Gulf of St. Lawrence*

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Many miles of the northern coast of Prince Edward Island and the eastern coast of New Brunswick consist of long sand beaches fronting narrow barrier islands or sand spits, some of which have well developed dunes. The Prince Edward Island National Park, in the central area of the northern coast, includes easily accessible sand beaches and dunes but the finest development of barrier islands, with sequences of old dune ridges, occurs further to the northwest. Hog Island, which protects Malpeque Bay, is a good example in a relatively natural state. Along the New Brunswick coast many of the barrier islands and sandspits are inaccessible other than by boat, but a new National Park has been established along Kouchibouguac Bay in an area which has been the site of detailed coastal studies since 1970 (E.A. Bryant, 1972; R. Davidson-Arnott, 1971; Greenwood and Davidson-Arnott, 1972; McCann and Bryant, 1970 and 1973). The Kouchibouguac barrier islands exhibit similar features to those of Prince Edward Island but on a much subdued scale, as the bay is protected from many of the waves developed in the southern Gulf of St. Lawrence. The Prince Edward Island north shore is a much higher wave energy coast than most parts of eastern New Brunswick.

There has been little research on the coastal sand formations of the Maritime provinces, and Johnson's comments (1925) provide the only generally known reference. It is clear, however, that the general conditions of the barrier systems of the eastern United States, (Dillon, 1970; Hoyt and Henry, 1967, 1971) with continual changes in configuration and overall shoreward retreat, are present here. The present barrier island systems probably originated at the lower sea levels of the Holocene as coastal beaches and spits which were able to build up significant dunes and beach deposits. As sea level rose the land behind these dunes was flooded forming lagoons. The beaches and dunes then underwent shoreward retreat as sea level continued to rise. The barrier islands thus represent a dynamic equilibrium between the slope of the land, the rise of sea level, and the intensity of wave attack. If the rise of sea level or amount of wave attack increases the barrier island can be destroyed offshore, on the other hand if the rise in sea level decreases and the slope increases the barrier island will be driven shorewards and become a land beach. The barrier island is thus one of the most dynamic coastal landforms subject to continual change in configuration and topography because of its environmental situation.

The configuration of the island systems of Kouchibouguac Bay and Prince Edward Island is a response to specific major events in that they owe their present outline more to the periodic storm activity than to the everyday seasonal coastal processes. The Kouchibouguac barriers show map evidence, over the past 150 years, of frequent breaching of the islands and infilling of inlet systems, that is a response to the wave refraction patterns of storm waves and the subsequent redistribution of sediment along the coastline. Not only are the barrier islands changing shape they are also being pushed shorewards as evidenced by accurate charts since 1839 and good aerial photographs since 1930. The field evidence of old marsh deposits emerging at about mid to high water make on the ocean side beaches in front of eroding dunes, and the truncation of old dune ridges by the modern shoreline, is further indication of this landward movement.

The transient feature of many of these barrier island systems is the tidal inlet. These inlets exist with a very low tidal range of 3.7 ft (.93 m) at Richibucto and Tracadie, New Brunswick, and 4.2 ft (1.28 m) at Malpeque, Prince Edward Island. At spring tides the currents through them obtain speeds of 1.25m/sec at Richibucto and slightly greater at Malpeque. The discharge and current speeds measured in the inlets of Kouchibouguac Bay agree with those for similar inlet and lagoon systems in the United States (Bruun, 1967). The stability of the inlets, which vary in width from 1 km at Malpeque to the less than 30 m for small inlets in the Kouchibouguac system, divides them into two classes. There are those which maintain the same relative position through time, though varying in exact location, and those short lived inlets which are caused by breaching of the barrier islands. The former type maintain their position because of important factors such as their position opposite an estuary, a central location in the lagoon system, or man-made breakwalls. The latter unstable type usually close because local tidal currents are not strong enough to flush away the sediment deposited by longshore drift. The weakness of the currents is due to small discharges through the inlets, which result from small lagoon areas or competition for lagoon waters by other more favourably located inlets. Factors such as the width and length of the inlet, and the amount of sediment being transported alongshore, are also important.

Many of the inlets of the Kouchibouguac and Prince Edward Island systems, which can be traced from old charts and air photographs, have been temporary features, which are now represented by relict washover fans and former ebb and flood tide delta systems. In Prince Edward Island the present major inlets of Malpeque, Conway, Palmer and Alberton appear to be relatively stable features, though one of these, Palmer inlet, is very shallow. An interesting case of changes due to man's activity is provided at Rustico, further east on the north coast of Prince Edward Island

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where the larger of two inlets has been infilled by a road causeway. This has caused the smaller inlet to increase in size in order to carry the additional volume of water which formerly passed through the sealed inlet. Many of the smaller inlets which are used by fishing boats have changing channels which have to be remarked frequently and in some instances dredged.

Something of the evolution of the larger barrier islands and spits can be determined from the trend of the older, stable dune ridges (see Figs. 2 and 3 in the account of Hog Island by S.B. McCann, this volume, p.108) which reach heights of 15 m. Some of the highest and oldest dunes in Prince Edward Island occupy the narrowest parts of the barriers. The orientation of these dunes is parallel to the present coastline except around present and former inlets where they recurve. Accumulation of sand and the growth of relatively stable new dunes is associated with infilled inlets and washovers. The pattern of these new dunes is irregular, quite unlike the strong linear pattern of the older dunes. The dunes provide a temporary source of sand to replenish the ocean beaches when these have been combed down in storms. Much material is also supplied to the beaches from the dunes by wind action, as evidenced by the conditions existing in May and June of 1972, when there were long periods of winds from a southwest direction i.e., offshore. There is a continual mixing of the nearshore, beach and dune sands. Large blowout systems exist within the dunes of Hog Island oriented parallel with the predominant wind direction. Some of these have been recolonized by a second sequence of vegetation, after which they may be reactivated as blowouts again. Wind erosion of the dunes initiated by heavy recreational use is in evidence in the more accessible areas of coastline.

The sand dune areas exhibit an interesting sequence of vegetational associations which will be familiar to those with a knowledge of dune areas elsewhere. The following remarks are based on a study carried out by M.M. Grandtner (1970), for the National Parks, of an area of high recreational use at Brackley on Prince Edward Island. He defined three plant associations within the area of blown sands at Brackley:-

a) Plant communities of the mobile dunes - the bare sands of the initial dunes become progressively occupied by the marram grass community, in which marram itself (Ammophila brevigulata) plays a major role in the formation and later fixing of the dune form. The association includes many species other than marram, however, with sea rocket (Cakila edentula) being important in open sand areas, and saltmarsh goldenrod (Solidago sempervirens), evening primrose (Oenthera sp.) and sea-beach sedge (Carex silicea) appearing in greater abundance as the marram cover thickens. At a later stage beach pea (Lathyrus japonicus, v. glaber), red fescue (Festuca ribra), fall dandelion (Leontodon automnalis), mosses and many lichens appear and the soil begins to possess a fragmentary surface horizon. An occasional white spruce (Picea glauca) occurs.

b) Plant communities of the fixed dunes - the beginning of the fixing of dry dunes begins with the growth of shrubs, such as bayberry (Myrica pensylvanica) and downy hudsonia (Hudsonia tomentosa), and the development of a thin discontinuous layer of litter and acid humus mixed with the sand. Further colonization by mosses and lichens immobilizes the surface and prepares the way for less specialized species - the shrub community replaces the marram community, and is in turn replaced by white spruce-bayberry forest. As the tree canopy of the open forest of white spruce (Picea glauca) eventually closes the bayberry disappears and there is an increase in forest herbs, mosses and lichens. The soil now begins to show distinct traces of podzolization.

c) Plant communities of the wet depressions - these are often blowouts in the dunes which reach down to the water table. The sequence begins with Baltic rush (Juncus balticus, v. littoralis) which prepares the way for an invasion by bayberry, meadowsweet (Spiraea latifolia) and sweet gale (Myrica gale), which is followed by other shrubs, willows (Salix sp.), grey birch (Betula populifolia) and hygrophilous herbaceous species. Grandtner stresses the sensitive nature of some of the plant associations and remarks on the effects of fire during the last two hundred years.

In considering the bodies of water which occur behind the offshore islands and spits a distinction must be made between estuaries, such as the Richibucto River, natural closed embayments, such as Miramichi, Cascumpeque and Malpeque Bays, and the narrow lagoons such as the Kouchibouguacis, in New Brunswick, and the Narrows in Prince Edward Island. The lagoons proper are less than 2 km wide and rarely exceed a few metres in depth except in the tidal distributary channels. Though they are relatively narrow there is sufficient fetch to generate waves which are of sufficient size to redistribute the sand on the inner side of the islands and form small cuspate forelands as described by Zenkovich (1967). The small waves generated within the lagoons are also sufficient to produce cliffs in till and in the soft red sandstones of Prince Edward Island. The sediments in the lagoons consist largely of sand which has been washed over the barrier during storms or pushed in at the inlets in the form of a flood tide delta. The larger estuaries are floored by finer sediments brought down by the rivers (Buckley, 1969), though most of the rivers drain only insignificant land areas and so contribute material only slowly. Extensive, active salt marshes occur in the protected areas of the lagoons and a clear vegetation sequence can be seen towards the high tide areas of the intertidal flats.

The beaches of the area undergo a distinct annual cycle during which there are marked changes in the beach and nearshore profile and variations in the intensity of the different processes at work. It is convenient to begin the 'beach year' with freeze-up and the cessation of wave action at the shore which begins in late December. By the end of January fast ice several centimetres thick may extend outwards from the beach on exposed coasts and extend completely across the lagoons and estuaries. This ice rises and falls with the tide and may shift somewhat on open coasts but remains fixed in the lagoons. Ice floes offshore averaging 1 m in thickness are abundant by late January and in February and early March there is frequently 8/10 to 10/10 ice cover continually in motion in the southern Gulf of St. Lawrence and Northumberland Strait. Break-up and clearing begins in late March and continues into early May, with considerable variations from year to year. This year, 1972, was a particularly late year and ice remained on the beaches well into May. The effects of the freeze-up period are to prevent any wave action on the beaches for about four months each year and to destroy or at least disrupt the wave formed submarine profile of the nearshore zone. The re-establishment of normal wave conditions in the spring is usually accompanied by the re-establishment of the system of bars and troughs, which characterizes the nearshore zone along most of the sandy coasts within this area of low tidal ranges. Three or four submarine bars are common and the outer ones are probably little modified by the winter ice and wave conditions. Systems or cells of longshore currents and rip currents become well established by late June and tend to persist throughout the rest of the year, unless altered by a major storm. The exposed beaches tend to be built up in the early part of the year and there is frequently the development of a large berm. Few of the summer hurricanes, which have such marked effects along the eastern coast of the United States, are particularly important in producing large waves in the southern Gulf which will affect either the mainland or Prince Edward Island shores. Fall is the main storm season and in each of the past three years the study beaches in Kouchibouguac have been combed down with erosion of the dune front, particularly in those areas where wave refraction has caused a concentration of wave energy. The largest storm in this period had strong northeast winds which blew continuously for two days.

There is currently a growth of interest in the problems associated with the evolution and present processes of the sand coasts of the southern Gulf of St. Lawrence. It is hoped that the new work in progress will mark the beginning of a period of much needed research on the coastline of Canada.

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