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BEACH MORPHOLOGY AND COASTAL CHANGES AT SELECTED SITES, MAINLAND NOVA SCOTIA

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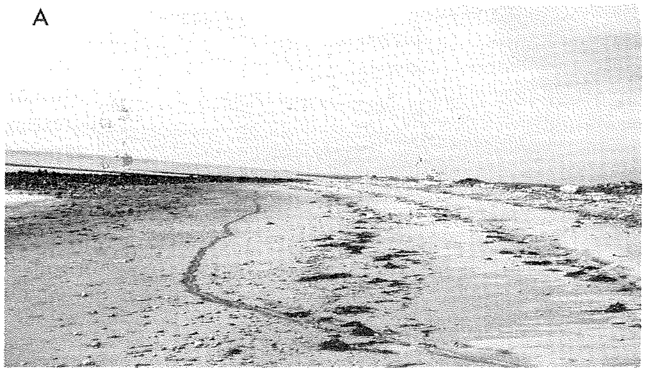

Figure 41. Views of Lower Saulnierville Beach – (A) at profile 3 the beach face is covered by sand whereas (B) near profiles 1 and 2 a very heterogeneous mixture of sediment exists. A cobble-boulder lag deposit covers the lower intertidal and nearshore zones all alongshore. (A) GSC 190829, (B) GSC 190830

Advocate Harbour Beach, Cumberland County

Physical and geological setting

Advocate Harbour Beach, locally known as Big Beach, is situated at the southwestern tip of the isthmus of Chignecto (Fig. 42). The area is part of a sedimentary lowland composed of Carboniferous and Triassic clastic rocks (Swift and Borns, 1967). To the north are the east-west trending Cobequid Hills which form part of an extensive igneous and metamorphic highland. The surficial deposits of the Advocate Harbour area are part of the Five Islands Formation, a late Pleistocene outwash deposit (Swift and Borns, 1967). The stratified sand and gravel deposits locally attain a thickness of over 60 m and can be divided into a glaciomarine and a glaciofluvial lithosome.

Advocate Harbour Beach consists of two converging spits which nearly completely enclose the harbour (Fig. 42). The spits extend from Cape Chignecto, a 210 m high granite headland to the west, and from Cape D'Or, a 150 m high headland composed of Triassic basalt, to the east. The part of Advocate Harbour Beach studied extends 3.5 km from the village of West Advocate in a southeasterly direction to the entrance of the harbour. The western 1.8 km of the spit forms the seaside protection for the low-lying dyked marshlands in the backshore. The marsh extends 1.3 km northward to the paved highway and the village of Advocate Harbour. The marsh, first put under cultivation in the 1700s by the Acadians, is not intensively used today. Large areas remain vacant, used only intermittently for the pasturing of livestock. An earthen dyke and cribwork constructed in 1958 separates the marsh from the tidal flats of the harbour. The flats extend from the mouth of Advocate River to the present beach.

The harbour is exposed to southwest winds which coincide with maximum fetch – the length of the Bay of Fundy; however, to the west-northwest it is protected by Cape Chignecto which limits wave fetch to 32 km.

The semi-diurnal tides in Advocate Bay have a mean range of 9.1 m and a spring tidal range of 12.6 m. Offshore tidal currents are strong. In the Minas Passage area south of Advocate Bay, current velocities of 5 $m \cdot s^{-1}$ have been recorded. The strong tidal currents have produced large water gyres in Advocate Bay (Kolberg and Duncan, 1979). On an incoming tide an anti-cyclonic gyre is generated and on the ebb tide a cyclonic gyre is initiated just northeast of Cape D'Or (Fig. 43). Using wave hindcast techniques Kolberg and Duncan (1979) estimated that in severe southwesterly gales, waves in the order of 3.7 m to 4.6 m high can reach Advocate Harbour Beach resulting in wave overwash at high water.

Detailed beach morphology

Foreshore zone. The foreshore of Advocate Harbour Beach is a homogeneous unit with few morphological changes alongshore (Table 15). Advocate, by virtue of its sediment composition, a gravel, pebble/cobble matrix, has a steep foreshore gradient. The slope which ranges from 5.6° to 7.7°, increases as beach width decreases in an east to west direction along the study area (Fig. 44). Sediment at the lower foreshore, also increases in mean clast size westward.

Backshore zone. Above high tide limit, shingle storm ridges extend upslope to the beach crest. Storm ridges are found along the entire length of the beach, although they vary in number and size (Table 15). The steepest storm ridges are

Table 15. Morphological characteristics of Advocate Harbour Beach, Cumberland County. July 28, 29, 1981

Profile number	Beach		Foreshore zone			Backshore zone			
						storm ridges			
	width[1] (m)	height[2] (m)	width (m)	height (m)	slope (o)	number	slope (°)[3]		
							upper	middle	lower
1	89	6.5	69.5	6.8	5.6	1	6.2	—	—
2	75	7.2	60.8	6.9	6.4	2	8.7	—	8.2
3	72	7.3	52.5	6.2	6.7	2	8.4	—	8.7
4	49	7.9	60.8	7.7	7.2	2	13.1	—	10.8
5	43	8.7	60.8	7.9	7.4	2	19.8	—	14.0
6	52	8.8	62.6	8.5	7.7	3	11.8	17.0	17.0

[1] MHTL to edge of marshland (1-3), and to seaward edge of road (4-6).
[2] Mean sea level to highest point on beach.
[3] Base to crest of seaward slope of each storm ridge.

in the vicinity of profiles 5 and 6. Since vegetation only grows at the top or back of the beach crest, the storm ridges are assumed to be mobile. Driftwood is scattered across all of the upper beach slope but is concentrated at the beach crest (Fig. 45).

The backslope increases in gradient and height from profiles 1 to 6. West of the dyke, the backslope was bulldozed by the local residents in order to increase beach height and prevent overwash (Fig. 48). Where the beach is lower, the backslope is characterized by overwash fans and channels (Fig. 46).

Farther inland of the beach there are two distinct geomorphological units separated by the Advocate dyke. To the east of the dyke is an extensive tidal flat which is covered by a well developed dendritic drainage system. Lewis (1979) concluded from an analysis of the drainage system that the present harbour entrance has always been the drainage outlet. The only marsh is at the southwest corner between the dyke and the beach. To the west of the dyke, there is marsh and pastureland.

Beach sediment characteristics

The Advocate Harbour Beach foreshore slope is composed of poorly sorted granule to pebble size clasts (Table 16). The samples collected were either bimodal or polymodal and the larger clasts were composed of basalt or granite (Fig. 47). At the base of the foreshore slope the mean size of sediment increased in an east to west direction

Table 16. Sedimentological characteristics of Advocate Harbour Beach, Cumberland County, July 28, 29, 1981.

Profile number	Mean grain size (∅)		Sorting (∅)		Skewness	
	LTL	HTL	LTL	HTL	LTL	HTL
1	−2.13	−2.78	1.11	1.73	−0.05	−0.14
2	−1.68	—	2.03	—	−0.25	—
3	−2.54	−4.29	1.36	0.54	−0.43	−0.03
4	−1.33	—	1.33	—	−0.08	—
5	−3.23	−3.72	1.80	0.53	−0.26	−0.09
6	−3.25	—	1.93	—	—	—

alongshore. Across the beach the sediment at high tide was slightly coarser and better sorted (except at profile 1) than sediment on the lower beach face. This trend of increasing sediment size upslope contrasts with the one observed by Wightman (1976) who studied the fabric and grain size of both the modern and raised beach ridges of Advocate Harbour. The difference arises because of the less detailed sampling scheme used in the present study.

Across the backshore zone the largest clasts are at the beach crest where cobbles overlie a granule-pebble base. Sediment size decreases downslope from the beach crest, and the smallest clasts are found in recently formed swash ridges. Visual observations suggest that the mean size of the sediment increases toward the west, as it did on the foreshore zone.

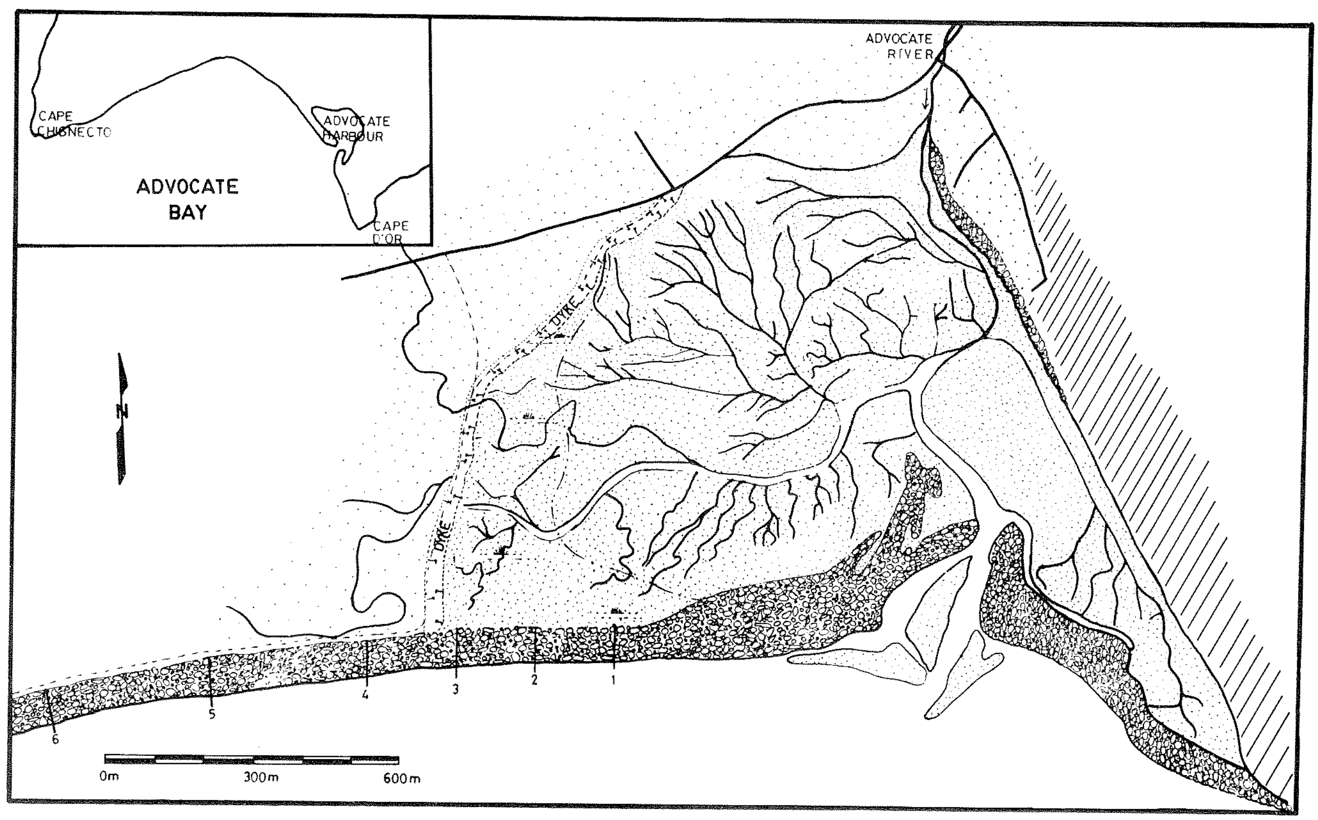

Figure 42. Morphological map of Advocate Harbour Beach, Cumberland County, based on 1975 airphotos 75041-11,19, (MRMS Amherst, N.S.). See Table 1 for key to symbols.

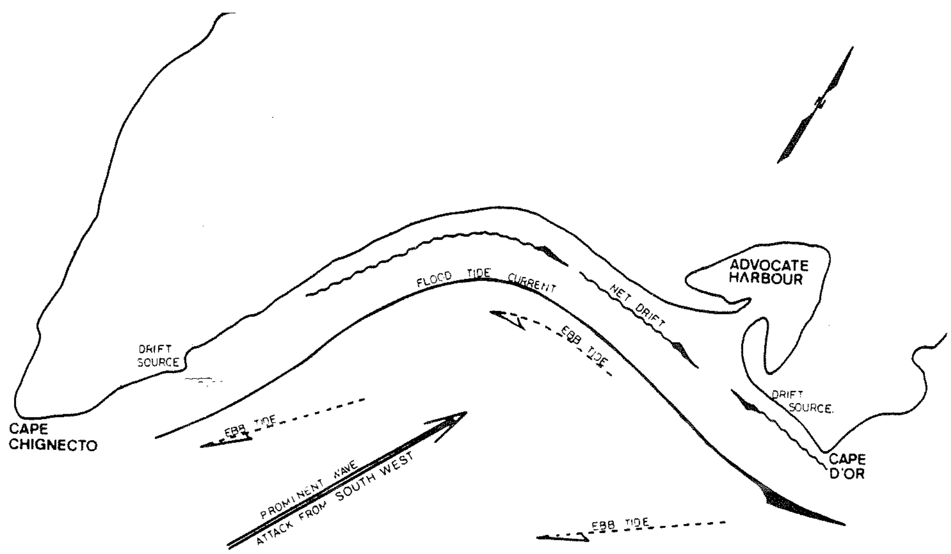

Figure 43. Strong tidal currents exist offshore of Advocate Harbour. They flow in a cyclonic direction on the ebb tide and anti-cyclonic direction on the flood tide (Kolberg and Duncan 1979).

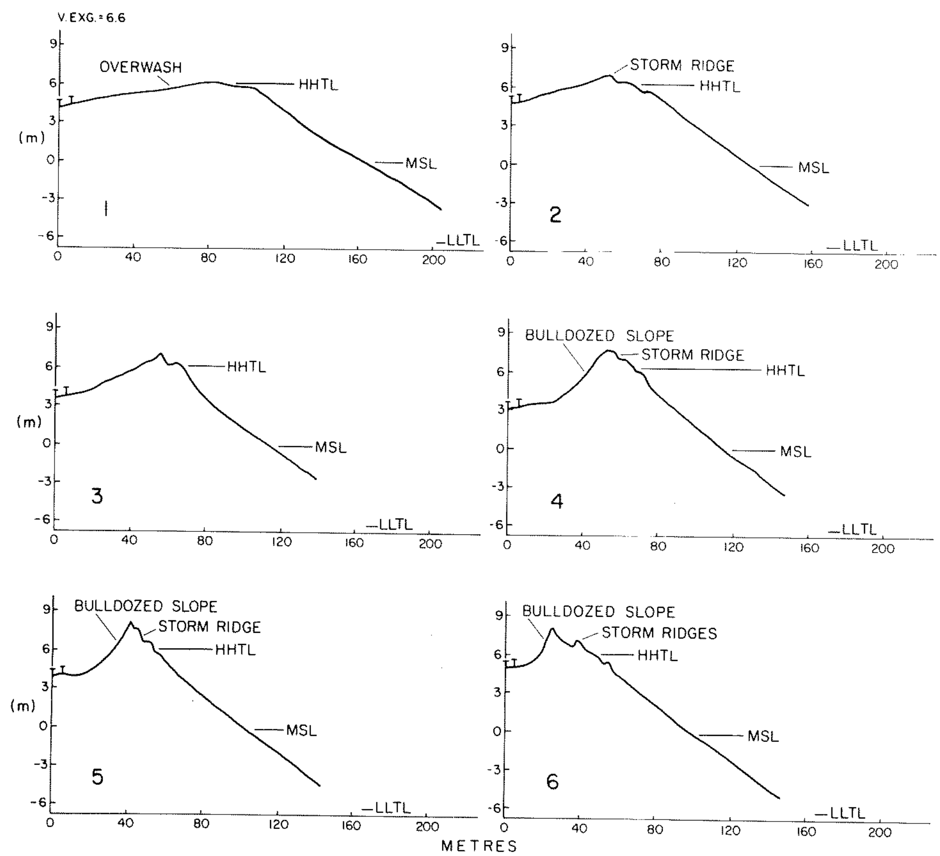

Figure 44. Six beach profiles surveyed along Advocate Harbour Beach on July 28, 29, 1981 show the changes in beach morphology alongshore. Beach slope increases from profile 1 to 6 located on Figure 42.

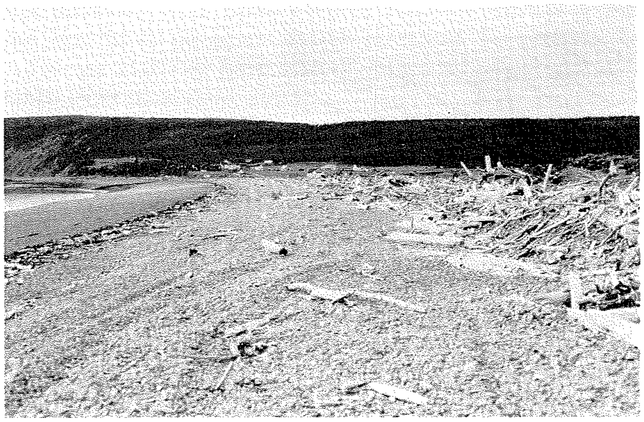

Figure 45. Driftwood is scattered across all of the upper beach slope but is concentrated at the beach crest of Advocate Harbour Beach. (GSC 190837)

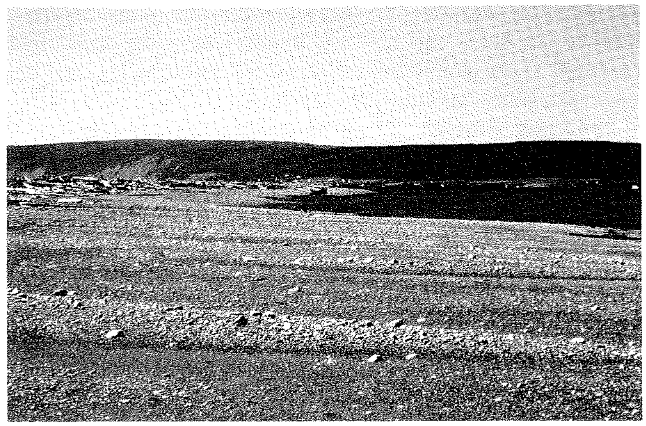

Figure 46. At the east end of Advocate Harbour Beach where the beach is lower, there are extensive washover features. (GSC 190831)

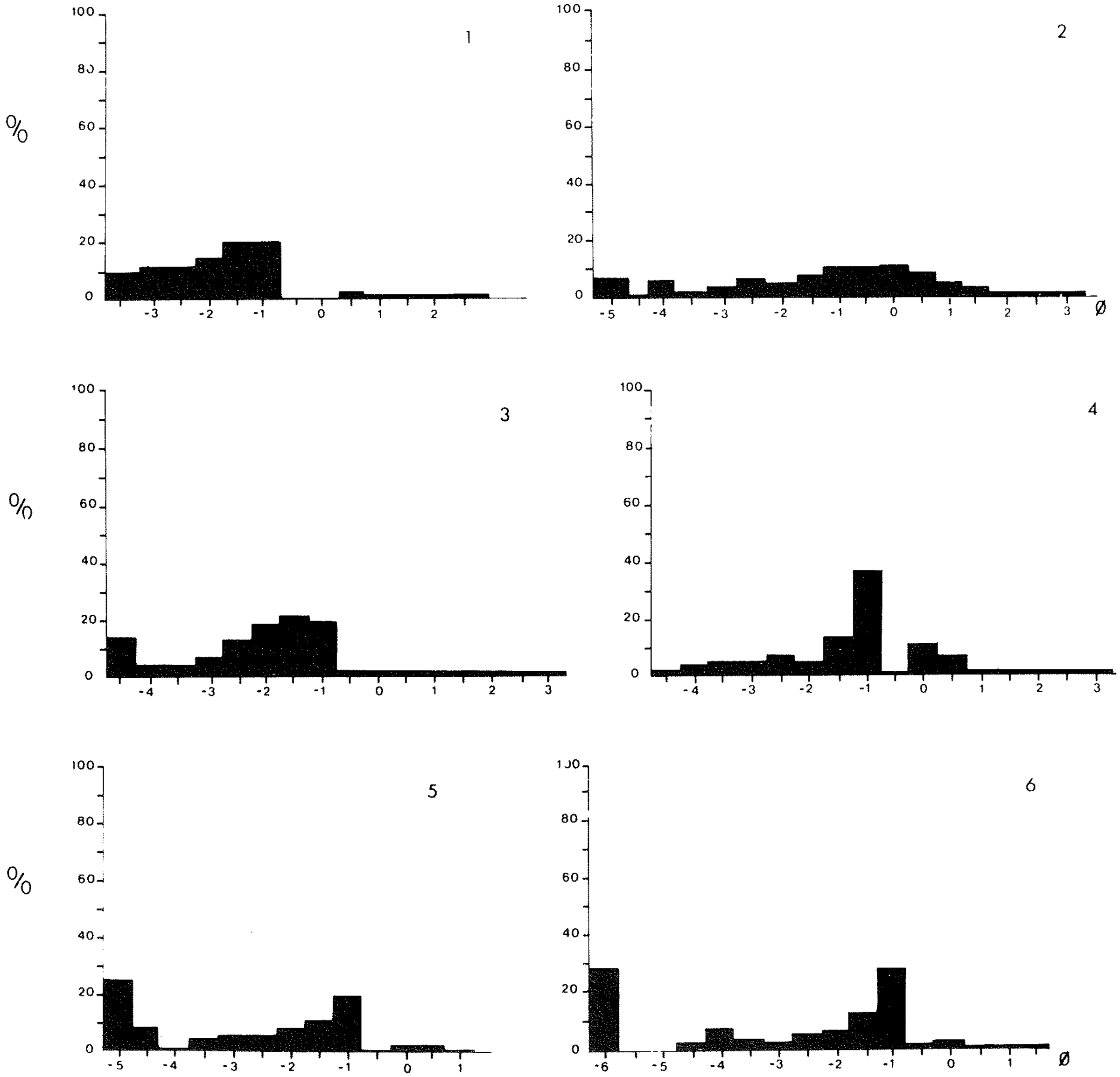

Figure 47. Histograms of the sediment sampled from the lower foreshore slope at each of the beach profiles. The bimodal distribution of some samples is attributed to the primary source of the sediment which is stratified sand and gravel glacial outwash deposits. The larger clasts are primarily basalt and granite.

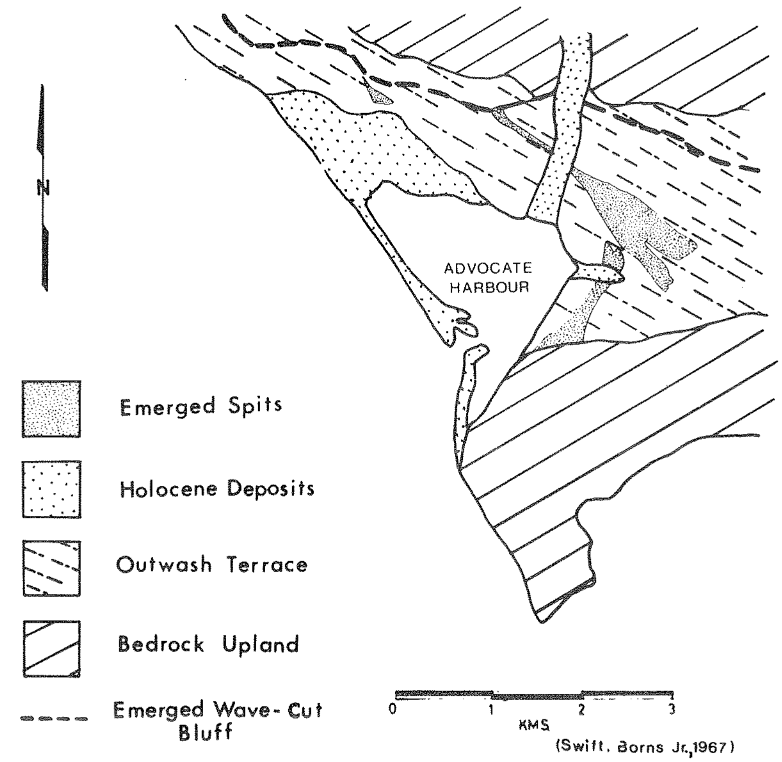

Figure 48. During the late Pleistocene, ridges resembling the present day spits were formed on the outwash terrace north of the present day Advocate Harbour (after Swift and Borns, 1967).

The nature and composition of the sediment samples collected along Advocate Harbour Beach suggest that they are primarily derived from local glacial outwash deposits exposed alongshore and offshore.

Beach development and evolution

The similarity in morphology between emerged and modern coastal features at Advocate Harbour led Swift and Borns (1967) to conclude that the factors governing wave attack and longshore drift have not changed since the late Pleistocene. However, sediment structures observed in the raised features suggest that they were formed under a much reduced tidal range. Wightman (1976) estimated a maximum paleotidal range of 3.4 m.

Swift and Borns (1967) presented a sequence of events that led to the deposition of the glacial outwash terrace that occurs along the north shore of the Minas Basin. The graded outwash plain that extends into the Minas Basin consists of an upper glaciofluvial unit and a lower glaciomarine unit separated by an erosional surface. As the ice dissipated in the Minas Basin it was followed by rising sea levels. In the valleys along the north shore of the Minas Basin the ice was replaced by prograding deltas which became dissected as they emerged. Subaerial alluvial fans subsequently prograded across the rising deltaic plain and buried the dissected surface. Then, as the supply of outwash debris decreased, the terrace continued to emerge and rivers entrenched themselves forming the present drainage system. After emergence became negligible, sea level continued to rise to its present level resulting in a gradual landward retreat of the modern shoreline.

The description of the upper glaciofluvial unit and the lower glaciomarine unit are important to consider when trying to determine the present source of beach sediment. Swift and Borns (1967) described the lower glaciomarine member as consisting of beds of openwork gravels rich in sedimentary clasts. In contrast, the upper unit was rich in metamorphic and igneous clasts and contained more of a mixture of sand and gravel. The latter unit was deposited when the ice margin was on the Cobequid Hills whereas the lower deposits were laid down when the ice margin rested on the sedimentary lowland. The present beach sediment more closely resembles the upper glaciofluvial unit known as the Saints Rest Member (Swift and Borns, 1967).

The retreat of Advocate Harbour Beach over the last 60 years is best illustrated by changes to 'Spruce Island'. Local residents describe 'Spruce Island' as a 50 acre grove of trees that was located east of the dyke along Advocate Harbour Beach (Fig. 42). It was a favourite picnic site in the early 1900s. By 1945 only part of 'Spruce Island' was visible on the airphotos and today only three tree stumps remain nearly buried by wave overwash material. Local residents estimate that the beach near 'Spruce Island' has retreated 100 m over the last 50 to 60 years. Beach ridges at the entrance to Advocate Harbour have also experienced minor changes since 1939 (Cameron, 1965).

During storm and extreme high tide stages, Advocate Harbour Beach is subject to wave overwash and percolation which is of concern to the local residents who are afraid that the lowlands behind the beach will flood one day. During the Groundhog Day storm of February 2, 1976, the marshland was flooded and the beach threatened to breach in several places. Following the storm a program was initiated with the Department of Agriculture to bulldoze the backslope of the beach west of the dyke. By adding sediment to the top of the beach, the crest elevation was artificially raised above the limit of natural deposition. By increasing the height of the beach, the width of the main storm ridge was decreased thus increasing water percolation through the beach during storms. Residents also built an access road to the beach along the edge of the marsh and they dumped armour rock at the base of the beach slope as another protective measure.

There are no known artificial factors, e.g. beach mining, that would have upset the equilibrium of Advocate Harbour Beach in the past, therefore it is assumed that the beach is retreating as part of a natural process not easily combatted by engineering projects. The only consolation to local residents is that as the beach retreats, more sediment may be made available for beach maintenance and development.

BEACH CHANGES AND COASTAL BLUFF RECESSION

Introduction

As part of the 1981 study, a network of shore stations was surveyed at selected shore bluffs and beaches along the coasts of mainland Nova Scotia. The objective was to establish bench marks along representative coastal segments so that accurate measurements of coastal morphological change could be measured in the future. Some of the survey stations were selected from sites previously established by other researchers, some were selected on the basis of files kept by the Nova Scotia Department of Environment on rapidly eroding shoreline and others were established at new sites. Where shore bluff recession stations or beach profiles had been established prior to 1981, a discussion of changes since the last survey is provided in this section. The first part of the section provides a brief physical description of each beach resurveyed and the morphological changes observed. The second part discusses factors affecting shore bluff recession, rates of erosion previously measured in the province, and then discusses rates of recession observed, primarily between 1980 and 1981, at eight shore bluff sites along the Atlantic coast.

Beach surveys

In 1981, surveys were completed at ten beaches where bench marks had been previously established (Fig. 49). The purpose was to determine the type and amount of change that had taken place at each of the beaches since the original surveys. At seven of the ten sites, the bench marks had been established by H.D. Munroe (1980) who had set up a series of 139 single profile stations along the Atlantic and Gulf of Maine coasts of Nova Scotia during the summer of 1978. The two beaches surveyed in Guysborough County were first monitored by E.H. Owens (1973). He had examined changes over a three-year period at two Chedabucto Bay beaches that had been contaminated by Bunker-C oil after the grounding of the oil tanker *Arrow* in 1970. The other beach resurveyed in 1981 was Crescent Beach, Lunenburg County, where morphological changes had been monitored over a five-month period during the winter of 1980 by S. Wittmann (1982).

A quantitative analysis of beach change was only possible at sites where old bench marks were found and sufficient information was available to accurately superimpose subsequent profiles. Where bench marks could not be found then only a qualitative analysis of change is attempted and the profiles are not superimposed on each other.

Beach access, profile location maps and the 1981 field survey data are available in Geological Survey of Canada Open File 976.

In all beach surveys, the Emery pole method (Emery, 1963) was utilized with the exception of Crescent Beach, Lunenburg County. There, standard levelling procedures, incorporating transit and stadia rod, were used because the fragile state of the dune system would not tolerate excessive trampling.

Where old profile markers could not be located, new markers (iron T-bars) or permanent structures (fence posts, telephone and power poles) were used to re-establish bench marks in the approximate location of the previous profile. Silva compass bearings running normal to the shore accompany resurveys where temporary bench marks (TBM) were not established. All surveys were conducted at low tide.

Hadleyville, Guysborough County

The beach at Hadleyville is on the northern coast of Chedabucto Bay. The coastline of the area is part of a submerged, undulating lowland area with glacial deposits exposed along the shore as cliffs. The glacial till overlies unresistant Horton Group (Mississippian) red sandstones and shales (Owens, 1971). Beach sediment ranges from sand in the intertidal zone to cobbles in the storm ridges. The backshore zone contains small pockets of swamp and a large lagoon situated at the western end of the beach. Aggregate is currently being removed from the beach east of the lagoon. Sediment transport is alongshore from the west at Murdoch Head to Oyster Point, east of the beach.

Bench marks used by Owens (1973) could not be located, consequently new stakes were placed at the western and eastern ends of the beach system and were designated BIO #1 and BIO #4, respectively (Fig. 50). The steep sloping beach is characterized by a high cobble crest. Effects of aggregate mining are evident at profile 4 (1981) where the backslope has been greatly steepened by sediment removal. A

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By County

Annapolis County
See: Fox (1979), Owens (1977a), Welsted (1974), Wilson (1981).

Colchester County
See: Amos and Long (1980); Atlantic Air Survey (1976); Gosselin (1972); Loucks *et al.* (1982).

Cumberland County
See: Cameron (1965); Gosselin (1972); Kolberg and Duncan (1979); Laub (1968); Lewis (1979); Owens (1974b); Owens and Bowen (1977); Owens and Harper (1972); Stea (1983); Swift and Borns (1967); Wightman (1976, 1980).

Digby and Yarmouth Counties
See: Bowen *et al.* (1975); Grant (1971, 1976, 1980a,b); Munroe (1980, 1982); Owens and Bowen (1977); Welsted (1974, 1979).