Post-Pleistocene Sea Level Changes in the Baie Verte

Estuary (Northumberland Strait) as Revealed by

Foraminiferal Studies

by

Garth A. Prime

A thesis submitted to the Geology
Department Honours Committee,
Dalhousie University in partial
fulfillment of the requirements
for the Bachelor of Science Honours
Degree.

Geology Department
Dalhousie University
Halifax, Nova Scotia
(March 20, 1980)

DEPARTMENT OF GEOLOGY
DALHOUSIE UNIVERSITY
HALIFAX, NOVA SCOTIA
CANADA
B3H 4J1

DALHOUSIE UNIVERSITY, DEPARTMENT OF GEOLOGY

B.Sc. HONOURS THESIS

<u>Author</u>:   Garth A. PRIME

<u>Title</u>:   POST-PLEISTOCENE SEA LEVEL CHANGES IN THE BAIE VERTE ESTUARY
         (NORTHUMBERLAND STRAIT) AS REVEALED BY FORAMINIFERAL STUDIES

Distribution License

DalSpace requires agreement to this non-exclusive distribution license before your item can appear on DalSpace.

NON-EXCLUSIVE DISTRIBUTION LICENSE

You (the author(s) or copyright owner) grant to Dalhousie University the non-exclusive right to reproduce and distribute your submission worldwide in any medium.

You agree that Dalhousie University may, without changing the content, reformat the submission for the purpose of preservation.

You also agree that Dalhousie University may keep more than one copy of this submission for purposes of security, back-up and preservation.

You agree that the submission is your original work, and that you have the right to grant the rights contained in this license. You also agree that your submission does not, to the best of your knowledge, infringe upon anyone's copyright.

If the submission contains material for which you do not hold copyright, you agree that you have obtained the unrestricted permission of the copyright owner to grant Dalhousie University the rights required by this license, and that such third-party owned material is clearly identified and acknowledged within the text or content of the submission.

If the submission is based upon work that has been sponsored or supported by an agency or organization other than Dalhousie University, you assert that you have fulfilled any right of review or other obligations required by such contract or agreement.

Dalhousie University will clearly identify your name(s) as the author(s) or owner(s) of the submission, and will not make any alteration to the content of the files that you have submitted.

If you have questions regarding this license please contact the repository manager at dalspace@dal.ca.

Grant the distribution license by signing and dating below.

_____   _____

Name of signatory   Date

T A B L E   O F   C O N T E N T S

Chapter 5 (Con't)

iii

ABSTRACT

Two cores were obtained from the Baie Verte estuary
of the Northumberland Strait to study relative sea level
changes by examination of foraminiferal distributions.

The base of the cores contained a layer of salt marsh
peat which can be accurately used to relocate former sea
levels. Distinct vertical faunal assemblages observed in the
cores indicate that there has been a change in the
foraminiferal environments of the estuary during the last
5,000 years. The development of the estuary has resulted in
the original, nontransitional estuary being transformed into
the transitional system which exists today in the area.
Evidence suggests that this change was due to alteration of
circulation patterns in the estuary.

The implication for sea level changes indicates that
a short period of emergence occurred at approximately 5,000
years B.P. This was followed by a continuous submergence
to the present time. Thus, the evidence provides support
for the models which have been developed to explain the
migration of the peripheral bulge that followed deglaciation
in the Maritimes.

A comparison of this study with one done in the
same area by McRoberts (1968) indicates variations in the
results obtained. In particular, large populations of
arenaceous foraminifera found in the cores of the present
study were not observed in McRoberts' (1968) core. The

result has been different interpretations of events in the area related to relative sea level changes since the last glaciation.

Acknowledgements:

CHAPTER I

INTRODUCTION

General:

In recent years, a substantial amount of scientific research has been focused on the usefulness of foraminiferal distributions as sea level indicators in the Maritime Provinces (Scott, 1977; Scott and Medioli, 1978a, 1980). In particular, the attention was concentrated on using the information obtained from such studies to reconstruct an outline of the relative sea level changes that have occurred since the last glaciation (McRoberts, 1968; Scott, 1977; Scott and Medioli, 1978b, 1979). As a part of continuing effort towards establishing detailed relative sea level records in different parts of the Maritimes, many areas have been sampled. One of the most important of these, a small area in the Northumberland Strait, is the subject of this thesis.

The complex pattern of relative sea level rise and fall observed in the Maritimes has been attributed to the deformation of the lithosphere caused by the migration of a "peripheral bulge" that formed in the marginal regions of the ice sheet during the last glaciation (e.g. Peltier and Andrews, 1976; Scott, 1977). The phenomenon of migration of the peripheral bulge has been quantified in several

mathematical models (Peltier and Andrews, 1976; Quinlan, 1978).
All such models, however, are based on assumptions on the
size of the last Laurentide ice sheet, the elasticity of the
lithosphere and viscoelasticity of the asthenosphere. The
only way to calibrate the assumptions is that of making
predictions by means of the model and verifying them in the
field. If the predictions are wrong, then the assumptions
must be modified. Hence, there is the need for accurate and
detailed measurements in the field.

The application of these models to the Maritimes,
supported by existing data, suggests that the western part
of the Northumberland Strait is now on the distal end of
the "peripheral bulge" (which is migrating westward) and
consequently, the relative sea level is steadily rising
(Scott, 1977). The specific area of interest in the present
study is the Baie Verte estuary, bordering on New Brunswick
and Nova Scotia and located in this western portion of the
Northumberland Strait.

Scope of Work:

Previous coring in the Baie Verte area (Kranck, 1972)
had revealed the presence of peat layers but sea level
results from these cores were questionable (McRoberts, 1968).
Since the old cores no longer existed, it was necessary to
return to the area where new cores were obtained (Fig.1,Table
1). It was hoped that foraminiferal assemblage zones could be
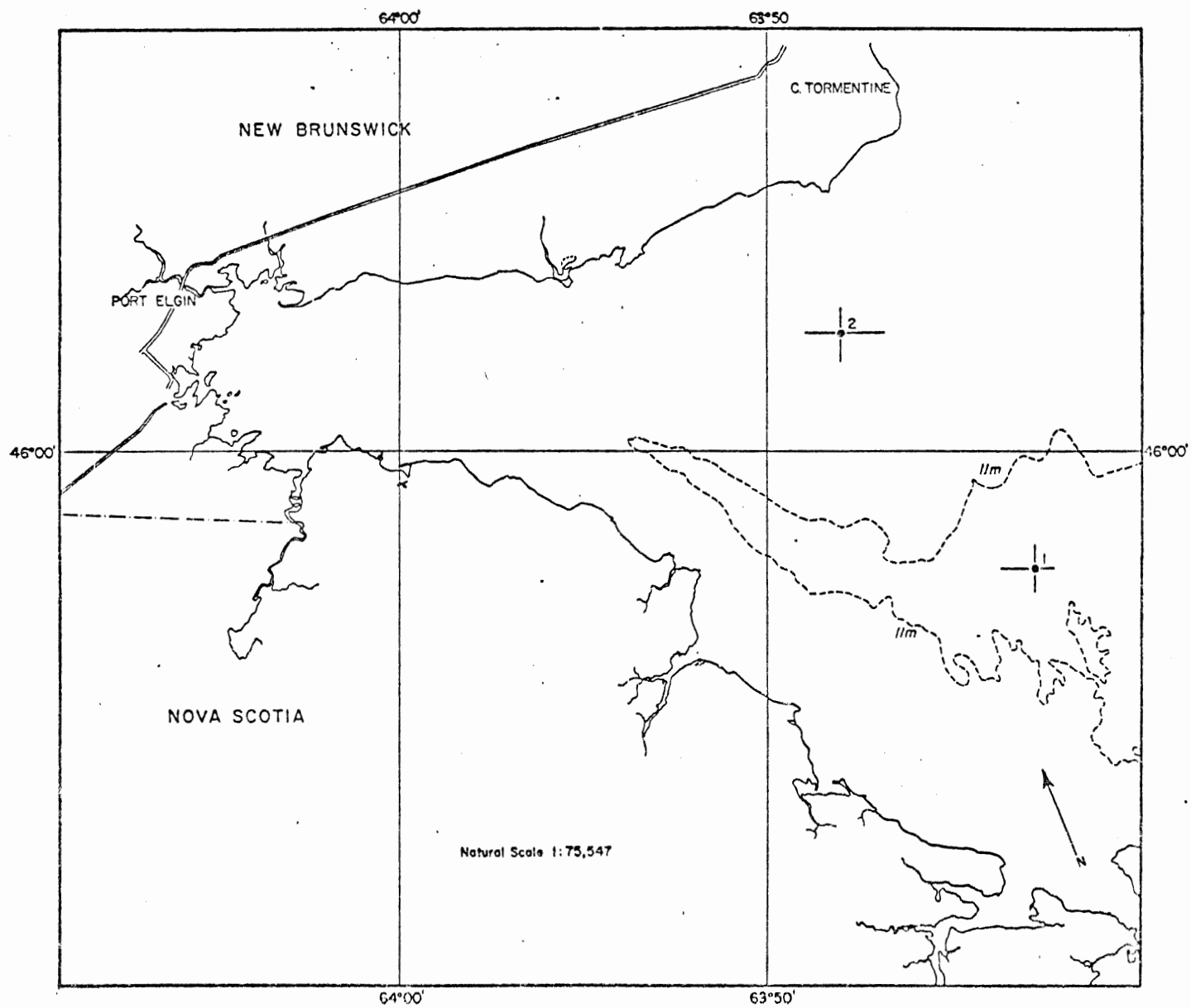
Figure 1.   Core Locations in Baie Verte

identified in the cores and related to modern estuarine and marsh environments. These results would help to establish the paleoecology of the area during this specific period of sedimentation. This information could be used to interpret the relative sea level changes in the development of this estuary. The sea level changes could then be related to the general studies on the migration of the "peripheral bulge" following deglaction.

More specifically, there was much interest to determine if the peat layers reported from previous cores (Kranck, 1972; McRoberts, 1968) were of freshwater or salt marsh origin. If the latter was the case, then extremely accurate sea levels could be derived using marsh foraminifera as indicators (Scott and Medioli, 1978a, 1980). It should be noted here that the organic material found in the cores of the present study is presently being C-14 dated. These dates were unavailable for incorporation into this study.

It was felt that one of these cores should be taken from the exact location as one obtained and analyzed by McRoberts (1968). In this way, the two could be compared in terms of foraminiferal distributions.

CHAPTER II

PREVIOUS WORK

Post-glacial History and Sea Level Investigations:

McRoberts (1968) conducted a study in which she examined the post-glacial history of the Northumberland Strait based upon distributions of foraminifera in two cores obtained by Kranck (1972). One of McRoberts' (1968) cores was from the same location as one examined in this study. She found a peat layer at the base of this core, describing it as depauperate of foraminifera and very rich in fresh water diatoms. She interpreted this as indicating fluvial deposits. Above this, an oyster shell layer was encountered. Samples examined by McRoberts above the basal peat layer consisted of a prolific Cribrononion fauna (=Elphidium in McRoberts, 1968). Arenaceous foraminifera were relatively rare in her samples. The upper section of the core was also recorded as depauperate and McRoberts concluded that this represented conditions similar to those existing in the modern Northumberland Strait.

In a study by Grant (1970) regarding recent costal submergence in the Maritime Provinces, he suggests that many areas in the Maritimes are still experiencing excessive submergence compared to the eustatic rate. Grant attributes this to a combination of crustal deflection by water load

5

from post-glacial eustatic rise of sea level and relaxation of the "peripheral bulge".

An extensive examination of the geomorphological development and post-Pleistocene sea level changes in the Northumberland Strait was carried out by Kranck (1972). Included in this study were two cores taken from the Baie Verte estuary at the same depths as the cores in this thesis (Table 1). The suggestion was made that "the Northumberland Strait may be on the edge of a region undergoing subsidence to compensate for post-glacial rebound in the centre of the continent (e.g. Newman and March, 1968). The ·area may straddle a fulcrum point separating a region of positive crustal movement from a region of negative crustal movement". (Kranck, 1972, p. 844)

Based on foraminiferal distributions in the cores taken from the estuarine - marsh systems at Chezzetcook, Chebogue, and Wallace, Nova Scotia, Scott (1977) observed differential relative sea level rises. He concluded that this could be attributed to the migration of the "peripheral bulge" following deglaciation in the Maritimes.

Additional studies are presently being conducted in the Maritimes by Scott and Medioli (1978b, 1979) to provide a more complete picture of relative sea level changes.

Foraminiferal Studies Related to This Work:

To obtain more precision in measuring former relative sea-levels, a method has been developed using vertical

zonations of marsh foraminifera as accurate indicators (Scott, 1977; Scott and Medioli, 1978a, 1980).

A study of the Miramichi River estuary was carried out by Scott et al. (1977). This study demonstrated that the distribution of foraminifera could provide a good indicator of circulation patterns and could be used to identify estuaries as either transitional or non-transitional. It was also shown by Scott et al. (1977) that faunal changes in estuaries can occur in a short time due to altered tidal circulation patterns.

Foraminifera and Environmental Factors:

It should be noted here that only species observed in the cores from this study will be discussed below.

Studies of the marsh foraminifera by Scott and Medioli (1978a, 1980) suggest that arenaceous species such as Trochammina inflata and Tiphotrocha comprimata occur only in the upper half of the salt marsh; this suggests that they are tolerant of long periods of exposure. Hence, since normal marshes inhabit only the upper half of the tidal range (Chapman, 1960), the presence of these arenaceous marsh forms limits a marine deposit to the upper quarter of the tidal range.

It has been suggested by Barlett (1966) that the proliferation of calcareous foraminifera in lower estuarine areas (in cool temperate climates) can be attributed to relatively higher salinities. He demonstrated that most

calcareous species such as <u>Cribrononion</u> species (=<u>Elphidium</u> species in Bartlett, 1966) require salinities higher than 20 ^{O}/oo to reproduce. This suggests that these forms will be confined to the lower parts of estuaries where salinities are higher.

Extensive research concerning the arenaceous species <u>Ammotium</u> <u>cassis</u> has been conducted in recent years (Olsson, 1976; Scott <u>et</u> <u>al</u>., 1977). A study of the Miramichi River estuary suggests that the most abundant <u>A. cassis</u> populations are found where transition zones exist. The "ponding effect" occurring in this zone is caused by altered circulation patterns resulting from river and tidal influences becoming more balanced in the estuary (Scott <u>et</u> <u>al</u>., 1977). One effect of this is the increase of suspended particulate matter (SPM) which is associated with increased river discharge (Nichols, 1977). This increase of SPM along with rapid sedimentation and increased organic content in the sediments favor the proliferation of <u>A. cassis</u> (Olsson, 1976; Scott <u>et</u> <u>al</u>., 1977).

METHODS

Collection of Cores:

Cores for this project were collected during May, 1979, by Medioli and Scott aboard the C.S.S. *Navicula* operating from Wallace Basin. Approximate positions of Kranck's (1972) Baie Verte core locations were reached and recorded (radar was used for navigation, Refer to Figure 1, Table 1). Other coring locations in the area were sampled but only the original two cores in Kranck's former locations proved useful.

A 600 kilogram Alpine head (with a 3.5 metre barrel) was used as a gravity corer. This was a modification of previous plans to use the complete Alpine piston corer since conditions proved too dangerous aboard the C.S.S. *Navicula* for piston coring. The two cores (called Navicula #1 and Navicula #2) were stored in plastic core liner until they could be split in the laboratory.

Splitting of Cores For Sampling:

The cores were split according to standard procedures; both the working and the archives halves are stored at Dalhousie University. After splitting, the cores were sampled at 10 cm. intervals (15 c.c. samples). Sometimes closer interval sampling was required, depending on lithology.

Sample Preparation:

All samples were prepared by standard procedures (Scott, 1977; Scott et al., 1977) which will briefly be described here. Each 15 c.c. sample was wet sieved through .5 mm. and .063 mm. sieves with the .5 mm. sieve retaining the coarse organics and allowing foraminifera to pass to the .063 mm. sieve where they were retained. Decantation was used to separate the fine organic material from the micro-fossils and sediment. The foraminifera samples were preserved in alcohol.

Due to excessively large numbers of foraminifera and volumes of sediment present in most of the samples, only a few of them were examined in the alcohol medium. The remaining samples were dried and the foraminifera separated from the sand by flotation in carbon tetrachloride (sp.g.-1.58). The separated foraminifera were then examined in a dry state. Because of the large numbers of foraminifera found in most of these samples, they were split to a workable number of 300-500 when necessary using an "Otto" micro-splitter.

Photography of Specimens:

Those foraminiferal species which were considered significant in the interpretation of the data were photographed using the Cambridge Scanning Electron Microscope located at the Bedford Institute of Oceanography. Polaroid N/P 55 film was used. The photographs were then assembled on a plate and rephotographed for display in this study.

CHAPTER IV

RESULTS

General Observations of Foraminiferal Distributions in the Cores:

Twenty-four species of foraminifera occur in the two cores (Table 2). There are commonly six to twelve of these species in each sample. Many species are represented by only a few individuals. Because of this, just the significant species are considered in the interpretation and correlation (Fig. 2, 3).

Most of the samples in both cores contain very large populations of foraminifera, typically ranging from 2,000 to 5,000 individuals per 15 c.c. Exceptions to this occur in Navicula #2 where two areas show a distinct decline in population size to about 100 individuals. One area occurs just above the bedrock (96 to 86 cm) while the other is located from 42 to 34 cm.

Sedimentary, Foraminiferal, and Environmental Descriptions:

Although a detailed sediment analysis was not conducted, basic distinctions were recorded in the preliminary examination of the cores (Fig. 2, 3).

Navicula #1:

At 15.51 metres below present MSL the base of the unconsolidated sediments is in contact with a bedrock

11
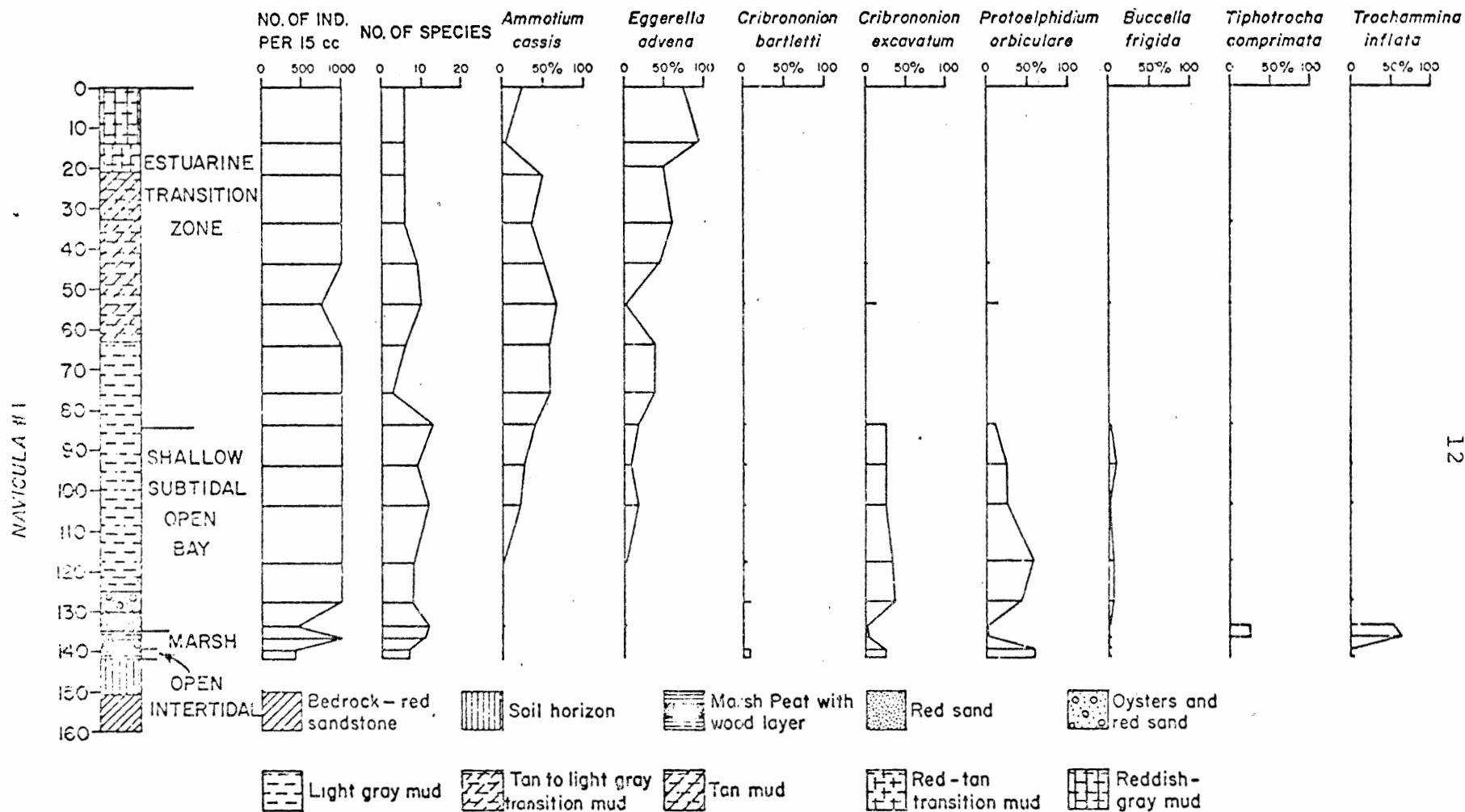
Figure 2

Lithostratigraphy and foraminiferal occurrences in Navicula Core #1

12

Figure 3

Lithostratigraphy and foraminiferal occurrences in Navicula Core #2

of red sandstone (151 cm. in the core, Fig. 2). This is followed by a soil horizon (151 to 142 cm.) which contains no foraminifera and separates the sandstone from the overlying marine deposits. At the base of the marine sequence is an organic layer mixed with wood material (142 to 134 cm.). This peat layer can be divided into two faunal assemblages. The lower assemblage (142-140 c.m) consists of a relatively small population of Protelphidium orbiculare and Cribrononion excavatum. These species are characteristic of an intertidal to subtidal open bay environment. The upper faunal zone (140 to 134 cm.) contains a large arenaceous population dominated by Trochammina inflata with smaller numbers of Tiphotrocha comprimata and Trochammina lobata. This indicates a salt marsh environment.

Above the organic material is a red sand layer (135 to 130 cm.) with an oyster shell horizon extending to the 125 cm. mark. A thick bed of light grey mud (125 to 62 cm.) overlies the shell horizon. From the base of the red sand layer (135 cm.) to the 84 cm. mark in the light-gray mud, an assemblage of P. orbiculare and C. excavatum is found. The upper part of this zone (105 to 84 cm.) contains Ammotium cassis and Eggerella advena which show a gradual increase in numbers approaching the top of the assemblage. Small numbers of Buccella frigida are also present throughout this zone. The predominant calcareous forms suggest an open bay environment which is changing toward the top of the zone.

A sequence of different coloured muds (62 to 0 cm.) overly the light-gray mud and trend from gray on the bottom to red-gray on the top. From the 84 cm. mark in the light-gray mud to the top of the core, as assemblage composed almost entirely of A. cassis and E. advena occurs. These two species (especially A. cassis) indicate a transition zone in an estuary.

Navicula #2:

The basic sediment sequence here is similar to that of Navicula #1, although compressed. At 9.96 metres below present MSL (96 cm. in the core), a bedrock of red sandstone is in contact with an organic layer (Fig. 3). This peat layer (96 to 91 cm.) defines the limits of a faunal assemblage zone. The foraminiferal population is very small here. Trochammina inflata is the most abundant species, with only slightly lesser numbers of Protelphidium orbiculare and Cribrononion excavatum. The strong presence of the T. inflata indicates a salt marsh environment.

Above the peat is a relatively thick gray sand and oyster shell horizon (91 to 65 cm.). Light gray mud extends from the top of the shell layer to the 26 cm. mark. From the bottom of the oyster shell layer to the middle of the light gray mud layer (91 to 40 cm.) a calcareous fauna is dominant. P. orbiculare and C. excavatum are both very prolific while Buccella frigida and Cribrononion bartletti occur in minor but persistent numbers. One small section from 64 to

62 cm. contains a significant population of C. gunteri. The abundance of calcareous forms suggests that this is an open bay environment.

Overlying the light gray mud, a series of coloured muds occur (65 to 0 cm.) with tan to light-gray on the bottom grading into red-gray at the top of the core. An assemblage dominated by Ammotium cassis and Eggerella advena occurs at the 40 cm. mark in the light-gray mud and continues to 0 cm. A transition zone is indicated by the presence of this assemblage.

CHAPTER V

DISCUSSION

General Comments:

The peat layers in the Navicula cores are presently
being C-14 dated; however, the results are not available at
the present time to be submitted with this study. McRoberts
(1968) and Kranck (1972) published C-14 dates which should
correspond quite closely to the Navicula cores (Table 1),
with one exception. The 10 metre core in the present study
should be slightly younger than McRoberts' 11.8 metre core.
Based on a proportionality calculation of sea level rise
using McRoberts' (1968) C-14 date, it can be inferred that
the peat layer at 10 metres below present MSL (in the
present study) occurred approximately 2,500 years B.P. With
these assumptions in mind, the dates discussed in this study
will be approximations based on the results of McRoberts
(1968) and Kranck (1972).

Faunal Assemblage Comparisons With Modern Day Environments:

Both cores show the same vertical sequence of faunal
assemblages with one exception. Navicula #1 has a small
open bay zone at the base which is not found in Navicula #2.
Other than this, both cores have a marsh foraminiferal
assemblage at the bottom overlain by an open shallow bay

17

assemblage and an estuarine transition zone occuring at the top.

The zone identified as the marsh environment contains a fauna similar to that described by Scott and Medioli (1978a, 1980). The important species are <u>Trochammina</u> <u>inflata</u> and <u>Tiphotrocha</u> <u>comprimata</u>. These arenaceous forms are dominants found in the upper marsh zones of the Maritimes (Scott and Medioli, 1978a, 1980).

This zone (in both cores) shows a relatively dramatic decrease in individuals at the base, which is strongly characteristic of higher high water areas in a marsh (Scott and Medioli, 1980).

<u>Cribrononion</u> <u>excavatum</u> and <u>Protelphidium</u> <u>orbiculare</u> define the open bay assemblage zone. These calcareous species are strongly characteristic of an intertidal to shallow, subtidal environment (Scott <u>et</u> <u>al</u>.,in press). This assemblage was observed by Scott <u>et</u> <u>al</u>. (1977) in the Miramichi River estuary. A salinity of greater than 20 $^o/_{oo}$ appears to be the requirement for the proliferation of these species (Bartlett, 1966). These conditions are satisfied in the open bay zone of an estuary.

Large populations of <u>Eggerella</u> <u>advena</u> and <u>Ammotium</u> <u>cassis</u> are strongly characteristic of an estuarine trans-ition zone. This assemblage has been identified by Scott <u>et</u> <u>al</u>., (1977) in the Miramichi River estuary. With the aid of cluster analysis, they suggested that only <u>A. cassis</u> can

define this zone while E. advena can be found in large numbers in either the transition or open bay faunal assemblage.

Paleoecology:

The evidence presented distinctly implied that the Baie Verte estuary developed from a two assemblage zone to a three zone system. It should be noted that the upper estuarine assemblage zone (defined by Miliammina fusca and and Ammotium salsum, Scott et al.,1977) described by Scott et al., (1977) was not found in the present study. This probably indicates that it was poorly developed due to low fresh water input, similar to conditions exhibited in Prince Edward Island estuaries (Scott et al., in press).

In the early phase of the estuary, it consisted of a fringing marsh zone and a directly adjacent shallow open bay zone. An arenaceous fauna of Trochammina inflata and Tiphotrocha comprimata dominated the marsh assemblage while open bay conditions were represented by the calcareous species Protelphidium orbiculare and Cribrononion excavatum. The absense of a transition zone was probably due to a circulation imbalance, with the marine influences being far greater than river influences (Scott et al., 1977). With time there was a change from this nontransitional estuary to a transitional type. This was apparently caused by the " ponding effect" which most likely resulted from more balanced marine and fluvial influences due to increased river discharge and/or decreased tidal influence from rising

sea level (Scott et al., 1977). The result was a transition
assemblage zone characterized by Ammotium cassis and Eggerella
advena separating the fringing marsh from the more seaward
open bay environment. It should be noted here that the
assumption has been made that an open bay zone presently
exists in a seaward direction from the study area cores.

Implications Regarding Relative Sea Level Changes:

The foraminiferal distributions indicate that 5,000
years B.P. (approximation of C-14 date, Kranck, 1972), there
was a short emergence stage in the Baie Verte estuary at
15.5 metres below present MSL. This is indicated by the
open bay assemblage at the base of Navicula #1, followed by
a marsh sequence (suggesting falling sea level). A marine
transgression then began. At approximately 2,500 years
B.P. (calculated from C-14 date, McRoberts, 1968) the marine
water had reached a point 10 metres below present MSL. The
evidence indicates that this submergence has apparently
been continuous to the present day.

Relationship Between Relative Sea Level Changes and
          Deglaciation:

The results appear to conform with the studies of
the migration of the "peripheral bulge" in the Maritimes
(e.g. Kranck, 1972; Scott, 1977). The temporary regression
of the sea at the base of Navicula #1 would suggest that the
maximum point of emergence is this area (where the cores
were obtained) was approximately 5,000 years B.P. at 15.5

metres below present MSL. Since that time there has been
continuous submergence. These results would be consistent
with the suggestion that the "peripheral bulge" has already
migrated westward through the western part of the Northumber-
land Strait and into New Brunswick (Scott, 1977). Thus, the
last effect of the "bulge" in the Baie Verte area occurred
approximately 5,000 years B.P. with the emergent feature of
the salt marsh being followed by submergence.

Paleoclimatic Conditions:

Most of the species (including Protelphidium
orbiculare, Cribroelphidum excavatum, Eggerella advena,
etc.) in the cores are associated with temperate to cold
temperate waters (Bartlett, 1966). This suggests that
the climatic conditions over the last 5,000 years have
probably been quite similar to the cool, temperate conditions
which exist in the Northumberland Strait today. One
exception to this assumption is the appearance of Cribrononion
gunteri in Navicula #2 (64 to 62 cm.). This species is
associated with warm temperate to subtropical waters (Snyder
and Katrosh, 1979). It might be suggested that conditions
in the Northumberland Strait were warmer at one time during
the last 5,000 years. However, because of the complexity
of this body of water and insufficient studies done in the
area, any conclusions drawn must be considered as mere
speculation.

Comparison to McRobert's (1968) Work:

A comparison of this study with that done by
McRoberts (1968) indicates a great deal of variation in
results obtained in the same study area. Although the
lithologies recorded in the two studies are very similar, the
foraminiferal distributions show wide discrepancies. To
begin with, her results show the basal peat layer as
depauperate of foraminifera while the Navicula cores have
significant numbers of arenaceous foraminifera in the
equivalent layers. The implication here is that the peat
was not a fresh water bog, but definitely the remains of a
salt marsh formation. Thus, the organic material can be
very accurately used as an indicator of former sea level
(Scott, 1977; Scott and Medioli, 1978a, 1980).

Another point of difference is that McRoberts (1968)
described the upper section of the core as either barren
or depauperate. In the Navicula cores very large populations
of arenaceous species are present (to the top of the cores).
This would suggest that the foraminiferal fauna is flourish-
ing in this area at the present day and not depauperate as
suggested by McRoberts (1968).

The differences encountered in the two studies can
probably be accounted for in terms of sampling techniques.
The methods for preserving the foraminifera and extracting
them from the cores have been substantially refined in
very recent years. Because many of these techniques were

not available at the time of the McRoberts (1968) study, it can be suggested that possibly the large arenaceous populations (observed in the present study) were destroyed when the cores were processed or sampled.

CHAPTER VI

CONCLUSIONS

(1) The organic layer at the base of each core contains an abundant arenaceous population including Trochammina inflata and Tiphotrocha comprimata. This confirms that these peat layers were salt marsh deposits and can be used as accurate indicators of first invasions of a marine environment.

(2) Foraminiferal distributions found in the cores suggest that the initial Baie Verte estuary in the study area consisted of two faunal assemblage zones. Trochammina inflata and Tiphotrocha comprimata define the fringing marsh environment while the calcareous forms Protelphidium orbiculare and Cribrononion spp. indicate the open bay environment.

(3) The most recent sediments in the study area indicate the presence of a transition zone in the estuary which is identified by large populations of Ammotium cassis.

(4) The results suggest that there has been a shift in the Baie Verte estuary from a nontransitional, two-zoned system to the present conditions of a transitional, three-zoned estuary.

(5) Relative sea level changes indicate that approximately 5,000 years B.P., there was a transgression of the sea in the Baie Verte estuary. This was followed by a period of emergence and finally a continuous submergence to the present day.

24

(6)   This study provides evidence supporting the recent models of the migration of the "peripheral bulge" in the Maritimes.   The results suggest that the "bulge" has already passed through the western part of the Northumberland Strait so that the Baie Verte area is now located at the distal end. The maximum emergence (the effect of the "bulge") in this area was experienced approximately 5,000 years B.P. at 15.5 metres below present MSL.

(7)   The species of foraminifera identified in the cores indicate that the paleoclimatic conditions over the last 5,000 years have most probably been similar to the cool, temperate conditions which exist at present.

(8)   A comparison with results obtained by McRoberts (1968) indicates variations from the data presented in this study concerning the same area.   The basic difference is that McRoberts found the peat layers and large sections of the top of the cores barren of foraminifera while in the present study, both of these sections contained abundant arenaceous species.

CHAPTER VII

SYSTEMATIC TAXONOMY

Of the foraminifera identified in this study, only those species which showed significant occurrences will be presented here. The references cited consist of original references and those that were pertinent to this study. The generic names are in accordance with Loeblich & Tappan (1964).

Ammonia beccarii (Linné)

Nautilus beccarii Linné. 1758, p. 710.

Ammonia beccarii (Linné). Brunnich, 1772, p. 232; Frizzell and Keen, 1949, p. 106; Gregory, 1970, p. 222, Pl. 12, figs. 4-6; Schnikter, 1974, pp. 216-223, Pl. 1; Cole and Ferguson, 1975, p. 32, Pl. 9, figs. 1, 2; Scott, 1977, pp. 164-165, Pl. 6, figs. 10, 11; Schafer and Cole, 1978, p. 27, Pl. 8, fig. 6; Scott and Medioli, 1980, p. 35, Pl. 5, figs. 8, 9.

Streblus beccarii (Linné). Fischer de Waldhiem, 1917, p. 449, Pl. 13; Bradshaw, 1957, p. 1138, text fig. 1a-c.

"Rotalia" beccarii (Linné) var. tepida Cushman; 1926, p. 79, Pl. 1; Parker, 1952a, p. 457, Pl. 5, figs. 7, 8.

Ammotium cassis (Parker)

Plate I, figure 7

Lituola cassis Parker in Dawson (1870) pp. 177, 180, fig. 3.

Buccella frigida (Cushman). Anderson, 1952, p. 144, figs. 4 a-c, 5, 6 a-c; Gregory, 1970, p. 220, Pl. 12, figs. 1-3; Cole and Ferguson, 1975, p. 33, Pl. 8, figs. 8, 9; Scott, 1977, p. 167, Pl. 8, figs. 10, 11; Scafer and Cole, 1978, p. 27, Pl. 8, figs. 1, 2.

<div align="center">

Cribrononion bartletti (Cushman)

Plate I, figure 16
</div>

Elphidium bartletti. Cushman, 1933, p. 4, Pl. 1, fig. 9; Gregory, 1970, p. 225, Pl. 13, figs. 3-5; Cole and Ferguson, 1975, p. 34, Pl. 7, figs. 3, 4; Schafer and Cole, 1978, p. 27, Pl. 10, fig. 4.

Cribroelphidium bartletti (Cushman). Scott, 1977, p. 169, Pl. 6, fig. 8.

Scott and Medioli (1980) have suggested that generic distinctions between Elphidium, Cribroelphidium, and Cribrononion require clarification for their proper usage. First of all, they do not agree with the criterion established by Loeblich and Tappan (1964) as acceptable in differentiating between Cribroelphidium and Cribrononion. The distinction that Loeblich and Tappan (1964) made was that Cribroelphidium has areal apertures in addition to the row of pores at the base of the septal face while Cribrononion lacks these areal apertures. According to Scott and Medioli (1980), this does not provide an acceptable basis for making a generic distinction; therefore, if the two can be considered as synonyms, the genus name Cribrononin has priority and must

be retained. In the particular species encountered in this study, _Elphidium_ does not appear appropriate either, according to the narrow definition invoked by Loeblich and Tappan (1964). The result is that _Cribrononion_ will be the generic name used where deemed necessary (Scott and Medioli, 1980).

<center>_Cribrononion excavatum_ (Terquem)</center>

<center>Plate I, figures 14, 15</center>

Polystomella excavata Terquem, 1876, p. 429, Pl. 2, figs. 2a-d.

Polystomella striato-punctata (Fichtel and Moll) var. _selseyensis_. Heron - Allen and Earland, 1911, p. 448.

Elphidium excavatum (Terquem). Cushman, 1930, p. 21, Pl. 8, figs. 1-3; Schafer and Cole, 1978, p. 27, Pl. 9, fig. 7; Levy _et al_., 1975, p. 176, fig. 9, Pl. 3, figs. 1, 2, 5, 6.

Cribrononion excavatum (Terquem). Lutze, 1965, pp. 96-101, Pl. 15, fig 39; Lévy _et al_. 1969, p. 93, Pl. 1, figs. 1a, b, 2a, b, 4a, b; Scott and Medioli, 1980, p. 35, Pl. 5, figs. 5, 6.

Elphidium excavatum (Terquem) formae. Feyling - Hanssen, 1972, pp. 337-354, Pls. 1-6.

Cribroelphidium excavatum (Terquem) forma _clavatum_ (Cushman). Scott _et al_., 1977, pp. 1578, 1579, Pl. 5, figs. 1, 2; Scott, 1977, p. 169, 170, Pl. 6, fig. 2.

Cribroelphidium excavatum (Terquem) forma _selseyensis_ (Heron-Allen and Earland). Scott _et al_., 1977, p. 1579, Pl. 5, fig. 3; Scott, 1977, p. 170, Pl. 6, fig. 3.

Both formae, _clavatum_ and _selseyensis_, are considered

under this species because it has been suggested that any
distinction between the two in the past was arbitrary
(Scott and Medioli, 1980). This decision has been substantial
as a result of photographic documentation by Miller (1979)
showing an intergradational series between the two formae.

Cribrononion gunteri Cole

Plate I, figure 13

Elphidium gunteri.Cole, 1931, p. 34, Pl. 4, figs. 9, 10;
Phleger, 1960, Pl. 3, fig. 22; Snyder and Katrosh, 1979, Pl.
2, figs. 1, 2

Elphidium gunteri Cole, var. galvestonense Kornfeld;Phleger
and Parker, 1948, p. 10, Pl. 5, fig. 14

Ephidium gunteri Cole, forma typicum.Poag, 1978, p. 402, Pl.
2, figs. 13-16.

Investigations by Poag (1978) have resulted in C.
gunteri (E gunteri according to Poag) being classified as
a distinct ecophenotype. However, more recent work done
by Miller and Scott indicates that it would be more appropri-
ate to consider C. gunteri as an ecophenotype of C.
excavatum (Miller & Scott, personal communication, 1980).

Cribrononion subarcticum (Cushman)

Plate I, figure 12

Elphidium subarcticum.Cushman, 1944, p.27, Pl. 3, figs.34-
35; Parker, 1952a, p. 449, Pl. 4, figs. 3-6, 8; Phleger
and Walton, 1950, p. 277, Pl. 2, figs. 19, 20; Gregory, 1970,

p. 229, Pl. 14, fig. 7; Cole and Ferguson, 1975, p. 34, Pl. 8, figs. 1, 2; Schafer and Cole, 1978, p. 27, Pl. 10, fig. 1.

Cribroelphidium subarcticum (Cushman). Scott, 1977, p. 171, Pl. 6, fig. 7.

Eggerella advena (Cushman)

Plate I, figure 8

Verneuilina advena.Cushman, 1921, p. 141.

Eggerella advena (Cushman). Cushman, 1937, p. 51, Pl. 5, figs 12-15; Phleger and Walton, 1950, p. 277, Pl. 1, figs. 16-18; Parker, 1952b, p. 404, Pl. 3, figs. 12, 13; Parker, 1952a, p. 447, Pl. 2, fig. 3; Gregory, 1970, p. 183, Pl. 4, figs. 1-3; Cole and Ferguson, 1975, p. 34, Pl. 3, figs. 10, 11; Scott et al., 1977, p. 1579, Pl. 2, fig. 7; Scott, 1977, p. 171, Pl. 6, fig. 9; Schafer and Cole, 1978, p. 27, Pl. 3, fig. 1; Scott and Medioli, 1980, p. 40, Pl. 2, figure 7.

Protelphidium orbiculare (Brady)

Plate I, figure 17

Nonionia orbiculare.Brady, 1881, p. 415, Pl. 21, fig. 5.

Nonion orbiculare (Brady). Cushman, 1930, p. 12, Pl. 5, figs. 1-3.

Elphidium orbiculare (Brady). Hessland, 1943, p. 262; Gregory, 1970, p. 228, Pl. 14, figs. 5, 6.

Protelphidium orbiculare (Brady). Todd and Low, 1961, p. 20, Pl. 2, fig. 11; Cole and Ferguson, 1975, p. 39, Pl. 7, figs. 7, 8; Scott et al., 1977, p. 1579, Pl. 5, figs. 5,6; Scott

1977, pp. 174, 175, Pl.6, fig. 9; Shafer and Cole, 1978, p.28, Pl. 10, fig. 5; Scott and Medioli 1980, p. 43, Pl. 5, fig. 7.

Reophax arctica Brady

Reophax arctica.Brady, 1881, p. 405, Pl. 21, fig. 2 a, b; Parker, 1952b, p. 395, Pl. 1, figs. 6, 7; Gregory, 1970, p. 168; Pl. 2, fig. 3; Cole and Ferguson, 1975, p. 40, Pl. 1, fig. 9; Scott, 1977, p. 175, Pl. 3, fig. 5; Schafer and Cole, 1978, p. 29, Pl. 2, fig. 5.

Bigenerina artica (Brady). Cushman, 1948, p. 31, Pl. 3, fig. 9.

Reophax nana Rhumbler

Reophax nana.Rhumbler, 1911, p. 182, Pl. 8, figs. 6-12; Parker, 1952a, p. 457, Pl. 1, figs. 14, 15; Scott et al., 1977, p. 1579, Pl. 3, figs. 1, 2; Scott, 1977, p. 175, Pl. 3, fig. 7; Schafer and Cole, 1978, p. 29, Pl. 2, fig. 4; Scott and Medioli, 1980, p. 43, Pl. 2, fig. 6.

Reophax nodulosa, Brady

Plate I, figure 9

Reophax nodulosa, Brady, 1879, p. 52, Pl. 4, figs. 7, 8; Brady, 1884, p. 294, Pl. 31, figs. 1-9; Schafer and Cole, 1978, p. 29, Pl. 2, fig. 6.

Reophax scorpiurus, de Montfort

Reophax scorpiurus.de Montfort 1808, p. 330; Scott et al., 1977, p. 1579, Pl. 3, figs. 3, 4.

Tiphotrocha comprimata (Cushman and Brönnimann)

Plate I, figures 3, 4

Trochammina comprimata. Cushman and Brönnimann, 1948b, p. 41,
Pl. 8, figs. 1-3.

Tiphotrocha comprimata (Cushman and Brönnimann). Saunders,
1957, p. 11; Parker and Athearn, 1959, p. 341, Pl. 50, figs.
14-17; Scott et al., 1977, p. 1579, Pl. 4, figs. 3,4;
Scott, 1977, p. 176, Pl. 5, figs. 14-16; Scott and Medioli,
1980, p. 44, Pl. 5, figs. 1-3.

Trochammina inflata (Montagu)

Plate I, figures 1,2

Nautilus inflatus. Montagu, 1808, p. 81, Pl. 18, fig. 3.
Trochammina inflata (Montagu). Parker and Jones, 1859,
p. 347; Phleger and Walton, 1950, p. 280, Pl. 2, figs. 1-3;
Parker, 1952b, p. 407, Pl. 4, figs. 6, 10; Parker, 1952a,
p. 459, Pl. 3, fig. 2a, b; Gregory, 1970, p. 180, Pl. 4,
figs. 3, 4; Cole and Ferguson, 1975, p. 43, Pl. 4, figs.
3, 4; Scott, 1977, p. 177, Pl. 4, figs. 12-14, Pl. 5, figs.
1-3; Scafer and Cole, 1978, p. 29, Pl. 5, fig. 2; Scott and
Medioli, 1980, p. 44, Pl. 3, figs. 12-14, Pl. 4, figs. 1-3.

Trochammina lobata Cushman

Trochammina lobata. Cushman, 1944, p. 18, Pl. 2, fig. 10;
Phleger and Walton, 1950, p. 281, Pl. 2, figs. 4, 5; Parker
1952b, p. 408, Pl. 4, fig. 7a, b; Parker, 1952a, p. 459,

Pl. 3, fig. 2a, b; Gregory, 1970, p. 180, Pl. 4, figs. 5, 6; Cole and Ferguson, 1975, p. 43, Pl. 4, figs. 5, 6; Scott et al., 1977, p. 1579, Pl. 4, figs. 1, 2; Scott, 1977, p. 179, Pl. 5, figs. 8, 9; Schafer and Cole, 1978, p. 29, Pl. 4, fig. 5.

<p style="text-align:center">Trochammina macrescens Brady</p>

<p style="text-align:center">Plate I, figures 5, 6</p>

Trochammina inflata (Montagu) var. macrescens.Brady, 1870, p. 290, Pl. 11, fig. 5a-c; Scott, 1976, p. 320, Pl. 1, figs. 4-7; Scott et al., 1977, p. 1579, Pl. 4, figs. 6, 7; Scott, 1977, p. 178, Pl.178, Pl. 4, figs. 1-8.

Jadammina polystoma. Bartenstein and Brand, 1938, p. 381, figs 1a-c, 2a-1; Parker and Athearn, 1959, p. 341, Pl. 50, figs. 21, 22, 27; Scott, 1977, p. 173, Pl. 4, figs. 9-11.

Trochammina macrescens Brady. Phleger and Walton, 1950, p. 281, Pl. 2, figs. 6, 7; Parker, 1952b, p. 408, Pl. 4, figs. 8a, b; Parker, 1952 a, p. 460, Pl. 3, figs. 3a, b; Parker and Athearn, 1959, p. 341, Pl. 50, figs. 23-25; Gregory, 1970, p. 181, Pl. 4, fig. 7; Cole and Ferguson, 1975, p. 43, Pl. 4, figs. 6, 7; Schafer and Cole, 1978, p. 29, Pl. 4, fig. 3; Scott and Medioli, 1980, p. 44, Pl. 3, figs. 1-8.

Jadammina macrescens (Brady). Murray, 1971, p. 41, Pl. 13, figs. 1-5.

It should be noted that the poor condition of the

individuals, as seen in the accompanying photographs, was typical of this species in the two cores examined.

Trochammina *squamata* Parker and Jones

Trochammina *squamata*. Parker and Jones, 1865, p. 407, Pl. 15, figs. 30, 31a-c; Phleger and Walton, 1950, p. 281, Pl. 2, figs. 12, 13; Parker, 1952b, p. 408, Pl. 4, figs. 11-16; Parker, 1952a, p. 460, Pl. 3, fig. 4a, b; Cole and Ferguson, 1975, p. 43, Pl. 4, figs. 11, 12; Scott, 1977, p. 180, Pl. 5, figs. 6, 7; Schafer and Cole, 1978, p. 29, Pl. 5, fig. 1; Scott and Medioli, 1980, p. 45, Pl. 4, figs. 6, 7.

Plate I

Figure 1,2.   Trochammina inflata (Montagu) 1. dorsal view,
               76.4 x, 2. ventral view, 76.4 x.

Figure 3,4.   Tiphotrocha comprimata (Cushman and Brönnimann)
               3. dorsal view, 100.9 x, 4. ventral view,
               93.5 x.

Figure 5,6.   Trochammina macrescens Brady 5. dorsal view,
               69.4 x, 6. ventral view, 90.7 x.

Figure 7.   Ammotium cassis (Parker) 7. side view, 53.5 x.

Figure 8.   Eggerella advena (Cushman) 8. side view, 83.7 x.

Figure 9.   Reophax nodulosa Brady 9. side view, 62.5 x.

Figure 10,11. Buccella frigida (Cushman) 10. dorsal view, 53.9
               x, 11. ventral view, 75.2 x.

Figure 12.   Cribrononion subarcticum (Cushman) 12. side
               view, 102 x.

Figure 13.   Cribrononion gunteri Cole 13. side view, 72.7
               x.

Figure 14,15. Cribrononion excavatum (Terquem) 14. side view,
               65.4 x, 15. side view, 50.7 x.

Figure 16.   Cribrononion bartletti (Cushman) 16. side
               view. 37.2 x.

Figure 17.   Protelphidium orbiculare (Brady) 17. side
               view, 60.5 x.
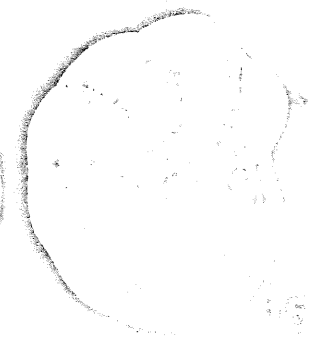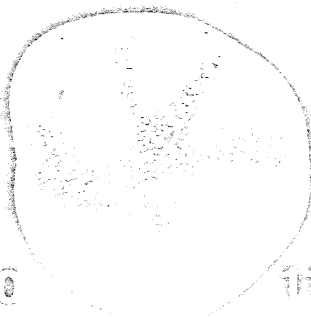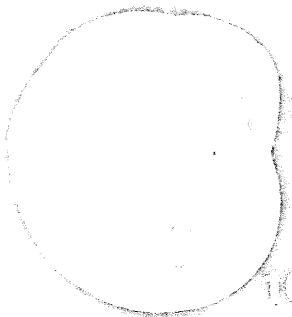
REFERENCES

Anderson, H. V. 1952. Buccella, a new genus of Rotalid
        foraminifera: Journal of Washington Academy of Science,
        42, pp. 143-151.

Bartenstein, H., and Brand, E. 1938. Die Foraminiferan -
        Fauna des Jade - Gebietes 1. Jadammina polystoma
        n. g., n. sp. aus dem Jade - Gebietes (for):
        Senckenbergiana, 20, no. 5, pp. 381-385.

Bartlett, G. A. 1966. Distribution and abundance of
        foraminifera and thecamoebina in Miramichi River
        and Bay. Bedford Institute of Oceanography, report
        66-2, 101 p, n.p.

Bradshaw, J. S. 1957. Laboratory studies on the rate of
        growth of the foraminifer, Streblus beccarri (Linné)
        var tepida (Cushman). Journal of Paleontology, 31,
        no. 6, pp. 1138-1147.

Brady, H. B. 1870, in Brady, G. S., and Robertson, D. 1870.
        The ostracoda and foraminifera of tidal rivers. With
        analysis and descriptions of foraminifera by H. B.
        Brady, Part II. Annual Magazine of Natural History,
        series 4, 6, pp. 273-306.

Brady, H. B. 1879, Notes on some of the reticularian rhizopoda
        of the Challenger Expedition. Quarterly Journal of
        Microscopical Science, new series, 19, Part 1, On
        new or little-known arenaceous types, pp. 20-63.

Brady, H. B. 1881, On some Arctic foraminifera from soundings
        obtained on the Austro-Hungarian North Polar Expedi-
        tion of 1872-76. Annual Magazine of Natural History,
        8, pp. 393-418.

Brady, H. B. 1884. Report on the foraminifera dredged by the
        H.M.S. Challenger, during the years 1873-1876.
        Reports of Scientific Results from Explorer. Voyage
        H.M.S. CHALLENGER, Zoology, 9, pp. 1-814, Pls. 1-115.

Brunnich, M.T. 1772, Brunnich Zoological Fundamentals:
        Grunde i, Dyrelorren (Hafniae at Lipsiae), 253 p.

Chapman, U. J., 1960, Salt Marshes and Salt Deserts of the
        World: Leonard Hill LTP, London, 392 p.

Cole, W. S. 1931, The Pliocene and Pleistocene foraminifera of Florida. Florida Geological Survey, Bulletin, 6, 79p.

Cole, F., and Ferguson, C. 1975. An illustrated catalogue of foraminifera and ostracoda from Canso Strait and Chedabucto Bay, Nova Scotia. Bedford Institute of Oceanography, Report Series BI-R-75-5, 55p, n.p.

Cushman, J. A. 1920. The foraminifera of the Atlantic Ocean. Pt. 2, Lituolidae. United States Natural History Museum, Bulletin, 104, pt. 2, 111 p.

Cushman, J. A. 1921. Results of the Hudson Bay expedition, 1920; I - The foraminifera. Toronto, Canada, Biological Board, Contributions to Canadian Biology (1921), 1922, no. 9, pp. 135-147.

Cushman, J. A. 1926. Recent foraminifera from Porto Rico. Carnegie Institute of Washington Publication 344, pp. 75-84.

Cushman, J. A. 1930, The foraminifera of the Atlantic Ocean. Part 7. Nonionidae, Camerinidae, Peneroplidae, and Alveolinellidae. United States Natural History Museum, Bulletin, 104, pp. 1-79.

Cushman, J. A., 1933, New Arctic Foraminifera collected by Captain R. A. Bartlett from Fox Basin and off the northeast coast of Greenland. Smithsonian Miscellaneous Collections, 89, no. 9, pp. 1-8.

Cushman, J. A., 1937, A monograph of the foraminiferal family Valvulinidae. Cushman Laboratory of Foraminiferal Research, Special Publication 8, 210 p.

Cushman, J. A. 1941. Some fossil foraminifera from Alaska: Cushman Laboratory Foraminiferal Research, Contributions, 17, pp. 33-38.

Cushman, J. A. 1944. Foraminifera from the shallow water of the New England Coast. Cushman Laboratory for Foraminiferal Research, Special Publication 12, pp. 1-37.

Cushman, J. A. 1948, Arctic foraminifera. Cushman Laboratory for Foraminiferal Research, Special Publication, 23, pp. 1-79.

Cushman, J. A., and Brönnimann, P. 1948a.   Some new genera
        and species of foraminifera from brackish water of
        Trinidad.   Cushman Laboratory for Foraminiferal
        Research, Contributions, 24, pp. 15-21.

Cushman, J. A., and Brönnimann, P. 1948b, Additional new
        species of arenaceous foraminifera from the shallow
        waters of Trinidad.   Cushman Laboratory for
        Foraminiferal Research, Contributions, 24, pp. 37-42.

Cushman, J. A., and Cole, W. S. 1930.   Pleistocene
        foraminiferida from Maryland.   Cushman Foundation for
        Foraminiferal Research, Contributions, 6, pp. 94-100.

Dawson, G. M. 1870.   On foraminifera from the Gulf and River
        St. Lawrence.   Canadian Natural and Quaternary
        Journal of Science, 5, new series, pp. 172-180.

De Montfort, D. 1808.   Conchyliologie systematique et
        classification methodique des coquilles.   1, 409 p.

Feyling-Hanssen, R. W. 1972.   The forminifer Elphidium
        excavatum (Terquem) and its variant forms. Micro-
        paleontology, 18, pp. 337-354.

Fischer de Waldhiem, G. 1917.   Adversaria zoologica.   Memoirs
        de la Societe Impériale des Naturalistes de Moscow,
        5, pp. 357-471.

Frizzell, D. L., and Keen, A. M. 1949.   On the nomenclature
        and generic position of Nautilus beccarri Linné
        (foraminifera "rotaliidae").   Journal of Paleontology,
        23, pp. 106-108.

Grant, D. R. 1970.   Recent costal submergence of the Maritime
        Provinces, Canada.   Canadian Journal of Earth
        Sciences, 7, no. 2, pp. 676-689.

Gregory, M. R. 1970.   Distribution of benthonic forminifera
        in Halifax Harbour, Nova Scotia, Canada.   PhD
        Dissertation, Dalhousic University, Halifax, N. S.

Heron-Allen, E., and Earland, A. 1911.   On the recent and
        fossil foraminifera of the shore-sands of Selsey
        Bill, Sussex, VIII.   Journal of Royal Microscopical
        Society, pp. 436-448.

Hessland, I. 1943, Marine Schalenablagerungen Nord-Bohusläns.
        Geologic Institute of Uppsala, Bulletin, 31p.

Kranck, K. 1972. Geomorphological development and post-Pleistocene sea level changes, Northumberland Strait, Maritime Provinces. Canadian Journal of Earth Sciences, 9, no. 7, pp. 835-844.

Lévy, A., Mathieu, R., Momeni, I., Poignant, A., Rosset-Moulinier, M., Rouvillois, A., and Ubaldo, M. 1969. Les représentant des la Famille de elphidiidae (Foraminifères) dans les Sables des plages des environs de Dunkerque. Remarques sur les espéces de Polystomella signallées par O. Terquem. Revue de Micropaleontolgie, 12, no. 2, pp. 92-98.

Linné, C. 1758. Systema nature per regna tria natural, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. ed. 10, 1, pp. 1-824, G. Engelmann (Lipsiae).

Loeblich, A. R. Jr., and Tappan, H. 1953. Studies of Arctic Foraminifera. Smithsonian Miscellaneous Collections, 121, pp. 1-150.

Loeblich, A. R. Jr., and Tappan, H. 1964. Sarcodian, chiefly "thecamoebians" and foraminiferida in:Moore, R.C. ed., Treatise on Inverlebrate Palsontology, Protista 2, Part C. Kansas University Press, Lawrence, K.S., 1, 2, 899p.

Lutze, G. F. 1965. Zur foraminiferen der ostee: Meyiana, 15, pp. 75-142.

McRoberts, J.H.E. 1968. Post-glacial history of Northumberland Strait based on benthonic foraminifera. Maritime Sediments, 4, pp. 88-95.

Miller, A.A.L., 1979, Taxonomy, morphology, and micro-probe analysis of the recent foraminfer Elphidium excavatum (Terquem) from a Labrador Shelf sediment core: Queen's University, Kingston, Ontario, Canada, unpublished B. Sc. thesis.

Montagu, G. 1803. Testacea Brittanica, or natural history of British shells, marine, land and freshwater, including the most minute. J. S. Hollis (Romsey, England), 606p.

Murray, J. W. 1971. An atlas of recent British Foraminiferids. America Elsevier Publishing Co., New York, N. Y.

Newman, W. S., and March, S. 1968. Littoral of the Northeastern United States. Late Quaternary warping. Sci., 160, pp. 1110-1112.

Nichols, M. M. 1977. Response and recovery of an estuary following a river flood. Journal of Sedimentary Petrology, 47, pp. 1171-1186.

Olsson, I. 1976, Distribution and ecology of the foraminiferan Ammotium cassis (Parker) in some Swedish estuaries. ZOON, 4, pp. 137-147.

Parker, F. L. 1952a. Foraminiferal distribution in the Long Island Sound - Buzzards Bay area. Bulletin of the Museum of Comparative Zoology, Harvard, 106, 00. 438-473.

Parker, F. L. 1952b, Foraminifera species off Portsmouth, New Hampshire. Bulletin of the Museum of Comparative Zoology, Harvard, 106, pp. 391-423.

Parker, F. L., and Athearn, W.D. 1959, Ecology of marsh foraminifera in Poponesset Bay, Massachusetts. Journal of Paleontology, 33, no. 2, pp. 333-343.

Parker, W.K., and Jones, T. R. 1859. On the nomenclature of the foraminifera, Part 2, on the species enumerated by Walker and Montagu. Annual Magazine of Natural History, 4, Series 3, pp. 333-351.

Parker, W. K., and Jones, T. R. 1865. On some Foraminifera from the North Atlantic and Arctic Oceans, including Davis Strait and Baffin Bay. Philosophical Transactions, 155, pp. 325-441.

Peltier, W. R., and Andrews, J. T. 1976. Glacial-isostatic adjustment - I. The forward problem. Geophysical Journal (Royal Astronomical Society), 46, pp. 605-646.

Phleger, F. B 1960. Ecology and distribution of recent foraminifera. Baltimore. John Hopkins Press, 297p.

Phleger, F. B and Parker, F. L. 1948, Ecology of foraminifera, northwest Gulf of Mexico, Memoir, 46, Part 2, 64p.

Phleger, F. B and Walton, W. R. 1950. Ecology of marsh and bay foraminifera, Barnstable, Massachusets. American Journal of Science, 248, pp. 274-294.

Poag, C. W. 1978, Paired foraminiferal ecophenotypes in Gulf Coast estuaries: ecological and paleocological implications. Gulf Coast Association of Geological Societies, Transactions, 28, pp. 395-421.

Quinlan, G. 1978. Wisconsinion Ice extent in Atlantic
    Canada - a geophysical perspective. Abstract to the
    Joint Annual Melting of the Geological Association of
    Canada and Geological Society of America, Toronto,
    Oct. 23-26, 1978, pp. 474-475.

Rhumbler, L. 1911. Die Foraminiferen (Thalamophoren) der
    Plankton - Expedition. Ergebnisse de Plankton -
    Expedition der Humboldt - Stiftung, 3, Lief. C., pp.
    1-331.

Saunders, J. B. 1957. Trochamminidae and certain Lituolidae
    (Foraminifera) from the recent brackish-water
    sediments of Trinidad, British West Indies. Smith-
    sonian Miscellaneous Collections, 134, Publication
    Number 4270, pp. 1-16.

Schafer, C. T., and Cole, F. E. 1978. Distribution of
    foraminifera in Chaleur Bay, Gulf of St. Lawrence.
    Geological Survey of Canada Paper 77-30, 55p.

Schnikter, D. 1974, Ecotypic variation in Ammonia beccarri
    (Linné). Journal of Foraminferal Research, 4, no. 4,
    pp. 216-223.

Scott, D. B. 1976, Brackish-water foraminifera from southern
    California and description of Polysaccammina ipohalina,
    n. gen., n. sp. Journal of Foraminiferal Research, 6,
    no. 4, pp. 312-321.

Scott, D. B., 1977, Distribution and population dynamics of
    marsh - estuarine foraminifera with applications to
    relocating Holocene sea-levels. PhD Dissertation,
    Dalhousie University, Halifax, 252p.

Scott, D. B., and Medioli, F. S., 1978a. Vertical zonations
    of marsh foraminifera as accurate indicators of former
    sea levels. Nature, 272, no. 5653, pp. 528-531.

Scott, D. B., and Medioli, F. S. 1978b. Studies of relative
    sea level changes in the Maritimes (unpublished
    manuscript). Progress Report to E.M.R., research
    agreement no. 2239-4-31/78, 79p.

Scott, D. B., and Medioli, F. S. 1979. Marine emergence and
    submergence in the Maritimes (unpublished manuscript).
    Progress Report to the Department of Energy, Mines,
    and Resources, research agreement no. 45-4-79, 69p.

Scott, D. B., and Medioli, F. S. 1980. Quantitative studies of marsh foraminiferal distributions in Nova Scotia: their implications for the study of sea level changes. Cushman Foundation for Foraminiferal Research, Special Publication no. 17, 58p.

Scott, D. B., Medioli, F. S., and Schafer, C.T. 1977. Temporal changes in foraminiferal distributions in Miramichi River estuary, New Brunswick. Canadian Journal of Earth Sciences, 14, no. 7, pp. 1566-1587.

Scott, D. B., Schafer, C. T., and Medioli, F. S. (in press). Eastern Canadian estuarine foraminifera: A framework for comparison. In press to Journal of Foraminiferal Research.

Snyder, W. S., and Katrosh, M. R. 1979. An exposure of marginal marine Pleistocene sediments, Pitt County, North Carolina. Southeastern Geology, 20, no. 4, pp. 247-259.

Terquem, O. 1876. Essai sur le classement des animaux qui vivant sur la page et dans les environs de Dunkerque: Première partie. Societé Dunderquoise, Memoirs, 19 (1874-1875), pp. 405-457.

Todd, R. and Low, D. 1961. Near-shore foraminifera of Martha's Vineyard Island, Massachusetts. Cushman Foundation for Foraminiferal Research, Contributions, 12, pp. 5-21.

APPENDIX

TABLE 1

Description of Comparison of Cores

Navicula Core #	Latitude and Longitude	Water Depth (m)	Core Length to base of organic layer (m)	Corresponding McRoberts (1968) Core #	Corresponding** Kranck (1972) Core # [*]	Water Depth (m)	Core Length (m)	Carbon 14 Dates for McRoberts (1968) and Kranck (1972) (years B.P.)
1	45° 57.8, N 63° 42.8 W	14.0	1.4	--	4	14.0	1.2	5125 ± 120 (Kranck, 1972)
2	46° 2.2 N 63° 48' W	9.0	1.0	11	2	9.0	2.8	$3000 \pm$ (McRoberts, 1968)

*   McRobert's (1968) core #11 and Kranck's (1972) core #2 are the same; therefore, only one description is necessary for both.

** The Navicula cores are the same as McRoberts' (1968) core and Kranck's (1972) cores according to water depth rather than map coordinates.

47

TABLE 2

CORE NUMBER AND DEPTH (cm.)	1-0	1-14	1-22	1-34	1-44	1-54	1-64	1-76	1-84	1-94	1-104	1-118	1-128	1-134	1-137	1-140	2-0	2-10	2-20	2-28	2-34	2-40	2-50	2-58	2-62	2-70	2-75	2-80	2-85	2-91
No. of species	6	6	6	6	9	10	6	3	13	9	12	8	8	12	11	7	7	12	5	5	7	7	9	7	7	7	8	7	7	8
No. of Individuals per 15 cc	4032	2040	2402	5312	5674	754	7560	3168	1708	2216	2000	2056	7200	430	3201	437	2812	4232	8768	1460	103	100	640	1832	2840	2380	4880	384	106	60
Ammobaculites dilatatus															X															
Ammonia becarii																														2
Annotium cassis	23	4	50	36	51	66	58	58	40	27	22	1		1			27	22	28	13	23	30	6							
A. salsum											X				1															
Buccella frigida						1			2	8	1	5	6	X	X	4							4	8	5	10	12	8	10	2
Cribrononion bartletti						1			1	1	1	2	9			7							3	4	6	2	2	5	11	
C. excavatum						X	13		26	27	25	33	36	X	4	26		X			1	1	26	36	34	36	49	53	25	18
C. gunteri																									2					
C. subarcticum											X		4										X		1	1	6	2	9	
Eggerella advena	76	93	49	61	44	3	39	38	19	10	18	1		X		X	67	75	69	84	50	63	5							2
Haplophragmoides bonplandi														X																
Hemisphaerammina brady																		X												
Protelphidium orbiculare					2	13	1		10	24	25	57	43	X	3	59						1	52	50	52	49	30	29	36	26
Pseudopolymorphina novangliae					X								X																	
Reophax arctica	X	X		1	X				X																					
R. nana		1		X	1		X		X		X							X	1	X		1								
R. nodulosa	X	X	X		1	X	1		X	1								X	X											
P. scorpiurus				X	2				X							1	X													
Spiroplectammina biformis	X		X											X	X	X	X													
Tiphotrocha comprimata				1		X			X			1	X	24	26			X			4			X			X	1	5	2
Trochammina inflata			X						X	1			1	52	63	4	X	X		X	6		2				1	X	2	34
T. lobata														12	1	1												2		
T. macrescens									X			X		7	1		1						1	1						13
T. squamata	1	2	X	2	X		1	4	1	2	5		X	1	X	X	3	1	2	2	15	3	1	1	X	X	X			

Table 2. Foraminiferal percentages in Navicula Cores 1 and 2; X is less than 1% of total

48

The following is a breakdown of the time spent in preparation
of this thesis.

Item	Time Spent (Hrs)
Foraminifera Identification	120
Sample Preparation	10
Tables and Diagrams	15
Touching up of Photographs	4
Preparation of Photographic Plate	1
Research and Writing	200
Total Time	350

Dave Scott and Bhan Deonairine did the SEM photography at
BIO.

The final draft of two diagrams and one table was done by the
Geology Department.

The typist did the final draft of the other table.

All of coring and most of sample preparation was done by
Drs. Scott and Medioli.

Garth Prime