

CRUISE REPORT 2004-302

Coastal Investigations of the Bras d'Or Lakes, Nova Scotia (Sensitivity to a Rising Sea Level)

R.B. Taylor and D. Frobel
Geological Survey of Canada (Atlantic)



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Front Cover: View looking north along Gillis Beach, Jamestown, on Bras d'Or Lake. The photo illustrates the sediment character at the survey line across of one of the larger barrier beaches. Although the tidal range within the Bras d'Or Lakes is only 5 to 20 cm, bands of kelp and swash ridges illustrate that waves can extend more than 1 m upslope above water level. In the distance you can see higher rock (white gypsum) shores where a railway line extends east alongshore towards Iona (Photo taken 27 October 2004).

Abstract

Sixteen shore sites were examined in the Bras d'Or Lakes to document their physical characteristics. Four beaches and one cliff site were surveyed and cliff top measurements were completed at two shore cliffs at the mouth of the Great Bras d'Or Channel. Barrier beaches varied from 10 to 75 m in width and their crest was built to less than 1 m above high tide level. Between 2002 and 2004 there was net beach progradation of 3 m at two barrier beaches (sites 1547, 1548) in Bras d'Or Lake. Both beaches have an abundance of sediment for building swash ridges which accounted for the progradation observed near high tide level. For other more sediment-starved barrier beaches, often in more wave-sheltered areas, much smaller swash ridges of granule migrate upslope over a coarse lag surface which is thought to restrict the amount of beach change.

Only one sample of poorly consolidated peat was found during the coring of the backbarrier beach ridges at four locations. The general absence of peat provides further confirmation that these coastal features are less than 1000 yrs in age. Further surveying and coring of the backbarrier lagoons and submerged barriers will require work to be completed by small boat in summer or from the ice cover in winter. Water depths are too deep to allow sampling by wading.

Cliff top recession was negligible over three years at Malagawatch Point despite some movement downslope of material. Cliff top retreat along the outer entrance of Great Bras d'Or Channel during the past 25 years was 0.4 to 1.25m /a. The abundance of eroding sand and gravel shore cliffs in that area provides a potential source of sediment for building the marine flood-delta feature observed between the narrow channel entrance and Seal Island bridge.

Field surveys confirmed the states (stages of evolution) of the larger barrier beaches interpreted from earlier aerial video surveys. The field surveys also provided more detailed information about the location and extent of a lag sediment surface. The lag surface extended across the lower intertidal zone in more wave-sheltered areas and more sediment-starved beaches, whereas it was only observed across the subtidal zone on beaches with more abundant sediment in more wave-exposed areas.

General Information

Responsible Agency:	Geological Survey of Canada, Atlantic,
Program:	Geoscience for Ocean Management, Project X29
Area of Operations:	Bras d'Or Lakes, Nova Scotia
Dates:	Phase 1 April 23, 2004 Phase 2 October 26-29, 2004

Objectives:

- 1) To resurvey shoreline sites and establish new ones along representative shores for monitoring rates and types of change.
- 2) To map the stratigraphy of the back barrier beach deposits and determine the age of the features.
- 3) To assess the potential source of sediment for building the flood-delta feature observed during marine surveys (Shaw et al., 2003) along the inner entrance of Great Bras d'Or Channel.
- 4) To ground truth shoreline mapping completed using 1996 aerial video.

Personnel:

R.B. Taylor	Coastal Geoscientist
D. Frobelt	Coastal Technician

Transportation: Government Vehicle -2000 Ford Pickup

Funding Agencies: Climate Change Directorate
Geological Survey of Canada

Summary of Operations

Surveys were completed during two phases of field work, phase 1 was during two days in April 2004 and phase two was completed during October 2004.

Phase 1 **April, 2004**

Day 112 (April 21, 2004): Taylor departed BIO at 11:30 for Cape Breton Island and arrived in Baddeck at 19:30 AST.

Day 113 (April 22, 2004). Taylor attended the Simbol (Science for Integrated Management of Bras D'Or Lakes) workshop and presented an update of coastal research in the lakes. He walked to Kidd Point, Baddeck to look for Canadian Hydrographic Service (CHS) benchmark 443 established 1946. It was not found. A local resident had rebuilt the shoreline when his house was constructed and he had not seen a monument. He remarked that this shore is impacted by sea ice ridging in winter.

Day 114 (April 23, 2004). We departed Baddeck and traveled east to Long Hill Road around the east side of Beinn Bhreagh. Taylor walked through the woods to the shore, first to Poker Dans Pond and then to McKillop Pond. He attempted to reach Starks Pond by following the road to Plaister Mines but there was too much snow. An attempt was made to reach the cliff site at Beinn Bhreagh, the Bell Homestead, but Jack Macdonald, the caretaker, advised the ground was too soft and snow covered for a visit at that time. He had never observed any CHS markers on the property.

Phase 2 **October, 2004**

Day 300 (October 26, 2004) Weather: Sunny, broken cloud cover, moderate north winds
Authors drove from Dartmouth to Baddeck for the evening.

Day 301 (October 27, 2004) Weather: Overcast with scattered showers, cool.
We departed Baddeck at 08:15 and returned by 17:55. We drove first to Derby Point to look for CHS markers and possibly to establish a cliff monitoring site. The barrier beaches at Site 1550 Grass Cove and Site 1547 Gillis Beach were surveyed and a reconnaissance coring of the backbarrier was completed in search of potential peat deposits to determine the age of these shoreline features.

Day 302 (October 28, 2004) Weather: Strong north winds gusting to 70 km; rain showers.
We departed Baddeck at 08:30 for New Campbellton to check out the shore deposits as potential sources for sediment observed in Great Bras d'Or Channel. We also ground truthed the coastal mapping based on aerial video. Ten stops were made at sites along the outer coast of Great Bras d'Or Channel and two along the shores of Big Harbour. Cliff measurements were completed at Black Rock Light (site 1553) at the east entrance and residence 1438 "Carey Place" (Site 1554) at the west entrance to Great Bras d'Or Channel.

Day 303 (October 29, 2004) Weather: Heavy frost, broken cloud, scattered showers, strong north winds.
We departed Baddeck at 08:30 and drove toward Big Harbour Island. Stop 1 and 2 were along the dirt road which fringed the south shore of North Basin just east of Orangedale. Cross-shore lines were surveyed at sites 1549 Malagawatch Point cliff and 1548 Johnson Cove Beach on Big Harbour Island. Reconnaissance coring was completed in the backbarrier to look for peat deposits. At Cape George the backbarrier deposits and a submerged barrier beach just north of the cape were investigated. We departed for Dartmouth at 16:45 and arrived at 20:00 ADT.

Methodology

During the first phase of field work reconnaissance shore surveys were conducted by only one person. Beach slope and width were measured with a Brunton Compass and tape measure. Geographic positioning was obtained using a Garmin GPS 45 personal navigator. In phase 2 of the surveys, both authors were involved. Geographic positioning of sites and samples was obtained using a Magellan NAVPRO 1000 handheld GPS. Beach surveys were completed using a Geodimeter 140H Total station with a Geodat 124 data logger and prism. The cliff survey at Malagawatch Point was completed using range poles, tape measure and hand level. A Hiller corer with one metre extensions was used to probe the dune and pond stratigraphy at the barrier beaches. A trowel was used to sample the surface beach material.

Acknowledgements

Thanks are extended to John Shaw, Geological Survey of Canada, Atlantic for his time in reviewing an earlier manuscript and constructive comments on how to improve it.

Beach Sites

Poker Dans Pond

A continuous, low barrier beach 400-500 m long fronts Poker Dans Pond (Fig.1- #8, Fig. 2). It is bounded by 4 to 8 m high shore cliffs at both ends (Fig. 2b) and anchored in the middle by two islands outlined by 2.5 to 3.0 m high shore cliffs. The islands are composed of conglomerate rock overlain by glacial till whereas the cliffs at both ends of Poker Dans Pond consist of more gypsum and conglomerate outcrop draped by glacial material. Blocks of gypsum had broken off, and mud (<5 cm thick) from the glacial deposits was flowing downslope over the 5.5 m wide beach. Reconnaissance measurements and observations were completed across two transects of the barrier beach. Line 1 was located approximately half way along the barrier west of the islands and Line 2 was to the east of the islands (Fig. 2a, c; Appendix 2).

At line 1 the barrier is only 15 m wide and 1.5 to 1.7 m above the waterline (Appendix 2). The backshore consists of a granule and fine pebble substrate covered by sparse dune vegetation. There are small washover fans along the lagoon shore and wood debris scattered along the back marsh. At the time of the visit there was evidence of ice melt pits and a swash ridge built against grounded ice.

Two to three small swash ridges had developed along the mid to upper beachface. The beach sediment varied from a subangular pebble-cobble lag surface across the subtidal and lower beach face to a better sorted, finer, pebble and granule material within the swash ridges across the upper beach (Fig. 2c). Isolated boulders were scattered across the subtidal zone.

Table 1 Textural analysis of sediment samples collected from the shores of the Bras d'Or Lakes in 2004.

Field Sample Number	Geographic Location	Feature	Textural Analysis				% composition		
			Mean (φ)	Mean (mm)	SD (φ)	SK (φ)	gravel	sand	mud
04002	Poker Dans Pond	swash ridge	-1.69	3.22	0.71	0.18	85.3	14.7	tr
04003	McKillop Pond	swash ridge	-3.74	13.36	1.13	1.32	97.0	3.0	–
10001	Gillis Beach	upper beach	-2.05	4.14	2.25	0.53	70.7	29.3	0.1
10002	Gillis Beach	swash ridge	-2.07	4.19	0.60	0.22	96.6	3.4	--
10005	North Basin	swash ridge	-3.80	13.93	0.79	0.77	99.9	0.1	--
10006	North Basin	lower beach	-5.08	33.83	0.17	23.96	99.9	0.1	--
10007	Johnson Cove	upper beach	-2.00	4.00	1.79	-0.15	77.8	23.2	tr
10008	Johnson Cove	swash ridge	-1.35	2.54	0.75	-0.29	67.3	32.7	--

*abbreviated sample numbers –actual number is 200404002.... 200410008 (year/month/sample#)

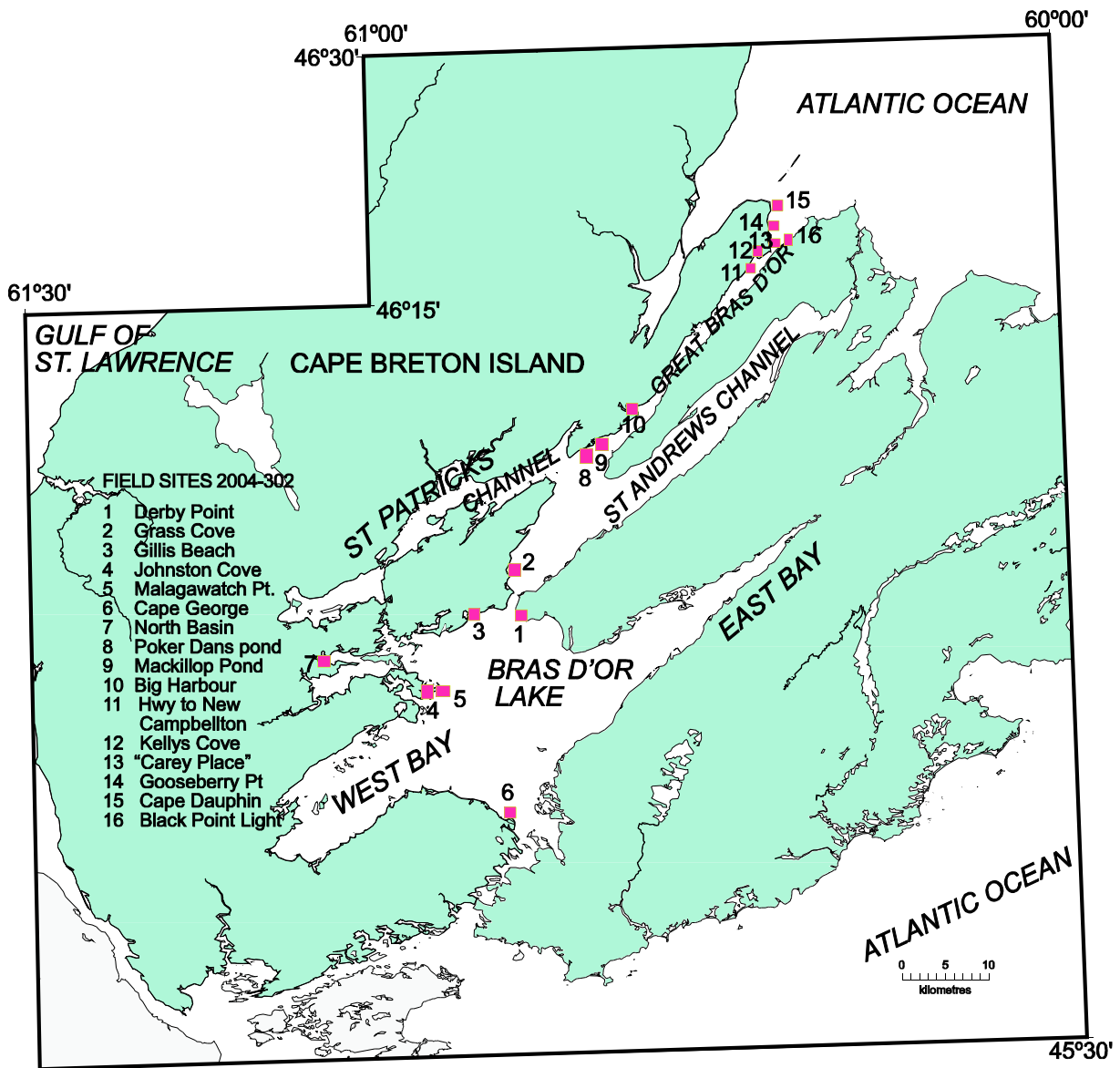


Figure 1. Location map of shore sites visited in 2004 along the Bras d'Or Lakes and place names used in the text.

Sediment sample 04002 was collected from a swash ridge (Table 1, Appendix 1, 2). The mean sediment size was -1.69ϕ (3.2 mm) which is granule. The sample was moderately sorted (Table 1).

The eastern mid-barrier at line 2 is narrower and lower than the western one. It is 9-11 m wide and just over 1 m high. The backshore is subject to wave overwash and devoid of vegetation whereas farther east and west alongshore the backshore is covered by dune grasses. The sediment becomes coarser toward the ends and the cliffed shores. Along the mid-barrier there is a washover channel and lobe which extends several metres into the pond (Fig. 2c). The washover channel has been closed off by a series of swash ridges. A short barrier beach backed by wetland /marsh vegetation exists east of Line 2 within the eastern headland (Fig. 2a).

The extent of wave overwash features and deposits suggest that higher energy waves are striking the mid to eastern ends of both barriers. The direction of waves overwashing the beach is from the southwest (Barra Strait area), the direction of longest fetch.

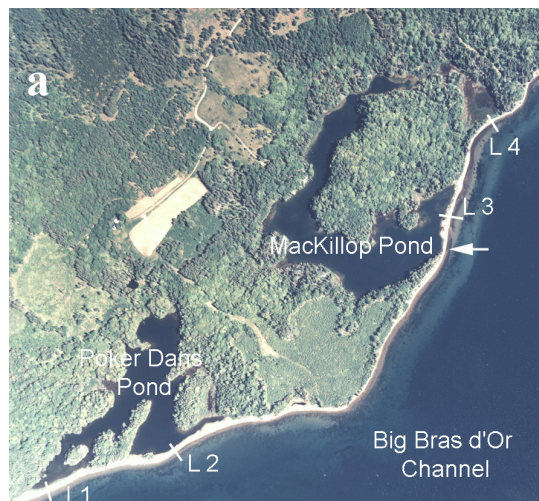


Figure 2. (a) Air photograph of shores along Poker Dans and MacKillop Ponds (AP99307-200, 1:10,000) showing the location of beach lines where observations were made and the location of the inlet (arrow). (b) View of shore cliff at west end of Poker Dans Pond Beach showing muds flowing over the beach and exposures of gypsum (white rock) (c) view to west along Poker Dans Beach at line 2 where a washover lobe extends into the pond. The channel was closed off by swash ridges in 2004 (photos taken April 23, 2004).



Other evidence, such as a submerged tree stump at base of the beach near low tide level and water seepage through the barrier, confirm it's in a state of early degradation (stage 4) as described by Taylor and Shaw (2002).

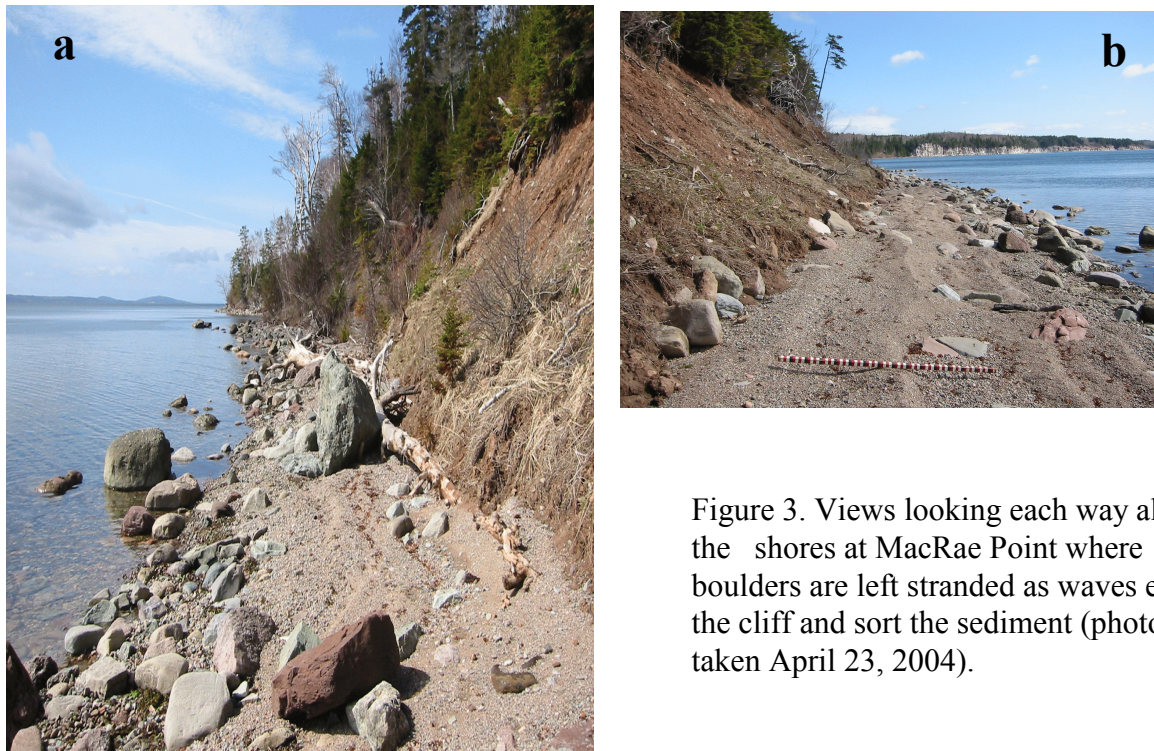


Figure 3. Views looking each way along the shores at MacRae Point where boulders are left stranded as waves erode the cliff and sort the sediment (photos taken April 23, 2004).

MacRae Point

MacRae Point is typical of much of the higher shores along this area. The headland separates the barrier beaches at Poker Dans and MacKillops Ponds. The shoreline consists of a fringing beach less than 5 m wide and consists of a boulder lag developed by waves winnowing away the fines from the backshore cliff (Fig. 3).

MacKillops Pond

MacKillops Pond consists of two barriers split in the middle by an island with a fringing beach (Fig. 1- #9, Fig. 2a). Along the fringing beach, a gravel ridge is migrating landward over the backshore dune grass.

The western barrier is the longer and higher of the two beaches. The western barrier beach is an estimated 15 m wide and 1.6 to 2.0 m high above water level with some small conifers growing on the backshore. A sediment sample (04003, Table 1) was collected from a swash ridge on the mid to upper beach. The sediment was a poorly sorted pebble gravel with a mean size of -3.74ϕ (13.36 mm) which is coarser than the sediment sampled at Poker Dans Beach. This barrier appears to be more impacted by waves from the northeast (Bras d'Or Channel). There is a shallow outlet ~ 10 m wide, cut through the western end of the barrier (Fig. 2a arrow, Fig. 4a) and evidence of an older dredged channel roughly 8 m wide and ~ 1 m deep just to the east of the

present one. A line of boulders extends offshore on the west side of the present outlet.

The eastern barrier beach is approx 15.5 m wide, with a crest elevation of 1.6 to 1.7 m. Old washover fans exist along the pond shore. Trees and rose bushes cover the crest and backshore. The upper foreshore slope consists of fine pebbles, granules and sand; the lower foreshore was covered by a coarse lag material. The eastern barrier is more stable than the western one and is presently in stage 3 (established) development. The western barrier is in a state of degradation mainly because of human intervention and the artificial openings cut through the barrier beach. The higher shore east of MacKillops Pond consists of bedrock (gypsum) overlain by glacial deposits.



Figure 4. Views of MacKillop Pond Beach (a) at the west end where the beach (L3, Fig. 2a) is coarser and a channel has been dredged through it and (b) the east end where more sand covers the upper beach slope and a pebble-cobble lag surface covers the lower intertidal and subtidal zones (L4, Fig. 2a.) (photos April 23, 2004).

Site 1550 Grass Cove Beach (Fig. 1- #2)

Line markers were established on this beach in October 2002; however, the first survey was not completed until October 27, 2004 (Fig. 5). The line markers at the dune crest and landward dune slope were surveyed into NS monument 215331 located beside the highway at the headland to the north. The cross-shore survey was extended seaward from the backbarrier pond to just offshore. Strong northerly winds and waves prevented surveying farther offshore.

The beach is northeast facing with a maximum potential wave fetch of 48 km toward St Andrews Channel and 17 km toward Great Bras d'Or Channel. The barrier beach is interpreted to be in an established stage of development (Taylor and Shaw, 2002) with multiple beach and dune ridges. It has a cross-shore gradation in vegetation from trees to dune grass and it is attached to the adjacent shores with no permanent inlet. A highway extends along its backshore (Fig. 5).

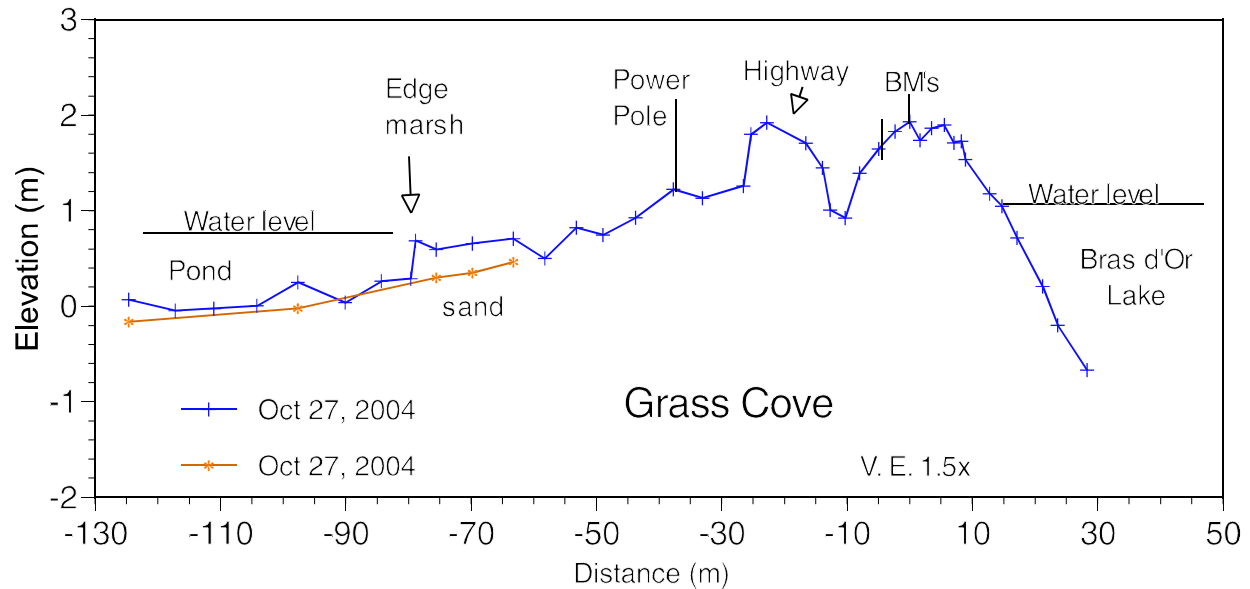


Figure 5. Cross-shore survey of Line 1 Grass Cove Beach showing the modern dune ridge backed by the highway and marsh which overlies a firm sand deposit in the backbarrier pond.

The backbarrier pond consisted of a very low gradient slope covered by less than 0.2 m of gyttja over firm sand with scattered pebbles. Closer to the edge of the marsh the vegetated mat and mud increases to 35 cm over sand (Fig. 5). No peat was observed in the cores. The marsh was fringed by an erosional cut on its pond side. The upper marsh consisted of cattails which progressed upslope into alders and trees closer to the highway. Young fir trees are growing in the swale along the seaward side of the highway. The remainder of the backshore is covered by a thin cover of dune grass. The sand in the backshore pond is interpreted to be part of a submerged portion of the barrier beach complex (Fig. 5). The south end of the pond has often been linked to the lakes by a channel artificially cut across the barrier beach.

The barrier beach which is 75 m wide (Table 2) consists of a single, wide ridge which slopes down toward the highway where a well defined swale exists. An older driftwood line extends alongshore at the back line marker where the largest cobbles also exist. The best defined recent driftline corresponds with the seaward edge of the dune grass. No sediment samples were collected. The sediment consists of granule to pebble clasts in the swash ridges and a moderately well sorted pebble cobble on the upper beach ridge and beach crest. The beach face is steep sloping ($\tan \theta = 0.14$), as are most of the other barriers surveyed (Table 2).

Although the tidal range is only 4 cm at Iona and 4.5 cm within the inner lake (Petrie and Bugden, 2002) the range in fluctuations caused by atmospheric pressure can be much greater, e.g., 0.6 m (Shaw et al., 2003). Hence, the reason for the greater vertical spread of swash ridges on most beaches. In October 2002 the pebble swash ridge at high tide was truncated (Fig. 6b) and the outlet at the south end of the beach was closed off by a swash ridge. A pebble cobble lag

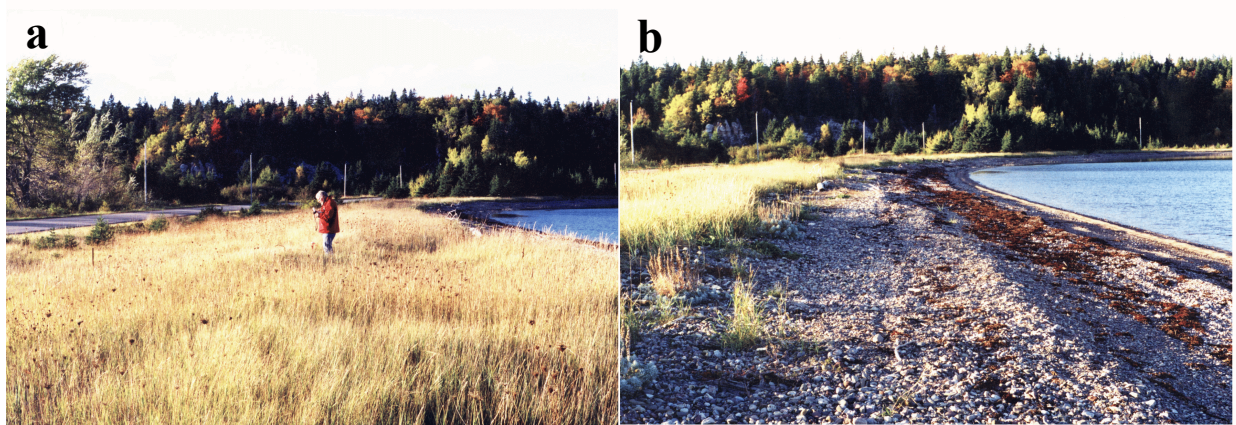


Figure 6 Grass Cove barrier beach (a) backshore dune and highway and (b) upper beach looking north showing the sediment texture (photos taken Oct.15, 2002).

covers the lower beach slope and subtidal zone which steeply slopes to more than 1.3 m water depth, where the seabed is covered by sand.

Site 1547-Gillis Beach:(Fig.1- #3)

The beach is southeasterly facing with a maximum potential wave fetch of 20-22 km across Bras d'Or Lake. Directly east of the beach the fetch is less than 11 km. The barrier extends 700 m alongshore enclosing Gillis Pond. It is primarily a swash aligned barrier consisting of multiple beach ridges which are 160 m wide at the north end and a smaller 6 m wide drift -aligned ridge along its southern end. The northern portion of the beach where the survey line crosses is 44 m wide between the water level of the lake and the lagoon (Table 2). Three surveys have been completed at the site but the line markers were lost after the first survey in 2000. A new line was established in the same location. The barrier beach is interpreted as stage 4, a breakdown phase of development (Taylor and Shaw, 2002).

In October 2002 the lagoon was open to the Bras d'Or Lakes at the south end of the road where a 3 m wide channel had been reopened, presumably to reduce flooding around the lagoon. At the far south end of the beach, where an opening through the barrier existed in 2000, the beach in 2002 was wider and the former breach was temporarily closed off by a swash ridge. In 2004 the artificial channel to the lagoon remained closed but water flowed through the south end of the barrier. A new residence was under construction, less than 0.5 m above sea level on the back of the barrier adjacent to the old inlet (Fig. 7a). An access road to the residence exists along the backshore from the north.

The 2004 survey was only completed seaward of the line markers because of the apparent lack of change across the backshore. The survey was extended offshore to a low rise (sandbar) covered by rippled sand. Since October 2002 the intertidal zone prograded by 3 m and the elevation of the barrier crest has increased slightly, e.g., 0.07 m (Fig. 8).

The barrier beach consists of multiple ridges which rise in elevation seaward and are covered by sparse dune grass. The coarsest sediment was observed at the most seaward ridge (Fig. 7b). The upper beach face is a mixture of sand to pebble and the high tide ridge consisted of more sand and kelp. Sediment samples (Table 1) and photos were collected at the upper beach (sample 10001) and a high tide swash line (sample 10002). The high tide ridge consisted of much better sorted pebble clasts than the upper beach face which consisted of mostly sand. Sediment in the high tide ridge was moderately well sorted which was similar to other actively built swash ridges sampled around the lakes (Table 1).

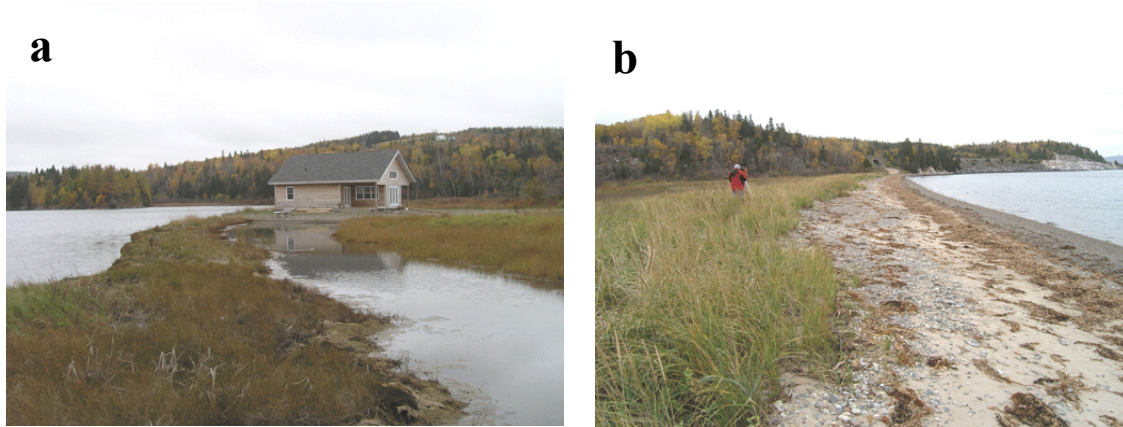


Figure 7. Views at Gillis Beach (Fig. 1- #3) (a) of the backshore ridges where a cottage was being constructed in 2004 and (b) the beach slope and dune crest at line 1, looking north alongshore. A greater abundance of sediment and the absence of an intertidal lag surface provides a sharp contrast with the conditions at Poker Dans or MacKillop Beaches shown in figures 2 and 4 (photos taken in October 2004).

A reconnaissance of backbarrier stratigraphy along our survey line was completed using a Hiller hand corer. Cores across the swales met coarse substrate and the occasional mud hole and the ridges had a thin marsh vegetation cover with buried rotted tree stumps. Generally most samples produced a very wet plant growth and no consolidated peat. The best sample of consolidated peat was in the most seaward submerged swale. It existed between two beach ridges lined by trees (Fig. 9a).

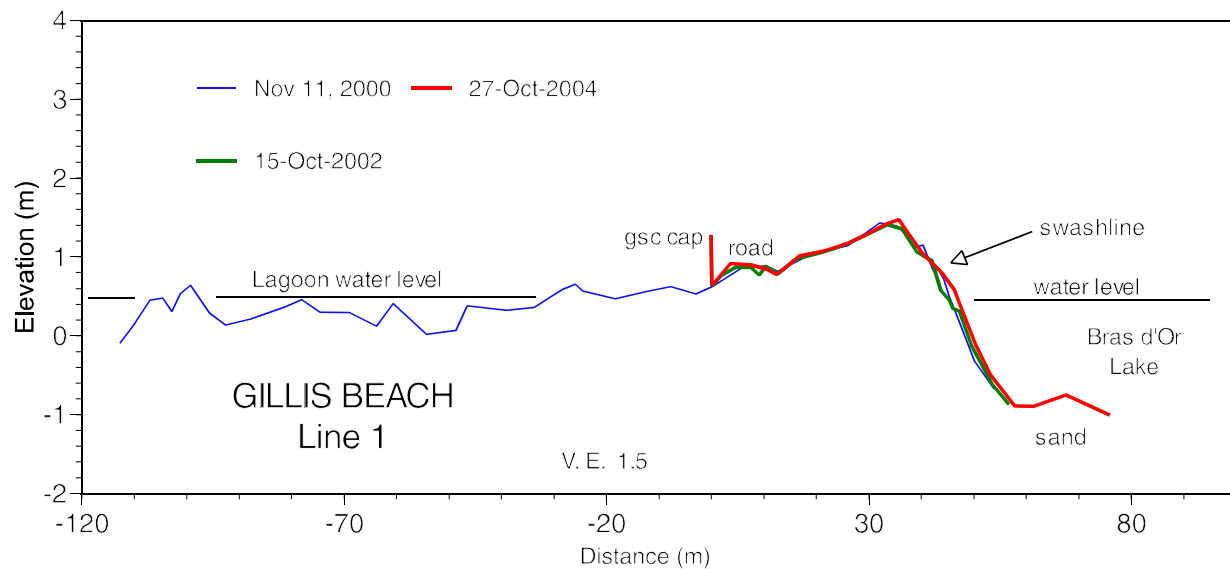


Figure 8. Cross section of Line 1 Gillis Beach showing the small changes in morphology from 2000 to 2004 and the number of backshore ridges which have been submerged by rising lagoon levels.

Table 2. Physical Characteristics of beaches surveyed in the Bras d'Or Lakes during 2004.

Geographic Name	Site No.	Evolution Stage ¹	Beach Width ² (m)	Crest Elev. above HTL (m)	Beach Slope ³ (Tanθ)
<u>Barrier Beaches</u>					
Gillis Beach	1547	4	48	0.69	0.152
Johnson Cove	1548	3	44	0.75	0.172
Grass Cove	1550	3	75	0.75	0.140
Poker Dans	----	early 4	10 to 16	----	----
McKillop	----	3 to 4	15	----	----
<u>Fringing Beaches</u>					
North Basin	----	----	3 to 4	0.56	0.140

¹ Stages of barrier beach evolution, based on Taylor and Shaw (2002).

² Width between lake and lagoon shores at an elevation of 0.6 m.

³ Slope of beach below water level.

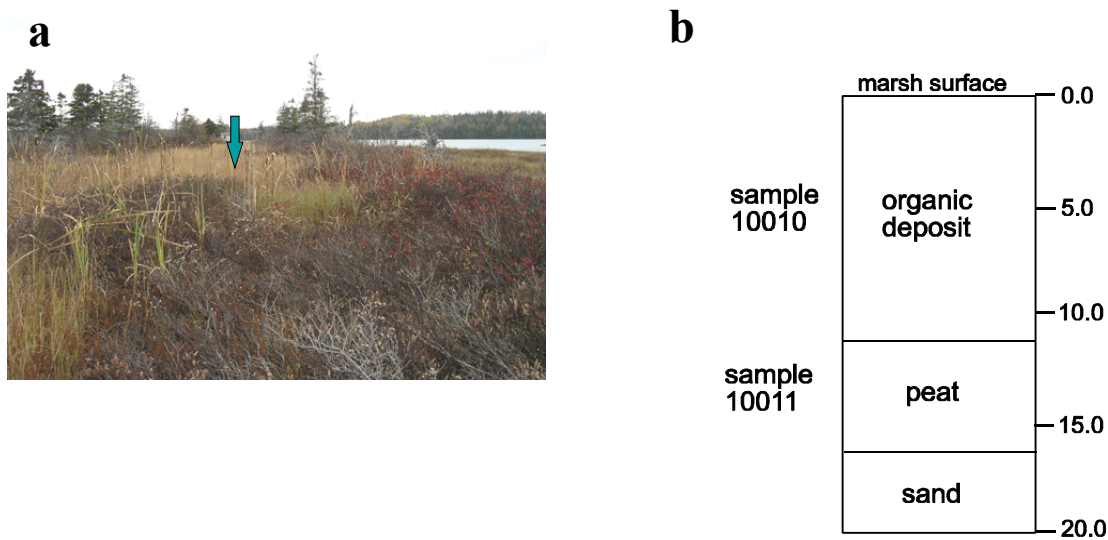


Figure 9. Backbarrier at Gillis Beach showing (a) coring location (arrow) in a swale between two beach ridges (trees) where a thin peat horizon was sampled, and (b) sketch of core stratigraphy.

Beneath the surface marsh vegetation which extended to a depth of roughly 0.11 m there was a more consolidated peaty deposit which was 5 cm thick. Below 16 cm depth sand extended 0.2 m the limit of the coring (Fig. 9b). Samples 10010 (0-11 cm depth) and 10011 (11-16 cm depth) were retrieved from the corer.

On October 27 there were strong northerly winds and the small waves striking the coast cutting a small scarp in the granular material.

Site 1548 Johnson Cove Beach: (Fig. 1- #4)

The southeast facing barrier beach has a maximum potential wave fetch of 31 km toward East Bay but more commonly a 17-23 km fetch toward the south end of Bras d'Or Lake and St Peters Inlet (Fig. 1- #4). The barrier beach which is just over 500 m long and 44 m wide, encloses Johnson Pond (Table 2, Fig. 10). The beach consists of a single, wide dune ridge with trees growing along the backshore. On the air photos there is evidence of additional submerged beach ridges in Johnson Pond but their character could not be confirmed because they were too deep to be reached by wading. It was found using a Hiller corer that the thickness of sand at the GSC cap was at least 1.23 m (limit of corer). The lake bed in Johnson Pond consisted of wet plant material and mud covering sand and scattered pebbles. There was no evidence of peat where we cored on the survey line. To obtain a better pond stratigraphy, coring in the pond beyond the old beach ridges may have to be completed when the pond is frozen.

There did not appear to be any significant change across the backshore dunes since the last survey in October 2001. Water level in the pond was slightly higher in 2004 than 2001. There was evidence of a more recent driftline 2 to 3 m into the dune vegetation which would suggest some storm activity. There has been 3 m of progradation across the intertidal zone by October 2004 mainly in the form of a large granule-pebble swash ridge built on the upper beach (sample 10007) and a series of smaller granule swash ridges at high tide level (sample 10008) (Table 1, Fig. 10a). The sediment is similar in composition (i.e., % sand and gravel) to the sediment sampled on upper Gillis Beach but slightly finer in mean grain size. As at Gillis Beach, the upper beach sediment at Johnson Pond was less well sorted than the more recently developed swash ridge. Across the subtidal zone, a pebble lag covered sand and where the seabed gradient decreased there was sand over pebble, and more weeds were growing up from the seabed.

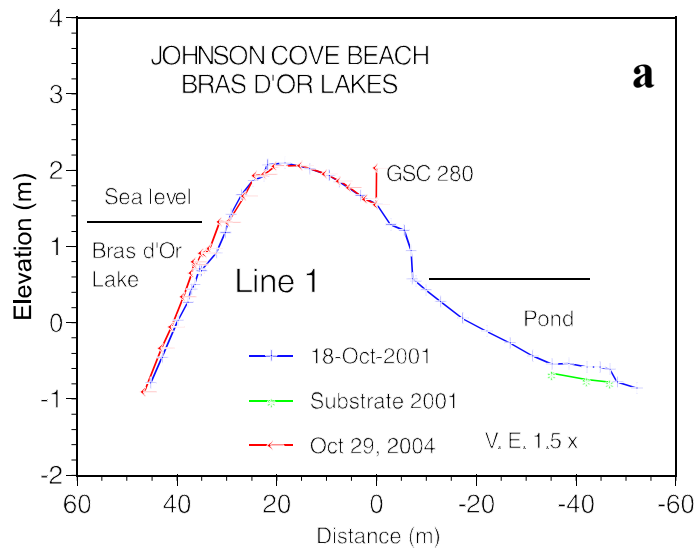


Figure 10. (a) Repetitive cross shore surveys from 2001 to 2004 and (b) photograph of line 1 at Johnson Cove Beach, Big Harbour Island, Bras D'Or Lakes (Fig. 1) (photos taken October, 29 2001).



North Basin, Denys Basin: (Fig. 1- #7)

The shore was originally mapped from aerial video surveys as vegetated shores or artificial shore with rip rap along the highway. A closer inspection indicated that the shoreline should have been mapped as fringing beach (Fig. 11a). A survey of the beach from the centre of the road and another line across the artificial shore with armour rock were completed to illustrate the elevation and vulnerability of the road to rising sea level. The road was only 0.65 to 0.80 m above present water level (Fig.12). A shore reconnaissance was made farther east along the road to confirm shoreline mapping using the video. Some short sections of low till cliffs were not distinguished in the original mapping. Many very small pockets of marsh were also not shown on the maps.

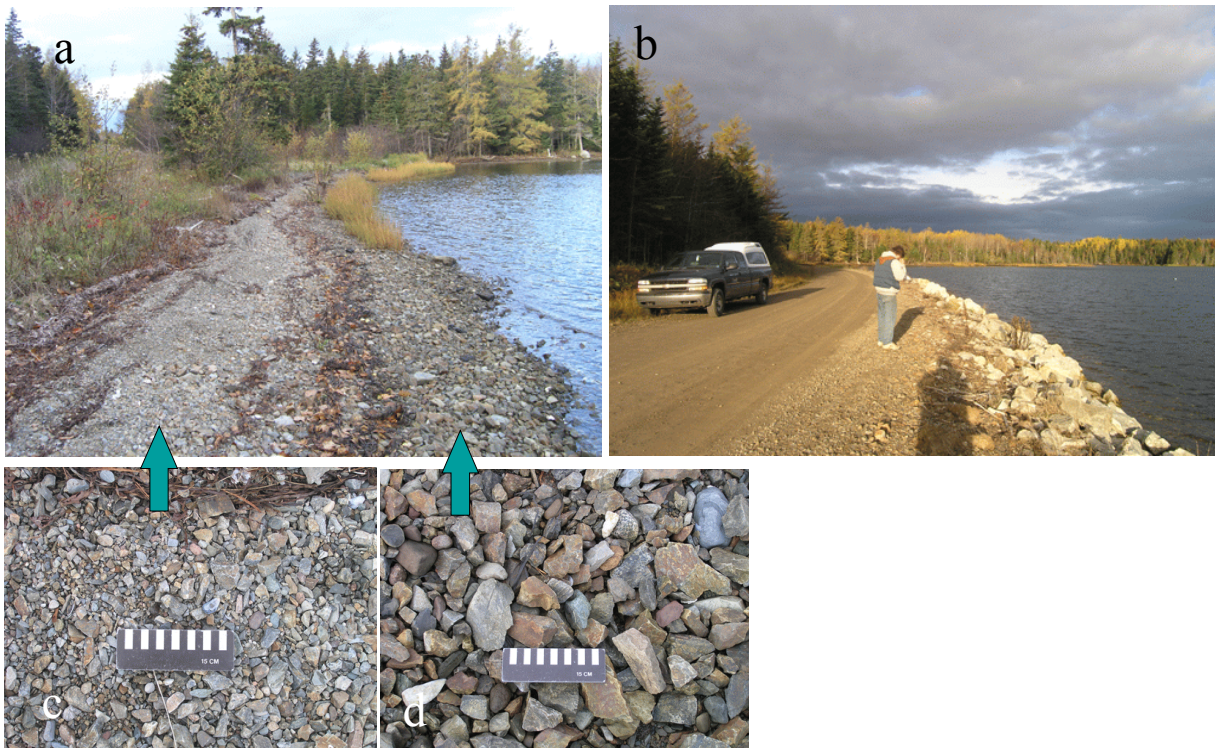


Figure 11. Views of the shoreline along North Basin where a survey was completed across (a) a fringing beach and (b) across a road and armour rock to water level. Sediment texture from (c) the upper swash ridge (sample 10006, Table 1) was much finer than sediment covering (d) the lower slope (sample 10005, Table 1) of (a) the fringing beach. Material sampled from the lower beach consisted of pebbles with a mean clast size of -5.08ϕ . It was very well sorted because only the surface lag material was sampled (photos taken October 29, 2004).

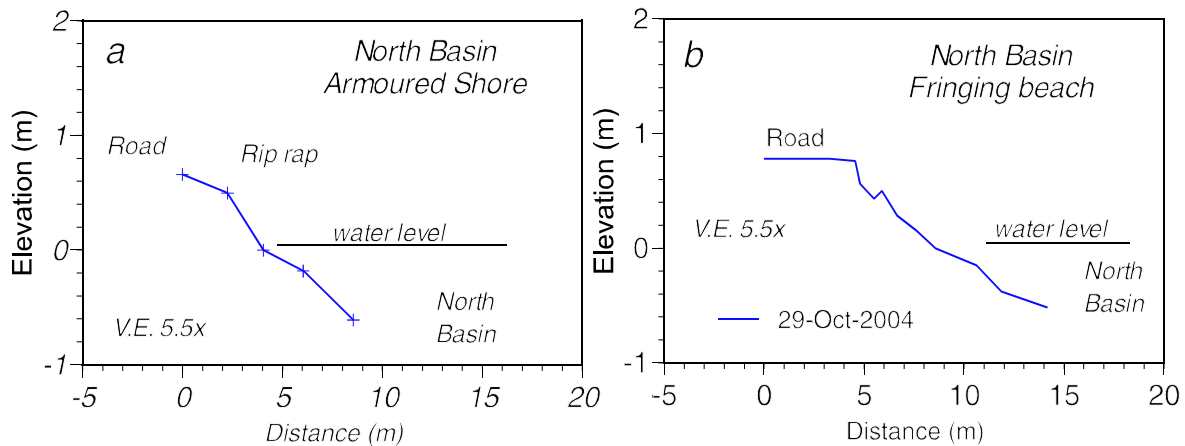


Figure 12. Examples of cross-shore profiles in North Basin across (a) an artificial shore where the road is protected by armour rock and (b) where a fringing beach exists seaward of the same road. Note the top of the road is only 0.65 to 0.8 m above present water level.

Cape George Beach: (Fig. 1- #6)

A 500 m long barrier beach connects to Cape George, a drumlin headland (Fig. 1- #6,13a) . The barrier is in an established stage of evolution (Taylor and Shaw, 2002). It is roughly 75 m wide and it covered by trees and marsh along the backshore. The objective was to look for possible backbarrier peat deposits and then survey the barrier. Only modern marsh growth and sand and gravel were observed. A survey was not completed at the site because of the lack of peat deposits and the strong onshore winds and waves at the time of the visit which limited length of the potential survey. The road and barrier beach had been recently overwashed at its northern end and breached at its southern end where an estimated 1.0 m deep channel was cut through the barrier. On a CHS map listing navigational control markers there was mention that the road was overwashed in 1977. On the 1993 vertical air photo (93309-36) and the 1996 aerial video the barrier beach was continuous with no inlet.

An unnamed submerged barrier beach (Fig. 13b) (stage 5, Taylor and Shaw, 2002) exists just northwest of the Cape George barrier beach. We reached the site by following a property line cut through the trees near the highway. The objective was to survey across the backbarrier lagoon and relict barrier beach. A transect was attempted across the middle section of the site; however the lagoon was too deep to wade completely across and waves were too high to extend the survey very far offshore so it was cancelled. The back lagoon/mainland shore consisted of a pebble-cobble shore lag over sand and mud. There was a soft gyttja on the bottom of the lagoon at least to a water depth of 1.7 m where the transect was halted. The relict barrier had a very steep landward slope extending from 0.2 m depth at the top of the barrier to 1.5 m in the lagoon. The barrier beach surface is covered by lag pebble-cobble clasts (Fig.13b) which cover finer sediment. The backslope of the barrier beach consisted of a firm sand which switched to a softer

mud (gyttja) overlying pebble cobble. It is estimated that the lagoon is less than 2.5 m deep. It will require a boat and sounding equipment to complete a survey transect across the site.

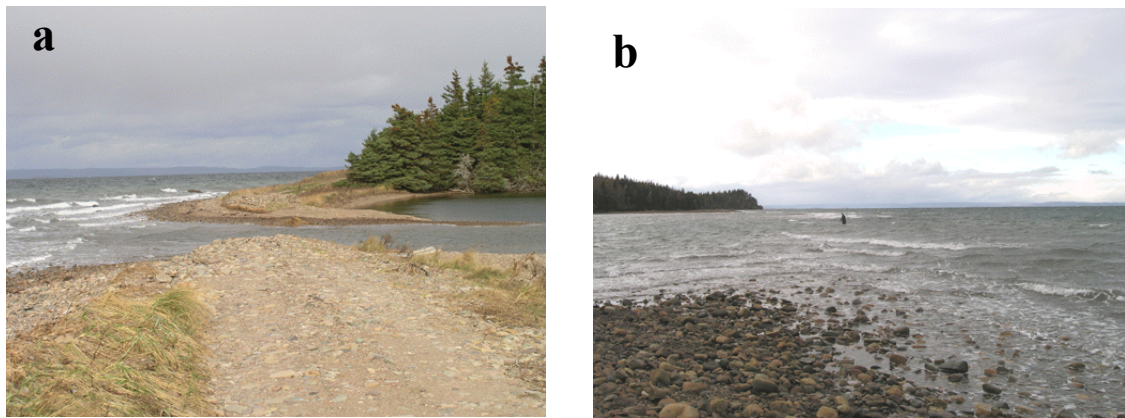


Figure 13. Views of (a) the breach in 2004 at the southeast end of Cape George Beach and (b) the submerged barrier to the north of the barrier beach. A person is walking along the top of the submerged barrier which is backed by water depths nearing 2.5 m. The submerged barrier consists of a pebble cobble lag surface (photos taken October 29, 2004).

Cliff Site 1549-Malagawatch Point: (Fig. 1- #5)

The shore cliff is the erosional edge of a drumlin (Grant, 1988). It is roughly 300 m long, extends to an estimated 8 m elevation and faces to the south-southwest. It is fringed by a narrow 3 to 4 m wide beach (Fig.14).

Two survey lines 12 m apart were established along the central part of the cliff in October 2001. The two lines are marked with GSC caps 7 m landward from the top edge of the cliff. It appeared that some tree clumps and large boulders had slid farther downslope since 2001. However, there was only 0.15 m of cliff top recession. A survey was completed along line 278 across the cliff face to just beyond present water level (Fig. 14c).

The composition of the cliff appears uniform across the whole slope, although the face was not cleared off for a more detailed examination. It is a reddish brown silt and clay with pebble to boulder clasts. The free face of the cliff at line 278 extends to 7.3 m above lake level. It is slightly stepped (Fig.14c) with a more gradual upper slope covered by grass sods or trees and a steeper lower slope incised by rill channels. The base of the cliff consists of a hard till, broken into blocks by wave undercutting. The beach, at high tide level, consists of moderately well sorted granules and pebbles and numerous large boulders lie just offshore (Fig.14).

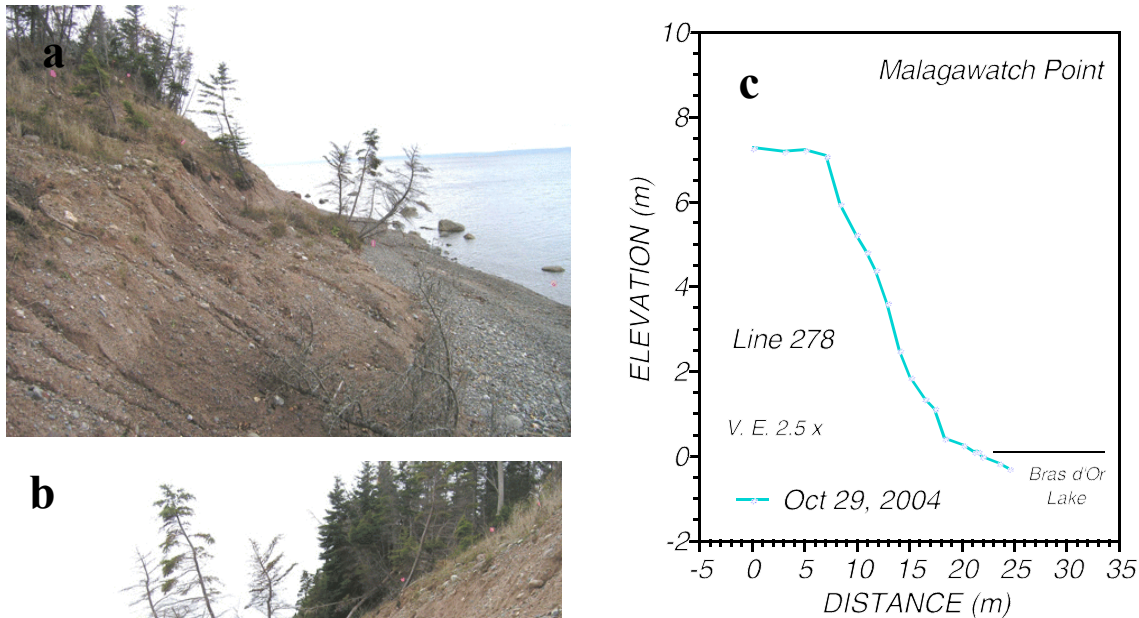


Figure 14. Views looking each way longshore at the Malagawatch Point cliff site (a, b) and (c) a profile of Line 278 which is marked by pink flags on the photos. Waves trim the base of the slope (b) deposits and trees slide downslope during wet conditions (photos taken October 29, 2004).

It is apparent that there is a slow downward movement of slope deposits triggered during wet periods. These deposits harden when dry, are cut by waves and become partially incised by rill wash during surface runoff.

Great Bras d'Or Channel:

During a marine survey of Great Bras d'Or Channel a wedge of sediment 10-15 m thick was observed landward of the narrow entrance to the channel (Shaw et al., 2003). The feature was interpreted as a flood-delta and the source of the material was suggested to be the 'ice-contact stratified drift' mapped by Grant (1994) along the outer coast. The objective of our field work was to examine these shores in more detail and determine the potential volume of sediment supplied from shoreline retreat.

A cliff recession site was established on both sides of the seaward entrance to Great Bras d'Or Channel, one at Black Rock Light, the other at a shore cliff just north of Carey Point (at residence #1438 "Carey Place" Fig. 1). The sites were selected because of their exposure to

waves, their reputation as erosional sites and because of the presence of buildings which could be used as permanent markers.

Cliff Site 1553 Black Rock Point: (Fig. 1- #16)

Four survey lines were established for measuring rates of cliff recession. Two lines were extended seaward from the sides of the lighthouse and two from a metal shed located just west of the lighthouse. The distance from the buildings to the cliff top edge was measured with a tape measure aligned along the sides of both buildings. The distance to the cliff top edge from the lighthouse was 12.9 m and from the shed 7.6 to 8.5 m. The length of the cliff face (top to bottom) was 20.2 m. In the sailing directions for the Bras d'Or Lakes it says the lighthouse is at 16.8 m elevation.

The cliff is composed of 13-14 m of light brown silty pebble cobble glacial material overtop of 4-5 m of grey clayey material over bedrock. The bedrock is sandstone, shale or limestone. The thickness of bedrock exposed along the base of the cliff increases toward the east. The sediment appears to be more coarse than the material in the cliffs on the opposite shore, north of Carey Point. Grant (1989) mapped all of these deposits as ice-contact stratified drift.

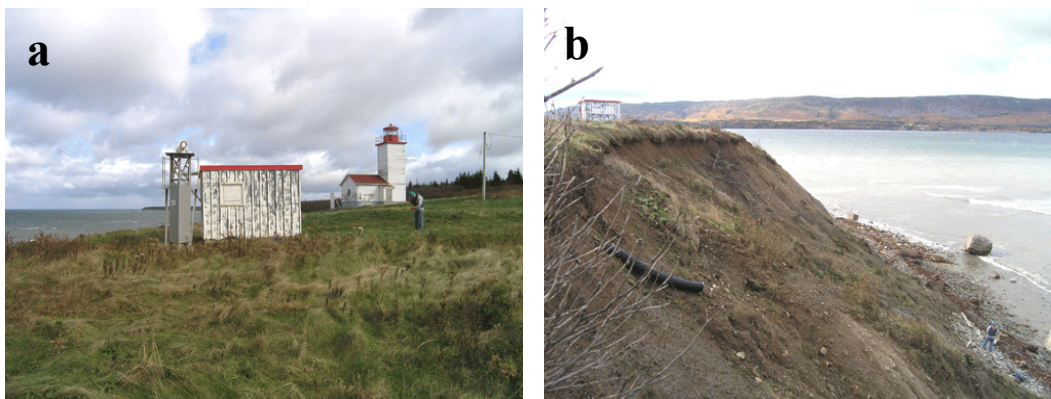


Figure 15. (a) shed and lighthouse which were used as reference markers to measure the distance to the cliff top edge in Oct. 2004 and (b) cliff face looking northwest and one of several large boulders and concrete pads observed at the cliff base.

A lighthouse has existed since 1868 according to the Lighthouse Preservation Society. Therefore an attempt was made to use older air photos from 1975 and 1953 to measure the distance from the lighthouse to the cliff edge. Unfortunately the lighthouse was rebuilt in 1978. A measurement of the distance between the highway and the cliff edge in 1975 and 1999 suggests a loss of 30 m during the 24 years which is a rate of 1.25 m/a. Between 1953 and 1975 the distance to the cliff edge from the lighthouse suggested a loss of only 8 m, a rate of 0.4 m/a. These figures should only be used as a rough guide and should be confirmed using rectified air photos. The loss of trails along the cliff line farther west suggested erosion but the amount could not be measured because of the lack of good control features. No volumes of sediment supplied from this shore were calculated.

Cliff Site 1554 Carey Point: (Fig.1- #13)

“Carey Place” is the name given to the residence at property address # 1438. The residence is situated back of a shore cliff which is estimated to extend 150 m longshore and 6 to 8 m in height. Barrier beaches backed by ponds lie to the north and south of the cliff. Since 1975 the barrier beach to the north has become higher and closed off as indicated by less wave overwash features on the 1999 photography. Measurements from known features on repetitive air photos suggest the seaward beach has migrated 15-30 m landward during the 24 years (1975-1999). Wave overwash deposits were also well developed along the backbarrier beach to the south suggesting landward migration into the marsh.

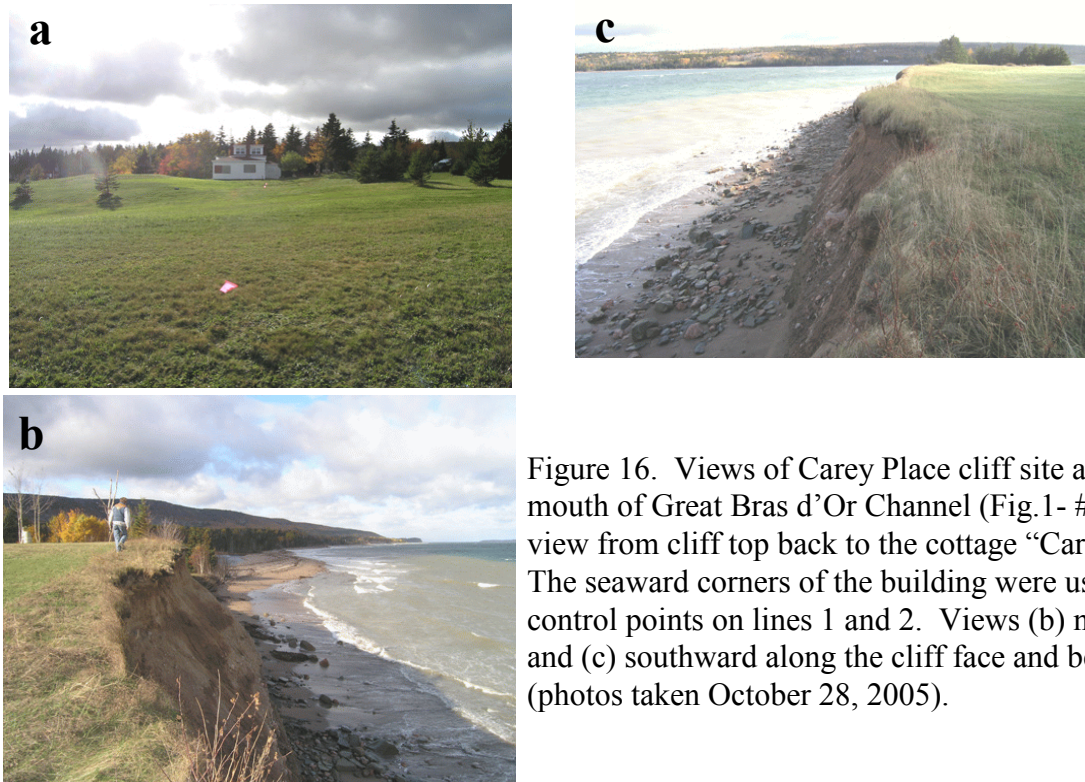


Figure 16. Views of Carey Place cliff site at the mouth of Great Bras d'Or Channel (Fig.1- #13). (a) view from cliff top back to the cottage “Carey Place”. The seaward corners of the building were used as control points on lines 1 and 2. Views (b) northward and (c) southward along the cliff face and beach (photos taken October 28, 2005).

On October 28, 2004 the cliff profile consisted of a erosional step on the upper 1 m which extended ~5 m seaward where the cliff face dropped steeply 4-5 m to a wide bouldery beach. The cliff face was not examined in detail but was composed of a sandy bouldery material. Grant (1998) mapped the cover as till. The storm in September 2004 caused considerable shore erosion along this coast, especially at Carey Place. The caretaker also recalled a major storm about six years ago on December 11-13, 1998 that knocked a lot of trees down in this area.

Measurements of the distance to the cliff edge from the house were made using unrectified air photos taken in 1953, 1975 and 1999. The distance was 88 m in 1953, 78 in 1975 (no addition to residence) and 60 m in 1999. Therefore the loss of cliff top was roughly 10 m every 22 to 24 years. This translates into a rate of recession of 0.40 to 0.45 m/a which is lower than typical rates

of cliff top recession for bluffs on the Atlantic coast of Cape Breton Island (Shaw et al., 1993). It should be noted that renovations were made to the residence before the 1999 photography. The building was extended seaward by 5-8 m which was taken into account in the calculations cliff retreat.

Spot checks of shore cliffs farther north alongshore suggested a similar loss of 8-10 m between 1975 and 1999; however, a small cliff in the pond just north of Carey Place is estimated to have retreated 30 m in the 24 years (1.25 m/a). A local resident suggested that at his property north of Gooseberry Point cliff has lost 80 feet (24.4 m) since 1988 (16 yrs) which is 1.5 m/a. Using vertical airphoto 99301-37 (1999), which covers Carey Point to Gooseberry Point, there is 2300 m of shoreline of which 900 m is cliffed. Roughly 400 m is 6 to 8 m in elevation and 500 m of shore cliff is 15-18 m in elevation. Using an elevation of 7 and 15 m and a retreat of 10 m for the 24 yr period, the total supply of sediment from these shore cliffs is estimated at 103,000 m³ or 4291 m³/a. It is not known how much of this sediment reaches the Great Bras d'Or Channel or is added to the nearby beaches but it is a potentially a large source of sediment.

Derby Point Cliff Site: (Fig.1 -#1)

In 2004 the navigation marker was located beside an old foundation which was assumed to be the old lighthouse at Derby Pt. According to the Canadian Hydrographic Service (CHS) files their monument "Piper" was located 8 cables (1.6 km) east of the Derby Point Lighthouse. We drove 1.2 km past the navigation marker where we found a conspicuous boulder 5.5 m seaward of the present road. A relic foundation, with two very large fir trees growing in the middle, was found approximately 18-20 m seaward of the boulder as marked in the CHS data sheets but no CHS markers were found. In 1972 the distance to the cliff top edge from the boulder was 57.9 m. In 2004 the distance to the cliff top edge from a location just south east of the boulder was 63.8 m (measurement from the boulder directly to the cliff edge was prevented by tree cover in 2004). The results suggest little or no change at the cliff top during the past 32 years. The lower cliff face consisted of a conglomerate shore ramp, a steeper mid slope and cover of glacial material. A visual comparison of the shoreline using vertical air photos (1:10,000 scale) taken in 1975 and 1999 also confirmed no significant change.



Figure 17. The cliffs at Derby Point consist of glacial deposits over a steeply dipping conglomerate rock (line). Little difference in distance to the cliff top from a rock foundation was observed in 1972 and 2004.

Shoreline Observations:



(Caption on next page)

Figure 18. Examples of shore cliff morphology and composition along the outer shores of Great Bras d'Or Channel: (a) cliffs at Cape Dauphin (Fig. 1- #15) are roughly 18 m in elevation and consist of sandy-gravel deposits overlying bedrock at the base. Where the photographer is standing in (a) the cliffs (b) are only 5 m high and consist of a bouldery deposit with angular granite and conglomerate clasts and pockets of mud; (c) at Gooseberry Point (Fig.1- #14) 15-18 m high sandy cliffs; (d) a stony clay deposit overlying a bedrock platform at the base of the cliff which may be part of the Sangamon age wave-cut platform mapped by Grant (1988, 1994) and (e, f) south of Kennys Pond where thick ice- contact stratified deposits (Grant,1988) with thick silt/clay units have been clear cut for development. At roughly 4-6m below the top of the cliff shown in (e) there is a well defined organic unit (closeup f) which may represent a Younger Dryas Deposit (R. Stea, pers. comm., 2004). The samples have been sent out for further analysis. These rapidly eroding cliffs provide a potentially large sediment supply for building the flood delta observed by Shaw et al. (2003) at the inner mouth of Great Bras d'Or Channel.



Figure 19. Shoreline observations along Great Bras d'Or Channel (a, b, c) and Big Harbour (d) illustrating : (a) the wave winnowed boulder shores along the highway leading to New Campbellton at Blue Nose Point (Fig.1 #11); (b) the barrier beach at Kelly Cove consisted of granule to pebble sized clasts and had a steep gradient subtidal sloped steeply offshore. The low elevation of the road makes it vulnerable to rising sea level (Fig. 1 #12); (c) the fringing beach at Big Harbour ferry and (d) the marsh at the head of the northern arm of Big Harbour (Fig.1 -#10).

DISCUSSION

The field program in 2004 was shorter than originally planned which meant fewer representative shore types were visited. In 2004 three barrier beaches, one fringing beach and a cliff site were surveyed, including repetitive surveys at two barrier beaches, Gillis Beach and Johnson Cove. Field surveys in 2004 at the various beach sites confirmed the information gathered from the 1996 aerial video of the Bras d'Or Lakes, with regard to the status of the barrier beaches. All of the barrier beaches examined were in either an established (phase 3) or breakdown (phase 4) stage of evolution (Taylor and Shaw, 2002). Collapsed (phase 5), submerged barriers were not surveyed which prevented a comparison of their physical character to the present barrier beaches. It was anticipated that surveys across the submerged barriers would provide clues about their original size, how they broke down and possibly a better understanding of the "barrier beach-like" features observed on the multibeam images at depths of -23 to -25m (J. Shaw, pers. comm. 2005).

Beaches

Physical Characteristics

As one would expect the physical characteristics of the beaches vary considerably along the Bras d'Or Lakes. Poker Dans and MacKillop barrier beaches at 10-15 m wide, were representative of the smallest of the coastal barriers surveyed whereas Grass Cove was the largest, at 75 m wide (Table 2). The beach face at all sites was steep sloping at 8-9° ($\tan \phi = 0.140$ to 0.172) which is attributed to the short period waves which rework these shores. To compare elevation aspects of the various beaches and understand differences in the magnitude of features built in wave-exposed vs wave-sheltered environments, a common vertical datum is required for the surveys. Only the line markers at Grass Cove were surveyed into official NS monuments which provide elevations relative to geodetic datum. Elevations at the other beach sites were derived from an elevation of 0.50 m assigned to water level at the time of each survey. Given the tidal range is only 0.1 m many might argue this method of comparing beach elevations is sufficient; however, water level fluctuations on the lakes can exceed more than 0.6m during certain climatic conditions (Shaw et al., 2003, Petrie et al., 2002). Therefore better vertical control between survey sites is preferred. Using Grass Cove as an example of a wave exposed barrier beach, its crest was built to an elevation of 1.93 m (geodetic datum) which was 0.75 m above high tide level and 1.2 m above water level at the time of the survey. In contrast at the fringing beach in North Basin (Fig. 1, #7) which is much more sheltered to wave attack, the highest swash ridge was only 0.56 m above water level.

Sediment Characteristics

In 2004 sediment samples (Table 1). were collected from the high tide swash ridge at five beaches to assess the competency of waves in moving sediment. Only eight sediment samples were collected from five beaches. The swash ridges were composed of sediment with a mean size that varied from 2.54 mm to 13.9 mm. Nearly all samples were moderately to moderately -well sorted, according to the Folk (1974) classification. The coarsest sediment was sampled from a swash ridge (Fig. 11c) at the North Basin site. The coarse nature of the material indicates that even in sheltered areas, short period waves can move sediment of this size but it may only be at infrequent intervals.

It is interesting that the coarsest sediment sampled was from a lag deposit covering the lower beach face at the North Basin site. The pebbles were a mean size of 33.8 mm. At Poker Dans and MacKillop Beaches where sediment supply is low a lag deposit also covered the lower beach slope. Small swash ridges built at various elevations across the beach suggested waves are capable of transporting the finer sediment (3.2 to 13.4 mm) across the lag surface which remains intact. The presence of coarse clasts on the upper beach and backshore suggested that coarse material can be moved during larger storms or when sea ice impinges on the beach. It is not known when or under which conditions the lag surface is reworked.

In contrast, at Gillis Beach and Johnston Cove Beach where sediment was more abundant, a lag deposit only covered the base of the beach face in the immediate subtidal zone. At these two beaches the thickness of mobile sediment was greater and the mean size of material was granule at 2.5 to 4.2 mm. Along the upper beach near the barrier crest a more mixed sand and gravel existed which was thought to reflect reworking by processes other than waves, such as winds. The question that arises out of the recent surveys concerns the presence and extent of the location more resistant lag beach surface and its impact on beach stability. Preliminary thoughts would suggest the location and extent of the surface reflects the abundance of sediment and possibly wave exposure.

Magnitude of Beach Changes

Repetitive surveys were only available at Gillis Beach (2000, 2002) and Johnson Cove (2001). No changes in morphology or vegetation were observed across the backshore and there was only minor building of the barrier crest at Gillis Beach. Beach progradation was 3 m at both sites because of swash ridge development near high tide level. At the time of the 2004 survey at Grass Cove, large waves from the northeast were building a similar magnitude swash ridge.

Age of Barrier Beaches

During earlier field surveys a number of barrier beaches were identified containing wetland, marsh and submerged backshore ridges. The intent in 2004 was to core these sites to see if there were any deposits of peat which could provide ages for these coastal features. Four locations were examined: Grass Cove, Gillis Beach, Johnson Cove and Cape George. All sites contained plant material 0.1 to 0.5 m thick but there was little evidence of older consolidated peat. The only poorly consolidated peat (5cm thick) was cored at a depth of 0.1 m in a swale between tree lined beach ridges on the backshore of Gillis Beach (Sample 10011, Fig. 9). It has not been submitted for C14 age analysis. The absence of peat and the rate of sea level rise derived from tide gauge records suggests these coastal features are less than 1000 years in age. It is concluded that to obtain a better chronology of these barrier beaches, sediment coring will be required beneath the backshore ponds. It could be accomplished when the ponds are frozen over in winter.

Shore Cliffs

The intent in 2004 was to measure retreat rates at shore cliffs composed of different material located in different parts of the lakes. The success of measuring cliff retreat using the present position of Canadian Hydrographic Service (CHS) control markers compared to their positions

relative to cliff top edge when they were established during marine surveys in the 1970s prompted the search for more CHS benchmarks. No other markers were found because of forest overgrowth or road and housing construction at the sites. At Derby Point, although many of the same physical features from 1970s were observed in 2004, the actual benchmarks could not be found; however, It was concluded, based on repetitive measurements from known features, that erosion of this conglomerate rock shore cliff has been negligible during the past 33 years.

Within the lakes only the Malagawatch Point shore cliff was resurveyed. Less than 0.1 m/a, of cliff top retreat occurred since 2001. A cross-sectional survey across the cliff face showed a smooth undulating surface (Fig. 14) and no scarps except at the base suggesting a slow movement of material downslope. Shore markers had been established at Cape George, and Big Pond, West Bay (Fig. 1) during a previous field trip but were not measured in 2004. These two sites have a well vegetated slope suggestive of shoreline stability. Future measurements will determine if there is any change in their condition.

In 2004 shore cliff surveys were completed mostly outside the lakes, at the mouth of Great Bras d'Or Channel. The objective was to determine the source of sediment for building the flood-tidal delta observed at the inner entrance to Great Bras d'Or Channel (J. Shaw, pers. comm. 2004). As noted by Grant (1994) earlier, active erosion was occurring in 2004 along the high sand and gravel shore cliffs. Rates of cliff top retreat during the past 30 years was 0.4 to 1.25m based on a comparison of shore cliff positions on repetitive vertical air photos north of the Channel. These rates of retreat are lower than the mean rates of 0.9 to 1.1m and maximum rates of 2.1m reported in the literature (Shaw et al., 1993) for other till based cliffs along the outer coast of Cape Breton Island. The retreat rates at the mouth of Great Bras d'Or Channel were considerably higher than the 0.3m/a (1972 to 2001) observed at Johnson Cove within the Bras d'Or Lakes (Taylor and Shaw, 2002)

Using the 1999 vertical air photo to divide the shores into low and high cliffs, and an average retreat rate of 10 m over the past 24 years, it was estimated that 103,000 cu m³ was eroded or 4291 m³/a,. An unknown portion of this material would be trapped onshore and not available for building the flood delta observed on the inner mouth of Great Bras d'Or Channel. A similar calculation of potential sediment supply was not completed for the cliffs adjacent to Black Rock Lighthouse.

New monitoring sites were established at Carey Point and Black Rock Lighthouse for measuring future rates of cliff top retreat at the mouth of Great Bras d'Or Channel.

Sensitivity To Sea Level Rise

It was observed that many of the secondary roads located along the banks of the Bras d'Or Lakes are very low. The only road surveyed relative to water level was in North Basin. The road surface was only 0.65 to 0.8 m above present water level which makes it vulnerable to future flooding given an estimated rise in sea level of 0.7 m in the next 100 years. People are continuing to build residences along unstable shore cliffs e.g. north of Carey Point, at points of sea ice impacts, e.g. Baddeck, and on very low relict backshore ridges e.g. Gillis Beach. It is

evident that people are not taking the present rate of sea level rise, let alone the much higher rise predicted as a result of from climate change, into consideration when building along the shores of the Bras d'Or Lakes.

References

- Folk, R.L. 1974.** Petrology of Sedimentary Rocks, The University of Texas Geology 370K, 383L, and 383M, Hemphill Publishing Co. Austin Texas; 182pp.
- Grant, D.R. 1988.** Surficial Geology, Cape Breton Island, Nova Scotia; *Geological Survey of Canada Map* 1631A, 1:125,000 scale.
- Grant, D.R. 1994.** Quaternary Geology, Cape Breton Island, Nova Scotia; *Geological Survey of Canada Bulletin* 482, Natural Resources Canada, Ottawa, 159 p.
- Nova Scotia Lighthouse Preservation Society web site:** <http://www.nslps.com/>
- Petrie, and Bugden, G. 2002.** The Physical Oceanography of the Bras d'Or Lakes; In Proceedings of the Nova Scotian Institute of Science, V.42, Part 1, pp. 9-36.
- Shaw, J., Taylor, R.B. and Forbes, D.L. 1993.** Impact of the Holocene transgression on the Atlantic coastline of Nova Scotia, *Géographie physique et Quaternaire*, 47(2), p. 221-238.
- Shaw J., Parrott D.R., Patton E., Atkinson A., Beaver D., Robertson A., and Girouard P., 2003.** Report on Cruise 2003-015 *CCGS Mathew* surveys in the Bras d'Or lakes, Nova Scotia 10-24 May 2003, 46 p.
- Taylor, R. B. and Shaw, J. 2002.** Coastal Character and Coastal Barrier Evolution In the Bras D'Or Lakes, Nova Scotia; in Proceedings of the Nova Scotia . Institute of Science, Vol. 42, Part 1, pp.149-181.

Appendix 1 Sample Inventory Cruise 2004302

Field Sample Number ¹	Station No.	Geographic Location	Site No.	Latitude (°)	Longitude (°)	Elevation ² (m)	Feature	Material
<u>Phase 1</u>								
04002	001	Poker Dans Pond	---	46.104	60.689	0.6	swash ridge	granule
04003	002	McKillop Pond	---	46.109	60.677	0.6	swash ridge	granule, pebble
<u>Phase 2</u>								
10001	003	Gillis Beach	1547	45.941	60.867	1.3	upper beach	sand, pebble
10002	004	Gillis Beach	1547	45.941	60.867	0.6	high tide swash	granule, pebble
10010	005	Gillis Beach	1547	45.933	60.868	0.5	backbarrier	organic 0-11cm
10011	006	Gillis Beach	1547	45.933	60.868	0.4	backbarrier	organic 11-16cm
10003	007	Cape Dauphin,	1857	46.306	60.419	~15	organic bed	peat, branches
10004	008	Cape Dauphin,	1857	46.306	60.419	~15	organic bed	basal peat
10005	009	North Basin	---	45.898	61.080	0.5	beach ridge	pebble-cobble
10006	010	North Basin	---	45.898	61.080	0.1	kelpline, beach	pebble cobble
10007	011	Johnson Cove	1548	45.862	60.916	1.3	beach ridges	sand to cobble
10008	012	Johnson Cove	1548	45.862	60.916	0.8	high tide ridge	granule

¹ abbreviated sample numbers –complete numbers are 200404002.... 200410008...(year/month/sample)

² elevation is above water level at the time of the survey.

Appendix 2

Beach Survey information

Poker Dans Pond

Beach Line 1: Extended tape measure across beach from water line to pond water level. Distance was 15.6 m. Beach in breakdown phase with washover features. Barrier crest is ~1.5 to 1.7 m elev above lake water level.

<u>Distance (m)</u>	<u>Description</u>
15.6	ocean water level (~12:00 UTM)
15.6 to 12.6	coarse cobble frame(intertidal)
12.6 to 8.0	sample 200404002 at 10 m distance, from a swash ridge; fine pebble, sand, granule
8.0	small scarp in crest
6.6	edge of grass (sand, pebble, cobble) backshore
3.8-3.9	small mounds of wave washover gravels thrown over the beach crest
0.8	landward edge of dune grass,
0.0	pond water level, water depth >1.0 m covered by gyttja and tree branches

Sediment sample 200404002 Location: Garmin Z20, 0678565 Easting 5108193 Northing 12:33 UTM WGS84 N 46° 06' 14.245" ; W 60° 41' 22.4427"; photos were taken: # 29 lower intertidal, #30 of swash ridges, and #31 of the backshore.

Beach Line 2: at eastern end of Poker Dans Beach (Fig. 2c). Barrier beach width from lake to lagoon shore was 9.8 m -just over 1 m crest elevation. Location: Garmen 45, Z20: 0678865 Easting, 5108296 Northing 12:45 UTM WGS84 N. 46° 06' 17.29748"; W 60° 41' 08.3406".

<u>Distance (m)</u>	<u>Description</u>
9.9 m	Water level Lake (12:33 UTM)
9.9-6.1	pebble-cobble frame at top of intertidal
0.0	Lagoon water level

Appendix 2 con't.

MacKillop Pond Beach

Line 1: Location: Garmin 45; Z20: 0679465 Easting, 5108839 Northing 13:50 UTM , WGS84 N 46° 06' 34.3098"; W 60° 40' 39.6768" ; **(Fig. 4a)**

Sediment sample 200404003 from swash ridge 4.5 m from lake water level.

Width of barrier was 15.3 m WLO to LLW.

Distance (m)	Description
0.00	water level lake, pebble, cobble lag
0.0-3.3	cobble, kelp at 3.3 m
3.3 to 5.6	sediment sample 200404003 upper beach swash ridge , pebble gravel
5.6 to 10.6	debris lines and sparse vegetation at crest
13.7	new tree growth conifers,
15.3	lagoon water level, lagoon >2m deep

Wave washover deposits along pond shore. A 0.5 m high scarp was eroded along the shore which separates the two parts of MacKillop Pond lagoon.