

Reports

Post-Glacial History of Northumberland Strait Based on Benthic Foraminifera*

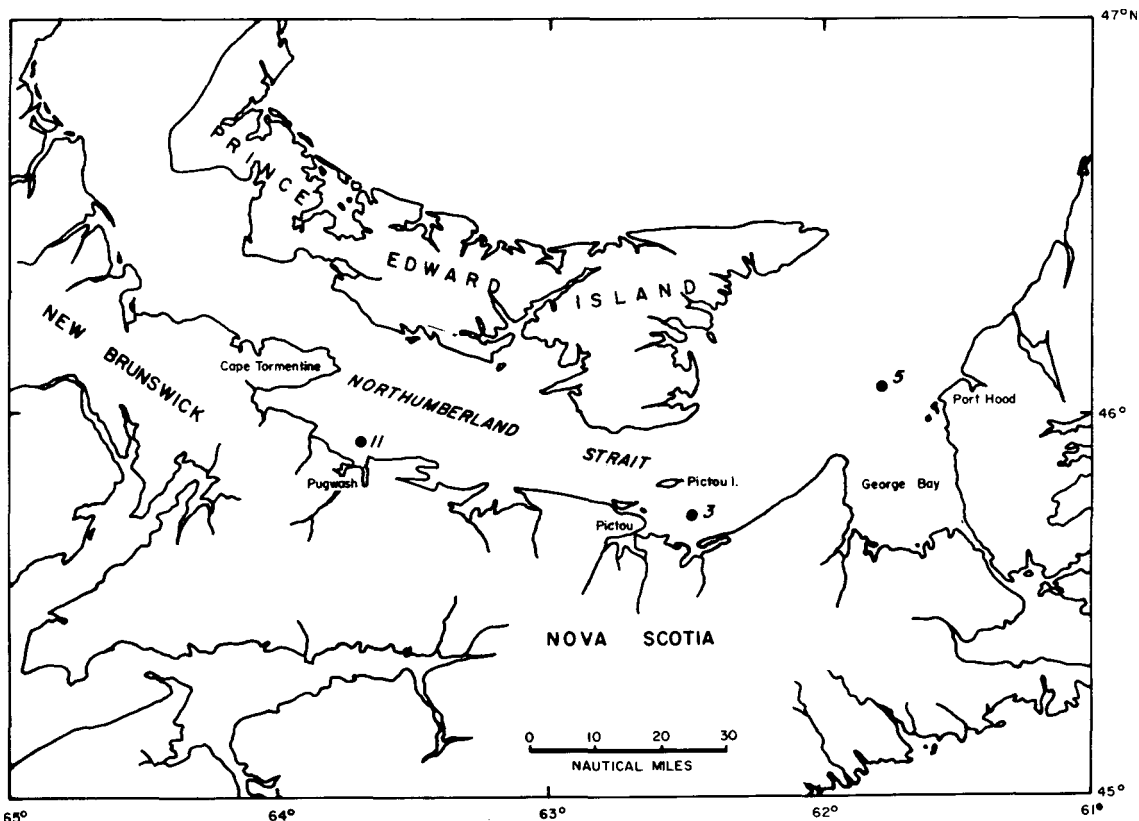
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Introduction

Three sediment cores were examined for foraminiferal content to determine the post-glacial history of Northumberland Strait. Northumberland Strait separates Prince Edward Island from the mainland of Nova Scotia and New Brunswick (Fig. 1) and is approximately 180 miles in length. Its width varies from 11 to 39 miles. The Strait shallows in its central portion, increasing in depth in the western and eastern ends where it merges with the Gulf of St. Lawrence. The Cape Breton submarine trough begins in the eastern end and terminates in the Laurentian channel, which passes north of the Strait. These troughs, as well as the irregular bottom topography, are attributed to the effects of Pleistocene glaciation of the region (Loring and Nota, 1966). Bottom lithology of the Strait ranges from coarse gravel, that is probably glacial in origin, to clay-size sediments, and its watermass is brackish due to the influence of the Gulf of St. Lawrence and fresh water inflow from rivers draining the bordering land.

The recent fauna in the Strait east of Cape Tormentine is dominantly arenaceous, consisting of Saccammina atlantica, Eggerella advena, Spiroplectammina biformis, Trochammina lobata, and Trochammina macrescens. The fauna in the western portion, and in water shallower than ten fathoms, is dominantly calcareous-hyaline, consisting mainly of Elphidium clavatum, E. incertum, E. orbiculare and various arenaceous forms, in particular Eggerella advena. Three centimetres below the mud-water interface the sediments are barren or depauperate of fauna, consisting of one or two specimens of E. clavatum, E. orbiculare, or Eggerella advena. (Bartlett, personal communication).



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Method of Study

The three sediment cores were collected from the C. S. S. KAPUSKASING during May 1966, using a piston corer with a two and a half-inch core barrel. The cores were positioned as follows:

	<u>Latitude</u>	<u>Longitude</u>	<u>Depth</u>	<u>Length</u>
Core 11	45°57'8"N	63°42'8"W	9 m.	307 cm.
Core 3	45°45'0"N	62°28'6"W	24 m.	388 cm.
Core 5	46°03'9"N	61°44'7"W	48 m.	810 cm.

The cores were logged and sampled during August of 1967 at the Bedford Institute where the sedimentological analysis was carried out.

The samples for faunal analysis were wet-sieved through two sieves - Tyler # 16 (.9801mm) and # 230 (.0628 mm). The material remaining on the # 230 sieve was dried and the foraminiferal tests were floated from this material using carbon tetrachloride (specific gravity 2.65). No more than 300 specimens were picked per sample. The foraminiferal analysis was conducted at Queen's University. Pollen analysis was kindly done by Dr. E. Stanley of the University of Georgia.

Sediment

The sediment in all three cores is generally similar. The predominant type is clayey silt. Sorting is poor to very poor, and all samples are positively skewed. This indicates (Folk and Ward, 1957) that most of the sediment was transported into a low energy environment where deposition was more operative than the winnowing action of currents (Bartlett, 1964; Duane, 1964).

Foraminifera

General:

The foraminiferal fauna in the cores is predominately calcareous-hyaline of which Elphidium is the major genus. The dominant species are Elphidium clavatum, E. incertum, E. orbiculare, and Buccella frigida. Arenaceous forms are relatively rare, and are represented by Eggerella advena, Saccammina atlantica, Reophax scorpiurus, and Trochammina spp.

A comparison is made of the core fauna with present day foraminiferal assemblages (Table 1). Most of the species are recorded in the Arctic regions, except Trochammina macresens, T. ochracea, and Ammonia beccarii. However, all of the forms except Pyrgo williamsoni have been found by Bartlett (1964; 1965a, b; 1966) in the cool temperate, brackish water of the Atlantic Provinces. A comparable fauna is found in warm temperature regions. However the fauna appears to have the closest affinity with the cool temperate environment of the Atlantic Provinces.

The faunal assemblages are sparse in both genera and species, consisting of ten genera and seventeen species. No samples generally contain less than five genera and commonly two. Faunas with less than twenty species inhabit water shallower than ten fathoms - the marginal marine facies (Walton, 1964). This is the most rigorous environment, since it is here that daily and seasonal fluctuations in temperature and salinity have the greatest effect. The marginal-marine facies is characterized by such nearshore features as bays, sounds, estuaries, intertidal marshes, and swamps.

The foraminiferal assemblages in the cores can be divided into: 1) a prolific Elphidium fauna in which E. clavatum, E. incertum, and E. orbiculare are the dominant species, with Buccella frigida as a minor constituent; and 2) a sparse Elphidium - Trochammina fauna. Both assemblages are found in core 3 and 11, whereas only the latter type is found in core 5.

The Elphidium fauna occurs in greatest abundance at depths of less than five fathoms (Walton, 1964). In northern areas this fauna is the most extensive of the marginal marine faunas, and represents the transitional fauna between the marginal marine and open marine faunal groups. The Elphidium fauna is dominant in outer estuaries and inner lagoons, and indicates salinity above 20‰ (Bartlett, personal communication).

The Elphidium fauna of the cores is similar to the fauna in the following environments: the nearshore facies of Long Island Sound (Buzas, 1965b); the shallow bay facies of Hudson Bay (Leslie, 1965); the bay facies of Barnstable, Massachusetts (Phleger and Walton, 1950). However, the fauna most closely resembles that of the Miramichi River Estuary, New Brunswick and the lagoonal environment of Tracadie Bay, Prince Edward Island (Bartlett, 1965a, 1966). Thus, ecological observations of the Miramichi assemblages should be valid for determining the paleoecology of the Elphidium fauna of the cores.

In his work, Bartlett (1965b) has observed a complete gradation between E. clavatum and E. incertum and consequently he grouped them together in the E. incertum "complex". Assemblages dominated by the E. incertum "complex" are prolific in baymouth environments on well-aerated, slightly turbulent, sand substrates, but also are found in large numbers on silt and silty clay throughout quiet central bays. The fauna at the mouth of the bay, and seaward from baymouth barriers is more diverse than the assemblages found inside the barrier with E. orbiculare, Buccella frigida and Eggerella advena as subordinate members. The inner bay fauna is less dominated by E. incertum "complex" and E. orbiculare. Eggerella advena, Buccella frigida and Trochammina spp. are minor constituents of the fauna.

The Trochammina fauna indicates a shallow subtidal environment such as the Spartina glabra zone (most seaward) of a tidal marsh. Usually the Trochammina fauna is associated with a Miliammina fauna (Said, 1953).

Sedimentary History of Northumberland Strait

Core 11:

Core 11 was taken in nine metres of water. From the bottom of the core, 307 centimetres, to the peat horizon at 280 centimetres, the sediment is barren to depauperate of foraminifera, poorly sorted, positively skewed, and red. Little organic debris is present but there is a high concentration of fresh water diatoms. These features indicate a fluvial deposit. The peat horizon is dated at 3000 \pm years B. P., and appears to have been derived from two source areas. This horizon is now 11.8 metres below sea level, consequently sea level must have been 11.8 metres lower at the time of deposition. A sand layer overlies the peat, and contains turritellids as well as a foraminiferal fauna indicative of an inner bay environment. In addition, the grain size, sorting, and skewness of the sediment is characteristic of a lagoonal deposit. Above the sand there is a shell horizon consisting of Crassostrea virginica, Crepidula fornicata, Balanus balanus, and turritellids which are characteristic bank formers in warm quiet shallow-water lagoons.

From the top of the peat layer (280 cm) to 140 centimetres a prolific Elphidium fauna persists, except for a barren interval at 160 centimetres (Fig. 2). The fauna is dominated by Elphidium incertum "complex" and E. orbiculare. Upward from the peat horizon the hardier form E. clavatum becomes dominant over E. incertum, in conjunction with a decline in importance of E. orbiculare. This indicates a transition to more turbulent conditions in a lagoonal environment. Also the smaller tests of E. clavatum suggest that the habitat is more favourable for this species.

An abrupt break in the fauna, along with a marked increase in the organic content of the sediment occurs at 160 centimetres (sample 9). This may be the result of an unfavourable anaerobic environment produced by decomposition of abundant plant matter. Above this the fauna returns.

From 140 centimetres to the top of the core the depauperate fauna is similar to the present day conditions of Northumberland Strait.

Core 3:

Core 3 was taken east of Pictou, Nova Scotia, in 24 metres of water. The bottom of the core (388 cm) penetrates sediment with a prolific Elphidium fauna, dominated by E. clavatum. This indicates turbulent brackish water. Overlying this is a barren to depauperate section bounded by upper and lower peat layers (240 and 377 cm). The absence of a transition fauna as the environment shifted from marine to fresh water may be attributed to the rapidity of the event, or loss of material during subaerial exposure.

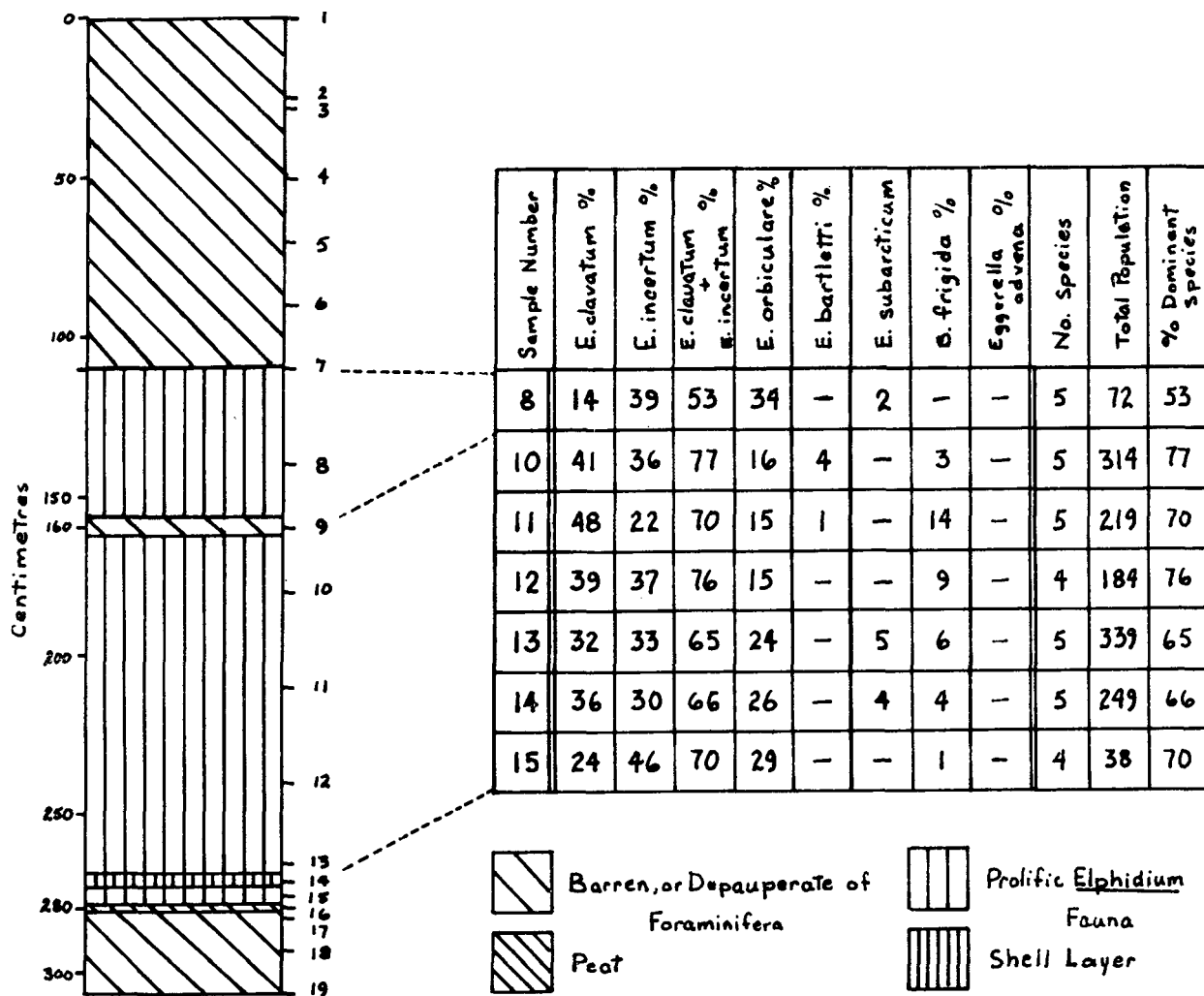


Fig. 2 - Position and percentage of foraminifera species in Core II

The lower peat layer (377 cm) represents the Plsietocene B pollen zone, indicating warmer than present conditions. The horizon is dated at 5200 \pm years B. P., corresponding with the warmest part of the Hypsithermal of Flint and Brandtner (1961).

The barren to depauperate section between the peat layers may be a result of unfavourable conditions. However, the brackish water of present day high marsh facies, usually supports an arenaceous fauna of Miliammina and/or Trochammina. The absence of foraminifera suggests that diagenesis has destroyed much of the population. Leaching during the formation of the upper peat layer or an increase in acidity within the sediment may account for the destruction of some of the tests. Many of the calcareous and arenaceous species are known to have a tectin or pseudo-chitin inner lining, that is indestructable even when treated with hydrofluoric acid (Van Veen, 1957). Thus, if the fauna were present, the inner linings may have been overlooked or destroyed when examining the cores.

The interval from the upper peat layer (240 cm) to 140 centimetres contains a prolific Elphidium fauna, and numerous shell layers (Fig. 3). The shell layers, dominated by Crassostrea virginica and associated with Ammonia beccarii, indicate warmer than present conditions. Lower than optimum salinity is probably responsible for the heavier, large Elphidium forms observed. Also, the association with Trochammina species suggests low salinity.

The Elphidium fauna is dominated by E. clavatum suggesting a high energy environment. However, the low frequency of Bucella frigida and the presence of shell layers indicates a semi-restricted brackish water environment. The shell layers alternate with sediment which may be the result of a migrating channel through the oyster bank (Fig. 3). At the top of the interval the increased importance of E. incertum in association with Trochammina spp. marks a decrease in salinity.

At 140 centimetres, there is an abrupt decline in foraminiferal population and number of species. No lithological or sedimentological change was observed to account for this. However, the few tests present show signs of secondary calcification. Bradshaw (1957, 1961) noted that tests of Ammonia beccarii tepida dissolved under conditions of low pH, but the individual is able to survive, and on return to normal pH is able to recalcify its test. Thus, secondary calcification indicates that during the lifetime of the fauna the pH or salinity dropped causing some test solution, and subsequent return of saline waters permitted the surviving forms to redeposit their tests.

From 140 centimetres to 54 centimetres, there is a reappearance of the Elphidium fauna with associated shell horizons. The absence of Ammonia beccarii, in conjunction with heavier, more robust Elphidium tests indicate a cooler climate. The Elphidium fauna dominated by E. clavatum and the shell horizons suggest an environment similar to the one before the break.

At 54 centimetres, the fauna is depauperate. The sparse Elphidium fauna is associated with Eggerella advena and Saccamina atlantica which is characteristic of present conditions in Northumberland Strait.

Core 5:

Core 5 was taken in 48 metres of water. The core lacked sufficient fauna to enable a definite paleoecological reconstruction.

Correlation of the Cores

Only two of the cores can be correlated. Cores 3 and 11 contain a comparable prolific brackish water Elphidium fauna as well as fresh water peat deposits (Figs. 2 and 3).

Because the sediments of the cores are uniform in character, the assumption is made that the forces acting on the system would also be uniform, and thus deposition would occur at a constant, though not necessarily equal, rate. In Core 11 the average sedimentation rate above the peat horizon at 280 centimetres (3000 \pm B. P.) is calculated to be 9.3 centimetres/hundred

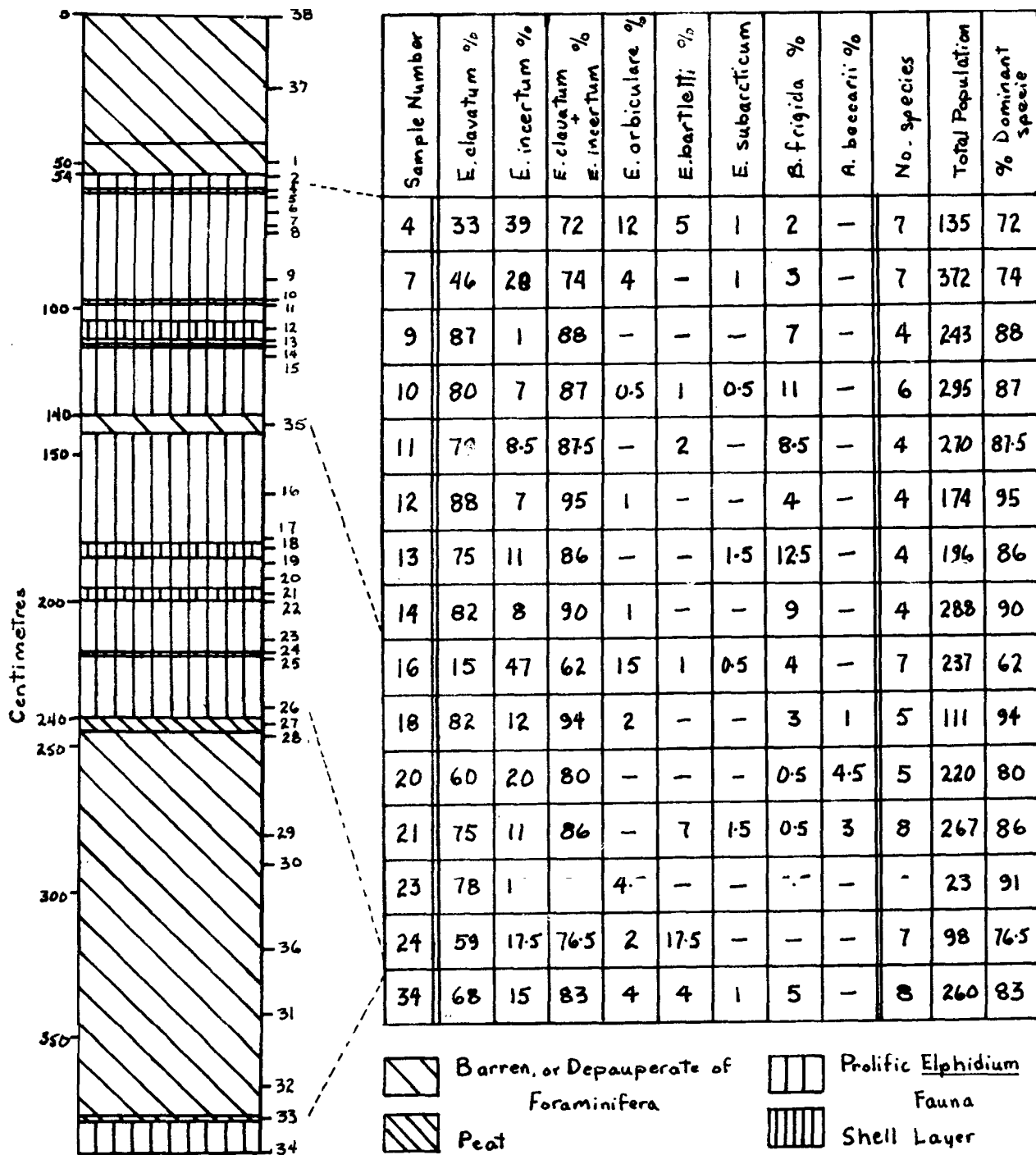


Fig. 3 - Position and percentage of foraminifera species in Core 3

years. From this the faunal break at 160 centimetres is calculated as 1714 \pm B. P. Similarly, in Core 3 the sedimentation rate above the lower peat layer (377 centimetres, 5200 \pm B. P.) is 7.3 centimetres/hundred years. The upper peat layer dates at 3200 \pm B. P. and the faunal break at 1750 \pm B. P. The peat layer in core 11 and the upper peat layer in core 3 appear to be contemporaneous, as does the faunal break in core 3 at 140 centimetres and in core 11 at 160 centimetres.

The post-glacial history of Northumberland Strait may be postulated as follows: immediately after the deglaciation of the area, sea level was lower by approximately 71 metres (300 feet). At this time the Strait would be completely exposed to subaerial influences. Drainage of the area was most likely to the north through the Cape Breton trough to the Laurentian Channel. Inundation of the area by marine waters about 11,800 years B. P. flooded the Strait and opened the Isthmus of Chignecto. As conditions became warmer, Crassostrea virginica and Ammonia beccarii migrated into the region. Isostatic rebound in the area resulted in the closure of the Isthmus of Chignecto at 6400 \pm B. P. (Bartlett, personal communication) and exposed the regions of core 3 and 11 to fresh water influence. At this time, water may have continued to drain through the Cape Breton trough. After 3000 \pm B. P. marine waters again invaded the Strait. A reversal, in conjunction with a fresh water influx around 1700 \pm B. P. resulted in a decline in the foraminiferal populations. This was followed by a brief period of more favourable conditions. The appearance of the depauperate fauna marked the onset of present Northumberland Strait conditions.

Acknowledgements

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