DISTRIBUTIONS AND POPULATION DYNAMICS
OF MARSH-ESTUARINE FORAMINIFERA WITH APPLICATIONS
TO RELOCATING HOLOCENE SEA-LEVEL

by

David B. Scott,
B.Sc. (Univ. of Washington), M.Sc. (West. Washington St. College)

A thesis submitted to the Faculty
of Graduate Studies, Dalhousie University
in partial fulfillment of the requirements for
the Degree of Doctor of Philosophy

Geology Department
Dalhousie University
Halifax, Nova Scotia
(September, 1977)

DALHOUSIE UNIVERSITY

FACULTY OF GRADUATE STUDIES

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by David B. Scott

in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Dated September 13/77

External examiner

Research Supervisor

Examining Committee

DALHOUSIE UNIVERSITY

Date SEPTEMBER, 1977

Author David Bruce Scott

Title Distributions and population dynamics of marsh-estuarine foraminifera with applications to relocating Holocene sea-level

Department or School Geology

Degree Ph.D. Convocation Fall Year 1977

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ABSTRACT

Approximately 1000 surface and subsurface samples were used to determine the marsh and estuarine foraminiferal distributions in four marsh-estuarine areas in Nova Scotia: Chezzetcook Inlet, Chebogue Harbour, Wallace Basin, and Summerville marsh.

Several assemblage zones could be recognized in the estuarine environment of Chezzetcook Inlet, however these zones were not accurate indicators of sea level. Detailed sampling in Chezzetcook revealed that marsh foraminiferal distributions demonstrated strong vertical zonation with respect to mean sea level and closely paralleled marsh floral zonation. These distributions could accurately relocate former sea levels to within ± 5 cm. Seasonal variations had little effect on total populations and they probably did not cause serious errors when interpreting subsurface foraminiferal assemblages.

Less detailed sampling of marsh areas in the other three study localities indicated that the same relationships observed in Chezzetcook occurred in these areas as well. Examination of detailed data from southern California and less detailed data from other parts of the world suggest that marsh foraminiferal assemblages generally can be used as accurate sea level indicators.

Subsurface borings in Chezzetcook, Chebogue, and Wallace are interpreted from recent foraminiferal data. Accurate determinations of former sea levels using marsh foraminiferal assemblages indicate that Chebogue is experiencing less relative rise now than in the past. The opposite is true for Chezzetcook where relative sea level rise has apparently increased in the last 2000 years. Wallace is experiencing a relatively low apparent sea level rise. The collapsing of the "peripheral bulge" following deglaciation is proposed as the mechanism causing these differential relative sea level rises.

ACKNOWLEDGMENTS

Special thanks to Dr. F. S. Medioli who assisted the author in most aspects of this work and without whose help and encouragement, this work could never have been accomplished.

Drs. D. J. W. Piper, H. B. S. Cooke, and C. Beaumont assisted the author in various aspects of this thesis. Alice Scott assisted in the drafting of figures and field work. Dr. R. Fournier loaned the author his salinity refractometer on many occasions. P. J. Mudie identified the marsh plants and provided many helpful suggestions. Dr. F. Aumento supplied an inflatable boat for collecting the estuarine samples. Dr. D. Huntley supplied the RS-5 salinity recorder. J. Letson performed the grain size analyses contained in this thesis and also assisted the author in the field on some occasions. D. Wightman, L. Jensen, D. Plasse, M. Alam and Dr. M. Price also contributed their assistance in the field. R. Stephenson proof-read the final manuscript for the author. Dr. J. S. Bradshaw of the University of San Diego kindly sent the author the post-hole auger used for drilling in this project; Dr. C. T. Schafer and F. Cole of Bedford Institute assisted with taxonomic and statistical problems. Captain Thorn of Bedford Institute provided the author with an outboard motor for collection the estuarine samples.

CHAPTER 1

INTRODUCTION

Marsh foraminifera can be used to detect small scale vertical zones along the marsh surface which generally parallel the known floral zones in vertical range. These relationships were first established by the author (Scott, 1976a) in the marshes of southern California, but have not been demonstrated adequately in other areas. Hence, another area of study, preferably of different climate, was needed to evaluate the generality of the relationships observed in California. Nova Scotia was chosen for two reasons: 1) its climate is humid and temperate as opposed to the arid, subtropical climate of southern California and 2) no previous investigations had been made of the marsh foraminifera of Nova Scotia.

Some basic criteria were established to select areas of study in Nova Scotia. First, inlets with large marsh areas were required to establish whether or not observed relationships remained constant over a broad continuous surface. Second, widely spaced marsh areas were needed to detect potential regional differences. Third, marshes in estuaries with a salinity gradient from upper to lower estuary were required to investigate its effect on the foraminiferal assemblages. Finally, marsh areas where thick subsurface deposits of marsh material were suspected were required in order to study lowered relative Holocene sea levels. Using these criteria as a guideline three primary study areas were selected: Chezzetcook Inlet, Chebogue Harbour, and Wallace Basin (fig. 1). A small secondary area, Summerville marsh (fig. 1),

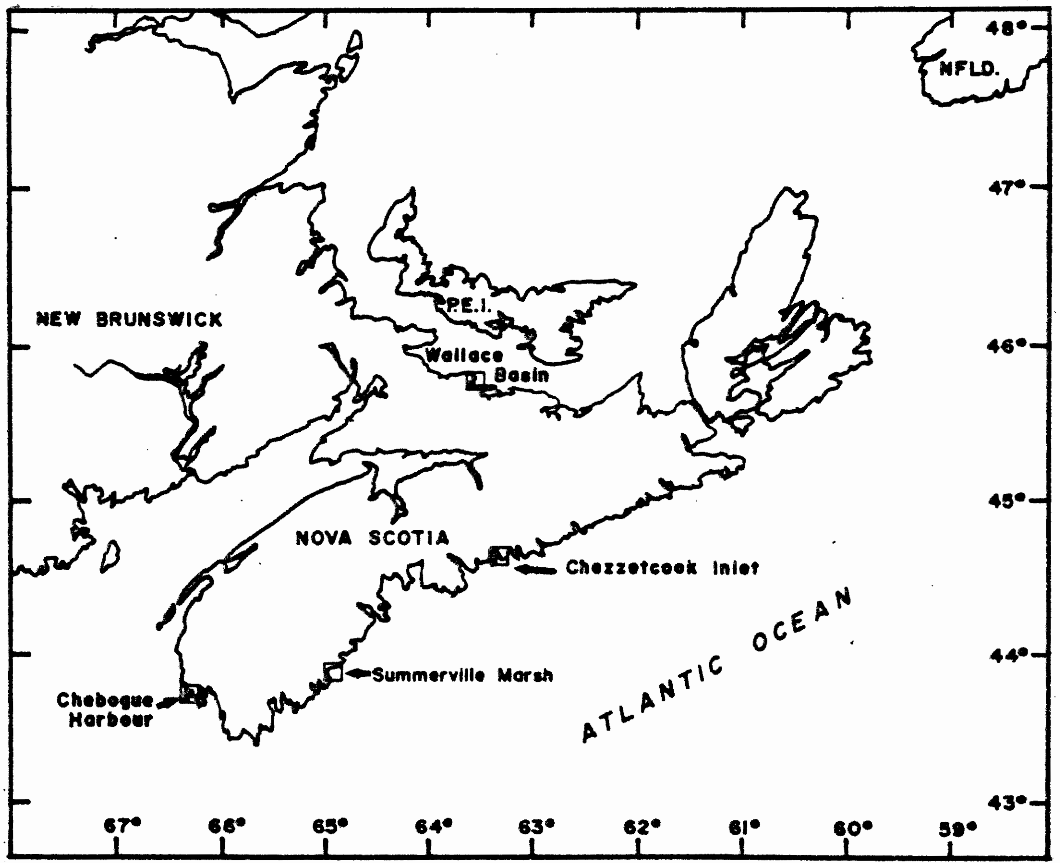


Figure 1. Map of Nova Scotia with study sites.

was selected to provide information regarding faunae observed in a newly forming marsh area. Chezzetcook was the most intensively examined because of its proximity to Halifax.

In Chezzetcook several types of surface samples were collected. First, areal or reconnaissance samples were collected to determine general relationships. Using information derived from these samples, areas of marsh were chosen for more intensive study. Detailed transects across the marsh surface, similar to those by Scott (1976a), were carried out. Along these transects, elevation in relation to mean sea level, salinity, floral percentages, and foraminiferal percentages were determined at each sampling locality. A large number of samples were collected along the transects so that intra-zonal as well as inter-zonal differences could be detected. Estuarine samples (below mean sea level) were collected to determine what, if any, differences existed between these and the marsh foraminiferal assemblages. Finally, at selected localities in the marsh, samples were collected at different times of the year to determine if seasonal variations would obscure the delineation of marsh assemblages. Information from this detailed sampling supplies a framework into which less detailed reconnaissance samples from other areas can be placed.

Less detailed data were obtained from the other study areas and, using the information from Chezzetcook, accurate foraminiferal relationships for each could be determined. In all areas (except Summerville) the information regarding surface distributions is applied to drill hole data and used to interpret the Holocene history of each area.

Many of the marine geological processes now occurring along the coast of Nova Scotia are related to changes in relative sea level. For example, investigations of coastal bays require information on when former sea levels were below the sill depth of a particular bay. If this information is available then a reliable date can be placed on the boundary of the open marine-stagnant brackish sequences occurring in cores from these areas (Piper and Keen, 1976). There has been a general rise in eustatic sea level of approximately 100 meters during the last 12,000 years as indicated by the many sea level curves prepared from data collected around the world (e.g. Scholl et al., 1969). This rise has been attributed to the melting of the glacial ice that covered much of the northern half of the northern hemisphere up to 13,000 ybp. In most areas sea level appears to have changed relatively little since 4000 ybp. However, the New England and Maritime Canada coastal areas are presently thought to be experiencing an excessive relative sea level rise (Redfield, 1967; Grant, 1970, a,b). It is not known whether this rise is occurring at a constant rate or if the rate changes with time. To determine if there are changes in the rate of relative sea level rise an accurate measure of former sea levels is required. Present methods of relocating former sea levels (by use of beach deposits, marine terraces and deltas, oyster beds, and undifferentiated salt marsh deposits) are inadequate to provide the accuracy needed to detect possible rate changes. The most accurate of these relocation methods is that of using salt marsh deposits as an undifferentiated deposit assigned an arbitrary sea level such as mean higher high water or extreme high water. This general method ignores the fact that salt marshes occupy the full upper half of the tidal range which, on the average varies from 1 to 2.5 meters. Salt marsh floral assemblages are known to accurately indicate tidal levels (Chapman, 1960) but plant remains are usually poorly preserved in subsurface sediments and difficult to differentiate on a routine basis. Marsh foraminifera, on the other hand, are usually preserved extremely well in subsurface marsh sediments. Most marsh foraminifera are of the agglutinated variety and are able to withstand burial in low pH marsh sediments without dissolving. If marsh foraminifera can be demonstrated to exhibit a strong vertical zonation similar to the plants then a valuable new tool is available to examine Holocene sea level changes.

Background information

General: A thorough review of salt marshes is provided by Chapman (1960). He notes that salt marshes usually form in protected areas with relatively high rates of sedimentation unless the area is emerging. Chapman suggests that all marshes have recognizable vertical plant zonations. The plant composition of the zones may vary with latitude and precipitation but some form of zonation usually exists. Additionally he notes that marshes appear to be confined to that elevation range between mean sea level and extreme high water.

The marsh in Barnstable Harbor, Massachusetts, was thoroughly examined by Redfield (1972). This study is particularly applicable to Nova Scotia because most of the plant species are common to both areas.

Redfield details not only present day plant distributions but also attempts to illustrate how the marsh zones were distributed through time. He places a date of 4000 ybp on the first marsh formation in the harbor (6 meters below the present marsh surface). Redfield also investigated how the salt marsh colonized new areas with a 12 year study mapping new marsh areas as they formed.

A quantitative study of both the salt marsh vegetation and molluscs along the Pacific coast of North America was carried out by MacDonald (1969). He demonstrated that some vertical zonation existed for both the flora and fauna within the salt marsh and that this zonation could be generally correlated with mean tidal heights (e.g. mean high water, mean higher high water, higher high water). In addition to the intra-marsh variations, regional differences were recognized between northern and southern areas. This study is one of the few that has examined plant and animal distributions together in a marsh. Unfortunately, molluscs have little use in paleoecologic marsh interpretations because their carbonate shells are dissolved in the low pH marsh sediments after burial.

It is interesting to note that in these well known publications there is little or no mention of marsh foraminifera.

Environmental factors: There is a large body of work concerning nutrient budgets and food supplies in marshes. However, these factors do not appear to be the limiting parameters in plant and animal distributions. The limiting factors appear more likely to be salinity and pH. The best documented rocord of these changes is from Mission Bay marsh, California (Phleger and Bradshaw, 1966; Bradshaw, 1968). A typical daily record from this area indicates that pH is lowest when dissolved oxygen is lowest. Oxygen is lowest during non-daylight hours when there is no photosynthetic activity. The salinity also changes diurnally but these variations are the result of the tidal cycle. At flood tide salinity is lowest as new sea water inundates the marsh, and salinity is highest immediately before the flood tide after evaporation has had its maximum effect. In Nova Scotia the opposite is probably true because freshwater runoff onto the marsh dominates over evaporation.

There appear to be vertical gradients within the marsh for both pH and salinity. Stevenson and Emery (1958) report lowest pH values at Newport Beach, California in the high marsh with increasing pH in the low marsh areas; this is also suggested by Scott (1976a) for Mission Bay. Salinity appears to be highest in the high marsh at Mission Bay (Scott, 1976a) where there is less supply of fresh sea water. In Nova Scotia again the opposite would be expected.

Temperature does not appear to be a limiting factor since all marsh surfaces experience wide temperature variations. These variations occur both on the diurnal and seasonal basis, and though variation is higher in the high latitudes, variations of temperature occurring even in subtropical climates are more than most marine organisms can tolerate. For this reason it is difficult to classify marsh faunal assemblages into zoogeographical zones (Scott, 1976b) as has been done for other marine groups.

Most of the variables discussed demonstrate a vertical gradient along the marsh surface with extreme values occurring in the higher areas of the marsh. The values of these parameters tend to become more marine and more stable lower in the marsh where there is increased marine influence. The stability of the environmental parameters just discussed with relation to elevation in the marsh probably determines patterns of distribution for the plant and animal communities of the marsh. Isolated determinations of salinity, pH, and temperature probably have little meaning in a highly variable environment such as a marsh.

Environmental capacities of some marsh organisms: Salt marsh vegetation is characteristic to salt marshes and rarely occurs outside the marsh area (except some high marsh forms). However, it has been clearly demonstrated that, when isolated from other species, the marsh species grow more vigorously in freshwater than in saline solutions (C. F. Phleger, 1971). This suggests that the plant species characteristic to salt marshes are really terrestrial species that have become non-competitive with other terrestrial species. Only their ability to survive some salt water inundation has prevented their extinction.

The opposite is true for most animals inhabiting the salt marsh. They are basically marine organisms occupying extremely marginal environment and must be able to tolerate environmental variations abnormally large for marine organisms. An experiment done with *Cerithidea californica* (California mud snail) indicates one way in which an organism copes with a highly variable surrounding (Scott and Cass, 1977). When submerged in freshwater (which is usually a temporary condition) the snail simply withdraws into its shell and remains there until salinity returns to normal.

Ecological tolerances have also been investigated for some marsh-estuarine foraminifera (Bradshaw, 1955, 1957, 1961), most notably *Ammonia beccarii* (Linne), a calcareous species. This species requires a particular set of conditions for reproduction but is able to survive under a much wider range of conditions. This is probably characteristic of many marsh species with reproduction occurring only during a short period of time when conditions are most favorable.

Distribution of marsh foraminifera: Marsh foraminiferal species are among the first described foraminifera (*Nautilus* (= *Ammonia*) *beccarii*, Linne, 1758; *Nautilus* (= *Trochammina*) *inflata*, Montagu, 1808; *Trochammina inflata macrescens* and *Quinqueloculina* (= *Miliammina*) *fusca*, Brady, 1870). However, their distributions were poorly known until relatively recently.

Most of the information regarding distribution of recent marsh foraminifera has been derived since 1950, and most of the investigations have been the work of Fred Phleger at Scripps Institution of Oceanography. Since 1950 he has examined distributions of marsh foraminifera from Barnstable, Massachusetts (Phleger and Walton, 1950), the Mississippi delta (Phleger, 1954, 1955), southwest Florida (Phleger, 1965a), southern Texas (Phleger, 1965b, 1966), the Pacific coast of North America (Phleger, 1967), Baja California (Phleger and Ewing, 1962) and Europe and New Zealand (Phleger, 1970). All these studies suggest high numbers of individuals and low numbers of species in marsh environments. Additionally, calcareous marsh species appear to prefer normal to hypersaline marsh environments while agglutinated forms dominate the brackish marshes. Some of Phleger's data suggest that zonation of marsh foraminifera, similar to that of the vegetation, also exists in marshes.

More recently the estuarine and marsh foraminifera of the James River estuary, Virginia, were examined in a thorough study by Ellison and Nichols (1976). They demonstrated within-marsh vertical variations of the foraminiferal assemblages as well as differences between slightly brackish and strongly brackish marsh areas.

Scott (1976a) demonstrated a clear relationship between floral and foraminiferal assemblages and surface elevations in the marshes of southern California. Scott (1976b) suggested similarities between foraminiferal faunas in brackish marshes in southern California and those of more northern regions such as British Columbia.

Terminology

A definition of terms crucial to understanding the following discussions is required.

There has been some confusion regarding the exact vertical and environmental limits of a salt marsh in the literature and it is necessary here to define precisely the limits that are applicable to this study. Chapman (1960, p. 1) provides a good basic explanation of these limits:

> "They (salt marshes) comprise areas of land bordering on the sea, more or less covered with vegetation, and subject to periodic inundation by the tide. They originate as bare mud - or sandflats which, as they become higher, are colonized by algae and flowering plants, the species involved varying in different parts of the world. The plants are enabled to occupy this habitat by virtue of their tolerance of the special conditions obtaining in salt marshes. The advent of the plants on the bare flats promotes further growth in height of land which, as this 'rising' takes place, results in changes in the environment so that different species can enter the area. Salt marshes, therefore, may extend vertically from about mean sea level up to the extreme upper limit of the tides, where they will abut on normal land vegetation or else grade into freshwater swamp."

In areas of extreme tidal range, such as the Bay of Fundy, the vertical range of the marsh no longer extends to mean sea level. For this reason the Fundy marshes are not included in this study. Additionally, marshes tend to form in protected areas such as lagoons or estuaries that allow sufficient sedimentation rates in regions of submergence. Since salt marshes are often associated with lagoons and estuaries, the terms marsh and estuary/lagoon are sometimes used interchangeably. From the above definition this is clearly not valid. All samples collected from the marsh will be denoted as marsh samples and those from below the marsh will be considered as estuarine samples.

The term "zone" is used to refer to either floral or faunal zones present within the vertical range of the marsh. Confusion arises when these zones are used to interpret Holocene stratigraphy of marsh sediments. "Zone" has also been used as a time stratigraphic unit. Marsh zones are, however, clearly not time-stratigraphic units. A necessary term is one which retains the vertical sense of a stratigraphic zone but not the time sense. The term selected here is KλĹVN ("kline" in English), a Greek work meaning "bed". The term "cline" has been used in population dynamics to describe an interbreeding population and is not applicable here. "Kline" is defined here as a biologic assemblage (either floral or faunal) that denotes a certain range of elevation relative to mean sea level. Boundaries of klines are delineated by changes in the dominant species characterizing a particular kline. "Subklines" are defined by the presence or absence of a subdominant species. "Sub-subklines" are recognized by the presence or absence of a subdominant species whose occurrence appears to be localized not only by elevation but also by some other parameter such as salinity. Klines and subklines can be used to locate former sea levels in Holocene sediments with an accuracy dependent upon the absolute vertical range defined by the kline or subkline. A sub-subkline can be used not only to locate a former sea level but also to indicate other environmental factors such as salinity. Since klines must be defined from modern assemblages for which there is good elevational and environmental control, the kline has no meaning in time and cannot be used to determine those former sea levels in sediments which are older than the range of the defining modern species.

There is usually some confusion when discussing sea level changes as to whether the change of sea level is caused by vertical land movements or by actual eustatic sea level change. To avoid this confusion the term "relative" or "apparent" sea level change is used. The symbol "r" is employed to denote relative sea level change and is written as follows:

$$r = R_e + R_w$$

where R_e and R_w are respectively, the sea level changes due to vertical land movements and eustatic variations. The rate of relative sea level change is r/t where t refers to time.

CHAPTER 2

METHODS

Collection of surficial samples

At all sampling localities in the marsh areas samples were collected by walking out on to the marsh during low tide and obtaining the material required for examination. Replicate samples of 10 cm^3 (10 cm^2 x 1 cm) were obtained at all localities. This is the standard size of sample collected by Phleger and has been used by the author for comparative purposes. Since the marsh material was rootbound and difficult to penetrate with standard plastic core liner, a stainless steel corer was developed by the author for special use in obtaining surface marsh samples (fig. 2).

The estuarine samples in Chezzetcook were obtained from a small craft at high tide. A small, lightweight box corer (15 x 15 cm) was used to obtain relatively undisturbed bottom samples. From each of these box core samples two 10 cm^3 replicates were collected.

Collection of subsurface material

Subsurface material was obtained in the form of cuttings by drilling with a posthole auger. The drilling method is the same as that used by Scott (1976a) and described for deep drilling by Medioli and Scott (1976). Drilling is confined to sediments with low sand content since the hole is uncased and caves in if the sediment is too sandy. The method works

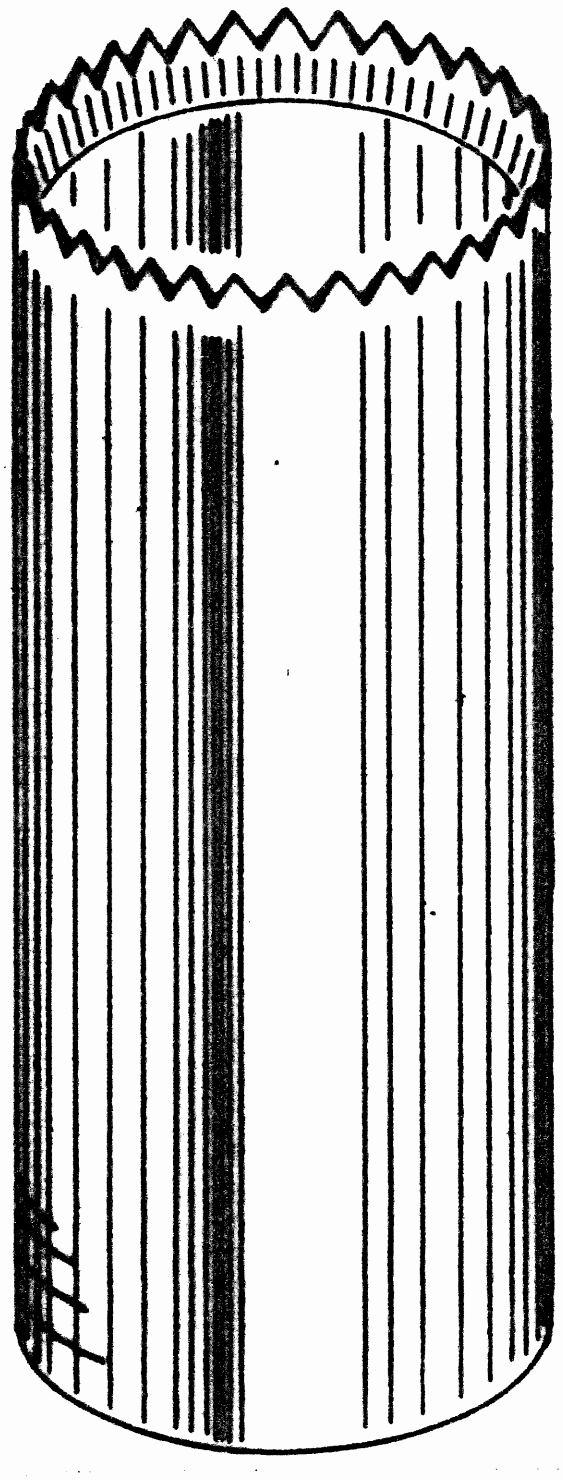


Figure 2. Scott surface marsh sampler: dimensions - i.d. = 3.5 cm, o.d. = 3.8 cm, length = 8-10 cm. Notice serated edge which is inserted into marsh surface. Made from stainless steel tubing.

best with three people but can be accomplished with two. The advantages of this method over other methods are the light weight of the equipment required and the relatively large samples obtained. The samples are usually of sufficient size to yield splits for foraminiferal, pollen, and diatom analysis as well as carbon-14 dating.

Collection of physio-chemical data

Salinities at all stations, estuarine and marsh, were recorded concurrently with the collection of the surficial material. At marsh locations an American Optical salinity refractometer (compensated for temperature variance) was used to determine the salinities. This instrument requires only a few drops of water for its determination and is especially useful in the dryer parts of the marsh. For estuarine values an RS-5 salinity recorder was used to obtain a salinity verses depth profile.

Temperatures were measured directly only in estuarine samples with the same RS-5 recorder. At marsh stations temperatures were not obtained directly since they were essentially the same as atmospheric values. Temperature-precipitation data for Middle Musquodoboit (a few km east of Chezzetcook) were obtained from the National Atmospheric Centre.

Preparation of samples

Grain size distribution was determined for some selected estuarine samples using the methods of Folk (1968). Organic carbon (dry weight) percentages were determined for all estuarine samples in Chezzetcook and some marsh localities. The samples were first dried at 100°C, weighed, and then ignited in a muffle furnace at 400-500°C for 12 hours and weighed again to obtain the percentage carbon.

Foraminiferal samples from surface locations were placed in a cold room subsequent to collection to prevent fouling. All samples were prepared by the following procedure within a week of collection: 1) wet sieved through .5 mm and .063 mm sieves (.5 mm retaining coarse organics and allowing foraminifera to pass to the .063 mm sieve where they were retained); 2) fine organic material was separated from forams and sand by decantation 3) sample was fixed in a solution of buffered formalin and Rose Bengal and allowed to stand overnight and 4) sample was washed free of formalin and Rose Bengal and preserved in alcohol. Those samples containing excess amounts of sand were dried and the foraminifera separated from the sand by floatation in Carbon tetrachloride. The separated foraminifera were then resuspended in alcohol. It is imperative that all specimens to be examined for presence or absence of Rose Bengal stain (living or dead respectively) be suspended in some liquid medium such as alcohol. This renders the test of the foraminifera more transparent and facilitates the detection of the stain.

Subsurface samples were prepared in much the same way as the surface samples. A 20 ml split was obtained from the bulk sample and sieved in the same manner as surface material. No formalin or Rose Bengal was added to these samples, but they were preserved in alcohol.

Examination, preservation, and photography of specimens

Most specimens were examined in alcohol; however, in subsurface samples where there was excess sand the samples were not resuspended and specimens were examined dry. In dried samples the residual foraminifera were split to a workable number of 300-500 when necessary using an "Otto" microsplitter.

Rose Bengal stain was used to stain protoplasm of individuals that were alive at the time of collection. The use of tissue stains is always subjective since stains never stain everything the same each time. Additionally, each person's perception of stained individuals is different. However, detection of significant changes in living populations is still possible since the changes are so large (sometimes two orders of magnitude) in the marsh environments examined.

A reference collection of all species has been prepared and placed with the collection of F. S. Medioli at the Atlantic Geoscience Centre, Dartmouth, Nova Scotia.

Photographs of species contained in this thesis were taken using the Cambridge scanning electron microscope at the Bedford Institute of Oceanography. Polaroid film with negative was used.

Map preparation

Since extremely detailed maps of the Chezzetcook area were required standard soil maps used in the other areas could not be used. Instead, color air photos were obtained and, using the Saltzman enlarging instrument at the Nova Scotia Department of Lands and Forests, they were enlarged, traced at a scale determined from a standard Department of Lands and Forests soil map, and pieced together to form the final map of Chezzetcook (fold-out 1). The same was done with the 1945 air photos of Chezzetcook.

Carbon-14 dating

Small wood fragments from basal deposits in drill holes were the prefered dating material. One freshwater peat was used to obtain a date, however peat was avoided whenever possible because of contamination from younger material growing above. The actual Carbon-14 dating was done commercially by Geochron Laboratories, Cambridge, Massachusetts.

CHAPTER 3

GEOLOGICAL SETTING

Areas of study along the Atlantic coast of Nova Scotia (Chezzetcook, Chebogue, Summerville) exhibit the characteristic geomorphology of formerly glaciated areas. Along the coast where inlets have their connection to the ocean, there are steep, eroding cliffs of glacial till with varying degrees of boulder armor in front of the cliffs. Inland there is irregularly rolling topography with both bedrock outcrops and large hills of glacial material being characteristic. In the larger coastal bays, such as St. Margaret's Bay and Mahone Bay, there are many drumlin islands; however, in smaller inlets there are usually few islands. Two notable exceptions are Chezzetcook and Chebogue inlets, both of which have many drumlin islands. Coincidently these two inlets are the only two along the Atlantic coast with large, well-developed marsh systems. This could indicate a causal relationship between the drumlin islands and marsh formation with the islands providing the protection from waves and strong currents as well as a large supply of sediments to newly forming marsh areas.

No bedrock is observed to be outcropping locally in Chebogue Harbour; however, in Chezzetcook there are areas where bedrock (Meguma Slate) is observed. Outcrops occur along the south shore of the West Head and along the eastern side of the inlet (where there is less marsh formation, fold out 1).

The Summerville marsh was a small marsh contained behind a beach barrier at the head of Port Mouton on the south shore of Nova Scotia. The marsh examined at this locality appeared to be the only marsh in the area; no extensive marsh system had developed outside of the area behind the beach barrier.

Wallace Basin, along the Northumberland Strait on the Nova Scotia shore, was in a much different geomorphological setting. This part of Nova Scotia together with the eastern shore of New Brunswick appear to have formed as marine terraces that have been raised by glacial rebound following the last deglaciation. The raised terraces are probably the landward extention of the marine terraces observed by Kranck (1972) in the Northumberland Strait. This area lacks the irregular rolling topography of the Atlantic shore. Topographic features such as gullies appear to be caused by postglacial erosion of streams in the area. There is little glacial drift; most of the soil in the area is derived from soft underlying Paleozoic sandstones.

CHAPTER 4

CHEZZETCOOK INLET-ESTUARINE DATA

Physiography

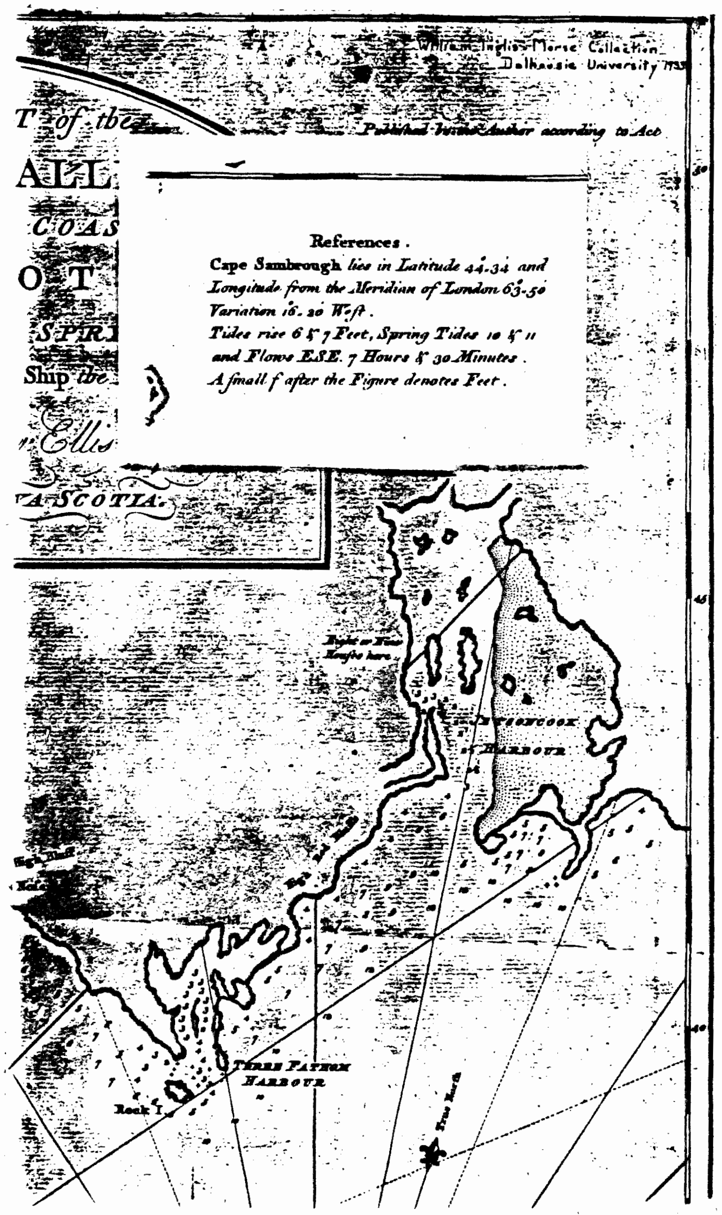
The mouth of the estuary is characterized by large sand spits having westerly and northerly extensions at Cape Entry and extending both north and east from Story Head (fold-out 1). Additionally, Red Island is primarily a sand bar. The largest features inside the inlet are the extensive intertidal mudflats and salt marshes. The intertidal areas are drained by a network of channels that dissect the mudflats. The channels begin at the head of the estuary as one large channel originating from the East Head which bifurcates just west of Labreque Island. A small channel from the West Head enters the main channel just above the bifurcation point and both continue down the estuary and empty into a large central area just south of Conrad Island. The upper part of the channel system in the East Head appears to be the remnant of a river channel; however, the channels in the open part of the inlet appear to be formed by tidal currents.

The inlet can be subdivided into several general areas: the nearshore area south of Conrad Island where the channels disappear into a large turbulent, shallow zone that is no longer intertidal; a large central region containing large mudflats and many drumlin islands; and an upper region which has comparatively narrow channels and a well-developed marsh area (East and West Heads). Additionally, there is a "pond" (stations 42-44) that is supplied with sea water only by the narrow channel that occurs between the spits at Cape Entry and the mainland.

Physical changes in Chezzetcook Inlet in historical times

Data sources: Rapid changes in the morphology of Chezzetcook Inlet over the last 200 years explain some recent sedimentological phenomena. The basic sources of information are a map prepared by Capt. James Cook in 1766, a British Admiralty Chart (no. 2439) prepared in 1854, a set of 1945 air photos and a set of 1974 air photos. Supplementary information was obtained from a 1927 topographic map.

Comparison of the 1766 and 1854 maps: The accuracy of the 1766 map (fig. 3) is poor compared to the excellent map produced in 1854 (fig. 4). Much of the distortion in the 1766 map may be the result of James Cook's inability to navigate past the entrance of the inlet with a large sailing ship. Near the entrance the major features appear to be mapped accurately. The 1766 map shows spits extending from Story Head and Cape Entry and a deep channel between the end of the Cape Entry spit and the small drumlin just west of Conrad Island. By 1854 this deep channel becomes shallow and is almost closed off. The entrance to the inlet is also substantially shallower. A large mudflat is shown on the east side of Chezzetcook in 1766 and by 1854 mudflats cover most of the inlet. It is doubtful that the large marsh shown behind the Cape Entry spit in 1854 was present in 1766. It is difficult to determine if the change in the size of the mudflat is real or not since the detail on the 1766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and Flows E.S.E. 7 Hours & 30 Minutes.
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True North

Figure 3. 1766 map of Chezzetcook prepared by James Cook.

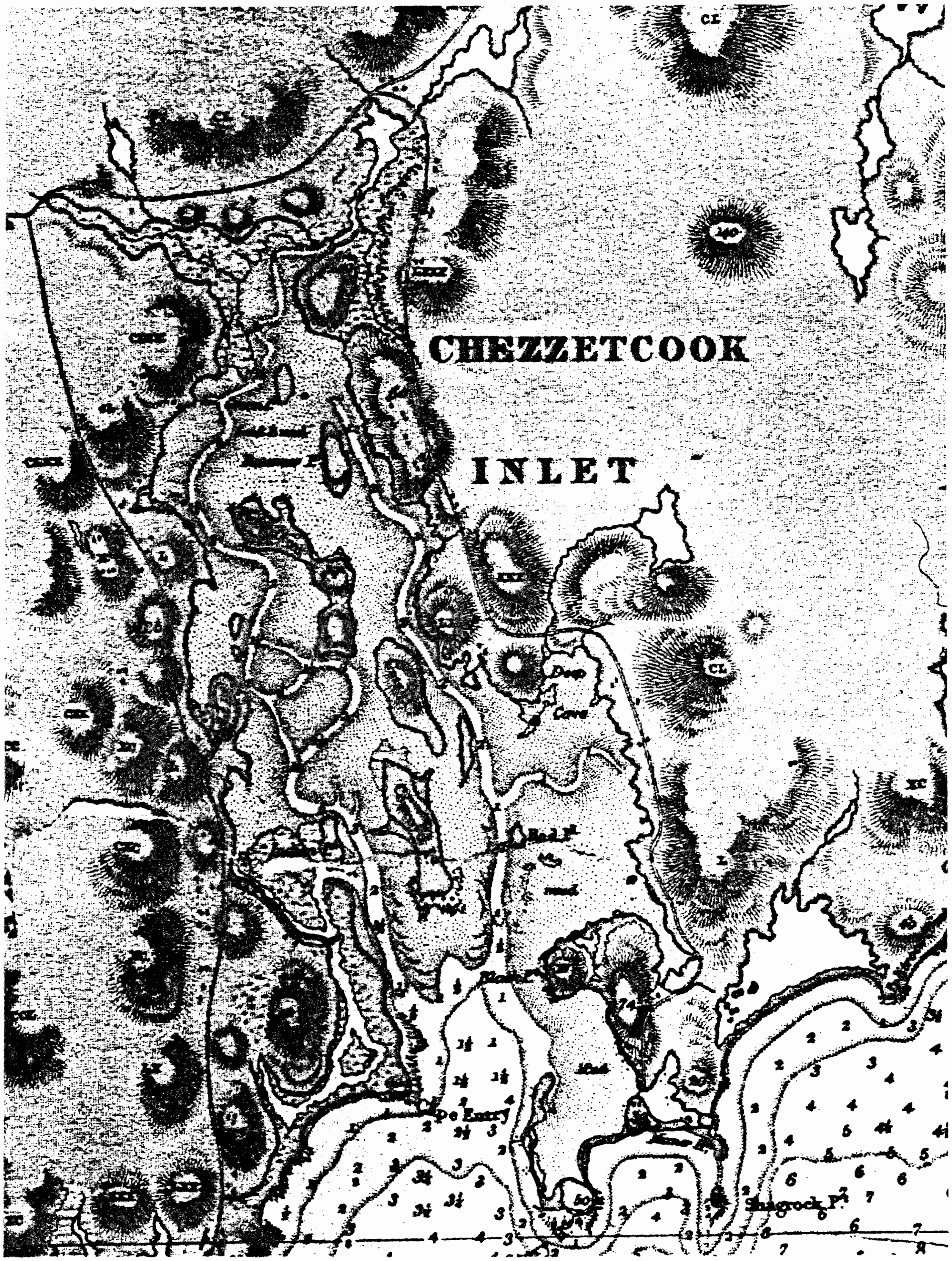


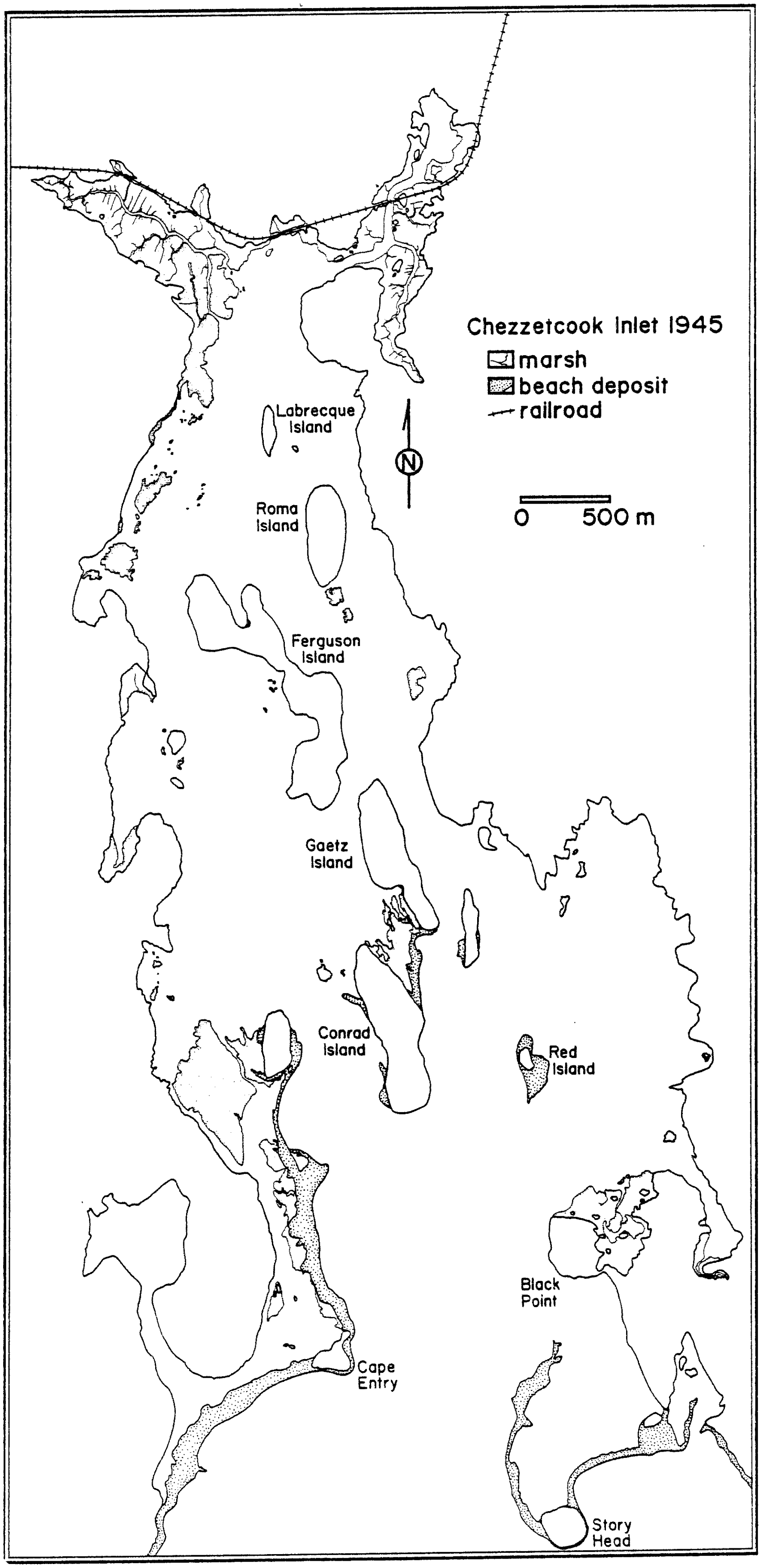
Figure 4. An 1854 map of Chezzetcook (British Admiralty chart).

map is completely distorted landward of Conrad Island. The most interesting and puzzling piece of information on the 1766 map is in the legend where the tidal range at Cape Sambro is given as follows: neap tides, 6 to 7 feet, and spring tides, 10 to 11 feet. On the 1854 map tidal ranges are given as the same as those today: neap tides 4-5 feet, spring tides 6½ to 7 feet.

The tidal range given for 1766 is controversial. Tidal measurements at Brest, France, measured with reliable accuracy since 1711, indicate that tides in the North Atlantic have since then changed less than 5% (Cartwright, 1972a, b). The apparent change at Halifax between 1766 and 1854 is of the order of 50%. Halifax is not in an area of extreme tides, like the Bay of Fundy, and changes in tidal range there should be similar to those elsewhere in the North Atlantic. It is difficult to dismiss the change as due to errors in measurement. Only simple vertical measurements are required to obtain spring and neap tidal ranges and these were certainly within the abilities of 18th century mariners. Insufficient measurements would only tend to minimize an apparent decrease in tidal range. Hence the possibility that there was a 50% decrease in tidal range between 1776 and 1854 can not be neglected.

Comparison of 1854 and 1945 maps: There were few major changes in the configuration of the inlet between 1854 and 1945. The 1945 photos (fig. 5) show no noticeable expansion of the marsh areas. There is a new small spit between Conrad and Gaetz Islands, which apparently formed after 1927, since it is not shown on the 1927 map. The opening in the

Figure 5. Map of Chezzetcook Inlet prepared from 1945 air photos.


Chezzetcook Inlet 1945
marsh
beach deposit
railroad
N
0
500 m
Labrecque Island
Roma Island
Ferguson Island
Gaetz Island
Conrad Island
Red Island
Black Point
Cape Entry
Story Head

northern extension of Cape Entry spit is closed by 1927. The houses on the small drumlin just west of Conrad Island suggest the closure may have been artificial. Some breakwaters that are still present today are shown near the entrance in 1927. The channel system has changed little since 1854; one new channel is shown on the 1945 air photos in the area between Ferguson and Roma Islands. The "pond" is shown as being swamp in 1854, but as open water in 1927 and 1945. The extent of marshes behind the Cape Entry spit (westerly extension) in 1854 appear greatly reduced by 1945. All islands appear to have remained the same size and shape between 1854 and 1945.

Comparison of the 1945 and 1974 maps: Changes between 1945 and 1974 (fold-out 1) are more pronounced than those between 1854 and 1945. Large movements of sand occurred near the entrance of the inlet. The spit on the west side of Conrad Island lengthened considerably between 1945 and 1974, further constricting the main channel which feeds the west part of the inlet. The small island just southeast of Gaetz island became connected by a sand bar to the main spit between Conrad and Gaetz Islands. The most pronounced change occurred in the vicinity of Red Island. It was a small, rounded island up until 1945; by 1974 it has an elongated, half-moon shape. Both the spits at Story Head and Cape Entry moved landward significantly between 1945 and 1974. This appears to have had little effect at Story Head but the Cape Entry spit has overridden existing marsh and isolated a small pond that had been open to tidal influence in 1945. North of the entrance to the inlet, mostly in its western part, much new marsh has formed since 1945. The large open mudflat north of Roma Island presently appears to be undergoing rapid colonization by marsh plants.

Oceanography

All currents in the inlet appear to be the result of tidal action. These currents are confined largely to the major channels and reach adjoining mudflats only during high tides. Although the estuary has a fairly large surface area its tidal prism is comparatively low because most of the water is contained in the channels which are small compared to the total area they supply. At low tide all of the water is contained in these channels and the mudflats are subaerially exposed. Consequently even the freshwater input, though it is comparatively low (no major rivers), dilutes the incoming seawater substantially, especially at low tide. This contrasts sharply with the LaHave estuary near Lunenberg, N. S. which is associated with a large river but has a smaller surface area. Seawater is not diluted as much as in Chezzetcook however, because it is deeper and has a larger tidal prism (Scott, unpublished data).

Detailed physio-chemical data were collected concurrently with foraminiferal samples (Tables 1, 2, appendix). Unfortunately most of these data were obtained only at the time of bottom sampling. At five stations (22B, 23B, 49, 50, 51) at least two measurements of the salinity/temperature/depth profile were made on different tidal cycles. Since it was not possible to reach most mudflat areas by boat except at high tide, most of the measurements were taken in the interval of two hours before high tide to two hours following the high tide. It was impossible to obtain measurements at the same moment of the tidal cycle for each station so values in Tables 1, 2 (appendix) should be interpreted in the context of the tidal cycle. Maximum salinity values would be expected at and just after flood tide.

The zones recognized by foraminiferal content can be briefly described in terms of maximum salinities recorded at these stations. The upper estuarine subzone A (Sta. 21A-27A, 28A-30C) has an average salinity of 15.8‰ (SD. = 3.20‰) with values ranging 11.6-21.1‰ with lowest values occurring in the West Head. The upper estuarine subzone B (27B, C, 31A-34C) has an average salinity of 20.4‰ (SD. = 4.31‰) with values ranging 13.1-26.4‰ with highest values occurring at the boundary with the lower estuarine zone. The lower estuarine zone (34D-39A) has an average salinity of 29.7‰ (SD. = 1.71‰) with values ranging 25-31‰ with highest values on boundary with the open bay zone. The open bay zone (Sta. 39B-41E) has an average salinity of 31.4‰ (SD. = .29‰) with values ranging 30.8-31.8‰. The nearshore zone is identical to the open bay zone in terms of salinity. The sparse data that could be obtained at low tide demonstrate that salinities can be much lower during low tide. Low tide bottom water salinities at stations 21-23 ranged from 0-2‰ while high tide salinities for stations 22B and 23B ranged 13-17‰. These stations are at the head of the estuary where the maximum variability would be expected with decreasing variability down the estuary. However, in the bottom water, salinity variations remain surprisingly high even near the mouth of the estuary. At stations 49, 50, and 51 values of 26, 27, and 29‰ respectively were obtained two hours before high tide. The same stations recorded values of 31, 31, and 31‰ one hour after high tide, showing increases of 5, 4 and 2‰ with high tide.

Stations in the "pond" area (Stations 42-44) had uniformly high salinities (31‰) at the time of sampling. Salinities here probably do not change substantially with the tidal cycle because of almost non-existent tidal action. Salinities were high because the sand barrier just seaward of station 44 had recently been breached by storm waves, allowing large amounts of undiluted sea water to invade the area. The "pond" was mildly brackish until recently as evidenced by the dead fresh-water plants that were observed during sampling. This area is important because it represents an area where neither a brackish condition or an oceanic condition can become permanently established.

The water temperatures in the inlet are controlled by two factors: atmospheric temperatures and ocean water temperatures. Atmospheric temperatures are the most variable. In areas where there is less oceanic influence (i.e. near the head of the estuary) water temperatures are close to air temperatures. The presence of a sharp halocline is usually associated with a well-defined thermocline with warmer, less saline water on top and colder more saline oceanic water below. During the winter when the ocean is warmer than the atmosphere, there is probably a reverse thermocline with warmer, oceanic water below colder, less saline water. Because of ice conditions, this could not be verified. Bottom water temperatures at the head of the estuary probably vary from -.5 (?) to +20°C over the year while temperatures at the mouth may vary between -.5 and +12°C, roughly the same as the ocean.

The Chezzetcook estuary cannot be simply classified as stratified, partially stratified, or vertically mixed because all three types are present. The estuary tends to be more stratified near the head and less stratified seaward. The stratification depends on the supply of freshwater and this supply decreases seaward. Stratification is most pronounced at high tide at the head of the estuary (e.g. Sta. 22B, June 2) and at low tide near the mouth (e.g. Sta. 49, 1010h).

The tidal range of the inlet, which is of great importance to this study, varies between the upper and lower parts of the estuary. At the East Head of the estuary tidal gauge data taken at the railroad trestle show the maximum tidal range to be 186 cm with higher high water at +192 cm and lower low water at +6 cm with Z_o (mean sea level) at +107 cm. The mouth of the estuary is taken to be the same as that observed at Halifax which has a maximum range of 214 cm with higher high water at +226 cm and lower low water at +12 cm with Z_o being at 125 cm.

Surficial sediments

The distribution of sediments with respect to grain size (Table 1) followed the characteristic pattern of a shallow, marine dominated estuarine-lagoon system. Fine sediments at the head of the estuary grade to coarser sediments at the mouth (Phleger, 1969, 1977). The modal grain size in the channels is at least one size class larger than sediments found on adjoining mudflats. In some river dominated systems, such as Miramichi (Reinson, 1976), the opposite occurs: finer sediments occur in channels and coarser sediments occur on adjoining shallow areas.

STATION NUMBER	22a	22b	33b	33c	34c	34d	39b	39c	49	53
Percentage (by wt.) > 1 Ø	0	0	0	0	0	0	0	0	1.0	0
0 - 1 Ø	0	0	.1	0	0	0	0	0	.6	0
1 - 0 Ø	0	0	0	.1	0	0	0	0	1.3	.2
1 - 2 Ø	0	0	0	.2	.1	0	.1	1.3	33.4	5.2
2 - 3 Ø	0	.3	.6	1.3	24.6	.3	9.4	77.1	61.1	88.4
3 - 4 Ø	0	3.6	13.8	3.0	32.0	8.1	47.6	17.0	.8	5.1
4 - 6 Ø	19.6	63.9	50.0	43.0	17.6	61.2	31.2	1.5	.5	.3
6 - 8 Ø	49.9	18.0	18.2	29.6	16.1	16.6	4.4	0	.5	.3
< 8 Ø	28.9	13.8	16.7	22.6	9.2	13.6	6.0	1.9	.5	.3

Table 1. The grain size distribution of some estuarine sediments, Chezzetcook Inlet.

Organic carbon content of the sediments is 10-15% (dry weight) near the head and decreases to less than 1% at the mouth (Sta. 49-55). Values on the mudflats were generally higher than in the channels.

Foraminiferal results

A total of 74 species of benthonic Foraminifera were identified in the estuarine samples of Chezzetcook. Thirty-one species had living representatives in the sediments at the time of sampling (fig. 6, fold-out 1,2). Six assemblage zones were recognized using an intuitive visual approach: upper estuarine zone A, upper estuarine zone B, lower estuarine, open bay, open ocean-nearshore, and stagnant-brackish "pond" (fig. 7). Additionally, a freshwater lake above the West Head of Chezzetcook was sampled for Thecamoebians (sta. A, B, fold-out 2).

The upper estuarine assemblage zone A (stations 21A-27A, 28A-30C) is characterized by high percentages of *Miliammina fusca* with lesser percentages of *Ammotium salsum* and *Ammobaculites foliaceus*. In areas where channels were narrow (i.e. sta. 25, 28-30) there were high numbers of the marsh species *Trochammina inflata macrescens*, *Trochammina inflata*, and *Tiphotrocha comprimata*. Since the sides of these channels were composed of marsh peat which was continually caving into deeper areas, the presence of these marsh species were probably the result of contamination and they are therefore not characteristic of zone A. This zone had an average number of species/station of 7.5 (SD = 1.26) with 99.1% (SD = 2.80) arenaceous species.

Figure 6. Sampling locations for estuarine samples, Chezzetcook. Note each sample is marked by a dot due to the small scale of the map.

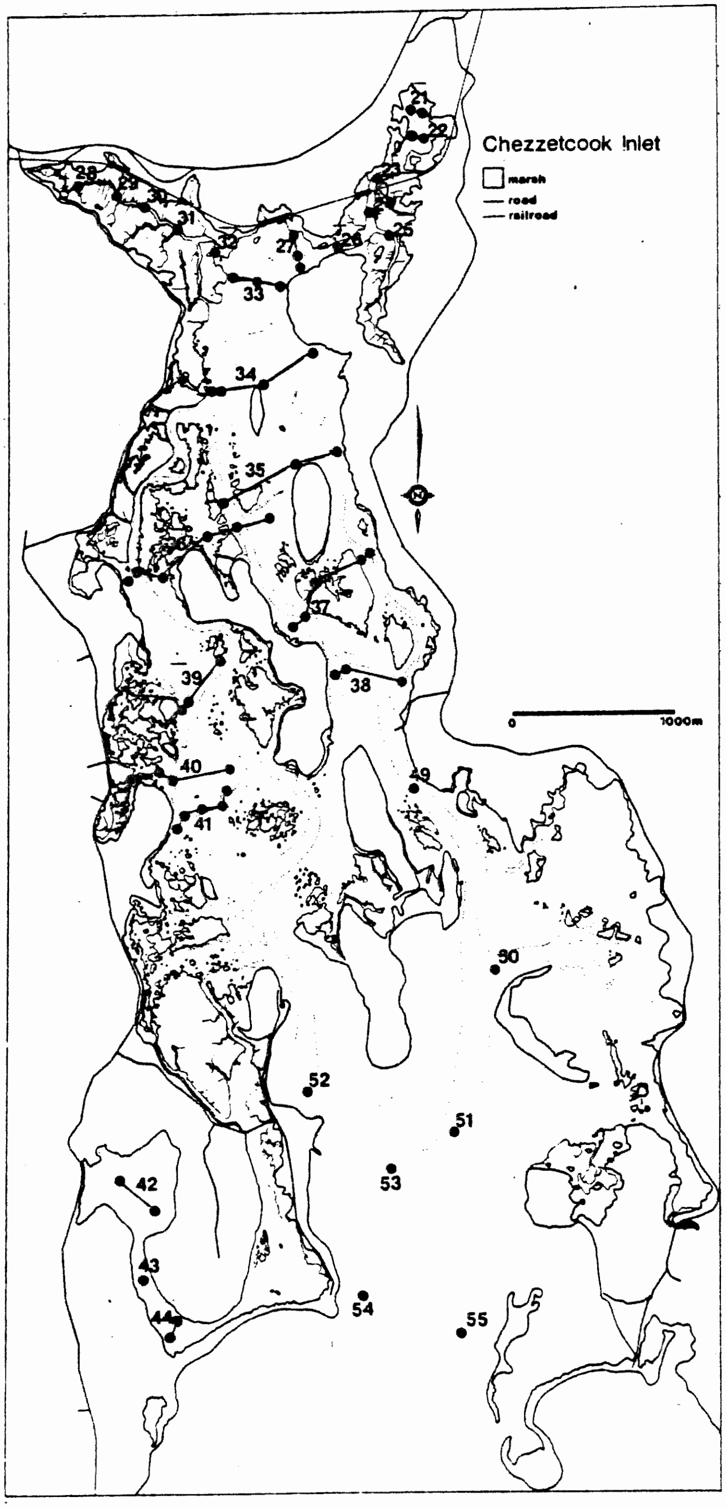

Chezzetcook Inlet
marsh
road
railroad
21
22
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
49
50
51
52
53
54
55
N
0
1000m

Figure 7. Distribution map of estuarine foraminiferal assemblages in Chezzetcook Inlet.

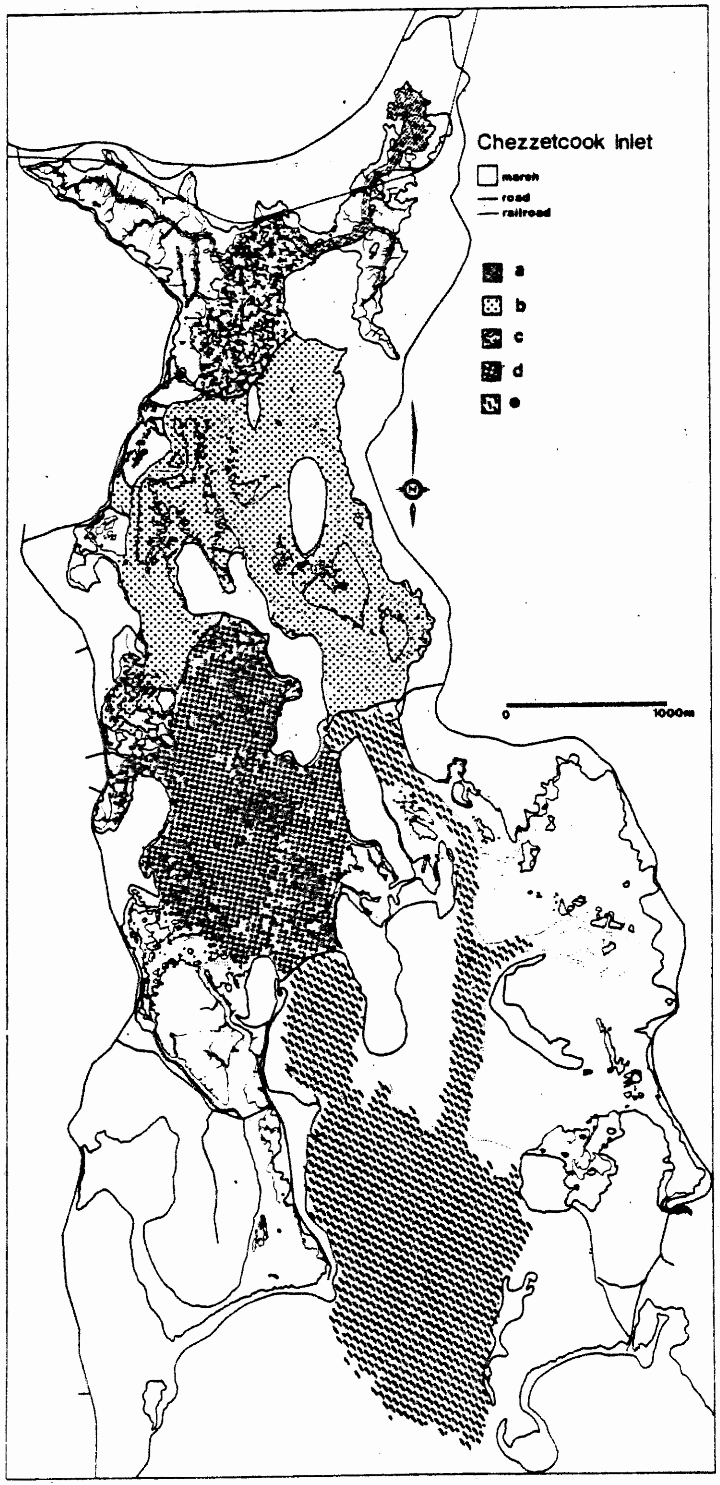
a - Upper estuarine zone A

b - Lower estuarine

c - Upper estuarine zone B

d - open bay

e - nearshore


Chezzetcook Inlet
marsh
road
railroad
a
b
c
d
e
N
0
1000m

The upper estuarine assemblage zone B (sta. 27B, C, 31A-34C) is a small zone that appears between the upper estuarine zone A and lower estuarine assemblage zones. *Miliammina fusca* is the dominant species, *A. salsum* increases and *A. foliaceus* decreases compared to zone A. Additionally, *Hemisphaerammina bradyi* and *Protelphidium orbiculare* occur more regularly. This zone had an average number of species/station of 8.7 (SD = 1.97) with 98.2% (SD = 2.0) arenaceous species.

The lower estuarine assemblage zone (sta. 34D-39A) is characterized by increased abundances of calcareous species. *Cribroelphidium excavatum*, *C. excavatum clavatum*, *C. excavatum selseyensis*, and *Ammonia beccarii*, all calcareous species, make their first sustained appearance in this assemblage zone. Also appearing more commonly are *Eggerella advena*, *H. bradyi* and *P. orbiculare*. Conversely, percentages of *M. fusca* and *A. salsum* decrease measurably with *A. foliaceus* disappearing almost completely. This zone had an average number of species/station of 12.8 (SD = 4.6) with 59.6% (SD = 26.2) arenaceous species.

The open bay assemblage zone (sta. 39B-41E) is characterized by the appearance in small but significant percentages of some open ocean species together with the disappearance or dramatic reduction of some of the estuarine forms. The dominant species are the *Cribroelphidium* spp., and *P. orbiculare*. The open ocean forms entering are *Buccella frigida*, *Cibicides lobatulus*, *Glabratella wrightii*, and *Rosalina columbiensis*. The estuarine forms disappearing are *A. salsum*, *H. bradyi*, and *M. fusca*. This zone had an average number of species/station of 24.9 (SD - 6.8) and 24.6% (SD = 12.0) arenaceous species.

The open ocean-nearshore assemblage zone (sta. 49-55) is characterized by the absence of the estuarine forms observed in other zones. The zone is dominated by *Cribroelphidium incertum* and *C. lobatulus* with *Quinqueloculina semiulum* and *R. columbiensis* being moderately common. This zone had an average number of species/station of 12.8 (SD = 6.0) and 0.6% (SD = 1.12) arenaceous species.

The final assemblage zone, the stagnant-brackish ("pond") zone is characterized by extremely low numbers of individuals. The most common species appear to be *P. orbiculare* and *A. foliaceus*. However, there is no regular distribution with such low abundances. This zone had an average number of species/station of 2.9 (SD = 2.3) and 65.7% (SD = 36.8) arenaceous species.

The lake contained only freshwater "thecamoebians". The samples taken were bulk samples, not standard size, collected for the purpose of locating the source of the few thecamoebians observed in the estuarine sediments.

These data were subjected to a Jaccard's coefficients of association, unweighted pair-group method (the same as that used by Scott *et al.*, 1977). Best confidence levels (.30) were recorded for the divisions between the lower estuarine-open bay group, the nearshore group, and the upper estuarine group. Lower confidence levels were recorded for the divisions between the lower estuarine zone and the open bay (.45) and between upper estuarine zone A and zone B (.50). For a comparison of the author's visual technique and this statistical approach see Scott *et al.* (1977).

Comparison with other estuarine environments in the Maritimes

Chezzetcook estuary differs from other estuaries investigated in Atlantic Canada because most of the estuary is intertidal rather than subtidal. In faunae reported from deeper estuaries of Atlantic Canada the species *Ammotium cassis* dominates at least part of the estuary (LaHave, Allen and Roda, 1977; Miramichi, Scott *et al*., 1977) with the notable exceptions of Tracadie Bay (Bartlett, 1965) which is a shallow estuary, and the same Miramichi estuary in 1964 (Bartlett, 1966). In Chezzetcook this species is completely absent.

Despite the absence of *A. cassis* the faunae observed in Chezzetcook are similar to those observed in Miramichi. The upper estuarine zone A in Chezzetcook compares almost exactly with the river assemblage of Bartlett (1966) and the upper river of Scott *et al*. (1977) in Miramichi. The upper estuarine zone B of Chezzetcook is moderately similar to the lower river assemblage of Scott *et al*. (1977) in Miramichi. The major difference between the upper estuarine faunae of Chezzetcook and the river faunae of Miramichi is that there are large numbers of thecameobians in Miramichi and very few in Chezzetcook. The lower estuarine and open bay faunae of Chezzetcook can be most closely compared with the open bay faunae observed in Miramichi by both Bartlett (1966) and Scott *et al*. (1977). However, the open bay fauna of Chezzetcook contains many more open ocean forms than anywhere in Miramichi. The transition fauna observed in Miramichi by Scott *et al*. (1977) appears to have no correspondent in Chezzetcook. There are no comparable environments for the "pond" or nearshore assemblages in Miramichi.

In other estuaries and bays in the Maritimes one assemblage usually dominates: *A. cassis*-*Eggerella advena*-*Protephidium orbiculare* in LaHave (Allen and Roda, 1977); *Cribroelphidium* group-*E. advena* in Halifax Harbour; (Gregory, 1970), and *Ammonia becarii* - *Cribroelphidium* spp. - *E. advena* in Tracadie Bay, P.E.I. (Bartlett, 1965). Tracadie Bay is interesting because it has the only other large populations of *A. beccarii* reported from the Maritimes. Schafer and Cole (1976) report an *A. cassis* - *E. advena* assemblage occurring near the head of Chaleur Bay, New Brunswick.

Bartlett (1964) reported on faunae in Mahone Bay and St. Margaret's Bay however, these faunae are nearshore, rather than estuary, assemblages.

Discussion

From the salinity data it can be observed that a major break in the salinity regime occurs between the upper estuarine and lower estuarine-open bay zones. This is reflected in the percentage of calcareous species observed in these two broad areas: usually less than 2% in the upper estuarine zones and 40-80% in the lower estuarine and open bay zones. The average maximum salinity in most of the upper estuary is less than 20‰ with minimum salinities much lower. The average maximum salinity in the lower estuary and open bay is close to 30‰ and probably does not fall below 20‰. It has been suggested by Bartlett (1966) that 20‰ is the lowest salinity that most calcareous forms can survive for extended periods of time and the Chezzetcook data appear to support this.

The differences between the open bay and upper estuarine faunae could depend on a number of factors. The proximity of the open bay zone to the nearshore environment makes this area slightly more stable in terms of environmental variability. However, it is also more susceptible to "contamination" from the much more diverse nearshore foraminiferal populations. This is reflected by a sharp difference in the average number of species between the lower estuarine zone (12.8 species/station) and the open bay zone (24.9 species/station).

Three of the described assemblage zones are not comparable with the ones just discussed: the nearshore zone, the "pond", and the freshwater lake. The nearshore assemblage appears to be an attached fauna and its occurrence can be correlated with the coarser sediments and strong currents present at stations 49-55. The "pond" fauna represents a stagnant-brackish condition in which foraminifera or even thecamoebian faunae are not likely to become established because the environment can change suddenly from a brackish to a marine condition. Cores in this area would possibly reveal if there have been periods of time when conditions were sufficiently stable to permit large populations of foraminifera or thecamoebians. Piper and Scott (in Piper and Keen, 1976) recognized a stagnant brackish sequence in a late Holocene deposit from a core in Mahone Bay which had short sequences containing a distinct nearshore fauna. This can occur when the barrier is breached in an area such as the "pond" in Chezzetcook and remains open over a period of a few years. The freshwater lake fauna was examined to establish the source of the few thecameobians in the upper estuarine fauna.

The number of thecamoebians in any upper estuarine fauna is probably directly proportional to the freshwater inflow. The Miramichi estuary, which not only has the large Miramichi River source but several other large streams discharging along its length as well, has a large representation of thecamoebians. Chezzetcook, with only two small streams entering at the head, has very few thecamoebians in the estuarine sediments. Bolli and Saunders (1954) suggest that thecamoebians do not live in estuarine sediments, but that they are only contaminants from freshwater sources upstream. The results from Chezzetcook and Miramichi tend to support Bolli and Saunders (1954).

A confused assemblage can occur in those areas in the upper estuary where the channels are narrow and steep with marsh peat continually falling into lower areas (sta. 28-30). However, such an assemblage in ancient sediments can be used to determine if subsurface intertidal-subtidal mud deposits were in close proximity to a salt marsh. It is likely that ancient sediments containing an upper estuarine fauna without high numbers of marsh species were deposited in an area at least as open as stations 21, 22 in the East Head of Chezzetcook.

One characteristic of the Chezzetcook assemblages is the total absence of *Ammotium cassis*. In the estuaries where *A. cassis* is observed, it is usually found in relatively deep, stable areas where there is a "ponding" effect with high organic content and rapid sedimentation rates (Scott *et al.*, 1977). Data from Chezzetcook indicate that temperature and salinity ranges (even in the deeper channels) are too great to allow

A. cassis populations. The author believes that A. cassis is essentially a nearshore form that invades estuaries where conditions are favorable (i.e. stable enough). Usually the associated sediments are high in organics and have a comparatively low pH which is favorable to A. cassis because it is an arenaeous form not subject to solution in acidic conditions. Ammotium cassis, while usually not particularly abundant in nearshore sediments, can occur in large numbers in estuaries. This is probably the result of a comparatively lower level of competition from the more primitive estuarine forms. This type of relationship has been recognized in the coastal lagoons of southern California where characteristic nearshore arenaceous forms occur in the inner part of the deeper lagoons in large numbers (Scott et al., 1976). As suggested by Scott et al. (1976) the presence of these arenaceous nearshore forms can be used to indicate the presence or absence of a deep, stable lagoon as opposed to a shallow, unstable lagoon. If A. cassis was observed in drill holes of cores in Chezzetcook, it would suggest that at one time Chezzetcook was a deeper, more stable estuarine system.

One species which occurs very rarely in the deeper estuaries, but is present in some abundance in Chezzetcook, is Ammonia beccarii. This species needs relatively high temperatures to reproduce (20°-30°C, Bradshaw, 1957) which do not occur in the deeper estuaries in northern areas. Significantly, the first reported occurrence of large living populations of A. beccarii in the Maritimes was in Tracadie Bay, P.E.I., another shallow, unstable estuarine area (Bartlett, 1965). Similarly, the northernmost reported occurrence of *A. beccarii* on the west coast of North America is at a shallow, protected intertidal bay 80 miles north of Seattle, Washington (Scott, 1974). Just as *A. cassis* signifies a deeper area, *A. beccarii* indicates a shallow, highly variable environment, especially in northern areas.

Comparison of adjacent intertidal and shallow subtidal samples in Chezzetcook indicates that no distinction can be made on the basis of foraminiferal content between intertidal mudflat and shallow subtidal environments in Chezzetcook. Conversely, in a deeper estuary (Miramichi) Bartlett (1966) demonstrated that the intertidal and subtidal areas could be distinguished by means of foraminifera. However, the contrast between the environmental stabilities of these areas is much higher in Miramichi than in Chezzetcook. If though there are slight differences in the sedimentological characteristics of the mudflats and channels in Chezzetcook, they are not sufficient to delineate intertidal from subtidal without faunal evidence. Since the intertidal and subtidal sediments of Chezzetcook cannot be delineated, their use as indicators of former sea levels can only be approximate. These environments extend from mean sea level (MSL) to approximately 5 meters below MSL and their accuracy as datum indicators is ± 2.5 m.

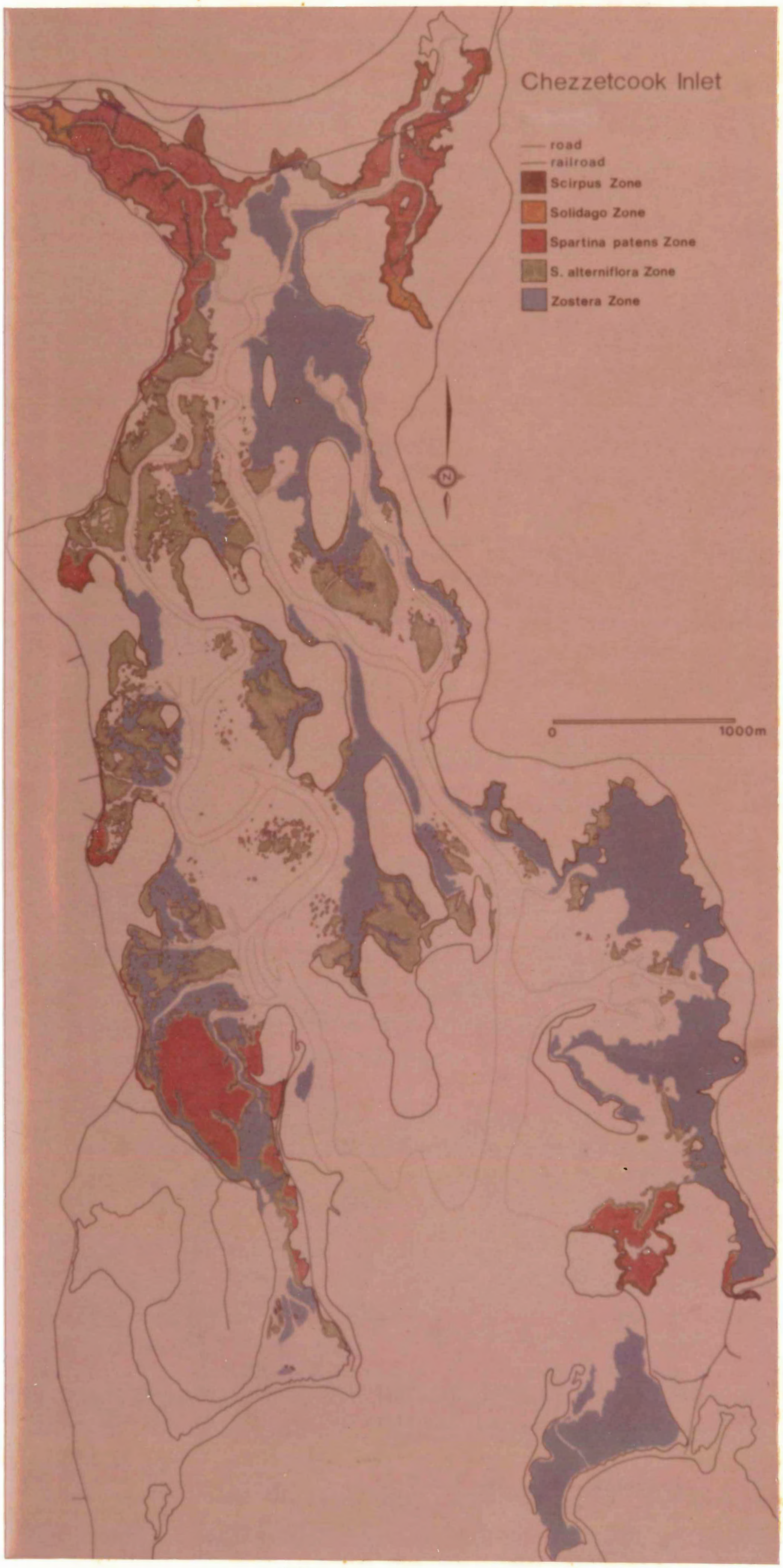
CHAPTER 5

CHEZZETCOOK SALT MARSH AREA

Vegetation

A distinctive characteristic of most salt marshes in the world is the apparent vertical zonation that occurs within the marsh (Chapman, 1960). Additionally, there are newly forming or colonizing marshes where the full vertical range has not become established as compared to an older or mature marsh where the full vertical zonation has developed. An overall view of the salt marsh distribution in Chezzetcook (fig. 8) illustrates that most of the mature marsh areas (*Spartina patens*) are confined to the upper estuary. One large mature marsh area is near the mouth behind the large barrier at Cape Entry. The mature marsh in the East and West Heads has a morphology distinct from the marsh areas on the lower estuary. Most of the marsh shown as *Spartina patens* is contained in an extremely narrow vertical range (15-20 cm) and has virtually no vertical gradient. The high marsh is a relatively narrow band of vegetation occurring along the landward edge of the area (*Scirpus* in fig. 8). The channels are steep-sided because the marsh peat forming the sides of the channels is continually being undercut which causes caving. On these steep sides the low marsh (*Spartina alterniflora* in fig. 8) is developed; however, because its horizontal extent is severely restricted, the low marsh does not develop to its fullest potential. Along these steep channels levees with a distinctive *Solidago* flora also develop. Areas lacking steep sided channels have poorly developed

Figure 8. Areal marsh vegetation distribution in Chezzetcook Inlet.


Chezzetcook Inlet
road
railroad
Scirpus Zone
Solidago Zone
Spartina patens Zone
S. alterniflora Zone
Zostera Zone
N
0
1000m

levees. In the lower estuary where marsh vertical gradients are more uniform, floral assemblages are not severely compressed laterally with the result that an additional floral assemblage forms in the low marsh. The large low marsh areas (S. alterniflora) in the central part of the estuary are newly formed and occupy only a small vertical range (10-15 cm a.m.s.l.). The Zostera (eel grass) beds are also illustrated (fig. 8), though they are not part of the salt marsh, to show that there are large areas of mudflat covered by aquatic vegetation other than salt marsh. It is possible that the eel grass beds may have a significant role in salt marsh formation by trapping more sediment thus allowing some surfaces to rise faster than sea level and eventually allowing salt marsh colonization. The areas in Chezzetcook that appear to be forming marsh most rapidly at the present time are those where eel grass is abundant.

Vertical zonations have usually been designated as high marsh "zone", low marsh "zone", etc. However, for reasons already described, the zonation will be defined in terms of floral and faunal "klines" rather than zones. Five transects, two in the upper estuarine marshes (trans. I, III, figs. 9, 10), two in the central area (trans. II, V, figs. 11, 12), and one at the mouth of the estuary (tran. IV, fig. 13) illustrate the vertical floral klines present in Chezzetcook. The high marsh floral klines are characterized by Scirpus spp., Juncus gerardi, Solidago sempervirens, and some terrestial plants in the upper range with occasional Potentilla anserina. Higher high water is marked by the first

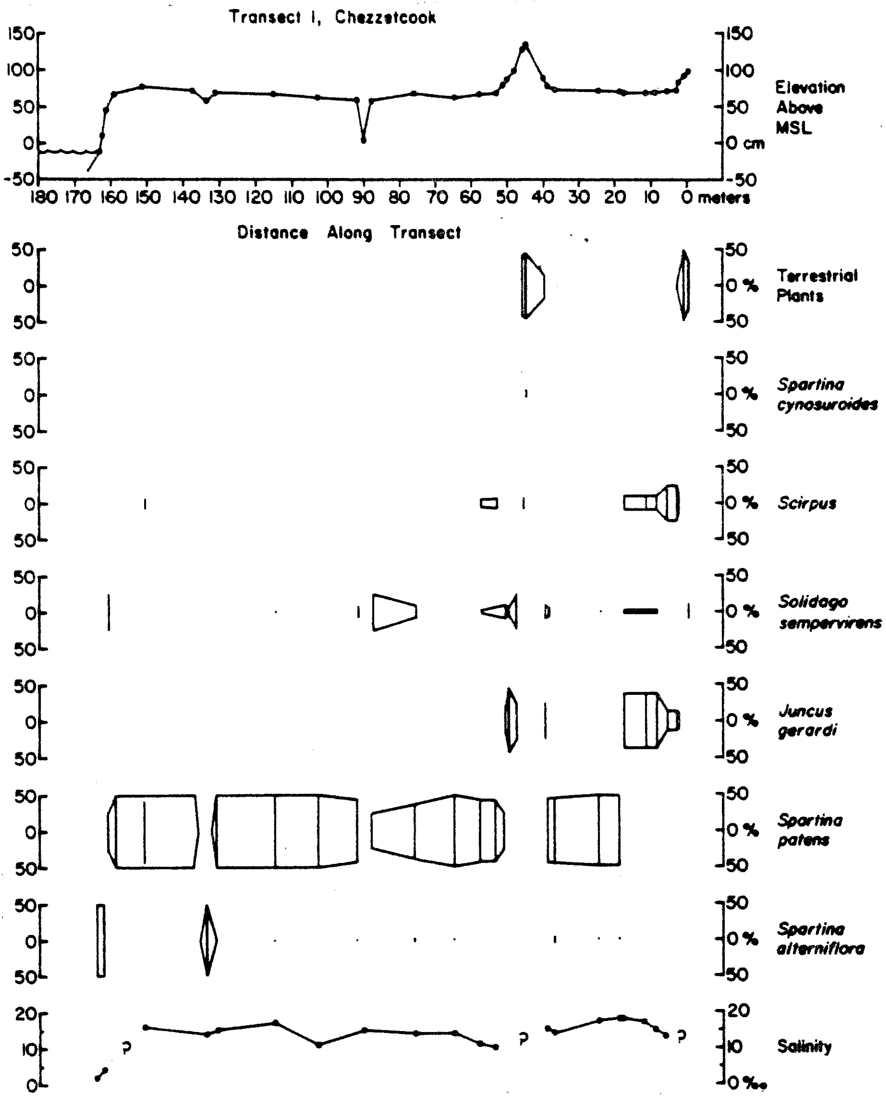


Figure 9. Plant and salinity distributions along transect I, Chezzetcook. Dots are sampling localities and vertical bars are percent occurrences of plant species at each locality.

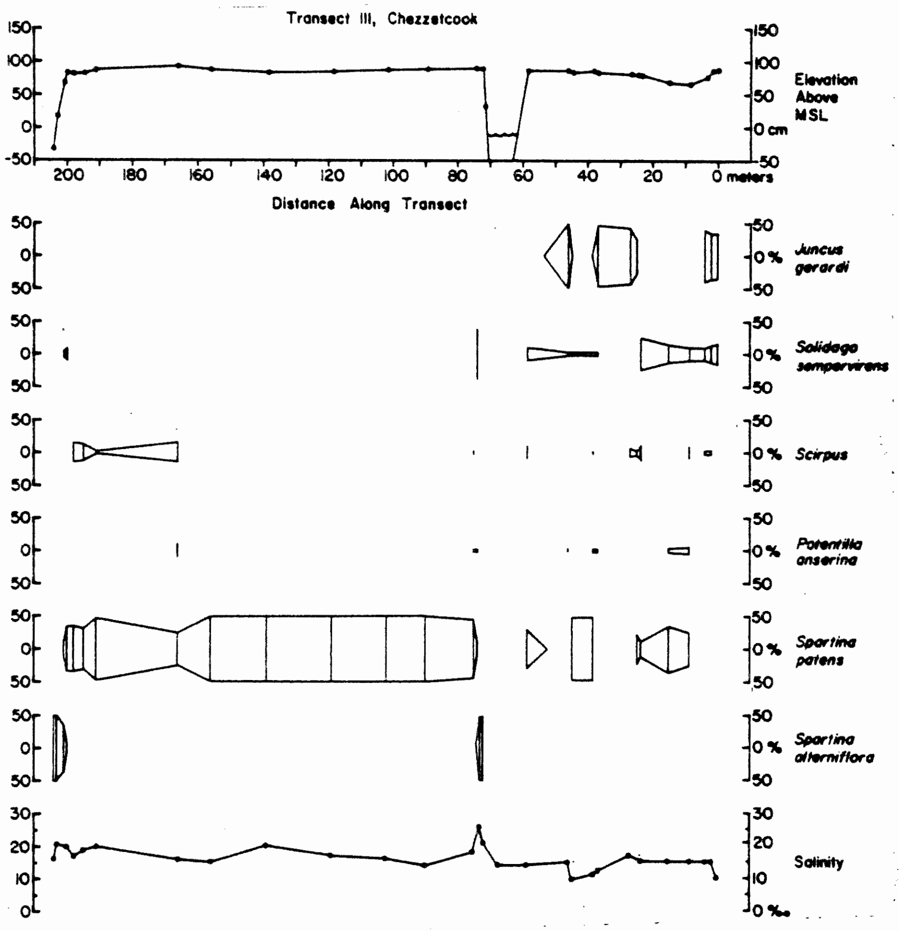


Figure 10. Plant and salinity distributions along transect III, Chezzetcook. Dots are sampling localities and vertical bars are percent occurrences of each plant species at each locality.

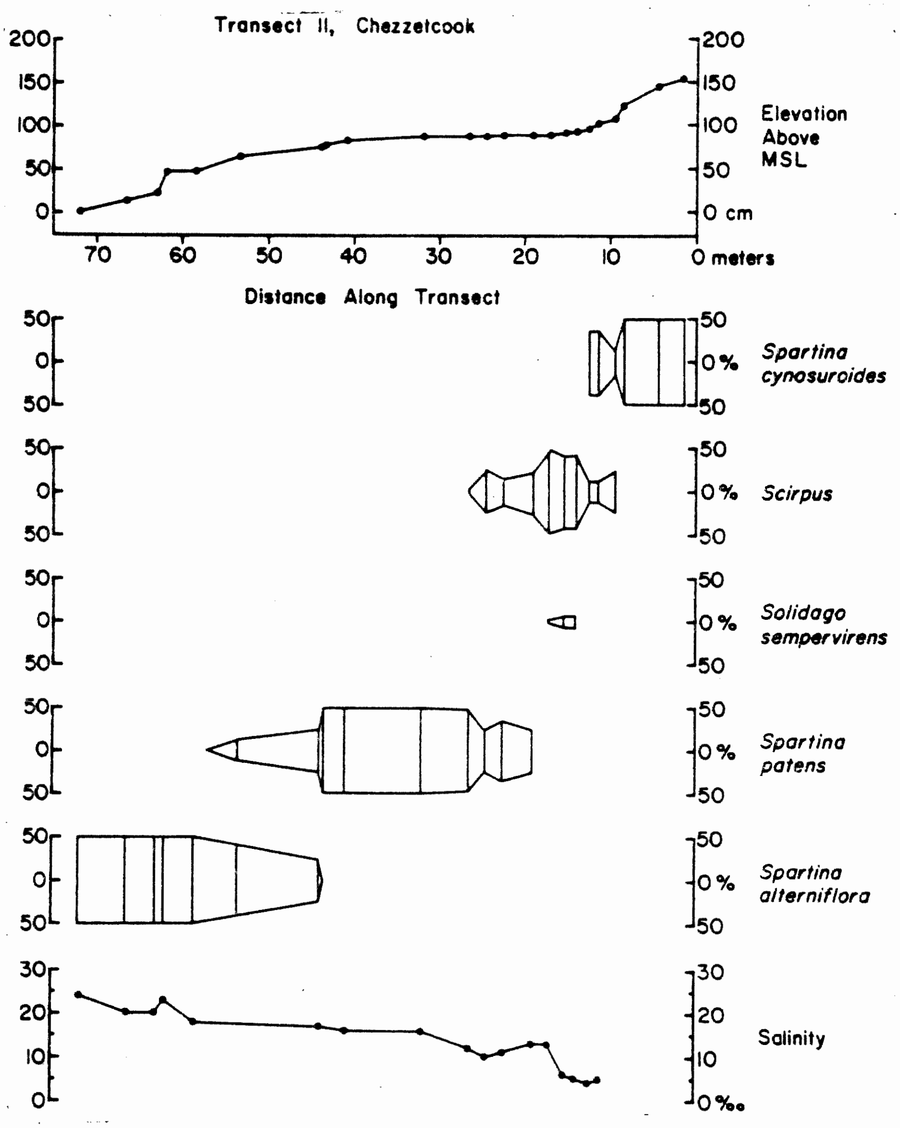
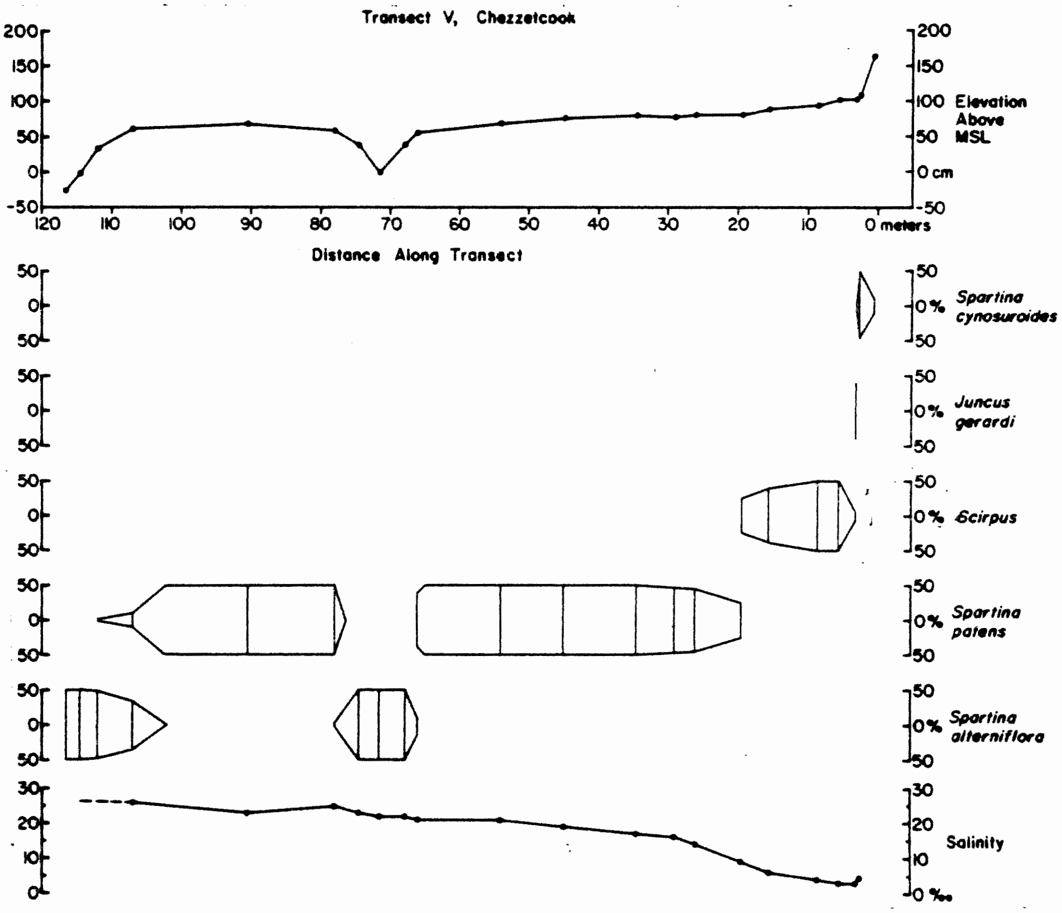


Figure 11. Plant and salinity distribution along transect II, Chezzetcook. Dots are sampling localities and vertical bars are percent occurrences of plant species at each location.

Figure 12. Plant and salinity distributions along transect V, Chezzetcook. Dots are sampling localities and vertical bars are percent occurrences of plant species at each locality.


Transect V, Chezzetcook
200
150
100
50
0
-50
Elevation Above MSL
0 cm
120
110
100
90
80
70
60
50
40
30
20
10
0 meters
Distance Along Transect
Spartina cynosuroides
Juncus gerardi
Scirpus
Spartina patens
Spartina alterniflora
0 %
Salinity
30
20
10
0 ‰

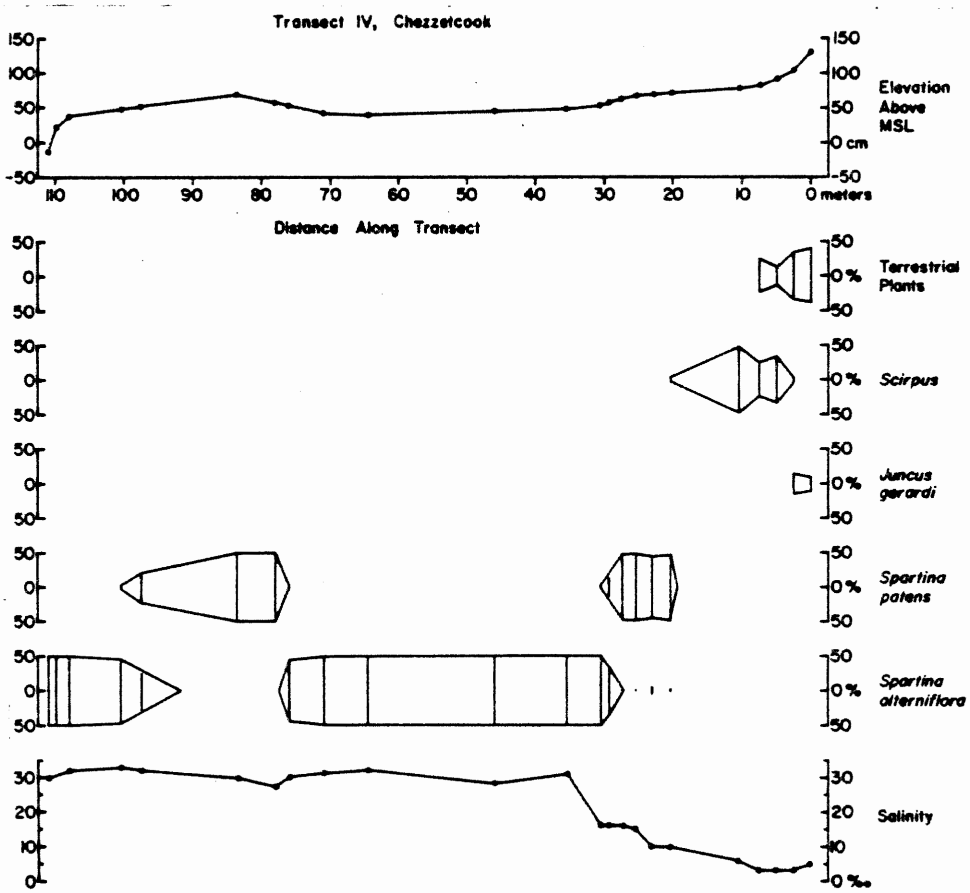


Figure 13. Plant and salinity distributions along transect IV, Chezzetcook. Dots are sampling localities and vertical bars are percent occurrences of plant species at each locality.

Other parameters that have been examined in Chezzetcook are salinity, total organic carbon content of the sediments, and seasonal variations of temperature and precipitation. Of these salinity was monitored the most closely. Due to the extreme difficulty of obtaining accurate sediment salinities at high tide, most salinity values were measured at low tide. Since salinities were measured at low tide they may represent minimum values, especially during periods of high freshwater runoff. At high tide the marsh is flooded with more saline water, probably raising the salinities temporarily.

Salinity measurements were obtained that show seasonal differences (fig. 14, table 2), differences along the vertical gradient in the marsh (figs. 9-13, table 2), and differences between marshes in the upper and lower estuary (figs. 9-13, table 2). The seasonal changes are best documented at stations 4, 7, and 20 (fig. 14). Station 4 is located in the upper, station 7 in the lower, and station 20 in the central estuary. All stations demonstrate that salinities are lowest in the spring and fall when freshwater runoff is at its maximum. Additional less detailed seasonal data show salinity increases from spring to summer (Table 2). The upper estuarine marsh station (4a, b) has the widest range of variability (0-20‰) but values in the upper estuarine marshes were never as high as those observed in the lower estuary (sta. 7c, d, 20-30‰). The best documented vertical salinity data were obtained along the five transects. Transects III-V are most easily compared as these data were collected at the same time of year (fig. 10, 13, 12 respectively). Transect III in the upper estuary il-

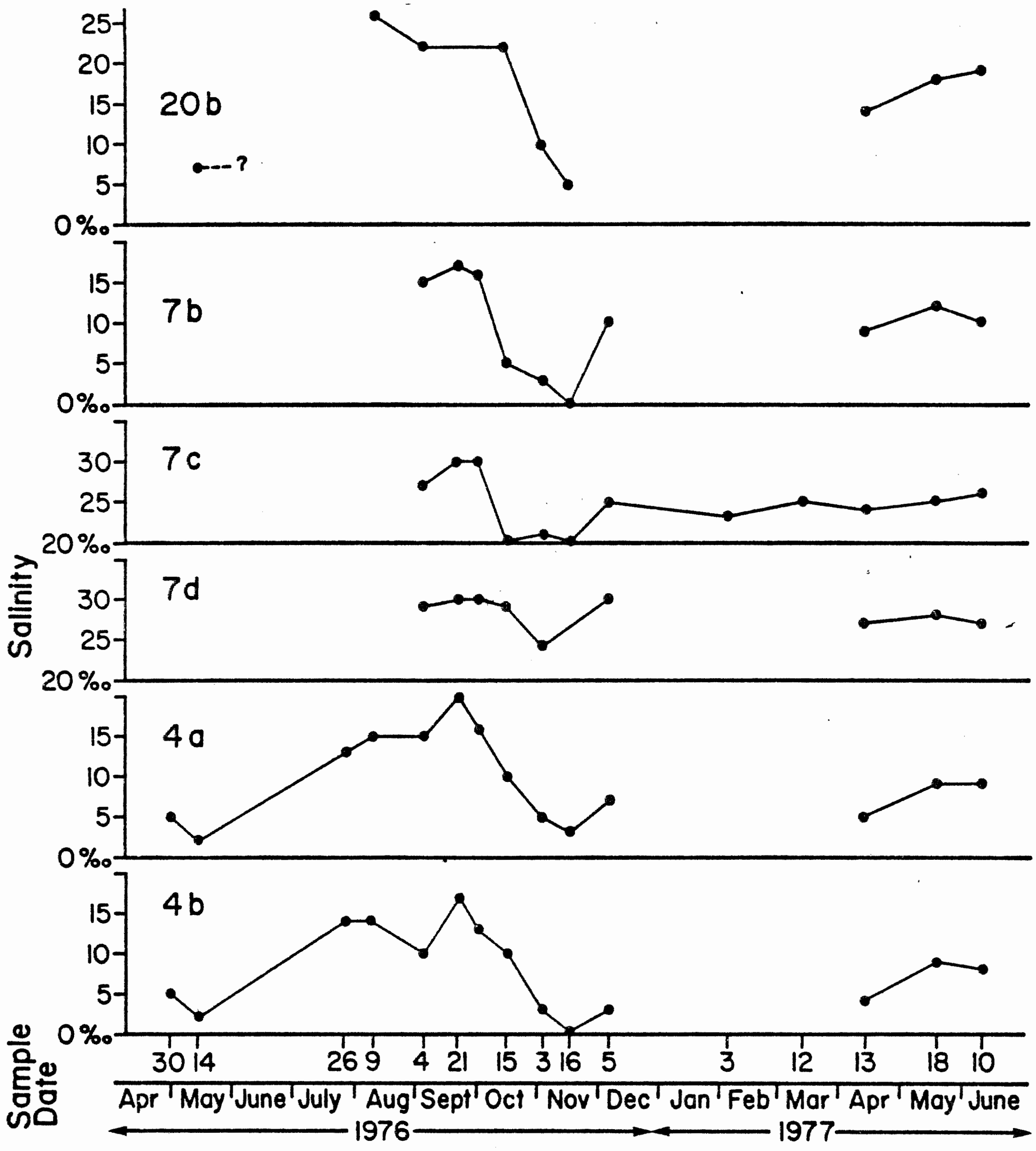


Figure 14. Seasonal variations of salinity at Chezzetcook stations 4a, b; 7c-d; 20b.

STATION NUMBER	1		2		3	4 *	5	6		7 *
SAMPLING DATES	4/30/76	8/9/76	5/14/76	8/9/76	9/20/75	9/25/75	9/25/75 3/27/76	4/6/76	8/9/76	4/11/76
VEG. - SALINITY AT EACH SUBSTATION A Veg.	s.c.		scp.		scp. Dy.	scp. Dy. G.R.	Scp. G.R.	scp. J.g.		Scp.
A Salinity	0‰		0‰	4‰				0‰	17‰	
A % C						44.2		20.4	18.2	
B Veg.	scp.		s.p.		s.p. G.R.	s.p. G.R.	scp. G.R.	s.p.		s.p.
B Salinity	0‰		1‰	25‰				.5‰	15‰	
B % C						35.0		31.9	33.8	38.9
C Veg.	scp. G.R.		s.p.		s.p. G.R.	s.p. G.R.	s.p.	s.a.		s.a.
C Salinity		13‰						0‰	12‰	
C % C			12.8					15.9	15.7	31.7
D Veg.	s.p.		s.a.		s.a.	M.F.	s.p.			s.a.
D Salinity	4‰	30‰	5-13‰							12.9
D % C										
E Veg.	s.p.		s.a.				s.p.			M.F.
E Salinity	15‰			28‰						
E % C										
F Veg.	s.a.						s.p.			
F Salinity	21‰	30‰								
F % C										
G Veg.	s.a.						s.a.			
G Salinity		30‰								
G % C										
H Veg.	M.F.									
H Salinity	5‰									
H % C										

STATION NUMBER	8	9	10	11	12		13		14		15		16	
SAMPLING DATES	8/9/76	4/11/76	4/11/76	4/20/76	4/25/76	8/11/76	4/25/76	8/11/76	4/25/76	8/11/76	4/25/76	8/11/76	4/25/76	8/11/76
VEG. - SALINITY AT EACH SUBSTATION A Veg.	s.p.	scp.	s.a.	s.a.	s.a.		s.a.		s.a.		s.a.		s.a.	
A Salinity	30‰				2‰	10‰	0‰	6‰	0‰	16‰	0‰	20‰	0‰	17‰
A % C														
B Veg.	s.a.	scp. s.p\	s.p.	s.p.	scp. J.g.		J.g. scp.		s.p. scp. G.R.		s.p. scp. [illegible] G.R.		s.p.	
B Salinity	31‰				0‰	12‰	5‰	14‰	4‰	15‰	2‰	15‰	9‰	24‰
B % C														
C Veg.	s.a.	s.p.	s.p.	scp.	scp.		scp.		scp. J.g. G.R.		s.p. Pl. scp. G.R.		s.p. G.R. scp.	
C Salinity					0‰	6‰	0‰	10‰	0‰	13‰	5-6‰	16‰	9‰	23‰
C % C														
D Veg.	M.F.	s.a.	scp.								J.g. G.R. scp.		scp. J.g. s.p. G.R.	
D Salinity											2‰	15‰	5‰	20‰
D % C														
E Veg.		M.F.												
E Salinity														
E % C														
F Veg.														
F Salinity														
F % C														
G Veg.														
G Salinity														
G % C														
H Veg.														
H Salinity														
H % C														

STATION NUMBER	17		18		19	20 *		45	46	47	48	54
SAMPLING DATES	4/30/76	8/9/76	4/30/76	8/9/76	4/30/76	5/14/76	8/9/76	8/9/76	9/6/76	9/6/76	9/6/76	10/15/76
VEG. - SALINITY AT EACH SUBSTATION A Veg.	scp. Dy.		scp. Dy.		s.p.	scp.		P.a. scp. G.R. J.g.	scp. J.g.	s.a.	s.a.	s.a.
A Salinity	5‰	10‰	2‰	14‰	28‰	0‰	20‰	5‰	9‰	30‰	30‰	4‰
A % C						48.5	50.3					
B Veg.	s.p. scp. G.R.		s.p.		s.p. s.a.	s.p.		s.a.	s.p.	s.a.	s.a.	
B Salinity	5‰	18‰	5‰	22‰	28‰	7‰	26‰	8‰	13‰	28‰	28‰	
B % C						28.5	25.5					
C Veg.	s.a.		s.a.		s.a.	s.a.			s.p. G.R.	s.a.	s.a.	
C Salinity	0‰	6‰	0‰	25‰	26‰	9‰	23‰		13‰	26‰	37‰	
C % C						12.5	11.3					
D Veg.					M.F.				s.a.	s.a.		
D Salinity					25‰					28‰		
D % C												
E Veg.									M.F.			
E Salinity									22‰			
E % C												
F Veg.												
F Salinity												
F % C												
G Veg.												
G Salinity												
G % C												
H Veg.												
H Salinity												
H % C												

Table 2. The vegetation, salinity, dates of collection and some organic carbon contents of the areal Chezzetcook marsh stations.

Plant abbrevations:

s.c. - *Spartina cynosuroides*	G.R. - *Solidago sempiverens*
s.p. - *S. patens*	scp. - *Scirpus* spp.
s.a. - *S. alterniflora*	Sn. - *Salicornia*
J.g. - *Juncus gerardi*	Dy. - *Distichlis*
Pl. - *Plantago*	Li. - *Limonium*
P.a. - *Potentilla anserina*	M.F. - mudflat

lustrated little salinity change with elevation largely because most of the transect was contained in one narrow vertical floral kline. However, the highest salinity measured was the low marsh (26‰) and the lowest in the high marsh (10‰) indicating an inverse relationship between salinity and elevation. The inverse relationship was established more clearly in transects IV and V where all floral klines were more equally represented. Salinities appeared to be uniformily low in all high marsh areas (3-10‰) but increased seaward in the middle and low marsh floral klines. Maximums of 30‰ in the low marsh areas of transect IV were observed. All measurements for transects III-V were carried out in the summer and they probably represented maximal salinity values. Transects I and II (figs. 9, 11) were carried out in the fall of the previous year and, although not strictly comparable to transects III-V, they showed the same inverse relationship.

Organic carbon content was measured at a few selected localities (table 2). These measurements demonstrated that the organic carbon content of the marsh sediments was ususally much higher than that of the adjacent mudflats. The data also illustrated a moderate vertical gradient in the organic carbon content, with organic carbon decreasing with decreasing elevation. High marsh values ranged from 18-50% organic carbon (dry wt.), middle marsh values ranged from 25-13%, and low marsh values ranged from 12-31%.

Temperature and precipitation data were obtained from the Environment Canada Atmospheric Centre (fig. 15). Since the marsh is subaerial much of time atmospheric temperatures are representative of those occurring

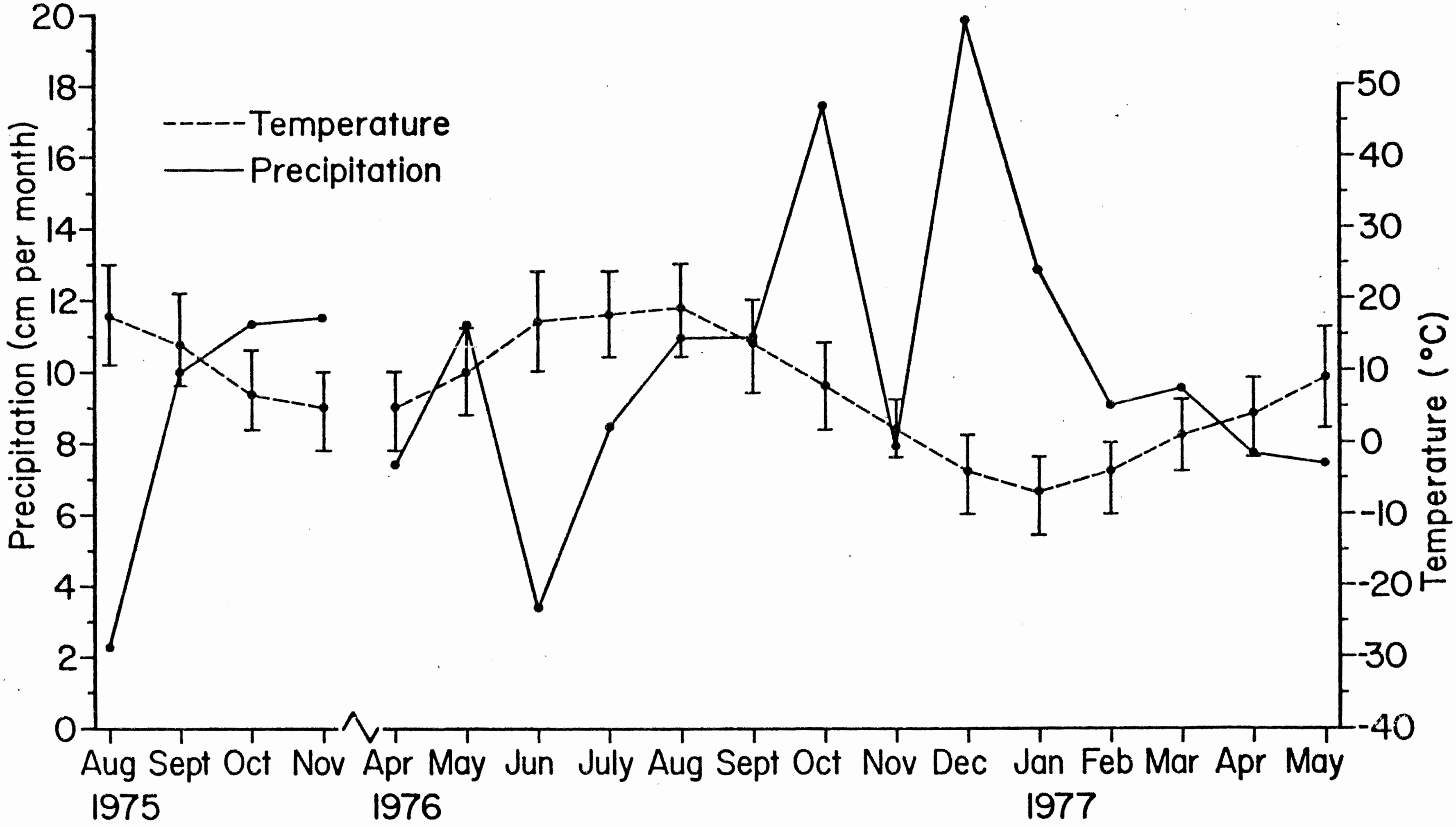


Figure 15. August, 1975 - June, 1977 precipitation-temperature data for Middle Muscodoboit.

on the marsh surface. The months of June-August have the highest average temperatures (15-20°C), with the fall months (Sept.-Nov.) averaging 0-10°C, the winter months (Dec.-Feb.) averaging -2 to -6°C, and the spring months (Mar.-May) averaging 3-10°C. These temperatures are highly variable but variability may decrease in the lower elevations of the marsh as the more stable marine influence increases. Temperature data did not exhibit any significant differences between 1975 and 1976; however, the precipitation data reflected the extremely dry summer preceding the fall of 1975 compared with an average summer precipitation preceding the fall of 1976. Although precipitation is high throughout the winter, freshwater runoff into the estuary is small because the water is bound as ice. Melting in the spring produces runoff much greater than precipitation records would indicate.

Sedimentation

No marsh sediments were analyzed for grain size distribution; however, it is known from treating the foraminiferal samples that most of the sediment in the marshes is in the silt and clay size range with little sand. Sedimentation rates are relatively low except at the lowest edge of the marsh where sediment rich waters first contact the marsh vegetation which serves as a sediment trap. The levees are probably the result of this trapping affect. Chapman (1976) demonstrated in marshes in Massachusetts similar to those of Nova Scotia, that accumulation rates in the marsh change vertically. The low marsh (*S. alterniflora*)was shown to accumulate at 6 mm/yr, the middle marsh (*S. patens*)at 1.3 mm/yr, and the high marsh at 0.6 mm/yr. Chapman (1976) included data from other sources suggesting the same trend for other marshes.

Foraminiferal results

Three types of sampling were carried out in the marsh area of Chezzetcook: 1) an areal survey to determine relatively large scale lateral variations, 2) extremely detailed transects across the marsh surface to determine small scale vertical and horizontal variations, and 3) seasonal sampling to determine if population peaks changed the overall composition of various faunal klines seasonally (e.g. could a low marsh faunal kline from a winter period be confused with a high marsh faunal kline from a summer period.

Areal samples: In these stations (1-20, 45-48, 56, foldout 1) 33 species, 19 living, were observed and vertical faunal klines as well as lateral groupings could be delineated. Vertical faunal klines will not be discussed in detail in conjunction with these samples. Both lateral and horizontal variations in foraminiferal associations can be divided into three distinct environmental groups: upper estuarine, central estuarine, and lower estuarine marshes.

Upper estuarine marshes: This association was observed in the East and West Head areas (Sta. 4, 5a-d, 6, 9-18, 45, 56, tables 3-5, appendix). It appears to be dominated at all levels by *Trochammina inflata macrescens*. Large populations of *Tiphotrocha comprimata* also occur. In higher elevations *Haplophragmoides bonplandi* is common and sometimes dominates.

In the lower areas *Miliammina fusca*, *Ammobaculites foliaceus*, and *Ammotium salsum* are common. In the uppermost estuarine areas *H. bonplandi* disappears (sta. 6, 9, 10). At stations 45 and 56 some thecamoebians are observed in the lower areas.

Central Estuarine marshes: This association was observed in the seaward portion of the West Head and down the estuary almost to the mouth (sta. 1-3, 5e-g, 20, 46-48, table 3-5, appendix). The central estuarine marshes are generally narrower with a more uniform vertical gradient than the marshes observed in the upper estuary. The area is dominated by *T. inflata macrescens* in the higher areas and *M. fusca* in the lower areas. *H. bonplandi* disappears from the high areas except for an isolated occurrence at station 46, and *A. foliaceus* is absent from the lower areas. The calcareous species, *Cribroelphidium excavatum*, *Protelphidium orbiculare*, and *Ammonia beccarii*, make their first appearances. Stations 47 and 48 represent areas of newly forming marsh and only the lowest marsh is present. The faunae observed at these stations correspond with the lowest parts of the fully developed marshes. Distributions at these stations are extremely irregular and populations are usually small.

Lower estuarine marsh: This is a relatively small marsh area near the mouth (sta. 7, 8, 19, tables 4, 5, appendix). The area is dominated almost exclusively by *M. fusca*; however, large populations of *C. excavatum*, *A. beccarii*, *Helenina andersoni*, *Hemisphaerammina bradyi*, *Trochammina inflata*, and *Jadammina polystoma* also occasionally occur.

Transects: Five transects were sampled, two each in the upper estuarine and central estuarine marshes and one in the lower estuarine marsh. Plant and salinity distributions for these transects have already been discussed.

Upper estuarine transects - I and III: Transect I (fig. 16, table 6, appendix) was located in the West Head and transect III (fig. 17, table 7, appendix) was in the East Head. At 95-100 cm a.m.s.l. foraminiferal numbers decrease sharply in transect I. Unfortunately no samples were obtained from comparably high elevations in transect III; however, the most landward sample (no. 2, table 7, appendix) at 88 cm a.m.s.l. shows a decreased population. This corresponds reasonably closely with the higher high water datum (HHW, 85 cm a.m.s.l.), as determined with tide gauges at the head of Chezzetcook. Just below (88-92 cm a.m.s.l.) an almost monospecific fauna containing 99-100% *Trochammina inflata macrescens* is observed (faunal kline I_A). In transect I a faunal sub-subkline is developed (I_{B-1}) in the elevation range 70-88 cm a.m.s.l. and is characterized by *T. inflata macrescens*, *Tiphotrocha comprimata*, and *Haplophragmoides bonplandi*. This faunal sub-subkline is developed only at the landward end of transect III. Faunal sub-subkline I_{B-2} (60-70 cm a.m.s.l. in I, 70-85 cm a.m.s.l. in III) is characterized by the same species as in I_{B-1} except for the absence of *H. bonplandi*. The lowest faunal kline in this area (II) is extremely compressed horizontally but is large vertically (see figs. 13, 14). The total range of this faunal kline is -12 to 60 cm a.m.s.l. in I and -34 to 70 cm

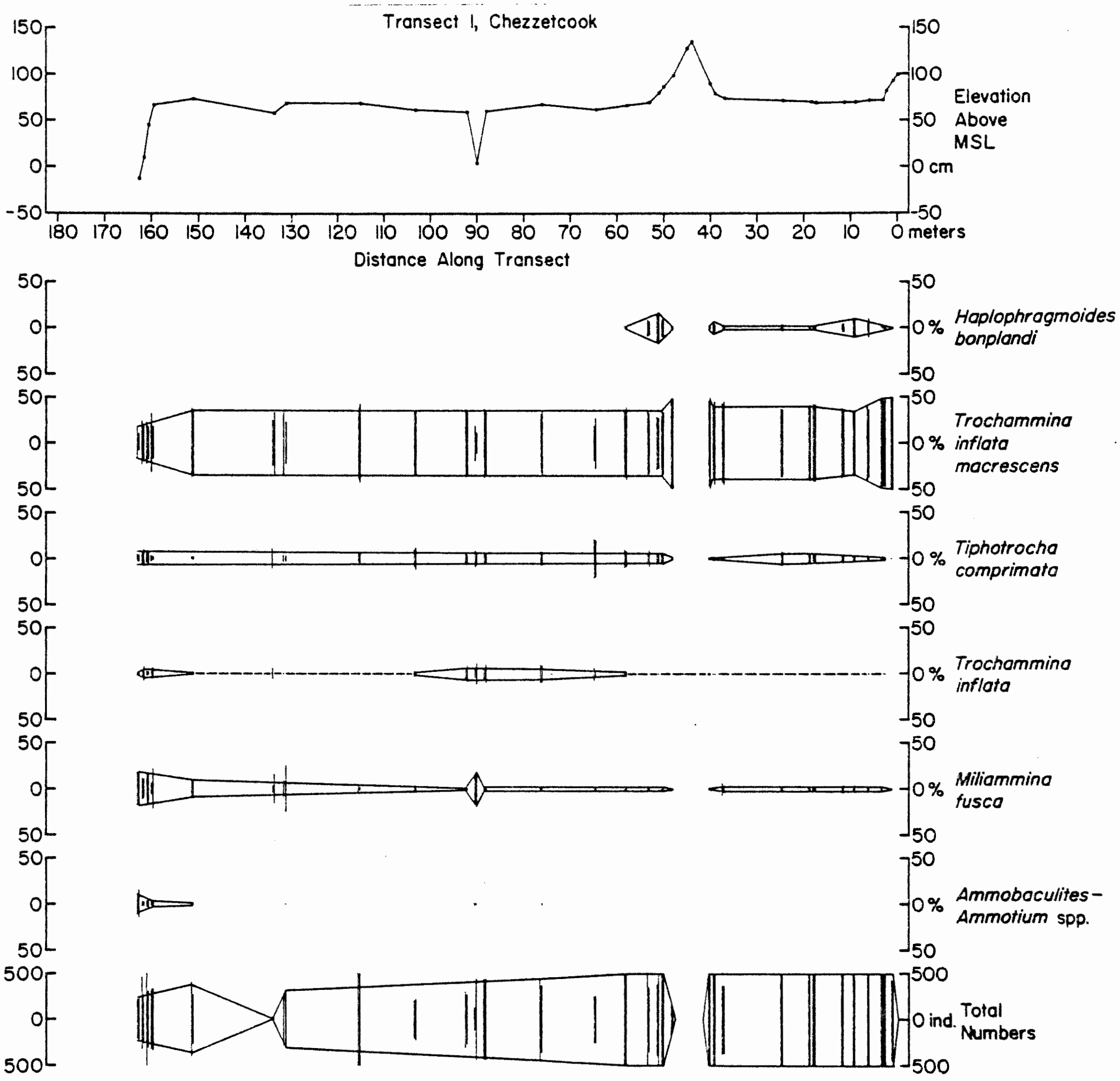
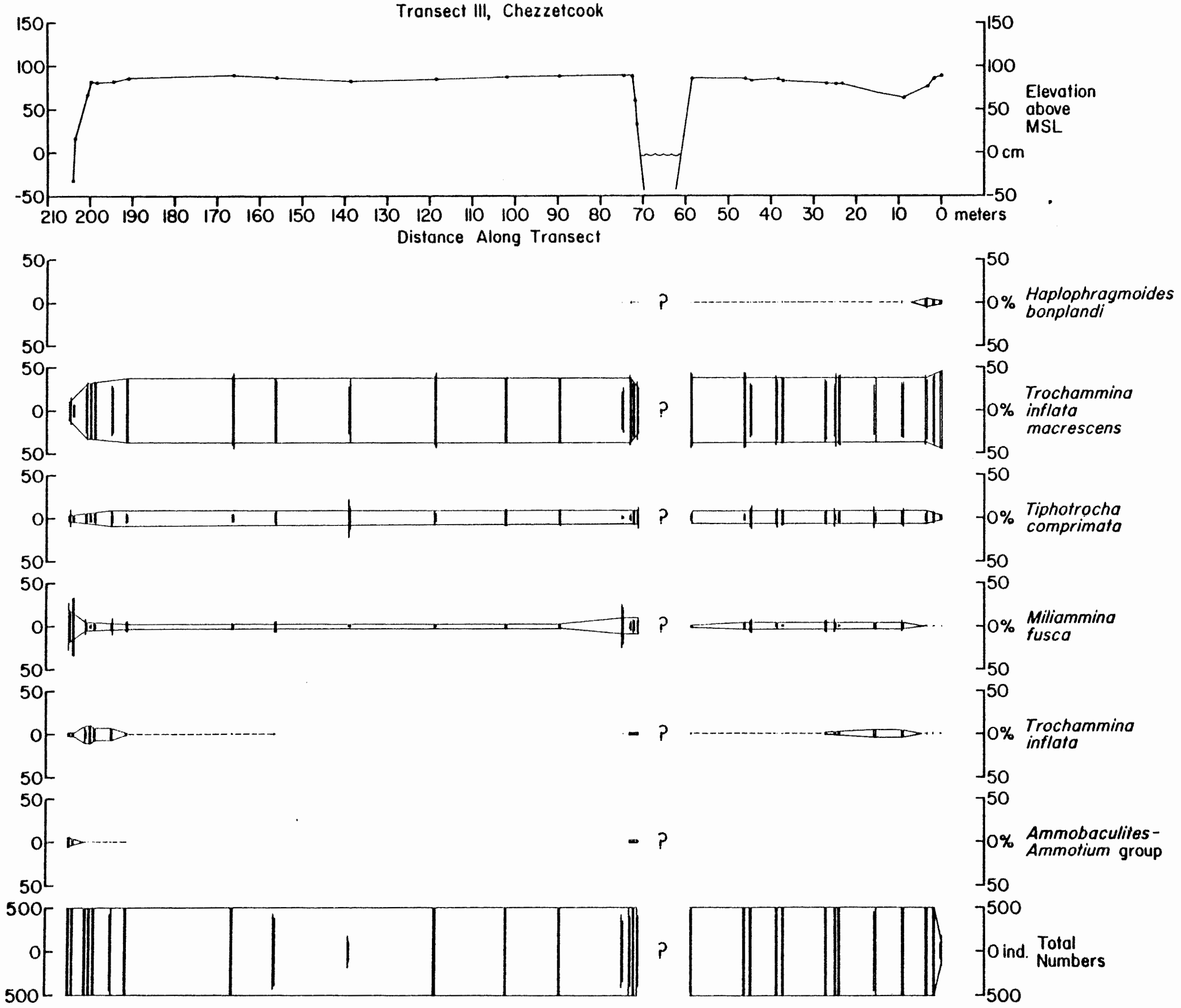


Figure 16. Foraminiferal occurrences along transect I, Chezzetcook. Dots are sampling localities, double vertical bars are replicate percents of species at each locality. Horizontal connecting lines are used here to subjectively average out intra-klinal variations. Total numbers often are higher than 1000, however all important variations occur between 0 and 1000.

Figure 17. Foraminiferal occurrences along transect III, Chezzetcook. Dots are sampling localities; double vertical bars are replicate percents of species at each locality. Horizontal connecting lines are used here to subjectively average out intra-klinal variations. Total numbers often are higher than 1000, however all important variations occur between 0 and 1000.

Transect III, Chezzetcook



a.m.s.l. in III. The faunal kline can be divided into two subklines (an upper subkline II_A and a lower II_B); however, their exact vertical boundaries could not be determined because the steep vertical gradient prevented good sample coverage. Faunal subkline II_A is characterized by the addition of *Miliammina fusca* and *Trochammina inflata* to the species of faunal sub-subkline I_{B-1}. Faunal subkline II_B is characterized by an increase in *M. fusca* accompanied by a decrease in the species from the upper klines and increases of *Ammotium salsum* and *Ammobaculites foliaceus*.

Central estuarine transects - II and V: Transect II (fig. 18, table 8, appendix) was the most seaward while transect V (fig. 19, table 9, appendix) was located farther up the estuary. At 100-110 cm a.m.s.l. in both transects the foraminiferal numbers decrease sharply. This corresponds closely with HHW (as obtained from tidal data for Halifax which is comparable to the open part of Chezzetcook) which occurs at 101 cm a.m.s.l. Just below HHW (95-100 cm a.m.s.l.) in both transects faunal subkline I_A is present with a fauna containing 99-100% *T. inflata macrescens*. Faunal subkline I_B (87-100 cm a.m.s.l. in II, 75-95 cm a.m.s.l. in V) is characterized here by high percentages of *T. inflata macrescens* with lower percentages of *T. comprimata* and *M. fusca*. Faunal kline II can again be divided into two subklines with the upper subkline divided into two sub-subklines. The highest sub-subkline, II_{A-1} (75-87 cm a.m.s.l. in II, 68-75 cm a.m.s.l. in V) is characterized by the complete dominance of *M. fusca*. The lowest sub-subkline, II_{A-2} (60-75 cm a.m.s.l. in II, 55-68 cm a.m.s.l. in V) is characterized by

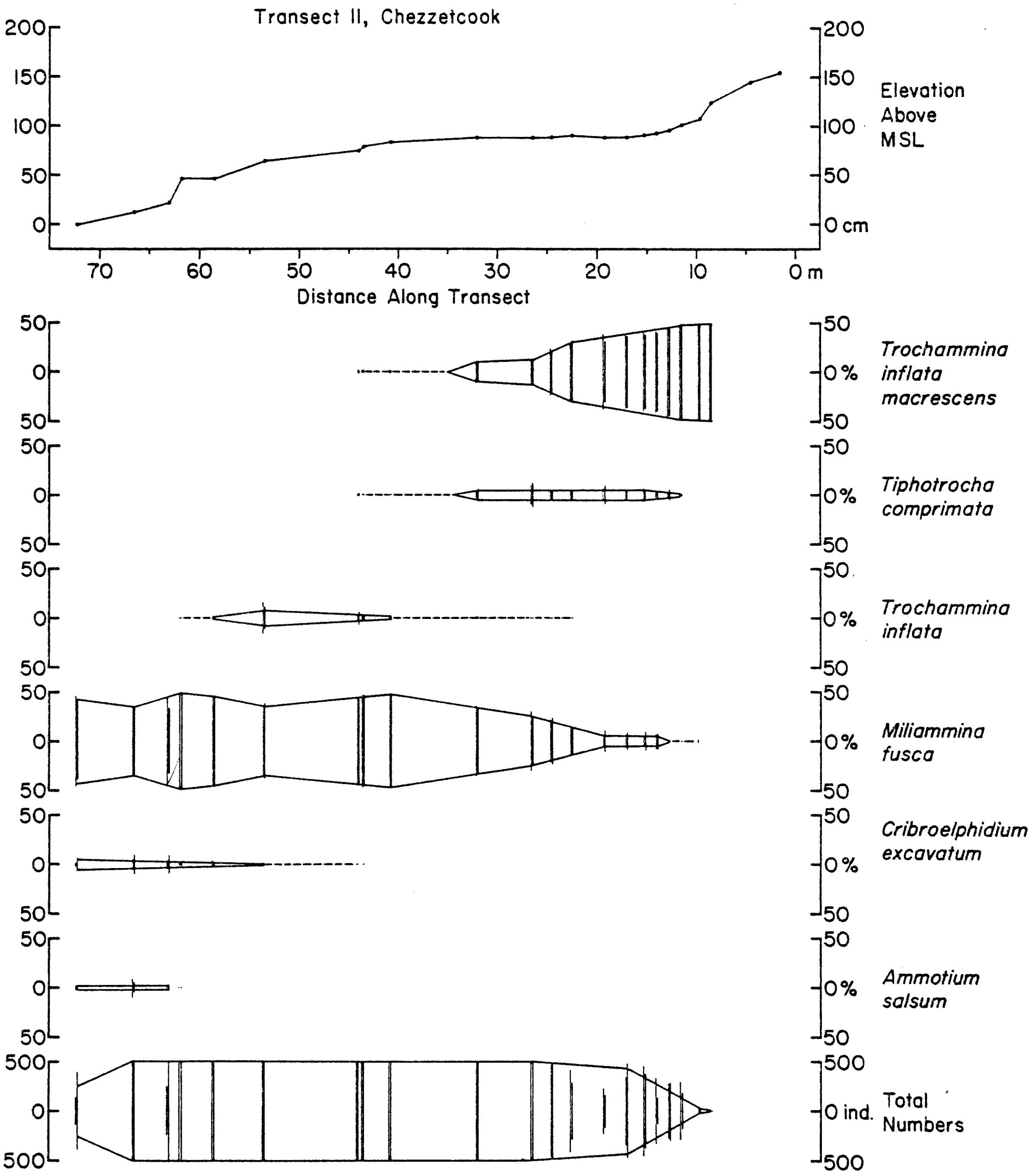


Figure 18. Foraminiferal occurrences along transect II, Chezzetcook; dots are sampling localities and double vertical bars are replicate percents at each locality. Horizontal connecting lines are used here to subjectively average out intraklinal variations. Total numbers often are higher than 1000, however all important variations occur between 0 and 1000.

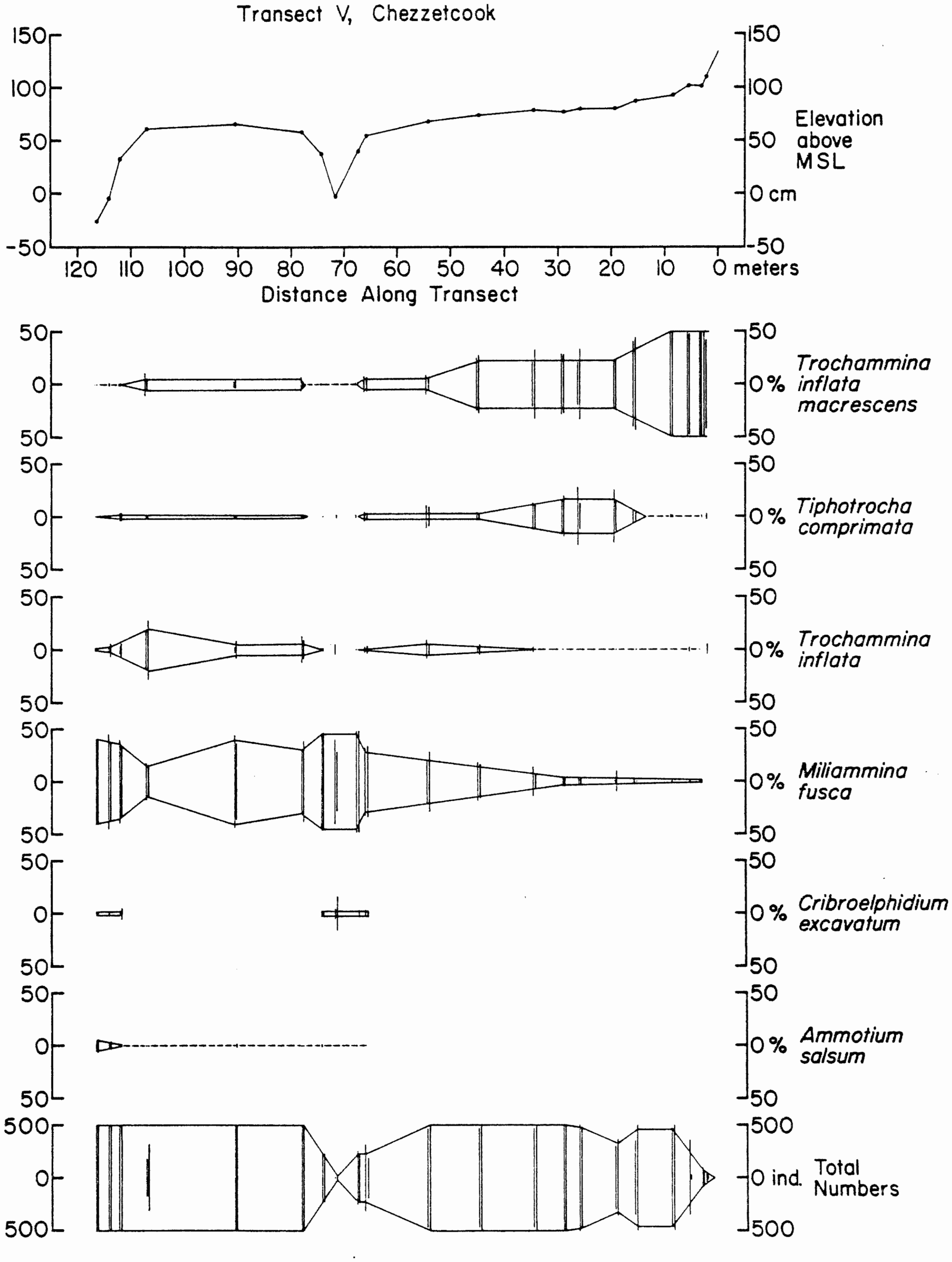


Figure 19. Foraminiferal occurrences along transect V, Chezzetcook. Dots are sampling localities and double vertical bars are replicate percents at each locality. Horizontal connecting lines are used here to subjectively average out intra-klinal variations. Total numbers often are higher than 1000, however all important variations occur between 0 and 1000.

the addition of *T. inflata*. The lowest faunal kline in this area, II_B (0-60 cm a.m.s.l. in II, -25 to 55 cm in V) is characterized by a decrease in *T. inflata* accompanied by increases of *Cribroelphidium excavatum* and *A. salsum* with *M. fusca* remaining the dominant species.

Lower estuarine transect-IV: Transect IV (fig. 20, table 10, appendix) was located in the relatively large marsh area near the mouth (fold-out 1). This area was chosen because it was the only area near the mouth having a fully developed marsh vegetation sequence. In the elevation range from 78 to 103 cm a.m.s.l. there was virtually no foraminiferal fauna. In the short range between 69 and 78 cm a.m.s.l. a fauna resembling those observed in higher elevations at the other transects, with large percentages of *T. inflata macrescens* and small percentages of *T. comprimata* and *M. fusca*, occurs. Below 68 cm a.m.s.l. *M. fusca* dominates with various points along the transect containing significant percentages of *Helenina andersoni*, *C. excavatum*, *T. inflata*, or *Jadammina polystoma*.

The total foraminiferal population (live plus dead) has been considered because assemblages were being defined. As pointed out by Albani and Johnson (1975) the total population is a more reliable indicator of assemblages because all of the seasonal variations are integrated into it, and no seasonal variation of living species will be overemphasized. Comparison of replicate samples indicates that variations between the total numbers at any one station are usually small in contrast with large variations between corresponding living populations. Any meaningful interpretation of the assemblages based only on living data would be extremely problematic because of these variations.

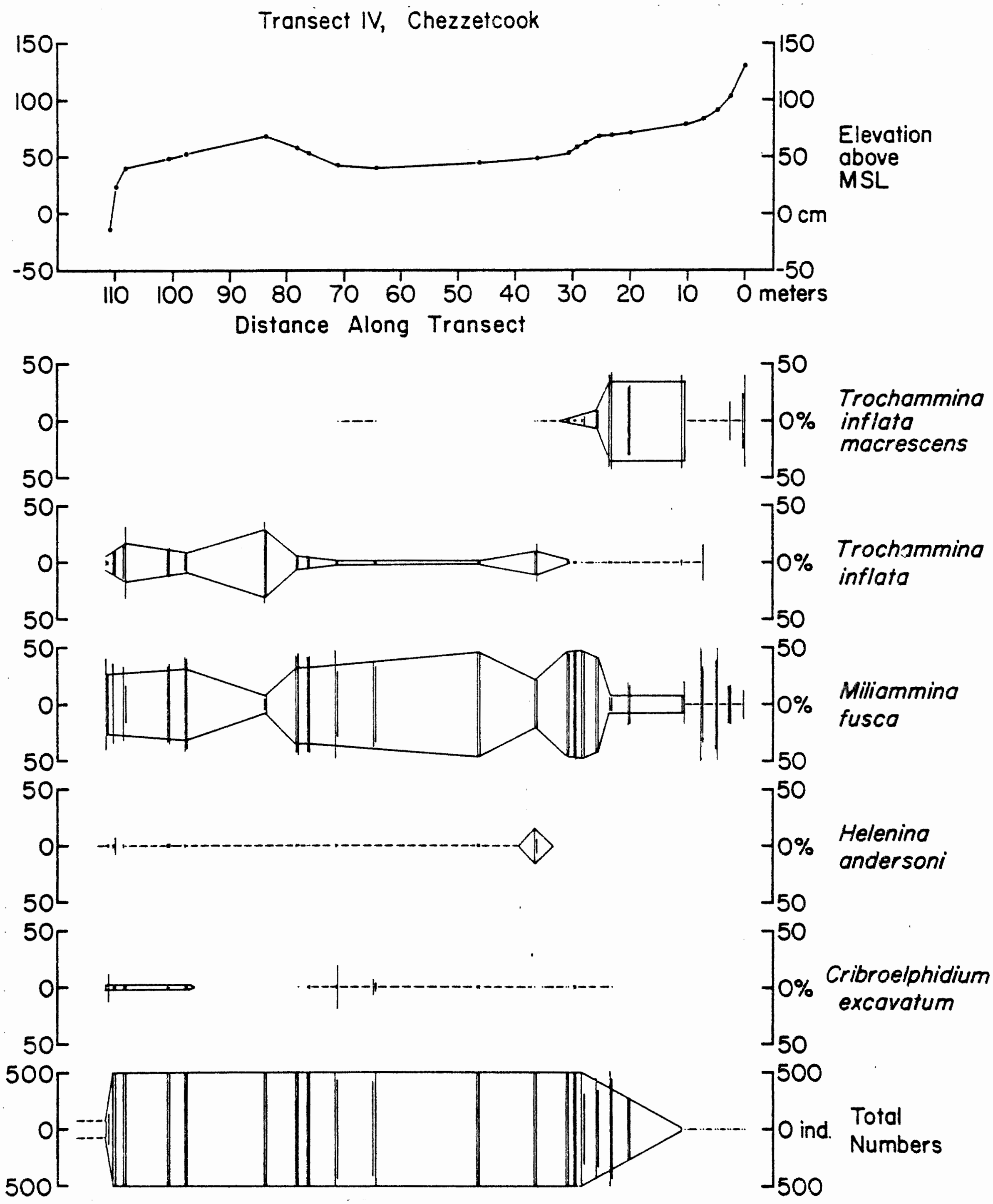


Figure 20. Foraminiferal occurrences along transect IV, Chezzetcook. Dots are sampling localities and double vertical bars are replicate percents at each locality. Horizontal connecting lines are used here to subjectively average out intra-klinal variations. Total numbers often are higher than 1000, however all important variations occur between 0 and 1000.

Seasonal data: Samples were collected over two seasonal cycles from three stations in Chezzetcook (4a, b, 7b-d, 20b). These samples were used to determine seasonal variations of living populations and also to demonstrate whether or not seasonal variations could significantly alter the observed total assemblages.

Station 4: Station 4 was in the upper estuary marshes with 4a being in high marsh and 4b in the middle marsh. Samples could not be collected in this area after December or before April because of ice conditions. At station 4a (fig. 21, 22, table 11, appendix) the living population in September, 1975 was low (20-100) but the total population was large (4000-4500). The following spring (April, 1976) the living and total populations were low and did not increase significantly until after May. Populations observed in July were markedly increased over those of May and continued to increase slowly through August. The populations remained stable through November but decreased slightly in December. In April, 1977, just after the ice had melted, both living and total populations were observed to be large, comparable to those of the previous November. They continued to be high through June, 1977. Although total numbers of individuals varied greatly depending on the season, the assemblage observed at this station remained unchanged; i.e. regardless of the total number of individuals, the relative percentages were virtually constant (fig. 22). At station 4b the total and living populations varied similarly to those at station 4a except for a more significant decrease in December, 1976 (fig. 23, 24, table 11, appendix).

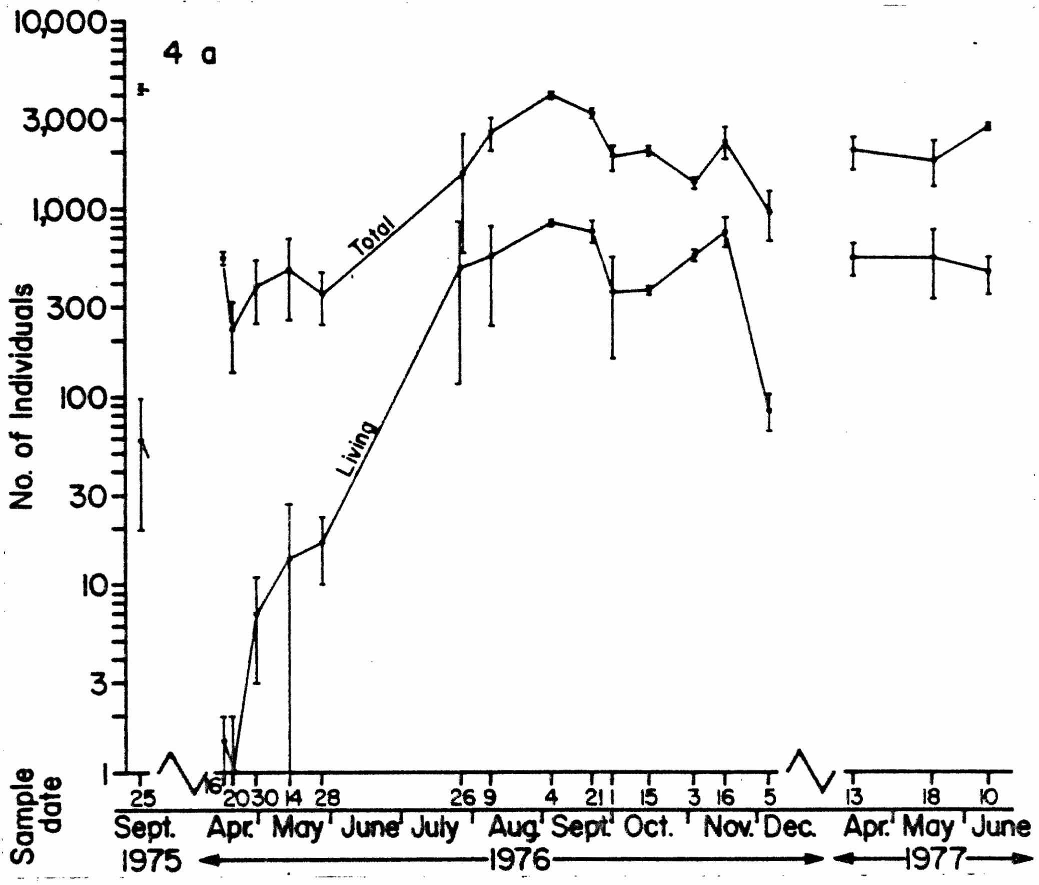


Figure 21. Chezzetcook station 4a seasonal foraminiferal total and living occurrences. Upper and lower values are actual replicate values while middle value is the average of the replicates; log-normal scale.

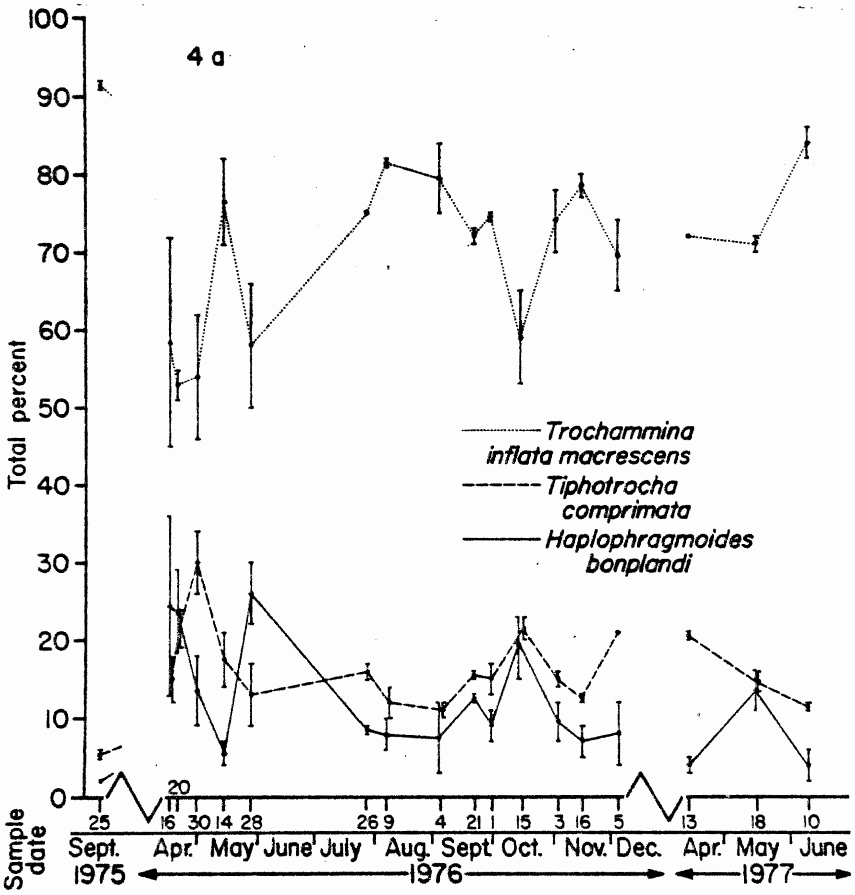


Figure 22. Chezzetcook station 4a seasonal foraminiferal percentage occurrences. Upper and lower values are actual replicate values while the middle value is the average of the replicates.

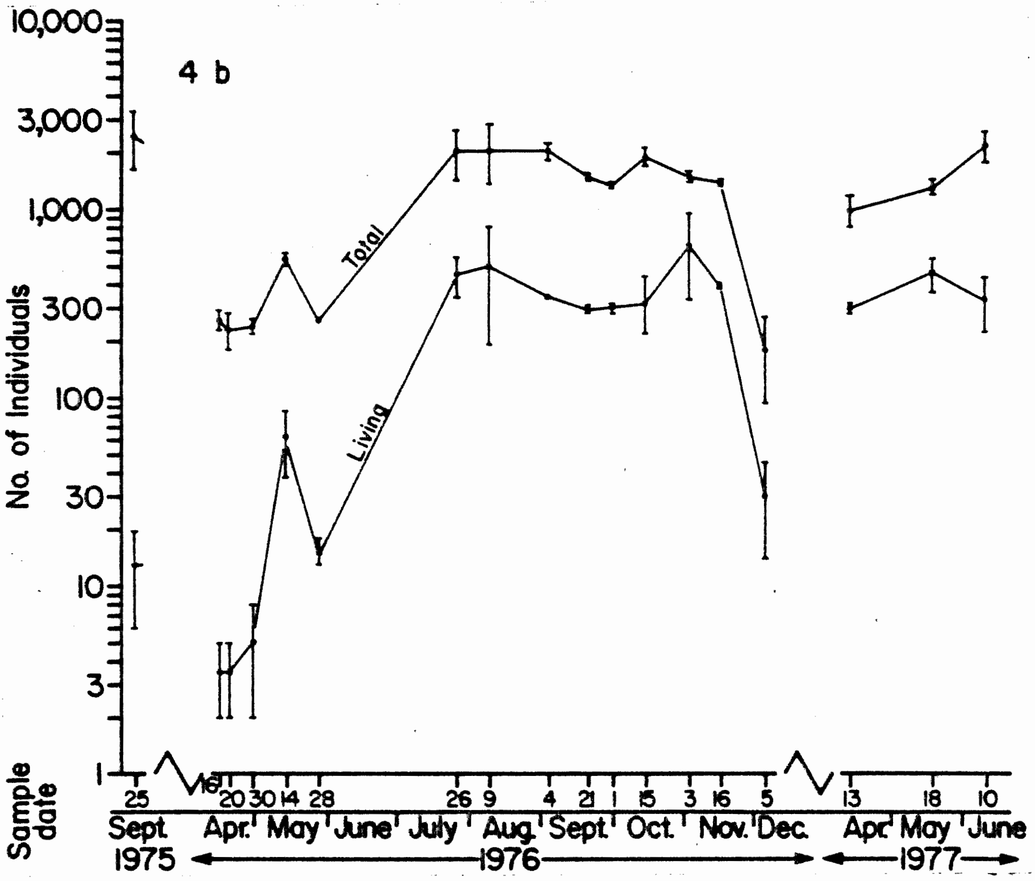


Figure 23. Chezzetcook station 4b seasonal foraminiferal living and total occurrences. Upper and lower values are actual replicate values while middle value is the average of the replicates; log-normal scale.

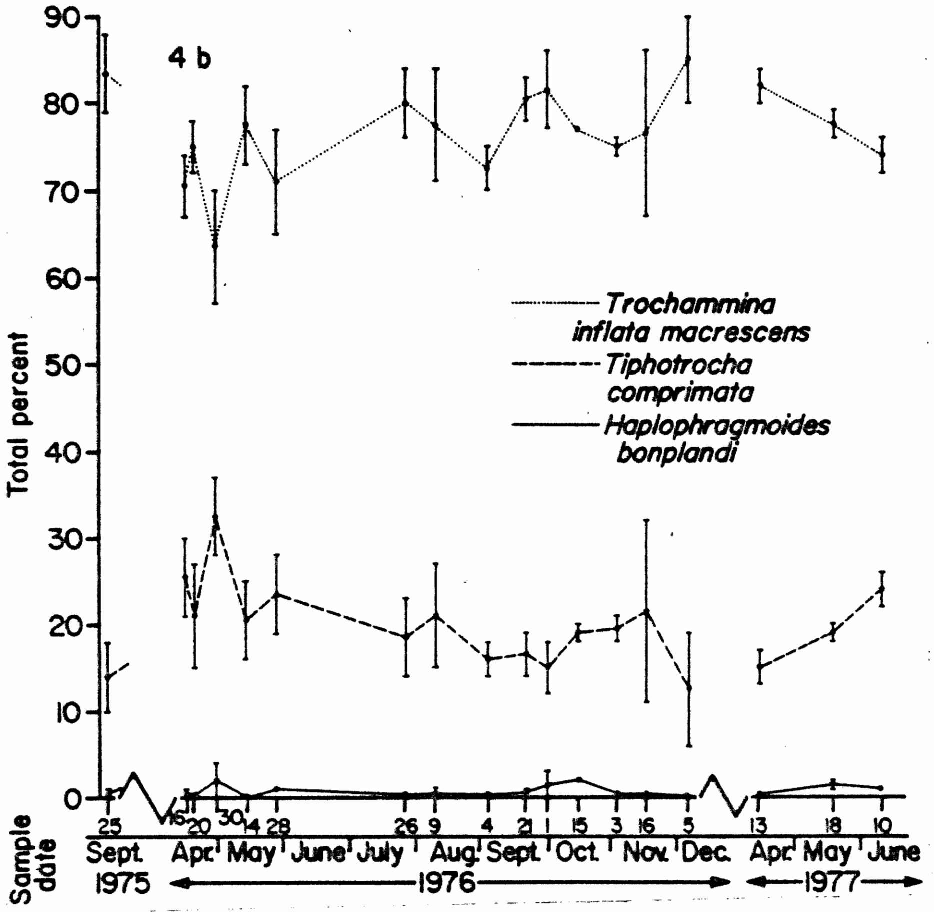


Figure 24. Chezzetcook station 4b seasonal foraminiferal percentage occurrences. Upper and lower values are the actual replicate values while the middle value is the average of the replicates.

Assemblages at this location also remained unchanged. The difference between 4a and 4b is the lower percentage of Haplophragmoides bonplandi occurring at 4b. Closer examination of table 11 (appendix) reveals that living populations of some species increase earlier than others but this does not appear to significantly change the overall assemblage.

Station 7: Station 7 was near the mouth of Chezzetcook Inlet in the lower estuarine marshes (near transect IV). Location 7b was in middle marsh, 7c was in upper low marsh and 7d' was near the lower edge of low marsh. Location 7b (fig. 25, 26, table 12, appendix) was located in the upper section of transect IV where it was difficult to collect comparable samples due to the variability typical of this middle marsh. Hence assemblages at 7b exhibit extremely high variabilty caused both by spatial as well as temporal factors. In spite of this, a large increase of the living population was observed in late September, 1976, and persisted at least until November. Following the melting of the ice in April, both total and living populations were uniformly high again. Variations in the assemblage appear to reflect variations of total and living populations with lower populations being associated with higher percentages of Trochammina inflata macrescens (fig. 25, 26). This suggests that some of the samples were at a slightly higher elevation than others. Location 7c (fig. 27, 28, table 12, appendix) illustrates a more typically seasonal pattern. Total numbers at this locality revealed little variation with time except in the December, 1976 samples. However, living populations varied considerably; May, 1976 samples exhibited low living populations (20-40) which increased to

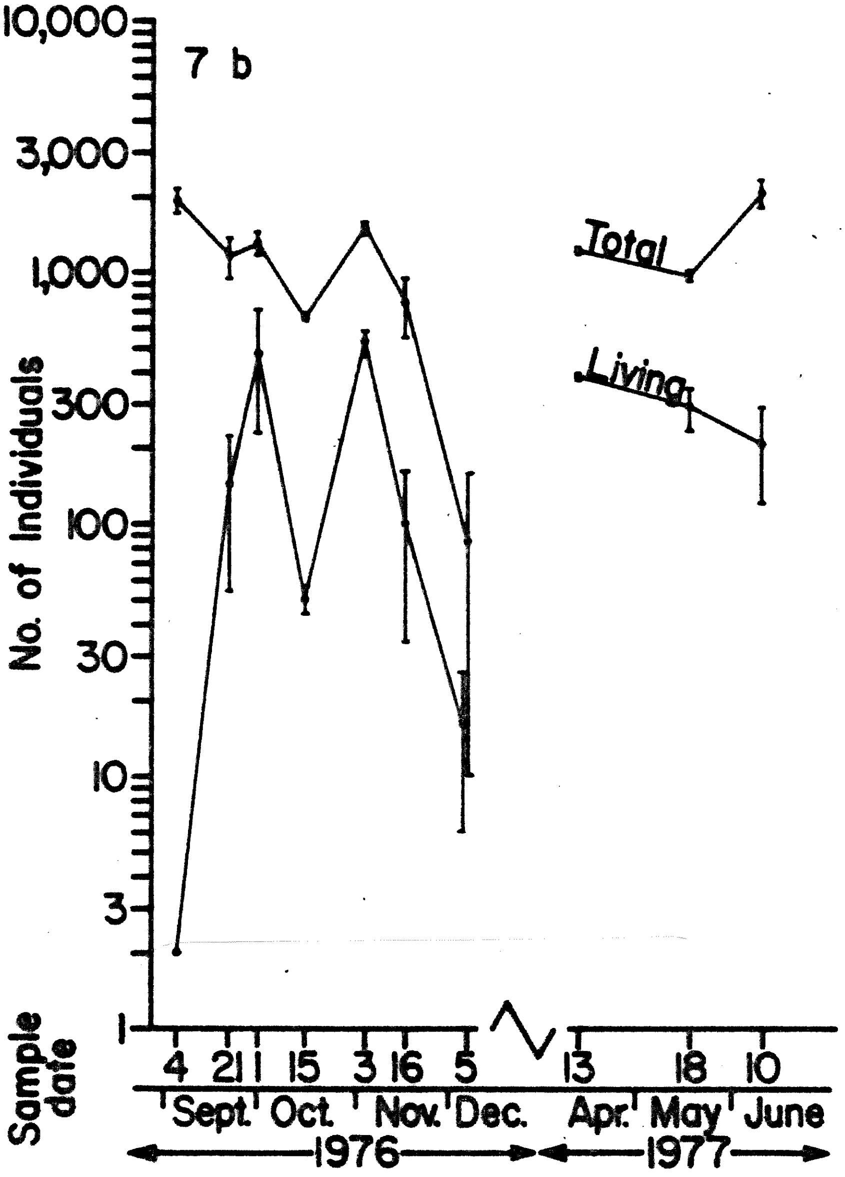


Figure 25. Chezzetcook station 7b seasonal foraminiferal living and total occurrences. Upper and lower values are actual replicate values while the middle value is the average of the replicates; log-normal scale.

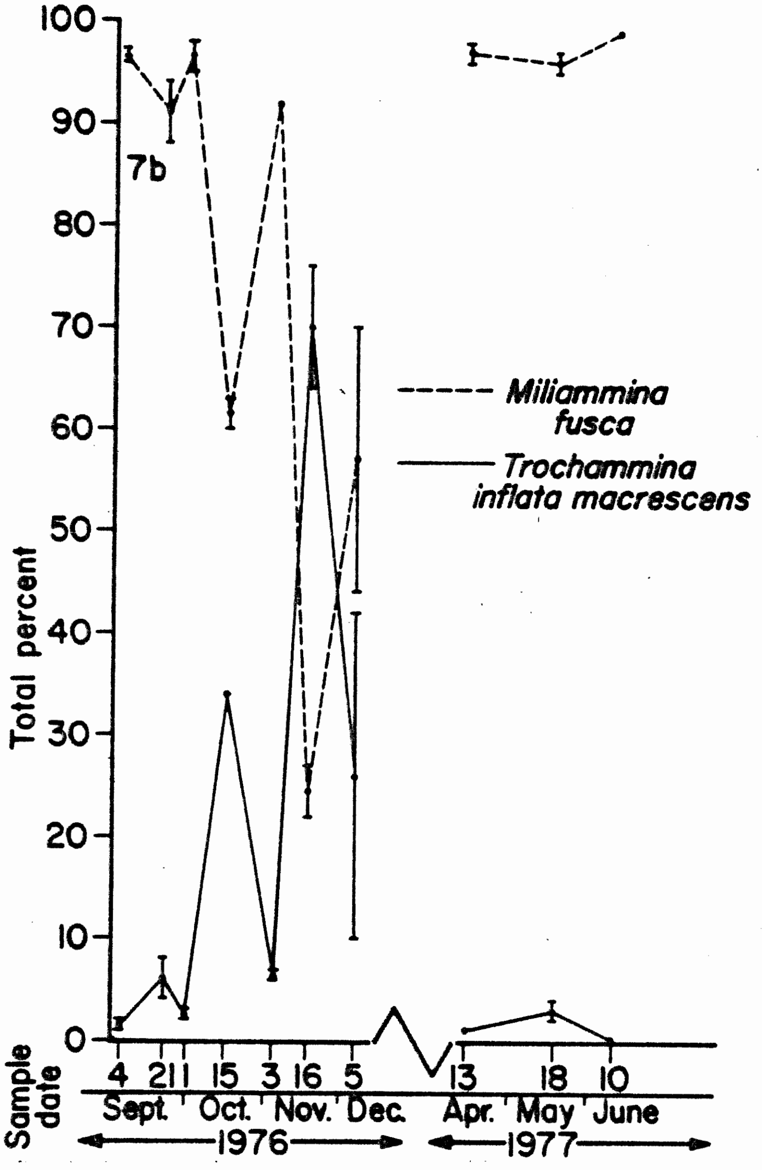


Figure 26. Chezzetcook station 7b seasonal foraminiferal percentage occurrences. Upper and lower values are actual replicate values while the middle value is the average of the replicates.

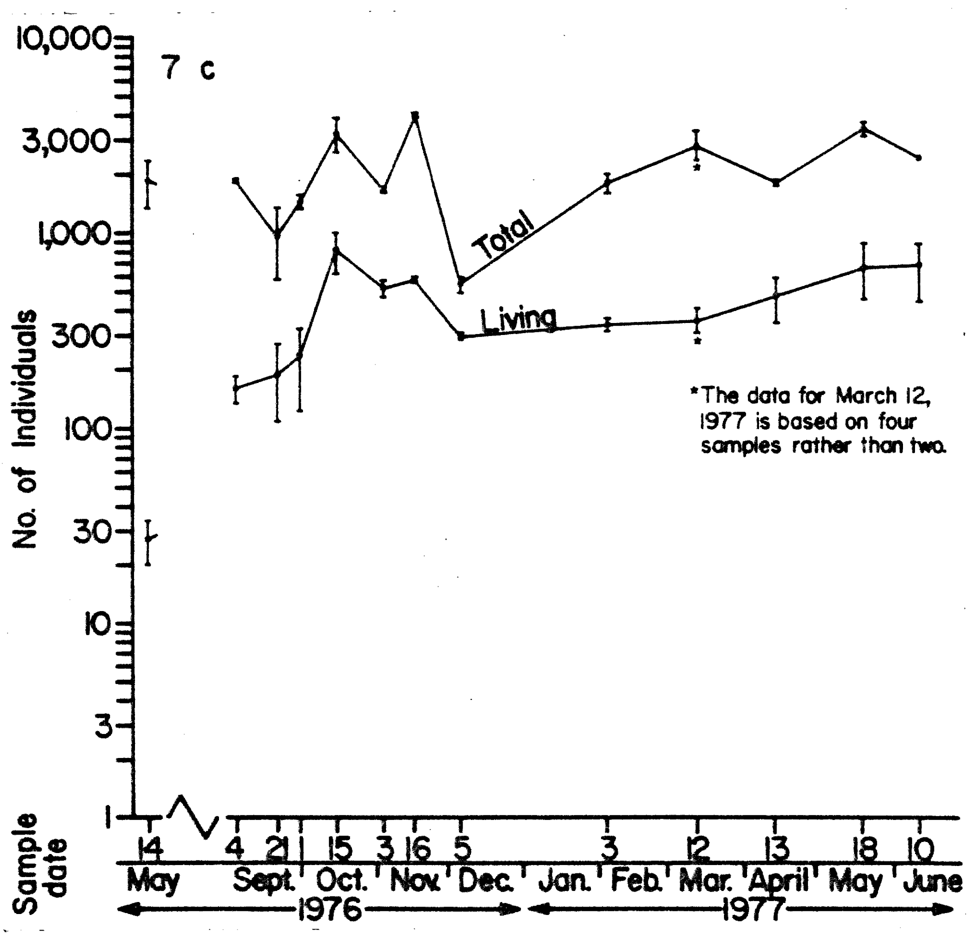


Figure 27. Chezzetcook station 7c seasonal foraminiferal living and total occurrences. Upper and lower values are the actual replicate values while the middle value is the average of the replicates; log-normal scale.

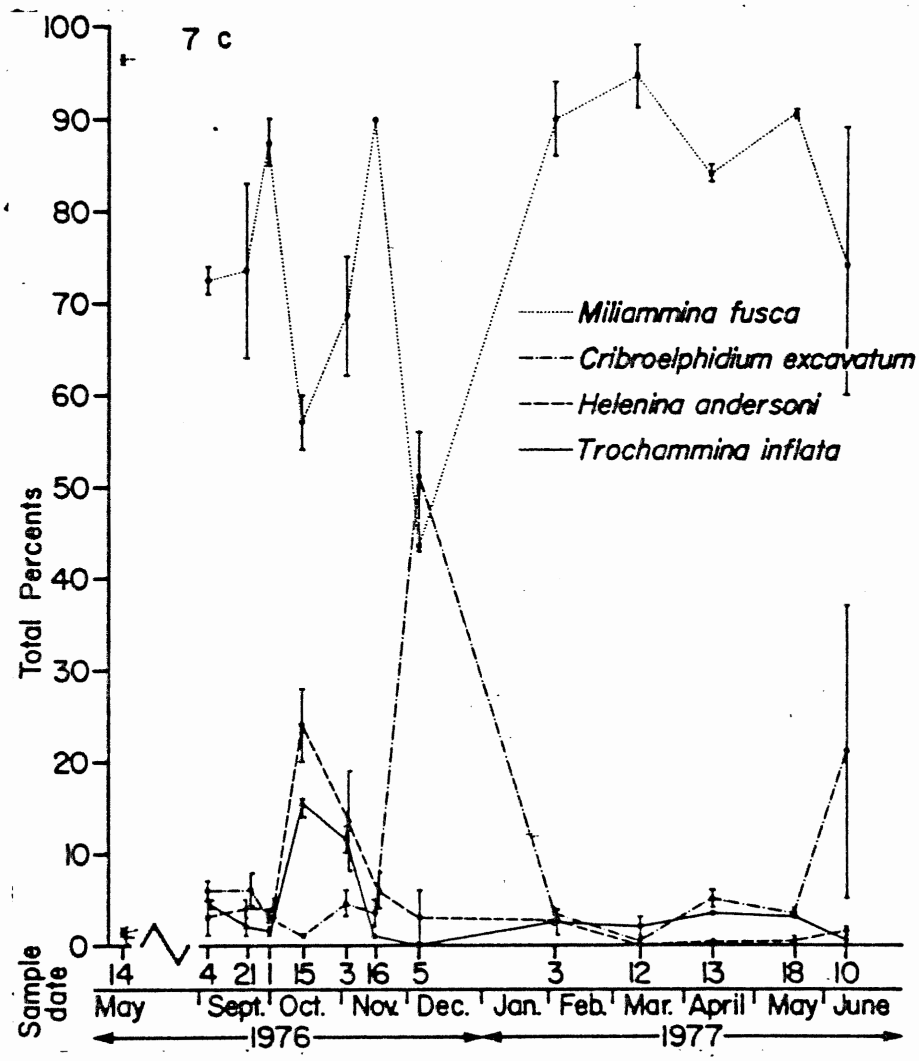


Figure 28. Chezzetcook station 7c seasonal foraminiferal percentage occurrences. Upper and lower values are the actual replicate values while the middle value is the average of the replicates.

140-190 in August and continued to increase to a maximum of 600-1000 living in October. The living number decreased to 300 in December, 1976 and then slowly increased through the winter and spring to 400-900 in June, 1977. The composition of the fauna also changed noticeably with the season (fig. 28). *Miliammina fusca* was the dominant form in all but one sample (December, 1976), with percentages varying from 60 to 98%. Percentages of *M. fusca* were lowest in October to December when living populations of the calcareous forms were large. The percentages of *M. fusca* were highest in the winter-spring period when populations of the calcareous species were extremely low. Location 7d' (fig. 29, 30, table 12, appendix) also exhibited its highest living and total populations in the October-December, 1976 time period with total numbers dropping noticeably in December. No data could be obtained for the January-March, 1977 interval. Following the melting of the ice in April, 1977, living and total populations were both observed to be high. As with 7c there was considerable seasonal variation in the assemblage observed at this station (fig. 30). *Miliammina fusca* again was the dominate form, while *Hemisphaerammina bradyi* and *Cribroelphidium excavatum* were common in the August-December, 1976 period. The April-May, 1977 samples show that *M. fusca* increased to 85-95% of the fauna while all other species combined decreased to 3-10%. As with 7c the living populations of *M. fusca* were highest in April and May and possibly were high throughout the winter.

Station 20b: This station was located in the central estuarine marsh area, close to the boundary with the upper estuary marshes, in the

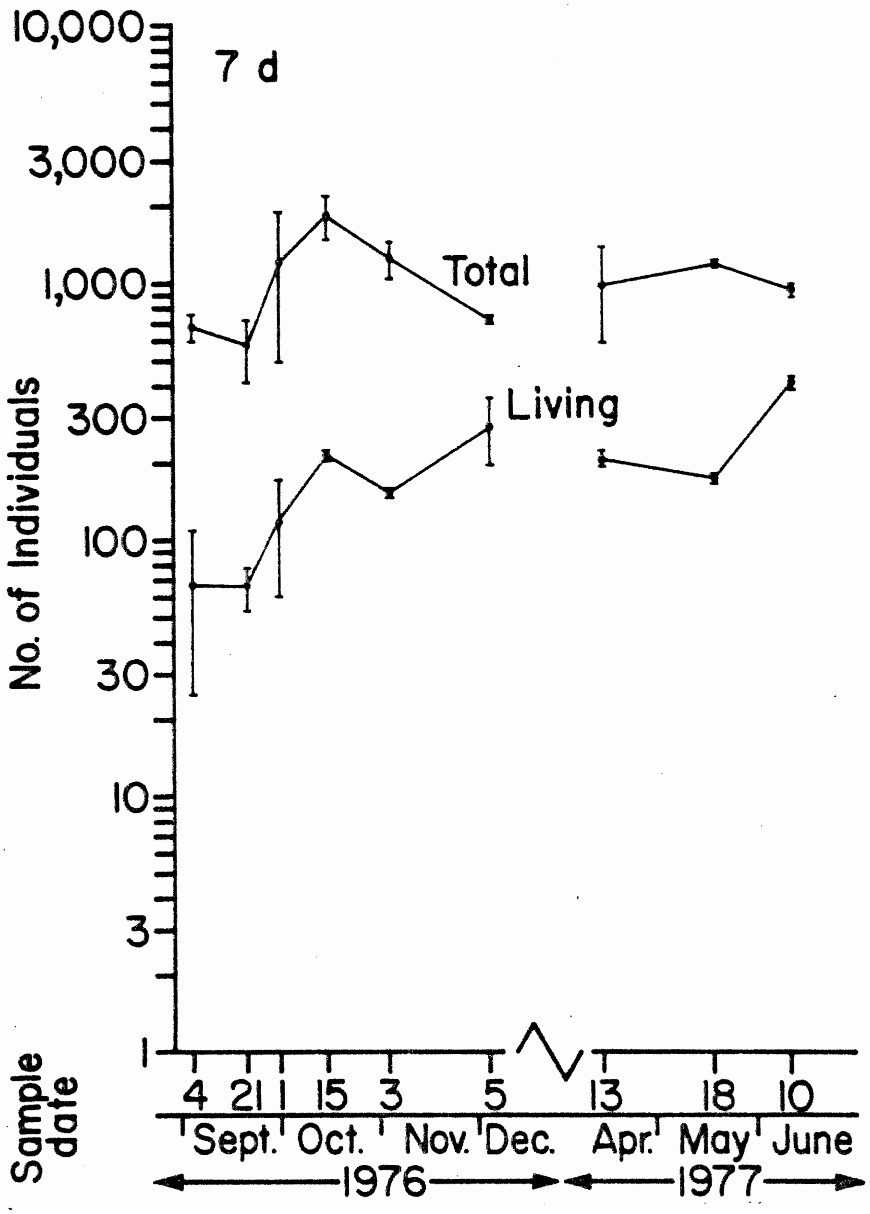


Figure 29. Chezzetcook station 7d' seasonal foraminiferal total and living occurrences. Upper and lower values are actual replicate values while the middle value is the average of the replicates; log-normal scale.

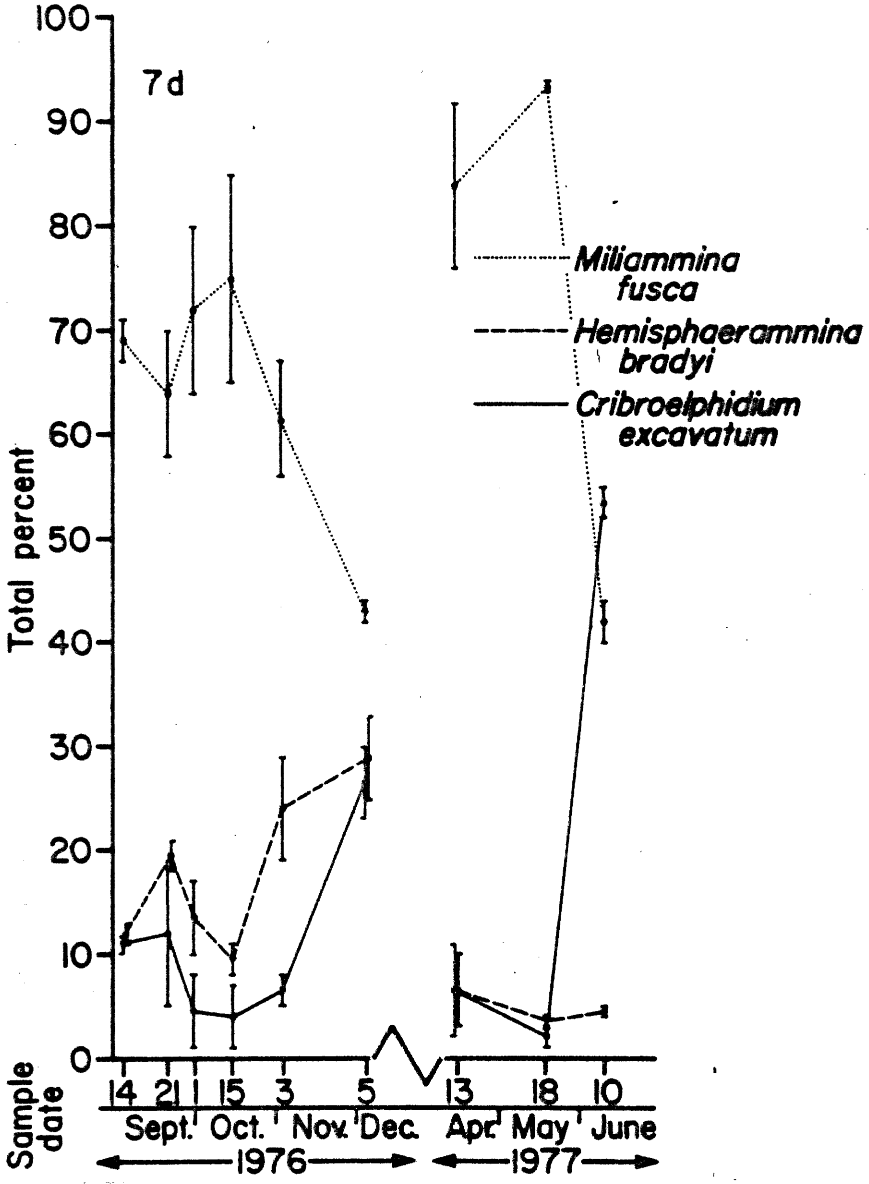


Figure 30. Chezzetcook station 7d' seasonal foraminiferal percentage occurrences. Upper and lower values are actual replicate values while middle value is the average of the replicates.

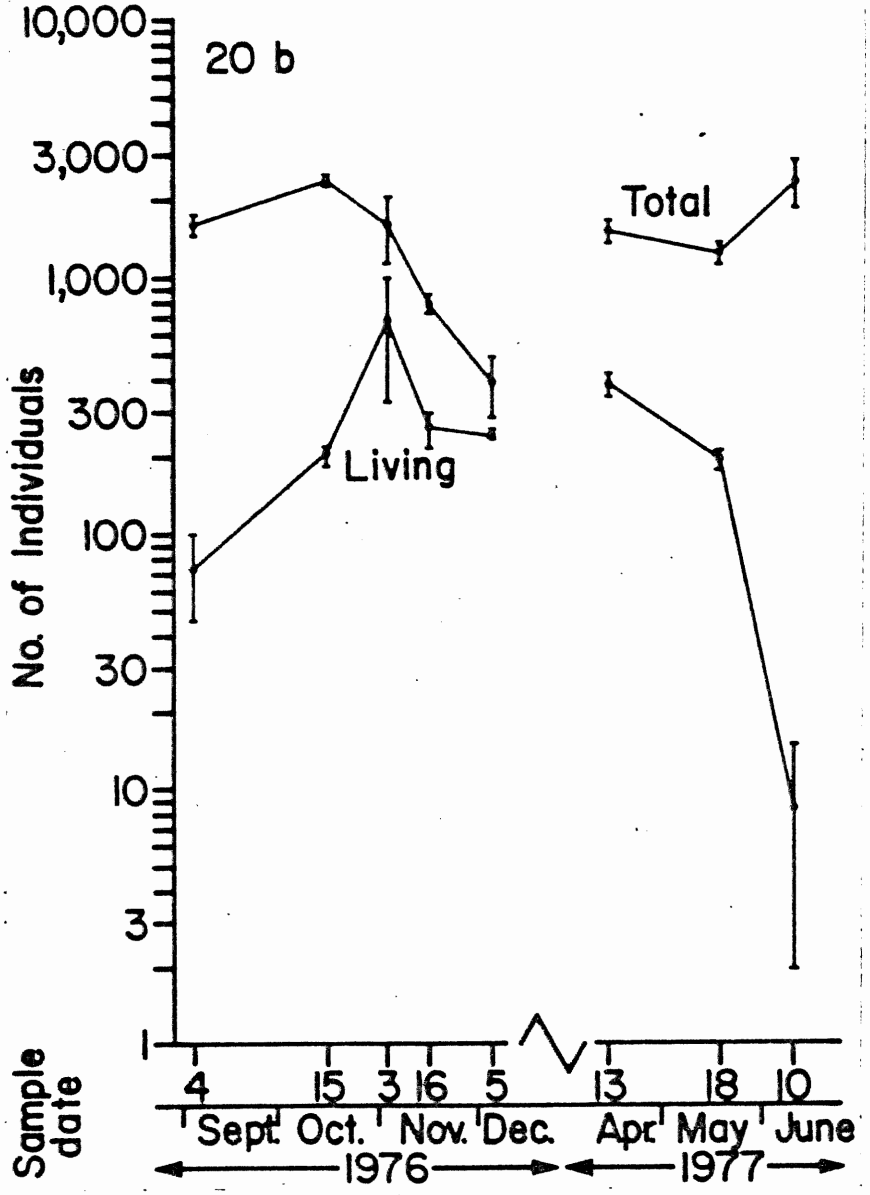


Figure 31. Chezzetcook station 20b seasonal foraminiferal total-living occurrences. Upper and lower values are the actual replicate values while the middle value is the average of the replicates; log-normal scale.

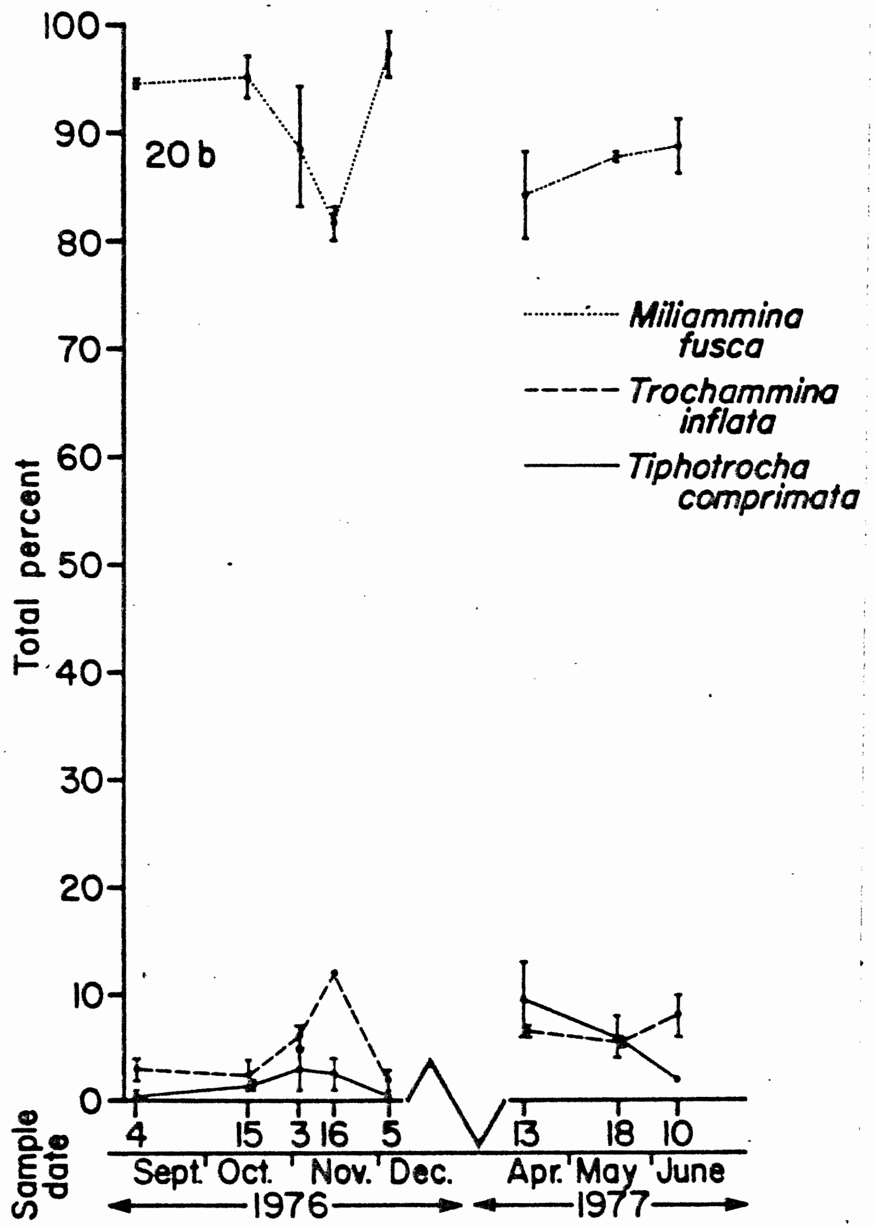


Figure 32. Chezzetcook station 20b seasonal foraminiferal percentage occurrences. Upper and lower values are the actual replicate values while the middle value is the average of the replicate.

middle marsh floral kline. Total populations at 20b were uniformly high except in May and December, 1976 (fig. 31, 32, table 13, appendix). Living populations were highest during the late fall and early spring (1977 only). As shown in figure 32, _M. fusca_ was the dominant form in all sampling intervals. The high living populations of this form observed at this locality occurred during the same time interval as those at station 7 except that living populations persisted into June, 1977 at Station 20b while dying out by June at 7.

Other marsh stations, mostly in the upper estuary, were sampled once in the early spring and once in the late summer (sta. 2a-c, 6a-c, 12b, 13b, 14b, 15b, 16a, b, 20a, c, table 14, appendix). Those stations in the upper estuary confirmed the observations at station 4 that populations were low in the spring of 1976 and were followed by higher populations in the summer of 1976. Stations from the high marshes of the central estuary (2a and 20a) established that populations in these areas also had low populations in the spring of 1976 and correspondingly higher populations in the summer, 1977.

Discussion

The detailed transect data are summarized in figure 33. The data in figure 33 are generalized and some small variations have been averaged. Considering the small vertical scale of the marsh and the many biological and physical variables both the floral and foraminiferal assemblages suggest well-defined distribution patterns within the marsh area.

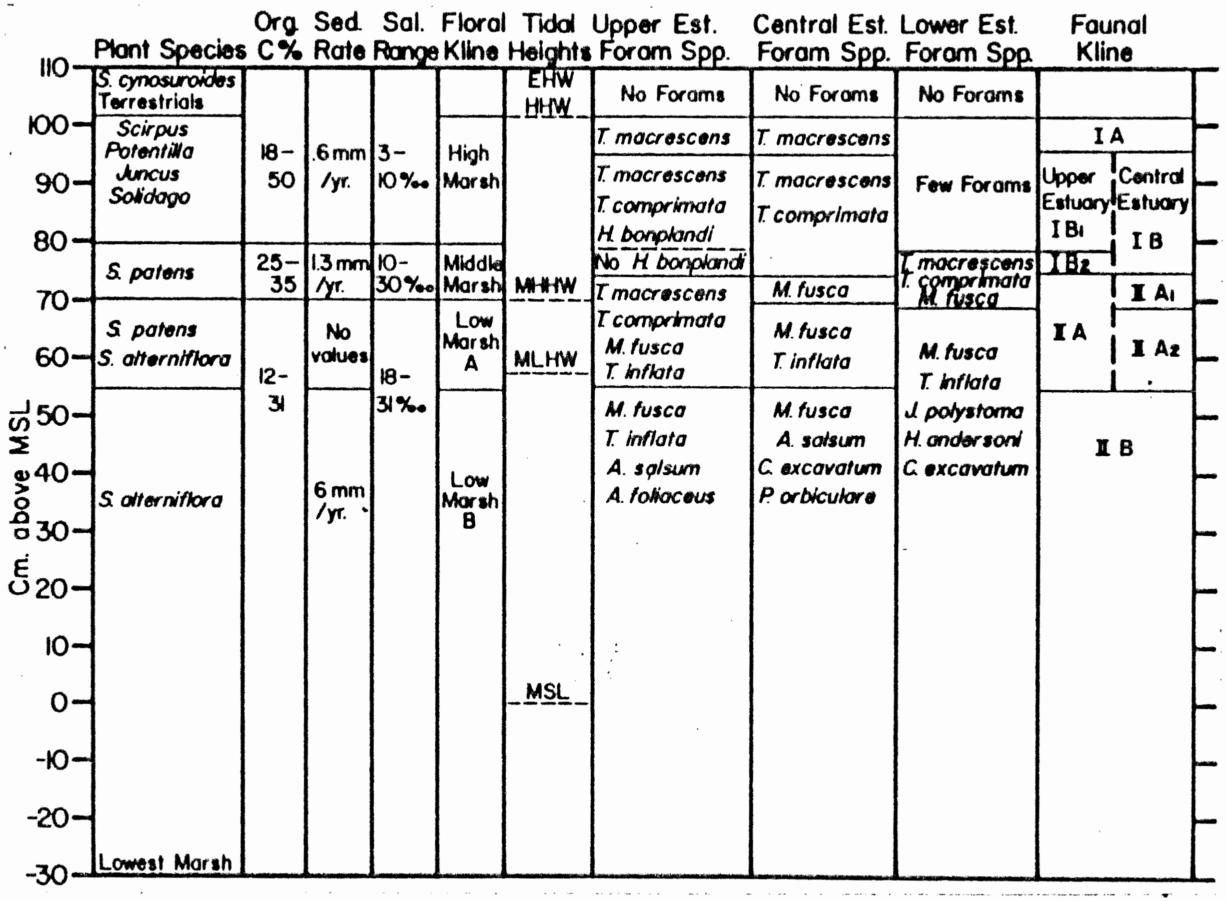


Figure 33. Summary of Chezzetcook marsh data.

The plants remain the same in each floral kline in all parts of the estuary although salinity changes noticeably from the upper to the lower parts of the estuary. Only one floral kline appears to be a response to lower salinity and that is the Solidago area which occurs in the middle marsh kline of the upper estuary (fig. 8). It appears that the development of floral klines is caused principally by elevation changes (i.e. time of exposure). The development of the high marsh floral kline, however, could be the result of increased freshwater in higher parts of the tidal range. Many of the characteristic high marsh floral types also inhabit freshwater and terrestial environments.

Since the floral klines are defined biologically some of the boundaries are variable. This is particularly true at the base of the low marsh where the bottom of the Spartina alterniflora can occur from mean sea level (MSL) to 30-49 cm below MSL. It is not uncommon to observe individuals from one floral kline growing in the next higher floral kline. This is not surprising when one considers that all these plants are restricted from higher elevations by competetion rather than being physically limited (C. F. Phleger, 1971).

Although there appears to be a close correspondence between the vertical ranges of the floral and faunal klines, it is not an exact one. There are only two major faunal klines compared with three major floral klines. The boundary between faunal klines I and II occurs in the central range of the middle marsh floral kline. The vertical boundaries of the faunal klines closely parallel mean tide levels: faunal kline I_A occurs at and just below HHW, I_B from MHHW to HHW, II_A from MLHW to to MHHW, and II_B from MSL (or below) to MLHW. Local occurrences of species such as Haplophragmoides bonplandi, Ammobaculites foliaceus, and the calcareous species not only increase the sensitivity of the faunal kline to elevation but also allow detection of other environmental characteristics such as salinity.

It appears clear that marsh foraminiferal faunal klines in Nova Scotia can be accurately equated with distinct vertical horizons in a salt marsh sequence. Thus, one is able to correlate non-modern subsurface marsh deposits with former sea levels much more accurately than had been thought possible. As the data from the transects demonstrate, however, certain faunal klines within the marsh yield higher accuracy than others since (the larger the vertical range, the lower the accuracy). The least accurate faunal kline is II, particularly II_B, because it has the largest vertical range of all the faunal klines. Faunal kline I_A has the lowest vertical range and the top of this kline is distinguished by a sharp decrease in foraminiferal numbers which accurately locates the HHW datum.

There are a number of reasons why, in addition to high accuracy, the HHW datum is a particularly favorable one to locate: 1) HHW represents a strandline deposit denoting the first marine incursion into an area thus representing the base of most marine transgressive sequences, 2) the basal sequence is usually overlying a non-compactible substrate such as glacial till, bedrock, paleosoil, etc., and is only marginally susceptible to autocompaction of salt marsh peat (Kaye and Barghoorn, 1964), 3) HHW is distinctive because of its low foraminiferal numbers, and

4) because HHW is a strandline deposit, it usually contains many small wood fragments that provide excellent carbon-14 dating material. This last point cannot be overlooked when attempting to determine temporal as well as spatial position of a changing sea level. Clearly, however, the HHW datum must be located in a continuous sequence of marsh deposit (such as in cores or drill holes) to give significance to the negative evidence of no foraminifera (which in itself is meaningless) as a datum indicator.

Most of the low marsh foraminiferal species also occur in the adjacent mudflat and shallow subtidal sediments. This makes it virtually impossible to distinguish faunal kline II_B from the mudflat and shallow subtidal areas in Chezzetcook using only foraminifera. The total numbers are usually higher in marsh sediments, but this is not always a good indicator. In sediments where low marsh is grading into mudflat, sedimentological data (i.e. the high organic content of the marsh sediments) as well as foraminifera must be considered.

The seasonal data gathered at Chezzetcook are potentially the most important part of this work because of the paucity of information regarding seasonal fluctuations of nearshore foraminifera. Its importance to this particular investigation was in demonstrating that, although large seasonal variations did occur in both living and total populations, these variations did not significantly affect the relative percentages of any species (i.e. the total assemblages did not change). This was best illustrated at station 4. Locations 4a and 4b were only a few meters apart; however, 4b was slightly lower than 4a. Haplophragmoides bonplandi was always relatively common at 4a but not at 4b. At station 7c there were significant changes in the total fauna but the changes were restricted to calcareous species; they would not cause confusion in paleo-marsh studies, because calcareous species disappear from subsurface sediments.

Some of the more interesting aspects of the seasonal data arise when comparing the two separate years of samples. Comparison of the fall, 1975 data with the fall, 1976 populations indicates something unusual had occurred in 1975 which lowered the living population to a bare subsistence level. This apparently had a devastating affect on the spring 1976 populations which remained low until at least June, 1976. By contrast, in the fall of 1976, living populations remained high until December and the following spring were observed to be high immediately after the ice melted. The only difference in general conditions between the two fall intervals appears to be the amount of precipitation occuring in the preceding summers. The summer of 1975 was one of the driest on record while the summer of 1976 had an average amount of precipitation. No salinity data were obtained in the fall and summer of 1975 but it may be speculated that salinities there were higher than those of the subsequent year. The higher salinities combined with a dessication affect may have caused the massive decrease in the living populations of 1975. A summer as dry as that of 1975 will probably not occur again for some time; therefore comparable results will not be readily available. In any event the data from 1976-1977 season should be the most typical.

Another interesting problem arising from the seasonal data of 1975 is that of the high total populations in the fall of 1975 and the much lower populations the following spring. What occurred to cause the disappearance of a large part of the fall population? Some marsh sediment containing foraminifera was divided into two equal halves; one half was frozen and the other half was examined for foraminifera immediately after collection to be used as a control. After a month the frozen sediment was examined and there was no difference in foraminiferal numbers between the frozen and unfrozen sediment indicating that freezing had no detrimental effect on the preservation of the foraminiferal tests. One possible explanation for the phenomenon is that during the high runoff periods of the late fall and early spring the foraminiferal fauna may have been diluted by terrigenous material. In the absence of living forms, which could migrate to the surface, the population was buried.

The data from the season of 1976-77 must be explained in a different manner. At station 4 in the fall of 1976 living populations remained high through November and suddenly decreased in December. The following spring populations were almost identical to those observed in November, 1976. It appears that the living population might have been migrating vertically to levels below the ice during the winter and returning to the surface following the melting of the ice. This would explain why the population dropped in December as ice was just beginning to form. It would also explain how the surface marsh became populated so quickly after the ice melted in the spring of 1977. Because of the cold temperatures during the winter, metabolic processes in the foraminifera would be greatly reduced, and there should be a low mortality rate during this period. Hence, the migration should be complete in both directions with little contamination of dead subsurface assemblages from living surface populations.

Large total populations of *Miliammina fusca* were observed in some summer samples with few living individuals. According to the accepted interpretation, the small L/T ratio here would suggest a low sedimentation rate. However, the late fall and winter samples demonstrated that large living populations of *M. fusca* occur in the winter, not the summer. Hence, the high total populations observed in the summer are residuals of the large living winter populations. Parker and Athearn (1959) also observed large winter populations of *M. fusca* in Massachusetts. Equally interesting was the large decrease of calcareous species during the winter. Walker (1976) recognized a similar relationship between calcareous and arenaceous species in the tide pools of Nova Scotia. Scott *et al*. (1977) noted that percentages of *Protelphidium orbiculare* (calcareous) were lower in the winter with corresponding higher percentages of *Ammotium cassis* (arenaceous) in Miramichi Estuary, New Brunswick. These data suggest that the calcareous and arenaceous species, at least in colder climates, do not really co-exist but live in separate time intervals. This could be either an environmental or competitive response or a combination of both. Certainly the shallow water calcareous forms are under environmental stress in many estuarine and marsh sediments where the pH is low. They are subjected to further stress in the winter because calcium carbonate is more soluble in cold water than in warm water (Greiner, 1974). The arenaceous forms, whose tests are not soluble in low pH sediments, may respond by successfully reproducing under what might be considered, at least for calcareous forms, unfavorable environmental conditions. It is not clear yet whether the arenaceous forms prefer the colder temperatures or if they are unable to compete with the calcareous forms during the warmer months.

The Chezzetcook marsh and estuary were sampled in an extremely detailed manner so that there would be sufficient information to determine an accurate model of the vertical distribution of marsh and estuarine foraminifera. In comparing the estuarine and marsh data it becomes immediately clear that the marsh foraminiferal assemblages are much more accurate sea level indicators than the intertidal and shallow subtidal sediments below the marsh. Therefore, in the areas studied after Chezzetcook only the marshes were sampled. In the following section less detailed networks of samples from Chebogue Harbour, Wallace Basin, and Summerville marsh will be described and placed in the framework of the model produced in Chezzetcook.

CHAPTER 6

OTHER MARSH AREAS IN NOVA SCOTIA

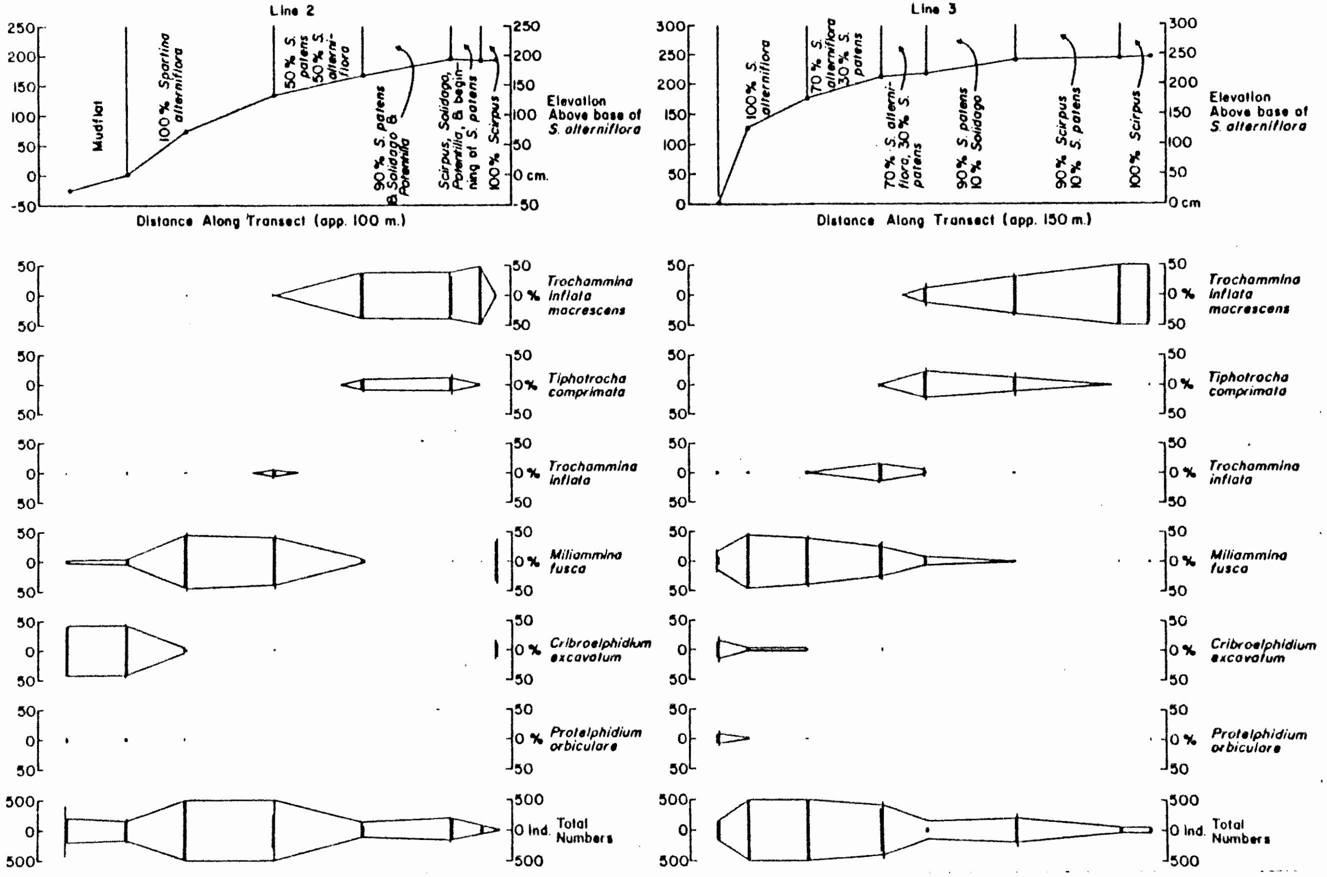
Chebogue Harbour

Chebogue is located in the southwestern part of Nova Scotia, close to Yarmouth (fig. 1), and is similar in size to Chezzetcook and, like Chezzetcook, contains an extensive marsh system. The marsh in Chebogue has a similar morphology to those areas at the head of Chezzetcook with steep sided channels and large low gradient areas comprising much of the marsh area. Unlike the head of Chezzetcook, however, most of the low gradient areas in Chebogue would be classified into low marsh floral subkline B rather than into the middle marsh floral kline.

Physical parameters: The most important physical characteristic of this marsh in relation to other areas is the expanded tidal range. Higher high water occurs at 250 cm a.m.s.l. with a total tidal range of 486 cm (data from Yarmouth). Since there were no benchmarks in the Chebogue area, the base of the marsh (i.e., base of Spartina alterniflora) was used as MSL in the semi-detailed transects carried out (fig. 34). In one transect the marsh range was 192 cm while in the other it was 245 cm. Considering the variance of the base of the marsh around MSL as observed in Chezzetcook, these values are sufficiently consistent to assume that the marshes in Chebogue, even with the expanded tidal range, still extend from approximately MSL to EHW. Marsh water salinities showed an

Figure 34. Plant and foraminiferal distribution at stations 2, 3, Chebogue. Dots are sampling localities and vertical bars are percent occurrences at each locality.

Chebogue Harbour Transects



STATION NUMBER		1	2	3	4	5	6	7	8	9	10
DATE		6/22/76	6/22/76	6/22/76	6/22/76	6/22/76	6/22/76	6/22/76	6/22/76	6/22/76	6/22/76
Substations A	Veg.	s.c., P.A., J.q.	Scp.	Scp.	s.a. (lowest)	s.a.	s.a.	s.c. J.g.	J.g. sn.	Scp. s.p.	70% s.p. 30% s.a.
	Sal.	10‰	3‰	5‰	31‰	33‰	30‰	18‰	10‰	7‰	21‰
B	Veg.	s.p., P.A., s.a.	Scp., P.A., G.R., s.p.	Scp. s.p.	50% s.p. 50% s.a.	50% s.p. 50% s.a.	s.p.	90% s.p. G.R.	50% s.p. 50% s.a.	90% s.p. 10% s.a G.R.	70% s.p. 30% s.a.
	Sal.	5‰	2‰	8‰	32‰	33‰	35‰	15‰	15‰	15‰	15‰
C	Veg.	50% s.p. 50% s.a.	90% s.p. Scp. P.A. G.R.	90% s.p. G.R.	80% s.p. 20% s.a.	s.p.	s.a.	50% s.p. 50% s.a.	s.a., s.p., sn.	s.a.	s.a.
	Sal.	15‰	2‰	12‰	26‰	35‰	28‰	27‰	23‰	27‰	22‰
D	Veg.	50% s.p. 50% s.a.	90% s.p. 10% s.a.	30% s.a. 70% s.p.	90% s.p. 10% G.R.	50% s.p. 50% s.a.	33% s.p., 33% s.a., 33% Pl.	70% s.a. 30% s.p.	s.p., s.a., Pl.		
	Sal.	25‰	12‰	13‰	19‰	33‰	33‰	25‰			
E	Veg.	s.a. (upper edge)	50% s.a. 50% s.p.	70% s.a. 30% s.p.		s.a.		s.a.	s.a.		
	Sal.	30‰	13‰	30‰		32‰		26‰	30‰		
F	Veg.	s.a. (lowest)	s.a.	Top of 100% s.a.					M.F.		
	Sal.	30‰	16‰	30‰					26‰		
G	Veg.		s.a. (lowest)	s.a.							
	Sal.		28‰	30‰							
H	Veg.		M.F.	bottom of s.a.							
	Sal.		9‰	30‰							

Table 3. Salinity, vegetation data for Chebogue Harbour marsh stations.

inverse relationship with elevation, similar to Chezzetcook (Table 3). High marsh values ranged from 2-19‰, and low marsh form 13-35‰. Salinities were lowest in isolated channels near the head of the estuary.

Vegetation: Plant species occurring in Chebogue are essentially the same as those in Chezzetcook and they appear to have a similar distribution pattern (Table 3). Some floral klines, especially the low marsh floral klines, however, are enlarged vertically because of the expanded tidal range. The low marsh kline, as defined in Chezzetcook, consisting of either 100% *Spartina alterniflora* (subkline B) or any mixture of *Spartina patens* and *S. alterniflora* (subkline A), occupies approximately 4/5 of the tidal range (approx. 200 cm) in Chebogue as compared with only 7/12 of the tidal range in Chezzetcook. High marsh floral subkline B consists of any combination of high marsh vegetation (*Solidago*, *Scirpus*, *Juncus*) together with varying percentages of *S. patens* (225-245 cm a.m.s.l.) with high marsh subkline A (245-250 cm a.m.s.l.) lacking *S. patens*. There is virtually no area that can be defined as the middle marsh floral kline. It also appears that the high marsh klines are compressed vertically with their relative vertical range decreasing in the higher tidal range of Chebogue while their absolute vertical range remains the same (25-30 cm).

Foraminifera: As in Chezzetcook all samples were collected in replicate. A total of 104 samples from 52 localities were analyzed for foraminiferal content (fig. 35). Thirty-two species, 15 of which were living, were observed in the samples (tables 15, 16, appendix).

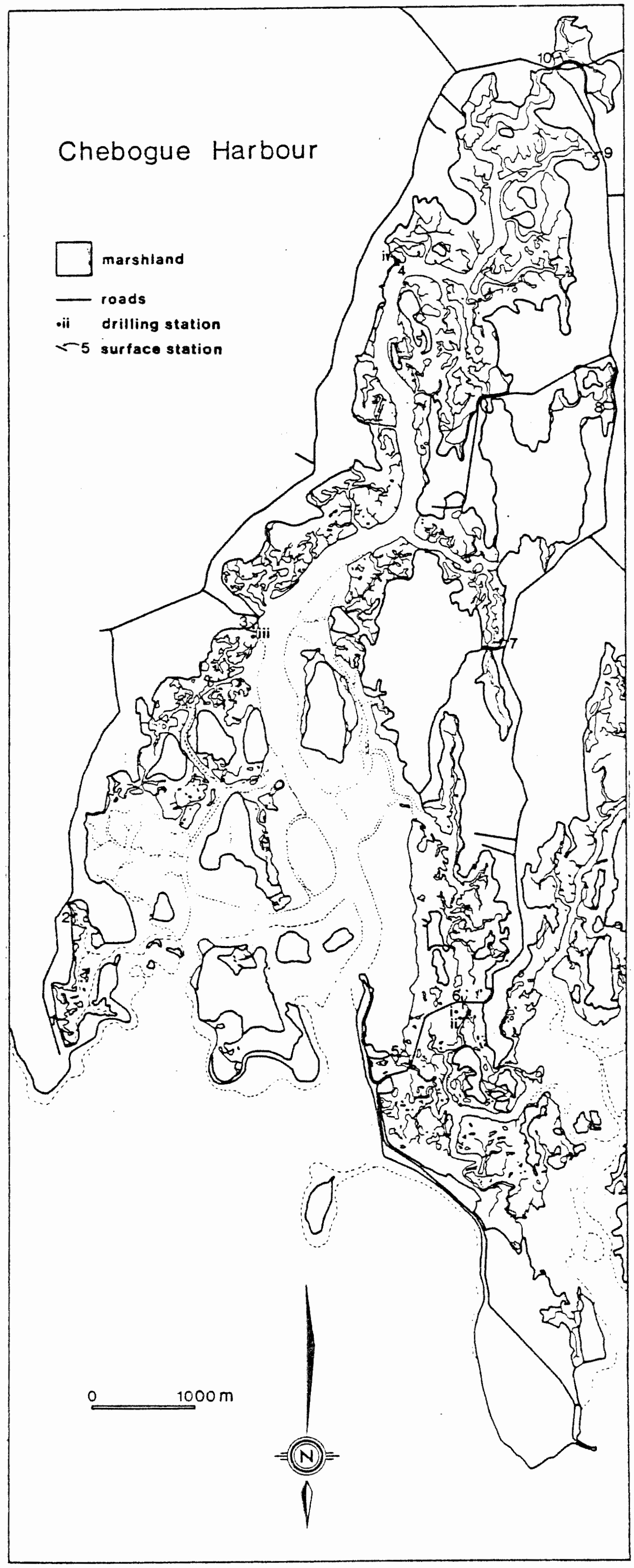


Figure 35. Surface sample and drill hole locations in Chebogue Harbour marsh.

Two semi-detailed transects (Stations 2, 3, fig. 34) were carried out in areas where there was a complete vertical section of marsh. Although these transects are not as detailed as those in Chezzetcook, the same basic characteristics emerged. At HHW the total populations in both transects decrease sharply. Just below HHW (5-10 cm below) the fauna is composed of almost 100% Trochammina inflata macrescens (faunal kline I_A). In the faunal subkline I_B T. inflata macrescens and Tiphotrocha comprimata are both common. Faunal kline II can again be divided into two subklines. In faunal subkline II_A Miliammina fusca and Trochammina inflata dominate with T. inflata macrescens and T. comprimata disappearing. In faunal subkline II_B M. fusca dominates with Cribroelphidium excavatum being common towards the lower end of this subkline. With the increase in calcareous species the total number decreases. Ammotium salsum, a common faunal kline II constituent in Chezzetcook, is absent from these transects as well as most of the other areas sampled in Chebogue.

These transects were in the central estuarine area; however, some samples collected in isolated channels (sta. 7, 9) demonstrated a faunal subkline I_B assemblage denoting more brackish conditions similar to those in Chezzetcook with significant percentages of Haplophragmoides bonplandi. Some areas had a more definitive faunal subkline II_A with higher percentages of T. inflata (stations 1d, 4b, c, 4b, d, 6b, d, 7c, 8b, d, tables 15, 16, appendix). A different faunal subkline I_B occurred at two localities (4d, 8a) dominated by T. inflata with varying percentages of *T. comprimata* and *T. inflata macrescens* and low percentages of *M. fusca*. These rare faunal subkline I_B faunae occurred where salinities were higher than would be expected for a high marsh area.

Wallace Basin

This marsh system occurs on the Nova Scotia shore just across from Prince Edward Island (fig. 1). The area is similar in many respects to Chezzetcook and Chebogue but is slightly smaller than the other two. The marsh is similar to Chebogue in that the middle marsh floral kline, if it exists at all, is extremely restricted. There are few areas with steep sided channels compared to those occurring in Chezzetcook and Chebogue.

Physical parameters: The upper "half" of the tidal range here is close to that in Chezzetcook with HHW occurring at 113 cm a.m.s.l. (from Malagash which is close to Wallace). However, the lower "half" of the tidal range is larger with lower low water occurring at 146 cm below MSL. The effect of this on the salt marsh in unknown; however, the upper and lower halves of the tidal range are more equal in Chezzetcook and Chebogue.

The salinity values have the same inverse relationship observed in the other two study areas. Salinities in Wallace were generally higher than those in Chezzetcook and Chebogue but the values were obtained later in the summer than those in the other two areas (table 4). High marsh salinities ranged from 6-20‰, middle marsh from 15-25‰, and low

STATION NUMBER		1	2		3		4	5	6		7		8	
DATE		7/16/76	7/16/76	8/22/76	7/16/76	8/22/76	7/17/76	7/17/76	7/17/76	8/22/76	7/17/76	8/22/76	7/17/76	8/22/76
Substations A	Veg.	Scp.	s.c. Scp. P.A.		50%s.c. 50%J.g.		s.c.	s.c.	s.c. J.g.		s.c. J.g.		M.F.	
	Sal.	18‰	10‰	20‰	20‰	20‰	5‰	3‰	6‰		15‰	20‰	23‰	28‰
B	Veg.	s.p.	J.g. P.A.		s.p.		s.c.	s.c.	J.g. P.A.		J.g. G.R. P.A.		s.a.	
	Sal.	22‰	15‰	20‰	25‰	33‰	2‰	0‰	21‰	22‰	18‰	20‰	25‰	28‰
C	Veg.	70% s.a. 30% s.p.	s.p. G.R.		50%s.p. 50%s.a.				s.p.		s.p.		s.p.	
	Sal.	25‰	15‰	23‰	27‰	35‰			22‰	31‰	22‰	27‰	23‰	28‰
D	Veg.	s.a.	70%s.p. 30%s.a.		s.a.				50%s.p. 50%s.a.		50%s.p. 50%s.a.		50%P.A. 50%s.p.	
	Sal.	23‰	27‰	28‰		30‰			24‰	31‰	20‰		23‰	27‰
E	Veg.		s.a.		M.F.				s.a.		s.a.		J.g.	
	Sal.		28‰	28‰		28‰			21‰	32‰	19‰		20‰	20‰
F	Veg.		M.F.						M.F.		M.F.		50%s.c. 50%J.g.	
	Sal.		22‰						22‰	28‰	8‰	17‰	8‰	15‰

Table 4. Salinity, vegetation data for Wallace Basin marsh stations.

marsh from 28-35‰ (Table 4). Values were generally higher at stations on the south side of the basin where the marsh was exposed to open circulation from the basin.

In addition to the salt marsh areas two stations were established in the upper reaches of Wallace Basin where it is no longer tidal (sta. 4, 5, fig. 36). The vegetation was monospecific with *Spartina cynosuroides* and salinities were low (0-5‰). The non-tidal condition appears to have been created artifically by a causeway placed seaward of stations 4 and 5. However, some sea water might enter this area once or twice a year which would account for the mildly brackish condition.

Vegetation: Vegetation here is similar to that in the other areas except that in the high marsh floral kline, *Juncus gerardi* is usually the dominant form rather than *Scirpus* (table 4). The middle marsh floral kline appears to be compressed into an extremely small vertical range of 5 cm with high marsh occupying the upper 50-70 cm and the low marsh floral kline (both subklines) occupying the lowest 50-70 cm.

Foraminifera: Seventy-three surface samples were collected from 37 localities in the Wallace marshes (fig. 36). A total of 19 species, 15 with living representatives, were observed from these samples (table 17, 18, appendix). One semi-detailed transect was performed (similar to Chebogue) at station 6 and data from station 8 were combined with those data from station 6 to plot figure 37. The data indicate the presence

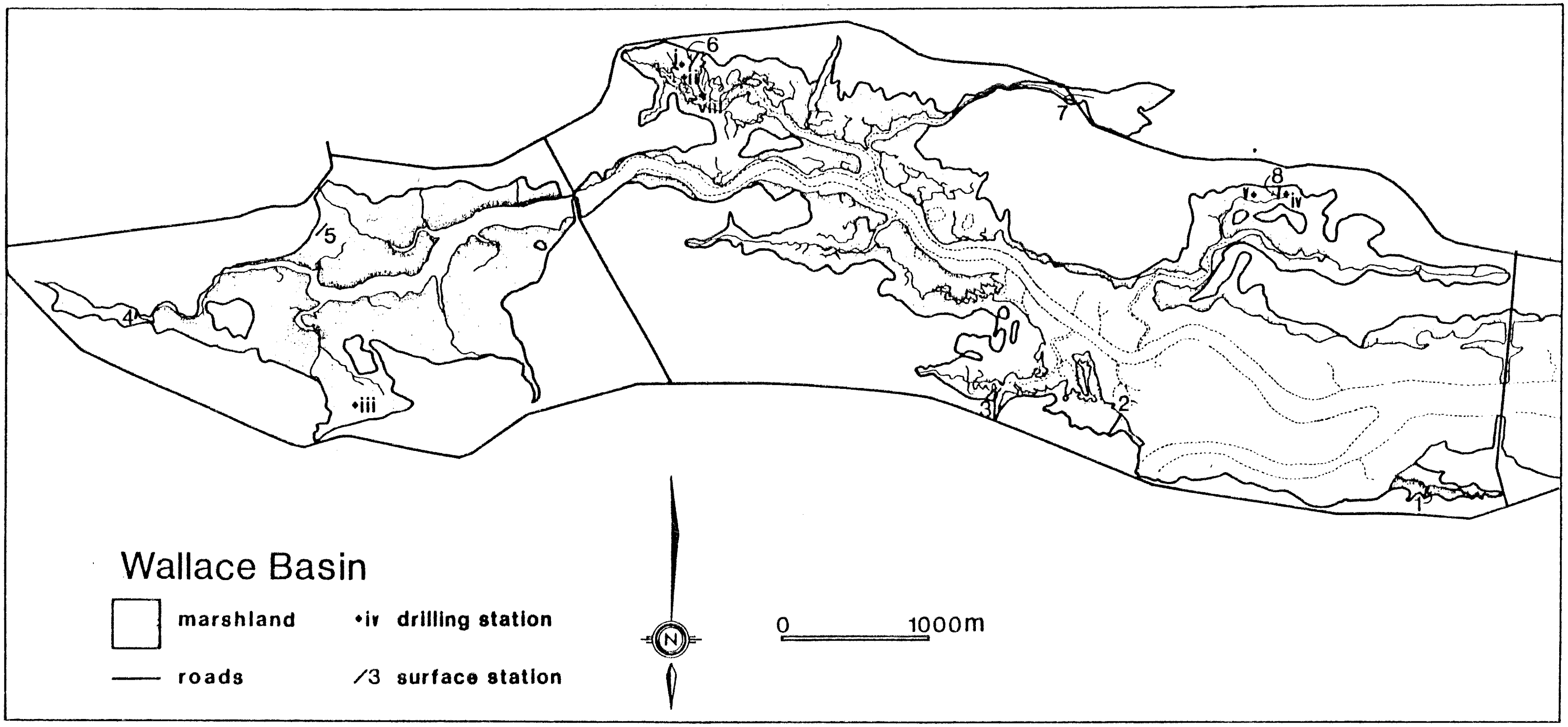


Figure 36. Surface sample and drill hole locations in Wallace Basin marsh.

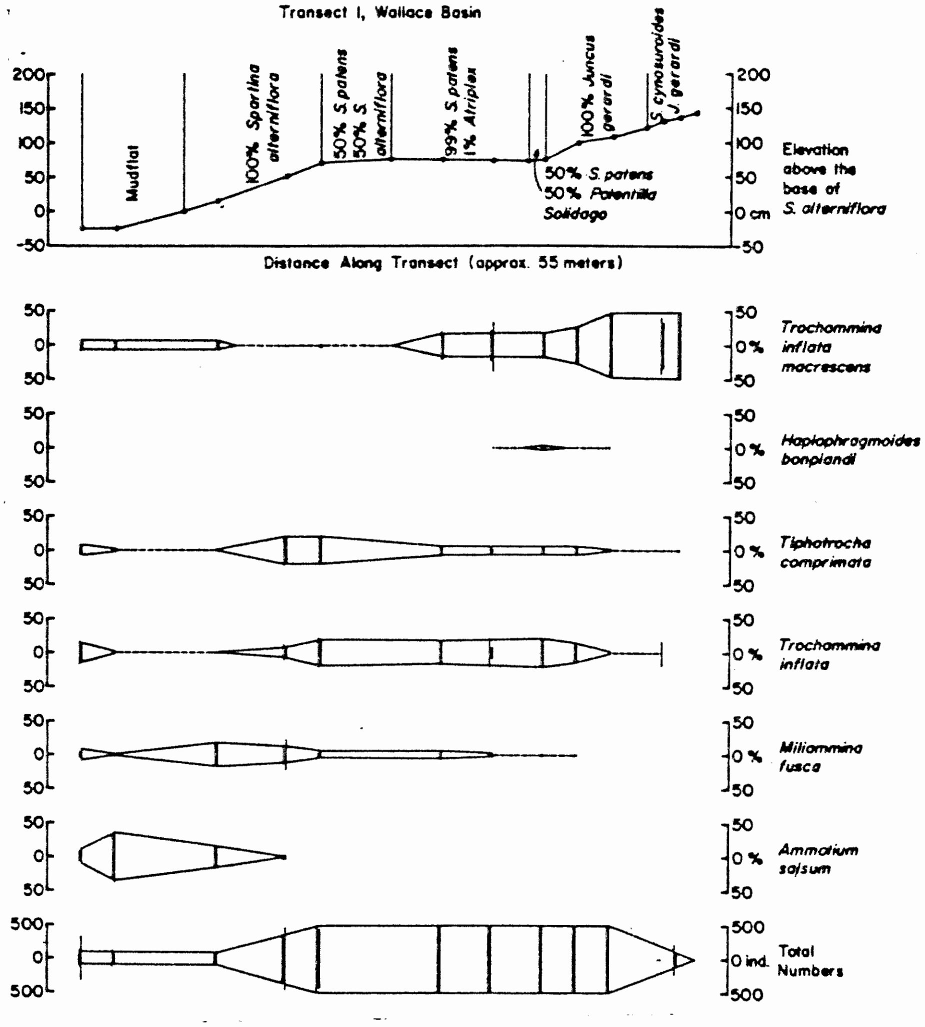


Figure 37. Plant and foraminiferal distributions in stations 6, 8, Wallace Basin. Dots are sampling localities, vertical bars are percent occurrences at each locality.

of two major foraminiferal faunal klines, similar to Chebogue and Chezzetcook. The HHW datum is again marked by sharp decrease in foraminiferal numbers and just below HHW a monospecific fauna of *Trochammina inflata macrescens* (faunal subkline I_A) occurs. Faunal subkline I_B contains large numbers of *T. inflata macrescens*, *Tiphotrocha comprimata* and *Trochammina inflata*. Faunal subkline II_A marked by a decrease in *T. inflata macrescens* together with an increase in *T. inflata*. Faunal subkline II_B is marked by decreases in *T. inflata* and *T. comprimata* together with increases in *Miliammina fusca* and *Ammotium salsum*.

As in other areas there are lateral differences which appear to be the result of salinity changes. *Haplophragmoides bonplandi* occurs in some of the more brackish areas to create a faunal sub-subkline I_{B1} and there is no fauna in the non-tidal areas (sta. 4, 5).

There was one completely anomalous area, unique to this marsh, represented by station 7 which was at the head of a narrow channel. The area corresponding to faunal subkline I_B was composed of large percentages of *H. bonplandi*, *T. inflata macrescens*, *T. inflata*, and *T. comprimata*. Below this fauna an assemblage occurred that was characterized by a species believed to be primarily a deep water form, *Astrammina rara*, together with the species from the faunal kline above. *A. salsum* did not occur in the lower areas.

Summerville Marsh

This small marsh is located behind a large sand barrier at the head of Port Mouton (fig. 1). It is probably of recent formation although no drilling was done to test peat thicknesses. The marsh studied occurred on the landward side of the sandspit (fig. 38). Hence there is probably little if any non-saline water table adjoining the marsh and any freshwater entering here must come from precipitation. Sediments in this marsh tend to be sandy and probably do not retain moisture as well as other types of marsh sediments.

Physical parameters: Tidal range at Port Mouton is similar to that in Chezzetcook with HHW occurring at 101 cm a.m.s.l. and a total tidal range of 208 cm. Salinities measured here were the highest of any area studied, especially considering the time of year during which they were obtained (mid-June). Salinities in the upper marsh ranged from 21-31‰ and in the lower marsh they ranged from 20-30‰ (table 5). There was no indication of an inverse salinity gradient with increasing elevation; in fact salinity appeared to increase with elevation in some instances.

Vegetation: Vegetation here can be divided into two floral klines, a high marsh composed of *Spartina patens* - *Juncus gerardi* - *Potentilla anserina* - *Limonium* sp. and a low marsh floral kline composed of *Spartina alterniflora* (table 5). At the upper end of the marsh the vegetation grades into dune grass.

Foraminifera: Thirty-four samples were obtained at 17 localities (fig. 38). From these samples 39 species, 9 with living representatives, were observed (table 6). Of the 39 total species, 33 were open ocean forms occurring in locations 1d-1f which were exposed to considerable

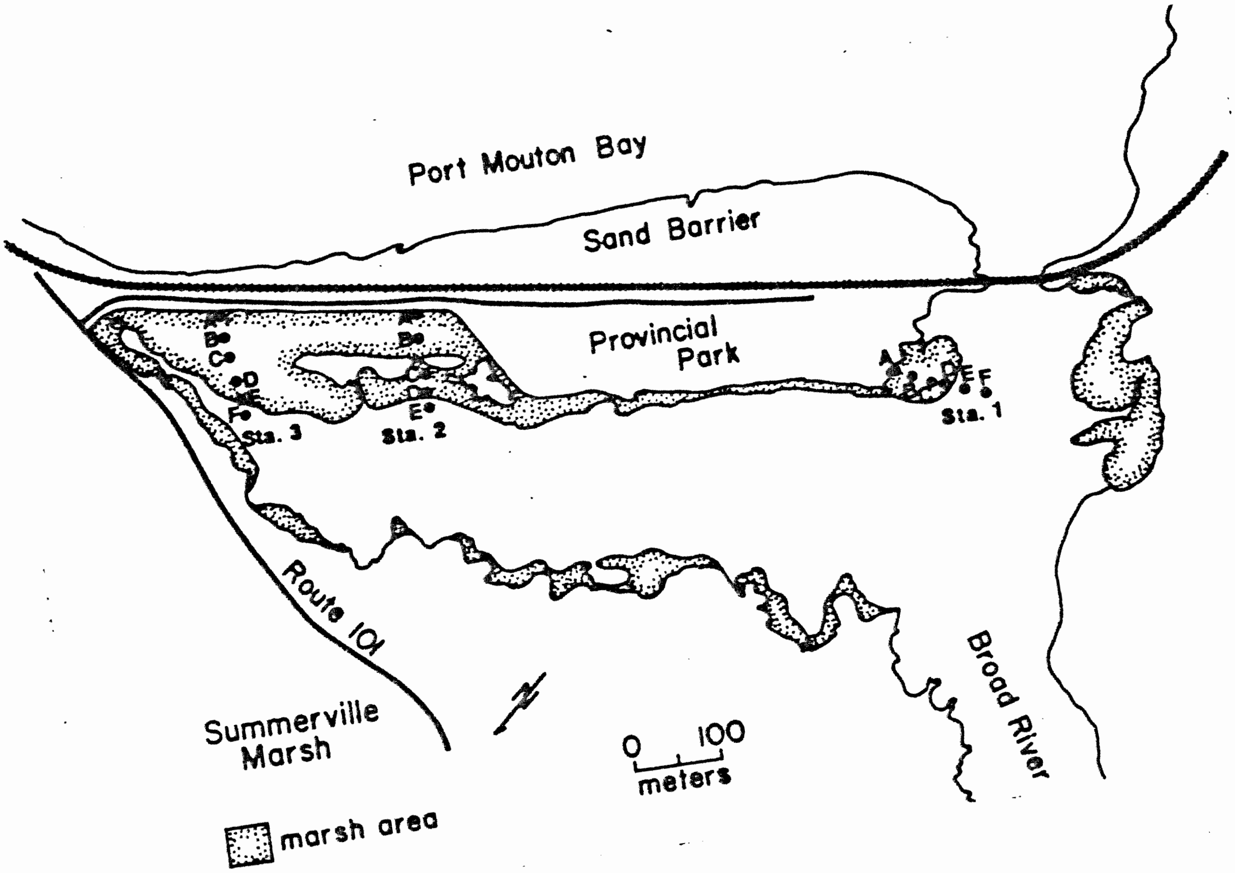


Figure 38. Summerville marsh station locations.

STATION NUMBER		1	2	3
DATE		6/21/76	6/21/76	6/21/76
Veg.-Sal. at each substation				
A	Veg.	s.p., Li.	s.p., J.g.	J.g.
	Sal.			29.5‰
B	Veg.	S.p., Li.	s.p., Li., P.A., J.g.	J.g., S.P., Li.
	Sal.		26‰	31.0‰
C	Veg.	S.a.	s.p., Li.,P.A.,J.g.,S.a.	J.g., s.p., Li.
	Sal.	31-33‰	28‰	29‰
D	Veg.	S.a.	S.a.	s.p., J.g., P.A.,Scp.
	Sal.		28‰	21-24‰
E	Veg.	m.f.	m.f.	S.a.
	Sal.		25‰	20‰
F	Veg.	m.f.		m.f.
	Sal.			24‰

Table 5. The Summerville marsh stations with date of collection, vegetation and salinity. Vegetation abbreviations same as those in Table 2.

STATION NUMBER		$1a_1$	$1a_2$	$1b_1$	$1b_2$	$1c_1$	$1c_2$	$1d_1$	$1d_2$	$1e_1$	$1e_2$	$1f_1$	$1f_2$	$2a_1$	$2a_2$	$2b_1$	$2b_2$	$2c_1$	$2c_2$	$2d_1$	$2d_2$	$2e_1$	$2e_2$	$3a_1$	$3a_2$	$3b_1$	$3b_2$	$3c_1$	$3c_2$	$3d_1$	$3d_2$	$3e_1$	$3e_2$	$3f_1$	$3f_2$
NO. OF SPECIES (Live/total)		0 7	0 11	0 5	1 5	0 3	0 5	0 13	4 20	4 22	0 15	0 12	0 18	3 5	0 4	1 4	0 4	1 4	0 4	1 4	0 2	0 4	0 3	0 4	3 5	3 4	0 4	1 4	0 4	0 4	2 4	0 4	2 4	0 4	1 5
NO. OF INDIVIDUAL PER 10 cm^3 (Living/total)		0 290	0 278	0 313	4 460	0 4720	0 1280	0 2016	64 2120	16 1852	0 1096	0 2080	0 2136	112 2914	0 3459	4 1368	0 576	1 624	0 572	4 1372	0 1240	0 864	0 450	0 6068	184 5490	12 637	0 860	5 822	0 568	0 1150	116 2310	0 1448	12 1036	0 3040	16 2192
Ammonia sp.	L																																		
	T									X																									
Ammotium salsum	L																																		
	T												X																						
Astrononion gallowayi	L																																		
	T								X				1																						
Bolivina pseudoplicata	L																																		
	T												X																						
Buccella inflata	L																																		
	T								1																										
B. frigida	L																																		
	T		1						X	2	X	3	3																						
Bulimina marginata	L																																		
	T							1																											
Cassidulina crassa	L																																		
	T		1						3	3	2	2	3																						
Cibicides lobatulus	L								25	25																									
	T	8	24	1	2			60	58	55	53	44	51																						
Cribroelphidium excavatum	L								50	25																									
	T							2	4	1			2																						
C. excavatum clavatum	L																																		
	T	3	6			X		12	11	6	23	28	6																						
C. excavatum selseyensis	L																																		
	T							1	1	1																									
C. frigidum	L																																		
	T							2	2																										
C. incertum	L																																		
	T							1	1	4			5																						
C. subarcticum	L									25																									
	T									3			3																						
Eggerella advena	L																																		
	T	6	17	4	7	11	16	8	6	2	4	5	4																						X
Fissurina marginata	L																																		
	T							3	X	1	1	1	X																						
Fursenkoina fusiformis	L																																		
	T									X	1	1																							
Islandiella teretis	L									25																									
	T									X																									
Jadammina polystoma	L																																		
	T						X																		X	X									
Miliammina fusca	L								12											100													67		
	T	1	2	4	4	89	82	3	2	1	2			X	X	4	1	6	3	94	98	10	87	17	X		4	1	2	8	10	76	72	75	57
Miliolina sp.	L																																		
	T									X																									
Nonionellina labradorica	L																																		
	T										X																								
Oolina costata	L																																		
	T	1	1																																
O. borealis	L																																		
	T							1	1	X	X	X	X																						
O. melo	L																																		
	T								X				X																						
Pateoris hauerinoides	L																																		
	T									X																									
Polysaccammina ipohalina	L																																		
	T													X																					
Protelphidium orbiculare	L								12																										
	T		4					5	5	11	6	4	8																						
Quinqueloculina seminulum	L																																		
	T								2			1	2																						
Rosalina columbiensis	L																																		
	T								1	4	3	7	8																						
Saccammina atlantica	L																																		
	T									X																									
Spiroplectammina biformis	L																																		
	T						1																												
Trifarina fluens	L																																		
	T		1					1	X	1	1																								
Tiphotrocha comprimata	L													4											11	25							33		
	T													9	4	6	3	6	6	1		39		X	22	16	10	10	9	1	2	4	4	3	11
Trochammina inflata	L													41											24	17					2				
	T	74	40	83	57									56	55	42	58	32	56	2	2	37	8	54	48	32	40	45	46	13	9	14	14	15	19
T. inflata macrescens	L				100									55		100		100							65	58		100			98				
	T	7	3	8	30									34	40	49	38	56	34	4		14	5	28	31	52	46	43	43	78	79	7	10	7	12
T. ochracea	L																																		
	T						X				X																								
Planktonics	L																																		
	T								X	1	3	4	3																						

Table 6. The foraminiferal occurrences in Summerville marsh: percent of living and total, number of species and specimens for each sample site; X refers to less than 1%, L = live, T - total.

open ocean influence. The remaining 6 species were indigenous marsh species.

Essentially two faunal klines, not including the open ocean forms occurring in station 1, were observed. Faunal kline I contained varying percentages of *Trochammina inflata*, *Trochammina inflata macrescens*, and *Tiphotrocha comprimata* with small percentages of *Miliammina fusca*. Faunal kline II was dominated by *M. fusca*.

CHAPTER 7

DISCUSSION AND COMPARISON OF NOVA SCOTIAN MARSH DATA

Comparison of marshes in Nova Scotia

A first impression of most marshes on the east coast of North America is that there are three distinct vertical floral klines delineated by vegetation types. In Nova Scotia this is best illustrated on the Atlantic coast at Chezzetcook Inlet and to a lesser extent in Chebogue and Wallace marshes (fig. 39). The middle marsh floral kline, although often covering extensive surface areas, is extremely reduced in vertical extent. In Chebogue and Wallace the middle marsh floral kline is also reduced in areal extent to the point where in Chebogue there is only one small area containing a pure stand of *Spartina patens.* The apparent sea level changes, discussed in detail in later sections, indicate that each area is experiencing a different rate of apparent sea level rise. Additionally, Chapman (1976) demonstrated that accumulation rates in the marsh vary vertically. A combination of sea level rise, accumulation rates and tidal ranges might determine how vegetation zones form within the marsh.

The foraminiferal faunas contained in the marshes examined were remarkably similar, especially considering the differences in salinities, tidal range, and climate in Nova Scotia. The fauna occurring at and just below higher high water is particularly important. In all marsh areas (except Summerville where there was no sampling at this level)

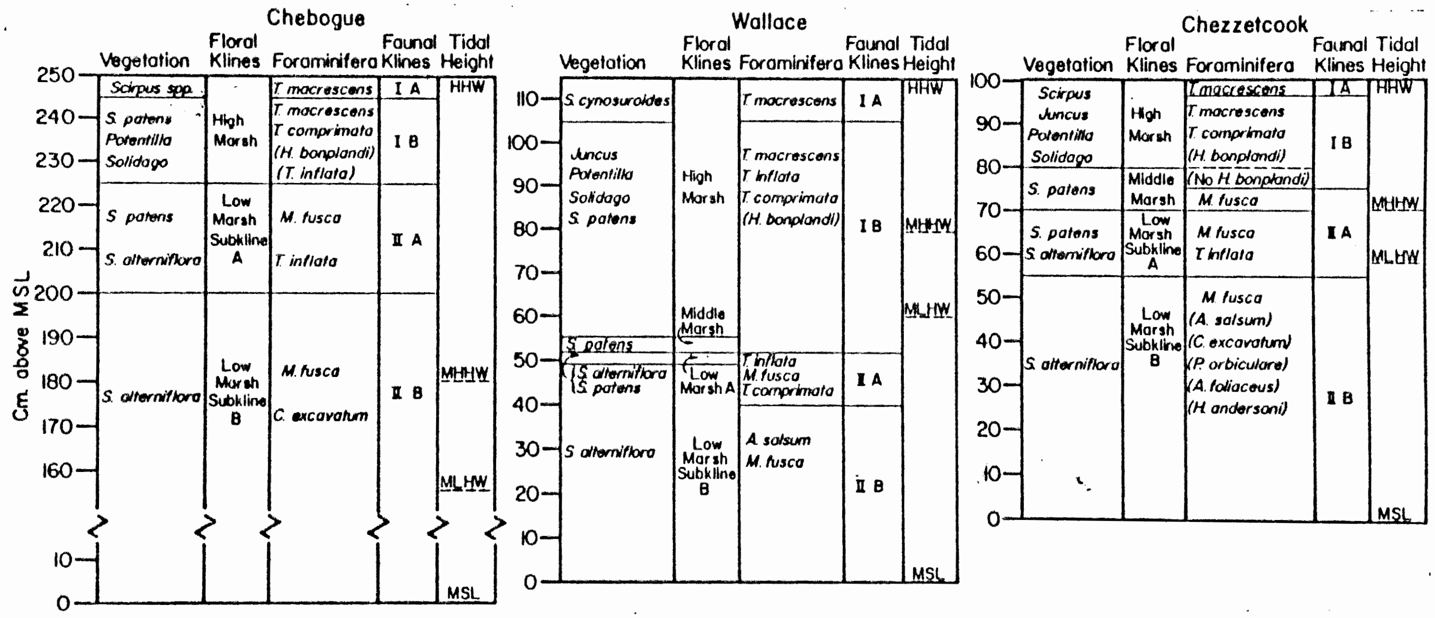


Figure 39. Summary of Nova Scotia marsh data.

foraminiferal numbers decrease dramatically at HHW. Just below HHW a fauna dominated by *Trochammina inflata macrescens* occurs in all three of the larger areas. Faunal subkline II_A is also surprisingly similar in the three major areas with a *Miliammina fusca* - *Trochammina inflata* fauna being recurrent, sometimes containing *Tiphotrocha comprimata* but not *T. inflata macrescens*. Faunal subkline II_B appears to always have the *M. fusca* element; however, the most pronounced regional differences also occur in this subkline. In Chebogue the dominant species in the faunal subkline II_B in addition to *M. fusca*, is *Cribroelphidium excavatum*, a calcareous species. In Wallace there are virtually no calcareous species with the dominant species being *Ammotium salsum* and *M. fusca*. In Chezzetcook there is a mixed subkline II_B assemblage with arenaceous elements in the upper estuary and calcareous elements (in addition to *M. fusca*) in the lower estuary. In Chezzetcook the subkline II_B species distribution, except for *M. fusca*, essentially parallels the species distribution in the estuarine sediments. This suggests that most subkline II_B species are actually estuarine forms with their upper range in the salt marsh. Using this information it should be possible to predict, without having to actually sample the estuarine environment, the type of estuarine fauna in an area from adjoining low marsh sediments. The only exception to this is *M. fusca* which occurs within the Maritimes in all subkline II_B areas regardless of salinity or region. Thus *M. fusca* would be a marsh species with its lower range in the more brackish parts of the estuary.

It is not surprising that most regional differences occur in subkline II_B since most of these species are estuarine forms. The estuary, although not a particularly stable environment, is largely subtidal and is much more stable than the marsh, especially with respect to temperature variances. With increased stability the species diversity increases along with the opportunity for faunal differentiation. In the marshes of Nova Scotia there are only 9 indigenous marsh species of which only 5 occur commonly. Usually there are only 2-3 species per subkline. Indications are that these 9 species dominate in all marshes (Murray, 1971a). With such small variety occurring on a worldwide scale there is little opportunity for sharp regional variations in faunal assemblages, particularly in the upper faunal klines. This observation had already been made, at least in part, by Scott (1976b) in explaining why zoogeographical zones were not applicable to salt marsh faunae on the west coast of North America.

In all Nova Scotian marshes the total foraminiferal numbers appeared to decrease just at the base of the marsh. However, living populations of foraminifera do not decrease noticeably in the lower part of the marsh. Therefore, the total numbers must be decreased by means of some physical process. As discussed previously, it has been demonstrated by Chapman (1976) that marsh accumulation rates are highest in the low marsh. Additionally, the rates of accumulation are probably highest at the base of the marsh where the sediment laden tidal water first comes in contact with the baffling effect of the salt marsh plants. The rapid accumulation at the base of the marsh causes dilution of the total faunal numbers in this area.

Summerville marsh was included in this study because of its distinctive faunal kline I fauna containing _Trochammina_ _inflata_ and _Trochammina_ _inflata_ _macrescens_. In this, and in other areas where this fauna occurs, the marsh appears to be newly formed and to have higher than average salinities. Although this type of marsh is not widespread in Nova Scotia today, it is conceivable that in the past, as sea level was rising thus creating the conditions for the formation of new marshes, that this faunal kline I fauna might have been present.

As tidal ranges increase the vertical zones do not appear to increase proportionally. The total marsh range appears to remain the same (MSL to EHW), however, comparison of vertical zones with the marsh at Chebogue and Chezzetcook demonstrates that as tidal range increases it is absorbed mostly into low marsh floral subkline B. The upper floral klines appear to retain virtually the same absolute vertical range. The phenomenon has been observed in the Fundy marshes where tidal ranges are even more extreme (Scott, unpublished data). Hence, the high marsh floral klines retain their absolute accuracy even with increased tidal ranges. This is true also for the corresponding faunal klines.

Comparison of Nova Scotian marshes with those in southern California

Nova Scotian and southern California data can be compared directly because, in both areas, detailed transect sampling was carried out (fig. 40). The California data are from Scott (1976a) and the Nova Scotia data are representative of Chezzetcook.

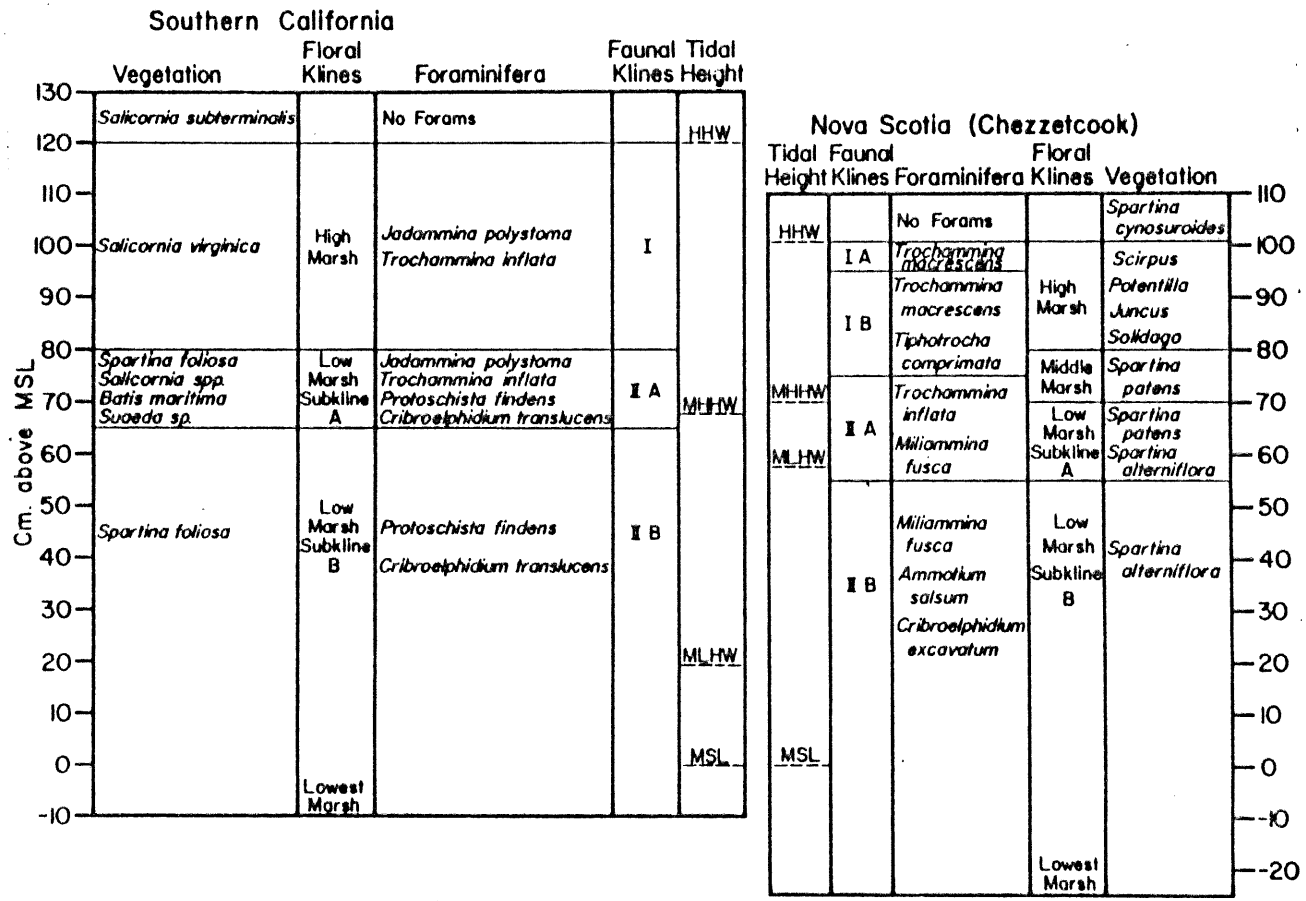


Figure 40. Comparison of southern Californian marsh data (from Scott, 1976a) to Nova Scotian marshes (from Chezzetcook).

The largest difference between the two widely separated localities occurs in the vegetation types. One species from California (*Salicornia virginica*) occurs only in isolated populations in Nova Scotia. In California only two distinct floral klines can be recognized with a transition one occurring between them, while in some marshes in Nova Scotia, although the middle kline is often narrow in extent, there are three recognizable floral klines.

The foraminifera are more comparable. Only one arenaceous marsh species from California (*Protoschista findens*) is not present in Nova Scotia and it is probably a lagoonal species rather than a true marsh form. Several of the arenaceous marsh species present in Nova Scotia are not present in California (*Haplophragmoides bonplandi*, *Tiphotrocha comprimata*, *Astrammina rara*, *Trochammina inflata macrescens*, *Polysaccammina ipohalina*). These species are all faunal kline I species and appear to be replaced in California by *Trochammina inflata* and *Jadammina polystoma* together with significant numbers of calcareous species such as *Quinqueloculina seminulum* and *Discorinopsis aguayoi*. The faunal kline II differences are more complete. However, this would be expected since few of the warm water lagoonal species in California exist in Nova Scotia. The distribution of *Miliammina fusca* in California is similar to that in Nova Scotia. This form appears to be more restricted in California, however, possibly by competition from southern low marsh-lagoonal forms.

In both California and Nova Scotia the total foraminiferal numbers decrease dramatically at HHW datum in addition to showing a less pronounced decrease at the lower edge of the marsh.

Comparison of Nova Scotian marsh foraminifera with other selected marsh faunae

Barnstable marsh, Massachusetts: Phleger and Walton (1950) reported on marsh faunae of Barnstable Harbor as part of a larger study involving the entire bay. They reported faunae containing *Trochammina inflata* and *Trochammina inflata macrescens* in high numbers from the marsh areas but no attempt was made to differentiate the assemblages into faunal klines. They also reported *Miliammina fusca* at some locations.

James River estuary, Virginia: Ellison and Nichols (1976) report on the marsh Foraminifera from the adjoining marshes of the James River estuary. They detected upper, middle, and lower estuarine marsh assemblages, similar to Chezzetcook. They also detected some vertical zonation within the marsh. Salinities in the James estuary, especially in the upper and middle estuarine areas, are much lower than those observed in any of the study areas in Nova Scotia. Tidal ranges also appear to be relatively low compared with those in Nova Scotia.

In the upper estuarine area an assemblage dominated by *Ammoastuta salsa* occurs in the marshes; in the middle estuary the assemblage is co-dominated by *A. salsa* and *Miliammina fusca*, and in the lower estuary *M. fusca* dominates.

Vertical zonation was demonstrated only in the upper estuarine marsh. Foraminifera appear to decrease sharply again at HHW. *Ammoastuta salsa* dominates the higher marsh together with lesser percentages of

Arenoparella mexicana, Tiphotrocha comprimata, and Trochammina inflata macrescens; Miliammina fusca dominates the lower marsh with Ammobaculites crassus beginning to appear on the mudflats.

This, except for the appearance of A. salsa, is not altogether different from what is observed in Nova Scotia, especially considering the different salinities, plant types, sediment types, and tidal ranges.

South Texas marshes: Phleger (1965a, 1966) examined a series of marshes in Matagorda Bay and Galveston Bay in south Texas. In Matagorda Bay two distinct floral klines are recognized with a transition kline occurring between them, much as in Nova Scotia and California. Trochammina inflata, Arenoparella mexicana, Ammonia beccarii, and Pseudoeponides (= Helenina) andersoni dominate in the upper Salicornia floral kline with Miliammina fusca, Ammotium salsum, Cribroelphidium spp., Miliolids, and A. beccarii dominating in the lower Spartina floral kline. Significantly, M. fusca and T. inflata together with A. beccarii dominate in the middle Spartina-Salicornia transition floral kline, as in Nova Scotia. In Galveston Bay the zonation is less distinct, however T. inflata appears to dominate the higher areas.

Although no salinity values are reported from this marsh, the range is probably somewhere between that of Nova Scotia and southern California. The Texas marshes have some brackish marsh species but they are in small numbers. Additionally, the warmer temperatures in Texas allow populations of some calcareous species such as A. beccarii and H. andersoni to develop.

Southern Holland, Europe: Phleger (1970) examined several marshes in Europe including some in Holland. The low marsh floral klines are characterized by a flora containing a *Salicornia*-*Spartina* assemblage and the high marsh floral kline is denoted by a *Puccinella*-*Halimione*-*Suaeda* assemblage. The marsh foraminifera were delineated into two vertical faunal klines: *Jadammina polystoma* and *Trochammina inflata* characterizing the faunal kline I and a variety of calcareous species denoting faunal kline II. Faunal kline I fauna is similar to that observed in California.

Discussion of all marsh data

As discussed by Scott (1976b) all marshes are subject to large sudden variations in temperature, regardless of latitude. Few marine species (i.e. the foraminifera) appear to be able to survive these temperature variations although those that do appear to exist in all marshes. Temperature restricted species appear to be those that are calcareous. More such species occur in warmer climates than in colder ones. Calcareous species are usually estuarine-lagoon rather than actual marsh forms. Additionally, they have limited use in paleo-marsh interpretations since they dissolve soon after death in the low pH marsh sediments.

The variable that appears to control distributions of marsh Foraminifera, besides elevation, is salinity. In extremely brackish areas, such as those reported by Ellison and Nichols (1976), *Ammoastuta salsa* dominates the faunal kline I. In moderately brackish areas, such as those in Nova Scotia, *Trochammina inflata macrescens* and *Tiphotrocha comprimata* dominate the faunal kline I. In areas that are borderline brackish (for example, Summerville marsh), a mixed fauna of *T. inflata macrescens* and *Trochammina inflata* occurs. In marshes with normal or higher salinities such as those in Holland and California, *T. inflata* and *Jadammina polystoma* dominate the faunal kline I. Faunal kline II distributions are much more complex, being controlled more by locally dominant estuarine-lagoon forms than by marsh forms. However, *Miliammina fusca* is a common constituent of most faunal kline II assemblages. It is worth noting here that the faunal kline I forms such as T. inflata, *T. comprimata*, and *T. inflata macrescens* occur only in the higher elevations of the marsh, or not at all, so that their distribution is controlled as much by elevation as by salinity.

The detailed data obtained in both California and Nova Scotia suggest a strong correlation between elevation above mean sea level and marsh foraminiferal zones. The marsh Foraminifera characterizing these zones are easily detected and well preserved in subsurface marsh sediments. Foraminiferal assemblages can be used to accurately (± 5 cm) locate the HHW datum in a marsh sequence. From that, sea level and former sea levels can be determined. Although this accuracy can only be proven in areas such as California and Nova Scotia where accurate measurements have been performed, less detailed data from other areas strongly suggest that the same accuracy could be obtained with further detailed studies.

It appears that foraminiferal numbers dramatically decrease at the HHW datum in most marshes. The sharp decrease in numbers at HHW may appear trivial at first; however, the phenomenon is not self-evident on closer examination of the area above HHW. Conditions in surface sediments above HHW could be considered favorable for support of large foraminiferal populations, especially in humid areas such as Nova Scotia. In Nova Scotian marshes moisture above HHW is supplied both by fresh-water runoff and sea water raised by capillarity, creating a mildly brackish environment. Therefore the absence of Foraminifera above HHW is significant and indicates that marsh Foraminifera require some tidal activity for survival. It is highly unlikely that marsh Foraminifera would be found in supra-tidal bogs of other fresh-water deposits resembling marsh sediments.

It cannot be assumed that marsh faunae occurring in apparently similar marsh areas will be exactly the same. Although the Nova Scotia studies demonstrate relatively few regional differences, in California the differences between two marshes that were extremely close together were sharp, especially in faunal kline II. These types of differences make it imperative that a detailed study of modern marsh faunae be conducted in areas where there is to be a subsurface study.

With the accurate method for locating former sea levels detailed above, it is now possible to measure small movements of sea level not previously measurable by other techniques. This method, now that it is established, can be used to solve some of the problems relating to eustatic sea level rise, subsidence, and rebound that have taken place during the Holocene in formerly glaciated areas. Results of some preliminary investigations into this field as they apply to Nova Scotia are presented in the following section.

CHAPTER 8

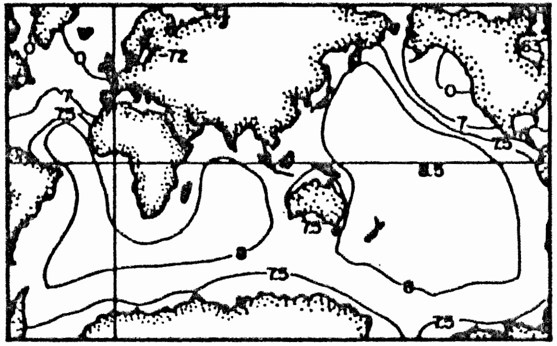
APPARENT SEA LEVEL CHANGES IN THE MARITIMES DURING THE HOLOCENE

Introduction

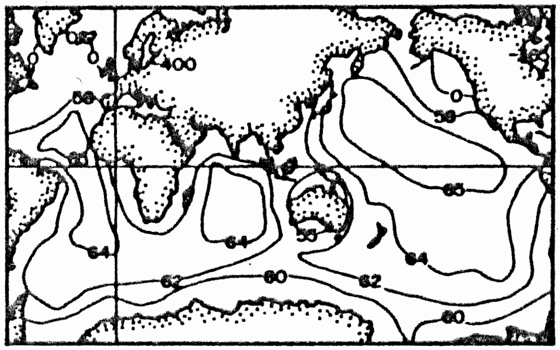
Most standard eustatic sea level curves (e.g. Shepard and Curray, 1967, Milliman and Emery, 1968, Scholl et al., 1969) indicate a fairly rapid rise in eustatic sea level (approx. 100 cm/cent.) from approximately 13,000 ybp until 6000-7000 ybp. In the last 4000-7000 ybp eustatic sea level rise is shown as being about 6 cm/century with some authors suggesting no eustatic sea level rise in the last 5000 years (Suggate, 1968). These curves have been derived from information relating to supposedly tectonically stable areas, such as Bermuda and Florida and are meant to represent the true rise in absolute water level (R_w).

Recently, a method has been presented for calculating the changes in sea level (R_w) that occur when ice and water loads are redistributed on the surface of elastic and viscoelastic Earth models (Farrell and Clark, 1976; Clark, 1977). They can thus calculate instantaneous elastic and delayed viscoelastic R_w during the partial melting of the Pleistocene ice sheets. Their results suggest R_w is not the same at all points in the ocean. For example, the North Atlantic appears to have experienced relatively little eustatic sea level change in the last 13,000 years (fig. 41). Hence, recognized eustatic sea level curves from other locations may not be applicable to the Maritimes.

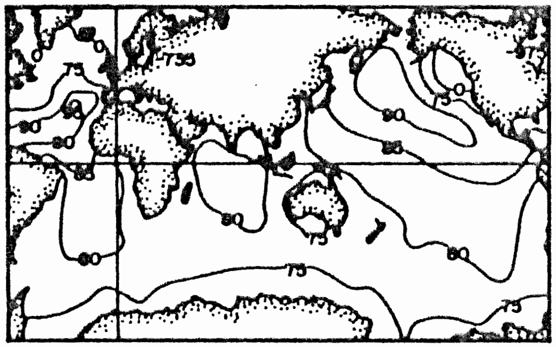
Figure 41. Predicted change in sea level (meters) since Wisconsin maximum (16,000 Y.B.P.). The melting of a realistic ice load in 1000 year increments since 16,000 Y.B.P. gives this non-uniform sea level change through time. The values of sea level change at selected localities can be compared directly to observed emergence or submergence curves (Fig. 42, Clark, 1977).



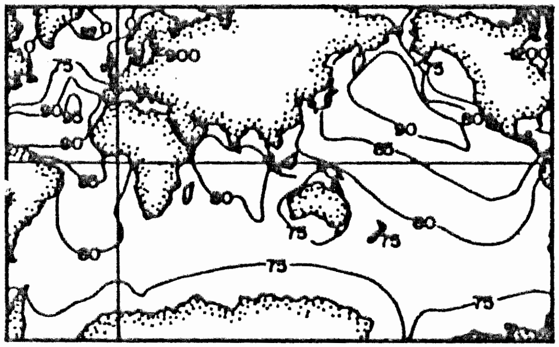
(A) 13,000 Y.B.P.



(B) 8,000 Y.B.P.



(C) 5,000 Y.B.P.



(D) PRESENT

There has been considerable interest in the Maritimes regarding Holocene sea level changes.[1] Swift and Borns (1967) suggest there is a zero isobase (in this case meaning a line of no crustal deflection) that bisects Nova Scotia and continues through Prince Edward Island. Raised post-glacial marine features occur to the west of the isobase with submerged features to the east. Kranck (1972) confirmed the interpretation of Swift and Borns (1967) in the Northumberland Strait. Grant (1970a, b) presented the largest body of data on submerged features in the Maritimes. He gave relative sea level rise rates (r/t) of 30 cm/century for the Bay of Fundy over the last 6000 years and 15 cm/century for the Atlantic coast of Nova Scotia over the last 1000-2000 years. Grant used higher high water as a datum and he attributed at least 15 cm/century of the submergence in the Bay of Fundy to resonant tidal amplification or the differential rise of high-tide level with respect to mean sea level. Since higher high water datum levels are the most commonly used sea level indicators, the Bay of Fundy is not a satisfactory area to study changes in mean sea level and this is one reason the present study has avoided this area.

In addition to his long term data Grant (1970a, b) presents tidal gauge data suggesting that several areas in the Maritimes are still experiencing rapid relative sea level rises. Studies of modern changes in

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[1] A workshop convened by Chris Beaumont and the author was held in January, 1977 at Dalhousie University to review the work done to date regarding sea level changes in the Maritimes. A short report on this workshop is scheduled to appear in the Fall, 1977, issue of Geoscience Canada.

relative sea level have been carried out by means of releveling techniques and the study of tidal gauge data (Dohler and Ku, 1970). Vaníček (1976) synthesized these data in the form of a map of recent vertical movements in the Maritimes. His results suggest a present day zero isobase bissecting New Brunswick with most of Prince Edward Island and Nova Scotia subsiding and land north of Miramichi Bay, New Brunswick, to be still rebounding.

These studies and additional ones from New England (fig. 42) indicate that this area is experiencing excessive relative sea level rise (Emery and Garrison, 1967; Redfield, 1967; Milliman and Emery, 1968; Grant, 1970a, b). Most studies have attributed this excessive apparent sea level rise to subsidence (R_e), but few authors have attempted to divide the relative sea level rise into quantitative components (i.e. R_e and R_w). Kaye and Barghorn (1964) did attempt to separate the two components for Boston, Massachusetts, by calculating a crustal movement curve (R_e) and using an assumed eustatic sea level curve. Their data suggest that sea level changes in New England during the last 4000 years have been dominated by R_e rather than R_w.

Bloom (1967) and Grant (1970a, b) have suggested that water loading on the continental shelves resulting from sea level rise has produced the excessive relative sea level rise observed in New England and the Maritimes. However, there are serious problems with this explanation. If a uniform, worldwide, eustatic sea level rise is assumed, then there should be uniform subsidence along all coastlines of uniform width, such as the Atlantic and Gulf coasts of North America. As suggested by

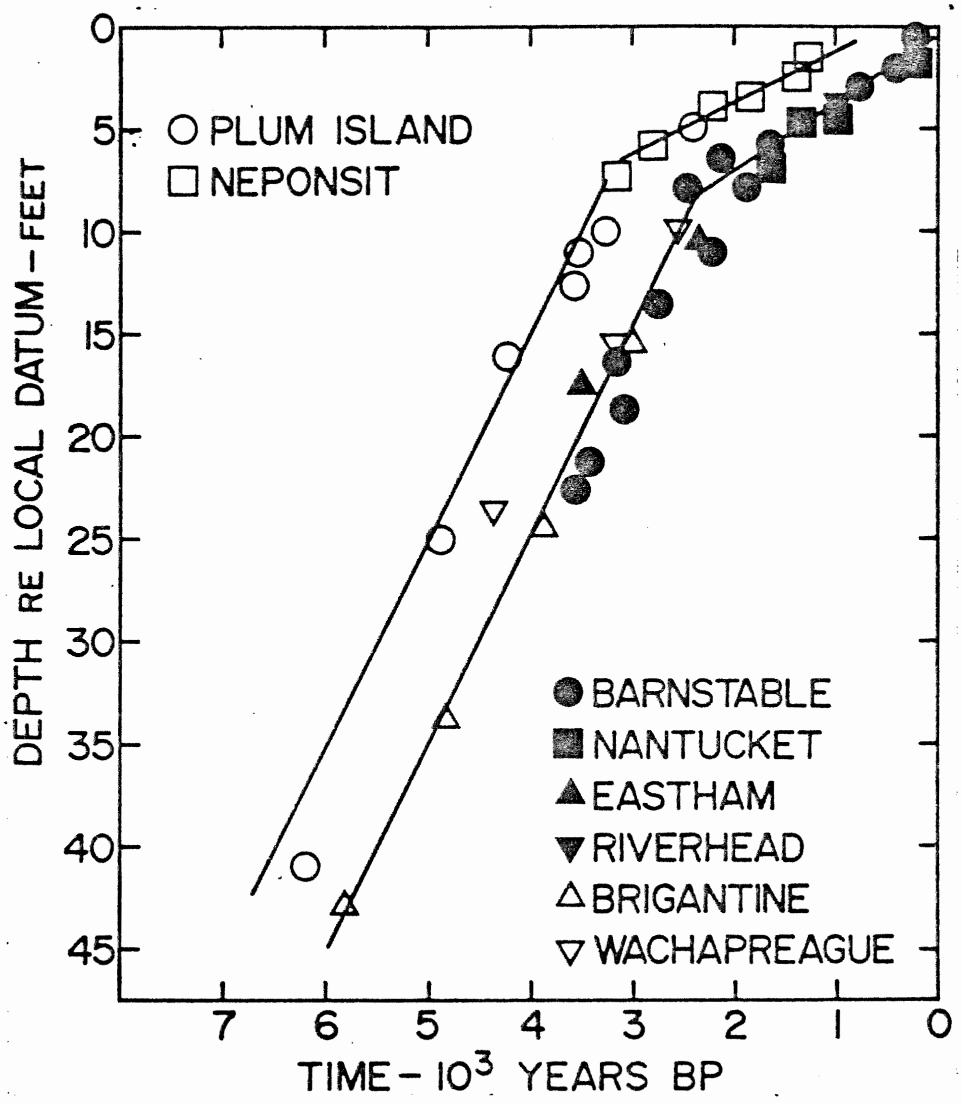


Figure 42. Relative sea level curves from New England (from Redfield, 1967).

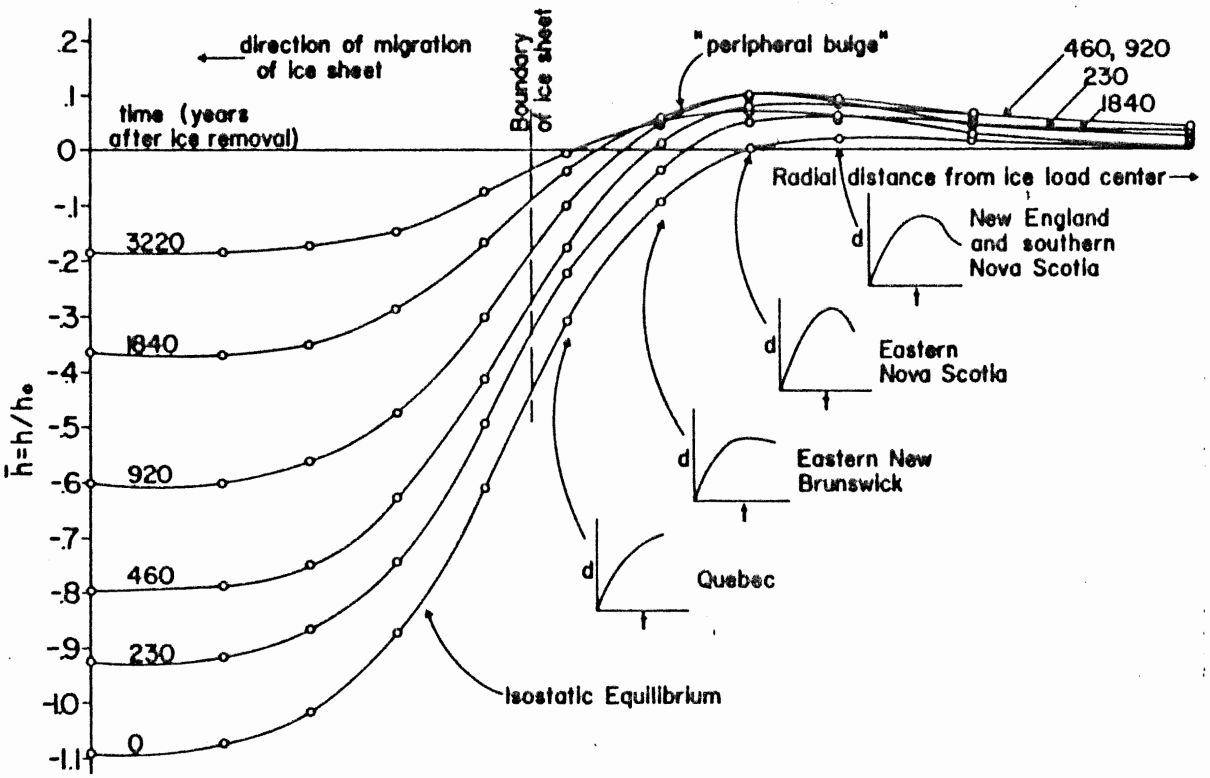
Newman and March (1968) the very existence of excessive subsidence along the northern Atlantic coast excludes water loading as a possibility for the cause of the excessive subsidence. If the models of Farrell and Clark (1976) and Clark (1977) are correct, excessive subsidence as a result of water loading would be expected in the Pacific, not the Atlantic. Moreover, there is a strong correlation between those areas now experiencing excessive subsidence and areas that were on the periphery of the ice sheet during the last glaciation. This would suggest that the excessive subsidence is caused by some effect related to the margin of ice loading such as the collapsing of a "peripheral bulge" as proposed by Barrell (1915) and Daly (1920). More recently Newman and March (1968) have suggested this as the mechanism for the downwarping of the New England continental shelf.

The idea of a "peripheral bulge" was first proposed by Jamieson (1882). The simple description of this phenomenon by Jamieson (1882, p. 461) describes the concept clearly:

> "It seems likely that there might be not only a slight sinking of the ice covered tract, but likewise a tendency to bulge up in the region which lay immediately beyond this area of depression, just as we sometimes see in advance of a railway embankment, which not only depresses the soil beneath it, but also causes the ground to swell up further off."

Barrell (1915) and Daly (1920) suggest that the collapsing of this bulge following deglaciation may cause depression or subsidence of the peripheral regions of a former ice sheet. Daly suggests in the same article that there is no way of quantifying this theory and that the theory must remain speculative for his forseeable future. Recently, Cathles (1975)

Figure 43. Uplift history of slightly filtered, square edged, cylindrical depression. $\bar{h}$ = approx. fractional amount of rebound, h_o = maximum amount of subsidence at equilibrium and h = absolute amount of rebound. This model has an elastic lithosphere, flexural rigidity 50×10^{23} newton-meters, underlain by uniform viscous asthenosphere, viscosity approximately 10^{22} poise (adapted from fig. 43, Cathles, 1975). Curves represent land surface at various periods of time following ice removal; notice that parts of the curves first show emergence followed by submergence in areas past the theoretical ice edge. Generalized curves are isolated for four areas; Quebec, Eastern New Brunswick, Eastern Nova Scotia, and New England, southern Nova Scotia. The right extension of each of these curves represents the present day situation.



.2
.1
0
-.1
-.2
-.3
-.4
-.5
-.6
-.7
-.8
-.9
-1.0
-1.1
$\bar{h}=h/h_0$
direction of migration of ice sheet
time (years after ice removal)
Boundary of ice sheet
"peripheral bulge"
460, 920
230
1840
3220
1840
920
460
230
0
Radial distance from ice load center
New England and southern Nova Scotia
Eastern Nova Scotia
Eastern New Brunswick
Quebec
d
t
Isostatic Equilibrium

presented a comprehensive treatment of the problems and illustrated several models of the behavior of the peripheral bulge following deglaciation. Each model is constructed assuming a different type of mantle response (e.g. a stratified visco-elastic mantle). A generalized diagram from Cathles (1975) depicting the response of the bulge following deglaciation assuming a uniform viscous asthenosphere and an elastic lithosphere is illustrated here (fig. 43). The location of the bulge beyond the edge of the ice sheet varies between models, but most place it at a distance of 200-1000 km. In figure 43 an idealized response history is shown for four areas: Quebec, New Brunswick, southern Nova Scotia, and eastern Nova Scotia. Walcott (1972a, b) suggested that examination of the Earth's response to ice removal might aid in determining the deep mechanical structure of the Earth. Cathles (1975) also suggests this and Peltier and Andrews (1976) have refined some of the models by Cathles. They suggest, after comparing their models with actual data, that there is clear evidence for an elastic or highly viscous lithosphere.

New sea level data are presented here that were derived from subsurface material collected in the three major areas of study: Chezzetcook, Chebogue, and Wallace. Although the data presented here are insufficient to completely evaluate the complex peripheral bulge model there are sufficient data to demonstrate how accurate sea level data, as determined using marsh foraminiferal klines, can be used to calibrate these models.

Results

Several holes were bored in each of the areas. Cuttings from each bore hole were examined for foraminiferal content; basal material from some holes was carbon-14 dated. All C^{14} dates with their standard errors, locations, etc. are listed in table 19 (appendix). In order to calculate rates of relative sea level change, the depth of a dated interval must be related to the elevation of its present day equivalent kline, rather than to a single datum. For example if an interval at Chezzetcook containing faunal kline I_A is dated at the base of a drill hole and the surface of the drill hole is in faunal sub-subkline I_{B-2}, then 25 cm must be added to the drill hole depth of the dated interval so that the depth below datum is the actual relative sea level rise, r.

Wallace Basin: Several holes less than 2 m were drilled in this marsh (fig. 36). In all cases a soil horizon was encountered at the base of the drill hole which was overlain by salt marsh peat. In basal sections from drill holes II and VIII carbon-14 dates were obtained from small wood fragments contained in the sediment. Both drill holes displayed similar stratigraphies (fig. 44, table 20, appendix) with a sequence of faunal subkline II_A overlying a section containing faunal subkline I_B ending in a HHW deposit underlain by a soil horizon. In drill hole VIII the HHW datum was dated at 1510 ybp indicating a relative sea level rise (r) of 197 cm and a rate of rise (r/t) of 13 cm/century. In drill hole II a level was dated that probably formed above HHW, and therefore cannot be used for an accurate sea level determination because it cannot be related to sea level.

Chebogue Harbour: Four holes were drilled (fig. 35). Material from the bases of two of these holes were dated (D.H. II and IV). In drill

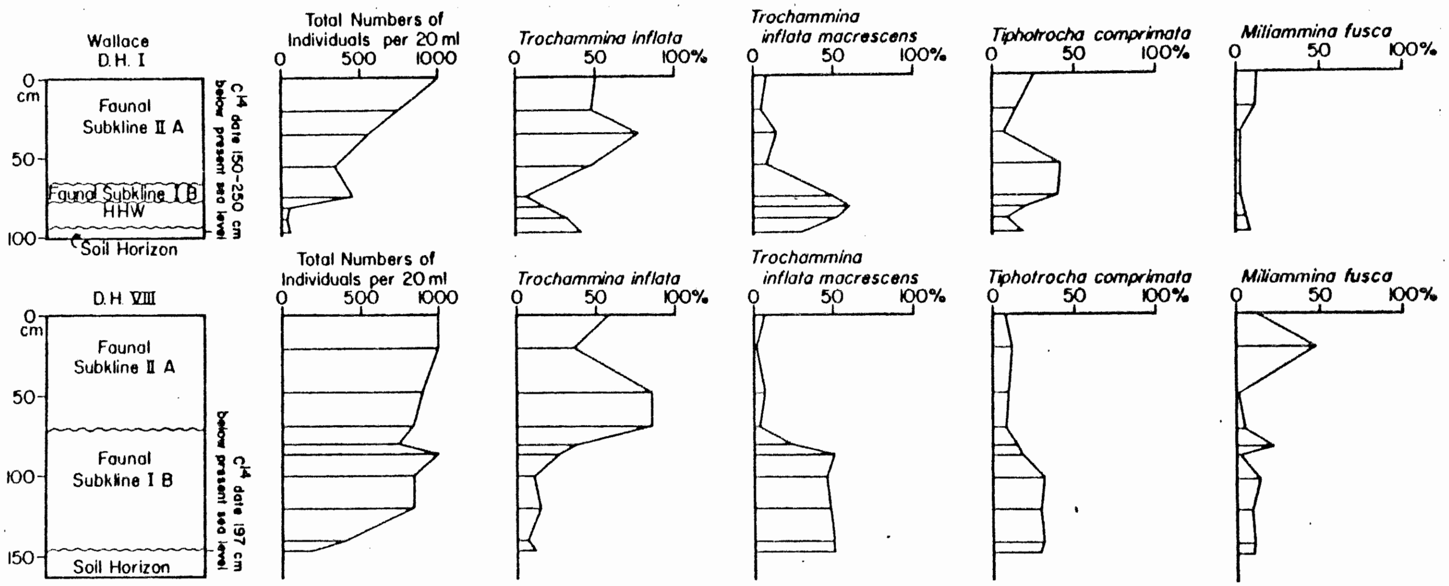
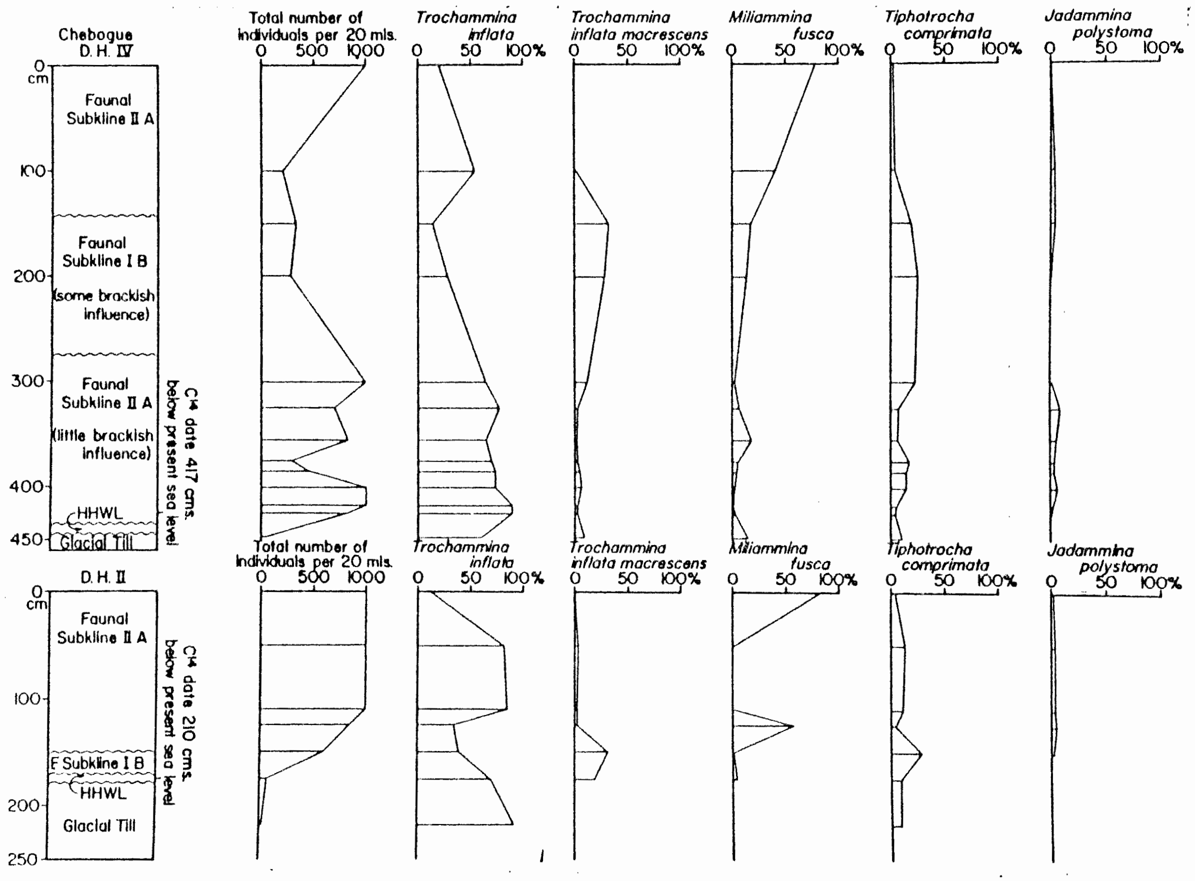


Figure 44. Foraminiferal occurrences in Wallace drill holes, II, VIII.

holes I, II, and IV glacial till was encountered at the base of the holes again overlain by salt marsh peat. In drill hole III rock was encountered at the base of the hole overlain by estuarine sediments. Although this boring had the deepest penetration (516 cm) the base of the hole was not suitable for indicating sea level becuase of the estuarine sediments. Drill hole I had essentially the same depth and stratigraphy of drill hole II and will not be discussed further here. In drill hole II a sequence of faunal subkline II overlies a faunal subkline I_B sequence followed by a HHW deposit underlain by glacial till (fig. 45, table 21, appendix). The HHW deposit is dated at 1390 ybp (r = 210 cm, r/t = 15 cm/century). Drill hole IV (also fig. 45, table 21, appendix) displays a slightly different stratigraphy from that observed in hole II. The upper 250 cm of this sequence are similar to drill hole II. Just below the 250 cm interval, the sequence reverts to a faunal subkline II_A sequence with high percentages of Trochammina inflata and low percentages of Trochammina inflata macrescens. This sequence ends between -417 and -447 cm, and is underlain by a HHW deposit and glacial till. The lower part of this subkline II_A deposit was chosen for dating because its sediments contained the most wood fragments and because the peat composing this lower interval was mixed with a sufficient amount of clastic material to minimize compaction effects. A date of 2650 ybp was obtained from the interval shown in figure 45 (r = 207 cm from 2650 to 1390 ybp with r/t = 16 cm/century during this time interval). An additional date was obtained from Grant (1970a, b) of 3220 ybp (r = 330 cm from 3220 to 2650 ybp with corresponding r/t = 58 cm/century). Grant (1970a, b) reports this date at 6.5 m hole depth which he inter-

Figure 45. Foraminiferal occurrences in Chebogue drill holes II, IV.


Chebogue
D.H. IV
0
cm
100
200
300
400
450
Faunal Subkline II A
Faunal Subkline I B
(some brackish influence)
Faunal Subkline II A
(little brackish influence)
HHWL
Glacial Till
C14 date 417 cms. below present sea level
Total number of individuals per 20 mls.
0 500 1000
Trochammina inflata
0 50 100%
Trochammina inflata macrescens
0 50 100%
Miliammina fusca
0 50 100%
Tiphotrocha comprimata
0 50 100%
Jadammina polystoma
0 50 100%
D.H. II
0
cm
100
200
250
Faunal Subkline II A
F Subkline I B
HHWL
Glacial Till
C14 date 210 cms. below present sea level
Total number of individuals per 20 mls.
0 500 1000
Trochammina inflata
0 50 100%
Trochammina inflata macrescens
0 50 100%
Miliammina fusca
0 50 100%
Tiphotrocha comprimata
0 50 100%
Jadammina polystoma
0 50 100%

prets as 7.5 m of relative sea level rise. However, there is some question as to the accuracy of this value of relative sea level rise since Grant was denoting all basal deposits as HHWL which, for example, clearly would have been inaccurate in drill hole IV.

Chezzetcook Inlet: Fourteen drill holes have been drilled in Chezzetcook to date but only those relevant to the present study are discussed here (fig. 46). Only three of these drill holes contained material suitable for both sea level determination and carbon-14 dating. The stratigraphy of the area drilled in Chezzetcook is substantially different from any areas in Wallace or Chebogue.

In drill hole V (fig. 47, table 22, appendix) the upper 60 cm is a faunal sub-subkline I_{B-2} sequence followed by 100 cm of faunal subkline II_B which is in turn underlain by 800 cm of shallow subtidal-intertidal mud, subdivided into upper estuarine (170-500 cm), lower estuarine (500-700 cm) and open bay (700-1000 cm). The basal sequence (1028-1149 cm) contains a gradational marsh sequence with relatively low numbers of Foraminifera. This basal marsh sequence is most similar in faunal content to those high marsh areas observed near the mouth of both Chezzetcook (Transect IV) and Chebogue (station 1). Dates obtained from this hole were from the freshwater peat immediately below the salt marsh peat at 1155 cm (9600 ybp; no sea level can be determined from this because it is a freshwater deposit) and from what was designated as HHW just above the freshwater sequence (6625 ybp, r = 1185 cm, r/t = 14 cm/century from 6625 to 1940 ybp).

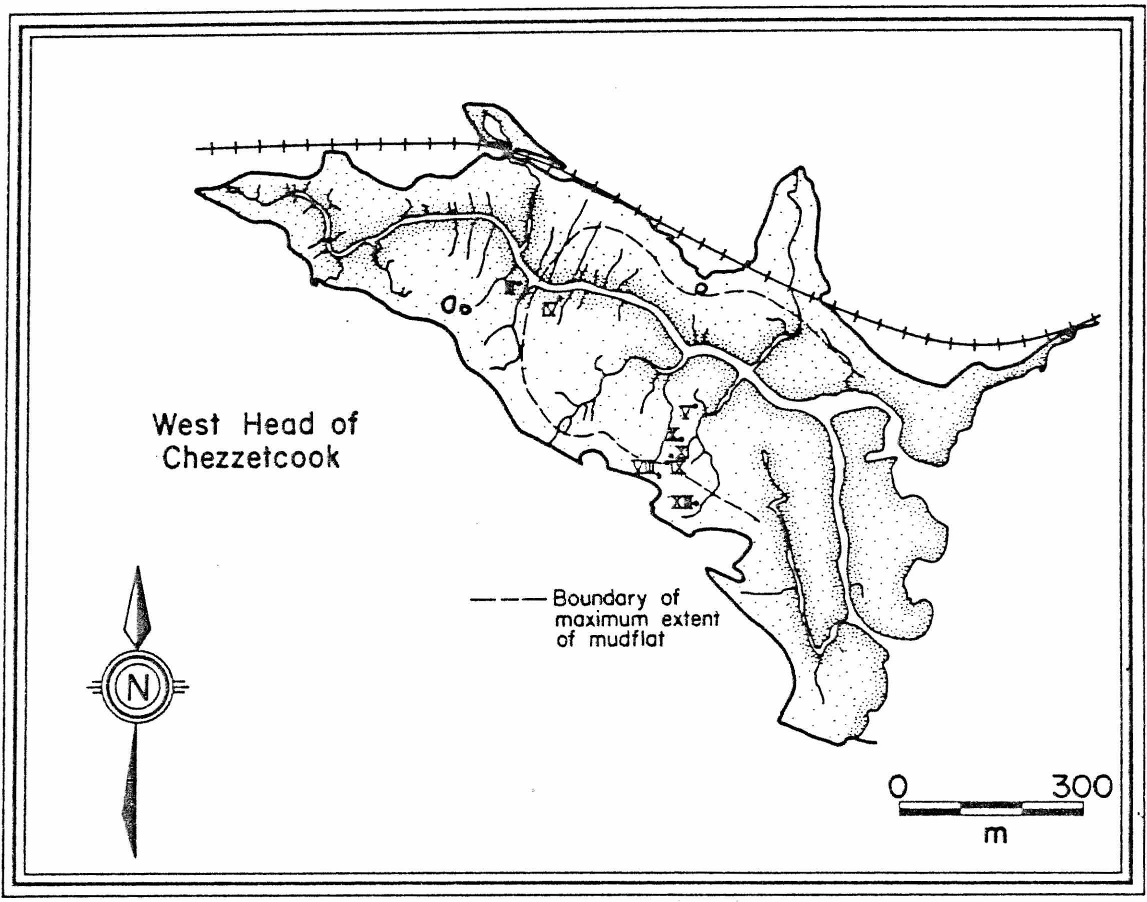


Figure 46. Drill hole locations in the West Head, Chezzetcook.

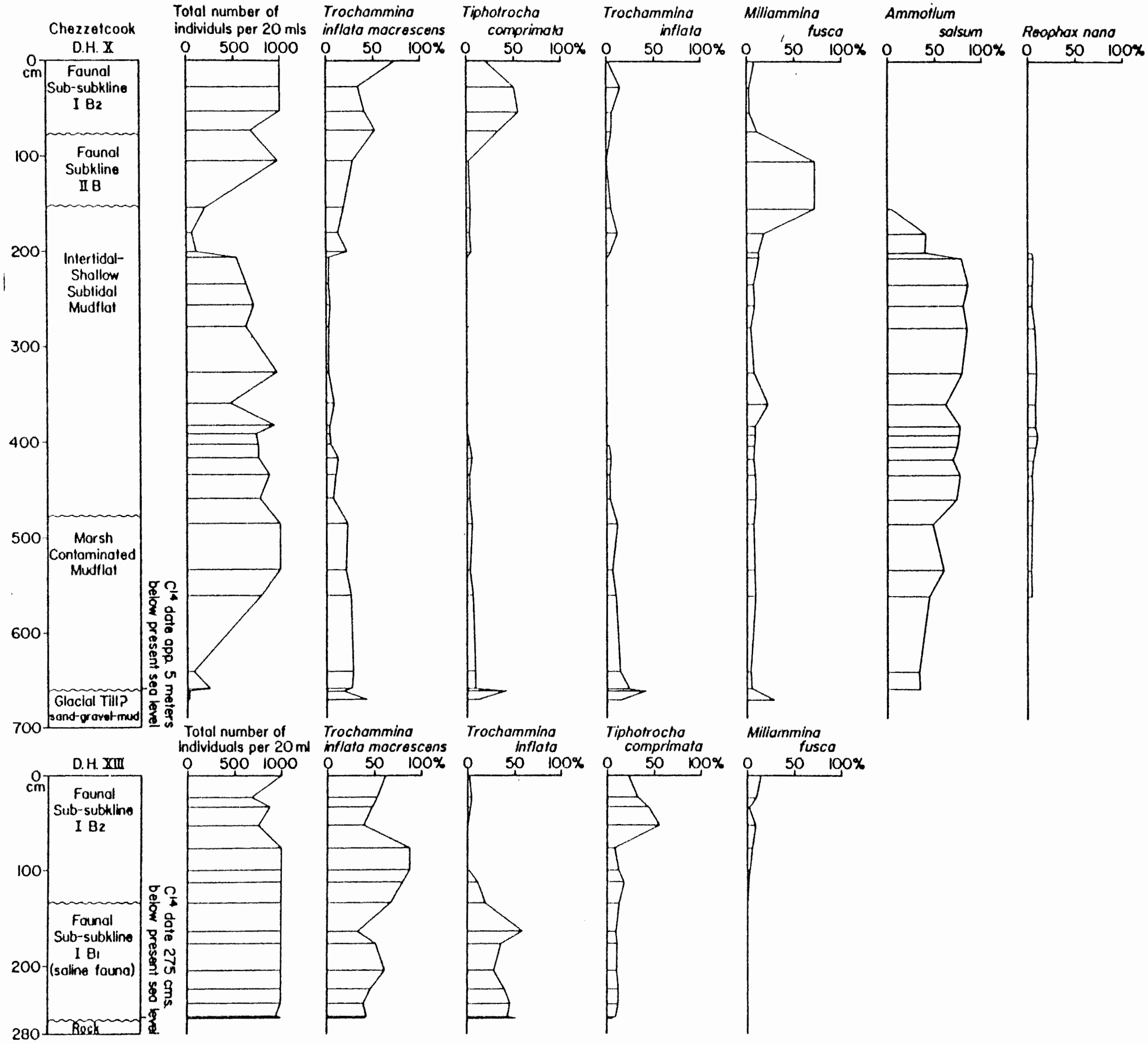

Chezzetcook
D.H. X
0 cm
100
200
300
400
500
600
700
Faunal Sub-subkline I B2
Faunal Subkline II B
Intertidal-Shallow Subtidal Mudflat
Marsh Contaminated Mudflat
Glacial Till?
sand-gravel-mud
C14 date app. 5 meters below present sea level
Total number of individuls per 20 mls
0 500 1000
Trochammina inflata macrescens
0 50 100%
Tiphotrocha comprimata
0 50 100%
Trochammina inflata
0 50 100%
Miliammina fusca
0 50 100%
Ammotium salsum
0 50 100%
Reophax nana
0 50 100%
D.H. XIII
0 cm
100
200
280
Faunal Sub-subkline I B2
Faunal Sub-subkline I B1 (saline fauna)
Rock
C14 date 275 cms. below present sea level
Total number of individuals per 20 ml
0 500 1000
Trochammina inflata macrescens
0 50 100%
Trochammina inflata
0 50 100%
Tiphotrocha comprimata
0 50 100%
Miliammina fusca
0 50 100%

Figure 47. Foraminiferal occurrences in drill hole V, Chezzetcook.

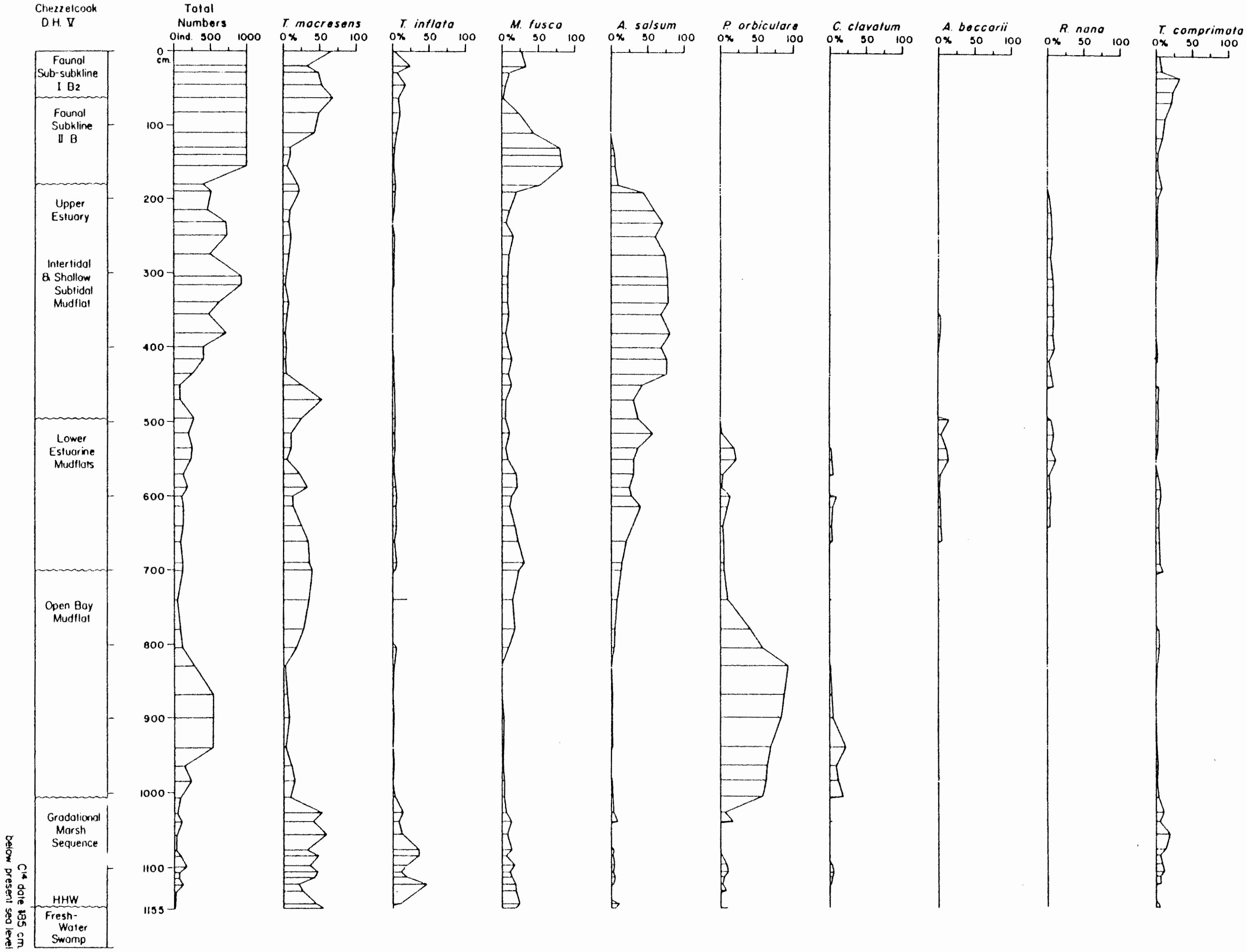
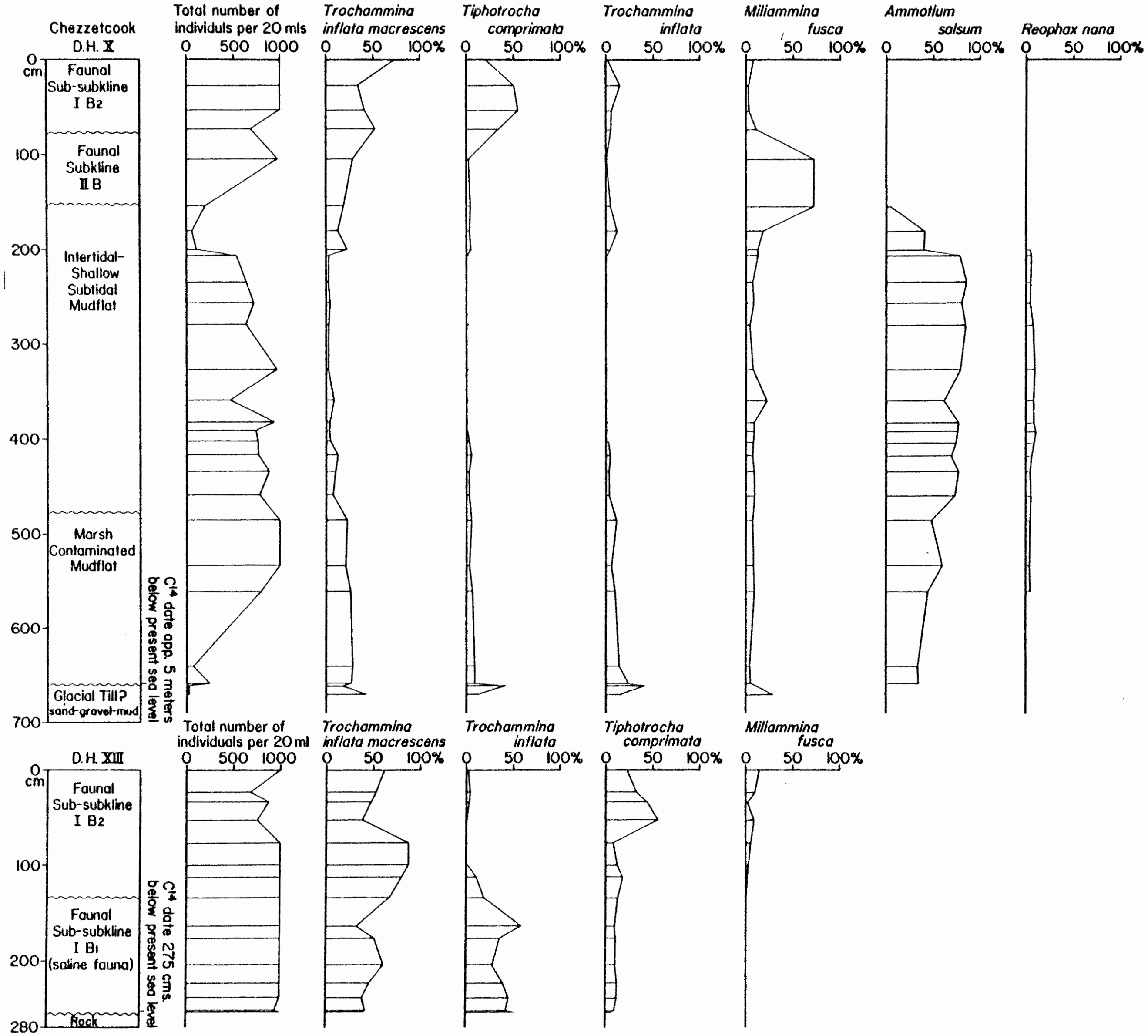

Chezzetcook
D.H. V
Total Numbers
0 ind. 500 1000
T. macrescens
T. inflata
M. fusca
A. salsum
P. orbiculare
C. clavatum
A. beccarii
R. nana
T. comprimata
0% 50 100
0 cm.
100
200
300
400
500
600
700
800
900
1000
1100
1155
Faunal Sub-subkline I B2
Faunal Subkline II B
Upper Estuary
Intertidal & Shallow Subtidal Mudflat
Lower Estuarine Mudflats
Open Bay Mudflat
Gradational Marsh Sequence
HHW
Fresh-Water Swamp
C14 date 1135 cm. below present sea level

Figure 48. Foraminiferal occurrences in drill holes X, XIII, Chezzetcook.


Chezzetcook
D.H. X
0 cm
100
200
300
400
500
600
700
Faunal Sub-subkline I B2
Faunal Subkline II B
Intertidal-Shallow Subtidal Mudflat
Marsh Contaminated Mudflat
Glacial Till? sand-gravel-mud
C14 date app. 5 meters below present sea level
Total number of individuls per 20 mls
0 500 1000
Trochammina inflata macrescens
0 50 100%
Tiphotrocha comprimata
0 50 100%
Trochammina inflata
0 50 100%
Miliammina fusca
0 50 100%
Ammotium salsum
0 50 100%
Reophax nana
0 50 100%
D.H. XIII
0 cm
100
200
280
Faunal Sub-subkline I B2
Faunal Sub-subkline I B1 (saline fauna)
Rock
C14 date 275 cms. below present sea level
Total number of individuals per 20 ml
0 500 1000
Trochammina inflata macrescens
0 50 100%
Trochammina inflata
0 50 100%
Tiphotrocha comprimata
0 50 100%
Miliammina fusca
0 50 100%

Drill hole X, the second deepest hole drilled (657 cm), had a stratigraphy similar to the first 600 cm of drill hole V (fig. 48, table 23, appendix). However, near the base of this hole a fauna similar to that observed in the narrow channels of the West Head (sta. 28-30, foldout 1,2) was present. The basal deposit was first thought to be a marsh deposit. However, the high numbers of *Ammotium salsum* that persist to the base of this hole suggest that the basal sequence is a marsh contaminated intertidal - shallow subtidal deposit. There were sufficient wood fragments in this basal deposit to give a carbon-14 date of 1940 ybp (r = approx. 225 cm between 1940 and 910 ybp with corresponding r/t = approx. 22 cm/ century). Drill hole XIII was the shallowest of the three holes with dated bases. Its stratigraphy (fig. 48, table 23, appendix) was similar in the upper 100 cm to that observed in V and X but below 130 cm there is a fauna similar to the faunal kline I fauna observed in Summerville with high numbers of both *Trochammina inflata* and *Trochammina inflata macrescens*. This type of marsh fauna was not observed anywhere in the modern marsh sediments of Chezzetcook. The base of this hole at -253 cm contained sufficient wood fragments for a carbon-14 date which was 915 ybp (r = 275 cm from 915 to the present with corresponding r/t = 30 cm/ century).

The apparent sea level rise data are summarized in figure 49. These data suggest that relative sea level rise during the last 2000 years has decreased at Chebogue and increased at Chezzetcook. In Wallace the sequence is not long enough to detect any changes in r/t; however, the average r/t is lower at present than in both the other two areas.

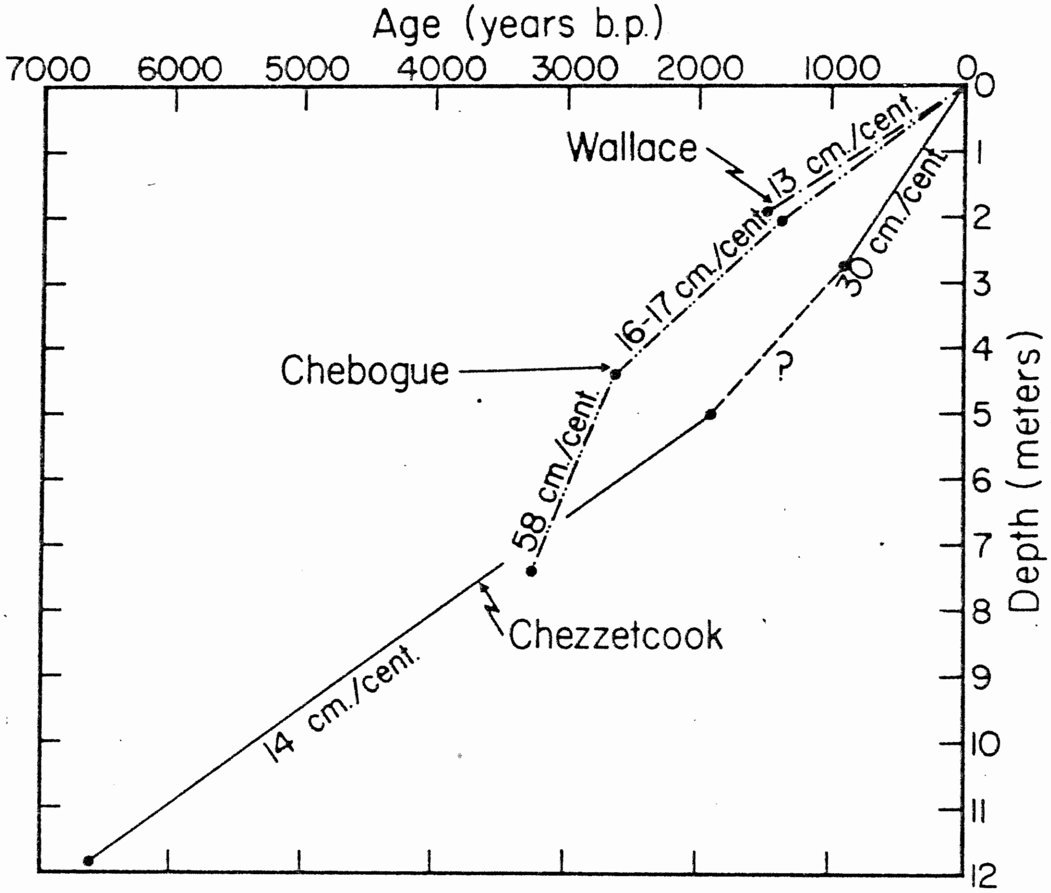


Figure 49. Summary of relative sea level changes in the three areas of study.

Stratigraphy and its relationships with apparent sea level rise.

In both Wallace and Chebogue the stratigraphies observed are consistent with a submerging coastline. The basal HHW deposits are quickly overridden by rising sea level because accumulation rates in this part of the tidal range are low (Chapman, 1976). Also, the upper marsh sequences denoted by faunal kline I are usually replaced by faunae characteristic of a lower faunal kline II which correspond approximately to the floral klines of middle or low marsh subkline A. This relationship can be also correlated with relative accumulation rates. Only in drill hole IV in Chebogue was there an apparently emergent area between the 300 and 150 cm depth where faunal subkline II_A is overlain by a faunal subkline I_B. This feature can be explained by the decreased rate of relative sea level rise that occurred during this approximate period.

The stratigraphy in Chezzetcook shows a remarkably different situation (fig. 50, 51). The base of drill hole V where the marsh is quickly overriden indicates a rapid apparent sea level rise while in the upper two meters apparent sea level appears either to be falling or at best, static. The entire mudflat area illustrated in figure 46 is apparently emergent. However, the dates indicate that the opposite has occurred with a smaller r/t between 6000 ybp and 2000 ybp and an increased r/t occurring the last 2000 years. The progradation of marsh at Chezzetcook must therefore be related to increased rates of sedimentation. This could be the result of either an increase in the sediment supply or by a slowing of the currents carrying the sediment resulting in less erosion and more sediment falling out of suspension.

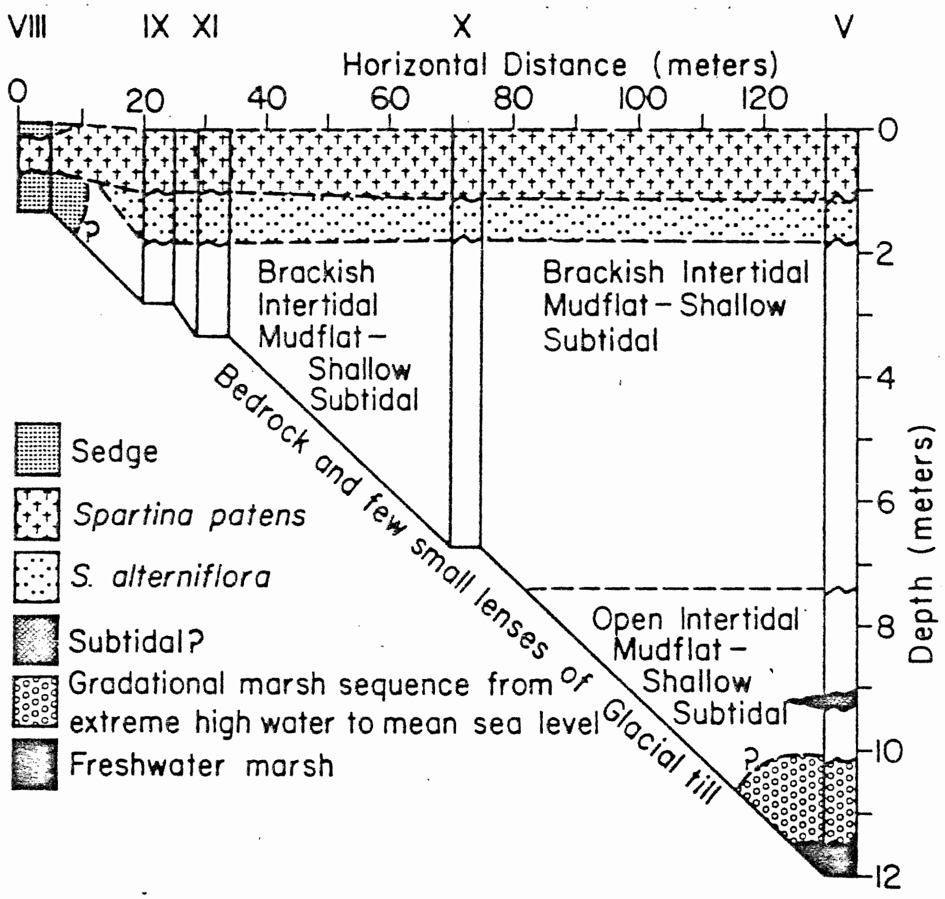

VIII
IX
XI
X
V
Horizontal Distance (meters)
0
20
40
60
80
100
120
0
2
4
6
8
10
12
Depth (meters)
?
Brackish Intertidal Mudflat – Shallow Subtidal
Brackish Intertidal Mudflat – Shallow Subtidal
Open Intertidal Mudflat – Shallow Subtidal
Bedrock and few small lenses of Glacial till
Sedge
Spartina patens
S. alterniflora
Subtidal?
Gradational marsh sequence from extreme high water to mean sea level
Freshwater marsh

Figure 50. Stratigraphy of drill holes V, VIII-X, Chezzetcook.

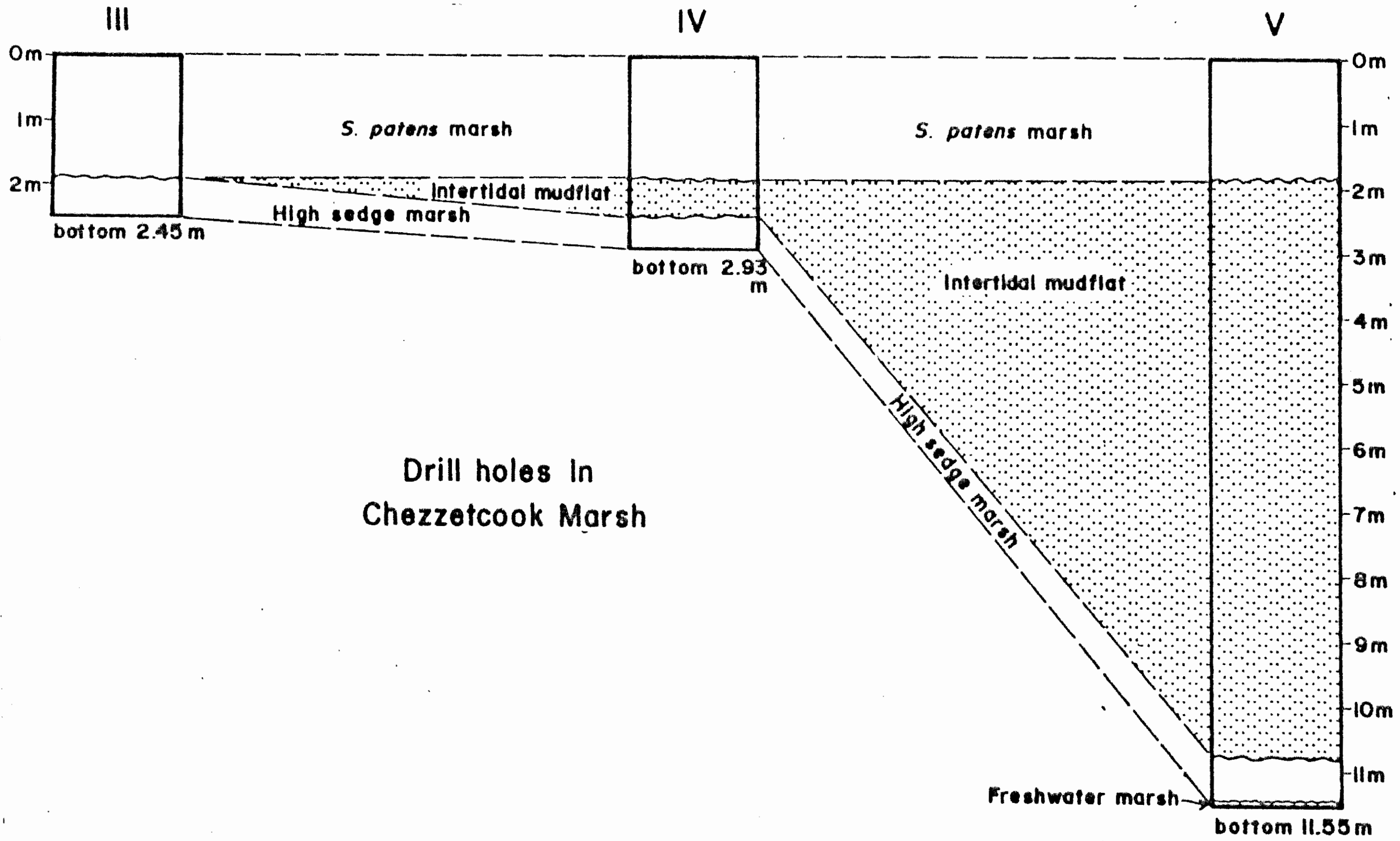


Figure 51. Stratigraphy of drill holes III-V, Chezzetcook.

Lowering of tidal range, as suggested by the 1766 map, would decrease tidal velocities because the volume of water flowing through the inlet on each tidal cycles would be reduced. If a relative sea level rise of 30 cm/century is assumed, then relative sea level would have been 60 cm lower 200 years ago. This is sufficiently low to coincide almost exactly with the first salt marsh formation in the West Head of Chezzetcook at 1.2-1.5 m below HHW since the lowest marsh begins to form at or just below mean sea level. The lowering of tidal range 200 years ago could have, therefore, precipitated the first marsh formation in the West Head. Such a lowering would have been a regional event and high sedimentation rates should have occurred in other inlets along the coast. In Three Fathom Harbour, just west of Chezzetcook, water depths of 5.4-7.2 m are indicated on the 1766 map while depths of 1-3 m are indicated for the same inlet in 1854. At the mouth of Chezzetcook a major channel was closed off between 1766 and 1854 and this also could have decreased tidal velocities and increased the sedimentation rates in Chezzetcook. However, it does not explain the increased sedimentation at Three Fathom Harbour. A third possibility is that increased human activity along the coast could have increased the amount sediment entering the marine environment and created higher sedimentation rates. Current velocities would not necessarily have to decrease in such a case. The resolution of the problem of why sedimentation rates increased is beyond the scope of this work, however, where there are high rates of sedimentation, regardless of the cause, the results of rising sea level can be masked. Attempts to classify coastlines, particularly estuarine coastlines, as emerging or submerging should not be based solely on recent geomorphological changes.

Discussion

Data on relative sea level change from New England are summarized in figure 42 and Grant's data reflect the same general trend except that Grant's curve shows greater subsidence in the Bay of Fundy because of tidal amplification. These data indicate that relative sea level 4000 years ago was between 7 and 8 meters lower than at present. The curves, especially those of Redfield (1967), indicate a decrease in the rate of relative sea level rise beginning at approximately 2500-3000 ybp. The data from Chebogue Harbour (fig. 49) agree closely with that of Redfield in this respect but the Chezzetcook curve illustrates a reverse trend with relative sea level rise being faster now than in the past. Figure 43 suggests that New England and southern Nova Scotia may have been farther from the ice load center than Chezzetcook. If this was the case, the southern areas may have already experienced their most rapid rates of relative sea level rise and are now relatively stable, while Chezzetcook may have entered the phase of rapid subsidence relatively recently. Wallace Basin appears to be only in the initial stages of submergence, as predicted by the work of Swift and Borns (1967) and Kranck (1972). Of course these ideas are all highly speculative since the new data presented here are sparse. However, if this hypothesis can be substantiated with further accurate data, it would demonstrate a much smaller scale for relative changes in rates of apparent sea level change than previously anticipated (Dr. C. Beaumont, pers. comm.).

Figure 43 indicates both an emergent and submergent phase. Although no direct sea level determination can be made from the freshwater peat, it is known that sea level had to have been at least 11.89 m lower 9600 ybp for the freshwater peat to form. This freshwater peat must have formed on the emergent part of the curve in Figure 43 so that a minimum age of emergence of 9600 ybp is indicated for the Chezzetcook area.

The purpose of this section has been to demonstrate that marsh foraminiferal distributions defined into faunal klines can be a useful means of accurately detecting small scale changes in relative sea level. The method can be used on a large scale to calibrate the models for the response of the peripheral bulge following deglaciation. The work should proceed in two directions: 1) obtain more data from Chezzetcook and Chebogue so that their respective sea level curves will be better established, and 2) data from different points along a line parallel to the direction of ice retreat must be obtained so that the scale and migration path of the peripheral bulge can be determined. Using a large body of information it should be possible to construct an accurate model of the migration of the peripheral bulge and from this make conclusions regarding the deep mechanical structure of the Earth.

CHAPTER 9

CONCLUSIONS

Estuarine foraminiferal distributions

1. Four major foraminiferal zones now exist in the estuarine sediments of Chezzetcook Inlet. Their distribution appears to be controlled principally by salinity variances except for the nearshore zone, occupied mostly by attached forms, which may be the result of strong currents in this area.
2. The presence or absence of species such as *Ammonia beccarii* or *Ammotium cassis* indicate certain depth-stability characteristics of estuarine environments in which they occur. This information can be used to determine if estuarine dynamics have changed through time in a particular estuary.
3. In shallow estuaries, such as Chezzetcook, intertidal mudflat and shallow subtidal sediments can not be distinguished on the basis of benthonic foraminiferal assemblages. Hence the use of estuarine foraminiferal assemblages as indicators of former sea levels has relatively large errors associated with it (± 2.5 m).

Marsh foraminiferal distributions

1. Despite the many variables present in the salt marsh environment the plant and foraminiferal assemblages suggest well defined distribution patterns.

2. Plant composition of the floral klines appears to be little affected by salinity changes from the head to the mouth of the estuary. However, some marsh foraminiferal species appear to be highly sensitive to both elevation and salinity.
3. Although the elevation ranges of the floral klines and corresponding faunal klines are similar to each other, they are not exact with the result that there are three distinguishable floral klines compared with only two faunal klines.
4. Seasonal variations in living populations of marsh foraminifera proved to be substantial, however these variations usually did not significantly alter the total percentage occurrences of species composing the dominant elements in marsh assemblages.
5. In some marsh sediments calcareous and agglutinated foraminiferal species occur together in the total population. However, the living populations illustrate a different pattern with the calcareous species dominating the summer populations and agglutinated forms dominating the winter populations.
6. Extremely detailed sampling in Chezzetcook allowed placing less detailed salt marsh data from Wallace, Chebogue, and Summerville into a framework for determining accurate former sea levels.
7. Data from all areas in Nova Scotia indicate that marsh foraminiferal faunal klines can be used to accurately locate former sea levels in subsurface sediments.
8. The higher high water mark appears to be the most accurate datum level that can be located using marsh foraminifera and is favorable for a number of other reasons. The dramatic decrease in foramini-

feral numbers at this level is useful for differentiating marine from non-marine peat deposits.

9. Examination of detailed studies in California and less detailed ones from many parts of the world suggest that marsh foraminifera could be generally used as accurate sea level indicators.

Relative sea level changes

1. Previous studies and the present one suggest that excessive relative sea level rise in New England and the Maritimes is the result of subsidence caused by collapsing of a "peripheral bulge" that formed in the marginal regions of the ice sheet during the last glaciation.
2. Data from the present study suggest a much smaller scale for relative sea level changes than previously anticipated, with southern Nova Scotia entering a more stable period while eastern Nova Scotia appears to be entering a more active phase.
3. A minimum date of emergence for the Chezzetcook area is determined to be 9600 ybp from a freshwater peat presently 12 meters below sea level.

CHAPTER 10

SYSTEMATIC TAXONOMY

"Thecamoebians"

The names used here are in accordance with those in Loeblich and Tappan (1964). Only the reference used to identify the species is included here together with any reference that has been discussed throughout the text which includes reference to these species.

Centropyxis encentricus (Cushman and Bronnimann)
Todd and Bronnimann, 1957, p. 22, pl. 1, fig. 9.
Scott, 1976b, p. 320, pl. 1, fig. 1,2.
Scott *et al.*, 1977, p. 1578, pl. 1, figs. 1, 2.
In this paper, pl. 1, fig. 1-3.

Difflugia caprelata Penard
Todd and Bronnimann, 1957, p. 21, pl. 1, fig. 3, 4.
Scott *et al.*, 1977, p. 1578, pl. 1, fig. 4, 5.
In this paper, pl. 1, fig. 4-7.

Difflugia urceolata Carter
Todd and Bronnimann, 1957, p. 21, pl. 1, fig. 1.
Scott *et al.*, 1977, p. 1578, pl. 1, fig. 9.
In this paper, pl. 1, fig. 8, 9.

Pontigulasia compressa (Carter)
Todd and Bronnimann, 1957, p. 21, pl. 1, fig. 5.
Scott *et al.*, 1977, p. 1578, pl. 1, fig. 3, 6.
In this paper, pl. 1, fig. 10-12.

Urnulina compressa Cushman
Parker, 1952a, p. 394, pl. 1, fig. 4
Scott *et al.*, 1977, p. 1578, pl. 2, fig. 6.
In this paper, pl. 1, fig. 13-15.

Foraminiferida

Species identifications are based on comparisons with the reference collection at Bedford Institute of Oceanography. Any synomonies suggested here are purely subjective. Approximately 75 species have been identified in this study but only those species with significant occurrences are included in this list.

and in the plates. The original reference and subsequent references to the same species under different names are listed for each species. Additionally, as for the Thecamoebians, any reference that has been discussed in the text which includes a reference to these species is listed here. Generic names are in accordance with Loeblich and Tappan (1964).

Ammobaculites _dilatatus_ Cushman and Brönnimann

Plate 2, figures 9, 10

Ammobaculites _dilatatus_ Cushman and Brönnimann, 1948a, p. 39, pl. 7, fig. 10, 11; Cole and Ferguson, 1975, p. 32, pl. 2, fig. 8, 9; Scott _et_ _al_., 1977, p. 1578, pl. 2, fig. 6.

Ammobaculites _foliaceus_ (H. B. Brady)

Plate 2, figures 6-8

Haplophragmium _foliaceum_ H. B. Brady, 1884, p. 304, pl. 33, fig. 20-25.

Ammobaculites c. f. _foliaceus_ (H. B. Brady). Parker, 1952b, p. 444, pl. 1, fig. 20, 21.

Ammobaculites _foliaceus_ (Brady). Scott et al., 1977, p. 1578, pl. 2, fig. 3.

Remarks: Some specimens of this species were sent to both Beverly Tate of the Smithsonian Institute and Ruth Todd in Massachusetts who verified the identification.

Ammonia _beccarii_ (Linné)

Plate 6, figures 10, 11

Nautilus _beccarii_ Linne, 1758, p. 710.

Ammonia _beccarii_ (Linne). Brunnich, 1772, p. 232, Frizzel and Keen, 1949, p. 106; Gregory, 1970, p. 222, pl. 12, fig. 4-6, Schnikter, 1974, p. 216-223, pl. 1; Cole and Ferguson, 1975, p. 32, pl. 9, fig. 1, 2.

Streblus beccarii (Linne). Fischer de Waldhiem, 1817, p. 449, pl. 13; Bradshaw, 1957, p. 1138, text fig. 1a-c; Phleger and Ewing, 1962; p. 179, pl. 5, fig. 22, 23.

"Rotalia" beccarii (Linne) var. tepida Cushman, 1926, p. 79, pl. 1, Parker, 1952b, p. 457, pl. 5, fig. 7, 8.

Remarks: Schnikter (1974) demonstrated with culturing techniques that most of the described varieties of A. beccarii are ecotypic variations of the same form hence no attempt was made here to distinguish the varieties.

Ammotium salsum (Cushman and Brönnimann)

Plate 2, figures 11-13

Ammobaculites salsus Cushman and Brönnimann, 1948b, p. 16, pl. 3, fig. 7-9.

Ammoscalaria fluvialis Parker, 1952b, p. 444, pl. 1, fig. 24, 25.

Ammotium salsum (Cushman and Brönnimann). Parker and Athearn, 1959, p. 340, pl. 50, fig. 6, 13; Scott et al., 1977, p. 1578, pl. 2, fig. 4, 5.

Arenoparella mexicana (Kornfeld)

Plate 5, figures 10-13

Trochammina inflata (Montagu) var. mexicana Kornfeld, 1931, p. 86, pl. 13, fig. 5.

Arenoparella mexicana (Kornfeld). Anderson, 1951, p. 31; Parker and Athearn, 1959, p. 340, pl. 50, fig. 8-10.

Remarks: This is the first reported occurrence of this marsh species in the Maritimes.

Astrammina rara Rhumbler

Plate 2, figures 1-3

Astrammina rara Rhumbler in Wiesner, 1931, p. 79.

Armorella sphaerica Heron-Allen and Earland, 1932, p. 257, pl. 2, fig. 4-11; Höglund, 1947, p. 55, pl. 5, fig. 1-9; Phleger and Walton, 1950, p. 277, pl. 1, fig. 1.

Remarks: This genus is rediscussed here because the type description (as reported in Loeblich and Tappan, 1964) and subsequent descriptions (Höglund, 1947) fail to mention that this genus has an inner transparent pseudochitinous lining upon which there is a fine to medium agglutinated layer. Previous reports have listed the genus as non-attached, however the specimens observed here were predominately attached. The attached side is usually barren of agglutinated material and this enabled the author to detect the extremely thin pseudochitinous layer (Pl. 2, fig. 3). Previous authors have probably examined their specimens dry which would account for their overlooking the inner lining.

There are two described type species - *A. rara* and *A. sphaerica* - however, variability is so high in these forms that it is doubtful whether there is more than one species here. These specimens have been placed with *A. rara* which has presidence over the name *A. sphaerica*.

Other occurrences: The original specimens were reported from the south Atlantic, however, specimens from Scandinavia (Höglund, 1947) have also been reported. These were primarily from deeper water (approx. 30 m).

Phleger and Walton (1950) and Ellison and Nichols (1976) have reported the species from marsh areas in Massachusetts and Virginia respectively. In this study the species was present in erratic numbers in the three major localities. It was only counted quantitatively in Wallace and the seasonal samples from station 7, Chezzetcook. I suspect this species to be a widespread marsh form, but its detection is difficult since it often resembles the organic debris to which it is attached. The form would not have been detected here had it not been common at one locality in Chebogue Harbour. Hopefully, future work will result in a better understanding of the distribution of this species.

Astrononion gallowayi Loeblich and Tappan

Plate 8, figure 5

Astrononion stellatum Cushman and Edwards, 1937, p. 32, pl. 3, fig. 9-11.

Astrononion gallowayi Loeblich and Tappan, 1953, p. 90, pl. 17, fig. 4-7; Gregory, 1970, p. 232, pl. 15, fig. 3; Cole and Ferguson, 1975, p. 32, pl. 6, fig. 15.

Bolivina pseudoplicata Heron-Allen and Earland

Plate 8, figure 3

Bolivina pseudoplicata Heron-Allen and Earland, 1930, p. 181, pl. 3, fig. 36-40; Gregory, 1970, p. 212, pl. 10, fig. 7-9; Parker, 1952b, 444, pl. 4, fig. 11; Cole and Ferguson, 1975, p. 32, pl. 6, fig. 6.

Buccella frigida (Cushman)

Plate 8, figures 10, 11

Pulvinulina frigida Cushman, 1921 (1922), p. 144.

Eponides frigida (Cushman) var. calida Cushman and Cole, 1930, p. 98, pl. 13, fig. 13a-c; Phleger and Walton, 1950, p. 277, pl. 2, fig. 21; Parker, 1952b, p. 449, pl. 5, fig. 3a,b.

Eponides frigidus (Cushman) Cushman. 1941, p. 37, pl. 9, fig. 16, 17; Parker, 1952b, p. 449, pl. 5, fig. 2a, b.

Buccella frigida (Cushman). Anderson, 1952, p. 144, fig. 4a-c, 5, 6a-c; Gregory, 1970, p. 220, pl. 12, fig. 1-3; Cole and Ferguson, 1975, p. 33, pl. 8, fig. 8, 9.

Buliminella elegantissima (d'Orbigny)

Plate 7, figures 1, 2

Bulimina elegantissima d'Orbigny, 1839, p. 51, pl. 7, fig. 13, 14.

Buliminella elegantissima (d'Orbigny). Cushman, 1919, p. 606; Parker, 1952a, p. 416, pl. 5, fig. 27, 28; Phleger and Ewing, 1962, p. 178, pl. 5, fig. 4; Gregory, 1970, p. 211, pl. 10, fig. 5, 6; Cole and Ferguson, 1975, p. 33, pl. 6, fig. 8, 9.

Cassidulina crassa d'Orbigny

Plate 8, figures 1, 2

Cassidulina crassa d'Orbigny, 1839, p. 56, pl. 7, fig. 18-20.

Cassidulina islandica Nørvang var. *minuta* Nørvang. Parker, 1952a, p. 421, pl. 6, fig. 22a,b, 23.

Cassidulina islandica Nørvang. Loeblich and Tappan, 1953, p. 118, pl. 24, fig. 1.

Cassidulina barbara Buzas, 1965, p. 25, pl. 5, fig. 2, 3.

Cibicides lobatulus (Walker and Jacob)

Plate 8, figures 8, 9

Nautilus lobatulus Walker and Jacob in Kanmacher, 1798, p. 642, pl. 14, fig. 36.

Cibicides lobatula (Walker and Jacob). Cushman, 1931, p. 118, pl. 21, fig. 3a-c.

Cibicides lobatulus (Walker and Jacob). Nørvang, 1945, p. 49, pl. 6, fig. 26a, b; Parker, 1952b, p. 446, pl. 5, fig. 11a, b; Gregory, 1970, p. 231, pl. 15, fig. 1, 2; Cole and Ferguson, 1975, p. 33, pl. 8, fig. 5, 6.

Cribroelphidium bartletti (Cushman)

Plate 6, figure 8

Elphidium bartletti Cushman, 1933, p. 4, pl. 1, fig. 9; Gregory, 1970, p. 225, pl. 13, fig. 3-5; Cole and Ferguson, 1975, p. 34, pl. 7, fig. 3, 4.

Cribroelphidium excavatum (Terquem)

Plate 6, figure 1

Polystomella excavata Terquem, 1876, p. 429, pl. 2, fig. 2a-d.

Elphidium excavatum (Terquem). Parker, 1952a, p. 412, pl. 5, fig. 8.

Cribroelphidium excavatum (Terquem). Scott et al., 1977, p. 1578, pl. 5, fig. 4.

Remarks: I believe that C. margaritaceum (Cushman) belongs with this species also. The difference between the two is that C. excavatum has a smooth, non-etched surface while C. margaritaceum has a strongly etched surface, possibly a post-mortem change. They are always found together in the same environment with C. excavatum being the more common form. (NOTE: a paper that has recently come to hand (Levy et al., 1969) shows original figures of C. excavatum (Terquem) and another form C. umbilicatula (Williamson). These figures clearly demonstrate that my species is probably C. umbilicatula, not C. excavatum.)

Cribroelphidium excavatum clavatum (Cushman)

Plate 6, figure 2

Cribroelphidium excavatum selseyensis (Heron-Allen and Earland)

Plate 6, figure 3

Remarks: The distinction of these forms has been an endless debate since about 1930 and the list of references does not clarify the problem. In my work the division of these forms is based on the work by Feyling-Hanssen (1972). It is believed by both myself and F. S. Medioli that these forms are included in a gradational series with one form grading into the next. Work by J. Dwyer in 1976 for a class project at Dalhousie demonstrated that some form of a gradational series could be obtained but the species must be cultured under a variety of conditions to solve the problem, much as Schnikter (1974) did with *Ammonia beccarii*.

Cribroelphidium frigidum (Cushman)

Plate 6, figure 6

Elphidium frigidum Cushman, 1933, p. 5, pl. 1, fig. 3; Gregory, 1970, p. 227, pl. 14, fig. 3; Cole and Ferguson, 1975, p. 34, pl. 7, fig. 6, 7.

Cribroelphidium incertum (Cushman) not Williamson

Plate 6, figures 4, 5

Elphidium incertum Cushman not Williamson, 1930, p. 18, pl. 7, figs. 8a,b, 9a, b.

Remarks: This was the largest of the *Cribroelphidium* spp. observed in this study. It is distinctive from the other species, particularly *C. excavatum clavatum*, by its angular cross-section as opposed to the rounded or oval cross-section of the other *Cribroelphidium* species.

This species was described by Cushman as that of Williamson (1858) but, as discussed by Loeblich and Tappan (1953) and Buzas (1966), Cushman's species does not resemble that of Williamson. Unfortunately, before this was detected, Cushman's form became known as _C._ _incertum_ (Williamson) which has resulted in a great deal of confusion. Buzas (1966) equated _C._ _incertum_ (Cushman) with _C._ _clavatum_ (Cushman), however, I feel that these species are distinct so I have retained _C._ _incertum_ (Cushman) not Williamson.

Cribroelphidium _subarcticum_ (Cushman)

Plate 6, figure 7

Elphidium _subarcticum_ Cushman, 1944, p. 27, pl. 3, fig. 34-35; Parker, 1952b, p. 449, pl. 4, fig. 3-6, 8; Phleger and Walton, 1950, p. 277, pl. 2, fig. 19, 20; Gregory, 1970, p. 229, pl. 14, fig. 7; Cole and Ferguson, 1975, p. 34, pl. 8, fig. 1, 2.

Eggerella _advena_ (Cushman)

Plate 6, figure 9

Verneuilina _advena_ Cushman, 1921, p. 141.

Eggerella _advena_ (Cushman). Cushman, 1937, p. 51, pl. 5, fig. 12-15; Phleger and Walton, 1950, p. 277, pl. 1, fig. 16-18; Parker, 1952a, p. 404, pl. 3, fig. 12, 13; Parker, 1952b, p. 447, pl. 2, fig. 3; Gregory, 1970, p. 183, pl. 4, fig. 1-3; Cole and Ferguson, 1975, p. 34, pl. 3, fig. 10, 11; Scott _et_ _al_., 1977, p. 1579, pl. 2, fig. 7.

Fissurina _marginata_ (Montagu)

Plate 8, figure 4

Vermiculum _marginatum_ Montagu, 1803, p. 524.

Lagena _marginata_ (Walker and Boys). Cushman, 1913, p. 37, pl. 22, fig. 1-7.

Entosolenia marginata (Montagu) var. Cushman and Todd, 1947, p. 65, pl. 15, fig. 23, 24.

Fissurina marginata (Montagu). Loeblich and Tappan, 1953, p. 77, pl. 14, fig. 6-9; Gregory, 1970, p. 207, pl. 10, fig. 1; Cole and Ferguson, 1975, p. 35, pl. 5, fig. 10.

Fursenkoina fusiformis (Williamson)

Plate 7, figures 9, 10

Bulimina pupoides d'Orbigny fusiformis Williamson, 1858, p. 64, pl. 5, fig. 129, 130.

"Bulimina" fusiformis Williamson. Höglund, 1947, p. 232, pl. 20, fig. 3, text figures 219-233.

Virgulina fusiformis (Williamson). Parker, 1952a, p. 417, pl. 6, fig. 3-6; Parker, 1952b, p. 461, pl. 4, fig. 6.

Fursenkoina fusiformis (Williamson). Gregory, 1970, p. 232.

Glabratella wrightii (Brady)

Plate 7, figures 11-13

Discorbina wrightii Brady, 1881, p. 413, pl. 21, fig. 6.

Glabratella wrightii (Brady). Leslie, 1965, p. 161, pl. 10, fig. 7; Cole and Ferguson, 1975, p. 35, pl. 8, fig. 10, 11.

Haplophragmoides bonplandi Todd and Brönnimann

Plate 3, figures 5, 6

Haplophragmoides bonplandi Todd and Bronnimann, 1957, p. 23, pl. 2, fig. 2; Scott et al., 1977, p. 1579, pl. 3, fig. 5, 6.

Remarks: Identification of this species was verified by Ruth Todd, one of the authors of the species.

Helenina andersoni (Warren)

Plate 6, figures 12, 13

Valvulineria sp. Phleger and Walton, 1950, pl. 2, fig. 22a, b.

Pseudoeponides andersoni Warren, 1957, p. 39, pl. 4, fig. 12-15; Parker and Athearn, 1959, p. 341, pl. 50, fig. 28-31.

Helenina andersoni (Warren). Saunders, 1961, p. 148.

Remarks: This is the first reported occurrence of this calcareous marsh species in the Maritimes.

Hemisphaerammina bradyi Loeblich and Tappan

Plate 2, figures 4, 5

Hemisphaerammina bradyi Loeblich and Tappan in Loeblich and collaborators, 1957, p. 224, pl. 72, fig. 2; Scott *et al*., 1977, p. 1579, pl. 3, fig. 7-8.

Crithionina pisum Goës. Gregory, 1970, p. 165, pl. 1, fig. 6.

Hemisphaerammina sp. Cole and Ferguson, 1975, pl. 1, fig. 4.

Jadammina polystoma Bartenstein and Brand

Plate 4, figures 9-11

Jadammina polystoma Bartenstein and Brand, 1938, p. 381, fig. 1a-c, 2a-1, 3; Parker and Athearn, 1959, p. 341, pl. 50, fig. 21, 22, 27; Phleger and Ewing, 1962, p. 179, pl. 4, fig. 13, 14.

Remarks: The similarity of this species and *Trochammina inflata macrescens* Brady will be discussed under *T. inflata macrescens*.

Miliammina fusca (Brady)

Plate 3, figures 1-3

Quinqueloculina fusca Brady, 1870, p. 47, pl. 11, fig. 2, 3.

Miliammina fusca (Brady). Phleger and Walton, 1950, p. 280, pl. 1, fig. 19a, b; Parker, 1952a, p. 404, pl. 3, fig. 15, 16; Parker, 1952b, p. 452, pl. 2, fig. 6a, b; Parker and Athearn, 1959, p. 340, pl. 50, fig. 11, 12; Gregory, 1970, p. 172, pl. 2, fig. 8; Cole and Ferguson, 1975, p. 37, pl. 4, fig. 1, 2; Scott *et al*., 1977, p. 1579, pl. 2, fig. 8, 9.

Pateoris hauerinoides (Rhumbler)

Plate 7, figures 6-8

Quinqueloculina subrotunda (Montagu) forma *hauerinoides* Rhumbler, 1936, p. 206, 217, 226, text fig. 167, 208-212.

Quinqueloculina subrotunda (Montagu). Parker, 1952a, p. 406, pl. 4, fig. 4a, b; Parker, 1952b, p. 456, pl. 2, fig. 9a, b, 10a, b.

Pateoris hauerinoides (Rhumbler). Loeblich and Tappan, 1953, p. 42, pl. 42, pl. 6, fig. 8-12, text fig. 1A, B; Gregory, 1970, p. 188, pl. 6, fig. 3, 4: Cole and Ferguson, 1975, p. 39, pl. 11, fig. 4, 5.

Polysaccammina ipohalina Scott

Plate 3, figures 10-13

Polysaccammina ipohalina Scott, 1976b, p. 318, pl. 2, fig. 1-4, text fig. 4a-c.

Remarks: This recently described species probably has a worldwide distribution in marshes but has suffered the same fate of non-recognition as *Astrammina rara* since it is sometimes difficult to differentiate from organic debris. The species was originally described as non-attached, however many of the specimens observed in Nova Scotia are attached to organic debris.

Protelphidium orbiculare (Brady)

Plate 6, figure 9

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

Nonion orbiculare (Brady). Cushman, 1930, p. 12, pl. 5, fig. 1-3.

Elphidium orbiculare (Brady). Hessland, 1943, p. 262, Gregory, 1970, p. 228, pl. 14, fig. 5, 6.

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

Quinqueloculina seminulum (Linne)

Plate 7, figures 3-5

Serpula seminulum Linne, 1758, p. 786.

Quinqueloculina seminulum (Linne). d'Orbigny, 1826, p. 303; Gregory, 1970, p. 187, pl. 6, fig. 1; Cole and Ferguson, 1975, p. 40, pl. 10, fig. 7.

Miliolina seminulum (Linne). Williamson, 1858, p. 85, pl. 7, fig. 183-185.

Quinqueloculian seminula (Linne). Cushman, 1929, p. 59, pl. 9, fig. 16-18; Parker, 1952a, p. 406, pl. 3, fig. 21a, b, 22a, b, pl. 4, fig. 1, 2; Parker, 1952b, p. 456, pl. 2, fig. 7a, b.

Reophax arctica Brady

Plate 3, figure 8

Reophax arctica Brady, 1881, p. 405, pl. 21, fig. 2a, b; Parker, 1952a, p. 395, pl. 1, fig. 6, 7; Gregory, 1970, p. 168, pl. 2, fig. 3; Cole and Ferguson, 1975, p. 40, pl. 1, fig. 9.

Bigenerina arctica (Brady). Cushman, 1948, p. 31, pl. 3, fig. 9.

Reophax nana Rhumbler

Plate 3, figure 7

Reophax nana Rhumbler, 1911, p. 182, pl. 8, fig. 6-12; Parker, 1952b, p. 457, pl. 1, fig. 14, 15; Scott *et al*., 1977, p. 1579, pl. 3, fig. 1, 2.

Rosalina columbiensis (Cushman)

Plate 8, figures 6, 7

Discorbis columbiensis Cushman, 1925, p. 43, pl. 6, fig. 13; Parker, 1952a, p. 418, pl. 6, fig. 7a, b, 8a, b, 9a, b; Parker, 1952b, p. 446, pl. 4, fig. 17a, b, 18a, b, 19a, b, 20a, b; Gregory, 1970, p. 218, pl. 11, fig. 6, 7.

Rosalina columbiensis (Cushman). Uchio, 1960, p. 66, pl. 8, fig. 1, 2.

Rosalina columbiense (Cushman). Phleger and Ewing, 1962, p. 179, pl. 5, fig. 10, 11.

Remarks: This species is probably the same as an earlier species, R. floridana (Cushman), however, in the absence of the type material of R. floridana I have left R. columbiensis as a separate species, particularly in view of the fact that Cushman was the author of both species.

Spiroplectammina biformis (Parker and Jones)

Plate 3, figure 4

Textularia agglutinans d'Orbigny var. biformis Parker and Jones, 1865, p. 370, pl. 15, fig. 23, 24.

Spiroplecta biformis (Parker and Jones). Brady, 1878, p. 376, pl. 45, fig. 25-27.

Spiroplectammina biformis (Parker and Jones). Cushman, 1927, p. 23, pl. 5, fig. 1; Parker, 1952a, p. 402, pl. 3, fig. 1, 2; Gregory, 1970, p. 177, pl. 3, fig. 6; Cole and Ferguson, 1975, p. 42, pl. 3, fig. 3.

Tiphotrocha comprimata (Cushman and Brönnimann)

Plate 5, figures 14-16

Trochammina comprimata Cushman and Brönnimann, 1948a, p. 41, pl. 8, fig. 1-3.

Tiphotrocha comprimata (Cushman and Brönnimann). Saunders, 1957, p. 11; Parker and Athearn, 1959, p. 341, pl. 50, fig. 14-17; Scott et al., 1977, p. 1579, pl. 4, fig. 3, 4.

Remarks: Large populations of this species appear to be restricted to marsh areas and only isolated, reworked specimens of this species occur outside the marsh. Since this is the first study of marshes in this area, previous authors in the Maritimes have probably only encountered isolated specimens of T. comprimata and these have been understandably placed with a more familiar and quite similar species - Trochammina squamata.

Trifarina fluens (Todd)

Plate 8, figures 12, 13

Angulogerina fluens Todd in Cushman and Todd, 1947, p. 67, pl. 16, fig. 6, 7.

Trifarina angulosa (Williamson). Gregory, 1970, p. 217, pl. 11, fig. 5.

Trifarina fluens (Todd). Feyling-Hanssen in Feyling-Hanssen et al., 1971, p. 242, pl. 7, fig. 12-15, pl. 18, fig. 10; Cole and Ferguson, 1975, p. 42, pl. 6, fig. 10.

Trochammina inflata (Montagu)

Plate 4, figures 12-14, Plate 5, figures 1-3

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, fig. 1-3; Parker, 1952a, p. 407, pl. 4, fig. 6, 10; Parker, 1952b, p. 459, pl. 3, fig. 2a, b; Phleger and Ewing, 1962, pl. 4, fig. 11, 12; Gregory, 1970, p. 180, pl. 4, fig. 3, 4; Cole and Ferguson, 1975, p. 43, pl. 4, fig. 3, 4.

Remarks: The microspheric form of this species (Pl. 5, fig. 1-3) has sometimes been referred to as T. inflata var. however measurements have shown that this form is simply the microspheric generation of T. inflata (Mary Price, Dalhousie Biology, pers. comm.).

Trochammina inflata macrescens Brady

Plate 4, figures 1-8

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

Trochammina macrescens (Brady). Phleger and Walton, 1950, p. 281, pl. 2, fig. 6, 7; Parker, 1952a, p. 408, pl. 4, fig. 8a, b; Parker, 1952b, p. 460, p. 3, fig. 3a, b; Parker and Athearn, 1959, p. 341, pl. 50, fig. 23-25; Gregory, 1970, p. 181, pl. 4, fig. 7; Cole and Ferguson, 1975, p. 43, pl. 4, fig. 6, 7.

Jadammina macrescens (Brady). Murray, 1971b, p. 41, pl. 13, fig. 1-5.

Remarks: I have left this species as a variety or forma of T. inflata because juvenile specimens of the two forms are almost identical, especially in the California material (Scott, 1976b). It appears that the forms diverge into separable forms only after some maturation.

A series of specimens is shown in plate 4 to illustrate the variability in the curvature of the suture lines on the ventral side of this species. At one extreme are the straight sutures with a large umbilicus and distinct umbilical teeth (Plate 4, figure 3). This grades into a curved suture line, a reduced umbilicus and no umbilical teeth. The curved extreme (Plate 4, figure 8) is indistinguishable from Jadammina polystoma (Plate 4, figure 9) except for the supplementary apertures of J. polystoma. Boltovskoy (1958) has suggested that supplementary apertures in some species may be environmental responses rather than distinct species characteristics and Parker and Athearn

(1959) have speculated that this may be true for *T. inflata macrescens* as well, which would place *J. polystoma* as a junior synonom to *T. inflata macrescens*. The distribution pattern of the two species also suggests that they might be ecotypes: *T. inflata macrescens* occurs in more brackish areas with *J. polystoma* occurring in more saline areas.

Attempts at culturing these species have proven unsuccessful and until the species can be cultured, I have chosen to leave the two forms separate.

Trochammina lobata Cushman

Plate 5, figures 8, 9

Trochammina lobata Cushman, 1944, p. 18, pl. 2, fig. 10, Phleger and Walton, 1950, p. 281, pl. 2, fig. 4, 5; Parker, 1952a, p. 408, pl. 4, fig. 7a, b; Parker, 1952b, p. 459, pl. 3, fig. 2a, b; Gregory, 1970, p. 180, pl. 4, fig. 5, 6; Cole and Ferguson, 1975, p. 43, pl. 4, fig. 5, 6; Scott *et al*., 1977, p. 1579, pl. 4, fig. 1, 2.

Trochammina ochracea (Williamson)

Plate 5, figures 4, 5

Rotalina ochracea Williamson, 1858, p. 55, pl. 4, fig. 112, pl. 5, fig. 113.

Trochammina ochracea (Williamson). Cushman, 1920, p. 75, pl. 15, fig. 3; Gregory, 1970, p. 182, pl. 4, fig. 8, 9; Cole and Ferguson, 1975, p. 43, pl. 4, fig. 9, 10; Scott *et al*., 1977, p. 1580, pl. 4, fig. 5, 8.

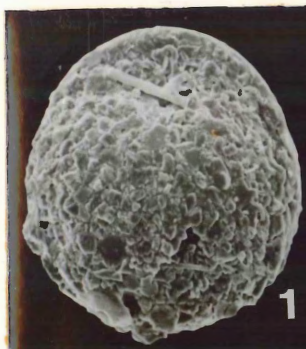
Trochammina squamata Parker and Jones

Plate 5, figures 6, 7

Trochammina squamata Parker and Jones, 1865, p. 407, pl. 15, fig. 30, 31a-c; Phleger and Walton, 1950, p. 281, pl. 2, fig. 12, 13; Parker, 152a, p. 408, pl. 4, fig. 11-16; Parker, 1952b, p. 460, pl. 3, fig. 4a, b, 4a, b; Cole and Ferguson, 1975, p. 43, pl. 4, fig. 11, 12.

Plate 1

Figure 1-3.	*Centropyxis excentricus* (Cushman and Brönnimann) 1. dorsal view, x129, 2. apertural view, x127, 3. side view, x191.
Figure 4-7.	*Difflugia capreolata* Penard 4. coarse grained specimen, x87, 5. aperture view, x183, 6. side view of typical form, x120, 7. side view of intermediate form, x120.
Figure 8, 9.	*Difflugia urceolata* Carter 8. aperture view, x112, 9. side view, x120.
Figure 10-12.	*Pontigulasia compressa* (Carter) 10. side view of typical specimen, x112, 11. side view of specimen with small spine, x112, 12. aperture view, x120.
Figure 13-15.	*Urnulina compressa* Cushman 13. side view of specimen with poorly developed spines, x192, 14. side view of specimen with well developed spines, x192, 15. aperture view, x192.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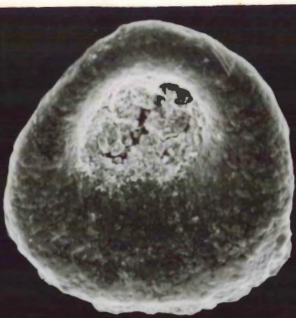
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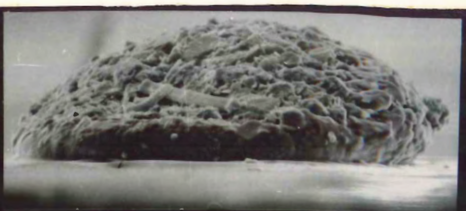
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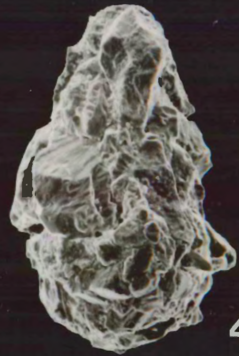
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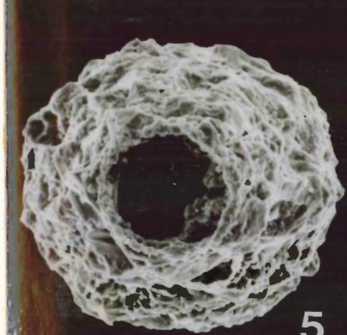
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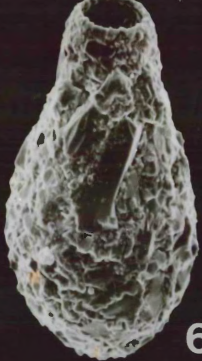
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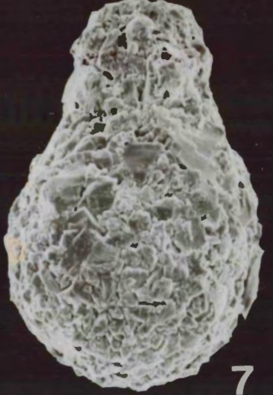
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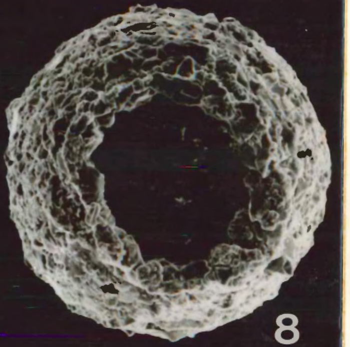
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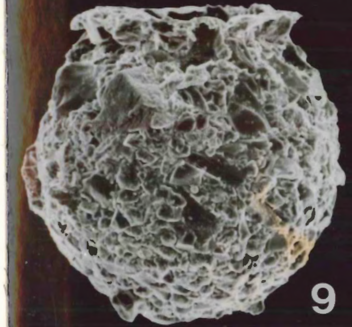
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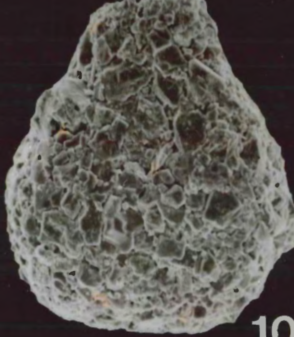
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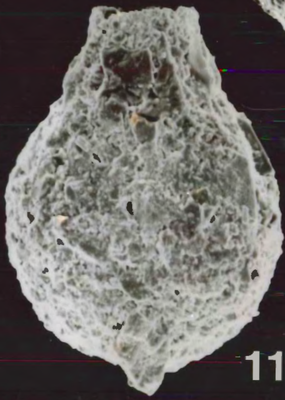
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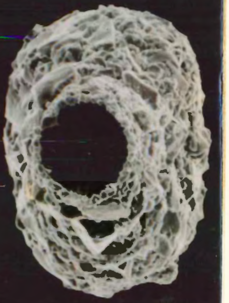
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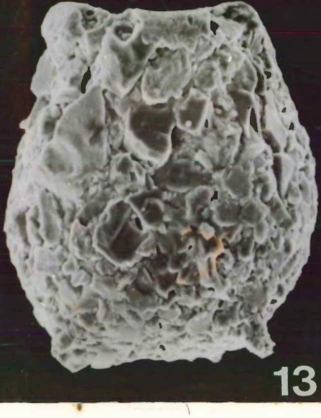
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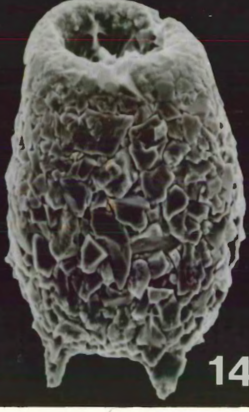
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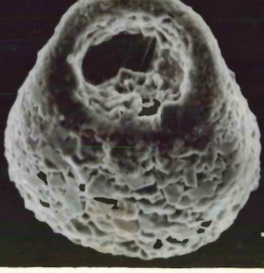
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Plate 2

Figure 1-3. *Astrammina rara* Rhumbler 1. specimen with several apertures, x91, 2. specimen with only one aperture, x72, 3. attached side of specimen with no agglutinated material, x82.

Figure 4, 5. *Hemisphaerammina bradyi* Loeblich and Tappan 4. several specimens attached to each other, x85, 5. specimen attached to *Miliammina fusca*.

Figure 6-8. *Ammobaculites foliaceus* (H. B. Brady) 6. side view of typical specimen, x70, 7. side view of specimen with extended uniserial chambers, x64, 8. aperture view, x85.

Figure 11-13. *Ammotium salsum* (Cushman and Brönnimann) 11. side view of specimen with extended uniserial chambers, x92, 12. side typical form, x126, 13. aperture view, x120.

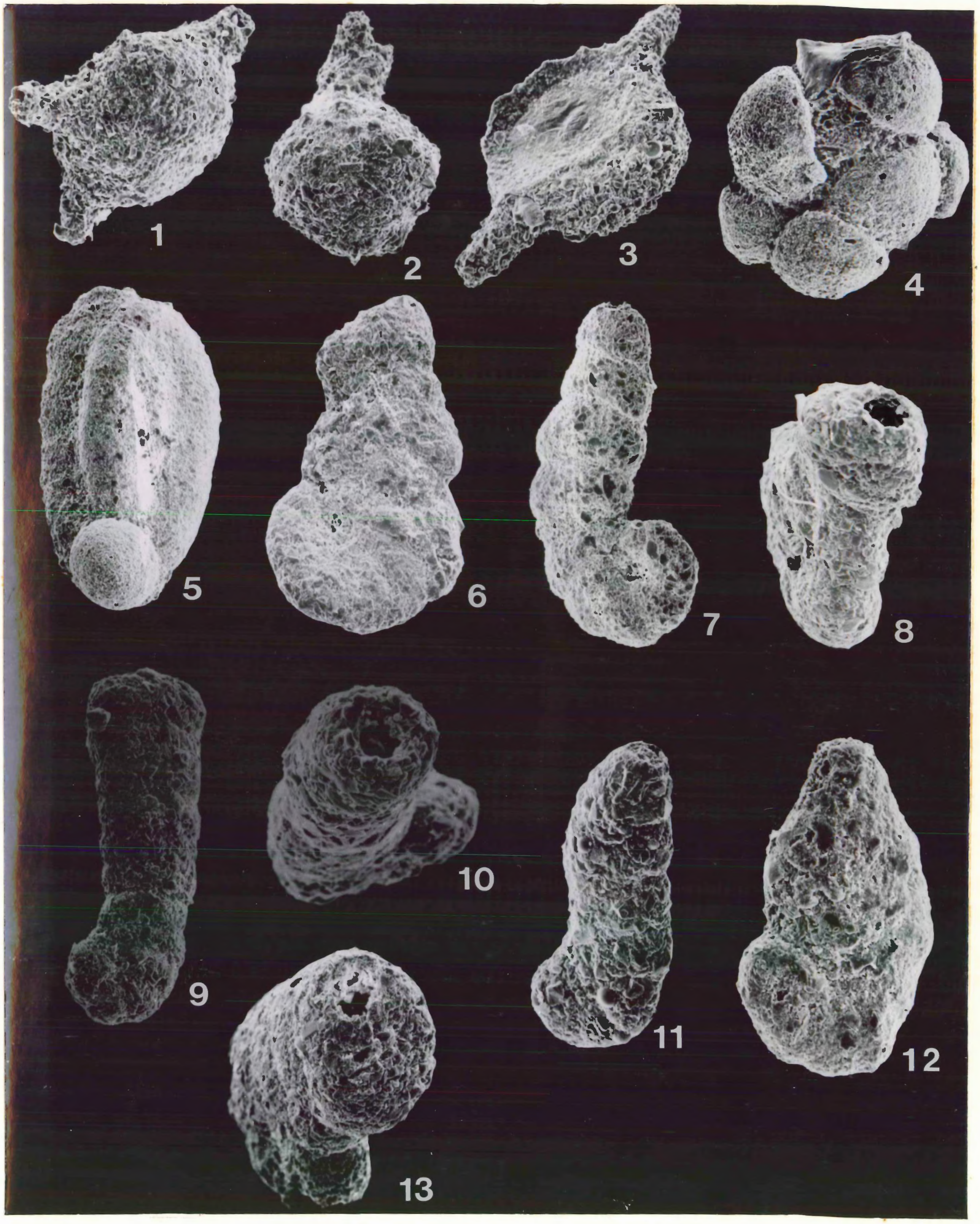
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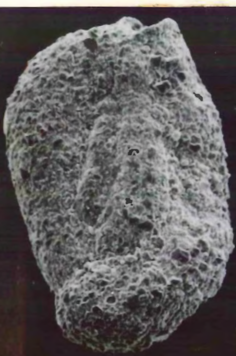
Plate 3

Figure 1-3.	*Miliammina fusca* (Brady) 1. side view (four chamber side), x68, 2. side view (three chamber side), x68, 3. aperture view, x102.
Figure 4.	*Spiroplectammina biformis* (Parker and Jones) 4. side view, x164.
Figure 5, 6.	*Haplophragmoides bonplandi* Todd and Brönnimann 5. side view, x110, 6. aperture view, x202.
Figure 7.	*Reophax nana* Rhumbler 7. side view, x265.
Figure 8.	*Reophax arctica* Brady 8. side view, x 223.
Figure 9.	*Eggerella advena* (Cushman) 9. side view, x145.
Figure 10-13.	*Polysaccamina ipohalina* Scott 10. side view of typical specimen, x122, 11. attached side of specimen, illustrating chamber flattening on attached side, x96, 12. enlargement of chamber connection, x224, 13. enlargement of aperture, x643.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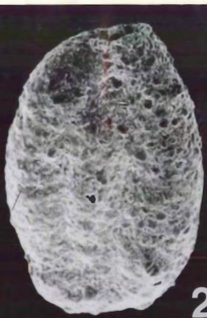
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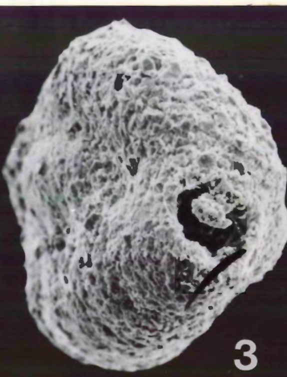
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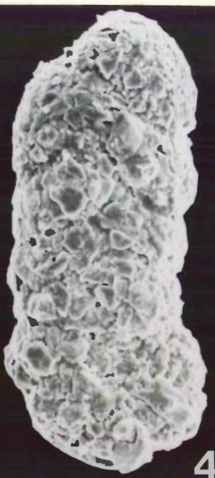
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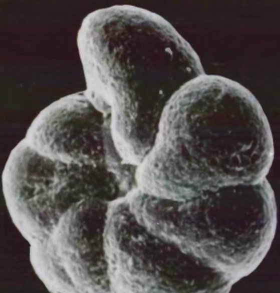
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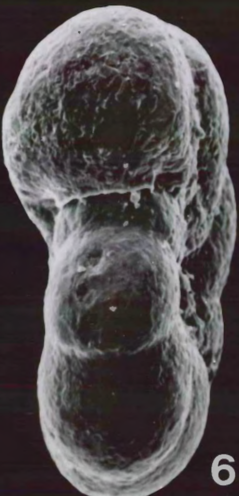
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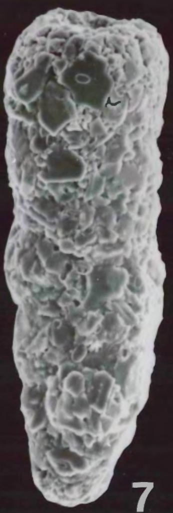
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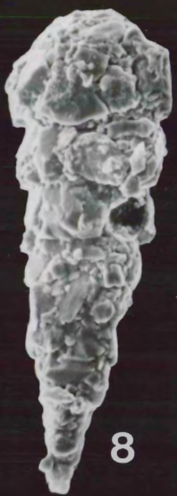
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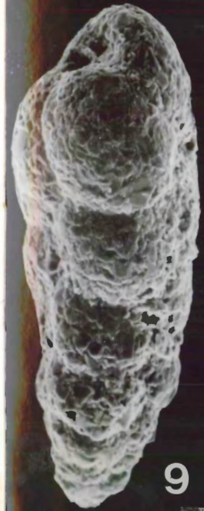
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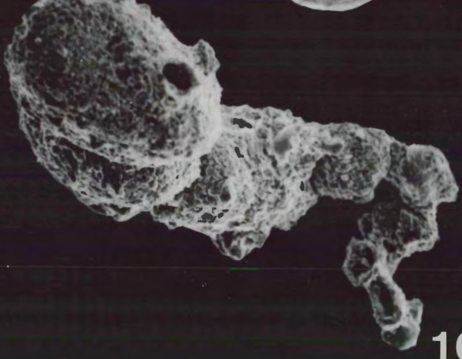
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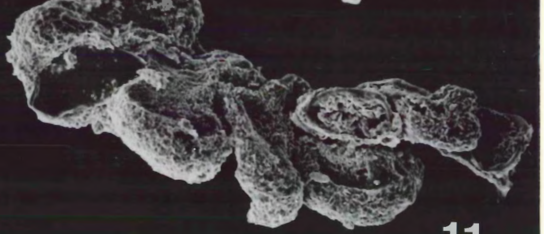
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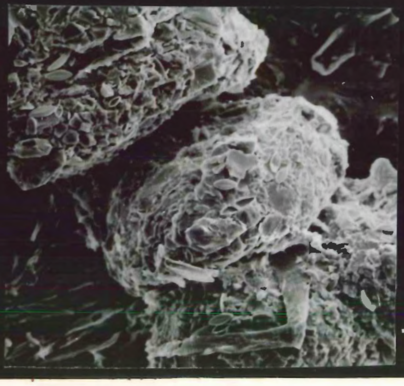
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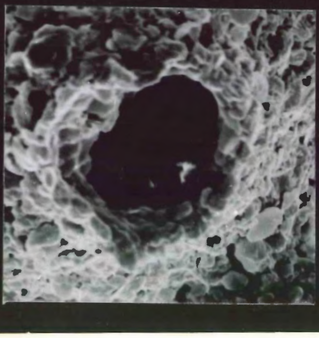
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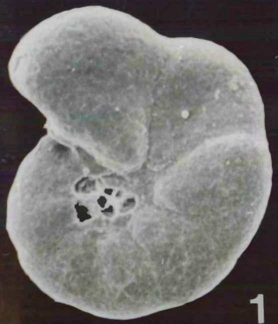
Plate 4

Figure 1-8. *Trochammina inflata macrescens* Brady 1. dorsal view, x98, 2. aperture view, x106, 3. ventral view of specimen with straight sutures, a deep umbilicus, and well defined umbilical teeth, x80, 4-8. series of specimens illustrating progressively more curved sutures and less of an umbilicus, x88.

Figure 9-11. *Jadammina polystoma* Bartenstein and Brand 9. ventral view, x94, 10. dorsal view, x135, 11. aperture view, x156.

Figure 12-14. *Trochammina inflata* (Montagu) - meglaspheric form 12. dorsal view, x87, 13. ventral view, x87, 14. aperture view, x79.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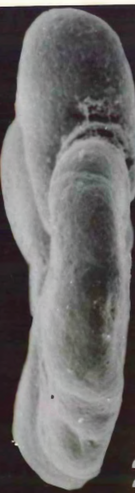
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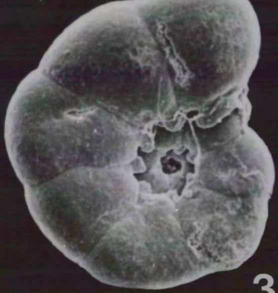
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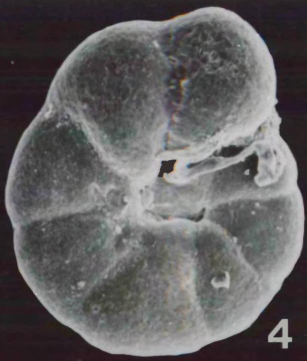
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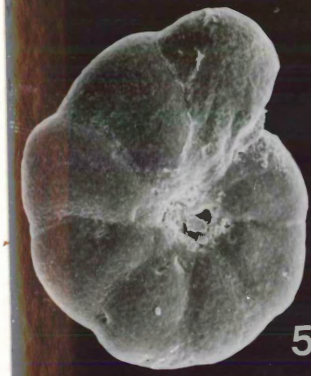
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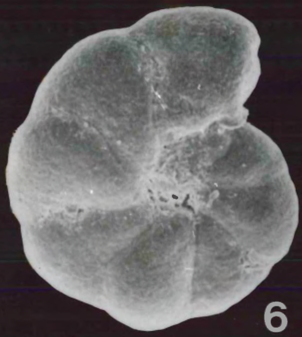
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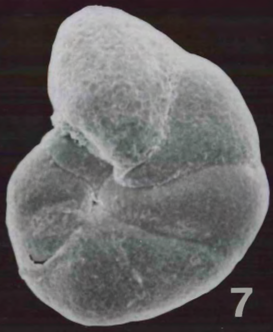
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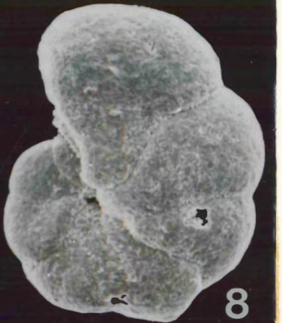
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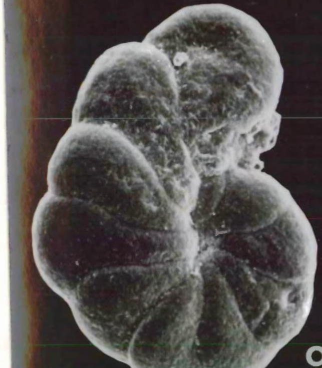
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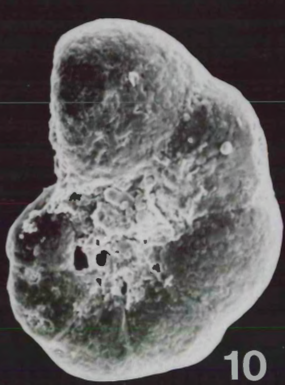
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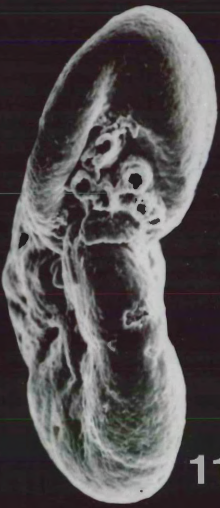
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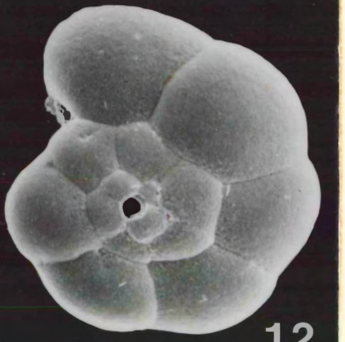
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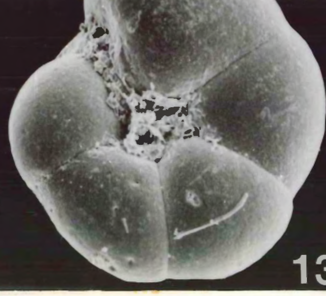
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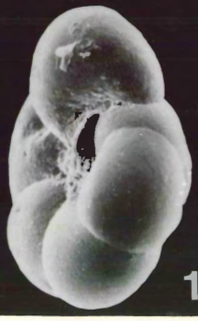
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Plate 5

Figure 1-3.	*Trochammina inflata* - microspheric form 1. dorsal view, x171, 2. ventral view, x135, 3. aperture view, x149.
Figure 4, 5.	*Trochammina ochracea* (Williamson) 4. dorsal view, x183, 5. ventral view, x166.
Figure 6, 7.	*Trochammina squamata* Parker and Jones 6. dorsal view, x188, 7. ventral view, x156.
Figure 8, 9.	*Trochammina lobata* Cushman 8. dorsal view, x144. 9. ventral view, x139.
Figure 10-13.	*Arenoparella mexicana* (Kornfeld) 10. dorsal view, x184, 11. ventral view, x135, 12. aperture view, aperture partially obscured, x176, 13. aperture view with additional aperture above the vertical slit, x156.
Figure 14-16.	*Tiphotrocha comprimata* (Cushman and Brönnimann) 14. dorsal view, x116, 15. ventral view of matrue specimen with characteristic T-shaped final chamber, x106, 16. less mature specimen without an irregular final chamber, x117.

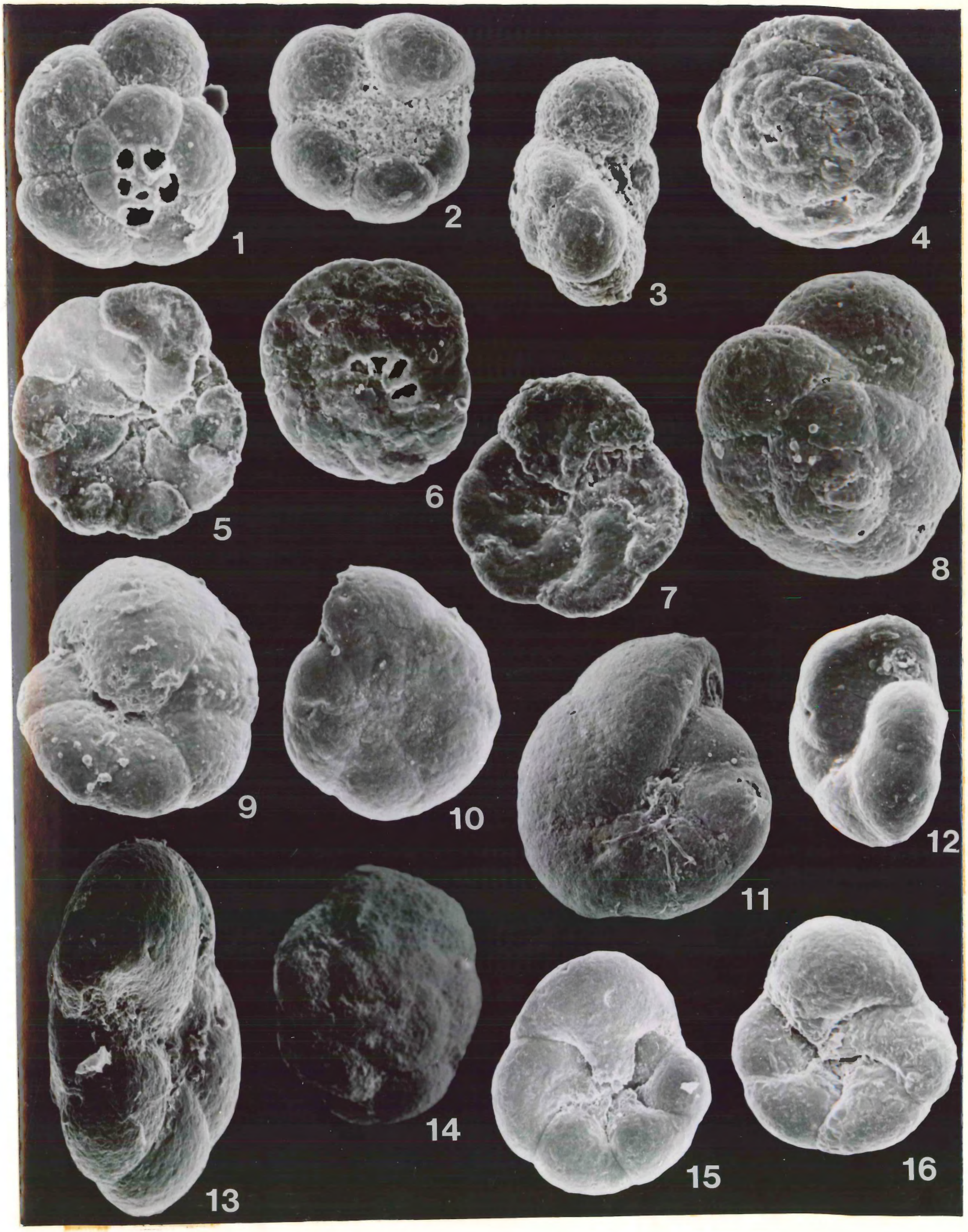
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Plate 6

Figure 1.	*Cribroelphidium excavatum* (Terquem) 1. side view, x94.
Figure 2.	*Cribroelphidium excavatum clavatum* 2. side view, x135.
Figure 3.	*Cribroelphidium excavatum selseyensis* 3. side view, x 164.
Figure 4, 5.	*Cribroelphidium incertum* (Cushman) not Williamson 4. side view, x109, 5. aperture view, note subacute profile, x110.
Figure 6.	*Cribroelphidium frigidum* (Cushman) 6. side view, x265.
Figure 7.	*Cribroelphidium subarcticum* (Cushman) 7. side view, x134.
Figure 8.	*Cribroelphidium bartletti* (Cushman) 8. side view, x92.
Figure 9.	*Protelphidium orbiculare* (Brady) 9. side view, x77.
Figure 10, 11.	*Ammonia beccarii* (Linne) 10. dorsal view, x204, 11. ventral view, x172.
Figure 12, 13.	*Helenina andersoni* (Warren) 12. dorsal view, x139, 13. ventral view, x140.

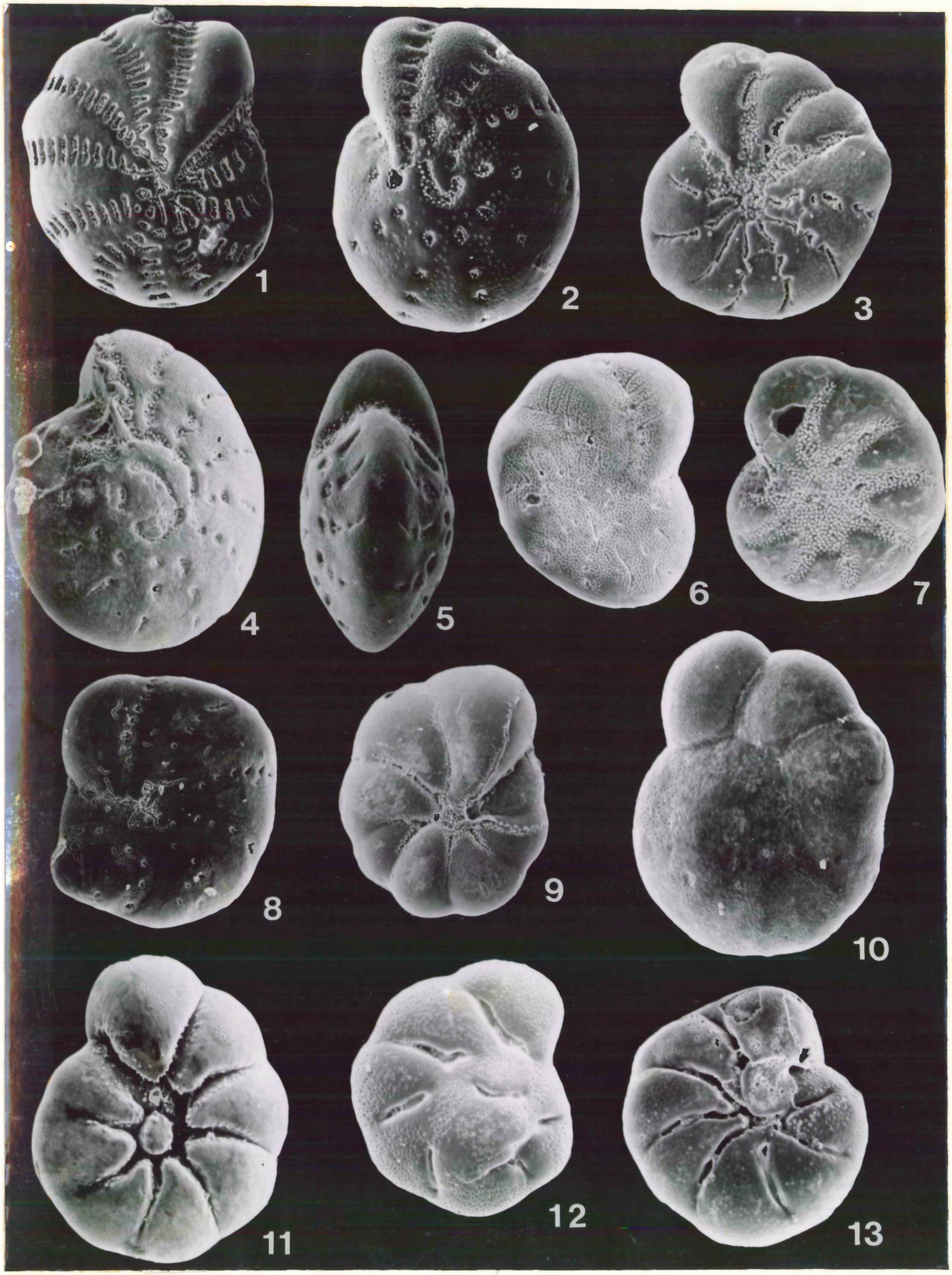
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Plate 7

Figure 1, 2.	_Buliminella_ _elegantissima_ (d'Orbigny) 1. back view, x192, 2. aperture view, x192.
Figure 3-5.	_Quinqueloculina_ _seminulum_ (Linne). 3. side view (four chamber side), x107, 4. side view (three chamber side), x98, 5. aperture view, x180.
Figure 6-8.	_Pateoris_ _hauerinoides_ (Rhumbler) 6. side view (many chambered side), x128, 7. side view (three chambered side), x44, 8. aperture view, x86.
Figure 9, 10.	_Fursenkoina_ _fusiformis_ (Williamson) 9. side-aperture view of typical specimen, x200, 10. side-aperture view of inflated specimen, x264.
Figure 11-13.	_Glabratella_ _wrightii_ (Brady) 11. dorsal view, x105, 12. ventral view, x183, 13. specimens in plastogamy, x315.

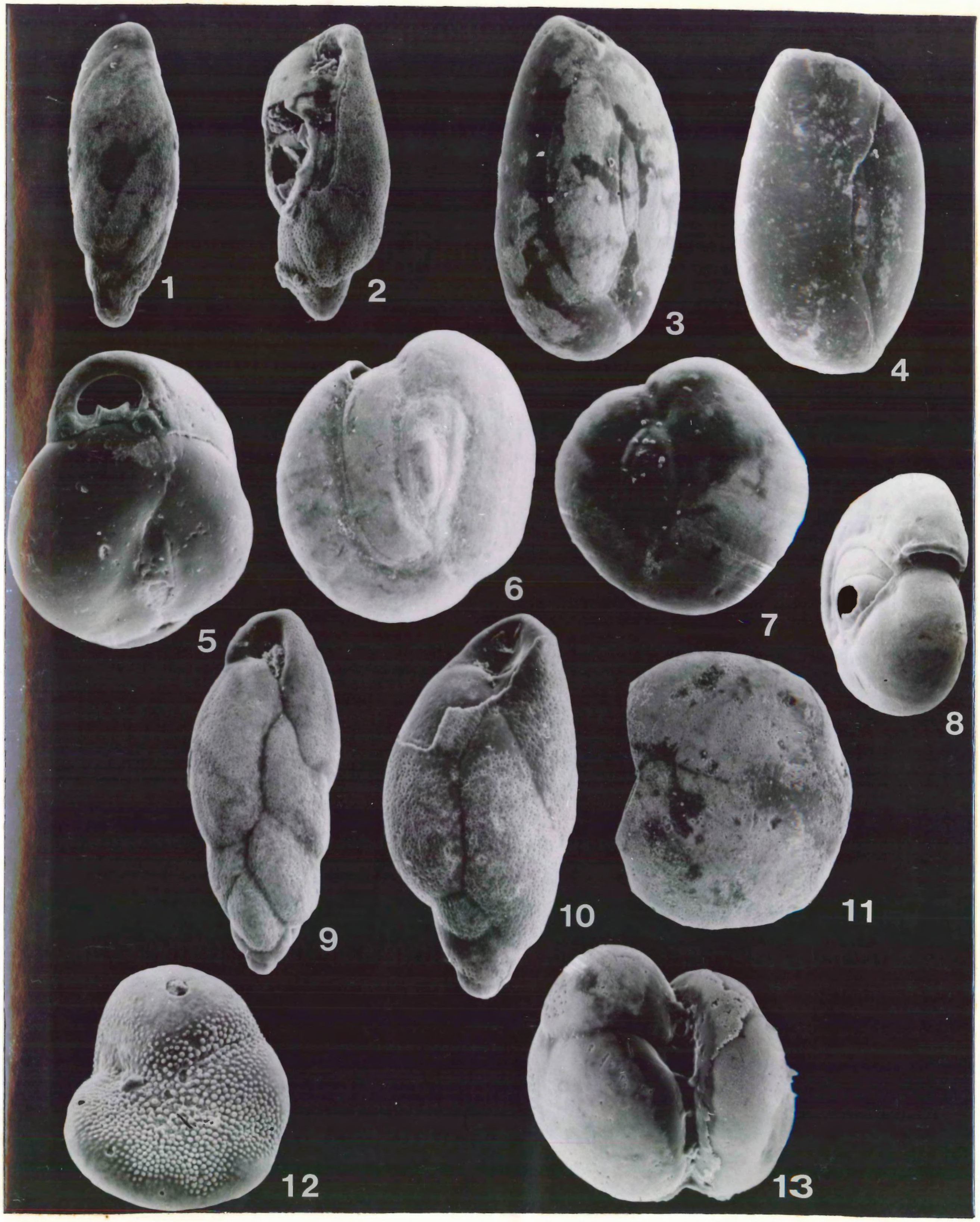
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Plate 8

Figure 1, 2. *Cassidulina crassa* d'Orbigny 1. side view, x270, 2. aperture view, x189.

Figure 3. *Bolivina pseudoplicata* Heron-Allen and Earland 3. side view, x252.

Figure 4. *Fissurina marginata* (Montagu) 4. aperture-side view, x321.

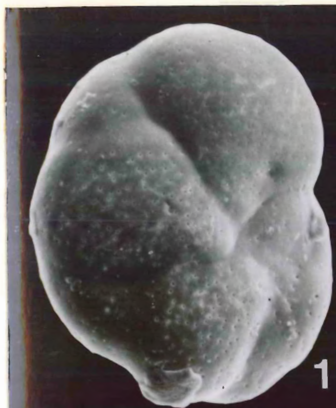
Figure 5. *Astrononion gallowayi* Loeblich and Tappan 5. side view, x167.

Figure 6, 7. *Rosalina columbiensis* (Cushman) 6. dorsal view, x170, 7. ventral view, x206.

Figure 8, 9. *Cibicides lobatulus* (Walker and Jacob) 8. "dorsal" or non-attached side, x64, 9. "ventral" or attached side, x101.

Figure 10, 11. *Buccella frigida* (Cushman) 10. dorsal side, x172, 11. ventral view, x154.

Figure 12, 13. *Trifarina fluens* (Todd) 12. side view, x164, 13. aperture view, x217.



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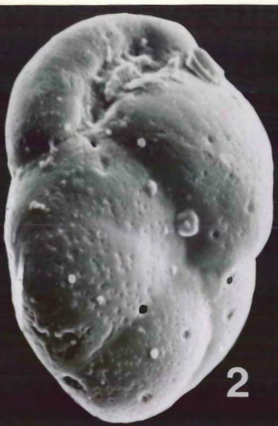

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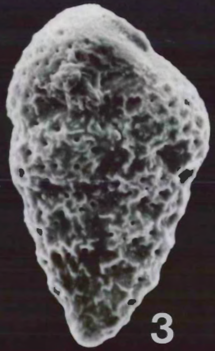

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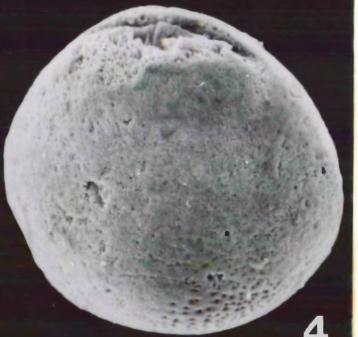

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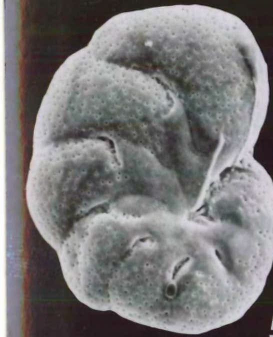

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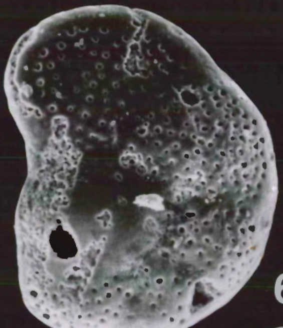

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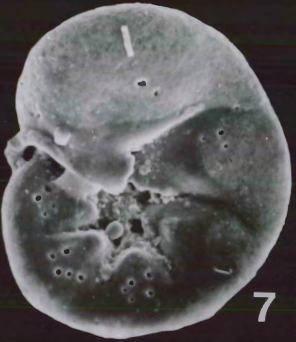

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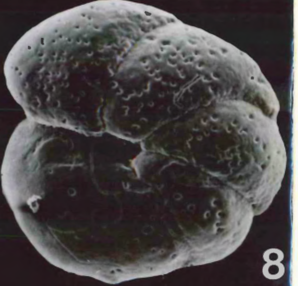

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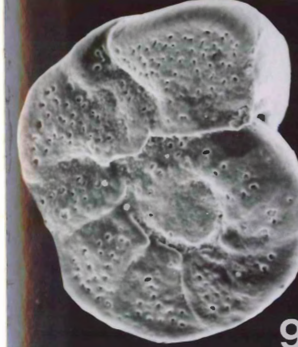

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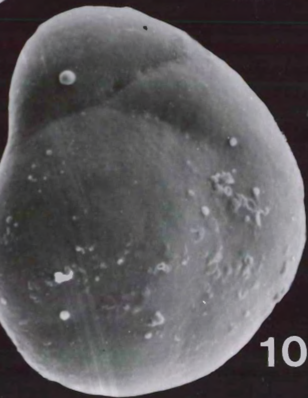

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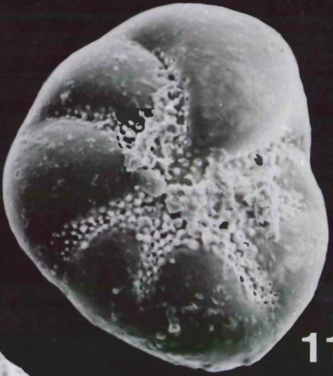

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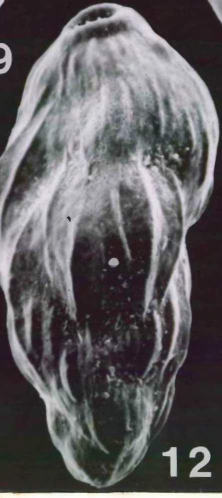

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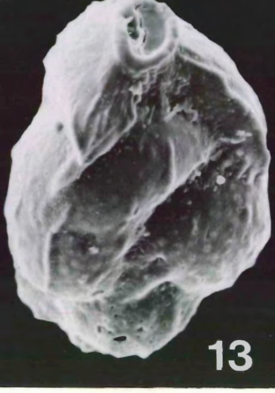

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REFERENCES

Albani, A. D., and Johnson, K. R., 1975, Resolution of foraminiferal biotopes in Broken Bay, N.S.W.: Jour. of Geol. Soc. of Australia, v. 22, p. 435-446.

Allen, R., and Roda, R., 1977, Reports on benthonic foraminifera from LaHave River Estuary, Nova Scotia: unpubl. student research reports at Dalhousie Univ., Halifax.

Andersen, H. V., 1951, Two new genera of Foraminifera from recent deposits of Louisiana: Jour. of Paleo., v. 25, p. 31-34.

______________, 1952, *Buccella*, a new genus of Rotalid Foraminifera: Jour. Wash. Acad. Sci., v. 42, p. 143-151.

Barrell, J., 1915, Factors in movements of the strandline and their results in the Pleistocene and post-Pleistocene: Amer. Jour. Sci., v. 40, p. 1-22.

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

Bartlett, G. A., 1964, Benthonic foraminiferal ecology in St. Margarets Bay and Mahone Bay southeast Nova Scotia: Bedford Inst. of Oceanography, report 64-8, 157 p.

______________, 1965, Preliminary investigation of benthonic foraminiferal ecology in Tracadie Bay, Prince Edward Island: Bedford Inst. of Oceanography, report 65-3, 56 p.

______________, 1966, Distribution and abundance of Foraminifera and Thecamoebina in Miramichi River and Bay: Bedford Inst. of Oceanography, report 66-2, 101 p.

Bloom, A. L., 1967, Pleistocene shorelines. A new test of isostasy: Bull. Geol. Soc. Amer., v. 78, p. 1477-1494.

Bolli, H. M. and Saunders, J. B., 1954, Discussion of some Thecamoebina described erroneously as Foraminifera: Contr. Cush. Found. Foram. Res., v. 5, pt. 2, p. 45-52.

Boltovskoy, E., 1958, The foraminiferal fauna of the Rio de la Plata and its relation to the Caribbean area: Cus. Found. Foram. Res., Contr., v. 9, p. 17-21.

Bradshaw, J. S., 1955, Preliminary laboratory experiments on ecology of foraminiferal populations: Micropaleo., v. 1, no. 4, p. 351-358.

______________, 1957, Laboratory studies on the rate of growth of the Foraminifer, Streblus beccarii (Linne) var. tepida (Cushman): Jour. of Paleo., v. 31, no. 6, p. 1138-1147.

______________, 1961, Laboratory experiments on the ecology of Foraminifera: Contr. Cush. Found. Foram. Res., v. 12, pt. 3, p. 87-106.

______________, 1968, Environmental parameters and marsh Foraminifera: Limnol. and Ocean., v. 13, no. 1, p. 26-38.

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: Ann. Mag. Natl. Hist., ser. 4, v. 6, p. 273-306.

___________, 1878, On the reticularian and radiolarian rhizopoda (Foraminifera and Polycystina) of the North-Polar Expedition of 1875-76: Ann. Mag. Natl. Hist., v. 1, series 5, p. 425-440.

___________, 1881, On some Arctic Foraminifera from soundings obtained on the Austro-Hungarian North Polar Expedition of 1872-76: Ann. Mag. of Nat. Hist., v. 8, p. 393-418.

___________, 1884, Report on the Foraminifera dredged by the H.M.S. Challenger during the years 1873-1876. Reports of scientific results from Explorer: Voyage of the H.M.S. Challenger, Zoology, v. 9, p. 1-814, pl. 1-115.

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

Buzas, M. A., 1965, Foraminifera from the late Pleistocene clay near Waterville, Maine: Smithson. Misc. Coll., v. 145, no. 8, 30 p.

___________, 1966, The discrimination of morphological groups of Elphidium (Foraminifer) in Long Island Sound through canonical analysis and invariant characters: Jour. of Paleo., v. 40, no. 3, p. 585-594.

Cartwright, D. E., 1972a, Some ocean tide measurements of the eighteenth century and their relevance today: Proceedings of the Royal Soc. England, Challenger Centenary Congress, v. 72, no. 32, p. 331-339.

_______________, 1972b, Secular changes in the oceanic tides at Brest, 1711-1936: Geophys. J. R. astr. Soc., v. 30, p. 433-449.

Cathles, L. M. III, 1975, The Viscosity of the Earth's Mantle: Princeton University Press, New Jersey, 386 p.

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

______________ , 1976, Coastal vegetation, second edition: Pergamon Press, Toronto, 292 p.

Clark, J. A., 1977, Global Sea Level Changes since the Last Glacial Maximum and Sea Level Constraints on the Ice Sheet Disintegration History: Ph.D. dissertation, University of Colorado.

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, 55 p.

Cushman, J. A., 1913, A monograph of the Foraminifera of the North Pacific ocean. Pt. 4, Lagenidae: U. S. Nat. Mus., Bull., v. 74, pt. 4, 125 p.

______________ , 1919, Recent Foraminifera from off New Zealand: U. S. Nat. Mus. Proc., v. 56, p. 593-640.

______________ , 1920, The Foraminifera of the Atlantic ocean. Pt. 2, Lituolidae: U. S. Nat. Mus., Bull., v. 104, pt. 2, 111 p.

______________ , 1921, Results of the Hudson Bay expedition, 1920; I - the Foraminifera: Canada, Biol. Board, Contr. Canadian Biol. (1921), Toronto, 1922, no. 9, p. 135-147.

______________ , 1925, Recent Foraminifera from British Columbia: Cush. Lab. Foram. Res., Contr., v. 1, p. 38-47.

______________ , 1926, Recent Foraminifera from Porto Rico: Carnegie Inst. Washington Publ. 344, p. 75-84.

______________ , 1927, An outline of a reclassification of the Foraminifera: Cush. Lab. Foram. Res., Contr., v. 3, p. 1-105.

______________ , 1929, The Foraminifera of the Atlantic ocean. Pt. 6, Miliolidae, Opthalmidiidae, and Fischerinidae: U. S. Nat. Mus., Bull., v. 104, pt. 6, 104 p.

______________ , 1930, The Foraminifera of the Atlantic ocean, pt. 7: U. S. Nat. Mus., Bull., v. 104, 55 p.

______________ , 1931, The Foraminifera of the Atlantic ocean, pt. 8. Rotaliidae, Amphistiginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae, and Homotremidae: U. S. Nat. Hist. Mus., Bull. 104, pt. 8, 179 p.

Cushman, J. A., 1933, New Arctic Foraminifer collected by Capt. R. A. Bartlett from Fox Basin and off the northeast coast of Greenland: Smithson. Misc. Coll., v. 89, no. 9, p. 1-8.

______________, 1937, A monograph of the foraminiferal Family Valvulinidae: Cush. Lab. Foram. Res., Spec. Publ. 8, 210 p.

______________, 1941, Some fossil Foraminifer from Alaska: Cush. Lab. Foram. Res., Contr. v. 17, p. 33-38.

______________, 1944, Foraminifera from the shallow water of the New England coast: Cush. Lab. Foram. Res., Spec. Publ. 12, p. 1-37.

______________, 1948, Arctic Foraminifera: Cush. Lab. Foram. Res., Spec. publ., v. 23, p. 1-79.

______________, and Bronnimann, P., 1948a, Additional new species of arenaceous Foraminifera from the shallow waters of Trinidad: Contr. Cush. Lab. Foram. Res., v. 24, p. 37-42.

______________, and ______________, 1948b, Some new genera and species of Foraminifera from brackish water of Trinidad: Contr. Cush. Lab. Foram. Res., v. 24, p. 15-21.

______________, and Cole, W. S., 1930, Pleistocene Foraminiferida from Maryland: Cush. Lab. Foram. Res., Contr., v. 6, p. 94-100.

______________, and Edwards, P. G., 1937, Astrononion, a new genus of Foraminifera and its species: Cush. Lab. Foram. Res., Contr., v. 13, p. 29-36.

______________, and Todd, R., 1947, A foraminiferal fauna from Amchikta Island, Alaska: Cush. Lab. Foram. Res., Contr., v. 23, p. 60-72.

Daly, R. A., 1920, Oscillations of level in belts peripheral to the Pleistocene ice caps: Geol. Soc. Amer. Bull., v. 31, p. 303-318.

Dohler, G. C., and Ku, L. F., 1970, Presentation and assessment of tides and water level records for geophysical investigations: Can. Jour. Earth Sci., v. 7, p. 607-625.

Ellison, R. L., and Nichols, M. M., 1976, Modern and Holocene Foraminifera in the Chesapeake Bay Region: 1st Int. Symp. on Benthonic Foraminifera of the Continental Margins. Part A. Ecology and Biology, MARITIME SEDIMENTS, Spec. publ. 1, p. 131-151.

Emery, K. O., and Garrison, L. E., 1967, Sea levels 7,000 to 20,000 years ago: Science, v. 157, no. 3787, p. 684-687.

Farrell, W. E., and Clark, J. A., 1976, On postglacial sea level: Geophys. J. R. astr. Soc., v. 46, p. 647-667.

Feyling-Hanssen, R. W., 1972, The Foraminifer *Elphidium excavatum* (Terquem) and its variant forms: Micropaleo., v. 18, no. 3, p. 337-354.

____________________, Jørgensen, J. A., Knudsen, K. L., and Anderson, A. L., 1971, Late Quaternary Foraminifera from Vendsyssel, Denmark and Sandnes, Norway: Bull. Geol. Soc. Denmark, v. 21, pt. 2, 3, 317 p., 26 pl.

Fischer de Waldheim, G., 1817, Adversaria zoologica: Soc. Imper. Nat. Moscou Mem., v. 5, p. 357-471.

Folk, R. L., 1968, Petrology of Sedimentary Rocks: Hamphill, Austin, Texas, 170 p.

Frizzel, D. L., and Keen, A. M., 1949, On the nomenclature and generic position of *Nautilus beccarii* Linne (Foraminifera "Rotaliidae"): Jour. of Paleo., v. 23, p. 106-108.

Grant, D. R., 1970a, Recent coastal submergence of the Maritime provinces, Canada: Can. Jour. Earth Sci., v. 7, no. 2, p. 676-689.

___________, 1970b, Recent coastal submergence of the Maritime provinces, Canada: Ph.D. dissertation, Cornell University, 109 p.

Gregory, M. R., 1970, Distribution of Benthonic Foraminifera in Halifax Harbour, Nova Scotia: Ph.D. thesis at Dalhousie University, Halifax.

Greiner, G. O., 1974, Environmental factors controlling the distribution of recent benthonic Foraminifera: Breviora, Mus. Comp. Zoology, Harvard pub., no. 420, p. 1-35.

Heron-Allen, E., and Earland, A., 1930, The Foraminifera of the Plymouth District, II: Jour. Roy. Micr. Soc., ser. 3, v. 50, pt. 2, p. 161-199.

______________, and __________, 1932, Some new Foraminifera from the south Atlantic. IV. Four new genera from South Georgia: Jour. Roy. Micr. Soc., London, v. 52, ser. 3, p. 253-261.

Hessland, I., 1943, Marine Schalenablagerungen Nord-Bohusläns: Bull. Geol. Inst. of Uppsala, ~~31 p.~~ V 31 348 p.

Höglund, H., 1947, Foraminifera in the Gullmar Fjord and the Skagerak: Ph.D. dissertation, University of Uppsala, Sweden, 328 p., 32 pl.

Jamieson, T., F. III, 1882, On the cause of the depression and relevation of the land during the glacial period: Geol. Mag., v. 9, p. 400-466.

Kanmacher, F., 1798, Adams essays on the microscope: the second edition, with considerable additions and improvements: Dillon and Keating (London).

Kaye, C. A., and Barghorn, E. S., 1964, Late Quaternary sea-level change and crustal rise at Boston, Massachusetts, with notes on the auto-compaction of peat: Geol. Soc. Amer. Bull., v. 75, p. 63-80.

Kornfeld, M. M., 1931, Recent littoral Foraminifera from Texas and Louisiana: Stanford Univ., Dept. of Geol., Contr., v. 1, no. 3, p. 77-101.

Kranck, K., 1972, Geomorphological development and post-Pleistocene sea level changes, Northumberland Strait, Maritime Provinces: Can. Jour. Earth Sci., v. 9, no. 7, p. 835-844.

Leslie, R. J., 1965, Ecology and Paleoecology of Hudson Bay Foraminifera: Bedford Institute of Oceanography, report 65-6, 192 p.

Levy, A., Mathieu, R., Momeni, I., Poignant, A., Rosset-Moulinier, M., Rouvillois, A., and Ubaldo, M., 1969, Les représentant de la Famille de Elphidiidae (Foraminiferes) dans les Sables des plages des environs de Dunkerque. Remarques sur les espéces de *Polystomella* signalées par O. Terquem: Revue de Micropaleontologie, v. 12, no. 2, p. 92-98.

Linne, C., 1758, Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis: ed. 10, v. 1, p. 1-824, G. Engelmann (Lipsiae).

Loeblich, A. R. Jr., and Tappan, H., 1953, Studies of Arctic Foraminifera: Smithson. Misc. Coll., v. 121, no. 7, p. 150.

________________, and ________, 1964, Sarcodian, chiefly "Thecamoebians" and Foraminiferida *in* Moore, R. C., ed., Treastise on Invertebrate Paleontology, Protista 2, pt. c, Kansas Univ. Press., v. 1, 2, 899 p.

________________, and collaborators: Tappan, H., Beckman, J. P., Bolli, H. M., Gallitelli, E. M., Troelsen, J. C., 1957, Studies in Foraminifera: U. S. Nat. Hist. Mus., Bull. 215, 321 p.

MacDonald, K. B., 1969, Quantitative studies of salt marsh faunas from the North American Pacific coast: Ecol. Monographs, v. 39, no. 1, p. 33-60.

Medioli, F. S., and Scott, D. B., 1976, A portable, hand operated device for drilling in soil and salt marsh deposits: Maritime Sediments, v. 12, no. 2, p. 77-78.

Milliman, J. D., and Emery, K. O., 1968, Sea levels during the past 35,000 years: Science, v. 162, p. 1121-1123.

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

__________, 1808, Testacea Britannica, supplement: Exeter, England, S. Woolmer, 183 p.

Murray, J. W., 1971a, Living Foraminiferids of tidal marshes: a review: Jour. Foram. Res., v. 1, no. 4, p. 153-161.

__________, 1971b, An Atlas of Recent British Foraminiferids: New York, Elsevier Publishing Co.

Newman, W. S., and March, S., 1968, Littoral of the northeastern United States: late Quaternary warping: Science, v. 160, p. 1110-1112.

Nørvang, A., 1945, The zoology of Iceland, Foraminifera: 2 pt., 2, 79 p., Ejnar Munksgaard (Copenhagen and Reykjavik).

d'Orbigny, A. D., 1826, Tableau methodique de la classe des cephalopods: Ann. Sci. Nat. Paris, ser. 1, v. 7, p. 245-314.

__________, 1839, Voyage dans l'Amerique Meridionale-Foraminiféres v. 5, pt. 8, 86 p., Pitois-Levrault et C^{ie} (Paris), V. Levrault (Strasbourg).

Parker, F. L., 1952a, Foraminifera species off Portsmouth, New Hampshire: Bull. Mus. Comp. Zool., Harvard, v. 106, no. 9, p. 391-423.

__________, 1952b, Foraminiferal distribution in the Long Island Sound-Buzzards Bay area: Bull. Mus. Comp. Zool., Harvard, v. 106, no. 10, p. 438-473.

__________, and Athearn, W. D., 1959, Ecology of marsh Foraminifera in Poponesset Bay, Massachusetts: Jour. of Paleo., v. 33, no. 2, p. 333-343.

Parker, W. K., and Jones, T. R., 1859, On the nomenclature of the Foraminifera, part 2, on species enumerated by Walker and Montagu: Ann. Mag. Natl. Hist., ser. 2, v. 4, p. 333-51.

Parker, W. K., and Jones, T. R., 1865, On some Foraminifera from the north Atlantic and Arctic oceans, including Davis Strait and Baffin's Bay: Phil. Trans., v. 155, p. 325-441.

Peltier, W. R., and Andrews, J. T., 1976, Glacial-isostatic adjustment - I. The forward problem: Geophys. J. R. astr. Soc., v. 46, p. 605-646.

Phleger, C. F., 1971, Effect of salinity of growth of a salt marsh grass: Ecology, v. 52, p. 908-911.

Phleger, F. B , 1954, Ecology of Foraminifera and associated microorganisms from Mississippi sound and environs: Bull. Amer. Assoc. Petr. Geol., v. 38, no. 4, p. 584-647.

______________ , 1955, Ecology of Foraminifera in southeast Mississippi delta area: Bull. Amer. Assoc. Petr. Geol., v. 39, no. 5, p. 712-751.

______________ , 1965a, Living Foraminifera from a coastal marsh, southwestern Florida: Bol. Soc. Geol. Mexicana, t. 28 n. 1, p. 45-60.

______________ , 1965b, Pattern of marsh Foraminifera, Galveston Bay, Texas: Limnol. and Ocean., v. 10, supplement, p. R169-R184.

______________ , 1966, Patterns of living marsh foraminifera in south Texas coastal lagoons: Bol. Soc. Geol. Mexicana t. 28, n. 1, p. 1-44.

______________ , 1967, Marsh foraminiferal patterns, Pacific coast of North America: An. Inst. Biol. Univ. Nal. Autón. Mexico 38, ser. cienc. Del Mar Y Limnol., v. 1, p. 11-38.

______________ , 1969, Some general features of coastal lagoons: in A. Ayala-Castañares and Phleger, F. B (editors), Coastal Lagoons, A symposium: Universidad Nacional Autonoma de Mexico, Mexico, p. 5-26.

______________ , 1970, Foraminiferal populations and marine marsh processes: Limnol. and Ocean., v. 15, no. 4, p. 522-534.

______________ , 1977, Soils of marine marshes: in Chapman, V. J., Wet Coastal Ecosystems: Elsevier Scientific Publishing Co., Amsterdam, ch. 4, p. 69-77.

______________ , and Bradshaw, J. S., 1966, Sedimentary environments in a marine marsh: Science, v. 154, no. 3756, p. 1551-1553.

______________ , and Ewing, C., 1962, Sedimentology and oceanography of coastal lagoons in Baja California, Mexico: Geol. Soc. Amer. Bull., v. 75, p. 145-182.

Phleger, F. B , and Walton, W. R., 1950, Ecology of marsh and bay Foraminifera, Barnstable, Mass.: Amer. Jour. Sci., v. 248, p. 274-294.

Piper, D. J. W., and Keen, M. J., 1976, Studies of Coastal Bays in Nova Scotia: Unpubl. report to the Dept. of Energy, Mines, and Resources, Canada, research agreement no. 1135-013-4-14/76.

Redfield, A. C., 1967, Postglacial change in sea level in the western north Atlantic ocean: Science, v. 157, no. 3787, p. 687-691.

_______________, 1972, Development of a New England salt marsh: Ecol. Monographs, v. 42, no. 2, p. 201-237.

Reinson, G. E., 1976, Surficial sediment distribution in the Miramichi Estuary, New Brunswick: Report of activities, part C, Geol. Surv. of Canada, paper 76-1C, p. 41-44.

Rhumbler, L., 1911, Die Foraminiferen (Thalamophoren) der Plankton-Expedition: Ergebnisse der Plankton-Exped. der Humboldt-Stiftung, v. 3, Lief. C., p. 1-331.

____________, 1936, Foraminiferen der Kieler Bucht, gesammelt durch A. Remane, Teil II (Ammodisculinidae bis einschl. Textulinidae): Kieler Meeresforschungen, v. 1, p. 179-242.

Saunders, J. B., 1957, Trochamminidae and certain Lituolidae (Foraminifera) from the recent brackish-water sediments of Trinidad, British West Indies: Smithson. Misc. Coll., v. 134, no. 5, publ. 4270, p. 1-16.

_______________, 1961, Helenina Saunders, new name for the foraminiferal genus Helenia Saunders, 1957, non Helenia Walcott, 1889: Cush. Found. Foram. Res., Contr., v. 12, pt. 4, p. 148.

Schafer, C. T., and Cole, F. E., 1976, Foraminiferal distribution patterns in the Restigouche Estuary: 1st Int. Symp. on Benthonic Foraminifera of the Continental Margins Part A. Ecology and Biology: MARITIME SEDIMENTS, Spec. publ. no. 1, p. 1-24.

Schnitker, D., 1974, Ecotypic variation in Ammonia beccarii (Linne): Jour. Foram. Res., v. 4, no. 4, p. 216-223.

Scholl, D. W., Craighead, F. C. Sr., and Stuiver, M., 1969, Florida submergence curve revised: its relation to coastal sedimentation rates: Science, v. 163, p. 562-564.

Scott, D. B., 1974, Recent benthonic Foraminifera from Samish and Padilla Bays, Washington: Northwest Sci., v. 48, no. 4, p. 211-218.

Scott, D. B., 1976a, Quantitative studies of marsh foraminiferal patterns in southern California and their application to Holocene stratigraphic problems: 1st Int. Symp. on Benthonic Foraminifera of Continental Margins. Part A. Ecology and Biology, MARITIME SEDIMENTS, Spec. publ. 1, p. 153-170.

___________, 1976b, Brackish-water Foraminfera from southern California and description of Polysaccammina ipohalina, n.gen., n.sp: Jour. Foram. Res., v. 6, no. 4, p. 312-321.

___________, Mudie, P. J., and Bradshaw, J. S., 1976, Benthonic Foraminifera of three southern California lagoons: ecology and Recent stratigraphy: Jour. Foram. Res., v. 6, no. 1, p. 59-75.

___________, and Cass, T. L., 1977, Response of Cerithidea californica (Haldeman) to lowered salinities and its paleoecological implications: S. Calif. Acad. Sci., Bull., v. 76, no. 2.

___________, Medioli, F. S., and Schafer, C. T., 1977, Temporal changes in foraminifera distributions in Miramichi River estuary New Brunswick: Can. Jour. Earth Sci., v. 14, no. 7, p. 1566-1587.

Shepard, F. P., and Curray, J. R., 1967, Carbon-14 determinations of sea level changes in stable areas: in Progress in Oceanography, v. 4, "The Quaternary history of the ocean basins", p. 283-291.

Suggate, R. P., 1968, Post-glacial sea-level rise in the Christchurch metropolitan area, New Zealand: Geol. en Mijnb., v. 47, no. 4, p. 291-297.

Swift, D. J. P., and Borns, H. W. Jr., 1967, A raised fluviomarine outwash terrace, north shore of the Minas Basin, Nova Scotia: Jour. Geology, v. 75, no. 6, p. 693-710.

Terquem, O., 1876, Essai sur le classement des animaux qui vivent sur la plage et dans les environs de Dunkerque: Premier partie. Societe Dunkerquoise, Memoires, v. 19 (1874-75), p. 405-457.

Todd, R., and Brönnimann, P., 1957, Recent Foraminifera and Thecamoebina from the Eastern Gulf of Paria: Cush. Found. Foram. Res., Spec. Publ. no. 3, 43 p.

________, and Low, D., 1961, Near-shore Foraminifera of Martha's Vineyard Island Massachusetts: Cush. Found. Foram. Res., Contr., v. 12, p. 5-21.

Uchio, T., 1960, Ecology of living benthonic Foraminifera from the San Diego, California area: Cush. Found. Foram. Res., Spec. Publ. no. 5, 71 p.

Vaníček, P., 1976, Vertical crustal movements pattern in Maritime Canada: Can. Jour. Earth Sci., v. 13, no. 5, p. 661-667.

Walcott, R. I., 1972a, Late Quaternary vertical movements in eastern North America: quantitative evidence of glacio-isostatic rebound: Reviews of Geophys. and Space Physics, v. 10, no. 4, p. 849-884.

_____________ , 1972b, Past sea levels, eustasy, and deformation of the earth: Quarternary Res., v. 2, p. 1-14.

Walker, D. A., 1976, An _in situ_ investigation of life cycles of benthonic midlittoral Foraminifera: 1st Int. Symp. on Benthonic Foraminifera of the Continental Margins. Part A. Ecology and Biology, MARITIME SEDIMENTS Spec. publ. 1, p. 51-60.

Warren, A. D., 1957, Foraminifera of the Buras-Scofield Bayou region, southeast Louisiana: Cush. Found. Foram. Res., Contr., v. 8, pt. 1, p. 29-40.

Wiesner, H., 1931, Die Foraminiferen der deutschen Südpolar Expedition 1901-1903: Deutsche Südpolar Exped., v. 20 (Zoology, v. 12), p. 53-165.

Williamson, W. C., 1858, On recent Foraminifera of Great Britain: Royal Soc. Publ., 107 p.

Appendix A

Tables 1, 2. The estuarine oceanographic information for the Chezzetcook stations, including date of collection, time, salinity, temperature, water depth, % carbon; ≠ indicates no bottom values obtainable because of strong currents, * indicates insufficient bottom material recovered to allow carbon analysis.

Tidal cycles for the days sampled in this study (from standard tide book for Halifax). Times adjusted to Atlantic Daylight Time.

May 24, 1976

High - 0555 (+ 162 cm)
Low - 1155 (+ 76 cm)
High - 1610 (+ 183 cm)

May 28, 1976

High - 0850 (+ 180 cm)
Low - 1440 (+ 73 cm)
High - 2050 (+ 196 cm)

June 2, 1976

Low - 0600 (+ 49 cm)
High - 1155 (+ 192 cm)
Low - 1830 (+ 79 cm)

June 3, 1976

Low - 0655 (+ 49 cm)
High - 1240 (+ 192 cm)
Low - 1920 (+ 76 cm)

June 15, 1976

Low - 0535 (+ 30 cm)
High - 1115 (+ 205 cm)
Low - 1805 (+ 67 cm)

June 16, 1976

Low - 0630 (+ 40 cm)
High - 1250 (+ 199 cm)
Low - 1850 (+ 73 cm)

September 30, 1976

High - 0045 (+ 183 cm)
Low - 0730 (+ 70 cm)
High - 1250 (+ 189 cm)
Low - 2015 (+ 52 cm)

Table 1.

			SALINITY ‰						TEMPERATURE °C							
DATE	TIME	STATION	0 m	1 m	2 m	3 m	4 m	5 m	0 m	1 m	2 m	3 m	4 m	5 m	% C	WATER DEPTH
5/24/76	1150	21A	0.00	0.00					12.75	12.65					15.5%	.5 m
5/24/76	1200	21B	0.00	0.00					12.55	12.48					13.6%	.75 m
5/24/76	1210	21C	0.00	0.00	1.82				12.55	12.50	12.45				10.6%	2 m
5/24/76	1215	21D	0.00	0.00					12.23	12.23					11.5%	.3 m
5/24/76	1230	22A	0.00	0.00					12.90	12.68					11.1%	.3 m
5/24/76	1240	22B	0.00	0.00	0.00				12.76	12.66	12.43				10.6%	1.5 m
6/3/76	1110	22B	1.6	11.55	12.95				15.6	13.9	13.65					
6/3/76	1405	22B	0.00	13.43	17.2				16.32	14.8	14.4					
5/24/76	1250	22C	0.00	0.00					12.80	12.97					8.9%	.3 m
5/24/76	1300	22D	0.00	0.00					13.16	13.22					12.3%	.3 m
5/24/76	1330	23A	0.00	0.00					13.25	13.22					8.1%	.3 m
5/24/76	1340	23B	0.00	0.00	0.00	0.00			12.95	12.70	12.70	13.20			5.1%	2.5 m
6/3/76	1120	23B	9.6	14.3	14.3				15.3	13.58	13.92					
5/24/76	1350	23C	0.00	0.00					13.04	13.00					7.9%	.3 m
5/28/76	1030	24A	4.13	12.95					11.80	10.65					9.6%	1 m
5/28/76	1045	24B	1.00		20.73				11.80	10.46	10.00				4.6%	2 m
5/28/76	1145	24C	2.55	9.93					12.40	11.55					7.3%	1 m
6/2/76	1130	25A	10.03	16.92	17.7				14.70	12.80	13.00				8.2%	1.5 m
6/2/76	1140	25B	12.40	17.83					14.20	12.9					11.4%	1 m
6/2/76	1150	25C	10.30	18.50					14.70	12.83					9.7%	1 m
6/2/76	1200	26A	15.95	19.1					14.02	13.15					10.0%	1.5 m
6/2/76	1210	26B	15.05	20.3	21.12				14.89	12.7	12.3				11.0%	1.5m
6/2/76	1220	26C	18.28	19.8					13.93	13.35					9.7%	1 m
6/2/76	1240	27A	19.18	19.9					13.52	13.33					20.6%	1 m
6/2/76	1250	27B	17.03	21.16	23.0	23.3	22.0		14.55	12.62	12.06	11.70	11.92		7.9%	4 m
6/2/76	1300	27C	19.45	21.25					13.50	12.60					10.5%	1 m
6/2/76	1330	28A	11.52	11.6					15.52	15.70					14.5%	.5m
6/2/76	1340	28B	10.5	11.85	12.5				16.20	15.50	15.35				9.8%	1.5m
6/2/76	1350	28C	9.54	11.9					16.20	15.50					13.8%	1 m
6/2/76	1400	29A	10.5	12.07					16.50	16.10					6.2%	.75m
6/2/76	1410	29B	10.5	12.93	14.80				16.70	15.50	14.70				10.5%	1.5m
6/2/76	1420	29C	9.65	12.2					14.08	16.4					8.8%	.5 m
6/2/76	1430	30A	12.77	13.80					16.40	15.80					9.6%	1 m
6/2/76	1440	30B	12.33	15.3	16.7				16.91	14.70	14.23				10.3%	2 m
6/2/76	1450	30C	11.7	13.55					17.0	16.0					9.5%	.5m
6/2/76	1500	31A	15.13	13.6					17.0	16.5					12.7%	1 m
6/2/76	1510	31B	12.97	15.1	19.6	19.9			17.35	14.7	13.6	13.5			4.4%	2.5m
6/2/76	1520	31C	12.89	13.1					18.4	18.3					8.4%	.75m
6/2/76	1530	32A	14.8	14.9					16.73	16.70					7.5%	.25m
6/2/76	1540	32B	14.05	19.25	20.6				17.0	15.2	15.0				*	2 m
6/2/76	1550	32C	14.55	14.75					17.95	17.02					9.8%	.25m
6/3/76	1130	33A	15.7	19.2					15.65	14.6					7.9%	1 m
6/3/76	1140	33B	17.17	20.28	21.2	26.78			15.15	14.35	15.92	14.2			5.2%	3 m
6/3/76	1150	33C	21.5	21.43					14.05	13.93					4.0%	1 m
6/3/76	1200	33D	21.5	21.3					14.70	14.17					5.6%	1 m
6/3/76	1210	34A	22.28	22.75					14.6	14.25					14.3%	1 m
6/3/76	1220	34B	22.3	23.00					15.5	15.5					11.6%	1 m
6/3/76	1230	34C	25.25	25.8	25.8	26.4			13.55	12.90	12.80	12.72			7.3%	3 m
6/3/76	1240	34D	24.6	25.00					13.7	13.6					4.6%	1 m
6/3/76	1300	35A	25.9	28.9	28.9	28.75	26.8		13.89	11.20	11.3	11.00	11.3		0.9%	4 m

Table 2.

			SALINITY ‰						TEMPERATURE °C							
DATE	TIME	STATION	0 m	1 m	2 m	3 m	4 m	5 m	0 m	1 m	2 m	3 m	4 m	5 m	% C	WATER DEPTH
6/3/76	1310	35B	27.9	28.75					12.7	11.2					1.9%	.5m
6/3/76	1320	35C	25.0	27.1					14.00	12.6					*	1 m
6/3/76	1330	35D	26.14	28.1					14.25	12.0					5.5%	1 m
6/3/76	1340	35E	24.3	27.00					14.45	12.90					3.9%	1 m
6/15/76	1210	36A	29.6	30.62					12.70	10.5					18.3%	1 m
6/15/76	1220	36B	29.62	31.0	30.78				11.75	8.69	8.65				3.2%	1.3m
6/15/76	1230	36C	30.6	31.0	31.0	30.8			10.45	9.3	8.98	8.75			*	3 m
6/15/76	1240	36D	30.95	30.94					9.95	9.55					7.5%	1 m
6/16/76	1130	36E	27.9	30.3					16.2	13.8					4.9%	1 m
6/16/76	1140	36F	30.8	30.6	30.9	30.8			12.6	12.3	12.0	12.0			*	3 m
6/16/76	1150	36G	30.7	30.4					12.2	12.2					3.0%	1 m
6/15/76	1255	37A	30.9	30.9					8.80	8.59					1.7%	1 m
6/15/76	1305	37B ≠	30.6	30.75	30.9				10.0	9.3	8.75				3.6%	5 m
6/15/76	1315	37C	29.65						13.75						13.0%	.1m
6/15/76	1420	37D	30.35	30.7					11.2	11.08					1.8%	1 m
6/15/76	1430	37E	31.3	30.82					12.9	11.47					1.5%	.7m
6/15/76	1440	37F ≠	29.9	29.8	30.0				13.25	12.9	13.0				*	4 m
6/15/76	1340	38A	30.7	30.75					9.5	9.45					3.3%	1 m
6/15/76	1350	38B	30.8	30.65					9.95	10.10					1.4%	1 m
6/15/76	1400	38C ≠	30.35	30.45					10.6	10.4					*	5 m
6/16/76	1200	39A	31.0	31.0					10.8	10.75					5.0%	1 m
6/16/76	1210	39B	31.3	31.8					8.0	7.7					2.4%	1 m
6/16/76	1220	39C	31.3	31.3	31.4	31.25	31.4		9.3	8.8	8.2	8.4	8.3		0.8%	4 m
6/16/76	1240	40A	31.0	31.2					9.85	9.2					2.0%	1 m
6/16/76	1250	40B	30.83	31.6	31.4	31.5	31.6	31.4	9.40	8.50	8.10	8.0	8.1	7.9	1.1%	5 m
6/16/76	1410	40C	31.6	31.2					11.4	11.2					3.0%	.75m
6/16/76	1420	40D	30.3	31.2					14.3	11.8					19.3%	1 m
6/16/76	1430	40E	30.8						14.7						6.6%	.1 m
6/16/76	1300	41A	31.7	31.5					7.1	7.4					2.2%	1 m
6/16/76	1310	41B	31.3	31.5	31.4	31.3	31.4		9.90	8.9	7.5	7.3	7.4		1.1%	4 m
6/16/76	1320	41C	31.7	31.7					9.00	7.6					3.1%	1 m
6/16/76	1330	41D	31.4	31.8	31.6	31.4			8.50	7.80	7.40	7.10			3.0%	3 m
6/16/76	1340	41E	31.7	31.8					8.10	8.20					4.6%	1 m
6/16/76	1530	42A	31.4	31.2					18.60	16.90					16.0%	1 m
6/16/76	1710	42B	31.4	31.3					15.0	14.40					15.8%	.5m
6/16/76	1600	43A	30.82	31.0					13.2	13.1					14.7%	.5m
6/16/76	1610	43B	31.2	31.0					12.10	12.50					11.4%	1 m
6/16/76	1620	43C	31.3	31.1					12.30	11.80					13.6%	1 m
6/16/76	1640	44A	31.2	31.2					13.70	13.45					17.4%	1 m
6/16/76	1650	44B	31.2	31.3					13.4	13.4					20.4%	1 m
6/16/76	1700	44C	31.4	31.3					14.3	14.1					20.7	1 m
9/30/76	1010	49	24.25	24.7	25.85	26.6			11.7	11.0	11.3	10.8			<1%	3 m
9/30/76	1334	49	31.0	31.15	31.3				11.3	11.4	11.0					
9/30/76	1030	50	27.25	27.0	27.2	27.2			11.27	11.95	11.1	10.85			<1%	3 m
9/30/76	1315	50	30.5	31.2	31.2				11.35	10.9	10.7					
9/30/76	1050	51	29.7	29.3	29.7				11.6	11.3	11.5				<1%	2 m
9/30/76	1300	51	31.9	31.4	31.1	31.7			10.45	10.2	10.3	10.3				
9/30/76	1110	52	30.05	30.27	30.5	30.2			11.35	11.64	11.4	11.50			<1%	3 m
9/30/76	1140	53	31.1	31.4	31.53	31.55			11.55	11.3	10.45	10.32			<1%	2.4m
9/30/76	1155	54	31.53	31.28	31.55	31.65	31.6		10.4	9.75	9.4	9.2	9.2		<1%	3.75m
9/30/76	1220	55	31.0	30.69	31.5	31.6	31.9	31.7	11.8	11.7	11.3	9.18	9.35	9.25	<1%	4.5m

STATION NUMBER		1a$_1$	1a$_2$	1b$_1$	1b$_2$	1c$_1$	1c$_2$	1d$_1$	1d$_2$	1e$_1$	1e$_2$	1f$_1$	1f$_2$	1g$_1$	1g$_2$	1h$_1$	1h$_2$	2a$_1$	2a$_2$	2b$_1$	2b$_2$	2c$_1$	2c$_2$	2d$_1$	2d$_2$	2e$_1$	2e$_2$	3a$_1$	3a$_2$	3b$_1$	3b$_2$	3c$_1$	3c$_2$	3d$_1$	3d$_2$
SAMPLING DATE		9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75	9/20/75
NO. OF SPECIES (LIVE/TOTAL)		0	0	2	0	0	3	2	4	5	6	3	4	6	5	3	6	2	6	3	6	6	2	5	4	6	4	3	4	3	4	4	5	3	3
		0	0	3	4	4	4	4	4	5	6	5	4	7	6	7	8	5	7	5	7	7	8	8	5	8	7	5	5	5	4	5	5	5	5
NO. OF INDIVIDUALS PER 20 ml (LIVE/TOTAL)		0	0	18	0	0	56	2	19	65	129	28	15	110	57	8	48	28	40	12	47	46	2	65	77	405	71	17	58	98	55	21	56	230	157
		0	0	885	1120	1600	1366	1824	2079	1107	1806	2594	5994	2845	846	205	201	241	909	1711	2835	2386	5911	1580	1035	1733	1751	690	585	3154	2863	4205	2040	2108	1247
Ammobaculites foliaceus	L																																		
	T																																		
A. dilatatus	L																																		
	T																										X								
Ammonia beccarii	L											4			2		2									12	4								
	T											X			X		1									4	X								
Ammotium salsum	L															25	2									X									
	T															12	3						X			X									
Arenoparella mexicana	L																																		
	T																					X	X	X											
Cribroelphidium excavatum	L										1			5	12		60		10		2	4		8	4	60	70							83	96
	T										X			X	1	3	21		1		X	X	X	1	X	26	6							16	20
Haplophragmoides bonplandi	L																																		
	T																																		
Jadammina polystoma	L									2	2	21	20	11	18		2		5			2	50	9	5				2			9	4		
	T									3	4	9	7	4	10	2	3	X	2	1	1	1	1	10	6	X	X	1	X	X		1	X		
Miliammina fusca	L						2	50	68	65	81		20	62	54	62	27	93	65	33	26	28		77	71	26	24	6	7	20	22	90	30	15	2
	T			X	X	5	6	52	39	63	70	29	43	88	76	78	65	69	48	65	55	58	63	63	67	69	93	X	1	4	4	46	26	69	59
Polysaccammina ipohalina	L																																		
	T																		X										X						
Protelphidium orbiculare	L															12	4									X	1								
	T													X	X	3	2									X	X								
Quinqueloculina seminulum	L													1							2														
	T													X							X			X											
Reophax nana	L																																		
	T																																		
Tiphotrocha comprimata	L						4	50	16	6	4		7					7	15	42	19	4	50	2				53	24	7	4	14	4		
	T				1	4	7	10	21	10	8	X	X	X				20	29	3	5	1	2	X	X			11	4	7	6	11	4	3	1
Trochammina inflata	L			6					10	5	5	75	53	21	14				2	25	30	46		3	19	X					2	33	18		
	T			2	2	X	X	23	16	11	10	62	49	6	12	1	2	1	X	22	31	17	24	25	27	X	X	X		X	X	30	25	2	4
T. inflata macrescens	L			94			95		5	23	8								2		21	15						41	67	72	73		45	2	2
	T			97	96	91	86	15	24	14	8					1	X	9	20	9	8	22	9	X		X		87	94	89	91	12	44	10	16

Table 3A.

Tables 3A and B. Foraminiferal occurrences in Chezzetcook areal marsh stations 1-6: percent living and total, number of species and specimens per sample; X refers to less than 1%, L = live, T = total.

STATION NUMBER		$4a_1$	$4a_2$	$4b_1$	$4b_2$	$4c_1$	$4c_2$	$4d_1$	$4d_2$	$5a_1$	$5a_2$	$5b_1$	$5b_2$	$5c_1$	$5c_2$	$5d_1$	$5d_2$	$5e_1$	$5e_2$	$5f_1$	$5f_2$	$5g_1$	$5g_2$	$6a_1$	$6a_2$	$6b_1$	$6b_2$	$6c_1$	$6c_2$
SAMPLING DATE		9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	9/25/75	3/27/76	3/27/76	3/27/76	3/27/76	3/27/76	3/27/76	4/6/76	4/6/76	4/6/76	4/6/76	4/6/76	4/6/76
NO. OF SPECIES (Live/total)		4	3	4	3	2	3	5	1	2	4	4	5	3	3	3	3	1	1	1	0	2	0	1	0	0	1	0	0
		5	5	4	4	6	5	7	8	5	6	4	6	5	4	3	4	4	5	5	5	8	8	2	2	4	4	7	5
NO. OF INDIVIDUALS PER 20 ml (Live/total)		19	99	20	6	2	5	32	1	8	58	28	160	17	62	76	13	5	6	9	0	2	0	1	0	0	2	0	0
		4644	4199	1613	3323	2776	2264	2041	1203	2364	3367	6138	5864	3621	4504	1822	1750	209	417	357	535	716	460	238	71	415	793	356	236
Ammobaculites foliaceus	L																												
	T																					7	8					2	X
A. dilatatus	L																												
	T					X		X	X													2	1						
Ammonia beccarii	L																												
	T								X																				
Ammotium salsum	L																					50							
	T																			X	X	5	4					2	4
Arenoparella mexicana	L																												
	T								X																				
Cribroelphidium excavatum	L							6	100																				
	T							X	X													1							
Haplophragmoides bonplandi	L	26	14	10	17		40			75	24																100		
	T	2	2	1	X	X	1	1		15	16	X	X	X												2	4	X	
Jadammina polystoma	L																												
	T		X																1										
Miliammina fusca	L	5		5	17	50		25				21	4	24	3	8	15	100	100	100		50							
	T	X	1	2	2	4	3	8	14	X	X	4	1	1	1	5	4	44	70	46	18	44	43	X	1	1	1	42	47
Polysaccammina ipohalina	L																												
	T																												
Protelphidium orbiculare	L																												
	T																												
Quinqueloculina seminulum	L												4																
	T										X		X																
Reophax nana	L																												
	T																					X	X						
Tiphotrocha comprimata	L	16	17	10			20	38			7	28	15	12	10	3	8												
	T	6	5	18	10	2	4	9	10	5	9	7	8	17	20	11	10	25	8	2	4	9	10			7	11	4	4
Trochammina inflata	L							3			5	28	26											•					
	T	X				X	X	X	1	2	1	5	6	1	1		X	18	9	40	44	18	23					X	
T. inflata macrescens	L	47	69	80	67	50	40	28		25	64	21	51	65	87	89	77							100					
	T	91	92	79	88	93	92	82	74	78	74	84	84	80	77	84	85	13	12	11	33	14	10	100	98	89	83	49	44

Table 3B.

STATION NO.		$7a_1$	$7a_2$	$7b_1$	$7b_2$	$7c_1$	$7c_2$	$7d_1$	$7d_2$	$7e_1$	$7e_2$	$8a_1$	$8a_2$	$8b_1$	$8b_2$
DATE SAMPLED		4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76
NO. OF SPECIES (Live/total)		0	0	0	0	2	2	3	4	2	6	3	3	2	4
		2	2	2	2	6	5	8	8	10	6	6	7	3	5
NO. OF INDIVIDUALS PER 10 cm (Live/total)		0	0	0	0	34	20	50	34	3	20	34	34	112	39
		7	2	119	100	2340	1313	2958	3297	111	111	1538	2200	791	410
Ammobaculites dilatatus	L														
	T														
A. foliaceus	L														
	T														
Ammonia beccarii	L														
	T					X	X	X	X	1			X		
Ammotium salsum	L														2
	T							X		1				X	3
Buccella frigida	L										10				
	T									2	2				
Centropyxis excentricus	L														
	T														
Cribroelphidium excavatum	L					41	55	56	53	67	45	35	35	80	69
	T					2	1	6	2	11	25	2	1	17	10
C. excavatum clavatum	L										15				
	T							1			5				
Haplophragmoides bonplandi	L														
	T														
Helenina andersoni	L								6	33	5		6		
	T							1	2	1	3		X		
Hemisphaerammina bradyi	L										5				
	T								X	33	25				
Jadammina polystoma	L														
	T					X	X	X		1		X	1		X
Miliammina fusca	L					59	45	40	35		20	59	59	20	26
	T	86	50	43	54	96	97	92	95	49	40	64	72	82	86
Protelphidium orbiculare	L														2
	T								X	1					X
Protoschista findens	L														
	T														
Quinqueloculina seminulum	L							4	6						
	T							X	X						
Tiphotrocha comprimata	L											6			
	T		50									1	2		
Trochammina inflata	L														
	T					2	X		X	1		33	24		
T. inflata macrescens	L														
	T	14		57	46	X						X			
Urnulina compressa	L														
	T														

STATION NO.		$8c_1$	$8c_2$	$8d_1$	$8d_2$	$9a_1$	$9a_2$	$9b_1$	$9b_2$	$9c_1$	$9c_2$	$9d_1$	$9d_2$	$9e_1$	$9e_2$
DATE SAMPLED		4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76
NO. OF SPECIES (Live/total)		7	4	5	3	0	1	0	0	3	1	0	1	1	1
		7	6	8	6	3	3	3	3	5	5	5	4	7	5
NO. OF INDIVIDUALS PER 10 cm (Live/total)		74	33	42	11	0	1	0	0	14	3	0	1	1	1
		1647	1073	144	70	93	427	464	398	777	606	261	206	287	214
Ammobaculites dilatatus	L														
	T											X			
A. foliaceus	L														
	T										X			X	
Ammonia beccarii	L	5	9	10	9										
	T	1	1	14	17										
Ammotium salsum	L														
	T									X		2	2	X	X
Buccella frigida	L	1		10	18										
	T	X	X	6	8										
Centropyxis excentricus	L														
	T													X	
Cribroelphidium excavatum	L	43	58	76	73										
	T	4	3	47	51										
C. excavatum clavatum	L														
	T														
Haplophragmoides bonplandi	L														
	T									X	X				X
Helenina andersoni	L			2											
	T			1	1										
Hemisphaerammina bradyi	L	3	6												
	T	X	X	6	3										
Jadammina polystoma	L														
	T														
Miliammina fusca	L	30	27							50			100		100
	T	94	95	22	18	3	2	3	5	17	11	47	54	55	43
Protelphidium orbiculare	L	16		2											
	T	1		1											
Protoschista findens	L														
	T														
Quinqueloculina seminulum	L	1													
	T	X	X												
Tiphotrocha comprimata	L									14					
	T					6	4	41	31	16	14	2	6	8	7
Trochammina inflata	L														
	T														
T. inflata macrescens	L						100			36	100			100	
	T			3		91	93	56	64	66	74	49	38	36	48
Urnulina compressa	L														
	T													X	

Table 4A.

Tables 4A and B. Foraminiferal occurrences at Chezzetcook areal marsh stations 7-15: percent living and total, number of species and specimens per sample; X is less than 1%, L = live, T = total.

STATION NUMBER		$10a_1$	$10a_2$	$10b_1$	$10b_2$	$10c_1$	$10c_2$	$10d_1$	$10d_2$	$11a_1$	$11a_2$	$11b_1$	$11b_2$	$11c_1$	$11c_2$	$12a_1$	$12a_2$	$12b_1$	$12b_2$	$12c_1$	$12c_2$	$13a_1$	$13a_2$	$13b_1$	$13b_2$	$13c_1$	$13c_2$	$14a_1$	$14a_2$	$14b_1$	$14b_2$	$14c_1$	$14c_2$	$15a_1$	$15a_2$	$15b_1$	$15b_2$	$15c_1$	$15c_2$	$15d_1$	$15d_2$
DATE SAMPLED		4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/11/76	4/20/76	4/20/76	4/20/76	4/20/76	4/20/76	4/20/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76
NO. OF SPECIES (Live/total)		1	1	1	2	0	0	1	2	0	0	2	1	0	0	0	0	1	0	0	1	1	2	3	2	1	2	1	2	2	3	2	2	4	1	2	1	3	3	3	3
		6	7	6	6	5	5	3	3	5	4	4	4	3	3	2	3	4	3	3	4	5	4	4	4	4	4	8	8	4	4	4	4	7	5	4	4	8	7	4	4
NO. OF INDIVIDUALS PER 10 cm (Live/total)		1	1	1	2	0	0	1	12	0	0	3	3	0	0	0	0	2	0	0	2	1	3	20	60	3	10	2	2	13	24	22	9	34	2	12	4	13	8	22	9
		471	429	497	393	315	314	289	299	570	361	299	392	67	72	437	149	556	291	252	360	57	129	1460	1536	733	411	756	1022	649	435	875	819	857	631	378	257	472	324	828	654
Ammobaculites dilatatus	L																																								
	T		X	X	X																							1	1									X	X		
A. foliaceus	L																											100	50												
	T	1	2	2	2																	2						8	6					X				2	2		
Ammonia beccarii	L																																								
	T																																								
Ammotium salsum	L		100		50																													3							
	T	2	2	1	1	1	1			X	X											2	2					1	2					2	1			X	1		
Buccella frigida	L																																								
	T																																								
Centropyxis excentricus	L																																								
	T																																								
Cribroelphidium excavatum	L																																								
	T																																								
C. excavatum clavatum	L																																								
	T																																								
Haplophragmoides bonplandi	L																							10	20		10			15	4	41	78							9	7
	T	X	X				X							7	18					1	1			13	22	4	5	X	1	5	12	20	32	X	X	3	1	X		12	11
Helenina andersoni	L																																								
	T																																								
Hemisphaerammina bradyi	L																																								
	T																																								
Jadammina polystoma	L																																								
	T																	X																							
Miliammina fusca	L	100		100									100																50					76		8		8	12		
	T	54	77	26	11	13	10	1	1	2	1	6	9			1	1	X	1	1		21	27	1	4	1	2	25	30	4	2	X	X	56	15	6	8	9	12	X	X
Protelphidium orbiculare	L																																								
	T																																								
Protoschista findens	L																																								
	T					X																																			
Quinqueloculina seminulum	L																																								
	T																																								
Tiphotrocha comprimata	L								33														33	10							4			6				23	25	4	14
	T	4	4	7	16	15	32	17	9	11	14	42	23	7			4	15	11	14	8	2	8	16	9	10	13	10	10	11	21	12	10	11	16	15	19	28	24	10	21
Trochammina inflata	L											67																													
	T									1		21	23		1													2	2					X				1	2		
T. inflata macrescens	L				50			100	67			33						100			100	100	67	80	80	100	90			85	92	59	22	15	100	92	100	69	62	86	79
	T	37	14	61	69	71	57	62	90	84	85	33	45	85	80	99	95	85	89	85	90	74	62	70	64	84	80	53	47	80	66	69	58	31	53	76	72	60	57	78	68
Urnulina compressa	L																																								
	T																																								

Table 4B.

Tables 5A and B. Foraminiferal occurrences in Chezzetcook marsh areal stations 16-20, 45-48, 56: percent living and total, X is less than 1%, L = live, T = total.

STATION NUMBER		$16a_1$	$16a_2$	$16b_1$	$16b_2$	$16c_1$	$16c_2$	$16d_1$	$16d_2$	$17a_1$	$17a_2$	$17b_1$	$17b_2$	$17c_1$	$17c_2$	$18a_1$	$18a_2$	$18b_1$	$18b_2$	$18c_1$	$18c_2$	$19a_1$	$19a_2$	$19b_1$	$19b_2$	$19c_1$	$19c_2$	$19d_1$	$19d_2$
DATE SAMPLED		4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/25/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76	4/30/76
NO. OF SPECIES (Live/total)		0	0	1	3	2	0	3	3	1	1	1	1	1	1	1	2	2	2	2	3	3	1	1	2	2	3	8	10
		5	5	4	5	5	5	5	5	4	3	5	7	7	8	4	4	4	5	8	9	6	3	5	5	6	7	14	14
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	0	5	4	10	0	12	14	1	15	19	2	2	2	3	4	14	2	2	5	13	24	2	15	26	252	186	183
		403	529	656	450	539	344	441	412	343	473	326	399	1018	1050	383	246	389	319	560	600	1519	2126	149	862	992	1316	522	544
Ammobaculites dilatatus	L														100														
	T											X	X	1	3					1	1								
A. foliaceus	L																												
	T												1	12	11					14	4								
Ammonia beccarii	L																											6	4
	T																										X	8	4
Ammotium salsum	L																												X
	T		X		X								X	2	3					8	6			1		X	X	X	X
Arenoparella mexicana	L																												
	T																			X									
Buccella frigida	L																											4	6
	T																											2	2
Centropyxis excentricus	L																												
	T									X																			
Cibicides lobatulus	L																												
	T																											X	X
Cribroelphidium excavatum	L																				20			100	40	62	65	50	57
	T																				X			1	1	2	18	31	28
C. excavatum clavatum	L																												
	T																												
C. excavatum selseyensis	L																												
	T																												
Difflugia capreolata	L																												
	T																												
D. urceolata	L																												
	T																												
Eggerella advena	L																											2	1
	T																											4	6
Glomospira gordialis	L																												
	T																												X
Haplophragmoides bonplandi	L							25	7								25												
	T							17	12						X	30	27		3										
Helenina andersoni	L																											2	2
	T																											1	1
Hemisphaerammina bradyi	L																											3	3
	T																											3	3
Jadammina polystoma	L																												
	T	X				X	X															X	X	8	1	1	X	1	1
Miliammina fusca	L				25	20														50	60	50	100		60	38	32	20	17
	T	4	15	36	36	6	5	13	5	1	8	8	8	29	26	X	1	13	12	43	44	80	87	33	84	94	76	39	47
Pontigulasia compressa	L																												
	T																												
Protelphidium orbiculare	L																					31					3	12	9
	T																					X					1	6	3
Protoschista findens	L																												
	T																												
Quinqueloculina seminulum	L																												X
	T																											X	X
Reophax nana	L																												
	T																				X								
Tiphotrocha comprimata	L				25			8	14									7			20								
	T	26	26	5	4	9	11	22	20	5	8	8	17	8	10	6	6	25	26	6	8	X			X	X			
Trochammina inflata	L																		50			15							
	T	4	3	31	36	46	46	4	5			1	X	3	3			16	12	11	6	19	13	57	14	2	5	4	3
T. inflata macrescens	L			100	50	80		67	78	100	100	100	100	100		100	75	93	50	50									
	T	66	55	29	22	38	37	45	58	94	84	83	73	44	44	63	66	46	46	17	30	X							
T. ochracea	L																												
	T																											X	
Urnulina compressa	L																												
	T																												
Planktonics	L																												
	T																												

Table 5A.

STATION NUMBER		$20a_1$	$20a_2$	$20b_1$	$20b_2$	$20c_1$	$20c_2$	$45a_1$	$45a_2$	$45b_1$	$45b_2$	$46a_1$	$46a_2$	$46b_1$	$46b_2$	$46c_1$	$46c_2$	$46d_1$	$46d_2$	$46e_1$	$46e_2$	$47a_1$	$47a_2$	$47b_1$	$47b_2$	$47c_1$	$47c_2$	$47d_1$	$47d_2$	$48a_1$	$48a_2$	$48b_1$	$48b_2$	$48c_1$	$48c_2$	$56a_1$	$56a_2$
DATE SAMPLED		5/14/76	5/14/76	5/14/76	5/14/76	5/14/76	5/14/76	8/9/76	8/9/76	8/9/76	8/9/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	9/6/76	10/15/76	10/15/76
NO. OF SPECIES (Live/total)		1	0	3	3	2	3	2	1	2	2	4	3	5	5	4	2	5	4	5	3	2	3	5	5	9	6	3	5	4	5	4	3	3	4	3	2
		4	4	4	4	9	8	3	2	8	12	4	4	6	5	8	6	8	8	11	7	7	7	10	8	13	9	5	6	6	6	7	7	5	10	5	5
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		4	0	27	68	71	42	126	64	138	84	210	134	230	670	53	38	202	81	14	27	7	9	492	902	1536	840	7	8	12	37	19	22	32	28	12	28
		555	508	530	960	1110	834	988	499	484	591	1680	1750	1438	2286	135	144	1230	711	227	195	27	36	1366	1748	3456	2216	38	62	260	148	71	143	942	731	297	370
Ammobaculites dilatatus	L									3																											
	T									1	2																										
A. foliaceus	L																																				
	T					X	X				X					2	1	1	X	3	3	7			X		1		6				3		X		
Ammonia beccarii	L										2									7			22	45	54	46	35		50		3	32	54	12	28		
	T										X									1		4	6	25	35	48	29	3	13	1	1	20	14	1	4		
Ammotium salsum	L																	1		14	4	14				X	2		12	8	8	5			11		
	T					X	X			X	1			X		8		2	X	16	12	26	6	1		X	3	5	6	4	3	6		2	4		
Arenoparella mexicana	L																																				
	T																																				
Buccella frigida	L																							X													
	T																							X													
Centropyxis excentricus	L																																				
	T									1	1										X																
Cibicides lobatulus	L																																				
	T																									X											
Cribroelphidium excavatum	L					89	83											32	57	14	41		11	3	2	3	2	28	12	25	24		9	6	32		
	T		X			9	5											8	7	1	6		3	2	1	3	3	5	2	1	6	1	1	X	2		
C. excavatum clavatum	L																																				
	T																			X	2																
C. excavatum selseyensis	L																									X	1										
	T																							X		1	X					1					
Difflugia capreolata	L																																				
	T									4	3																									X	X
D. urceolata	L																																				
	T																																			1	3
Eggerella advena	L																									X											
	T																									2	2										
Glomospira gordialis	L																																				
	T																																				
Haplophragmoides bonplandi	L											8	22	2	2					7																	
	T										X	6	15	4	5		2			1																	
Helenina andersoni	L																																				
	T																																				
Hemisphaerammina bradyi	L																																				
	T															1										X							1				
Jadammina polystoma	L																	1																			
	T					X	X									1		X	X					X										X	X		
Miliammina fusca	L			41	63	11	14			97	98	2		13	20	6	24	50	41	57	56		67	31	31	40	50	43	12	58	49	10		81	28	33	64
	T	3	2	58	64	90	92	1		86	78	5	4	18	20	34	38	86	89	66	72	30	72	61	54	34	46	82	69	93	84	44	48	97	88	8	13
Pontigulasia compressa	L																																				
	T									2	4									X																	
Protelphidium orbiculare	L																	17	1			86		20	12	9	10	28	12	8	16	53	36				
	T					X												3	X			26	6	13	13	8	11	3	3	X	4	23	32		X		
Protoschista findens	L																																				
	T																			X																	
Quinqueloculina seminulum	L																								X												
	T																								X	X											
Reophax nana	L																									X											
	T																									X	1								X		
Tiphotrocha comprimata	L			4	1		2	2				10	14	3	8	2																				8	
	T	4	10	3	4	X	X	2	3	X	2	7	12	11	12	2	6			1																1	X
Trochammina inflata	L													3	1	4			1																		
	T	X		18	13	X	X							1	X	4	2	X	X				3	X											X		
T. inflata macrescens	L	100		56	35			98	100			80	64	79	68	89	76									X										58	36
	T	93	87	22	19	X	1	98	97	5	8	82	69	66	62	49	51	X	2	10	4				X	1				X			1		X	90	83
T. ochracea	L																																				
	T																					4	6	X	X	X					1	3					
Urnulina compressa	L																																				
	T										X																										
Planktonics	L																																				
	T																					4															

Table 5B.

Tables 6A and B. Foraminiferal occurrences along transect I, Chezzetcook marsh: percent living and total, number of species and specimens per sampling elevation; X is less than 1 %, L = live, T = total.

Table 6A.

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b	9a	9b	10a	10b	11a	11b	12a	12b	13a	13b	14a	14b	15a	15b	16a	16b	17a	17b
NO. OF SPECIES (Live/total)		0	0	1	0	0	2	2	2	0	2	4	1	2	4	1	3	2	4	0	1	4	1	3	0	1	1	2	1	1	0	0	0	2	3
		0	0	4	3	4	4	4	4	5	5	4	4	4	4	4	4	4	4	4	4	5	4	6	6	5	5	4	2	4	4	5	3	4	4
ELEVATION IN cm ABOVE MSL		98	98	92	92	81	81	71	71	71	71	69	69	69	69	68	68	70	70	71	71	74	74	79	79	89	89	99	99	86	86	80	80	69	69
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	0	77	0	0	70	18	138	0	54	76	2	6	198	2	30	8	88	0	2	73	10	68	0	34	2	17	12	4	0	0	6	4	10
		0	0	879	2368	1546	1572	1324	1582	2537	3030	957	2352	1128	1398	1994	1912	1220	2118	1112	1230	740	754	1897	2124	1562	1562	233	334	1276	1072	1572	972	694	1153
Ammobaculites dilatatus	L																																		
	T																																		
Ammobaculites foliaceus	L																																		
	T																																		
Ammotium salsum	L																																		
	T																																		
Arenoparella mexicana	L																																		
	T																																		
Cibicides lobatulus	L																																		
	T																																		
Cribroelphidium excavatum	L																																		
	T																																		
Haplophragmoides bonplandi	L						6	22	1		11	33	100	67	18		13		7			4		9				6							20
	T			X	X	3	4	1	1	21	9	20	21	10	9	2	5	2	3	8	6	1	1	6	15	X	4	1	1	21	18	34	31	14	17
Miliammina fusca	L											5			4				2			1												25	10
	T			X				2	2	1	3	6	5	9	6	3	3	5	4	3	3	6	13	X	X	X	X	X		X	X	X		4	1
Polysaccammina ipohalina	L																																		
	T																																		
Protelphidium orbiculare	L																																		
	T																																		
Quinqueloculina seminulum	L																																		
	T																					X			X										
Reophax nana	L																																		
	T																																		
Tiphotrocha comprimata	L											1			10		7	25	4			1		3											
	T			X		2	4	1	X	1	5	4	7	8	8	10	7	12	12	14	16	4	2	3	6	X	1	1		12	10	10	12	16	12
Trochammina inflata	L																																		
	T					X	X			X														X	X	X	1					X			
T. inflata macrescens	L			100			94	78	98		89	60		33	68	100	80	75	86		100	93	100	88		100	100	94	100	100			100	75	70
	T			100	100	94	92	96	97	74	82	70	68	72	76	84	85	82	80	74	75	89	85	90	78	99	94	98	99	66	71	55	57	65	70
Jadammina polystoma	L																																		
	T				X						X													X											

Table 6B.

STATION NUMBER		18a	18b	19a	19b	20a	20b	21a	21b	22a	22b	23a	23b	24a	24b	25a	25b	26a	26b	27a	27b	28a	28b	29a	29b	30a	30b	31a	31b	32a	32b	33a	33b	34a	34b
NO. OF SPECIES (Live/total)		0	1	2	3	1	0	1	0	1	3	0	2	3	3	2	0	2	3	0	0	0	0	3	0	5	5	5	5	4	4	0	0	0	0
		5	5	4	5	5	5	6	4	8	6	4	5	5	5	4	4	5	6	2	6	6	8	9	7	10	12	10	11	11	9	0	0	0	0
ELEVATION IN cm ABOVE MSL		66	66	61	61	67	67	59	59	4	4	59	59	61	61	68	68	68	68	58	58	73	73	67	67	45	45	10	10	-12	-12	127	127	135	135
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	2	7	9	4	0	1	0	1	3	0	7	4	4	14	0	27	4	0	0	0	0	17	0	29	128	14	40	4	14	0	0	0	0
		1984	958	504	496	741	896	871	864	874	251	532	614	454	410	1212	1072	630	566	3	24	532	816	863	654	601	1260	522	914	443	424	0	0	0	0
Ammobaculites dilatatus	L																																		
	T									X														X			X		X	1					
Ammobaculites foliaceus	L																																		
	T									X	2							X	X			2	1	4	3	6	5	3	4	23	17				
Ammotium salsum	L																																		
	T					1												X	X			1	1	2	1	2	1	X	1	6	6				
Arenoparella mexicana	L																																		
	T																											X	X	X					
Cibicides lobatulus	L																																		
	T																									X									
Cribroelphidium excavatum	L										33															17	7	21	28	25	14				
	T							X			X														X	1	1	X	1	X	X				
Haplophragmoides bonplandi	L																																		
	T	1	1							1													X				X	X							
Miliammina fusca	L										33			25	50			44	25					82		45	80	14	10		64				
	T	2	X	4	5	1	2	1	3	38	33	1	2	3	8	3	6	50	17	33	8	17	16	43	14	34	33	21	22	39	35				
Polysaccammina ipohalina	L																																		
	T																				X														
Protelphidium orbiculare	L																							6		7	2	14	18	25	14				
	T																						X	X		X	X	X	1	X	X				
Quinqueloculina seminulum	L														25																				
	T						X	X							X												X								
Reophax nana	L																																		
	T									X											4			X		X	X		X	X	X				
Tiphotrocha comprimata	L			57	44								28	25		14			25							10	6	43	40	25					
	T	16	19	38	42	14	15	11	10	14	17	9	12	24	18	12	14	5	8		21	3	3	3	5	15	10	18	13	8	8				
Trochammina inflata	L				22			100		100					25													7	5	25					
	T	4	6	2	14	17	20	20	11	24	10	18	12	2	6	X	1		X		12	2	1	11	11	4	4	16	8	3	3				
T. inflata macrescens	L		100	43	33	100					33		71	50		86		56	50					12		21	5				7				
	T	78	74	55	39	67	64	67	75	22	38	71	74	71	67	85	78	45	72	67	50	74	77	36	65	36	45	38	47	19	31				
Jadammina polystoma	L																																		
	T				X									X																					

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b	9a	9b	10a	10b	11a	11b	12a	12b	13a	13b	14a	14b	15a	15b
ELEVATION IN cm ABOVE MSL		86	86	88	88	76	76	66	66	69	69	80	80	80	80	81	81	83	83	86	86	83	83	86	86	86	86	33	33	60	60
NO. OF SPECIES Living/total		3	4	3	2	5	4	5	5	4	4	4	4	4	4	3	4	4	5	4	3	3	3	3	3	4	4	5	7	5	6
		4	5	5	4	5	5	5	5	5	4	5	5	4	5	4	4	5	6	5	3	3	4	3	3	5	5	8	9	8	7
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		634	1144	115	44	692	840	524	568	387	284	1194	1334	728	434	498	738	458	380	734	696	536	310	896	1162	440	167	102	99	170	298
		1294	2076	346	193	1766	1942	2972	2158	1197	908	2116	2546	1918	1572	1180	1770	1730	1122	1910	1430	1420	1096	2050	2328	1400	934	819	1125	1022	1656
Ammobaculites dilatatus	L																														1
	T																											X	X	X	X
A. foliaceus	L																												1		
	T																												X	X	
Ammotium salsum	L																												2		1
	T																		X									X	X	X	1
Arenoparella mexicana	L																											2			
	T																											1			
Cribroelphidium excavatum	L																														
	T																														
Difflugia sp.	L																														
	T																														
Hemisphaerammina bradyi	L																														
	T																														
Haplophragmoides bonplandi	L	4	10	3	2	10	8	X	1				X						X							1	X		1	X	
	T	8	8	4	2	11	9	X	1	X		X	X		X				1	X			X			X	X	X	X	X	X
Jadammina polystoma	L																												1		
	T																												X		
Miliammina fusca	L					X		1	2	4	3	X		X	10	2	6		X	1	X	8	7	3	4			13	9	13	8
	T	X	X	X		2	1	6	12	7	8	1	3	5	15	15	14	2	3	6	3	15	14	6	4	3	3	18	12	14	15
Polysaccammina ipohalina	L																	X													
	T																	X													
Protelphidium orbiculare	L																														
	T																														
Reophax nana	L																														
	T																														
Tiphotrocha comprimata	L	7	8	3		16	8	15	10	6	31	12	7	10	24	8	12	24	15	18	14	22	17	5	4	8	14	42	45	26	23
	T	12	14	5	7	15	9	22	16	10	25	15	12	8	21	18	12	18	18	23	16	26	22	8	8	11	9	25	16	18	15
Trochammina inflata	L		X			4	X	16	21	8	15	1	3	1	4		1	1	1	X						2	2	1		4	4
	T		1	X	1	2	X	7	9	8	9	1	3	2	4	X	1	X	X	X						1	1	3	2	3	4
T. inflata macrescens	L	89	81	94	98	70	84	68	65	82	51	87	90	88	61	90	81	74	83	80	86	70	76	92	92	89	83	42	40	56	63
	T	80	76	90	90	70	81	65	63	75	58	83	81	85	60	68	72	78	78	70	82	59	64	86	88	84	87	51	68	63	63
T. ochracea	L																														
	T																														
T. squamata	L																														
	T																														

Table 7A.

Tables 7A and B. Foraminiferal occurrences along transect III, Chezzetcook marsh: percent living and total, number of species and specimens per sampling elevation, X is less than 1%, L = live, T = total.

STATION NUMBER		16a	16b	17a	17b	18a	18b	19a	19b	20a	20b	21a	21b	22a	22b	23a	23b	24a	24b	25a	25b	26a	26b	27a	27b	28a	28b	29a	29b	30a	30b
ELEVATION IN cm ABOVE MSL		89	89	89	89	88	88	87	87	85	85	83	83	87	87	91	91	86	86	82	82	81	81	82	82	67	67	16	16	-34	-34
NO. OF SPECIES (Living/total)		8 9	6 8	4 4	5 7	3 3	4 4	3 3	3 3	3 3	3 3	2 3	3 4	3 6	4 6	3 5	3 5	5 7	5 7	5 7	5 6	4 8	4 5	5 5	4 .9	3 6	4 7	9 13	6 12	6 11	7 10
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		259 817	1158 2106	430 686	448 838	478 1580	362 1352	442 1158	728 2742	566 1466	458 1546	61 236	105 365	186 768	250 863	636 1250	264 984	434 1218	822 1826	386 1164	346 864	402 1572	682 2010	89 1353	281 1411	126 3391	352 2796	295 1102	116 1788	188 1264	435 2297
Ammobaculites dilatatus	L	X	X																									1		3	4
	T	X	X																X			X						1	X	1	1
A. foliaceus	L	X																										3		11	16
	T	X	X																								X	1	1	5	7
Ammotium salsum	L		X																									4		8	9
	T	1	X		X									X	X			X		X	X	X	X		X	X		2	2	6	4
Arenoparella mexicana	L																												7		
	T																											X	2		
Cribroelphidium excavatum	L																												2	X	
	T																												X	X	
Difflugia sp.	L																	1		X	1			2							
	T																X	1	X	X	1	X		1	X	X	X	1	X		
Hemisphaerammina bradyi	L																											X			
	T																											X			
Haplophragmoides bonplandi	L	1																													
	T	1	X		X																				X		X	X	X	1	1
Jadammina polystoma	L	X											4			X			X												
	T	X											2			X			X	X					X					X	X
Miliammina fusca	L	4	3	51	70	4	8	4	X	X	2			1	6		1	6	5	1	1	1	1	2	X		3	83	41	76	70
	T	11	9	43	52	4	5	4	8	2	3	1	X	13	13	4	8	13	11	20	10	5	8	4	3	9	17	69	68	34	55
Polysaccammina ipohalina	L				X																										
	T				X									X																	
Protelphidium orbiculare	L																											2	12	X	
	T																											X	1	X	
Reophax nana	L																														
	T																					X			X			X			X
Tiphotrocha comprimata	L	10	2	1	2	19	19	18	16	8	16	31	69	19	14	8	7	6	11	9	11	14	9	21	10	35	16	2	19		1
	T	9	5	2	4	20	19	20	20	10	17	26	44	16	12	9	9	8	12	12	16	12	10	9	10 •	11	11	6	8	20	6
Trochammina inflata	L	1	X	X	X		1								X			5	5	14	11	20	24	36	21	27	33	X			X
	T	3	2	X	X		X							X	1	X	1	3	3	13	14	14	15	22	20	12	20	3	2	2	5
T. inflata macrescens	L	83	94	48	28	77	72	77	83	91	82	69	27	80	80	92	92	82	79	76	76	64	65	38	69	38	48	4	19		X
	T	75	83	53	44	76	76	76	72	88	80	73	54	70	74	87	82	74	73	54	59	68	67	65	65	68	52	15	15	31	20
T. ochracea	L																														
	T																	X													
T. squamata	L																														
	T														X																

Table 7B.

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b
ELEVATION IN cm ABOVE MSL		154	154	145	145	123	123	107	107	101	101	96	96	92	92	91	91
NO. OF SPECIES (Live/total)		0 0	0 0	0 0	0 0	0 1	0 1	1 1	1 2	1 3	0 2	1 4	4 4	1 3	2 3	0 3	0 4
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		0 0	0 0	0 0	0 0	0 6	0 10	8 70	3 61	24 345	0 576	2 565	11 550	4 255	6 662	0 744	0 897
Ammonia beccarii	L																
	T																
Ammotium salsum	L																
	T																
Cribroelphidium excavatum	L																
	T																
C. excavatum clavatum	L																
	T																
Haplophragmoides bonplandi	L																
	T																
Jadammina polystoma	L																
	T																
Miliammina fusca	L														17		
	T								2	X		X	X	15	14	18	8
Protelphidium orbiculare	L																
	T																
Protoschista findens	L																
	T																
Quinqueloculina seminulum	L																
	T																X
Tiphotrocha comprimata	L																
	T									1	4	11	7	5	4	6	11
Trochammina inflata	L																
	T											X	X				
T. inflata macrescens	L							100	100	100		100	100	100	83		
	T					100	100	100	98	98	96	88	92	80	82	75	80
Reophax nana	L																
	T																

STATION NUMBER		9a	9b	10a	10b	11a	11b	12a	12b	13a	13b	14a	14b	15a	15b	16a	16b
ELEVATION IN cm ABOVE MSL		89	89	89	89	90	90	89	89	88	88	88	88	83	83	79	79
NO. OF SPECIES (Live/total)		0 3	1 3	2 3	2 3	 1	2 4	2 4	1 4	3 4	1 4	2 4	2 4	1 5	0 5	2 6	2 5
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		0 945	2 678	8 330	36 451	17 569	19 823	41 954	1 939	143 1248	44 1174	445 1975	25 1649	12 2308	0 1408	32 1890	32 1568
Ammonia beccarii	L																
	T																
Ammotium salsum	L																
	T																
Cribroelphidium excavatum	L																
	T															X	
C. excavatum clavatum	L																
	T																
Haplophragmoides bonplandi	L																
	T																
Jadammina polystoma	L																
	T													X	X	1	X
Miliammina fusca	L			12	19	100	89	91	100	98	100	99	88	100		94	94
	T	17	14	21	11	26	30	47	42	48	60	66	71	94	94	93	95
Protelphidium orbiculare	L																
	T																
Protoschista findens	L																
	T																
Quinqueloculina seminulum	L																
	T																
Tiphotrocha comprimata	L																
	T	9	11	17	13	10	9	9	9	25	17	14	6	X	X	X	X
Trochammina inflata	L									1						6	6
	T					X	X	X	X	X	X	1	1	4	3	4	4
T. inflata macrescens	L		100	88	80		10	7		1		1	12				
	T	73	74	62	76	61	60	44	48	26	23	18	21	1	2	2	1
Reophax nana	L																
	T																

STATION NUMBER		17a	17b	18a	18b	19a	19b	20a	20b	21a	21b	22a	22b	23a	23b
ELEVATION IN cm ABOVE MSL		75	75	65	65	47	47	46	46	22	22	14	14	0	0
NO. OF SPECIES (Live/total)		3 6	4 7	5 5	4 5	3 5	3 5	3 7	2 5	5 7	4 7	4 6	5 5	4 6	4 6
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		47 1665	56 1568	134 3328	32 2478	172 2702	278 2302	87 1913	29 2733	290 1294	139 504	184 3143	270 1376	130 776	17 261
Ammonia beccarii	L			6	25	8	5			24	1	8	3	5	
	T			X	X	X	1	X		11	1	2	2	2	
Ammotium salsum	L												3		6
	T							X	X	4	X	8	10	3	4
Cribroelphidium excavatum	L	2	4	25	12	55	44	46	24	53	22	67	44	69	29
	T	X	X	1	X	4	7	2	X	18	7	17	11	13	2
C. excavatum clavatum	L									1					
	T									X					
Haplophragmoides bonplandi	L														
	T		X												
Jadammina polystoma	L														
	T	X	1	X	1	1	X	X	X		X				X
Miliammina fusca	L	89	86	31	6	17	51	50	76	22	69	20	49	25	59
	T	86	90	76	67	91	90	97	99	66	89	72	69	82	92
Protelphidium orbiculare	L							1		1	8	5	1	3	6
	T							X		X	2	1	X	X	X
Protoschista findens	L														
	T											X			
Quinqueloculina seminulum	L														
	T														
Tiphotrocha comprimata	L		4												
	T	1	2											X	
Trochammina inflata	L	8	7	36	56										
	T	11	6	22	11	1	1	X	X						
T. inflata macrescens	L														
	T	1	1												
Reophax nana	L														
	T									X	X				X

Table 8. Foraminiferal occurrences along transect II, Chezzetcook marsh: percent living and total, number of species and specimens per sampling elevation; X is less than 1%, L = living, T = total.

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b	9a	9b	10a	10b	11a	11b
ELEVATION IN CM ABOVE MSL		162	162	109	109	101	101	102	102	94	94	89	89	80	80	80	80	77	77	79	79	75	75
NO. OF SPECIES (Live/total)		0	0	1	1	2	1	1	1	2	2	3	2	3	2	2	2	2	2	3	4	4	4
		0	0	3	1	3	4	3	1	2	3	5	4	6	5	3	3	3	5	4	4	6	5
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	0	7	57	80	119	31	349	500	370	460	286	198	223	418	602	510	134	678	144	384	270
		0	0	19	68	125	186	38	714	1324	930	1058	693	720	608	948	1590	1534	1244	2282	934	1322	942
Ammobaculites dilatatus	L																						
	T													X									
A. foliaceus	L																						
	T																					X	
Ammonia beccarii	L																						
	T																						
Ammotium salsum	L																						
	T												X	2									
Arenoparella mexicana	L																						
	T																						
Cribroelphidium excavatum	L																						
	T																						
Difflugia sp.	L																						
	T																						
Eggerella advena	L																						
	T																						
Haplophragmoides bonplandi	L																						
	T																						
Jadammina polystoma	L																						
	T														X							X	X
Miliammina fusca	L													7						1	1	34	32
	T					3	2	1			1	X	5	18	1	7	4	7	10	12	29	31	35
Polysaccammina ipohalina	L											X											
	T											X			X				X				
Protelphidium orbiculare	L																						
	T																						
Reophax nana	L																						
	T																						
Tiphotrocha comprimata	L					1				1	3	16	22	42	54	31	75	46	51	26	50	2	1
	T			5		1	X			1	2	10	14	29	50	25	55	38	33	22	24	5	7
Trochammina inflata	L																				1	7	2
	T			10			X	3				X		X					X	X	5	9	5
T. inflata macrescens	L			100	100	99	100	100	100	99	97	84	78	50	46	69	25	54	49	72	47	58	66
	T			84	100	96	97	95	100	99	98	89	81	50	48	68	41	55	57	66	42	55	52
T. ochracea	L																						
	T																						

STATION NUMBER		12a	12b	13a	13b	14a	14b	15a	15b	16a	16b	17a	17b	18a	18b	19a	19b	20a	20b	21a	21b	22a	22b
ELEVATION IN CM ABOVE MSL		68	68	55	55	40	40	-2	-2	37	37	58	58	67	67	61	61	33	33	-3	-3	-26	-26
NO. OF SPECIES (Live/total)		4	4	5	4	2	4	1	0	4	5	5	4	4	6	6	4	6	5	4	8	6	6
		5	6	7	7	6	6	4	3	6	7	8	7	10	7	8	7	9	8	10	12	12	9
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		260	54	39	100	19	75	6	0	154	49	350	508	26	118	118	74	330	91	620	1240	378	598
		1058	944	380	632	451	501	28	10	453	469	1643	1830	1098	1084	644	350	1086	1581	4484	5512	3936	2518
Ammobaculites dilatatus	L																				X		
	T																			X	X	X	
A. foliaceus	L																				5	X	4
	T											X	X	X					X	X	1	5	7
Ammonia beccarii	L																						1
	T																	X					X
Ammotium salsum	L																		2	6	8	10	5
	T				X						1	X	X	1		X	X	1	1	6	4	12	10
Arenoparella mexicana	L														2	2							
	T														X	1			X	X	X	X	
Cribroelphidium excavatum	L			36	47	53	20	100		10	35							35	52		4	4	3
	T			4	7	3	3	32	10	4	4							11	3		1	X	1
Difflugia sp.	L																						
	T										X			X	X	X					X		
Eggerella advena	L																						
	T													X									
Haplophragmoides bonplandi	L																						
	T																4						
Jadammina polystoma	L										4	1		8	2	1		1			X		
	T	2	1	1	X	X	X			X	1	1	X	1	1	1	1	X		X	X	X	
Miliammina fusca	L	85	44	51	50	47	75			88	57	59	32	38	52	4	10	47	37	93	81	85	87
	T	62	41	67	64	95	95	57	80	94	93	76	60	73	86	28	35	68	[illegible]	[illegible]	89	80	81
Polysaccammina ipohalina	L																						
	T		X	X																			
Protelphidium orbiculare	L																			1	1	1	
	T																				X	X	
Reophax nana	L																						1
	T																	X		X		X	1
Tiphotrocha comprimata	L	9	30	5	1		4					6	2		2	1	1	6	7	1		X	
	T	18	23	6	8	X	1	4		X		3	2	2	1	2	2	6	6	2	1	X	X
Trochammina inflata	L	4	4	3						1	2	27	41	38	17	72	38	10	2	1			
	T	7	16	7	5	X	X		10	1	1	16	25	16	5	56	36	12	2	14	2	1	1
T. inflata macrescens	L	2	22	5	2		1			1	2	7	25	15	25	20	51	1			X		
	T	11	19	14	15	1	1			X	1	4	13	7	6	12	22	1	[illegible]	1	X	X	X
T. ochracea	L																						
	T							7				X		X									

Table 9. Foraminiferal occurrences along transect V, Chezzetcook marsh: percent living and total, number of species and specimens per sampling elevation; X is less than 1%, L = live, T = total.

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b
ELEVATION IN cm ABOVE MSL		130	130	103	103	91	91	83	83	78	78	71	71
NO. OF SPECIES Living/total		1	0	0	0	0	2	1	0	0	0	3	2
		2	3	3	2	1	2	2	1	2	3	5	5
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		1	0	0	0	0	2	1	0	0	0	26	34
		6	4	3	3	2	5	3	2	3	22	523	551
Ammonia beccarii	L												
	T												
Ammotium salsum	L												
	T												
Cribroelphidium excavatum	L												
	T												
C. excavatum clavatum	L												
	T												
C. excavatum selseyensis	L												
	T												
Centropyxis [illegible]	L												
	T				67								
Cibicides lobatulus	L												
	T												
Difflugia capreolata	L												
	T		25										
Haplophragmoides bonplandi	L												
	T			33									X
Helenina andersoni	L												
	T												
Hemisphaerammina bradyi	L												
	T												
Jadammina polystoma	L												
	T												
Miliammina fusca	L						50	100				8	6
	T		25	33	33	100	80	67	100	33	14	35	39
Polysaccammina ipohalina	L											4	
	T											1	
Quinqueloculina seminulum	L												
	T												
Tiphotrocha comprimata	L						50						
	T	17					20					1	1
Trochammina inflata	L												
	T							33			5	1	X
T. inflata macrescens	L	100										88	94
	T	83	50	33						67	86	62	60

STATION NUMBER		7a	7b	8a	8b	9a	9b	10a	10b	11a	11b	12a	12b
ELEVATION IN cm ABOVE MSL		69	69	68	68	62	62	58	58	53	53	49	49
NO. OF SPECIES Living/total		4	2	1	3	3	3	3	4	6	5	6	5
		5	5	4	4	5	4	6	5	6	6	5	6
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		203	232	1	241	116	232	76	352	130	434	1296	1998
		876	1052	687	882	614	968	1408	1496	1514	1516	3682	4666
Ammonia beccarii	L												
	T												
Ammotium salsum	L												
	T												
Cribroelphidium excavatum	L	X						16	11	2	1		X
	T	X						1	2	X	X		X
C. excavatum clavatum	L												
	T												
C. excavatum selseyensis	L												
	T												
Centropyxis [illegible]	L												
	T												
Cibicides lobatulus	L												
	T												
Difflugia capreolata	L												
	T												
Haplophragmoides bonplandi	L												
	T												
Helenina andersoni	L											39	78
	T											14	34
Hemisphaerammina bradyi	L												
	T												
Jadammina polystoma	L					2	1		X	2	1	8	2
	T					2	X	X	1	3	2	11	4
Miliammina fusca	L	1		100	93	96	98	79	88	91	94	16	5
	T	13	11	82	85	90	96	96	94	89	93	41	41
Polysaccammina ipohalina	L									2		X	
	T		X			X				2	X	X	
Quinqueloculina seminulum	L												
	T												
Tiphotrocha comprimata	L	1	7		1								
	T	2	6	6	3	X		X					
Trochammina inflata	L						1	5	X	2	2	37	15
	T	X	1	X	X		X	1	1	1	1	34	20
T. inflata macrescens	L	98	93		6	2				3	1	X	
	T	85	82	12	12	7	3	1	1	4	4	X	X

STATION NUMBER		13a	13b	14a	14b	15a	15b	16a	16b	17a	17b	18a	18b
ELEVATION IN cm ABOVE MSL		45	45	40	40	42	42	53	53	57	57	67	67
NO. OF SPECIES Living/total		5	4	3	4	3	4	5	5	5	4	4	4
		5	6	6	6	7	5	5	5	6	[illegible]	4	4
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		272	232	348	259	362	374	96	416	452	[illegible]	706	382
		3736	2128	1412	834	868	3236	2146	2584	2916	[illegible]	2464	2074
Ammonia beccarii	L												
	T												
Ammotium salsum	L			39	16								
	T		X	26	7	X				X	X		
Cribroelphidium excavatum	L	24	12	27	42	87	8	33	6	X			
	T	2	1	7	13	38	1	1	1	X			
C. excavatum clavatum	L												
	T												
C. excavatum selseyensis	L												
	T												
Centropyxis [illegible]	L												
	T												
Cibicides lobatulus	L												
	T												
Difflugia capreolata	L												
	T												
Haplophragmoides bonplandi	L												
	T												
Helenina andersoni	L	24	9			X	12	8	X	2	3		
	T	2	1			X	2	X	X	1	1		
Hemisphaerammina bradyi	L												
	T												
Jadammina polystoma	L	4			X			4	5	1	1	10	9
	T	1	1	1	1	2	X	4	3	1	2	9	8
Miliammina fusca	L	43	67	34	42	13	74	48	59	84	[illegible]	2	2
	T	92	93	66	76	58	94	84	84	90	[illegible]	17	10
Polysaccammina ipohalina	L												
	T												
Quinqueloculina seminulum	L												
	T												
Tiphotrocha comprimata	L											29	37
	T											17	10
Trochammina inflata	L	4	11				5	6	29	13	15	59	52
	T	3	4	1	1	1	3	10	12	9	[illegible]	57	72
T. inflata macrescens	L												
	T			X	X	X							

STATION NUMBER		19a	19b	20a	20b	21a	21b	22a	22b	23a	23b
ELEVATION IN cm ABOVE MSL		52	52	49	49	40	40	24	24	-13	-13
NO. OF SPECIES Living/total		4	4	4	5	5	5	6	6	6	4
		7	5	5	5	6	6	9	6	8	7
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		134	152	116	250	152	254	105	334	87	6
		1994	3960	2110	2152	1452	3072	3683	3246	264	120
Ammonia beccarii	L										
	T									X	
Ammotium salsum	L										
	T	X				X					
Cribroelphidium excavatum	L	45	67	2	38	9	17	6	19	67	17
	T	3	3	X	4	1	1	4	3	25	1
C. excavatum clavatum	L									13	17
	T									12	10
C. excavatum selseyensis	L									10	
	T							X		4	
Centropyxis [illegible]	L										
	T										
Cibicides lobatulus	L										
	T							X			
Difflugia capreolata	L										
	T										
Haplophragmoides bonplandi	L										
	T										
Helenina andersoni	L	6	16	55	28	4	11	67	6	3	17
	T	X	1	3	4	X	3	15	4	3	1
Hemisphaerammina bradyi	L										
	T						X				2
Jadammina polystoma	L				1	3	2	2	4		
	T	X	X	1	X	2	1	4	3	1	1
Miliammina fusca	L	24	16	5	8	29	31	17	51	6	50
	T	80	83	71	67	33	65	55	68	51	80
Polysaccammina ipohalina	L										
	T										
Quinqueloculina seminulum	L							1	1		
	T							1	X		
Tiphotrocha comprimata	L										
	T	X						X			
Trochammina inflata	L	25	1	38	25	55	39	8	18	1	
	T	16	12	25	24	63	29	21	20	4	5
T. inflata macrescens	L										
	T										

Table 10. Foraminiferal occurrences along transect IV, Chezzetcook marsh: percent living and total, number of species and specimens per sampling elevation; X is less than 1%, L = live, T = total.

STATION NO.		$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$	$4a_1$	$4a_2$
DATE OF SAMPLES		4/16/76	4/16/76	4/20/76	4/20/76	4/30/76	4/30/76	5/14/76	5/14/76	5/28/76	5/28/76	7/26/76	7/26/76	8/9/76	8/9/76	9/4/76	9/4/76	9/21/76	9/21/76	10/1/76	10/1/76	10/15/76	10/15/76	11/3/76	11/3/76	11/16/76	11/16/76	12/5/76	12/5/76	4/13/77	4/13/77	5/18/77	5/18/77	6/10/77	6/10/77
NO. OF SPECIES (LIVING/TOTAL)		1/5	2/4	0/5	1/4	2/4	2/4	1/4	1/3	2/4	2/4	3/4	4/4	4/4	4/5	5/5	4/4	3/4	4/5	3/4	4/5	3/4	3/4	4/4	5/5	4/5	4/5	3/4	2/5	4/5	6/6	4/5	4/4	4/6	4/5
NO. OF SPECIES PER 10 cm^3 (Living/Total)		1 596	2 501	0 134	2 323	3 245	11 538	27 699	1 256	23 460	10 238	119 577	864 2522	824 3068	237 2051	880 3934	824 4300	872 3444	666 3058	162 1570	566 2238	388 2168	352 1912	610 1298	528 1468	902 2742	630 1836	104 1232	66 686	422 1666	668 2434	330 1324	782 2310	351 2669	564 2842
Ammobaculites dilatatus	L																																		
	T																																		
Ammotium salsum	L																																		
	T																																	X	
Centropyxis excentricus	L																																		
	T																																		
Cribroelphidium excavatum	L																																	X	
	T																																	X	
Haplophragmoides bonplandi	L	100	50		100	33	9			30	20	9	8	9	12	25	7	23	34	15	17	28	17	4	4	18	6	15	27	3	8	21	23	5	10
	T	36	13	18	29	18	9	4	7	22	30	9	8	10	6	12	3	13	12	7	11	24	15	7	12	9	5	4	12	3	5	11	16	2	6
Jadammina polystoma	L																																		
	T																																		
Miliammina fusca	L												X	1	3	X	1							1	X		X				X		2		1
	T	1	3	2	1	2	3	1		2	3	1	X	2	3	1	2	X	X	1	1	X	X	1	2	1	2	1	1	1	X	X	1	X	1
Polysaccammina ipohalina	L																														1				
	T																														X				
Tiphotrocha comprimata	L								100			20	14	14	12	6	5	5	5	2	4	10	8	10	6	4	3	6		8	8	7	7	8	4
	T	18	12	25	19	34	26	14	21	9	17	15	17	14	10	12	10	16	15	17	13	23	20	14	16	12	13	21	21	20	21	16	13	12	11
Trochammina inflata	L															X			X		X				X	1				6	2	1			
	T	X		1											X	X			X		X				1	X	X		X	4	1	1		X	
Trochammina inflata macrescens	L		50			67	91	100		70	80	70	77	76	73	67	87	72	61	83	78	62	75	86	89	78	90	79	73	83	80	71	69	87	86
	T	45	72	54	51	46	62	82	71	66	50	75	75	82	81	75	84	71	73	74	75	53	65	78	70	77	80	74	65	72	72	72	70	86	82

Table 11A.

Table 11A and B. Seasonal foraminiferal occurrences at Station 4a, b, Chezzetcook: percent living and total, number of species and specimens per sample; X is less than 1%, L = live, T = total.

STATION NUMBER		$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$
DATE OF SAMPLES		4/16/76	4/16/76	4/20/76	4/20/76	4/30/76	4/30/76	5/14/76	5/14/76	5/28/76	5/28/76	7/26/76	7/26/76	8/9/76	8/9/76	9/4/76	9/4/76	9/21/76
NO. OF SPECIES (Living/total)		2 4	1 5	1 4	3 5	2 4	1 3	2 4	2 3	1 4	2 4	4 6	2 4	3 6	4 4	2 3	2 4	5 6
NO. OF SPECIES PER 10 cm^3 (Living/total)		2 228	5 295	2 182	5 281	8 219	2 265	38 594	86 503	18 269	13 260	560 2660	342 1420	192 1366	810 2818	352 2218	352 1838	314 1420
Ammobaculites dilatatus	L																	
	T																	
Ammotium salsum	L																	
	T							X										
Centropyxis excentricus	L																	
	T																	
Cribroelphidium excavatum	L																	
	T																	
Haplophragmoides bonplandi	L				20									8	X			1
	T	X	1	X	X	4				1	1	X	X	1	X		X	1
Jadammina polystoma	L																	
	T											X		X				
Miliammina fusca	L											X			X			
	T	2	1	5	X	2	2	2	1	6	3	1		1	1	1	1	2
Polysaccammina ipohalina	L																	1
	T																	X
Tiphotrocha comprimata	L	50			20	12		3	2		8	12	22	49	18	5	10	6
	T	30	21	15	27	37	28	28	16	28	19	14	23	27	15	14	18	14
Trochammina inflata	L											1						1
	T		2		X							X	X	X				X
Trochammina inflata macrescens	L	50	100	100	60	88	100	97	98	100	92	87	78	43	81	95	90	91
	T	67	74	78	72	57	70	73	82	65	77	84	76	71	84	85	80	83

STATION NUMBER		$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$	$4b_1$	$4b_2$
DATE OF SAMPLES		9/21/76	10/1/76	10/1/76	10/15/76	10/15/76	11/3/76	11/3/76	11/16/76	11/16/76	12/5/76	12/5/76	4/13/77	4/13/77	5/18/77	5/18/77	6/10/77	6/10/77
NO. OF SPECIES (Living/total)		2 5	4 4	3 4	2 4	2 4	4 5	4 4	3 4	4 5	2 4	2 3	2 4	2 5	4 4	4 7	3 5	4 4
NO. OF SPECIES PER 10 cm^3 (Living/total)		282 1528	278 1304	328 1382	224 1710	446 2126	336 1382	972 1600	368 1438	416 1348	14 94	46 265	262 812	338 1174	364 1204	554 1430	444 2596	222 1784
Ammobaculites dilatatus	L															X		
	T															X		
Ammotium salsum	L																	
	T													X		X		
Centropyxis excentricus	L																	
	T															X		
Cribroelphidium excavatum	L																	
	T																	
Haplophragmoides bonplandi	L		1	1				X	2	1					3	2	3	4
	T	X	3	X	2	2	X	X	X	X	1		X		1	2	1	1
Jadammina polystoma	L																	
	T																	
Miliammina fusca	L		1				1	X		1	7				1			1
	T	3	2	2	2	2	6	4	1	2	2	1	2	2	2	X	1	2
Polysaccammina ipohalina	L																	
	T									X								
Tiphotrocha comprimata	L	7	5	3	5	8	8	10	32	7		13	10	12	21	21	27	14
	T	19	18	12	20	18	18	21	32	11	6	19	13	17	20	18	26	22
Trochammina inflata	L						2											
	T	X					X							X			X	
Trochammina inflata macrescens	L	92	93	96	95	91	89	90	67	91	93	87	90	88	74	76	71	80
	T	78	77	86	77	77	76	74	67	86	90	80	84	80	76	79	72	76

Table 11B.

STATION NUMBER		7b1	7b2	7b1	7b2	7b1	7b2	7b1	7b2	7b1	7b2	7b1	7b2	7b1	7b2	7b1	7b2
DATE OF SAMPLES		9/4/76	9/4/76	9/21/76	9/21/76	10/1/76	10/1/76	10/15/76	10/15/76	11/3/76	11/3/76	11/16/76	11/16/76	12/5/76	12/5/76	4/13/77	4/13/77
NO. OF SPECIES (Living/total)		1/6	1/6	2/6	3/4	2/6	3/5	3/4	3/5	4/6	3/7	3/6	3/5	3/4	3/4	4/5	3/4
NO. OF SPECIES PER 10 cm³ (Living/total)		2 2138	7 1717	54 946	226 1174	228 1112	720 1460	44 646	56 660	592 1592	465 1409	37 537	164 944	26 160	6 10	392 1222	378 1200
Ammonia beccarii	L																
	T																
Ammotium salsum	L																
	T																
Astrammina rara	L	100				1	x	2	7	x		14	1	27			
	T	1	x	1		1	x	1	2	x	x	3	x	9			
Cibicides lobatulus	L																
	T																
Cribroelphidium excavatum	L																
	T																
C. excavatum clavatum	L																
	T																
C. excavatum selseyensis	L																
	T																
Helenina andersoni	L																
	T																
Hemisphaerammina bradyi	L																
	T																
Jadammina polystoma	L									1	x					3	1
	T	x	1	x		x				x	x		x			2	1
Miliammina fusca	L		100	96	97	99	99	84	71	96	97	54	27	27	67	95	98
	T	96	97	88	94	95	98	61	60	92	92	37	22	44	70	96	98
Polysaccammina ipohalina	L																
	T								x		x	1					
Protelphidium orbiculare	L																
	T																
Quinqueloculina seminulum	L																
	T																
Tiphotrocha comprimata	L				1										17		
	T	x	x	4	2	x	x	2	3	x	x	4	1	4	10	x	
Trochammina inflata	L														17	1	x
	T	x	x	x	x	x	x			x	x	1			10	x	x
T. inflata macrescens	L			4	2		x	14	21	3	3	32	72	46		1	
	T	2	1	8	4	1	2	34	34	6	7	64	76	42	10	1	1
Trochammina squamata	L																
	T																

STATION NUMBER		7b1	7b2	7b1	7b2	7c1	7c2	7c1	7c2	7c1	7c2	7c1	7c2	7c1	7c2	7c1	7c2
DATE OF SAMPLES		5/18/77	5/18/77	6/10/77	6/10/77	9/4/76	9/4/76	9/21/76	9/21/76	10/1/76	10/1/76	10/15/76	10/15/76	11/3/76	11/3/76	11/16/76	11/16/76
NO. OF SPECIES (Living/total)		2/5	2/3	3/8	1/4	6/8	4/7	5/9	5/7	5/6	4/6	6/7	7/8	5/6	6/6	4/6	5/6
NO. OF SPECIES PER 10 cm³ (Living/total)		236 1018	346 902	288 2303	122 784	186 1062	134 1840	268 582	137 1345	144 1542	122 1394	624 2590	1006 1844	468 1676	567 1443	598 1886	556 [illegible]
Ammonia beccarii	L					1											
	T					x											
Ammotium salsum	L							1									
	T					x	x	1									
Astrammina rara	L					10	4	4	4	4		1	x		1		x
	T			x		8	9	15	3	4	4	1	x	x	x	x	x
Cibicides lobatulus	L																
	T																
Cribroelphidium excavatum	L			x		68	33	17	16	7	28	4	2	21	9	15	35
	T			x		7	5	8	4	2	4	1	1	6	3	2	5
C. excavatum clavatum	L																
	T																
C. excavatum selseyensis	L																
	T																
Helenina andersoni	L					8	48	9	30	12	36	70	87	20	49	27	17
	T					1	5	5	3	3	5	20	28	8	12	8	1
Hemisphaerammina bradyi	L																
	T																
Jadammina polystoma	L					1						1	x	x	x		
	T	x		x	x	4	5	2	x	x		3	2	1	2	x	x
Miliammina fusca	L	97	99	99	100	11	15	63	10	75	14	5	4	56	31	58	45
	T	95	97	99	99	74	71	64	81	90	85	60	54	75	82	82	92
Polysaccammina ipohalina	L																
	T			x													
Protelphidium orbiculare	L																
	T																
Quinqueloculina seminulum	L												x				
	T												x				
Tiphotrocha comprimata	L																
	T	x	1	x				1									
Trochammina inflata	L									2	2	16	6	1	10	x	x
	T	x		x	x	5	4	1	1	1	2	15	16	10	11	1	1
T. inflata macrescens	L	2	x	1					1								
	T	4	2	x	x			x	x		x	x	x				
Trochammina squamata	L																
	T																

STATION NUMBER		7c1	7c2	7c1	7c2	7c1	7c2	7c3	7c4	7c1	7c2	7c1	7c2	7c1	7c2	7d1	7d2
DATE OF SAMPLES		12/5/76	12/5/76	2/3/77	2/3/77	3/12/77	3/12/77	3/12/77	3/12/77	4/13/77	4/13/77	5/18/77	5/18/77	6/10/77	6/10/77	9/4/76	9/4/76
NO. OF SPECIES (Living/total)		4/7	3/5	4/6	3/6	5/7	5/9	4/6	4/5	7/7	7/7	5/6	4/6	5/7	4/7	3/10	7/9
NO. OF SPECIES PER 10 cm³ (Living/total)		339 537	282 447	326 2004	362 2591	326 2604	416 3130	368 2667	304 2342	342 1860	598 3719	886 3104	448 3658	494 2394	878 2384	25 598	110 763
Ammonia beccarii	L																5
	T															6	2
Ammotium salsum	L		x							2	1						
	T	x	1							5	1					x	
Astrammina rara	L	1				2				2	2			2			
	T	1	1	x	x	1	1	x	x	2	4			2	1		x
Cibicides lobatulus	L																
	T						x										
Cribroelphidium excavatum	L	83	94	18	11	7	1	9	5	20	16	4	14	22	91	88	65
	T	46	56	4	3	1	x	1	x	4	6	3	4	5	37	10	12
C. excavatum clavatum	L																2
	T															x	1
C. excavatum selseyensis	L														x		
	T														x		
Helenina andersoni	L	4		4	1		1	x	1	4	2	2	5	8	2	4	5
	T	6		4	1		x	x	x	1	x	x	1	2	1	2	2
Hemisphaerammina bradyi	L															8	13
	T							x								11	11
Jadammina polystoma	L					2	1			1	x	x		x			
	T			2	x	4	1			1	1	1	1	1	1	1	1
Miliammina fusca	L	12	3	75	87	81	89	90	93	67	76	69	77	68	6		7
	T	44	41	86	94	91	94	99	99	85	83	91	90	89	60	67	71
Polysaccammina ipohalina	L																
	T					x	x										
Protelphidium orbiculare	L																
	T																
Quinqueloculina seminulum	L																2
	T																x
Tiphotrocha comprimata	L																
	T												x				
Trochammina inflata	L			2		8	7	x	1	5	4	4	6				
	T	x	x	2	2	1	3	x	1	1	4	1	1	1	x	x	
T. inflata macrescens	L																
	T	2				x	x					x		x		1	
Trochammina squamata	L																
	T																

STATION NUMBER		7d1	7d2	7d1	7d2	7d1	7d2	7d1	7d2	7d1	7d2	7d1	7d2	7d1	7d2	7d1	7d2
DATE OF SAMPLES		9/21/76	9/21/76	10/1/76	10/1/76	10/15/76	10/15/76	11/3/76	11/3/76	12/5/76	12/5/76	4/13/77	4/13/77	5/18/77	5/18/77	6/10/77	6/10/77
NO. OF SPECIES (Living/total)		6/11	4/8	7/11	6/8	6/8	7/12	5/8	6/7	3/6	5/5	5/8	4/6	4/5	4/7	3/5	4/7
NO. OF SPECIES PER 10 cm³ (Living/total)		79 416	51 721	60 486	176 1925	236 1186	221 1479	158 1037	146 1426	196 692	354 732	190 587	222 1387	180 1192	164 1154	365 889	467 972
Ammonia beccarii	L	2	4	5	28	24	34	8	14		1						
	T	2	2	5	5	4	11	5	8	x	x						
Ammotium salsum	L																
	T	x		x										x			
Astrammina rara	L														1	x	
	T	1		x			x					x			x	x	x
Cibicides lobatulus	L																
	T																
Cribroelphidium excavatum	L	82	49	30	9	10	39	48	34	81	60	8	67	12	5	98	98
	T	19	5	8	1	1	7	8	5	23	30	2	11	3	1	55	52
C. excavatum clavatum	L																
	T	x		x			x	x	1								
C. excavatum selseyensis	L		2			1											x
	T		x		x	x		x									x
Helenina andersoni	L	2		5	11	8	10	2	3		x	2	2	4	13		
	T	1		4	3	x	3	1	1	x	x	1	2	1	2		
Hemisphaerammina bradyi	L	8	45	48	15	20	9	32	15	15	7		3	1			x
	T	18	21	17	10	8	11	29	19	33	25	3	10	3	4	5	4
Jadammina polystoma	L				1							x					
	T	x	x	x	x	x	x	x		x		x	x		x		x
Miliammina fusca	L	4		8	16	19	5	10	31	4	31	89	10	82	80	2	1
	T	58	70	64	80	86	65	56	67	42	44	92	76	93	94	40	44
Polysaccammina ipohalina	L																
	T																
Protelphidium orbiculare	L	1					1		1								
	T	x	x				x		x								
Quinqueloculina seminulum	L			2			2					1					
	T			x			x					x					
Tiphotrocha comprimata	L																
	T	x															
Trochammina inflata	L			2													
	T		x	1	x	x	x								x	x	
T. inflata macrescens	L																
	T						x						x				x
Trochammina squamata	L																
	T											x					

Table 12. Seasonal foraminiferal occurrences at station 7c-d, Chezzetcook: percent living and total, number of species and specimens per sample; X is less than 1%, L = live, T = total.

STATION NO.		$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$	$20b_1$	$20b_2$
SAMPLE DATE		9/4/76	9/4/76	10/15/76	10/15/76	11/3/76	11/3/76	11/16/76	11/16/76	12/5/76	12/5/76	4/13/77	4/13/77	5/18/77	5/18/77	6/10/77	6/10/77
NO. OF SPECIES (LIVING/TOTAL)		1 5	3 5	2 4	4 4	6 6	5 6	5 6	5 5	3 3	5 5	4 6	4 4	3 4	4 5	4 6	1 7
NO. OF SPECIES PER 10 cm^3 (Living/Total)		100 1753	46 1486	188 2276	218 2486	356 1118	998 2048	228 723	294 854	252 286	232 494	342 1332	420 1658	210 1332	178 1108	15 2857	2 1852
Ammonia beccari	L																
	T											X					
Ammotium salsum	L																
	T																X
Astrammina rara	L					8		1	3		1						
	T					3	X	1	1		1					1	2
Cribroelphidium excavatum	L										X					7	
	T		X								X					X	
Haplophragmoides bonplandi	L																
	T											X					
Jadammina polystoma	L					X	X								1		
	T	X				X	X	X						X	1		X
Miliammina fusca	L	100	91	98	94	84	96	86	74	99	94	94	82	77	84	27	
	T	95	94	97	94	83	94	83	80	99	95	88	80	87	88	86	91
Tiphotrocha comprimata	L			2	2	1	X	1	4	1		2	7	16	7	27	
	T	1	X	1	2	5	1	1	4	1		6	13	8	4	2	2
Trochammina inflata	L		4		3	3	3	9	16	X	3	3	10	7	8	40	100
	T	2	4	1	4	7	5	12	12	1	3	6	7	5	6	10	6
Trochammina inflata macrescens	L		4		1	3	X	4	3		1	X	1				
	T	1	1	1	X	2	X	2	2		1	X	1		1	X	X

Table 13. Seasonal foraminiferal occurrences at Chezzetcook station 20b: percent living and total, number of species and specimens in each sample; X is less than 1%, L = live, T = total.

STATION NUMBER		$2a_1$	$2a_2$	$2b_1$	$2b_2$	$2c_1$	$2c_2$	$2a_1$	$2a_2$	$12b_1$	$12b_2$	$13b_1$	$13b_2$	$14b_1$	$14b_2$	$15b_1$	$15b_2$	$16a_1$	$16a_2$	$16b_1$	$16b_2$	$6a_1$	$6a_2$	$6b_1$	$6b_2$	$6c_1$	$6c_2$	$20a_1$	$20a_2$	$20c_1$	$20c_2$
DATE OF COLLECTION		5/14/76	5/14/76	5/14/76	5/14/76	5/14/76	5/14/76	10/15/76	10/15/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	8/11/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76	9/4/76
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		3 474	1 270	24 821	30 682	158 2820	266 2672	75 688	120 1025	180 1184	206 1166	181 847	222 2104	200 1136	294 1568	322 2204	190 948	264 1420	268 1456	152 916	130 1024	127 693	129 350	142 1118	168 1942	184 1898	54 872	502 1389	508 1588	42 1078	82 1118
Ammobaculites dilatatus	L																														
	T																		X												
A. foliaceus	L																	1	2												
	T						X											X	1		X									X	X
Ammonia beccarii	L																														
	T					X																									
Ammotium salsum	L					1												2	1												
	T			1	X	X	X											1	X		X					X				1	X
Arenoparella mexicana	L																		1												
	T																		X												
Centopyxis excentricus	L																														
	T							X														X								X	
Cribroelphidium excavatum	L				7	72	89																							5	17
	T				X	8	14																							1	1
Eggerella advena	L																														
	T	X																													
Haplophragmoides bonplandi	L									2		21	10	12	25			1	1			2		12	6	1	7				
	T									X	X	10	2	6	12	X		X	1			2	X	5	3	2	2		X		
Hemisphaerammina bradyi	L																														
	T			X																											
Jadammina polystoma	L																		1						1						
	T				X	X	X												X						X		X			X	X
Miliammina fusca	L	33		71	37	25	10	39	17	7	1	2	4		2	5	2	12	16	49	52				1	2	15			81	56
	T	5	4	48	43	90	86	8	3	3	2	2	1	2	2	4	4	34	37	40	36	X	X	4	3	8	14	2	X	90	87
Polysaccammina ipohalina	L								1																						
	T								X													X									
Protelphidium orbiculare	L				7	1	1																								
	T				X	X	X																							X	
Tiphotrocha comprimata	L				10				2	10	36	22	27	15	21	21	20	45	39	9	3	9	1	34	42	63	48	3	2		
	T	X	1	9	16			2	3	5	25	23	20	12	14	16	16	28	20	10	8	5	2	24	15	15	15	3	2	1	1
Trochammina inflata	L																		1	1	8									12	24
	T			5	10	1	X			X					X			2	1	10	11									5	8
T. inflata macrescens	L	67	100	29	40			61	81	81	63	55	59	73	52	74	78	39	38	41	37	88	99	54	50	34	30	97	98	2	2
	T	95	95	35	30	X		90	94	91	73	65	77	80	73	80	80	33	39	40	44	93	98	67	79	74	68	95	98	3	2

Table 14. Supplementary seasonal foraminiferal occurrences from stations 2, 12-16, 6, and 20, Chezzetcook: percent living and total, number of species and specimens per sample; X is less than 1%, L = live, T = total.

STATION NUMBER		1a$_1$	1a$_2$	1b$_1$	1b$_2$	1c$_1$	1c$_2$	1d$_1$	1d$_2$	1e$_1$	1e$_2$	1f$_1$	1f$_2$	2a$_1$
NO. OF SPECIES (Live/total)		0	0	1	1	1	3	4	0	4	4	5	2	1
		0	0	1	2	6	5	5	6	10	7	8	6	2
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	0	23	9	1	10	222	0	671	738	48	9	1
		0	0	139	298	54	217	1768	970	2120	2249	83	71	4
Ammobaculites dilatatus	L													
	T												1	
A. foliaceus	L													
	T													
Ammonia beccarii	L													
	T													
Ammotium salsum	L													
	T												1	
Arenoparella mexicana	L													
	T													
Buccella frigida	L													
	T													
Cribroelphidium excavatum	L									79	53	50	26	100
	T									12	28	40	19	25
C. excavatum clavatum	L													
	T									X	X	1		
C. excavatum selseyensis	L											2		
	T											1		
C. frigidum	L													
	T													
Cibicides lobatulus	L													
	T													
Difflugia sp.	L													
	T													
Eggerella advena	L													
	T							X	1			1		
Fissurina marginata	L													
	T									X				
Fursenkoina fusiformis	L													
	T													
Glabratella wrightii	L													
	T													
Haplophragmoides bradyi	L													
	T													
Helenina andersoni	L													
	T									X				
Jadammina polystoma	L					100	10	1						
	T					20	2	X	2	X	X	1		
Miliammina fusca	L						80	32		4	25	27		
	T				X	44	66	78	74	60	64	19	32	75
Polysaccammina ipohalina	L													
	T					6								
Protelphidium orbiculare	L									14	21	17	74	
	T									6	7	11	23	
Quinqueloculina seminulum	L									X	X			
	T									X	X			
Reophax nana	L													
	T												1	
Rosalina columbiensis	L													
	T													
Textularia earlandi	L													
	T													
Tiphotrocha comprimata	L						10	10						
	T					11	12	3	2	X				
Trochammina inflata	L							57				4		
	T					11	17	19	21	1	1	4		
T. inflata macrescens	L			100	100									
	T			100	100	7	1		X					
T. ochracea	L													
	T													
T. squamata	L													
	T													
Planktonics	L													
	T													

STATION NUMBER		2a$_2$	2b$_1$	2b$_2$	2c$_1$	2c$_2$	2d$_1$	2d$_2$	2e$_1$	2e$_2$	2f$_1$	2f$_2$	2g$_1$	2g$_2$
NO. OF SPECIES (Live/total)		0	1	1	2	0	4	2	3	2	3	3	3	2
		2	3	2	3	3	4	4	5	4	4	5	10	6
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		0	1	11	20	0	20	31	8	6	30	74	247	171
		3	122	58	314	415	133	191	1626	542	1239	1432	393	255
Ammobaculites dilatatus	L													
	T													
A. foliaceus	L													
	T													
Ammonia beccarii	L													
	T												X	
Ammotium salsum	L													
	T													
Arenoparella mexicana	L													
	T													
Buccella frigida	L													
	T													
Cribroelphidium excavatum	L								25		10	81	25	95
	T	33							X		X	10	82	91
C. excavatum clavatum	L													
	T													
C. excavatum selseyensis	L												X	
	T												X	
C. frigidum	L													
	T													1
Cibicides lobatulus	L													
	T												X	
Difflugia sp.	L													
	T													
Eggerella advena	L													
	T												X	
Fissurina marginata	L													
	T													
Fursenkoina fusiformis	L													
	T													X
Glabratella wrightii	L													
	T													
Haplophragmoides bradyi	L													
	T													
Helenina andersoni	L													
	T													
Jadammina polystoma	L													
	T							X	1	1		X	X	
Miliammina fusca	L						10		50	38	80	5		
	T	67	3		1		4	9	42	79	99	89	10	3
Polysaccammina ipohalina	L													
	T					X								
Protelphidium orbiculare	L						5					14	4	5
	T						1					1	5	4
Quinqueloculina seminulum	L													
	T													
Reophax nana	L													
	T													
Rosalina columbiensis	L													
	T													
Textularia earlandi	L													
	T													
Tiphotrocha comprimata	L				10		5	3						
	T			2	36	20	22	17						
Trochammina inflata	L									67	10			
	T		1						6	18	X	X	1	
T. inflata macrescens	L		100	100	90		80	97	25					
	T		97	98	64	79	73	74	1	7	X			
T. ochracea	L													
	T													X
T. squamata	L													
	T												X	
Planktonics	L													
	T													

STATION NUMBER		2h$_1$	2h$_2$	3a$_1$	3a$_2$	3b$_1$	3b$_2$	3c$_1$	3c$_2$	3d$_1$	3d$_2$	3e$_1$	3e$_2$	3f$_1$
NO. OF SPECIES (Live/total)		2	3	2	1	1	1	2	2	4	4	4	3	5
		7	5	4	2	1	2	4	4	4	5	6	6	7
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		116	506	4	12	40	10	39	60	1	11	54	30	92
		366	840	66	101	71	74	516	351	89	86	912	715	2868
Ammobaculites dilatatus	L													
	T													
A. foliaceus	L											X		
	T													
Ammonia beccarii	L													
	T													
Ammotium salsum	L													
	T										X		X	
Arenoparella mexicana	L													
	T													
Buccella frigida	L													
	T	X												
Cribroelphidium excavatum	L	74	92									41		52
	T	83	84									2		2
C. excavatum clavatum	L													
	T													
C. excavatum selseyensis	L		X											
	T	2	1											
C. frigidum	L													
	T													
Cibicides lobatulus	L													
	T	X												
Difflugia sp.	L													
	T												1	X
Eggerella advena	L													
	T													
Fissurina marginata	L													
	T													
Fursenkoina fusiformis	L													
	T													
Glabratella wrightii	L													
	T													
Haplophragmoides bradyi	L													
	T													
Helenina andersoni	L													22
	T													2
Jadammina polystoma	L													
	T											X	X	X
Miliammina fusca	L										9	11	47	11
	T	6	8	3	1		1	X	1	6	19	65	59	88
Polysaccammina ipohalina	L													
	T													
Protelphidium orbiculare	L	26	8	25										2
	T	8	6	2										X
Quinqueloculina seminulum	L													
	T													
Reophax nana	L													
	T													
Rosalina columbiensis	L													
	T													
Textularia earlandi	L													
	T													
Tiphotrocha comprimata	L							18	23	67	18	4	6	
	T			2				38	26	55	41	1	2	
Trochammina inflata	L										16	44	47	13
	T		X					X	1	2	13	30	37	7
T. inflata macrescens	L			75	100	100	100	82	77	11	36			
	T			95	99	100	99	61	71	12	24			
T. ochracea	L													
	T													
T. squamata	L													
	T													
Planktonics	L													
	T													

STATION NUMBER		3f$_2$	3g$_1$	3g$_2$	3h$_1$	3h$_2$	4a$_1$	4a$_2$	4b$_1$	4b$_2$	4c$_1$	4c$_2$	4d$_1$	4d$_2$
NO. OF SPECIES (Live/total)		5	4	2	5	5	5	5	2	1	1	3	3	3
		8	7	5	14	21	6	6	8	8	5	5	5	5
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		206	182	36	79	55	46	73	8	2	6	3	9	40
		2512	2170	1212	277	318	1358	1982	1648	916	800	651	968	1322
Ammobaculites dilatatus	L													
	T													
A. foliaceus	L													
	T													
Ammonia beccarii	L				2	2								
	T				5	6			X					
Ammotium salsum	L													
	T		X											
Arenoparella mexicana	L													
	T													
Buccella frigida	L					1								
	T					1								
Cribroelphidium excavatum	L	28	19	78	44	45	40	11	75	100	100	33		
	T	5	2	4	45	27	4	X	X	X	1	X		
C. excavatum clavatum	L													
	T					1								
C. excavatum selseyensis	L				4		4							
	T				8	5	X							
C. frigidum	L													
	T				X	X								
Cibicides lobatulus	L													
	T				1	1								
Difflugia sp.	L													
	T	X								X				
Eggerella advena	L													
	T				1	2				X				
Fissurina marginata	L													
	T					1								
Fursenkoina fusiformis	L													
	T													
Glabratella wrightii	L													
	T					X								
Haplophragmoides bradyi	L													
	T					X								X
Helenina andersoni	L	61	8			2	35	16						
	T	10	X			1	1	1	X	X				
Jadammina polystoma	L													
	T	X	X	X	X			X	X	X	1	1	X	
Miliammina fusca	L	6	50		1		4	60					11	
	T	78	95	95	13	37	88	96	78	80	55	48	5	5
Polysaccammina ipohalina	L													
	T													
Protelphidium orbiculare	L	2	21	22	48	49	9	11						
	T	X	2	X	22	14	X	X						
Quinqueloculina seminulum	L													
	T				X	X								
Reophax nana	L													
	T													
Rosalina columbiensis	L													
	T					X								
Textularia earlandi	L													
	T					X								
Tiphotrocha comprimata	L											13	56	60
	T	X			X				1	X	9	8	26	31
Trochammina inflata	L	3						1	25			33	33	30
	T	6	1	X	3	2	6	2	30	16	14	41	62	55
T. inflata macrescens	L													10
	T				X	X			X				5	8
T. ochracea	L													
	T													
T. squamata	L													
	T				X	X								
Planktonics	L													
	T					X								

Table 15

Table 15, 16. Foraminiferal occurrences in the Chebogue Harbour marshes: percent living and total; number of species and specimens per sample; X is less than 1%, L = live, T = total.

STATION NUMBER		$5a_1$	$5a_2$	$5b_1$	$5b_2$	$5c_1$	$5c_2$	$5d_1$	$5d_2$	$5e_1$	$5e_2$	$6a_1$	$6a_2$	$6b_1$	$6b_2$	$6c_1$	$6c_2$	$6d_1$	$6d_2$	$7a_1$	$7a_2$	$7b_1$	$7b_2$	$7c_1$	$7c_2$	$7d_1$	$7d_2$	$7e_1$	$7e_2$	$8a_1$	$8a_2$	$8b_1$	$8b_2$	$8c_1$	$8c_2$	$8d_1$	$8d_2$	$8e_1$	$8e_2$	$8f_1$	$8f_2$	$9a_1$	$9a_2$	$9b_1$	$9b_2$	$9c_1$	$9c_2$	$10a_1$	$10a_2$	$10b_1$	$10b_2$	$10c_1$	$10c_2$
NO. OF SPECIES (Live/total)		4 8	3 7	6 7	6 7	5 7	3 4	4 6	4 5	3 8	3 7	5 6	5 6	0 5	3 6	3 8	3 5	3 6	4 4	0 4	1 4	3 5	4 5	3 7	5 6	3 4	3 4	4 4	5 6	3 3	3 3	3 5	0 4	0 6	0 3	1 4	0 3	5 8	7 7	3 7	3 7	3 5	4 5	2 5	3 6	6 7	4 5	3 5	4 4	3 4	3 6	1 6	5 6
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		51 129	65 356	22 1814	48 1305	78 2734	20 2094	230 2356	240 2888	67 202	96 414	212 3486	88 2898	0 700	8 1044	136 921	44 290	72 1246	36 1364	0 36	3 24	68 1218	92 1134	40 1472	266 1206	38 3136	20 2376	104 2996	140 2056	180 1582	34 1094	2 414	0 381	0 106	0 97	4 954	0 1594	10 1106	10 2148	9 32	3 37	34 920	28 769	11 467	12 836	68 1364	34 1136	8 233	10 390	6 512	3 360	12 948	39 975
Ammobaculites dilatatus	L																																																				
	T																																																				
A. foliaceus	L																																																				
	T																																																				
Ammonia beccarii	L									1																																											
	T									x	x																																										
Ammotium salsum	L																																																				
	T										x																									x		x	1	3	3												
Arenoparrella mexicana	L												6																																	4	14						3
	T												x																																	x	x						x
Buccella frigida	L																																					20															
	T																																					x															
Cribroelphidium excavatum	L	61	70		4	26		3	2	96	92	1	16		50	1	43	3	6					30	1			36	50									20	80	89	100												2
	T	18	25		x	1		x	x	42	37	x	1		x	x	1	x	x					1	x			1	4						1			x	1	31	22												x
C. excavatum clavatum	L																																																				
	T																																																				
C. excavatum selseyensis	L																																																				
	T																																																				
C. frigidum	L																																																				
	T																																																				
Cibicides lobatulus	L																																																				
	T																																																				
Difflugia sp.	L			9																																																	
	T			x										x	x																																						
Eggerella advena	L																																																				
	T																																																				
Fissurina marginata	L																																																				
	T																																																				
Fursenkoina fusiformis	L																																																				
	T																																																				
Glabratella wrightii	L																																																				
	T																																																				
Haplophragmoides bonplandi	L																					32	30																			17	25			4							
	T																			14	17	25	20	x										1								7	9	2	1	x			x		x		
Helenina andersoni	L		5	9	21	5		3				8	32						8									27	18									20	20														
	T		1	x	x	3		x				1	3						x									2	2									x	1		3												
Jadammina polystoma	L							1				1													2																					4							
	T	3	2	1	1	x	1	1	x			1	1	3	2	x	x	1	2					x	3	1	x	x				5	12	10	7	7	2	1	x	6	3				x	x	x	1	2	x	x		
Miliammina fusca	L	31	14	27	17	44	30	39	53		5	39	11			90	35	8							17	22	10	31	24	6	17	100				50							11		12	38	28	50	40	100	67	100	46
	T	52	54	73	83	89	87	66	76	54	66	59	46	45	57	83	88	39	37	6		x	1	8	20	[illegible]	77	93	87	10	16	77	73	74	48	17	38	90	89	31	50	1	10	13	9	56	51	73	68	89	80	91	89
Polysaccammina ipohalina	L																																																				
	T																															x	3																				
Protelphidium orbiculare	L	6	2	18	33	15				3	3							3											4											11													
	T	1	x	x	1	x				1	1							x											x											4													
Quinqueloculina seminulum	L																																																				
	T									x	x																																										
Reophax nana	L																																																				
	T																																																				
Rosalina columbiensis	L																																																				
	T																																																				
Textularia earlandi	L																																																				
	T																																																				
Tiphotrocha comprimata	L			18	21		60	2	16						25			36	44			18	22	35	2	[illegible]	50											20				35	18	82	38	25	28		20				10
	T	x	x	2	2	x	3	x	4			x		3	2	x	3	11	19	6	4	23	22	34	10	3	3	x	x					1				x			3	21	21	18	11	10	16	6	5		x	1	2
Trochammina inflata	L	2	2	18	4	10	10	54	29			34	38		25	9	22	30	44				15	35	63	32	40	6	7	47	11					50		20								25	28	25	20		33		36
	T	25	18	24	13	9	10	32	20	1	2	39	47	48	38	16	13	50	41	20	21	22	14	56	68	[illegible]	19	4	6	44	52	17	13	11	47	81	39	9	8	12	16	3	1	7	6	33	32	17	14	7	18	5	9
T. inflata macrescens	L																				100	50	33							47	72											53	86	18	50			25	20				
	T																			47	58	30	38	x	8					24	31	1		3	1				x	9		70	59	60	72	x		8	10	3	3	1	x
T. ochracea	L																																																				
	T																																																				
T. squamata	L																																																				
	T																																																				
Planktonics	L																																																				
	T																																																				

Table 16

STATION NUMBER		$1a_1$	$1a_2$	$1b_1$	$1b_2$	$1c_1$	$1c_2$	$1d_1$	$1d_2$	$2a_1$	$2a_2$	$2b_1$	$2b_2$	$2c_1$	$2c_2$	$2d_1$	$2d_2$	$2e_1$	$2e_2$	$2f_1$	$2f_2$	$3a_1$	$3a_2$	$3b_2$	$3b_1$	$3c_1$	$3c_2$	$3d_1$	$3d_2$	$3e_1$	$3e_2$	4a*	$4b_1$	$4b_2$
NO. OF SPECIES (Live/total)		5	4	6	7	5	7	5	6	2	2	4	3	6	5	4	4	5	2	3	5	4	5	6	5	5	5	6	5	9	5	0	0	0
		6	7	8	9	7	9	7	7	3	2	5	4	8	7	9	8	11	9	12	10	7	5	8	9	8	7	10	11	13	11	0	0	0
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		184	58	144	382	128	520	398	130	46	51	60	22	46	38	36	48	60	20	22	16	344	200	62	142	176	308	84	120	149	34	0	0	0
		868	524	2180	2176	1462	1860	923	801	273	232	490	233	611	359	1477	1100	500	216	680	520	1848	1700	1042	1426	1728	1534	754	462	629	760	0	0	0
Ammobaculites dilatatus	L																											5		3	6			
	T																											2	X	1	1			
A. foliaceus	L																	3		46	25									9	6			
	T																	1		3	2							X	1	8	6			
Ammotium salsum	L								2									3	10	46	25			3				10	5	34	24			
	T				X		X	1	1			X			1	X	X	4	6	7	4			2	X	X		10	10	28	28			
Arenoparella mexicana	L			6	2											44	17									6				1				
	T			1	X	X	X									4	4	2		1					X	2	1	1	1	X	X			
Astrammina rara	L			3	1	8	4	4	3			3		2	5		8				12		1	3	8		1							
	T			1	1	2	6	7	2			1		2	6	8	8	3	5	X	1	2	2	3	6	X	X		1	X				
Centropyxis excentricus	L																																	
	T																																	
Cribroelphidium excavatum	L																																	
	T																																	
Difflugia sp.	L																																	
	T																																	
Eggerella advena	L																																	
	T																																	
Haplophragmoides bonplandi	L	1			X		1						14	2	2																			
	T	1	X	1	X		X						3	1	X			1	2	5	2	X		X	X					X				
Jadammina polystoma	L						2	2	2							11										9	6		1					
	T	X	X	X	X	X	1	2	1					X		6	4	1	3	1	2	X		X	X	4	7	X	X	X	X			
Miliammina fusca	L	9	17	22	19	25	7	65	58							11	25	60	90		25	1	4	3	8	6	1	74	88	46	47			
	T	17	42	44	48	21	22	64	76	1			X	X	X	30	36	29	30	10	17	3	4	6	6	19	9	64	73	44	38			
Polysaccammina ipohalina	L													2																				
	T		X											X		1			1															
Pontigulasia compressa	L																																	
	T																			X														
Protelphidium orbiculare	L																											5	1	4	17			
	T																											X	X	1	1			
Reophax nana	L																													1				
	T																	X		2	2									X	X			
Tiphotrocha comprimata	L	17	31	12	12	17	30	8	8		4	28	23	28	37			7		9		27	21	64	14	11	4	2		1				
	T	19	14	17	13	34	26	7	5		2	8	7	34	43	7	7	13	7	18	21	26	22	20	16	3	4	2	3	3	5			
Trochammina inflata	L	24	12	46	58	48	56	21	28	2		2		15	53	33	50	27			12	44	27	23	48	68	87	5	5	1				
	T	36	9	29	32	40	42	20	14	X		X		30	37	43	40	36	38	35	30	45	24	66	64	72	79	16	10	7	9			
T. inflata macrescens	L	49	40	11	8	2	1			98	96	67	64	50	3							28	47	3	21									
	T	28	34	6	5	2	3	X	X	98	98	91	90	31	12	1	1	9	8	18	18	24	47	4	7	X	X	2	1	7	11			

Table 17

Tables 17 and 18. Foraminiferal occurrences in Wallace Basin marshes: percent living and total, number of species and specimens per sample, X is less than 1%, L = live, T = total, * 60 ml sample.

STATION NUMBER		$5a_1$	$5a_2$	$5b_1$	$5b_2$	$6a_2$	$6a_1$	$6b_1$	$6b_2$	$6c_1$	$6c_2$	$6d_1$	$6d_2$	$6e_1$	$6e_2$	$6f_1$	$6f_2$	$7a_1$	$7a_2$	$7b_1$	$7b_2$	$7c_1$	$7c_2$	$7d_1$	$7d_2$	$7e_1$	$7e_2$	$7f_1$	$7f_2$	$8a_1$	$8a_2$	$8b_1$	$8b_2$	$8c_1$	$8c_2$	$8d_1$	$8d_2$	$8e_1$	$8e_2$	$8f_1$	$8f_2$
NO. OF SPECIES (Live/total)		1	0	0	0	2	2	3	3	5	5	4	2	7	7	4	7	0	3	5	5	6	6	7	4	5	6	0	1	4	2	6	7	3	4	5	5	4	4	1	0
		1	0	2	1	3	2	4	4	5	5	6	8	10	9	10	11	5	6	7	6	7	7	9	10	10	9	6	7	9	7	8	8	6	6	6	7	4	4	2	2
NO. OF INDIVIDUALS PER 10 cm^3 (Live/total)		1	0	0	0	99	249	116	100	94	199	106	38	59	53	26	19	0	15	48	216	216	140	164	96	26	124	0	1	30	19	39	78	114	118	188	56	43	131	1	0
		1	0	8	1	168	440	1408	1218	1266	1055	864	1204	897	712	666	257	650	425	3300	2240	816	593	1948	2624	960	1108	85	33	237	129	145	183	950	1010	1010	1232	923	1087	6	3
Ammobaculites dilatatus	L													2			10													20	5	3	1								
	T													X	X	1	1													3	2	1	X								
A. foliaceus	L															8	5																								
	T															X	X																								
Ammotium salsum	L													7	8	62	42													73	95	36	19								
	T													3	1	20	17							X	1	X				68	76	38	30	1			X				
Arenoparella mexicana	L																																								
	T												X		X	1	1																								
Astrammina rara	L					1	X							17	11					17	7	18	36	27	59	54	31		100	3		10	31		2	3	7		1		
	T					1	X					3	3	2	1					1	5	24	30	32	17	7	8	2	12	X	2	6	14		X	1	X		X		
Centropyxis excentricus	L	100																																							
	T	100																											1												
Cribroelphidium excavatum	L													3																											
	T													X																											
Difflugia sp.	L																																								
	T													X					X					X	X	X	X														
Eggerella advena	L																																								
	T																X																								
Haplophragmoides bonplandi	L																			33	22	39	26	2			5									7	4	2			
	T																	4	1	21	18	19	11	2	2	1	1	5	3					1	X	7	4	2			
Jadammina polystoma	L									2	X			3	4		5								8							1	3								
	T									X	1	1	2	2	4	1	X								1	X	X					1	2								
Miliammina fusca	L									2	2	6		48	42	23	10							24	8	15	36					44	41								
	T							1	1	11	8	10	6	45	26	20	10	7	X	X	1	6	7	15	47	65	68	38	30	2	2	34	33	2	5	2	4				
Polysaccammina ipohalina	L																					1	1	2		8															
	T												X				X			X		X	2	1	1	1	X			X										17	
Pontigulasia compressa	L																																								
	T																																								
Protelphidium orbiculare	L																													3											
	T															X														X											
Reophax nana	L																																								
	T																																								
Tiphotrocha comprimata	L							3	10	17	8	66	90	20	19	8	21		33	25	7	9	17	34	33	15	19					5	3	4	3	6	18	9	9		
	T					1		13	14	16	13	46	40	32	44	17	19	17	33	22	17	14	22	18	15	9	12	22	27	6	5	4	6	9	5	9	12	1	4		
Trochammina inflata	L							38	42	15	18	26	10		15		5		20	17	41	6	3	2			2							72	27	66	46	5	2		
	T			88	100			24	31	15	35	36	44	14	23	26	33	35	36	22	17	7	4	2	5	7	5	15	18	3	3	3	X	41	18	44	43	2	1		33
T. inflata macrescens	L					99	100	59	48	64	71	2			2				47	8	22	28	16	7		8	8						3	25	68	17	25	84	88	100	
	T			12		99	100	62	54	38	44	4	5	X	X	14	16	37	27	34	44	31	24	10	12	8	4	18	6	17	11	12	14	47	72	38	38	96	96	83	67

Table 18

C-14 Date	Lab No.	Location and drill hole no.	Depth below present sea level	Type of material used for data
915 ± 130 ybp	GX-4825	Chezz. D.H. XIII	270 cm	small wood fragment
1510 ± 145 ybp	GX-4651	Wallace D.H. VIII	197 cm	small wood fragment
1845 ± 125 ybp	GX-4595	Wallace D.H. I	150-250 cm	small wood fragment
1940 ± 140 ybp	GX-4652	Chezz. D.H. X	approx. 500 cm	small wood fragment
1390 ± 160 ybp	GX-4596	Cheboque D.H. II	210 cm	small wood fragment
2645 ± 130 ybp	GX-4597	Cheboque D.H. IV	417 cm	small wood fragment
6625 ± 240 ybp	GX-4594	Chezz. D.H. V	1185 cm	small wood fragment
9600 ± 220 ybp	GX-4542	Chezz. D.H. V	over 1190 cm	fresh water peat

Table 19. Carbon-14 dates obtained in this study from subsurface marsh sediments in Nova Scotia.

DRILL HOLE DEPTH (cm)	I-0	I-20	I-35	I-55	I-74	I-82	I-88	I-97	VIII-0	VIII-20	VIII-47	VIII-67	VIII-80	VIII-86	VIII-100	VIII-120	VIII-140	VIII-147
NUMBER OF SPECIES	7	6	5	4	5	3	4	5	8	7	4	5	8	8	5	6	7	6
NO. OF INDIVIDUALS PER 20 MLS	1403	738	552	322	455	57	34	57	836	2150	890	840	750	1001	846	838	411	178
Ammotium salsum		4							X				1	X		X	X	1
Arenoparella mexicana	X								4	X			X				X	
Astrammina rara	4								14	X				X				
Haplophragmoides bonplandi			X					2					X	4	X	1	2	1
Jadammina polystoma	1	19							X	4		X	X	X				
Miliammina fusca	12	11	1	2	2		6	7	12	48	X	4	22	X	13	7	10	8
Tiphotrocha comprimata	25	14	6	42	40	21	9	19	7	11	8	7	15	18	31	28	31	28
Trochammina inflata	50	47	77	48	6	18	32	42	57	36	85	85	38	26	10	15	6	12
T. inflata macrescens	8	5	15	8	52	61	53	30	6	1	7	3	24	51	46	48	51	51

Table 20. Foraminiferal occurrences in Wallace drill holes II, VIII: percent, number species and specimens per 20 ml at each sampling depth; X is less than 1%.

DRILLHOLE DEPTH (cm)	II-0	II-50	II-110	II-125	II-150	II-175	II-217	IV-0	IV-100	IV-150	IV-200	IV-300	IV-325	IV-355	IV-375	IV-385	IV-400	IV-417	IV-425	IV-447
No. of species	7	6	6	6	6	5	2	8	7	8	9	8	8	7	6	8	8	6	7	5
No. of individuals per 20 ml	3520	2335	1374	850	601	58	12	1668	198	325	372	1124	696	828	292	440	1005	2030	818	54
Ammobaculites foliaceus										X	X									
Ammonia beccarii								X												
Ammotium salsum				1					1	6	4		X	4	2	X	X		X	
Arenoparella mexicana											X	X					X			
Astrammina rara									X				X	X		X				
Cribroelphidium excavatum	X							X												
Haplophragmoides bonplandi					1	2				X	2	1	1				X	2	2	4
Helenina andersoni								X												
Jadammina polystoma	1	3	3	4	1			X	2	2	X	1	8	5	3	2	5	1	X	
Miliammina fusca	82	X	X	57	X	2		78	39	17	13	1	6	17	5	4	2	X	2	15
Polysaccammina ipohalina		X	X									X				X				
Protelphidium orbiculare	X																			
Tiphotrocha comprimata	4	13	11	4	28	9	8	1	2	19	25	23	6	6	17	14	14	5	4	11
Trochammina inflata	14	82	85	34	38	69	92	20	54	23	28	63	77	66	70	73	73	90	90	61
T. inflata macrescens	X	2	1	1	32	19		X	X	32	27	11	2	2	3	5	5	2	2	9

Table 21. Foraminiferal occurrences in Chebogue drill holes II, IV: percent, number of species and specimens per 20 ml split at each sampling depth, X is less than 1%.

DEPTH IN cm	0	20	29	45	63	82	110	130	141	155	180	190	215	232	250	275	303	316	339	356
NO. OF SPECIES	4	5	5	4	5	5	5	7	7	7	10	9	11	8	10	12	11	9	9	9
NO. OF SPECIES IN 20 ml	110	1260	2848	3670	3836	1222	1556	1646	2818	1776	197	256	163	712	730	502	942	934	634	478
Ammobaculites dilatatus								X	1	2	1		1	1		X	1	1		1
A. foliaceus								X					X			X			X	
Ammonia beccarii															X	X	X			3
Ammotium salsum		X	X		X		X	4	5	6	12	45	60	72	60	74	77	77	77	67
Arenoparrella mexicana						X											X			
Buccella frigida													X							
Cribroelphidium excavatum																				
C. excavatum clavatum																				1
C. excavatum selseyensis																				
Difflugia sp.																				
Eggerella advena									X		X	X	X		X	X				X
Haplophragmoides bonplandi																				
Jadammina polystoma																X				
Miliammina fusca	27	14	11	5	2	24	43	81	81	84	54	20	12	6	16	10	8	7	7	10
Polysaccammina ipohalina											X							X		
Protelphidium orbiculare												X			X		X			
Protoschista findens																			X	
Reophax nana										X	X	1	5	8	4	4	7	7	8	9
Rosalina columbiensis																				
Textularia earlandi																				
Tiphotrocha comprimata	5	8	33	24	21	11	7	2	1	1	7	3	2	2	2	2	X	1	X	
Trochammina inflata	2	25	6	19	9	12	4	3	2	1	3	3	2	X	2	1	1	1		
T. inflata macrescens	66	33	50	53	48	57	44	11	10	6	21	21	10	9	11	9	4	4	7	6
T. ochracea											1	3	6	3	2	1	1	1	1	3
Unidentified inner linings																			X	

DEPTH IN cm	382	400	416	435	451	469	496	515	535	551	571	587	600	611	640	661	690	700	740	760
NO. OF SPECIES	12	11	8	10	7	5	14	11	11	13	11	10	11	12	13	10	6	8	10	6
NO. OF SPECIES IN 20 ml	726	410	410	254	90	70	239	200	259	238	126	194	109	111	127	85	123	115	40	76
Ammobaculites dilatatus	X		X	X			X			1									2	
A. foliaceus				X																
Ammonia beccarii	1	1					15	4	11	14	2	1	2	3	4	5			2	
Ammotium salsum	91	68	78	76	41	31	37	58	36	31	31	25	28	41	31	21	15	14	8	5
Arenoparrella mexicana	X						X													
Buccella frigida																				
Cribroelphidium excavatum		1					X	1	4									1		
C. excavatum clavatum		X		X					1	3	5		10	4	2	4			2	
C. excavatum selseyensis									1	3	3	4	1	1	2	1	1		2	
Difflugia sp.																				
Eggerella advena	X			1			1		2	X	1				1					
Haplophragmoides bonplandi					1															
Jadammina polystoma		X					1				1		1		1					
Miliammina fusca	6	8	14	7	14	6	5	11	5	7	20	27	14	12	18	21	31	24	15	18
Polysaccammina ipohalina								1												
Protelphidium orbiculare	X						X	1	18	21	4	1	14	10	3	5	5	6	10	41
Protoschista findens																				
Reophax nana	7	10	2	6	8		5	8	5	11	2	3	5	4	4					
Rosalina columbiensis													1	1						
Textularia earlandi		X																		
Tiphotrocha comprimata	X	1	1		4	2	3	1	1	X	2	6	6	3	3	4	5	10		4
Trochammina inflata	X	X	1	2	3		4	2	3	1	2	5	6	5	5	2	6	3	20	
T. inflata macrescens	2	5	4	4	26	54	25	12	12	6	24	34	11	14	25	35	36	40	35	28
T. ochracea	2	3		2			3		1	3	4	1	2	3	2	2	2	1	3	4
Unidentified inner linings		1	X			6		1												

DEPTH IN cm	804	830	869	900	940	965	985	1006	1028	1040	1056	1076	1085	1098	1106	1114	1122	1132	1147	1155
NO. OF SPECIES	7	8	8	7	9	6	10	9	7	7	4	5	7	8	7	7	8	4	5	5
NO. OF SPECIES IN 20 ml	111	274	543	542	529	153	234	72	47	99	15	28	97	186	64	69	143	11	14	16
Ammobaculites dilatatus							X						1							
A. foliaceus																				
Ammonia beccarii							X							X						
Ammotium salsum	4	X	1	1	2		2	1	2	10		4	3	5	2	6	3		12	6
Arenoparrella mexicana																				
Buccella frigida					X			1												
Cribroelphidium excavatum																				
C. excavatum clavatum		1	3	5	22	9	12	18		4				3	6	4	1			
C. excavatum selseyensis			2				1	3												
Difflugia sp.																	1	46		
Eggerella advena																				
Haplophragmoides bonplandi																				
Jadammina polystoma																				
Miliammina fusca	10	X	X	2	2	1	4	4	6	14	7	14	5	18	11	14	17	18	25	19
Polysaccammina ipohalina																				
Protelphidium orbiculare	57	93	88	83	69	75	62	57	6	17			1	8	11	6	4	9		12
Protoschista findens																				
Reophax nana	1	X			X															
Rosalina columbiensis																				
Textularia earlandi																				
Tiphotrocha comprimata	6	1	X	X	X	2	1	3	11	6	20	14	6	9	11	6	6		4	6
Trochammina inflata	5	1	X	1	X	1	X	4	15	8	13	36	36	20	11	20	48		12	
T. inflata macrescens	19	2	6	8	3	12	15	8	53	40	60	32	48	36	48	43	21	27	48	56
T. ochracea																				
Unidentified inner linings									6											

Table 22. Foraminiferal occurrences in drill hole V, Chezzetcook: percent, number of species, specimens in 20 ml splits from each depth; X is less than 1%.

DRILL HOLE NUMBER AND DEPTH (cm)	X-0	X-26	X-52	X-72	X-103	X-153	X-180	X-200	X-206	X-234	X-256	X-278
NUMBER OF SPECIES	4	5	4	5	5	6	8	12	9	8	9	9
NO. OF INDIVIDUALS PER 20 mls	1016	1824	2010	680	974	205	46	97	520	638	717	628
Ammobaculites dilatatus									X			1
A. foliaceus									X			1
Ammonia beccarii												X
Ammotium salsum						3	41	39	78	85	80	85
Arenoparrella mexicana								1				
Cribroelphidium excavatum							9	4			X	
C. excavatum clavatum												
C. excavatum selseyensis												
Difflugia sp.				X	X							
Eggerella advena										X	X	
Glomospira gordialis												
Haplophragmoides bonplandi		X										
Jadammina polystoma								1				
Miliammina fusca	7	1	1	10	71	71	17	12	12	6	8	4
Polysaccammina ipohalina												
Protelphidium orbiculare							4	2			1	
Protoschista findens												
Reophax nana								4	5	4	4	6
Rosalina columbiensis								1				
Tiphotrocha comprimata	20	51	55	33	1	4	2	4	X	X		1
Trochammina inflata	1	14	4	4	X	3	11	3	X	X	1	
T. inflata macrescens	72	33	40	52	27	18	11	22	2	1	3	1
T. ochracea						X	4	6	2	1	2	1

DRILL HOLE NUMBER AND DEPTH (cm)	X-326	X-358	X-382	X-392	X-401	X-416	X-433	X-458	X-485	X-533	X-560	X-640	X-657	X-660	X-670
NUMBER OF SPECIES	11	10	11	10	12	14	11	15	15	12	15	9	11	3	4
NO. OF INDIVIDUALS PER 20 mls	968	462	936	733	768	764	874	768	1278	998	795	57	251	12	7
Ammobaculites dilatatus	X		2	2	3	2	1	1	X	1	X	2	1		
A. foliaceus		X	X	X	1	X									
Ammonia beccarii	X		1		X	X	X	X	1	X	X		X		
Ammotium salsum	78	61	78	76	74	67	76	72	49	60	45	33	33		
Arenoparrella mexicana		X						X	X	X	X		X		
Cribroelphidium excavatum				X	X	X		X			X				
C. excavatum clavatum					X		X		1		X	2	X		
C. excavatum selseyensis			X						X						
Difflugia sp.															
Eggerella advena	X			X				X							
Glomospira gordialis															
Haplophragmoides bonplandi						X			X		X				
Jadammina polystoma						X		X		X	X				
Miliammina fusca	7	21	8	9	7	6	8	8	6	7	8	2	4		26
Polysaccammina ipohalina						X	X		X		X	2	X		
Protelphidium orbiculare	X	X					X	X	X	X	1	9	3		
Protoschista findens					X			X							
Reophax nana	9	7	8	10	7	5	4	5	4	3	4				
Rosalina columbiensis															
Tiphotrocha comprimata	1	1	X	X	1	3	1	2	5	2	6	9	7	42	14
Trochammina inflata	X	X	X	X	1	5	1	3	11	5	8	14	24	42	14
T. inflata macrescens	2	8	2	1	4	11	8	6	22	20	26	28	26	17	43
T. ochracea	1	2	1			X		1	X	X					

DRILL HOLE NUMBER AND DEPTH (cm)	XIII-0	XIII-23	XIII-33	XIII-52	XIII-76	XIII-99	XIII-112	XIII-134	XIII-163	XIII-178	XIII-204	XIII-223	XIII-238	XIII-252	XIII-253
NUMBER OF SPECIES	6	5	7	5	4	6	5	8	6	7	6	9	10	8	7
NO. OF INDIVIDUALS PER 20 mls	1074	688	876	757	2786	1762	1310	1692	2426	3188	4155	2204	1101	945	1074
Ammobaculites dilatatus															
A. foliaceus															
Ammonia beccarii															
Ammotium salsum												X	X	X	
Arenoparrella mexicana								X		X	X	X	X	1	X
Cribroelphidium excavatum															
C. excavatum clavatum															
C. excavatum selseyensis															
Difflugia sp.													X		
Eggerella advena															
Glomospira gordialis							X								
Haplophragmoides bonplandi	X		4			X		X	X	1	1	X	X	2	3
Jadammina polystoma			X				X	1	X			X	X		X
Miliammina fusca	14	8	1	7	5	1		X		1	1	1	2	2	1
Polysaccammina ipohalina	X	3	1	X		X		X	X	X		X	X	X	
Protelphidium orbiculare															
Protoschista findens															
Reophax nana															
Rosalina columbiensis															
Tiphotrocha comprimata	22	32	45	56	8	12	11	18	7	10	10	11	12	9	4
Trochammina inflata	2	4	3	X	X	1	8	13	60	36	27	40	46	43	52
T. inflata macrescens	61	53	47	37	87	86	81	67	32	52	61	46	39	43	19
T. ochracea															

Table 23. Foraminiferal occurrences in drill holes X, XIII, Chezzetcook: percent, number of species, specimens per 20 ml at each depth, X is less than 1%.

Chezzetcook Inlet
marsh
road
railroad
0
1000m
N
West Head
East Head
Sta 45
Sta 21
Sta 22
Sta 9 a-e
Sta 10 a-d
Sta 29a-c
Sta 28a-c
Sta 56
Sta 6a-c
Sta 17a-c
Sta 4a-d
Trans I
Sta 18a-c
Sta 30a-c
Sta 31a-c
Sta 23
Sta 11a-c
Sta 24
Trans III
Sta 25
Sta 27
Sta 32a-c
Sta 26
Sta 16 a-d
Sta 33
Sta 5a-g
Sta 15a-d
Sta 20a-d
Sta 3a-d
Trans V
Sta 14a-c
Sta 13a-c
Sta 12a-c
Sta 46a-e
Sta 34
Sta 2a-e
Labrecque Island
Sta 47a-d
Sta 35
Roma Island
Sta 48a-c
Sta 36
Sta 36
Sta 37
Ferguson Island
Sta 37
Sta 38
Sta 39
Sta 40
Sta 40
Trans II
Sta 41
Sta 1a-h
Sta 49
Gaetz Island
Conrad Island
Sta 8a-d
Sta 50
Red Island
Sta 7a-e
Trans IV
Sta 19a-d
Sta 52
Sta 51
Sta 42
Sta 53
Black Point
Sta 44
Sta 54
Cape Entry
Sta 43
Sta 55
Story Head