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QUANTITATIVE STUDIES OF MARSH FORAMINIFERAL DISTRIBUTIONS IN NOVA SCOTIA: IMPLICATIONS FOR SEA LEVEL STUDIES

by

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QUANTITATIVE STUDIES OF MARSH FORAMINIFERAL DISTRIBUTIONS IN NOVA SCOTIA: IMPLICATIONS FOR SEA LEVEL STUDIES

D. B. SCOTT AND F. S. MEDIOLI

ABSTRACT

The study of surface samples was used to determine the marsh foraminiferal distributions in five marsh areas in Nova Scotia: Chezzetcook Inlet, Chebogue Harbour, Wallace Basin, Summerville marsh, and Newport Landing.

Detailed surface sampling in Chezzetcook revealed that marsh foraminifera are distributed in well-defined vertical zonations with respect to mean sea level and closely parallel marsh floral zonations. These zones vary slightly between marshes but appear to remain broadly similar throughout the world.

The foraminiferal zonation in Chezzetcook Inlet is used to exemplify the general situation in Nova Scotia. In this estuary the vertical range of the marsh can be divided into two zones, each divisible into two subzones. Zone II, which covers most of the middle and lower marsh, extends from approximately mean sea level (0) to about +75 cm and is characterized by the presence of *Cribrononion umbilicatulum, Ammotium salsum, Miliammina fusca* and *Trochammina inflata*. At +75 cm these forms are replaced by *Tiphotroca comprimata* and *Trochammina macrescens* which characterize zone I up to +101 cm, where all foraminifera disappear abruptly. The foraminiferal disappearance marks the higher high water level. This distribution can be used to relocate former sea levels in subsurface material to an accuracy of within ±5 cm.

Less detailed sampling of marsh areas in the other four study localities indicated that the same relationships observed in Chezzetcook occur there as well. Examination of detailed data from southern California and less detailed data from other parts of the world suggests that marsh foraminiferal assemblages can be used universally as accurate indicators of former sea levels.

We describe a new species, *Thurammina? limnetis* n.sp. and, using an intergradational series, we place *Jadammina polystoma* in synonymy with its senior, subjective synonym *Trochammina macrescens*.

INTRODUCTION

Several previous papers (Phleger, 1965a, 1966, 1967, 1970; Phleger and Bradshaw, 1966; Ellison and Nichols, 1976), have suggested that vertical foraminiferal zones exist in salt marshes which correlate with comparable floral assemblages. Until recently no detailed study accurately identifying the extent and limits of these zones has been attempted. Scott (1976a) examined in detail two marshes in southern California, defined the exact limits of the marsh foraminiferal zones present, and correlated them with floral assemblages and elevation above mean sea level (hereafter indicated as: a.m.s.l.). This study was of limited value because it was restricted to a particular set of climatic conditions (i.e., arid-warm) and the results could not necessarily be extrapolated to other climatic regions. To determine the potential and applicability of this study a similar investigation had to be initiated under a different climatic regime. The present study examines, with the same techniques and detail used in California, several marshes from the temperate-humid climate of Nova Scotia. The results from the two areas can now be compared directly and a more comprehensive picture of the vertical distribution of marsh foraminifera can be compiled.

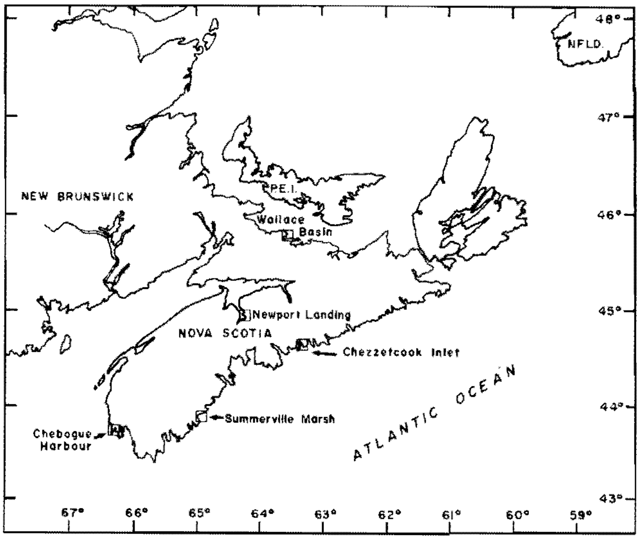


FIGURE 1
Regional map showing the five areas of investigation.

The marshes for study in Nova Scotia were chosen with four criteria in mind:

1) they had to be large enough to establish if observed relationships remained valid over a broad, continuous surface;

2) they had to be widely spaced to assess the magnitude of potential regional differences;

3) they had to be characterized by a strong salinity gradient from head to mouth to determine what effect salinity changes might have on vertical distribution of marsh foraminifera; and

4) they had to have a wide diversity of tidal range to determine what effect tidal range had on the overall marsh vertical range.

Based on these criteria three major and two subsidiary marsh areas were chosen: Chezzetcook Inlet, Chebogue Harbour, Wallace Basin, Summerville marsh, and Newport Landing (Fig. 1). The small subsidiary marsh areas, Summerville and Newport Landing, were included to provide information on faunal characteristics in an incipient marsh (Summerville), and on an area with an extreme tidal range (Newport Landing in the Bay of Fundy). Chezzetcook was studied in the greatest detail and the information from this area forms a basic framework into which less detailed data from the other sources can be placed.

Little attention has previously been given to accurate foraminiferal zones within marshes and even less to their possible application in determining Holocene sea level changes. Comparison of the Nova Scotian data with those from California and, to some extent with those of other parts of the world, allows us to determine the reliability of the vertical relationships observed for marsh foraminifera. Once the reliability is established on a worldwide basis, then the information can be used universally to relocate former sea levels accurately, as suggested by Scott and Medioli (1978). Such a conclusion would be particularly important because previous methods for relocating former sea level, based on undifferentiated marsh deposits, had an accuracy of ±100 cm at best, while the use of marsh foraminiferal zonations may refine the resolution of these deposits to an accuracy of ±5 cm.

Although the term "marsh" is a common one, it is often misused. In the present study the term refers to an area limited vertically by mean sea level and higher high water level and covered by various types of vegetation as discussed by Chapman (1960). "Marsh," as defined above, does not include tidal mudflats, shallow subtidal estuarine areas, or freshwater swamps.

PREVIOUS WORK

No previous work has been done on modern salt marsh foraminifera in Nova Scotia. F. B Phleger has contributed most of the knowledge concerning distributions of modern marsh foraminifera in other areas of the world with studies in 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), Europe and New Zealand (Phleger, 1970). Lutze (1968) investigated some marsh areas in Germany near Kiel in the course of studying a large brackish lagoon. More recently a thorough study of marsh foraminifera was done in the James River estuary (Virginia) by Ellison and Nichols (1976) and Scott (1976a) examined marsh foraminifera in Tijuana and Mission Bay marshes, southern California. Scott (1976b) did a reconnaissance study of some brackish marshes in southern California. Zaninetti and others (1977) reported on marsh foraminifera from Brazil. A recent paper (Scott and others, in press) has just been completed on modern marsh foraminifera in Greece.

There are many general investigations of marshes which do not relate directly to foraminifera but are important in contributing to the overall understanding of marsh ecology and processes. A few relevant examples are listed here. Chapman (1960, 1976) provided a comprehensive review of all marshes; Redfield (1972) performed an integrated biological and geological study of Barnstable marsh, Massachusetts; MacDonald (1969) did one of the few studies where plants and animals (mollusks in this case) were compared quantitatively along a marsh gradient; Waisel (1972) examined salt tolerances of some marsh plant species which yielded insights as to the mechanism of floral zonations; Bradshaw (1968) illustrated the variability of some marsh parameters in Mission Bay, California, and Stevenson and Emery (1958) reported physical marsh parameters along a vertical gradient in Newport Beach, California.

METHODS

Collection of Surface Material

At all marsh stations samples were collected along transect lines by walking out onto the marsh surface at low tide and obtaining the material required for study. Replicate samples of 10 cm^3 (10 cm^2 × 1 cm) were obtained at all localities (the same standard size used by Phleger). Since the marsh material was root-bound and difficult to penetrate, a small, hand-held, stainless steel corer with a sharp, serrated edge at one end was developed (i.d. = 3.6 cm, o.d. = 3.8 cm, length = 8–10 cm) by the authors. This tube cuts through the marsh material without compressing it and produces a small core that can be extruded with one finger and from which the top 1 cm can easily be sliced. Foraminiferal samples were placed in a cold room subsequent to collection to prevent fouling.

Collection of Physio-chemical Data

Salinities were recorded at most stations concurrently with the collection of surficial sediments. An American Optical salinity refractometer (compensated for temperature variance) was used to determine salinities. This instrument requires only a few drops of water and is especially useful for measuring interstitial water in the drier parts of the marsh.

Accurate elevations along transects were obtained using a transit and stadial rod and measurements were tied into nearby benchmarks.

Temperatures were not measured directly because the variance in the marsh environment mirrors the extremely high variations in the atmosphere which renders spot measurements meaningless.

Preparation of Samples

Organic carbon content (dry weight) was determined for 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.

All foraminiferal samples were prepared by the following procedure within a week of collection: 1) wet sieved through 0.5 mm and 0.063 mm sieves (0.5 mm retaining the coarse organics and allowing the foraminifera to pass through to the 0.063 mm screen); 2) fine organic material was separated from the foraminifera by decantation; 3) fixed in a solution of buffered formalin and Rose Bengal and allowed to stand overnight; and 4) washed free of formalin solution and preserved in denatured ethanol.

Samples containing excessive amounts of sand were dried and the foraminifera separated from the sand by flotation in carbon tetrachloride (sp.g. 1.58). The separated foraminifera were then resuspended in alcohol. All samples were examined in a liquid medium which makes the test transparent thus facilitating detection of Rose Bengal stain.

Photographs of species were taken using the Cambridge Scanning Electron Microscope located at the Bedford Institute of Oceanography, Dartmouth, N.S. Polaroid N/P 55 film was used.

NOVA SCOTIAN MARSHES

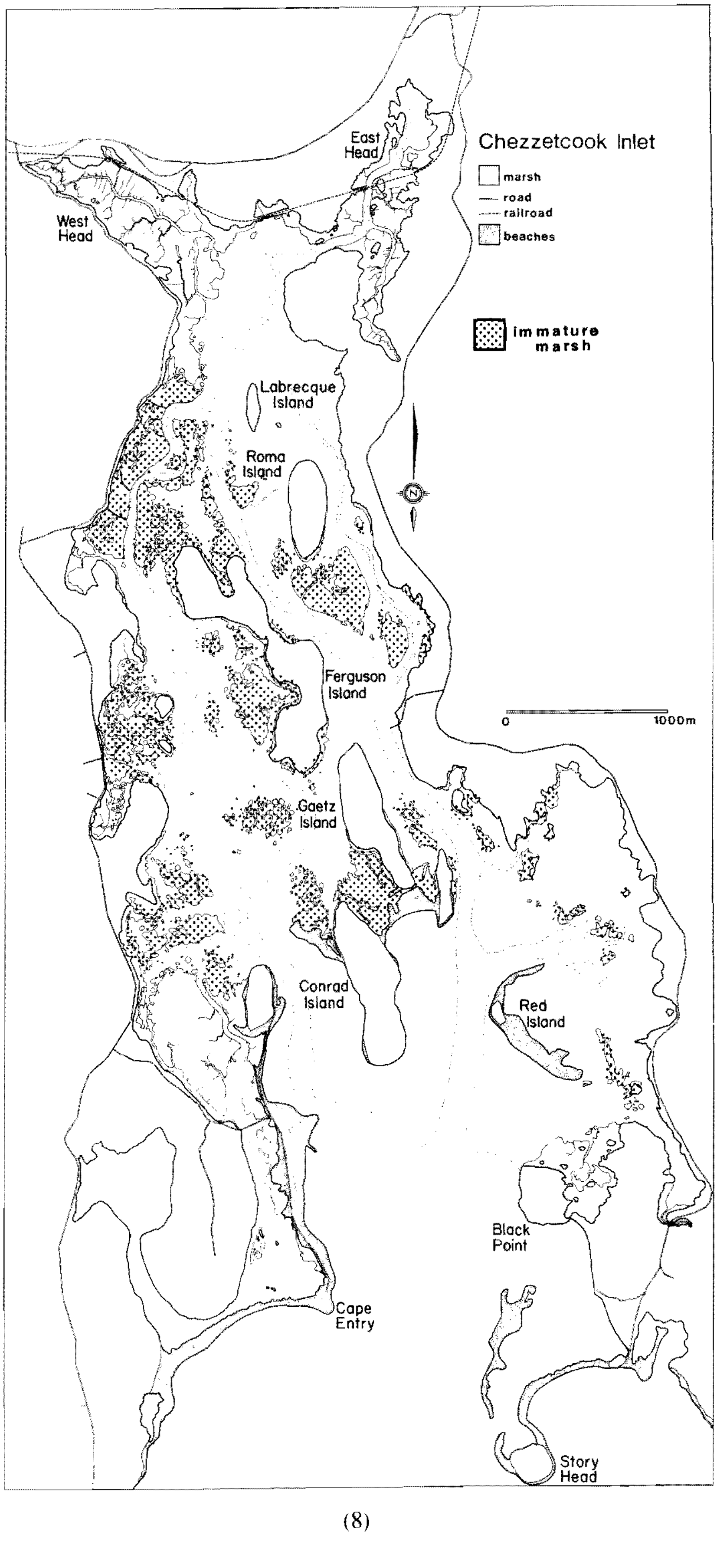
Chezzetcook Inlet

Introduction

Chezzetcook Inlet (Fig. 1, Fig. 2, see foldout 1) is located 45 km ENE of Halifax, along the Eastern shore of Nova Scotia. Together with Chebogue Harbour (at the extreme southern tip of the province), this is the only area on the Atlantic Coast of Nova Scotia with extensive marsh formations.

Vegetation

A distinctive characteristic of most salt marshes in the world is the vertical zonation of plants (Chapman, 1960). In incipient marshes this vertical zonation may not be as well established as in a mature marsh. An overall view of the salt marsh distribution in Chezzetcook (Fig. 2) illustrates that most of the mature marsh areas (characterized by wide areas of *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 large low marsh areas (immature marsh in Fig. 2) in the central part of the estuary are newly formed and occupy only a small vertical range (10–15 cm a.m.s.l.). *Zostera* (eel grass) beds form on mudflats below mean sea level. It is possible that the eel grass beds may play a significant role in salt marsh


Chezzetcook Inlet
marsh
road
railroad
beaches
immature marsh
East Head
West Head
Labrecque Island
Roma Island
Ferguson Island
0
1000m
Gaetz Island
Conrad Island
Red Island
Black Point
Cape Entry
Story Head

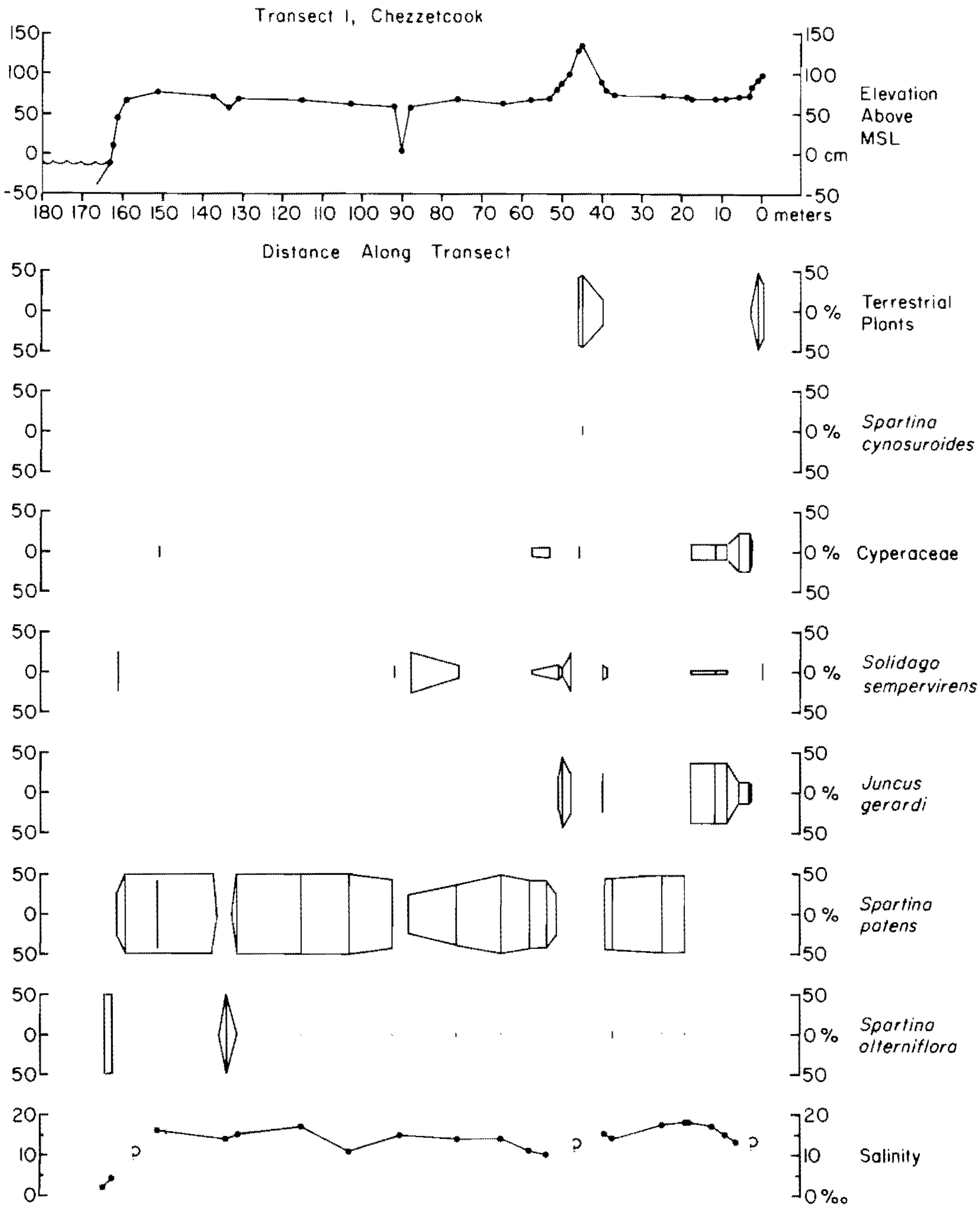


FIGURE 3

Plant and salinity occurrences on transect I, Chezzetcook Inlet. Dots in upper part of diagram are sampling localities while vertical bars below represent percentage occurrences of each plant type at each locality.

formation by trapping 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.

Five transects (foldout 1), two in the upper estuarine marshes (trans. I, III, Figs. 3, 4), two in the central

←

FIGURE 2

Map of Chezzetcook Inlet delineating the mature (unshaded) marsh areas from the immature (shaded) or newly formed marsh areas.

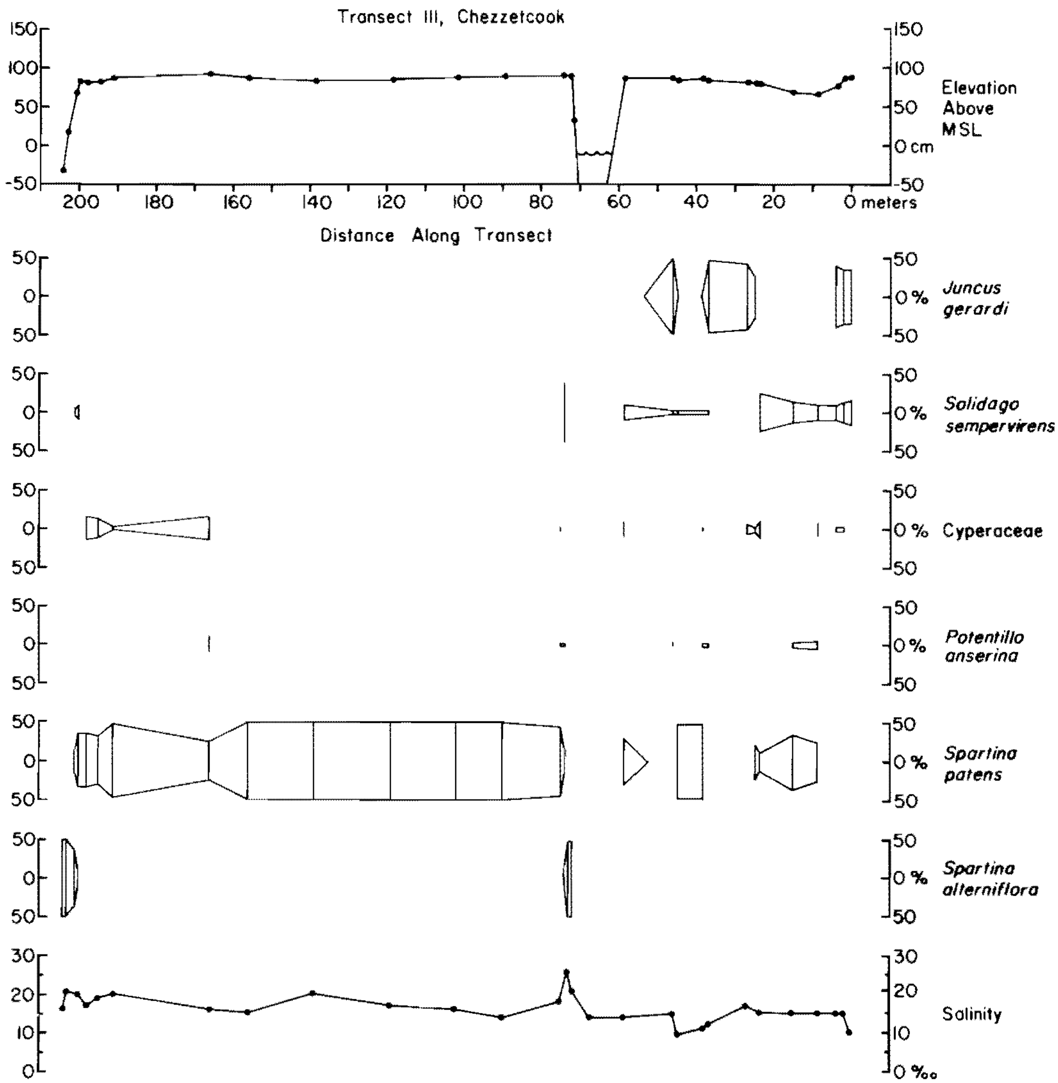


FIGURE 4

Plant and salinity occurrences on transect III, Chezzetcook Inlet. Format is the same as Fig. 3.

area (trans. II, V, Figs. 5, 6), and one at the mouth of the estuary (trans. IV, Fig. 7) illustrate the vertical floral zones present in Chezzetcook.

Higher high water is marked by the first occurrences of *Spartina cynosuroides*. The high-marsh floral zone occurs at 80–110 cm (a.m.s.l.) in the central transects and at 70–100 cm a.m.s.l. in the upper and lower estuarine transects. The middle-marsh floral zone has the vertical range of 70 ± 5 cm to 85 ± 5 cm a.m.s.l. in the central estuary and a corresponding lower range in the upper and lower estuarine transects (50 ± 5 cm to 70 ± 5 cm a.m.s.l.). The low-marsh floral zone can be divided into two subzones: the higher low-marsh subzone A (55 ± 5 to 70 ± 5 cm a.m.s.l.) and the lower low-marsh subzone B (−30 to 55 ± 5 cm a.m.s.l.). These subdivisions can only be distinguished in the central and lower estuarine transects because the sides of the channels, due to the undercutting of the marsh peat by the tidal streams, are too steep in the upper estuary to allow the full development of low marsh.

Physical Parameters

Physical parameters that have been examined in Chezzetcook are tidal range, salinity, total organic carbon content of the sediments, and seasonal variations of temperature and precipitation. Of these, salinity was monitored the most closely.

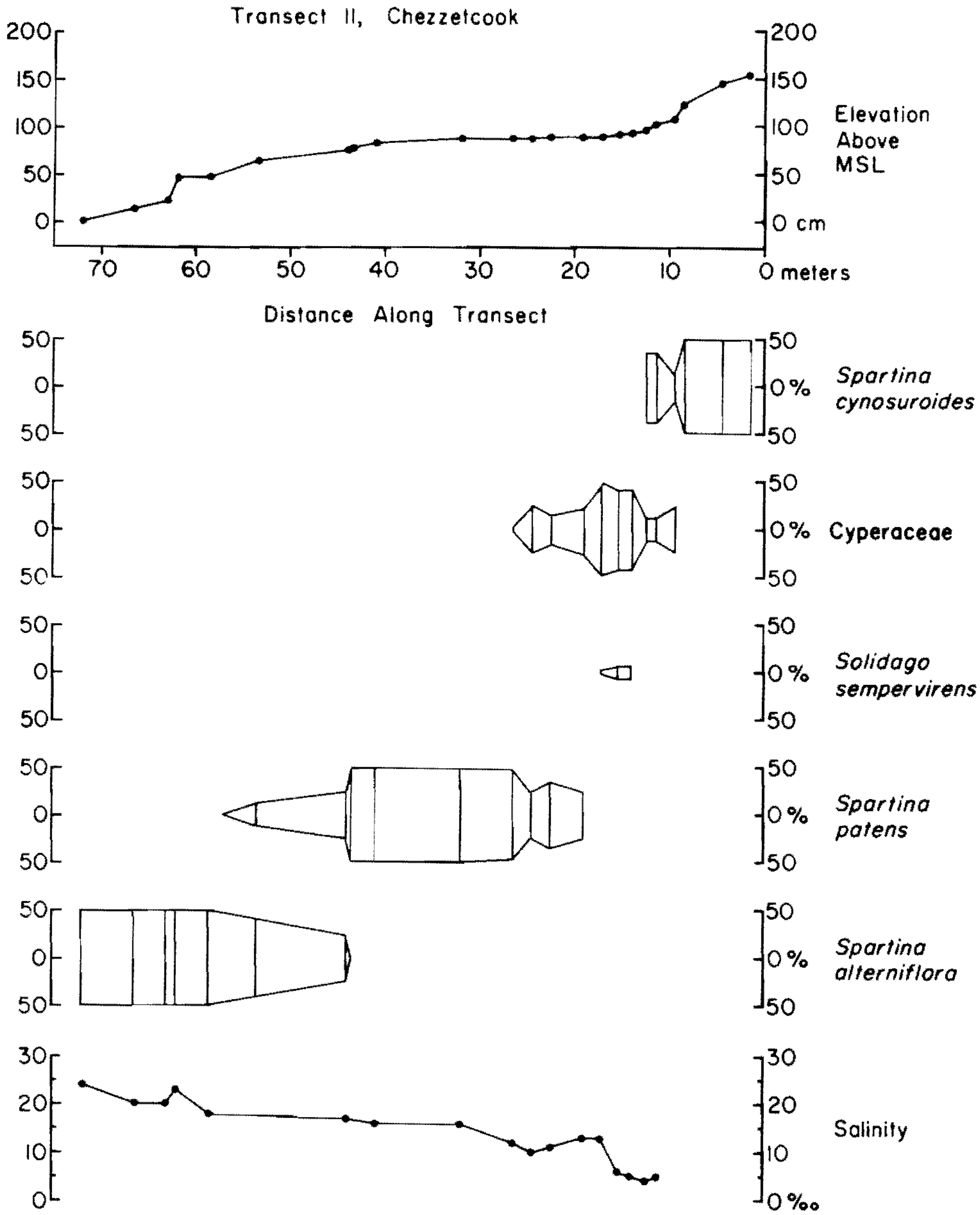


FIGURE 5

Plant and salinity occurrences on transect II, Chezzetcook Inlet. Format is the same as Fig. 3.

Tidal range is slightly lower at the head of the estuary than at the mouth. At the head (tidal gauge data from the railroad trestle in East Head) the maximum tidal range was 186 cm with higher high water at +192 cm and lower low water +6 cm with Zo (mean sea level) at +107 cm.

At the mouth of the estuary (taken to be the same as Halifax Harbour) the maximum range is 214 cm with higher high water at +226 cm and lower low water at +12 cm, with Zo at +125 cm.

Due to the extreme difficulty of obtaining accurate sediment salinities at high tide, measurements were performed at low tide and they may represent minimum values, especially during periods of high freshwater runoff. At high tide the marsh is flooded with more saline water, which results in temporarily increased salinities.

The salinity data show seasonal differences (Fig. 8, Table 1), along the vertical gradient in the marsh (Figs. 3–7, Table 1), and differences between marshes in the

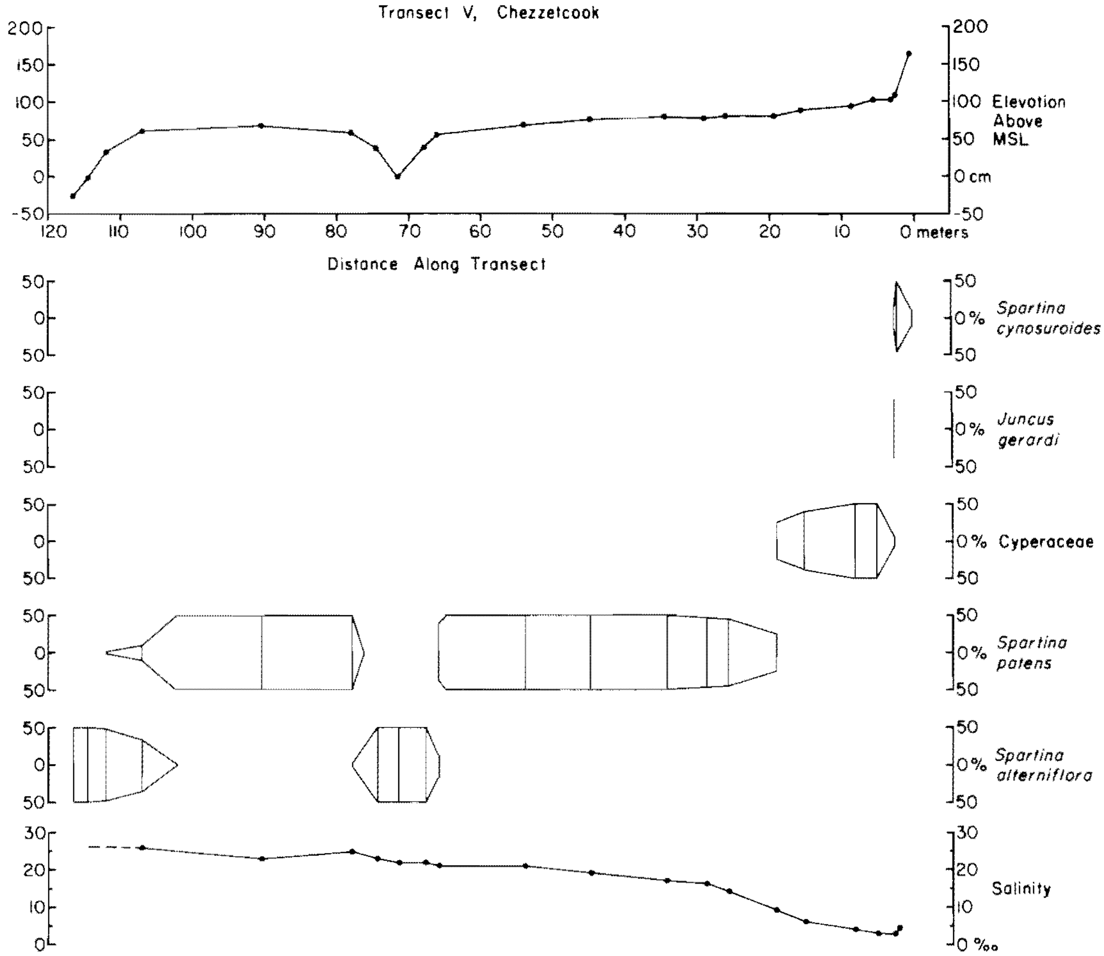


FIGURE 6

Plant and salinity occurrences on transect V, Chezzetcook Inlet. Format is the same as Fig. 3.

upper and lower estuary (Figs. 3–7, Table 1). The seasonal changes are best documented at stations 4, 7, and 20 (Fig. 8). 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 and salinity increases to its maximum values during the summer. These trends are substantiated on a marshwide basis by less detailed measurements from other stations (Table 1). 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 to V are most easily compared as these data were all collected in July, 1976 (Figs. 4, 7, 6, respectively). Transect III, in the upper estuary, illustrates little salinity change with elevation largely because most of the transect is contained in one narrow vertical floral zone. However, the highest salinity measured was in the low marsh (26‰) and the lowest in the high marsh (10‰) which indicates an inverse relationship between salinity and elevation. The inverse relationship is established more clearly in transects IV and V where all floral zones are more equally represented. Salinities appear to be uniformly low in all high marsh areas (3–10‰) but increase seaward in the middle- and low-marsh floral zones. Maxima of 30‰ in the low marsh areas of transect IV are observed. All measurements for transects III to V were carried out in the summer and they probably represent maximum salinity values. Transects I and II (Figs. 3, 5) were carried out in the fall of the previous year and,

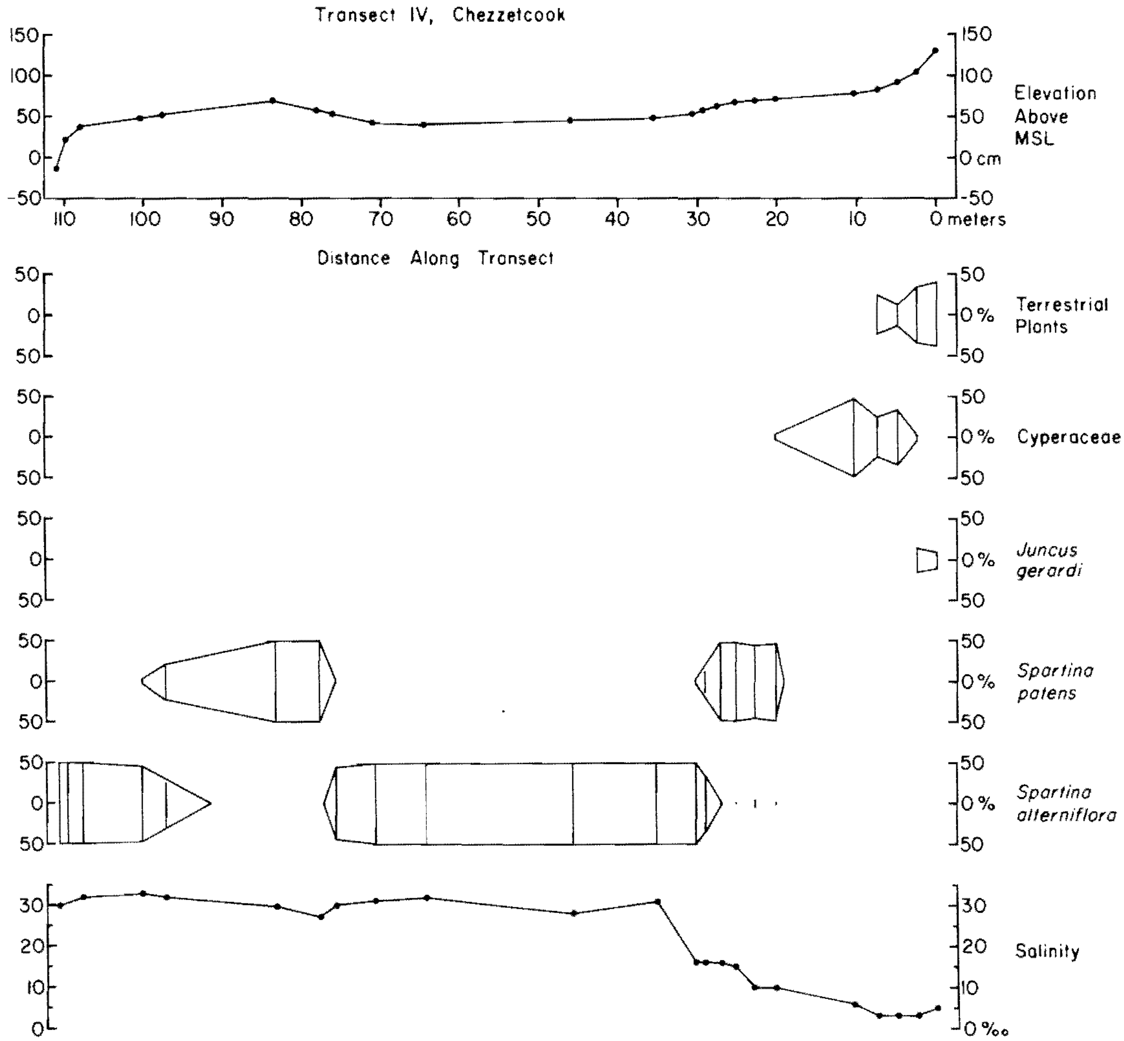


FIGURE 7

Plant and salinity occurrences on transect IV, Chezzetcook Inlet. Format is the same as Fig. 3.

although not strictly comparable to transects III to V, they show the same inverse relationship between elevation and salinity.

Organic carbon content was measured at a few selected localities (Table 1). These measurements demonstrate that the organic carbon content of the marsh sediments is usually much higher than that of the adjacent mudflats. The data also illustrate a moderate vertical gradient in the organic carbon content, with organic carbon decreasing with decreasing elevation.

Sedimentation

No marsh sediments were analyzed for grain size distribution. 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. Levees, commonly observed along marsh channels, are the result of this trapping effect. Chapman (1976) demonstrated in marshes in Massachusetts, similar to those of Nova Scotia, that accumulation rates in the marsh change vertically. The low marsh (*Spartina alterniflora*) was shown to accumulate at 6 mm/yr, the middle marsh (*Spartina 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. Harrison and

TEXT TABLE 1

The vegetation, salinity, dates of collection and organic carbon percent of sediment (only at stations 2, 4, 6, 7, 20) of the areal Chezzetcook marsh stations.

STATION NUMBER	1		2		3	4	5	6		7	8
SAMPLING DATES	4/30/76	8/9/76	5/14/76	8/9/76	9/20/75	9/24/75	9/24/75 3/27/76	4/6/76	8/9/76	4/11/76	8/9/76
VEG. + SALINITY AT EACH SUBSTATION A Veg.	s.c.		Scp.		Scp. Dy.	Scp. Dy. G.R.	Scp. G.R.	Scp. J.g.		Scp.	s.p.
A Salinity	0‰		0‰	4‰				0‰	17‰		30‰
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.	s.a.
B Salinity	0‰		1‰	25‰				5‰	15‰		31‰
B % C						35.0		31.9	33.8	36.9	
C Veg.	Scp.		s.p.		s.p. G.R.	s.p. G.R.	s.p.	s.a.		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.	M.F.
D Salinity	4‰	30‰	5-13‰								
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	9	10	11	12		13		14		15		16	
SAMPLING DATES	4/11/76	4/11/76	4/21/76	4/24/76	8/11/76	4/24/76	8/11/76	4/24/76	8/11/76	4/25/76	8/11/76	4/24/76	8/11/76
A Veg.	Scp.	s.a.	s.a.	s.a.		s.a.		s.a.		s.a.		s.a.	
A Salinity				2‰	10‰	0‰	6‰	0‰	16‰	0‰	20‰	0‰	17‰
A % C													
B Veg.	Scp. s.p.	s.p.	s.p.	Scp. J.g.		Scp. J.g.		s.p. Scp. G.R.		s.p. Scp. P.A. G.R.		s.p.	
B Salinity				0‰	12‰	5‰	14‰	4‰	15‰	2‰	15‰	9‰	24‰
B % C													
C Veg.	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.	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	56
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	[illegible]	9/6/76	[illegible]	10/15/76
A Veg.	Scp. Dy.		Scp. Dy.		s.p.	Scp.		S.A. Scp. J.g.	Scp. J.g.	s.a.	s.a.	s.a.
A Salinity	5‰	10‰	4‰	14‰	29‰	0‰	20‰	4‰	[illegible]	10‰	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.a.	s.a.	s.a.	
B Salinity	5‰	18‰	5‰	22‰	28‰	7‰	26‰	8‰	14‰	20‰	20‰	
B % C						28.5	25.[illegible]					
C Veg.	s.a.		s.a.		s.a.	s.a.			s.a. G.R.	s.a.	s.a.	
C Salinity	0‰	6‰	0‰	25‰	26‰	9‰	23‰		11‰	26‰	32‰	
C % C						22.5	[illegible]					
D Veg.					M.F.				s.a.	s.a.		
D Salinity					25‰					28‰		
D % C												
E Veg.									M.F.			
E Salinity									2‰			
E % C												
F Veg.												
F Salinity												
F % C												
G Veg.												
G Salinity												
G % C												
H Veg.												
H Salinity												
H % C												

Plant abbreviations:

s.c.	— *Spartina cynosuroides*	G.R.	— *Solidago semivirens*
s.p.	— *S. patens*	Scp.	— Cyperaceae
s.a.	— *S. alterniflora*	sn.	— *Salicornia*
J.g.	— *Juncus gerardi*	Dy.	— *Distichlis*
Pl.	— *Plantago*	Li.	— *Limonium*
P.A.	— *Potentilla anserina*	M.F.	— mudflat

Bloom (1977) have shown that sedimentation rates in marshes are closely related to tidal range with higher sedimentation occurring in marshes with higher tidal ranges.

Foraminiferal Distribution

Two types of sampling were carried out in the marsh area of Chezzetcook: 1) an areal survey to determine relatively large-scale lateral variations, and 2) extremely detailed transects across the marsh surface to determine small-scale vertical and horizontal variations. Additionally, seasonal variations were examined at selected locations to determine if the composition of the various faunal zones changed seasonally (Scott, 1977, 1978).

Areal samples: At these stations (1–20, 45–48, 56, see foldout 1) 33 species, 19 of which had living representatives, were observed. Vertical faunal zones as well as lateral groupings could be delineated. Detailed vertical faunal zones cannot be discussed in conjunction with these samples; however, lateral 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, Appendix Tables 1–3). It appears to be dominated at all levels by *Trochammina 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, on foldout 1, Appendix Tables 1–3). 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. 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, *Cribrononion umbilicatulum*, *Protelphidium orbiculare*, and *Ammonia beccarii*, make their first appearances in the lower part of the central estuarine marshes. Stations 47 and 48 represent areas of newly forming marsh and only the lowest marsh is

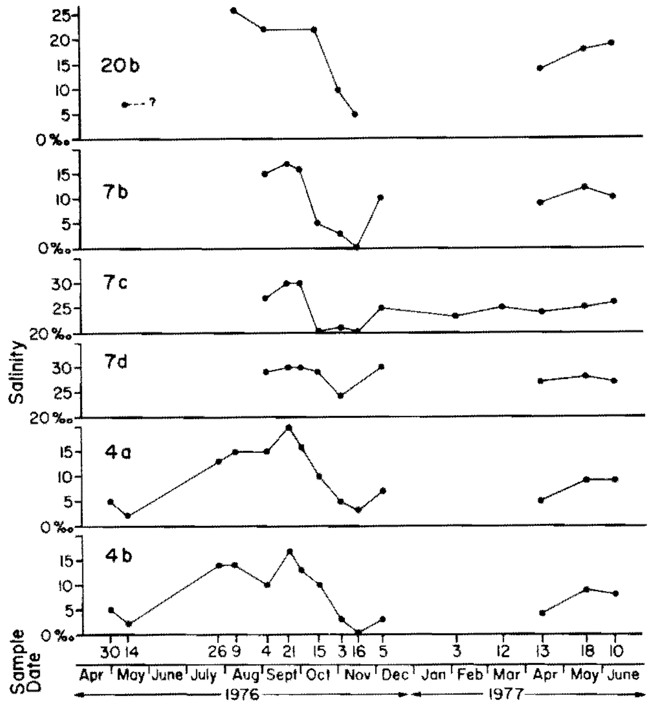


FIGURE 8

Seasonal variations of salinity at Chezzetcook stations 4a, b; 7b–d; 20b.

present. The fauna observed at these stations corresponds with the lowest parts of the fully developed marshes. Distributions at stations 47 and 48 are extremely irregular and populations are usually small.

Lower estuarine marsh: This is a relatively small area near the mouth (sta. 7, 8, 19 on foldout 1, Appendix Tables 2, 3). The area is dominated almost exclusively by *M. fusca*; but large populations of *C. umbilicatulum*, *A. beccarii*, *Helenina andersoni*, *Hemisphaerammina bradyi*, *Trochammina inflata*, and *Jadammina polystoma* (an ecotype of *T. macrescens*; see SYSTEMATIC TAXONOMY) also occasionally occur.

Transects: The same five transects discussed above were sampled for foraminifera (foldout 1). Using these transects the marsh foraminiferal faunae can be divided into distinct vertical zones. Here we use the dominant species to define a zone, presence or absence of subdominant species to recognize subzones, and subsubzones are delimited on the presence or absence of a subdominant species whose occurrence appears to be restricted not only by elevation, but also by some other parameter (such as salinity).

Upper estuarine transects—I and III: Transect I (Fig. 9, Appendix Table 4) was located in the West Head and transect III (Fig. 10, Appendix Table 5) in

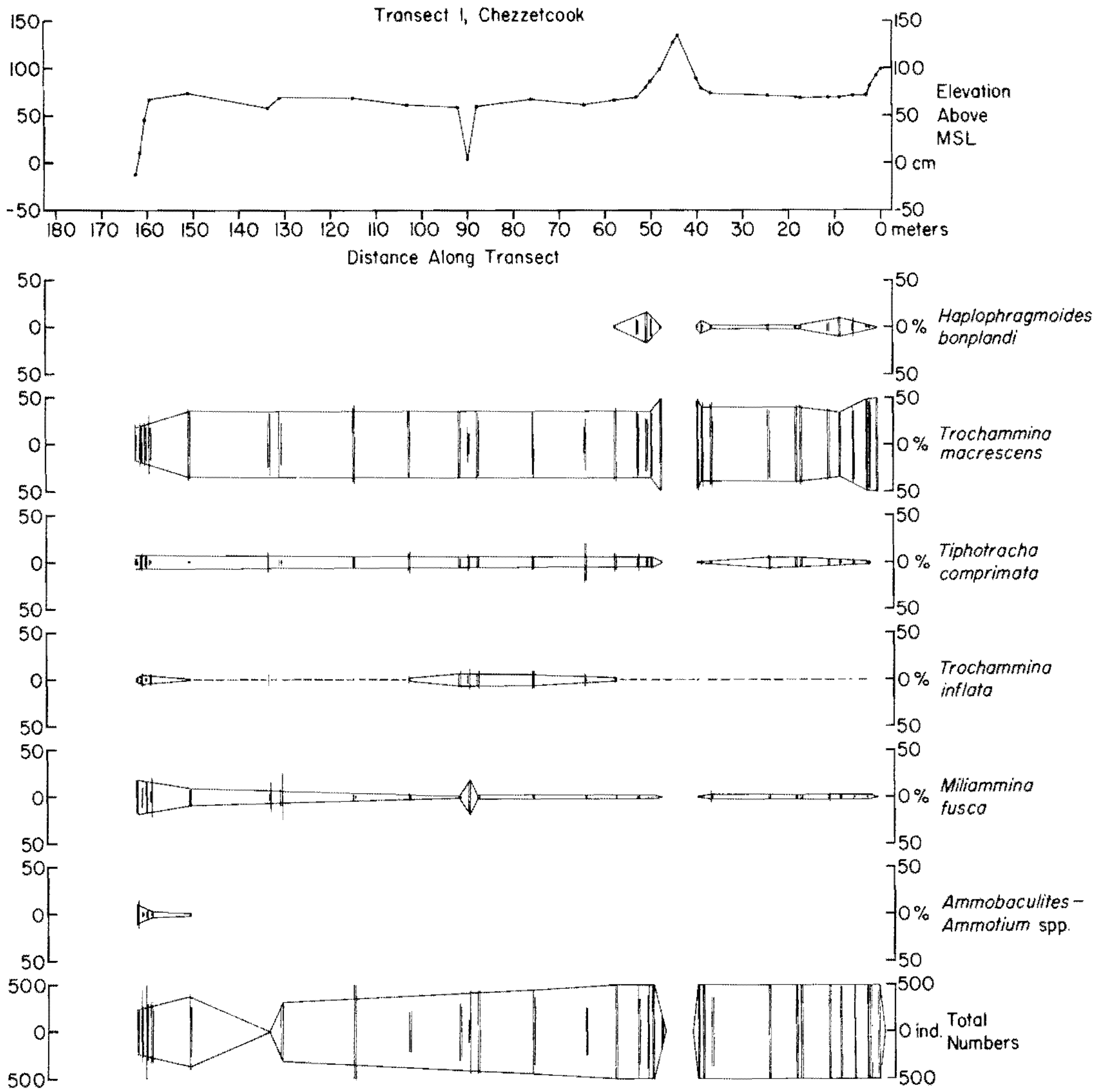


FIGURE 9

Foraminiferal occurrences along transect I, Chezzetcook Inlet. Dots in upper part of diagram are sampling localities. Double vertical bars below represent replicate percentage occurrences of each species along the transect, except the lowest set which indicate total numbers per 10 cm³. Horizontal connecting lines indicate averaging, hence vertical lines ending either outside or inside these lines are intra-zonal rather than inter-zonal differences. Total numbers are often higher than 1,000; however, significant variations appear to occur only between 0 and 1,000 so the scale is limited to this figure.

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, Appendix Table 5) at 88 cm a.m.s.l. shows a decrease in population. This decrease corresponds closely with the higher high water datum (HHW, 92 cm a.m.s.l.), as determined with tide gauges at the head of Chezzetcook. Below HHW the marsh fauna in the upper estuary can be divided into two zones: zone I (65 ± 5 to 95 cm a.m.s.l.) and zone II (−15 ± 15 to 65 ± 5 cm a.m.s.l.). Additionally zone I can be subdivided into two subzones I_A (88–95 cm a.m.s.l.) and I_B (65 ± 5 to 88 cm a.m.s.l.). Subzone I_B can be further divided into sub-subzones I_{B_1} (70–88 a.m.s.l.) and I_{B_2} (60–70 cm a.m.s.l., Trans. I only). The faunal zone II can be divided into two subzones (an upper subzone II_A and a lower II_B); however, their exact vertical boundaries could not be determined because the steep vertical gradient prevented reliable sample coverage.

Central estuarine transects—II and V: Transect II

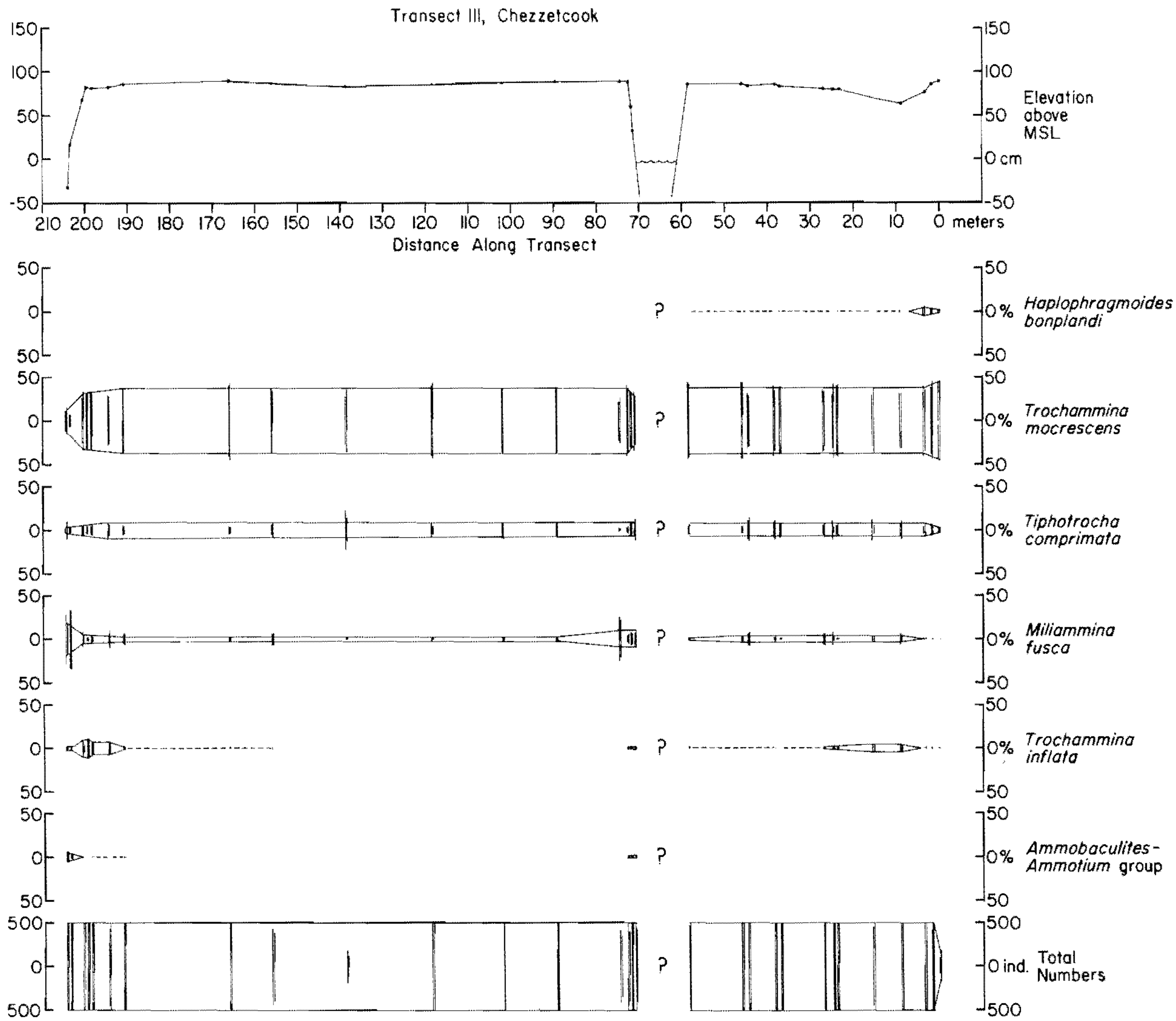


FIGURE 10

Foraminiferal occurrences along transect III, Chezzetcook Inlet. Format is the same as Fig. 9.

(Fig. 11, Appendix Table 6) was the most seaward while transect V (Fig. 12, Appendix Table 7) 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. Below HHW (95–100 cm a.m.s.l.) again two zones can be distinguished: zone I (75 ± 5 to 100 cm a.m.s.l.) and zone II (−15 ± 15 to 75 ± 5 cm a.m.s.l.). As in the upper estuary these zones can be subdivided into subzones and sub-subzones. Zone I can be divided into two subzones, I_A (95 to 100 cm a.m.s.l.) and I_B (75 ± 5 to 95 cm a.m.s.l.). Zone II can be divided into two subzones: II_A (55 ± 5 to 75 ± 5 cm a.m.s.l.) which is divisible into two sub-subzones (II_{A_1}, 70 ± 5 to 75 ± 5 cm a.m.s.l.; II_{A_2}, 55 ± 5 to 70 ± 5 cm a.m.s.l.) and II_B (−15 ± 15 to 55 ± 5 cm a.m.s.l.).

Lower estuarine transect—IV: Transect IV (Fig. 13, Appendix Table 8) was located in the relatively large marsh area near the mouth (foldout 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 were virtually no foraminifera. 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

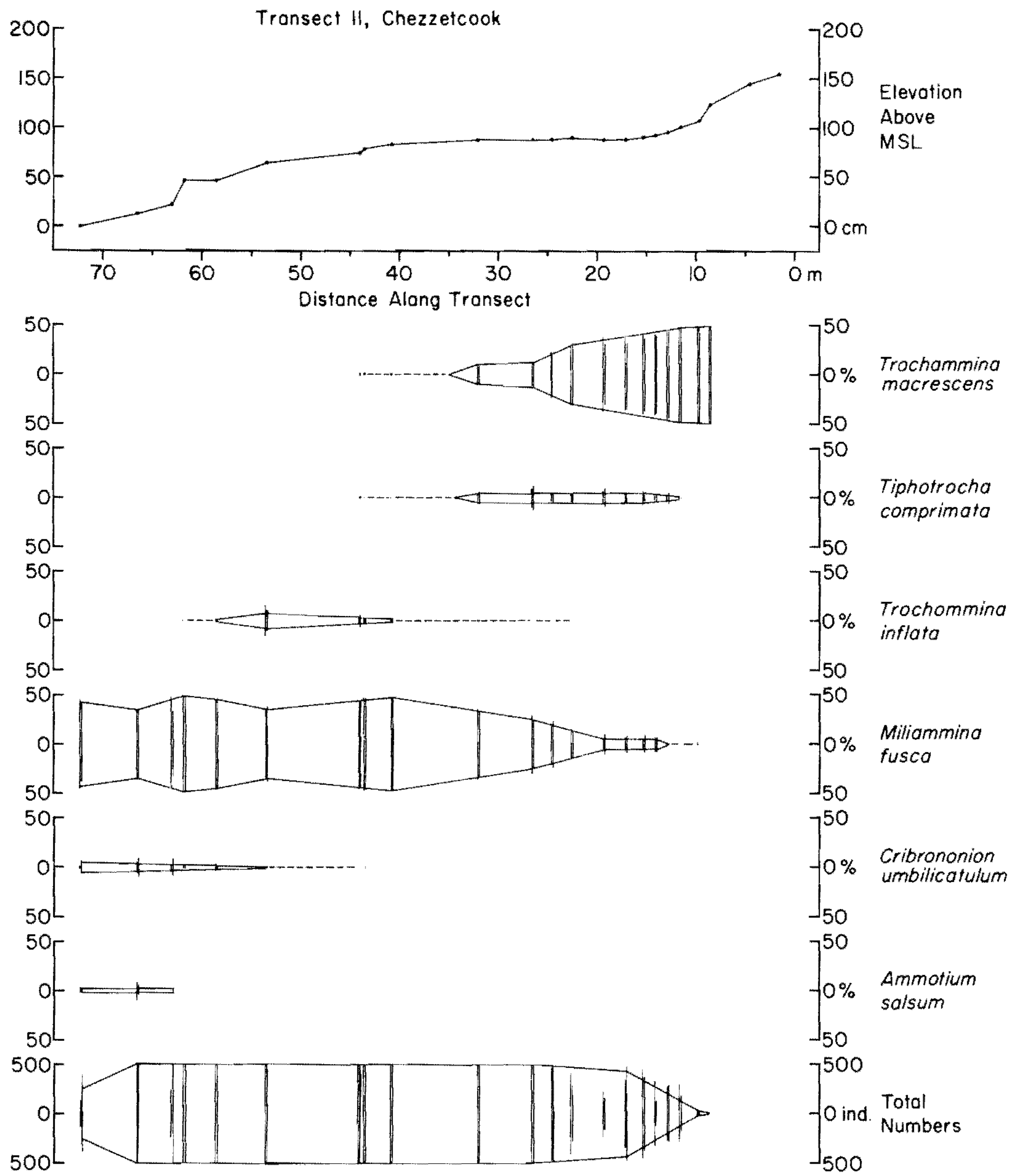


FIGURE 11

Foraminiferal occurrences along transect II, Chezzetcook Inlet. Format is the same as Fig. 9.

occurs. Below 68 cm a.m.s.l. a faunal zone II occurs but is much more diverse than those in the upper and central estuary. The upper part of this transect was probably not representative since salinities were abnormally low, probably because of excessive runoff which was funneled into this location.

All information from Figures 3–7 and 9–13 is summarized in Fig. 14.

The total foraminiferal population (live plus dead) has been used to define assemblages. 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 comparison with the large variations between corresponding living populations. Consequently, any meaningful interpretation of the assemblages based only on living data would be ex-

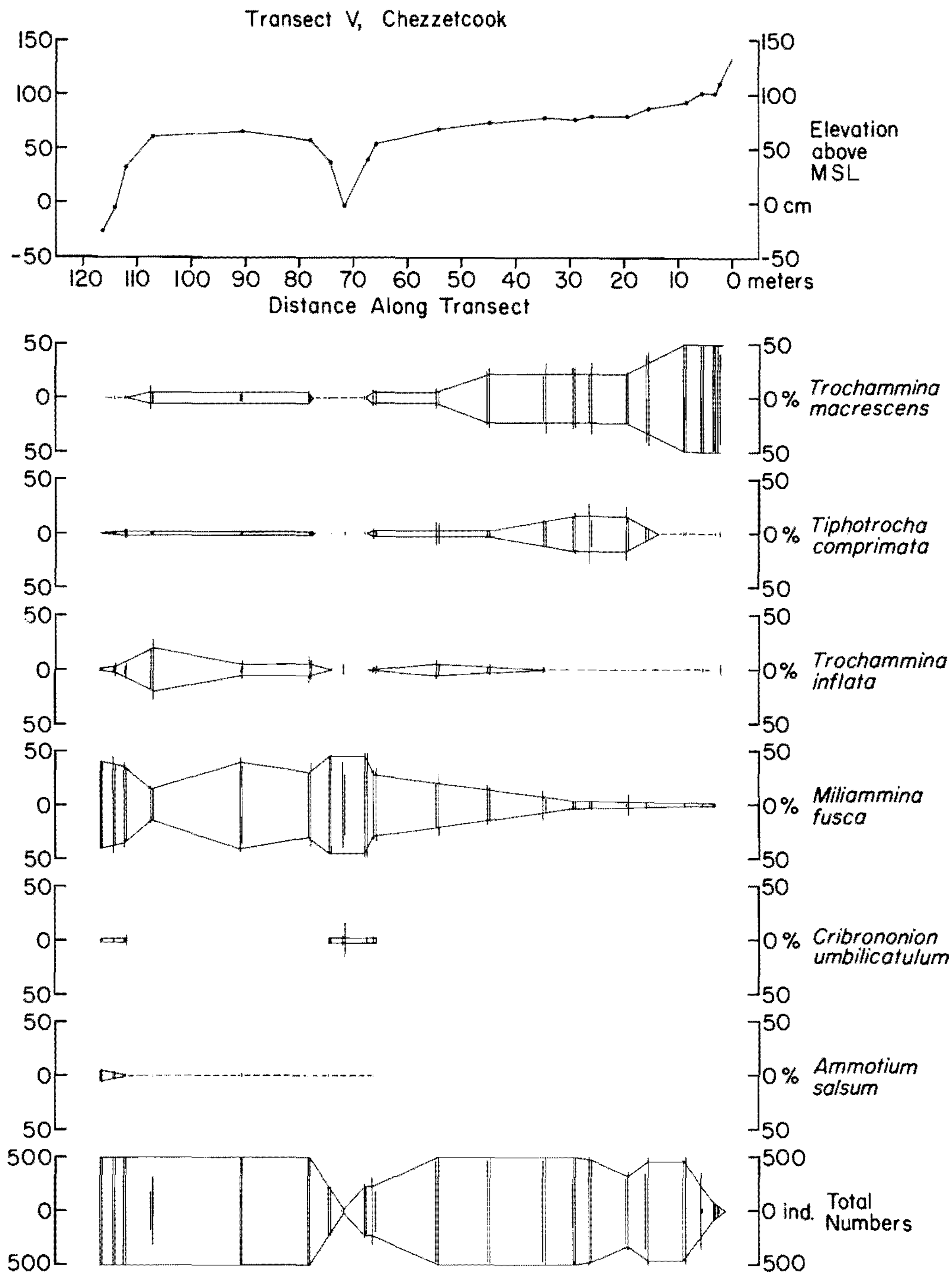


FIGURE 12

Foraminiferal occurrences along transect V, Chezzetcook Inlet. Format is the same as Fig. 9.

tremely problematic. This conclusion is further supported by seasonal studies in this area (Scott, 1977, 1978) which show that, although living populations vary considerably during the seasonal cycle, total assemblages do not change significantly.

Chebogue Harbour

Introduction

Chebogue Harbour is located in the southwestern part of Nova Scotia (Fig. 1); it is similar in size to

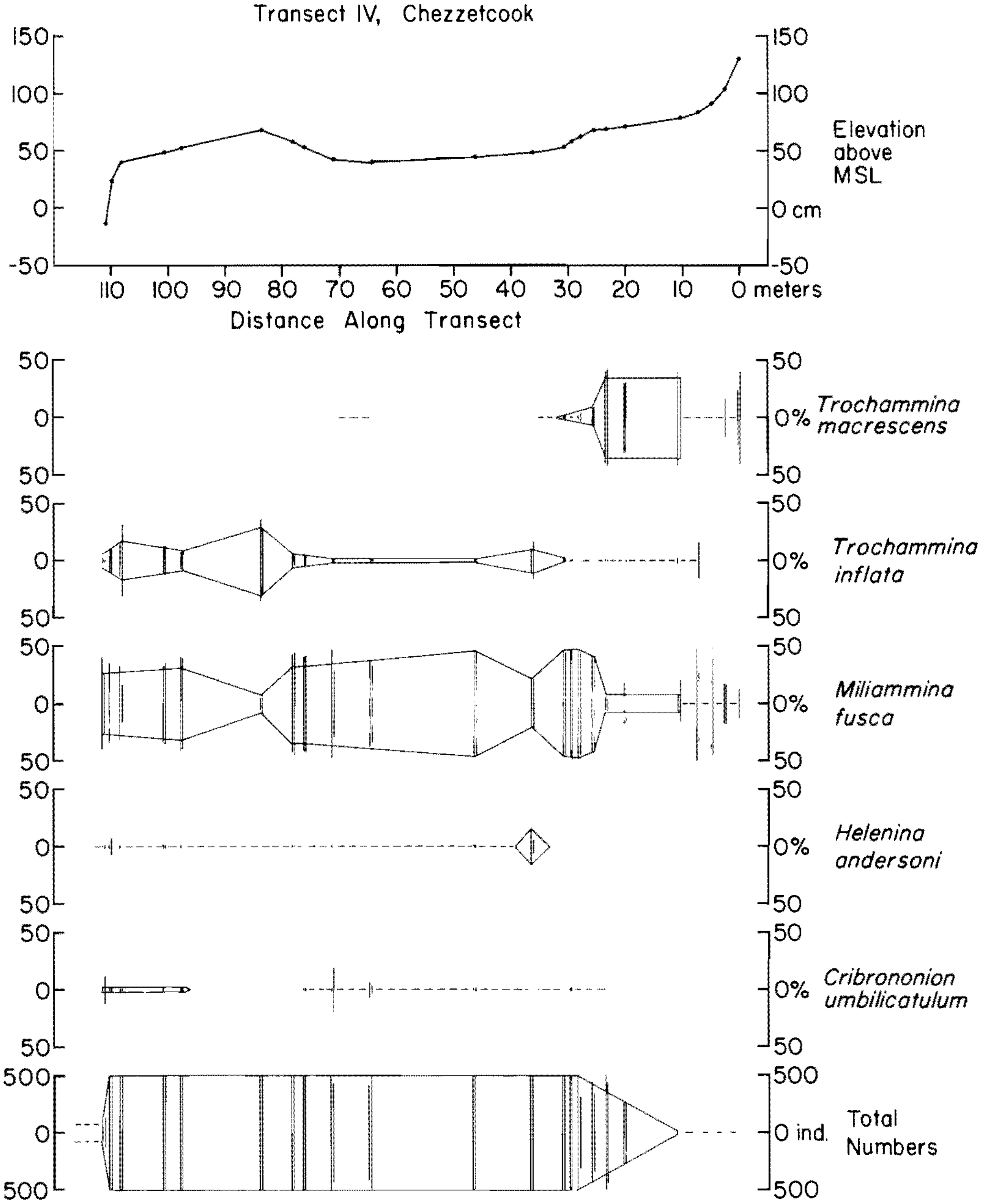


FIGURE 13
Foraminiferal occurrences along transect IV, Chezzetcook Inlet. Format is the same as Fig. 9.

Chezzetcook and, like Chezzetcook, contains an extensive marsh system (Fig. 15). 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. Unlike the head of Chezzetcook, however, most of the low-gradient areas in Chebogue would be classified into low-marsh floral subzone A rather than into the middle-marsh floral zone.

Vegetation

Plant species occurring in Chebogue are essentially the same as those in Chezzetcook and they appear to have a similar distribution pattern (Table 2). Some floral zones, especially the low-marsh floral zones, however, are enlarged vertically because of an expanded tidal range (Fig. 16). The low-marsh zone, consisting of either 100% *Spartina alterniflora* (subzone B) or

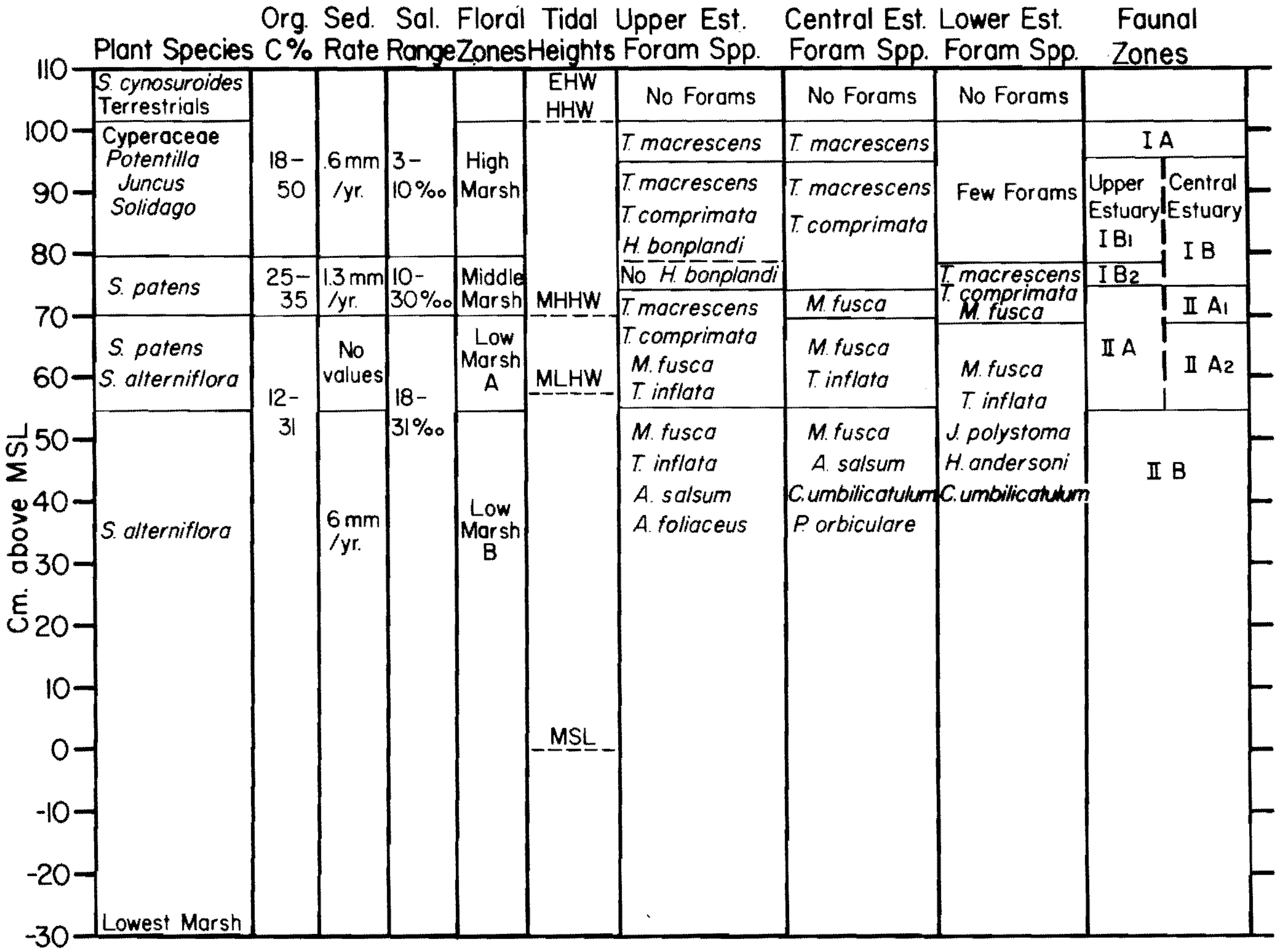


FIGURE 14

Summary of Chezzetcook physical, vegetation, and foraminiferal data. Abbreviations: EHW = extreme high water, HHW = higher high water, MHHW = mean higher high water, MLHW = mean lower high water, MSL = mean sea level.

any mixture of *Spartina patens* and *S. alterniflora* (subzone 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 subzone B consists of any combination of high-marsh vegetation (*Solidago sempervirens,* Cyperaceae, *Juncus* spp.) together with varying percentages of *S. patens* (225–245 cm a.m.s.l.) with high marsh subzone 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 zone. It appears that the high marsh zone is compressed vertically with its relative vertical range decreasing in the higher tidal range of Chebogue while its absolute vertical range remains the same (25–30 cm).

Physical Parameters

The most important physical characteristic of this marsh in relation to the others 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 no convenient benchmarks could be located, the base of the marsh (i.e., bottom of the *Spartina alterniflora*) was used as MSL indicator in the semi-detailed transects carried out (Fig. 16). 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 tid-

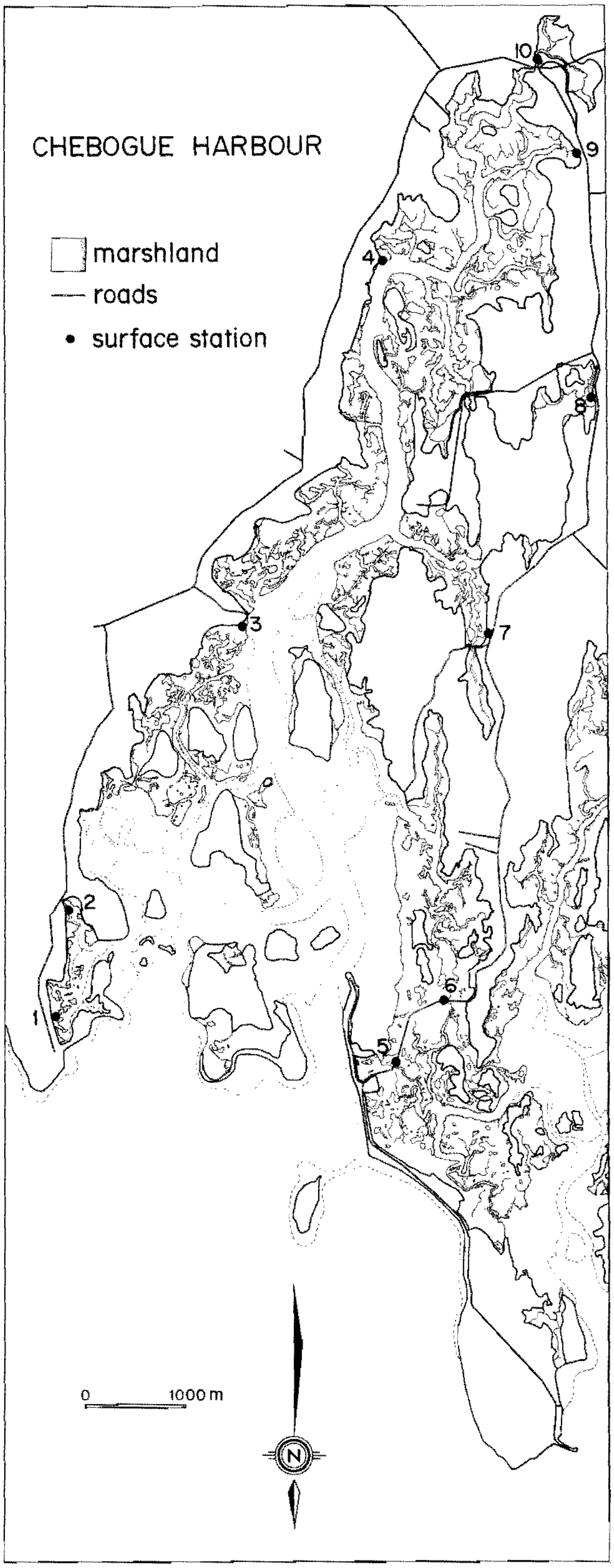


FIGURE 15
Surface sample locations in Chebogue Harbour marsh.

al range, still extend from approximately MSL to HHW. Water salinities showed an inverse relationship with elevation, similar to Chezzetcook (Table 2). High marsh values ranged from 2–19‰, and low marsh from 13–35‰. Salinities were lowest in isolated channels near the head of the estuary.

Foraminiferal Distribution

As in Chezzetcook all samples were collected in replicate. One hundred and four samples from 52 localities were analyzed for foraminiferal content (Fig. 15). Thirty-two species, 15 of which had living representatives, were observed in the samples (Appendix Tables 9, 10).

Two semi-detailed transects (Stations 2, 3, Fig. 16) 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 macrescens* (faunal zone I_A). In the faunal subzone I_B *T. macrescens* and *Tiphotrocha comprimata* are both common. Faunal zone II can again be divided into two subzones. In faunal subzone II_A *Miliammina fusca* and *Trochammina inflata* dominate with *T. macrescens* and *T. comprimata* disappearing. In faunal subzone II_B *M. fusca* dominates with *Cribrononion umbilicatulum* being common towards the lower end of it. With the increase in calcareous species the total number decreases. *Ammotium salsum*, a common faunal zone 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 the existence of a faunal subzone I_B assemblage denoting more brackish conditions similar to those in Chezzetcook with significant percentages of *Haplophragmoides bonplandi*. A different faunal subzone I_B occurred at two localities (4d, 8a) dominated by *Trochammina inflata* with varying percentages of *Tiphotrocha comprimata* and *Trochammina macrescens* and low percentages of *Miliammina fusca*. These rare faunal subzone I_B associations occurred where salinities were higher than would be expected for a high marsh area. Some areas had a more clearly characterized faunal subzone II_A with higher percentages of *Trochammina inflata* (stations 1d, 4b, c, 4b, d, 6b, d, 7c, 8b, d, Appendix Tables 9, 10).

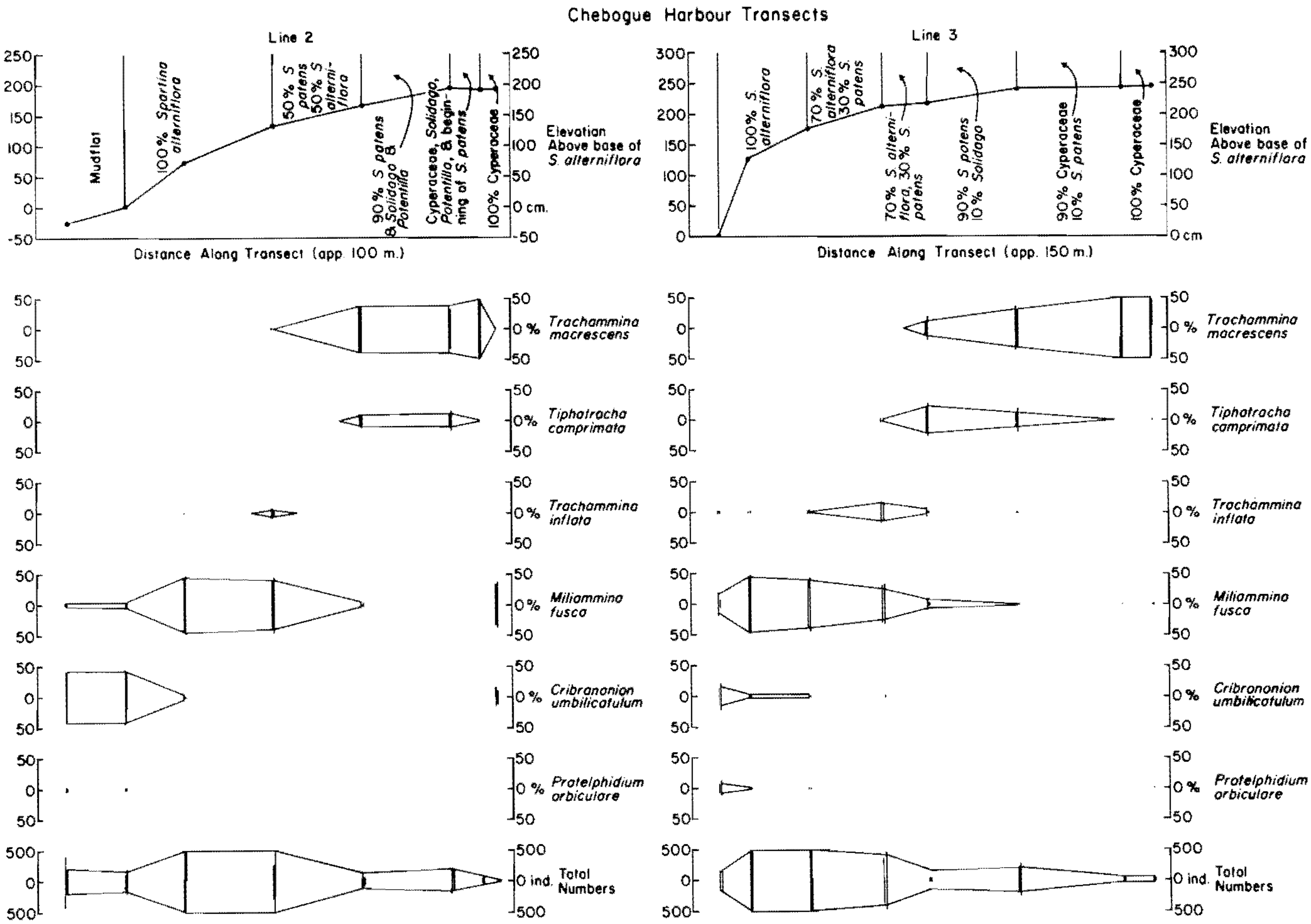


FIGURE 16

Plant and foraminiferal distribution at stations 2, 3 in Chebogue Harbour. Format similar to Fig. 9 but less detailed.

Wallace Basin

Introduction

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 zone, if it exists at all, is extremely restricted. There are few areas with steep-sided channels compared to those occurring in Chezzetcook and Chebogue.

Vegetation

Vegetation here is similar to that in the other areas except that, in the high-marsh floral zone, *Juncus gerardi* is usually the dominant form rather than the Cyperaceae (Table 3). The middle-marsh floral zone 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 zone (both subzones) occupying the lowest 50–70 cm.

Physical Parameters

The tidal regime in Wallace as well as the rest of the Gulf of St. Lawrence is a mixed system; it is influenced equally by semi-diurnal and diurnal components. Hence this tidal system is not strictly comparable with the Atlantic coast. However, HHW is reported as occurring at 113 cm a.m.s.l. (from Malagash which is close to Wallace), which is comparatively close to HHW at Chezzetcook.

TEXT TABLE 2

The vegetation, salinity, and dates of collection for Chebogue Harbour marsh stations. Plant abbreviations are the same as those in Text Table 1.

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.g.	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‰							

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 3). High-marsh salinities ranged from 6–20‰, middle marsh from 15–25‰, and low marsh from 28–35‰ (Table 3). Values were generally higher at stations on the south side of the basin where the marsh was exposed to more open circulation from the basin.

In addition to the salt marsh areas, two stations were established in the upper reaches of Wallace Basin where there is no longer tidal influence (sta. 4, 5, Fig. 17). The vegetation in this area was monospecific with *Spartina cynosuroides* and low salinities (0–5‰). The non-tidal condition appears to have been created artificially by a causeway placed seaward of stations 4 and 5. However, some seawater might enter this area once or twice a year, which accounts for the mildly brackish condition.

TEXT TABLE 3

The vegetation, salinity, and dates of collection for Wallace Basin marsh stations. Plant abbreviations are the same as those in Text Table 1.

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‰	30‰	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‰	3‰	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.	26‰	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% s.a. 50% s.p.	
	Sal.	23‰	27‰	28‰		30‰			24‰	31‰	20‰		29‰	27‰
E	Veg.		s.a.		M.F.				s.a.		s.a.		J.g.	
	Sal.		20‰	24‰		20‰			21‰	32‰	19‰		20‰	20‰
F	Veg.		M.F.						M.F.		M.F.		50% s.c. 50% J.g.	
	Sal.		22‰						22‰	28‰	9‰	17‰	8‰	15‰

Foraminiferal Distribution

Seventy-three surface samples were collected from 37 localities in the Wallace marshes (Fig. 17). A total of 19 species, 15 of which had living representatives, were observed (Appendix Tables 11, 12). One semi-detailed transect was performed (similar to Chebogue) at station 6 and data from station 8 were combined with data from station 6 to plot Figure 18. The data indicate the presence of two major foraminiferal faunal zones, 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 macrescens* (faunal subzone I_A) occurs. Faunal subzone I_B contains large numbers of *T. macrescens*, *Tiphotrocha comprimata*, and *Trochammina inflata*. Faunal subzone II_A is marked by a decrease in *T. macrescens* together with an increase in *T. inflata*. Faunal subzone II_B is marked by decreases in *Trochammina inflata* and *Tiphotrocha 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-subzone I_{B_1}. There are no foraminifera in the non-tidal areas (sta. 4, 5).

A completely anomalous area, unique to this marsh, was found at station 7, which was at the head of a narrow channel. At this location the area corresponding to faunal subzone I_B contained large percentages of *H. bonplandi*, *Trochammina macrescens*, *T. inflata*, and *Tiphotrocha comprimata*. Below this fauna an assemblage occurred that was characterized by *Thur-*

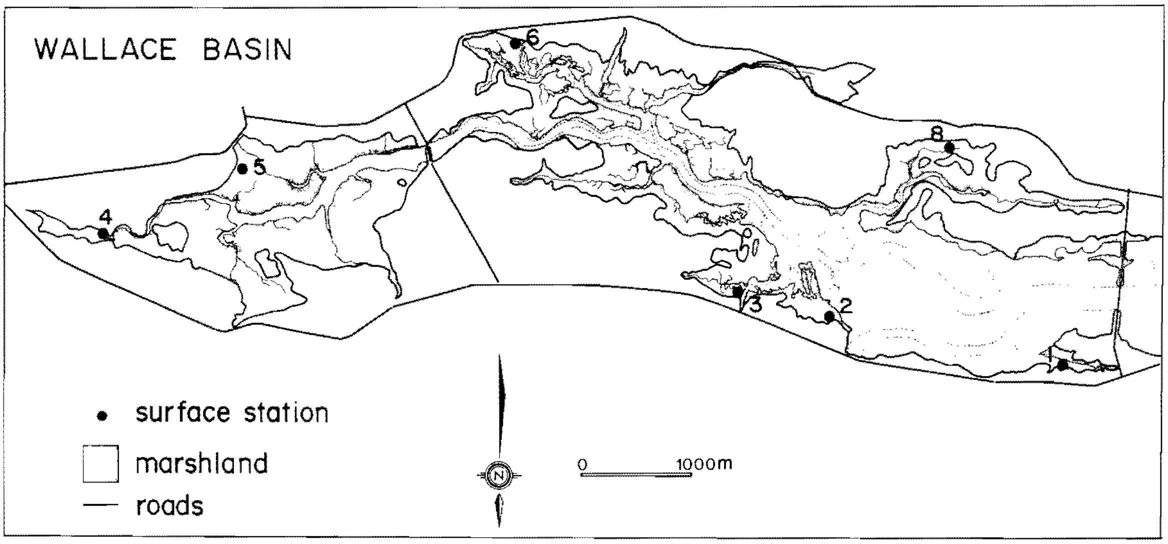


FIGURE 17

Surface sample locations in Wallace Basin marsh.

ammina(?) *limnetis* (new species) together with the species from the faunal subzone above. *A. salsum* did not occur in the lower areas.

Summerville Marsh

Introduction

This small marsh is located behind and on the landward side of a large sand barrier at the head of Port Mouton (Fig. 19). It is probably of recent formation although no drilling was done to test peat thicknesses. Any freshwater entering the marsh is probably from precipitation; nonsaline ground water, if present, is only a minor contributor. Sediments tend to be sandy and probably do not retain moisture as well as other types of marsh sediments.

Vegetation

The vegetation can be divided into two zones, a high-marsh floral zone composed of *Spartina patens–Juncus gerardi–Potentilla anserina–Limonium* sp. and a low-marsh floral zone composed of *Spartina alterniflora* (Table 4). In the higher elevations of the marsh the vegetation grades into dune grass.

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 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 4). There was no indication of an inverse salinity gradient with increasing elevation; in fact salinity appeared to increase with elevation in some instances.

Foraminiferal Distribution

Thirty-four samples were obtained at 17 localities (Fig. 19). From these samples 39 species, 9 of which had living representatives, were observed (Appendix Table 13). Of the 39 total species, 33 were open ocean forms, occurring in locations 1d–1f which were exposed to considerable open ocean influence. The remaining 6 species were indigenous marsh species.

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

Newport Landing Marsh

Introduction

The area sampled was part of a large marsh system that borders the eastern side of the Avon River estuary

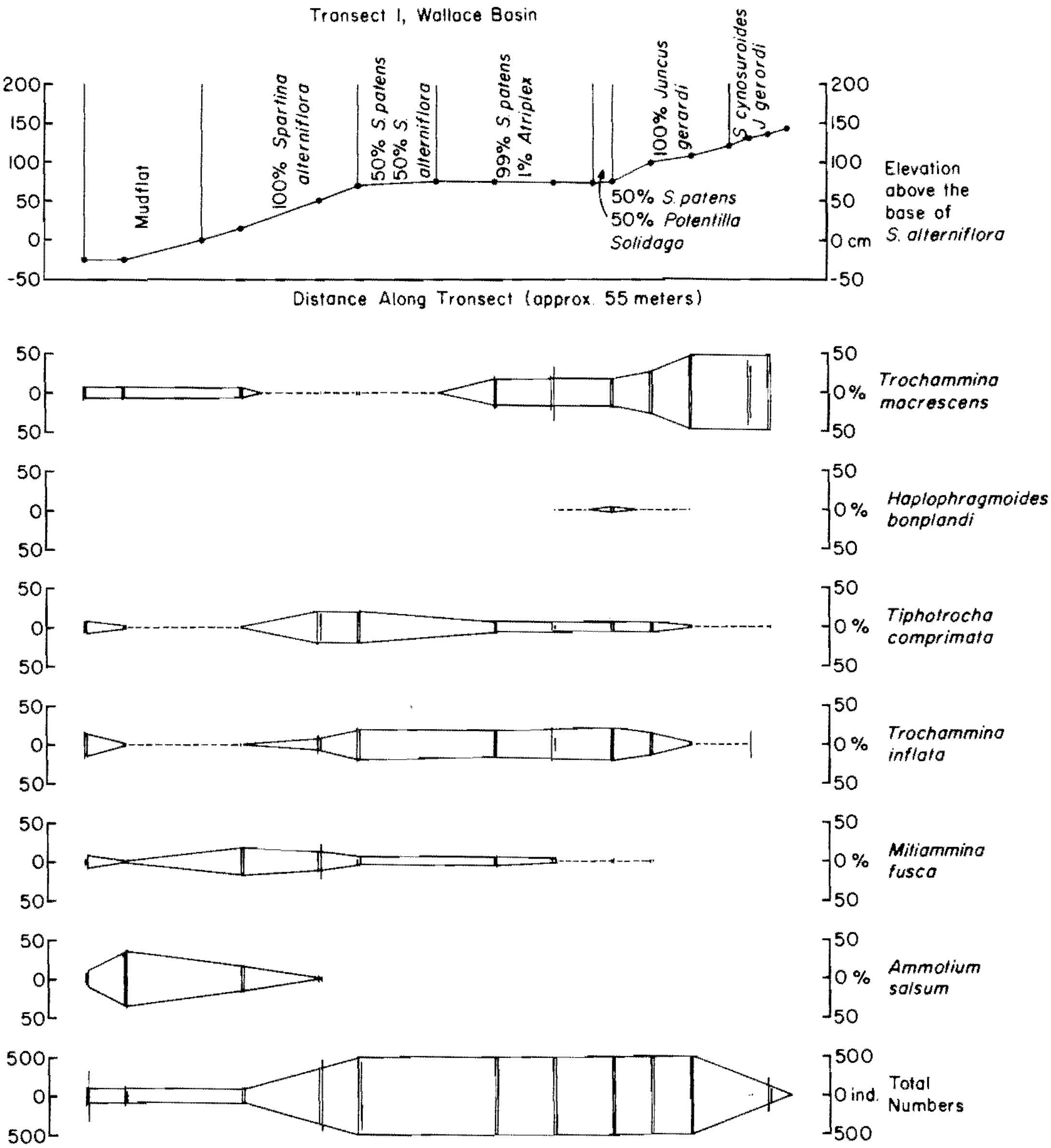


FIGURE 18

Plant and foraminiferal distributions at Stations 6, 8, Wallace Basin. Format is similar to Fig. 9 but less detailed.

which empties into the south side of the Minas Basin, Bay of Fundy (Fig. 1). There is a small freshwater stream that bisects the marsh in the area sampled so that salinities in this area may be slightly lower than those of adjacent marshes.

Vegetation

The vegetation is similar to that observed in other areas with *Solidago* sp., *Juncus* sp. and other grasses characterizing the high marsh (Fig. 20). The Cyperaceae are not observed, however. Rather typical is the narrow, both horizontally and vertically, middle marsh characterized by *Spartina patens*, with a low-marsh subzone A (*S. patens* and *S. alterniflora*) and a wide, both vertically and horizontally, low-marsh subzone B with *S. alterniflora* (Fig. 20). The low marsh ends at approximately +4.00 m a.m.s.l. so that the entire vertical range of the marsh covers slightly less than the upper quarter of the tidal range. The low-marsh

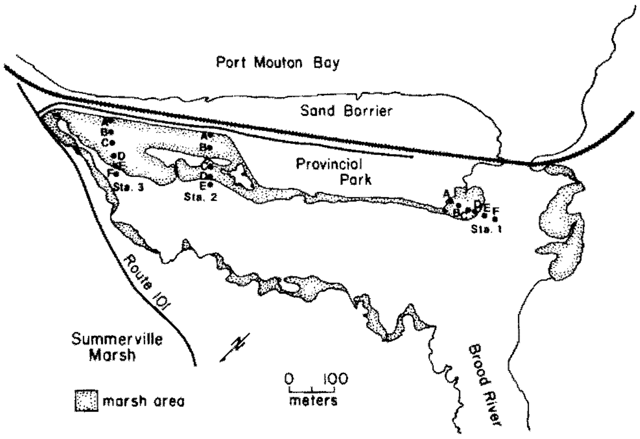


FIGURE 19
Surface sampling localities at Summerville marsh.

TEXT TABLE 4
The vegetation, salinity, and dates of collection for the Summerville marsh stations. Plant abbreviations are the same as those in Text Table 1.

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.	N.F.	N.F.	s.a.
	Sal.		25‰	20‰
F	Veg.	N.F.		N.F.
	Sal.			24‰

zone accounted for approximately ⅔ of this range while the high-marsh zone accounted for ⅓ or approximately 1 m of elevation range. Hence the absolute vertical range of the high marsh is at least double that observed in the other study areas but this increase is not proportional to the increase in tidal range which is 3–7 times greater here than in any other area examined.

Physical Parameters

Unfortunately no salinity measurements were made at the time of sampling, however, salinities here probably reflect those of the Avon estuary which are usually well over 20‰. It is not known if the salinity decreases with elevation as it does in the three major study areas already discussed.

The surface sediments are not the typical peat-like materials seen in the other areas. The low-marsh sediments are typically fine sand and silt with little organic material while the upper marsh has less sand and more organic material. Sedimentation rates here are probably high, reflecting the high sedimentation rates observed in the Avon estuary as a whole. This corresponds with the suggestion by Harrison and Bloom (1977) that higher sedimentation rates occur in marshes with large tidal ranges.

The distinctive characteristic of this marsh is its high tidal range (14.94 m) with HHW occurring at +7.72 m. This is roughly three times the tidal range at Chebogue which already has an expanded tidal range. The transect done here was tied into a benchmark since it was assumed correctly that the lower end of the marsh would no longer correspond with MSL.

Foraminiferal Distributions

Thirty-six surface samples were collected in one detailed transect. Twelve species, 9 of which had living representatives, were observed in the samples (Appendix Table 14). Both total and living numbers were approximately an order of magnitude lower than in the other 4 marshes. This might be due in part to the higher sedimentation rates which might dilute the total population. In addition the samples were collected in late November, 1975, when living populations were no longer at their peak.

Despite its peculiarities this marsh can still be divided into two faunal zones, I and II, based on foraminifers (Fig. 20). Zone I (no subzones) is characterized by *Trochammina inflata*, *Haplophragmoides bonplandi*, and *Tiphotrocha comprimata* with small percentages of *Jadammina polystoma* and *Eggerella advena* (+6.5–7.5 m a.m.s.l.). Zone II can be divided into subzone II_A characterized by *T. inflata*, *Cribrononion umbilicatulum* and *Protelphidium orbiculare* (+6.3–6.5 m a.m.s.l.) and subzone II_B characterized by *P. orbiculare*. The higher high water mark is again marked by the absence of a significant foraminiferal population (between +7.5 and 7.8 m a.m.s.l.). *Trochammina macrescens*, a common constituent of faunal zone I in the other areas, is rare in this marsh.

DISCUSSION AND COMPARISON OF NOVA SCOTIAN MARSHES

Distribution of Plants

A generalized observation on most marshes of the east coast of North America is that there usually are three distinct vertical floral zones 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. 21).

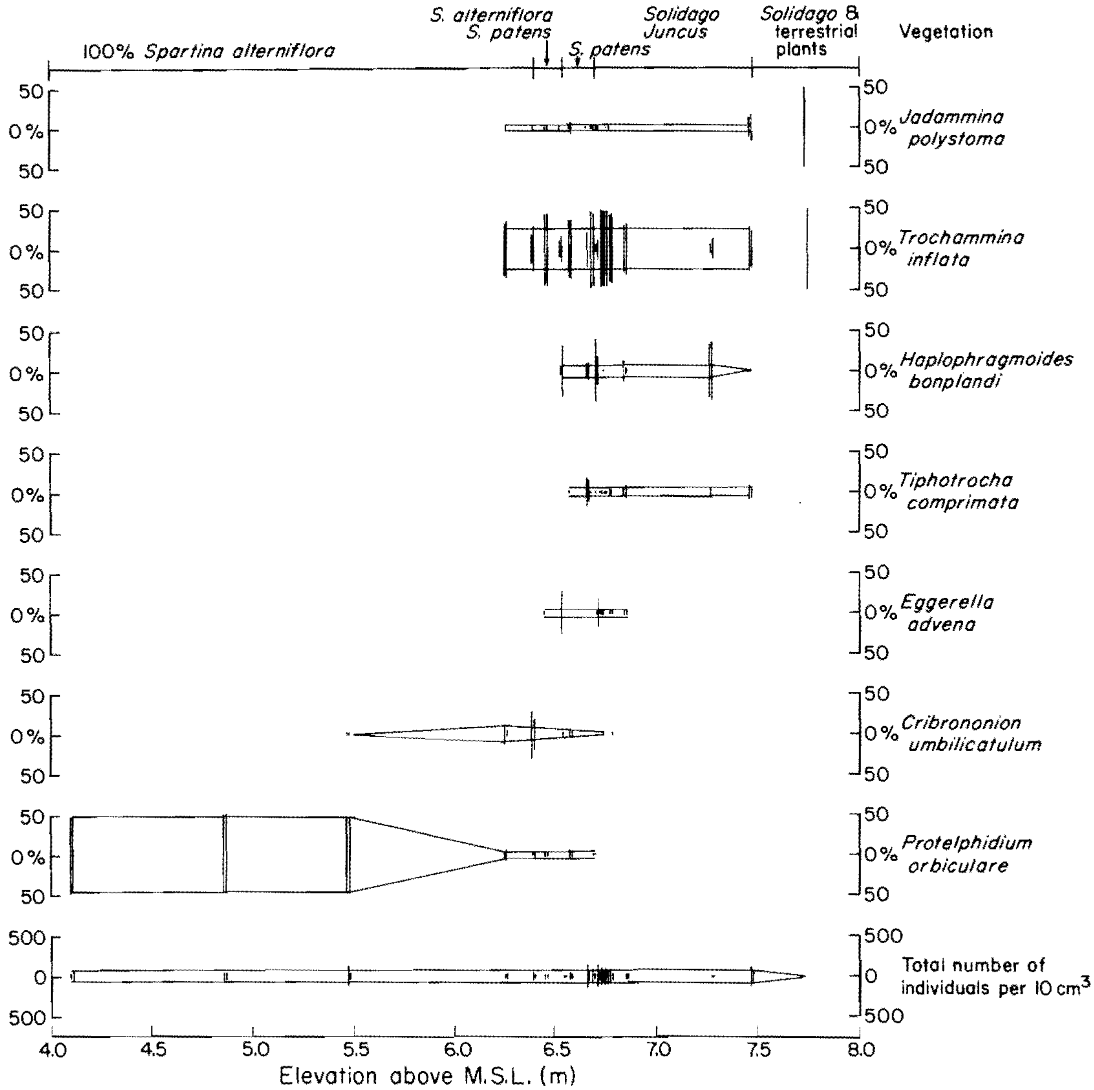


FIGURE 20

Foraminiferal and plant distributions along the Newport Landing transect. Format similar to Fig. 9 except that there is no horizontal component in this diagram and the species percentages are plotted directly against elevation above mean sea level.

In Chezzetcook, the plants remain the same in each zone in all parts of the estuary, although salinity changes noticeably from the upper to the lower parts of it. Only one zone appears to be a response to lower salinity and that is the *Solidago sempervirens* area which occurs in the middle marsh of the upper estuary. It appears that the development of zones is caused principally by elevation changes (i.e., time of exposure between tidal cycles). The development of the high-marsh zone, however, could be the result of increased freshwater influence in higher parts of the tidal range. Many of the characteristic high-marsh plants also inhabit freshwater and terrestrial environments. All of these plants are restricted from higher elevations more by competition than by actual inability to live there (Waisel, 1972).

Since the zones are biological entities, 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 MSL to 30–49 cm below MSL. It is not uncommon to observe individuals typical of one zone growing in the next higher one. The middle-marsh zone, although often covering extensive surfaces, is extremely reduced in vertical ex-

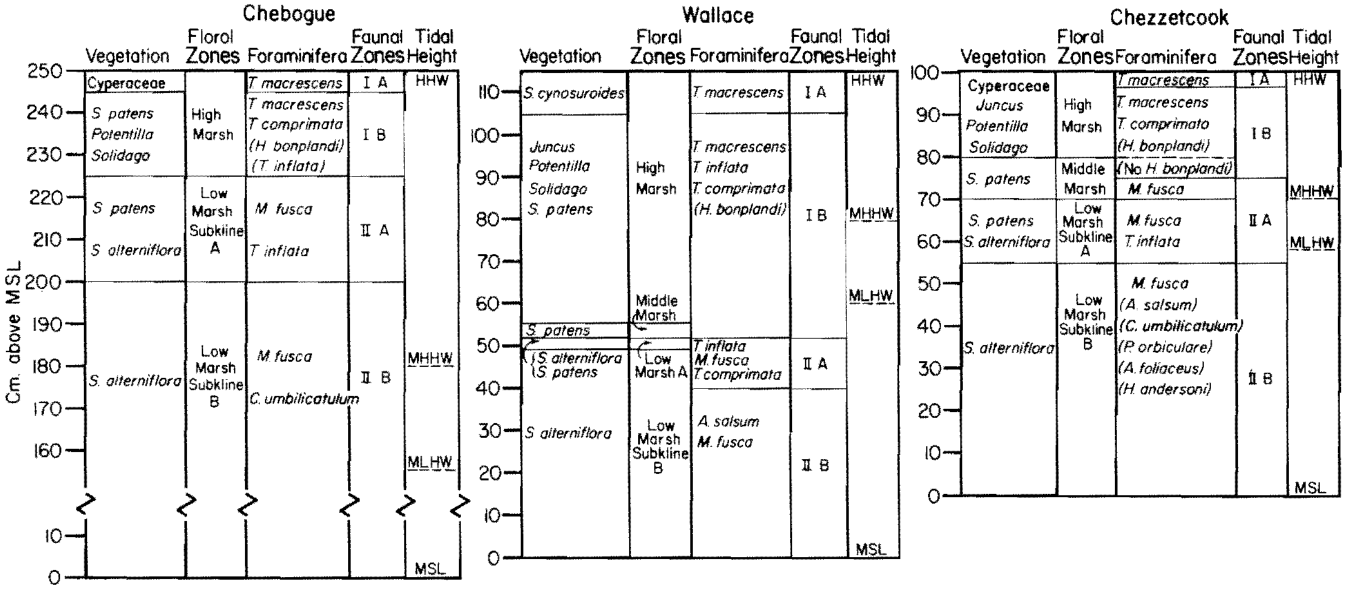


FIGURE 21

Summary and comparison of vegetation and foraminiferal data from the three major study areas in Nova Scotia.

tent. In Chebogue and Wallace the middle-marsh zone 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 (Scott, 1977) 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 (as discussed by Harrison and Bloom, 1977) might determine how vegetation zonations form within the marsh.

In the Bay of Fundy marshes the relationship between the lower edge of the marsh and MSL disappears due to the greatly expanded tidal range. These data indicate that not only time of exposure but also the depth of submergence at flood tide may be an important factor. The total vertical range of the Newport Landing marsh is approximately 3.5 m suggesting that *S. alterniflora* cannot survive at water depths greater than this. This would also suggest that if the total tidal range is more than 7 m the marsh will no longer extend down to MSL.

Distribution of Foraminifera

The foraminiferal faunae contained in the marshes examined were remarkably similar, especially considering the differences in salinities, tidal range, and climate in Nova Scotia (Fig. 21). The fauna occurring at and just below HHW is particularly important. In all marsh areas (except Summerville where there was no sampling at this level) foraminiferal numbers decrease dramatically at HHW. Just below HHW a fauna dominated by *Trochammina macrescens* occurs in all three of the larger areas. Differences in faunal zone I_B occurrences in the three areas were not substantial and could be traced to salinity differences with some species indicating a more brackish area (*Haplophragmoides bonplandi*) where others indicated a more saline area (*Trochammina inflata*). Faunal subzone 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 *Trochammina macrescens*. Faunal subzone II_B appears always to have the *M. fusca* element; however, the most pronounced regional differences occur in this subzone. In Chebogue the dominant species in subzone II_B in addition to *M. fusca*, is *Cribrononion umbilicatulum*, 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 subzone 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 subzone II_B species distribution is the same as that observed in the estuarine sediments (Scott, 1977). This suggests that most subzone II_B species are actually estuarine forms whose upper range is in the salt marsh. Using this information it should be possible to predict, without having actually to 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 Maritime Canada in almost all subzone 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.

The faunae observed in the Newport Landing marsh deserve a separate discussion. Faunal zone I is in many ways similar to those of other areas with *Trochammina inflata*, *Tiphotrocha comprimata* and *Haplophragmoides bonplandi* and low numbers of *Jadammina polystoma*. However, it differs markedly in not containing any *Trochammina macrescens*. Also this is the only marsh in the world where *Eggerella advena* has been reported as a significant component of an upper marsh fauna. The zone II fauna, composed almost entirely of *Protelphidium orbiculare*, is the only Nova Scotian marsh with few or no *M. fusca*. It cannot be generalized, from this one small area, that the foraminiferal faunae in all the Fundy marshes are similar to this one. This is particularly true in those parts of the Bay of Fundy where sedimentation rates are lower and consequently the organic content of the sediment is higher. B. Deonarine (personal commun., 1978) studied a marsh area in a small inlet along the Bay of Fundy (Clementsport) where tidal ranges were high and sedimentation rates comparatively low. The foraminiferal associations in such an area were more similar to those observed in other marshes in Nova Scotia than to those in the Newport Landing.

It is not surprising that most regional differences occur in subzone II_B since most of these species are estuarine forms. An estuary, although not a particularly stable environment, is largely subtidal and is much more environmentally stable than the marsh, especially with respect to temperature variances. With increased stability the species diversity increases along with the opportunity for faunal differentiation (Gould, 1976). 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 subzone. Indications are that, although more variety may occur locally, 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 zones. 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 appear to decrease just at the base of the marsh. Living foraminiferal populations 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 zone I fauna containing *Trochammina inflata* and *Trochammina 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 situation is not widespread in Nova Scotia today, it is conceivable that in the past, as sea level rise created the conditions for the formation of new marshes, this type of zone I fauna might have been more common.

The Tidal Role

As tidal ranges increase the zonal ranges do not appear to increase proportionally. The total marsh range appears to remain the same (MSL to HHW). Comparisons of zonal ranges at Chebogue and Chezzetcook demonstrate that most of the increases are absorbed by low marsh floral subzone B. The upper floral zones appear to retain virtually the same absolute vertical range, regardless of tidal range. In the Fundy marshes the absolute range expands but not proportionally to the increase of the tidal range. We can conclude that the high-marsh floral zones in all but extreme cases retain their absolute accuracy as sea level indicators even with increased tidal ranges and this appears to be true also for the corresponding faunal zones.

COMPARISON OF NOVA SCOTIAN AND SOUTHERN CALIFORNIAN MARSHES

Nova Scotian and southern Californian data can be compared directly because, in both areas, detailed transect sampling was carried out (Fig. 22). The Cal-

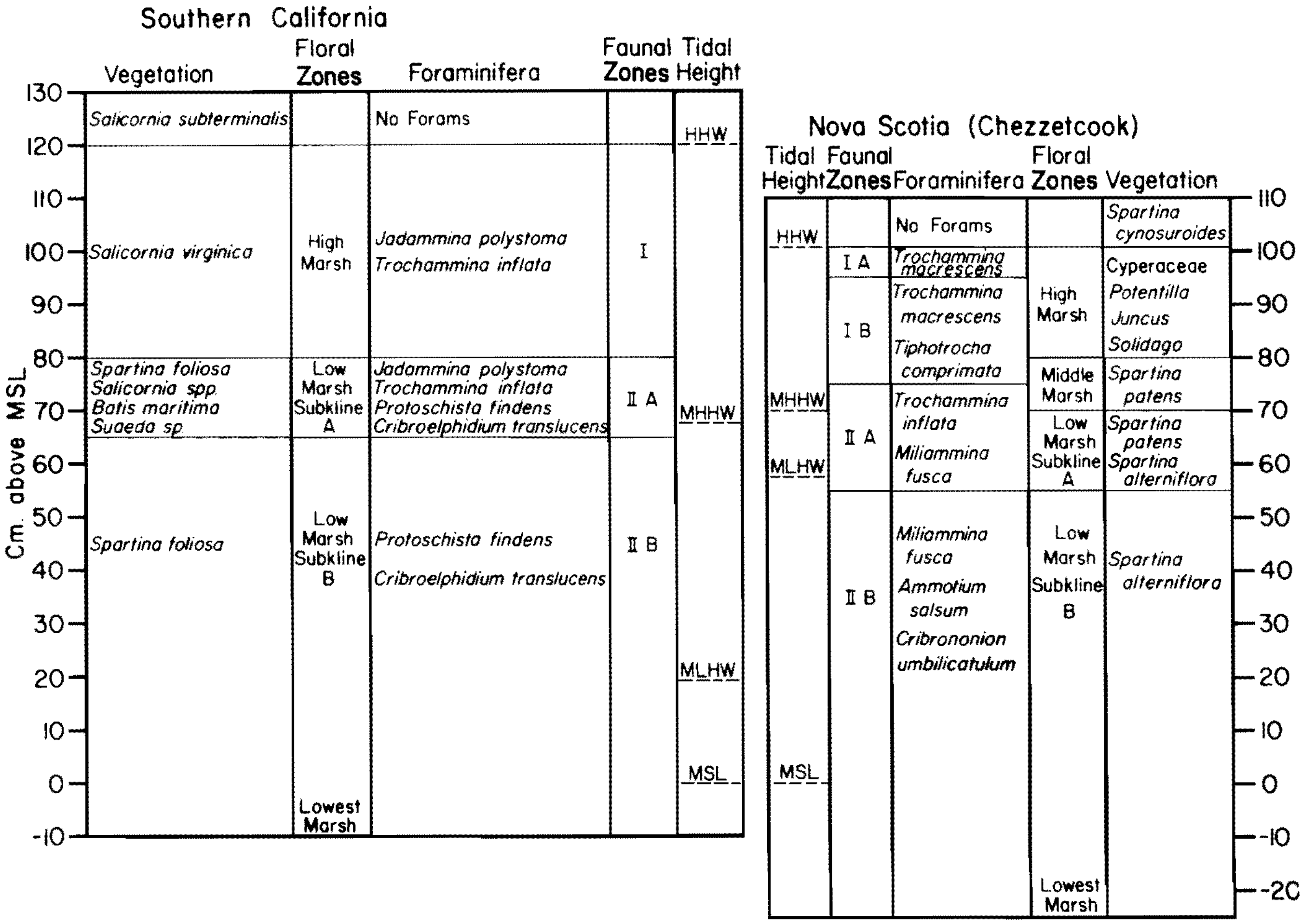


FIGURE 22

Comparison of southern Californian marsh data (from Scott, 1976a) and Nova Scotian marshes (data from Chezzetcook Inlet).

ifornian data are from Tijuana and Mission Bay (Scott, 1976a), and the Nova Scotian data are 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 and is of questionable taxonomic equivalence. In California only two distinct floral zones can be recognized with the lower zone divided into two subzones, while in some marshes in Nova Scotia, although the middle one is often narrow in extent, there are three recognizable floral zones.

The foraminiferal associations have more similarities. 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, Thurammina*(?) *limnetis, Trochammina macrescens, Polysaccamina ipohalina*). These species are all faunal zone 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 zone II differences are more complete. However, this would be expected since few of the warm-water lagoonal species in California inhabit 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 FORAMINIFERA FROM OTHER SELECTED MARSH AREAS

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 macrescens* in high numbers from the marsh areas but no attempt was made to differentiate the assemblages into faunal zones. 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 James River estuarine area an assemblage dominated by *Ammoastuta salsa* occurs in the marshes; in the middle estuary the assemblage is codominated by *A. salsa* and *Miliammina fusca*, and in the lower estuary by *M. fusca*.

Vertical zonation was demonstrated only in the upper estuarine marsh. Foraminifera appear to decrease sharply at HHW. *Ammoastuta salsa* dominates the higher marsh together with lesser percentages of *Arenoparella mexicana*, *Tiphotrocha comprimata*, and *Trochammina 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 zones are recognized with a transition zone 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 zone with *Miliammina fusca*, *Ammotium salsum*, *Cribrononion* spp., Miliolids, and *A. beccarii* dominating in the lower *Spartina* floral zone. Significantly, *M. fusca* and *T. inflata* together with *A. beccarii* dominate in the middle *Spartina–Salicornia* transition floral zone, 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 zones are characterized by a flora containing a *Salicornia–Spartina* assemblage and the high-marsh floral zone is denoted by a *Puccinella–Halimione–Suaeda* assemblage. The marsh foraminifera were delineated into two vertical zonations: *Jadammina polystoma* and *Trochammina inflata* characterizing the upper marsh and an array of calcareous species denoting the lower marsh. The upper marsh fauna is similar to that observed in California.

Kiel, Germany

Lutze (1968) examined marsh areas associated with the large, brackish Bottsand Lagoon. Although his sample coverage was limited in the marsh areas, he did indicate a vertical foraminiferal zonation similar to that in Nova Scotia. Salinities recorded were low (4–14‰).

In the highest part of the marsh Lutze (1968) reported *Tiphotrocha comprimata* and *Haplophragmoides bonplandi* as being dominant with *Trochammina macrescens–Jadammina polystoma* occurring slightly lower together with *Trochammina inflata* and *Ammotium salsum*. Lowest marsh was dominated by *Miliammina fusca* and *Cribrononion articulatum* (=*C. umbilicatulum* in this paper). These species are identical to those in Nova Scotia, particularly the presence of *H. bonplandi* in the brackish marsh.

Western Greece

Scott and others (1979) recently completed a study of some salt marsh foraminifera from the Acheloos and Evinos River deltas in Western Greece. This investigation, though not quite as detailed as the Nova Scotia or southern California studies, is sufficiently quantitative to make direct comparisons between Greece and these areas possible. The climate makes this area most comparable to southern California and salinities observed in both summer and winter seasons are similar to those of southern California. The vegetation in Greece is mostly *Salicornia* sp. with no *Spartina* spp.; there is no obvious plant zonation but an obvious foraminiferal zonation is present. *Jadammina polystoma* and *Trochammina inflata* together with *Discorinopsis aguayoi* dominate the high marsh while *Ammonia beccarii, Protelphidium depressulum,* and *Cribrononion translucens* dominate low marsh areas. Except for a couple of species these marsh faunae are exactly the same as those in California. The peculiarity that emerges from this comparison is that despite the microtidal environment in Greece (45–75 cm), the marsh foraminiferal relationships remain the same as those in other areas, although greatly compressed.

DISCUSSION

The large amount of data presented in this paper may appear to be excessive simply to substantiate apparently obvious vertical zonations that occur in the range of a salt marsh. This amount of supportive data, however, was necessary to conclusively validate the reliability of the unusual relationships observed between marsh foraminifera and absolute elevation. These relationships are not common among foraminifera; for example: estuarine foraminiferal distributions are generally controlled by salinity gradients and since many estuarine forms also inhabit salt marshes, the same might be expected of marsh foraminifera. However, the data presented demonstrate that the distributions of the marsh foraminifera are controlled at least as much by elevation above mean sea level as by salinity. Hence the controlling parameters for marsh foraminiferal distributions appear to be different from those controlling foraminiferal distributions in adjoining estuaries and lagoons. The marsh is the most marginal of the marginal marine environments, being subject to large, sudden variations in temperature and salinity, regardless of latitude (Scott, 1976b). Clearly, any species sensitive to large variations of these parameters could not survive under such conditions. The most distinctive variable in a marsh is the tidal cycle and the long times of exposure that accompany it. Relatively few marine organisms can withstand sustained exposure to the atmosphere which results in the extremely low diversity observed in marsh foraminiferal populations. As demonstrated by the marsh plant population (Waisel, 1972) these marsh organisms are not competitive under normal conditions and can colonize only areas where competition is minimal. However, salinity remains an important parameter in determining distributions of marsh foraminifera. In brackish areas, such as those in Nova Scotia, *Trochammina macrescens* and *Tiphotrocha comprimata* dominate the faunal zone I. In areas that are borderline brackish (for example, Summerville marsh), a mixed fauna of *Trochammina macrescens* and *T. inflata* occurs. In marshes with normal or higher salinities such as those in Holland and California, *T. inflata* and *Jadammina polystoma* dominate the faunal zone I. Faunal zone 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 zone II assemblages. It is worth noting here that the faunal zone I forms such as *T. inflata, J. polystoma, Tiphotrocha comprimata,* and *Trochammina macrescens* normally occur in large populations only in the upper quarter of the tidal range or not at all, regardless of salinity. This is important to paleo-oceanographic work since the presence of these species will reliably indicate the upper half of the marsh.

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 sediment. It appears clear that in salt marsh sequences foraminiferal zones can be accurately equated with distinct vertical horizons bearing a fixed relationship with the tidal cycle. Thus, non-modern subsurface marsh deposits can be correlated with former sea levels much more accurately than had been thought possible (Scott and Medioli, 1978). As the data from the Chezzetcook transects demonstrate, certain faunal zones within the marsh yield higher accuracy than others (the larger the vertical range, the lower the accuracy). The least accurate is faunal zone II, particularly subzone II_B, because it has the largest vertical range of all the faunal divisions. Faunal zone I_A has the lowest vertical range and the top of this zone 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 useful one to locate: 1) HHW represents a strandline deposit denoting the first marine incursion into an area, thus it represents 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 dynamic 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, and in itself meaningless, evidence of no foraminifera as a datum indicator. As foraminiferal zone I_A usually covers the smallest vertical interval (seldom exceeding 5 cm) at the top of the high marsh, this subzone is the most accurate indicator of sea level. HHW can be considered as the top of this subzone, where foraminifera diminish markedly. Theoretically, in a borehole, once zone I_A has been located and the point of disappearance of foraminifera has been identified, the error in sea level determination should be so small as to be negligible. More realistically we estimate the error in sea level determination does not exceed 5 cm. 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.

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

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, as suggested by Scott and Medioli (1978), 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 freshwater runoff and seawater raised by capillary action, 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 supratidal bogs or other freshwater deposits resembling marsh sediments.

The accurate determination of sea level using marsh foraminifera has many potential applications. For example accurately knowing the sea level changes in marsh sequences can aid in the development of models for changes in coastal water bodies. Additionally, it appears that certain marsh levels could be used as accurate datums in coastal zone planning which was the original impetus for examining marsh foraminifera by the senior author and John Bradshaw in San Diego. However, the most obvious application is to the problem of Holocene sea level changes. The authors have successfully used marsh foraminiferal assemblages to determine small-scale variations of apparent sea level that have taken place during the last 2,000–3,000 years in Atlantic Canada. The observed changes are in the order of 1 to 5 meters and *could not have been detected* without the use of marsh foraminiferal assemblages to locate accurately the sea level datum. These extremely accurate measurements can then be used to calibrate recently derived geophysical models of relative sea level changes (Farrell and Clark, 1976) and crustal movements (Peltier and Andrews, 1976) following deglaciation.

CONCLUSIONS

1. Despite the many variables present in the salt marsh environment the plant and foraminiferal assemblages seem to follow well-defined distribution patterns. These patterns appear to become less defined only in extreme tidal situations such as the Bay of Fundy.
2. Plant composition of the floral zones 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. Seasonal variations in living populations of marsh foraminifera (Scott, 1977, 1978) although substantial, usually do not significantly alter the total percentage occurrences of species composing the dominant elements in marsh assemblages.
4. Extremely detailed sampling in Chezzetcook allowed placing less detailed salt marsh data from Wallace, Chebogue, Summerville, and Newport Landing into a framework for determining accurate former sea levels.
5. Data from all areas in Nova Scotia indicate that marsh foraminiferal zones can be used to accurately locate former sea levels in subsurface sediments.
6. 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 foraminiferal numbers at this level is useful for differentiating marine from nonmarine peat deposits.
7. Examination of detailed studies in California and less detailed ones from many parts of the world suggests that marsh foraminifera could be generally used as accurate sea level indicators on a worldwide basis.

SYSTEMATIC TAXONOMY

Approximately 40 foraminiferal species have been identified in this study but only those with significant occurrences are discussed. Representative specimens of all illustrated species have been deposited in the Smithsonian Institution collections together with the holotype and two paratypes of the newly described species.

Specimens of species that were not familiar to the authors were sent either to the Smithsonian Institution in Washington, D.C., or to Ruth Todd in Massachusetts for verification. The original reference and some of the subsequent ones under different names are listed for each species. Included are local references and those that are discussed in the text. Generic names are in accordance with Loeblich and Tappan (1964) with two exceptions discussed under the appropriate species.

Ammobaculites dilatatus Cushman and Brönnimann
Plate 1, Figures 9, 10

Ammobaculites dilatatus CUSHMAN AND BRÖNNIMANN, 1948a, p. 39, pl. 7, figs. 10, 11; COLE AND FERGUSON, 1975, p. 32, pl. 2, figs. 8, 9; SCOTT AND OTHERS, 1977, p. 1578, pl. 2, fig. 6; SCOTT, 1977, p. 164, pl. 2, figs. 9, 10; SCHAFER AND COLE, 1978, p. 27, pl. 3, fig. 9.

Ammobaculites foliaceus (H. B. Brady)
Plate 1, Figures 6–8

Haplophragmium foliaceum H. B. BRADY, 1884, p. 304, pl. 33, figs. 20–25.
Ammobaculites c.f. *foliaceus* (H. B. Brady). PARKER, 1952b, p. 444, pl. 1, figs. 20, 21.
Ammobaculites foliaceus (Brady). SCOTT AND OTHERS, 1977, p. 1578, pl. 2, fig. 3; SCOTT, 1977, p. 164, pl. 2, figs. 6–8.

Ammonia beccarii (Linné)
Plate 5, Figures 8, 9

Nautilus beccarii LINNÉ, 1758, p. 710.
Ammonia beccarii (Linné). BRUNNICH, 1772, p. 232; FRIZZELL AND KEEN, 1949, p. 106; GREGORY, 1970, p. 222, pl. 12, figs. 4–6; SCHNIKTER, 1974, p. 216–223, pl. 1; COLE AND FERGUSON, 1975, p. 32, pl. 9, figs. 1, 2; SCOTT, 1977, pl. 6, figs. 10, 11; SCHAFER AND COLE, 1978, p. 27, pl. 8, fig. 6.
Streblus beccarii (Linné). FISCHER DE WALDHIEM, 1817, p. 449, pl. 13; BRADSHAW, 1957, p. 1138, text fig. 1a–c; PHLEGER AND EWING, 1962; p. 179, pl. 5, figs. 22, 23.
"*Rotalia*" *beccarii* (Linné) var. *tepida* CUSHMAN, 1926, p. 79, pl. 1; PARKER, 1952b, p. 457, pl. 5, figs. 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 them.

Ammotium salsum (Cushman and Brönnimann)
Plate 1, Figures 11–13

Ammobaculites salsus CUSHMAN AND BRÖNNIMANN, 1948b, p. 16, pl. 3, figs. 7–9.
Ammoscalaria fluvialis PARKER, 1952b, p. 444, pl. 1, figs. 24, 25.
Ammotium salsum (Cushman and Brönnimann). PARKER AND ATHEARN, 1959, p. 340, pl. 50, figs. 6, 13; SCOTT AND OTHERS, 1977, p. 1578, pl. 2, figs. 4, 5; ZANINETTI AND OTHERS, 1977, p. 177, pl. 2, figs. 4, 5; SCOTT, 1977, p. 165, pl. 2, figs. 11–13.

Arenoparella mexicana (Kornfeld)
Plate 4, Figures 8–11

Trochammina inflata (Montague) 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, figs. 8–10; ZANINETTI AND OTHERS, 1977, p. 177, pl. 2, figs. 3, 7; SCOTT, 1977, p. 165, pl. 5, figs. 10–13.

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

Cribrononion excavatum (Terquem)
Plate 5, Figures 5, 6

Polystomella excavata TERQUEM, 1876, p. 429.
Polystomella straito-punctata (Fichtel and Moll) var. *selseyensis* HERON-ALLEN AND EARLAND, 1911, p. 448.

Elphidium excavatum (Terquem). CUSHMAN, 1930, p. 21, pl. 8, figs. 1–3; SCHAFER AND COLE, 1978, p. 27, pl. 9, fig. 7; LÉVY AND OTHERS, 1975, p. 176, fig. 9, pl. 3, figs. 1, 2, 5, 6.
Cribrononion excavatum (Terquem). LUTZE, 1965, p. 96–101, p. 15, fig. 39; LÉVY AND OTHERS, 1969, p. 93, pl. 1, figs. 1a, b, 2a, b, 4a, b.
Elphidium excavatum (Terquem) formae. FEYLING-HANSSEN, 1972, p. 337–354, pls. 1–6.
Cribroelphidium excavatum (Terquem) forma *clavatum* (Cushman). SCOTT AND OTHERS, 1977, p. 1578, 1579, pl. 5, figs. 1, 2; SCOTT, 1977, p. 169, 170, pl. 6, fig. 2.
Cribroelphidium excavatum (Terquem) forma *selseyensis* (Heron-Allen and Earland). SCOTT AND OTHERS, 1977, p. 1579, pl. 5, fig. 3; SCOTT, 1977, p. 170, pl. 6, fig. 3.

Remarks: Although we have differentiated the two formae *clavatum* and *selseyensis* after Feyling-Hanssen (1972) in our plates and in the tables, we recently have reached the conclusion that the separation is completely arbitrary since there appeared to be a continuous series of intermediate forms between the two extremes. Miller (1979) has produced detailed photographic documentation of such an intergradational series.

It is quite clear that there is some confusion regarding the differences between *Elphidium*, *Cribroelphidium*, and *Cribrononion*. We agree with Loeblich and Tappan (1964) on a narrow definition of *Elphidium* which makes the genus unsuitable for this species. We do not accept their criterion of differentiating between *Cribroelphidium* and *Cribrononion*. Loeblich and Tappan (1964) state that the difference between the two genera is that *Cribroelphidium* has areal aperture(s) in addition to the row of pores at the base of the septal face while *Cribrononion* lacks the areal apertures. As we will show later in this section, and has been suggested by Boltovskoy (1958), for *Trochammina macrescens* Brady, this trait may not even be a

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PLATE 1

1–3 *Thurammina*(?) *limnetis* n.sp. 1. Specimen with several apertures, holotype, USNM 278127, ×58. 2. Specimen with only one aperture, paratype, USNM 278128, ×46. 3. Attached side of specimen with no agglutinated material, paratype, USNM 278129, ×52. All specimens from station 7c, Wallace Basin.

4, 5 *Hemisphaerammina bradyi* Loeblich and Tappan. 4. Several specimens attached to each other, ×54. 5. Specimen attached to *Miliammina fusca*. All specimens from station 7d, Chezzetcook Inlet.

6–8 *Ammobaculites foliaceus* (H. B. Brady). 6. Side view of typical specimen, ×44. 7. Side view of specimen with extended uniserial chambers, ×41. 8. Aperture view, ×54. All specimens from station 14a, Chezzetcook Inlet.

9, 10 *Ammobaculites dilatatus* Cushman and Brönnimann. 9. Side view, ×94. 10. Aperture view, ×193. Specimens from station 8a, Wallace Basin.

11–13 *Ammotium salsum* (Cushman and Brönnimann). 11. Side view of specimen with extended uniserial chambers, ×58. 12. Side view of typical form, ×80. 13. Aperture view, ×76. Specimens from station 6f, Wallace Basin.

PLATE 2

1–3 *Miliammina fusca* (Brady). 1. Side view (four-chamber side), ×43. 2. Side view (three-chamber side), ×43. 3. Aperture view, ×65. Specimens from station 20b, Chezzetcook Inlet.

4, 5 *Haplophragmoides bonplandi* Todd and Brönnimann. 4. Side view, ×70. 5. Aperture view, ×129. Specimens from station 4a, Chezzetcook Inlet.

6 *Reophax nana* Rhumbler. 6. Side view, ×169. Specimen from station 47c, Chezzetcook Inlet.

7 *Eggerella advena* (Cushman). 7. Side view, ×92. Specimen from station 5a, Newport Landing.

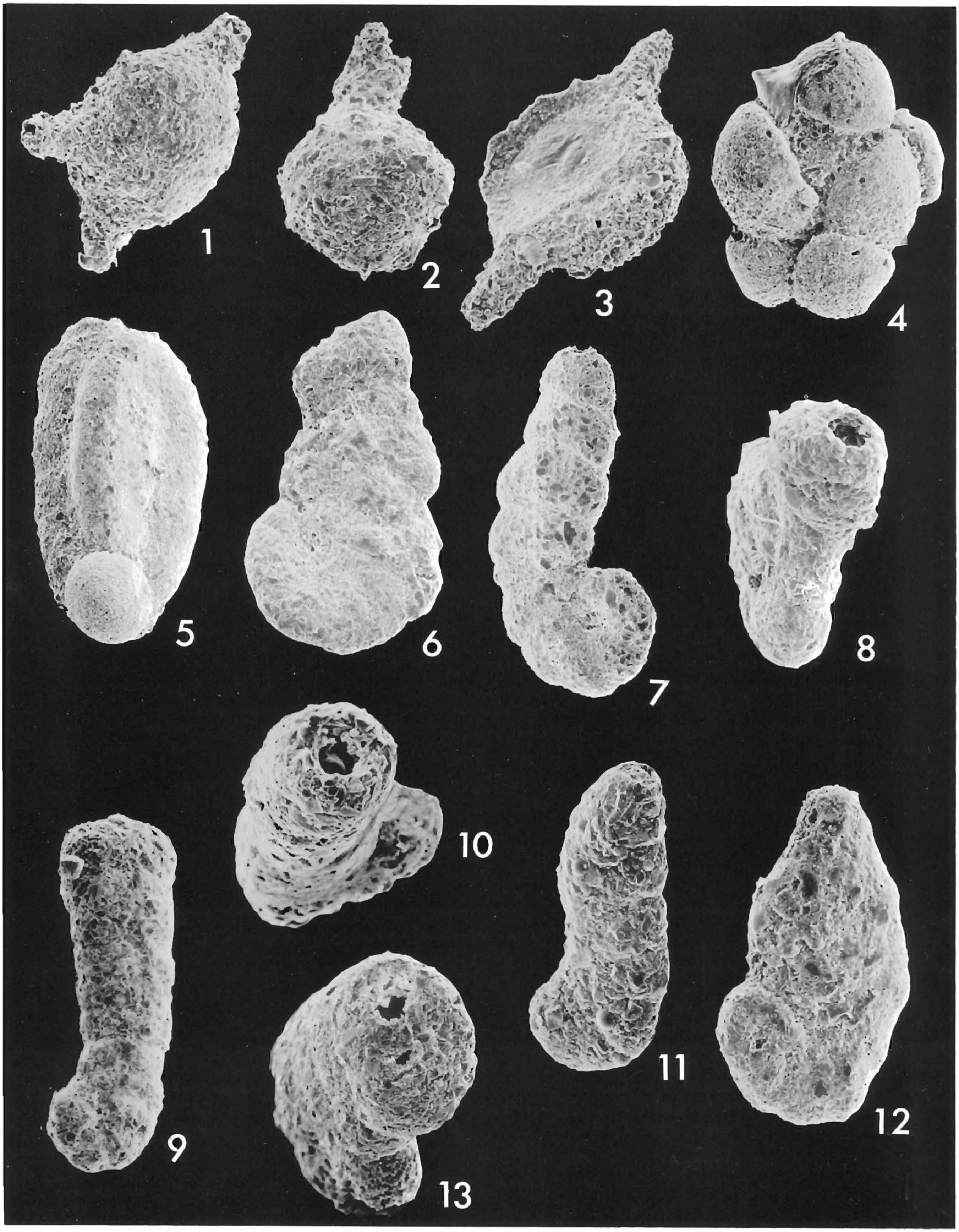
8–11 *Polysaccammina ipohalina* Scott. 8. Side view of typical specimen, ×78. 9. Attached side of specimen, illustrating chamber flattening on attached side, ×61. 10. Enlargement of chamber connection, ×143. 11. Enlargement of aperture, ×410. All specimens from station 7b, Chezzetcook Inlet.

PLATE 3

1–8 *Trochammina macrescens* Brady. 1. Dorsal view, ×98. 2. Aperture view, ×68. 3. Ventral view of specimen with straight sutures, a deep umbilicus, and well-defined umbilical teeth, ×51. 4–8. Series of specimens illustrating progressively more curved sutures and less of an umbilicus, ×56. All specimens from station 46, Chezzetcook Inlet.

9–11 "*Jadammina polystoma*." 9. Ventral view, ×60. 10. Aperture view, note the large number of supplementary apertures, ×51. 11. Dorsal view, ×55. Note similarity between Fig. 8 and Fig. 9. Only difference is the supplementary apertures. Specimens from station 7c, Chezzetcook Inlet.

12–14 *Trochammina inflata* (Montagu)—meglaspheric form. 12. Dorsal view, ×55. 13. Apertural view, ×86. 14. Ventral view, ×109. All specimens from station 1F, Chezzetcook Inlet.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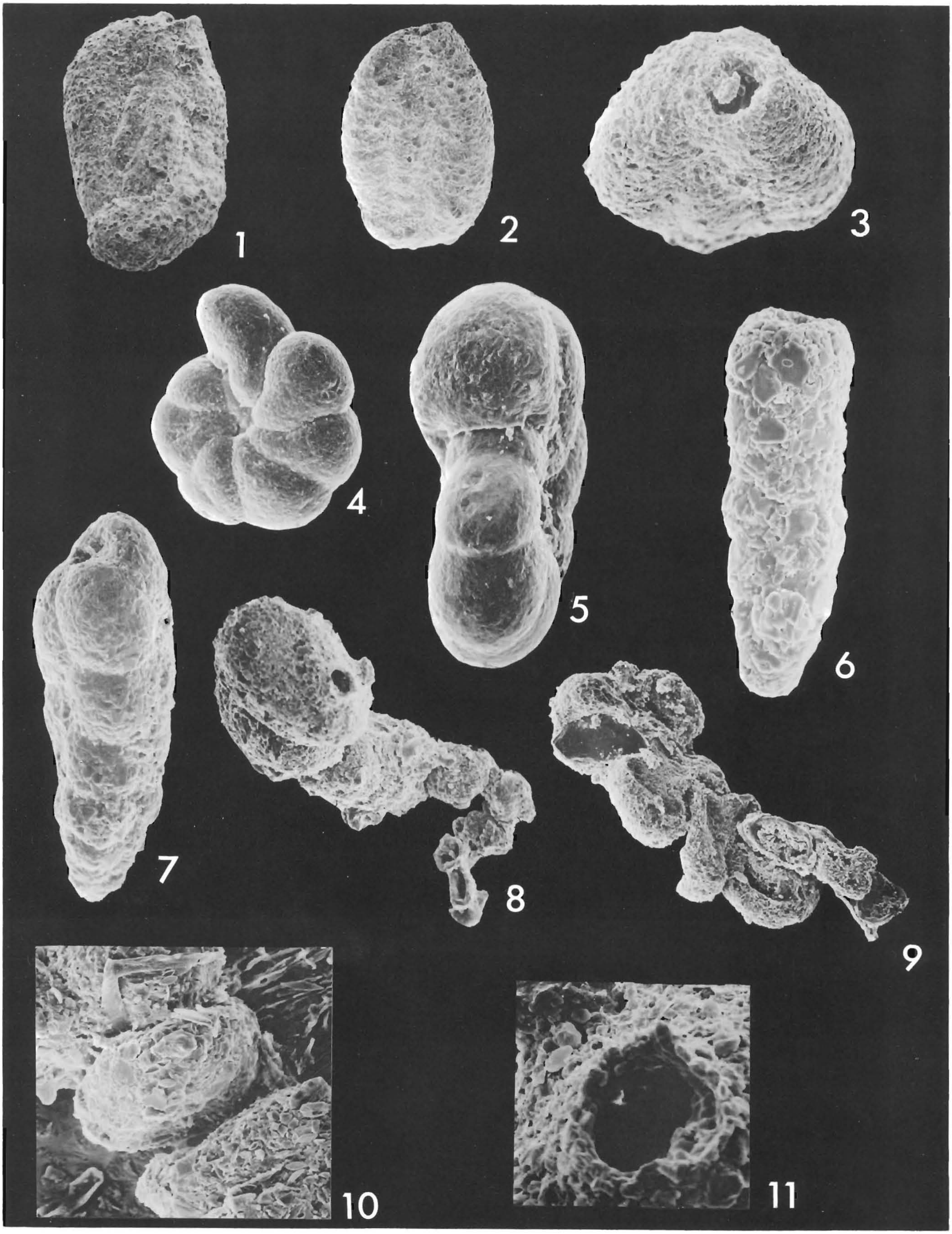
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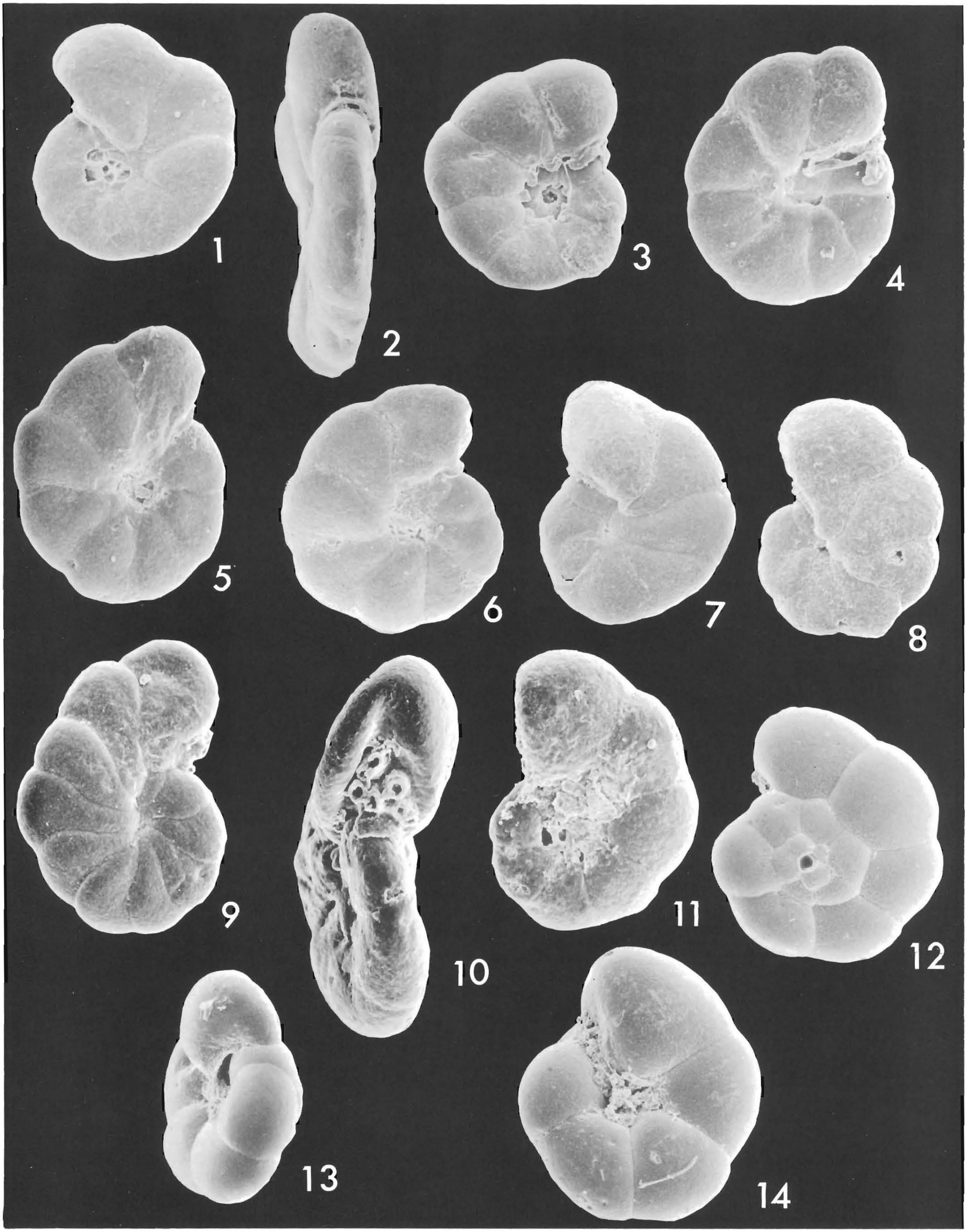
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defining one at the specific level. Hence in our opinion *Cribroelphidium* and *Cribrononion* are synonyms and *Cribrononion* must be retained since it has priority.

Recently Lévy and others (1975) and Rosset-Moulinier (1976) reported the presence of retral processes in *C. excavatum* and placed the species back into the genus *Elphidium*. However, we believe that the presence of retral processes only does not necessarily mean that the species belongs to *Elphidium*, especially considering the type species of the genus, which is quite different from *C. excavatum*. Hence we have left this species in *Cribrononion*. It is possible that the Thalmann (1947) definition of *Cribrononion* may need revision, after a study of its type species, to include the possible presence of retral processes.

Cribrononion umbilicatulum (Williamson)
Plate 5, Figure 4

Polystomella umbilicatula WILLIAMSON, 1858, p. 42–44, figs. 81–82.
Elphidium excavatum (Terquem). CUSHMAN, 1930, p. 21, pl. 8, figs. 4–7.
Cribrononion cf. *alvarezianum* (d'Orbigny). LUTZE, 1965, p. 101, pl. 15, fig. 46.
Elphidium umbilicatulum (Williamson). LEVY AND OTHERS, 1969, p. 96, pl. 1, figs. 6a, b, pl. 2, figs. 1, 2.
Cribroelphidium excavatum (Terquem). SCOTT AND OTHERS, 1977, p. 1578, pl. 5, fig. 4; SCOTT, 1977, p. 169, pl. 6, fig. 1.

Remarks: In our opinion this species has commonly been called *Cribroelphidium excavatum* or sometimes *Cribroelphidium margaritaceum* in this area. Examination of the work of Lévy and others (1969) and our own material clearly indicate that our material belongs to the species *Cribrononion umbilicatulum* and should not be placed with the *Cribroelphidium excavatum* group.

Eggerella advena (Cushman)
Plate 2, Figure 7

Verneuilina advena CUSHMAN, 1921, p. 141.
Eggerella advena (Cushman). CUSHMAN, 1937, p. 51, pl. 5, figs. 12–15; PHLEGER AND WALTON, 1950, p. 277, pl. 1, figs. 16–18; PARKER, 1952a, p. 404, pl. 3, figs. 12, 13; PARKER, 1952b, p. 447, pl. 2, fig. 3; GREGORY, 1970, p. 183, pl. 4, figs. 1–3; COLE AND FERGUSON, 1975, p. 34, pl. 3, figs. 10, 11; SCOTT AND OTHERS, 1977, p. 1579, pl. 2, fig. 7; SCOTT, 1977, p. 171, pl. 6, fig. 9; SCHAFER AND COLE, 1978, p. 27, pl. 3, fig. 1.

Haplophragmoides bonplandi Todd and Brönnimann
Plate 2, Figures 4, 5

Haplophragmoides bonplandi TODD AND BRÖNNIMANN, 1957, p. 23, pl. 2, fig. 2; SCOTT AND OTHERS, 1977, p. 1579, pl. 3, figs. 5, 6; SCOTT, 1977, p. 172, pl. 3, figs. 5, 6.

Helenina andersoni (Warren)
Plate 5, Figures 10, 11

Valvulineria sp. PHLEGER AND WALTON, 1950, pl. 2, figs. 22a, b.
Pseudoeponides andersoni WARREN, 1957, p. 39, pl. 4, figs. 12–15; PARKER AND ATHEARN, 1959, p. 341, pl. 50, figs. 28–31.
Helenina andersoni (Warren). SAUNDERS, 1961, p. 148; SCOTT, 1977, p. 173, pl. 6, figs. 12, 13.

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

Hemisphaerammina bradyi Loeblich and Tappan
Plate 1, Figures 4, 5

Hemisphaerammina bradyi Loeblich and Tappan in LOEBLICH AND COLLABORATORS, 1957, p. 224, pl. 72, fig. 2; SCOTT AND OTHERS, 1977, p. 1579, pl. 3, figs. 7, 8; SCOTT, 1977, pl. 2, figs. 4, 5; SCHAFER AND COLE, 1978, p. 28, pl. 1, fig. 5.
Crithionina pisum Goes. GREGORY, 1970, p. 165, pl. 1, fig. 6.
Hemisphaerammina sp. COLE AND FERGUSON, 1975, pl. 1, fig. 4.

Miliammina fusca (Brady)
Plate 2, Figures 1–3

Quinqueloculina fusca BRADY, 1870, p. 47, pl. 11, figs. 2, 3.
Miliammina fusca (Brady). PHLEGER AND WALTON, 1950, p. 280, pl. 1, figs. 19a, b; PARKER, 1952a, p. 404, pl. 3, figs. 15, 16; PARKER, 1952b, p. 452, pl. 2, figs. 6a, b; PARKER AND ATHEARN, 1959, p. 340, pl. 50, figs. 11, 12; GREGORY, 1970, p. 172, pl. 2, fig. 8; COLE AND FERGUSON, 1975, p. 37, pl. 4, figs. 1, 2; SCOTT AND OTHERS, 1977, p. 1579, pl. 2, figs. 8, 9; SCOTT, 1977, p. 173, pl. 3, figs. 1–3; SCHAFER AND COLE, 1978, p. 28, pl. 12, fig. 2.

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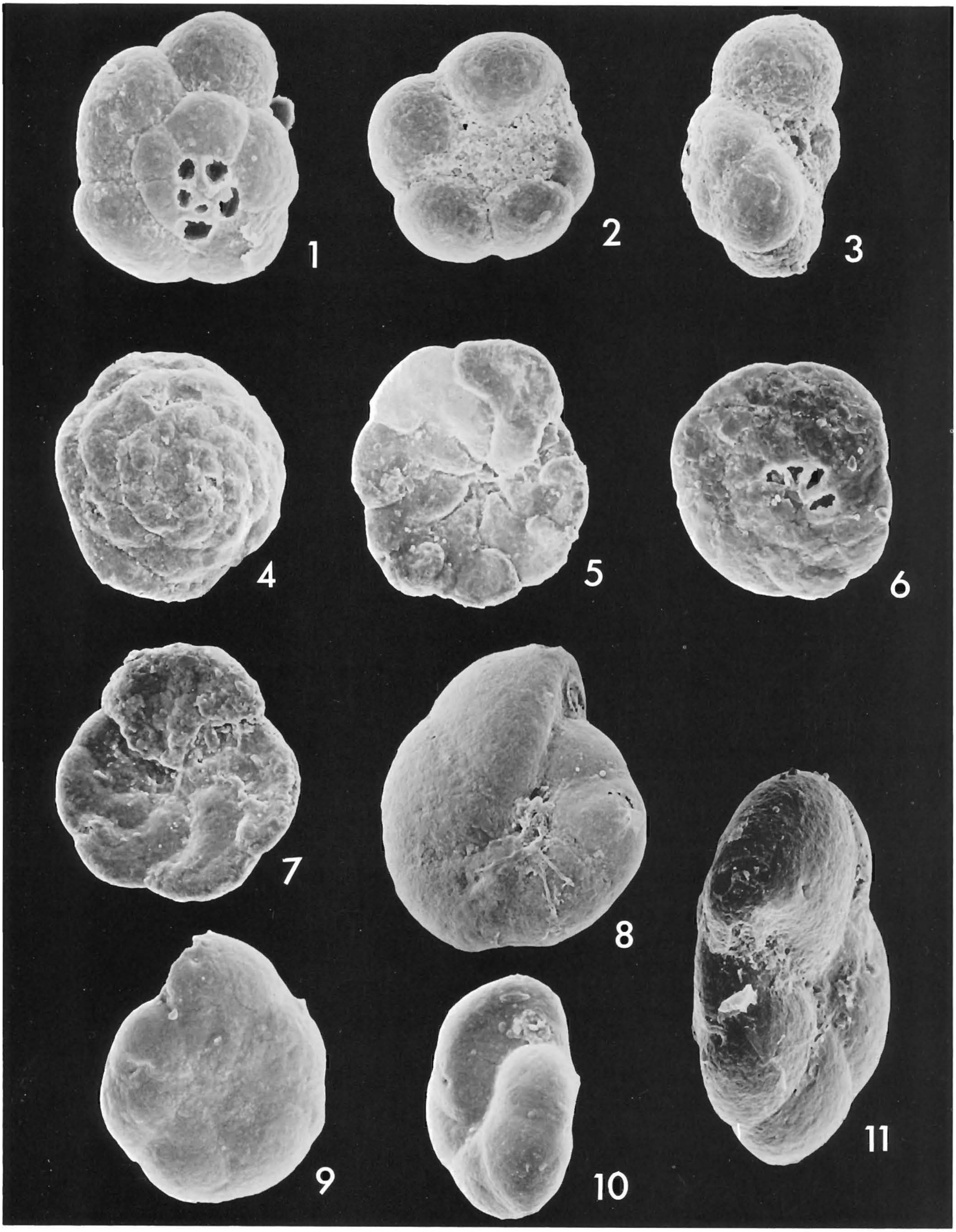
PLATE 4

1–3 *Trochammina inflata*—microspheric form. 1. Dorsal view, ×95. 2. Ventral view, ×86. 3. Apertural view, ×95. All specimens from station 1F, Chezzetcook Inlet.

4, 5 *Trochammina ochracea* (Williamson). 4. Dorsal view, ×116. 5. Ventral view, ×106. Specimens from station 17a, transect V, Chezzetcook Inlet.

6, 7 *Trochammina squamata* Parker and Jones. 6. Dorsal view, ×120. 7. Ventral view, ×99. Specimens from station 3h, Chebogue Harbour.

8–11 *Arenoparella mexicana* (Kornfeld). 8. Ventral view, ×86. 9. Dorsal view, ×117. 10. Aperture view, aperture partially obscured, ×112. 11. Aperture view with additional aperture above the vertical slit, ×99. Specimens from station 29b, transect III, Chezzetcook Inlet.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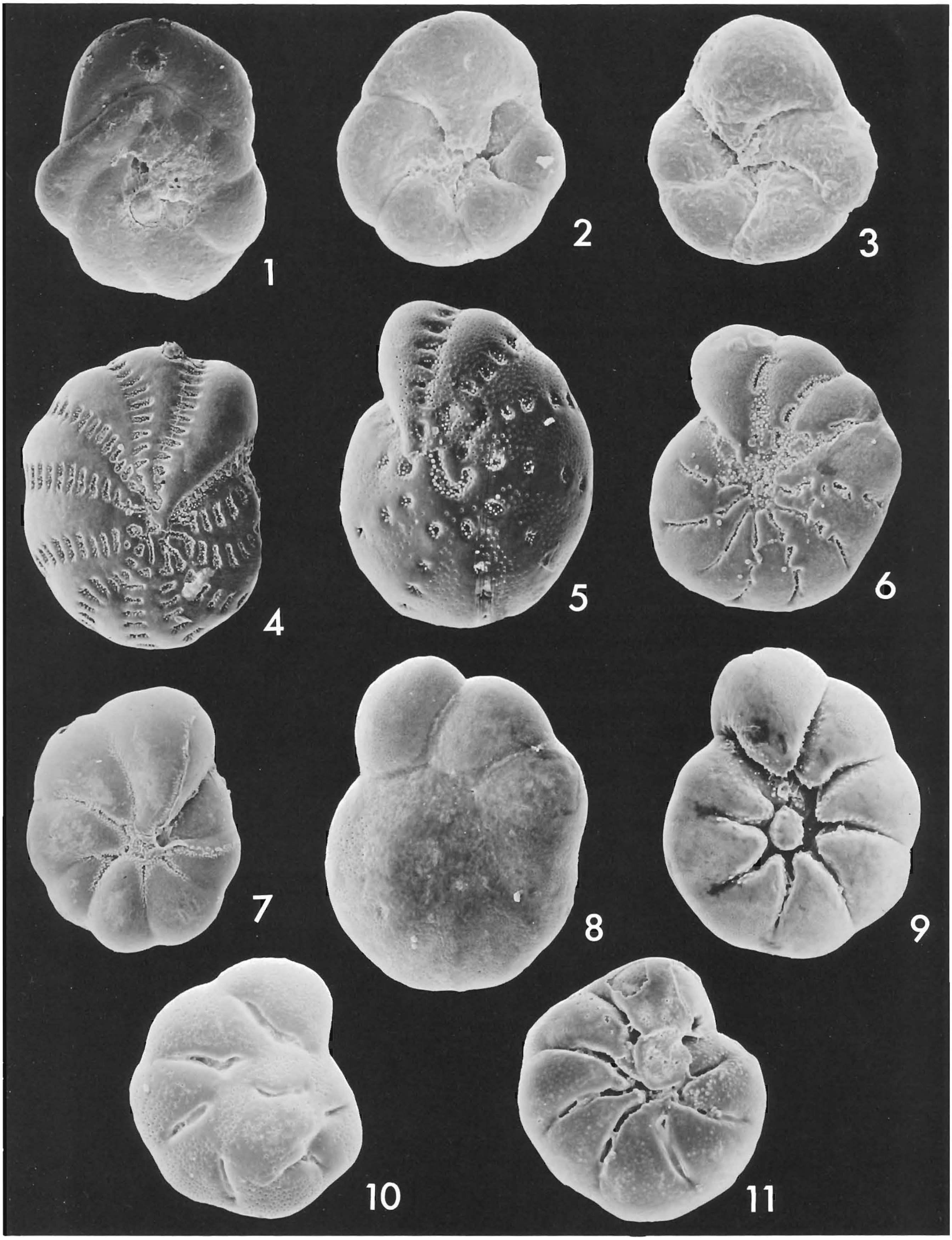
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Polysaccammina ipohalina Scott
Plate 2, Figures 8–11

Polysaccammina ipohalina SCOTT, 1976b, p. 318, pl. 2, figs. 1–4, text figs. 4a–c; ZANINETTI AND OTHERS, 1977, p. 176, pl. 1, fig. 7; SCOTT, 1977, p. 174, pl. 3, figs. 10–13.

Remarks: This recently described species probably has a worldwide distribution in marshes but has suffered the fate of non-recognition 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 5, Figure 7

Nonionia orbiculare BRADY, 1881, p. 415, pl. 21, fig. 5.
Nonion orbiculare (Brady). CUSHMAN, 1930, p. 12, pl. 5, figs. 1–3.
Elphidium orbiculare (Brady). HESSLAND, 1943, p. 262; GREGORY, 1970, p. 228, pl. 14, figs. 5, 6.
Protelphidium orbiculare (Brady). TODD AND LOW, 1961, p. 20, pl. 2, fig. 11; COLE AND FERGUSON, 1975, p. 39, pl. 7, figs. 7, 8; SCOTT AND OTHERS, 1977, p. 1579, pl. 5, figs. 5, 6; SCOTT, 1977, p. 174, pl. 6, fig. 9; SCHAFER AND COLE, 1978, p. 28, pl. 10, fig. 5.

Reophax nana Rhumbler
Plate 2, Figure 6

Reophax nana RHUMBLER, 1911, p. 182, pl. 8, figs. 6–12; PARKER, 1952b, p. 457, pl. 1, figs. 14, 15; SCOTT AND OTHERS, 1977, p. 1579, pl. 3, figs. 1, 2; SCOTT, 1977, p. 175, pl. 3, fig. 7; SCHAFER AND COLE, 1978, p. 29, pl. 2, fig. 4.

Thurammina(?) limnetis n.sp.
Plate 1, Figures 1–3

Armorella sphaerica Heron-Allen and Earland. PHLEGER AND WALTON, 1950, p. 277, pl. 1, fig. 1.
Astrammina rara Rhumbler. ELLISON AND NICHOLS, 1976, p. 141; SCOTT, 1977, p. 166, pl. 2, figs. 1–3.
Astrammina sphaerica (Heron-Allen and Earland). ZANINETTI AND OTHERS, 1977, p. 176, pl. 1, fig. 9.

Holotype: One specimen from Wallace Basin, USNM [no.] 278127.

Paratypes: Two specimens from Wallace Basin, USNM [nos.] 278128, 278129.

Type locality: Wallace Basin marsh, Station 7c.

Trivial name: λιμνῆτισ = living in marshes.

Description: Test small, free or attached, monothalamous, subglobular; variable number of irregular mammillae usually occur on the surface. Wall of variable thickness, flexible, made up of mineral grains loosely cemented to an inner, transparent, pseudochitinous layer. Apertures at the apex of mammillae. The pseudochitinous layer is normally visible in the area of attachment.

Ecology and occurrence: In our work this species was only observed from marsh sediments. Examination of material reported on by Phleger and Walton (1950) and Ellison and Nichols (1976) corroborates our own studies. In Nova Scotia the species appears restricted to middle and lower marsh areas with rare occurrences in high marsh. Salinities ranged from 10–30‰ with an optimum range for this species probably between 20 and 30‰.

This species may have suffered the same fate of non-recognition as *Polysaccammina ipohalina* because it often is difficult to differentiate from organic detrital material, particularly when it is attached. The species was included in quantitative counts only from Wallace Basin but is known to occur in all the study areas. As with *P. ipohalina* the species probably has a worldwide distribution.

Remarks: This species has been referred to the genus *Astrammina* (=*Armorella*) by various authors. Specimens of *Astrammina* collected by Cushman on the east coast of North America were examined and appear to have little in common with our forms. Our opinion, supported by examination of similar material (R. Todd, personal commun., 1978), is that this form is closer to *Thurammina* than to *Astrammina* (*As-*

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PLATE 5

1–3 *Tiphotrocha comprimata* (Cushman and Brönnimann). 1. Dorsal view, ×74. 2. Ventral view of mature specimen with characteristic T-shaped final chamber, ×68. 3. Less mature specimen without an irregular final chamber, ×74. Specimens from station 46, Chezzetcook Inlet.

4 *Cribrononion umbilicatulum* (Williamson). 4. Side view, ×60. Specimen from station 7c, Chezzetcook Inlet.

5 *Cribrononion excavatum* (Terquem) forma *clavatum*. 5. Side view, ×86. Specimen from station 7c, Chezzetcook Inlet.

6 *Cribrononion excavatum* (Terquem) forma *selseyensis*. 6. Side view, ×104. Specimen from station 47c, Chezzetcook Inlet.

7 *Protelphidium orbiculare* (Brady). 7. Side view, ×49. Specimen from station 47b, Chezzetcook Inlet.

8, 9 *Ammonia beccarii* (Linné). 8. Dorsal view, ×130. 9. Ventral view, ×110. Specimen from station 47b, Chezzetcook Inlet.

10, 11 *Helenina andersoni* (Warren). 10. Dorsal view, ×88. 11. Ventral view, ×89. Specimens from station 12b, transect IV, Chezzetcook Inlet.

trammina, as pointed out by Loeblich and Tappan, 1964, p. 185, is an *Astrorhiza*-like form with a spherical rather than discoidal center and bears very little resemblance, on close examination, with our material).

We have doubtfully attributed the species to the genus *Thurammina* only because very few *Thurammina* specimens were available for comparison and we could not ascertain whether the flexibility of the *Thurammina* wall was due to the presence of an inner pseudochitinous layer. There are few doubts, however, that a new genus (possibly "*Pseudothurammina*") is in order. In fact, *Thurammina* is reported as free, living in normal salinity water and no mention is ever made to the pseudochitinous layer while our material can be free or attached, possesses a pseudochitinous layer and seems to be restricted to marshes. Such new genus would probably belong to the subfamily Saccammininae of which it possesses most of the diagnostic features.

Tiphotrocha comprimata
(Cushman and Brönnimann)
Plate 5, Figures 1–3

Trochammina comprimata CUSHMAN AND BRÖNNIMANN, 1948a, p. 41, pl. 8, figs. 1–3.
Tiphotrocha comprimata (Cushman and Brönnimann). SAUNDERS, 1957, p. 11; PARKER AND ATHEARN, 1959, p. 341, pl. 50, figs. 14–17; SCOTT AND OTHERS, 1977, p. 1579, pl. 4, figs. 3, 4; ZANINETTI AND OTHERS, 1977, p. 176, pl. 1, figs. 4, 6; SCOTT, 1977, p. 176, pl. 5, figs. 14–16.

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 the 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*.

Trochammina inflata (Montagu)
Plate 3, Figures 12–14, Plate 4, 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, figs. 1–3; PARKER, 1952a, p. 407, pl. 4, figs. 6, 10; PARKER, 1952b, p. 459, pl. 3, figs. 2a, b; PHLEGER AND EWING, 1962, pl. 4, figs. 11, 12; GREGORY, 1970, p. 180, pl. 4, figs. 3, 4; COLE AND FERGUSON, 1975, p. 43, pl. 4, figs. 3, 4; ZANINETTI AND OTHERS, 1977, p. 176, pl. 1, figs. 1, 2; SCOTT, 1977, p. 177, pl. 4, figs. 12–14, pl. 5, figs. 1–3; SCHAFER AND COLE, 1978, p. 29, pl. 5, fig. 2.

Remarks: The microspheric form of this species (Pl. 4, Figs. 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* (M. Price, Dalhousie Biology, personal commun., 1979).

Trochammina macrescens Brady
Plate 3, Figures 1–8

Trochammina inflata (Montagu) var. *macrescens* BRADY, 1870, p. 290, pl. 11, figs. 5a–c; SCOTT, 1976b, p. 320, pl. 1, figs. 4–7; SCOTT AND OTHERS, 1977, p. 1579, pl. 4, figs. 6, 7; SCOTT, 1977, p. 178, pl. 4, figs. 1–8.
Jadammina polystoma BARTENSTEIN AND BRAND, 1938, p. 381, figs. 1a–c, 2a–l; PARKER AND ATHEARN, 1959, p. 341, pl. 50, figs. 21, 22, 27; PHLEGER AND EWING, 1962, p. 179, pl. 4, figs. 13, 14; SCOTT, 1977, p. 173, pl. 4, figs. 9–11.
Trochammina macrescens Brady. PHLEGER AND WALTON, 1950, p. 281, pl. 2, figs. 6, 7; PARKER, 1952a, p. 408, pl. 4, figs. 8a, b; PARKER, 1952b, p. 460, pl. 3, figs. 3a, b; PARKER AND ATHEARN, 1959, p. 341, pl. 50, figs. 23–25; GREGORY, 1970, p. 181, pl. 4, fig. 7; COLE AND FERGUSON, 1975, p. 43, pl. 4, figs. 6, 7; SCHAFER AND COLE, 1978, p. 29, pl. 4, fig. 3.
Jadammina macrescens (Brady). MURRAY, 1971b, p. 41, pl. 13, figs. 1–5.

Remarks: There has always been some question as to whether *Trochammina macrescens* and *Jadammina polystoma* were distinct from each other. To help solve this problem we prepared an intergradational series between the two to determine if they were linked. This technique was discussed and successfully used on a more complex foraminiferal group in a recent paper (Medioli and Scott, 1978).

A series of specimens is shown in Pl. 3 to illustrate the variability of the curvature of the suture lines on the ventral side of this group, together with other characteristics of the ventral side. Dorsally all specimens look the same. At one extreme of the series are the straight sutures with a large umbilical cavity and distinct umbilical teeth (Pl. 3, Fig. 3). Plate 3, Figs. 5–8 show specimens with progressively more curved suture lines, a reducing umbilical cavity and no umbilical teeth. The form with extremely curved sutural lines (Pl. 3, Fig. 8) is indistinguishable from what has been previously called *J. polystoma* (Pl. 3, Figs. 9–11) except for the supplementary apertures (Pl. 3, Fig. 10). Boltovskoy (1958) has suggested that supplementary apertures in some species may be environmentally controlled, rather than distinct specific characteristics. Parker and Athearn (1959) speculated that this may be the case for *T. macrescens*.

Additionally, in our material (and in the figures of Bartenstein and Brand, 1938) the number of supplementary apertures in the *J. polystoma* form appears to vary between 1 and 5, suggesting that the number of apertures is an individual rather than a specific characteristic. This, in turn, means that supplementary apertures, at least in this case, have no taxonomic significance (particularly to define a genus, i.e., *Jadammina*). If, to this consideration, we add the evidence of the intergradational series there remains little doubt that *J. polystoma* and *T. macrescens* belong to the same species. Murray (1971b) had already placed the two forms together in *J. macrescens* but, as *Jadammina* appears now to be a junior synonym of *Trochammina*, the latter has priority and these forms should then be placed in *Trochammina macrescens* Brady.

If, as it has been suggested, supplementary apertures are environmentally controlled, one would not expect the two forms to occur together. In our counts, in fact, they appeared to have different distribution patterns. The form without supplementary apertures was restricted to areas where the salinity was below 20‰ (Barnstable, Mass.; James River, Va.; Nova Scotia) whereas the one with supplementary apertures occurs in high salinity marshes (Greece, southern California, Europe). Temperature does not appear to have any influence on these forms, as shown by the presence of the form without supplementary apertures in a brackish marsh in southern California (Scott, 1976b). These forms are useful salinity indicators and it appears desirable to keep them separated. We propose the following terminology (which clearly has no taxonomic value): the form without supplementary apertures to be identified as *Trochammina macrescens macrescens*, and the one with supplementary apertures as *Trochammina macrescens polystoma*.

Trochammina ochracea (Williamson)
Plate 4, 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, figs. 8, 9; Cole and Ferguson, 1975, p. 43, pl. 4, figs. 9, 10; Scott and others, 1977, p. 1580, pl. 4, figs. 5, 8; Scott, 1977, p. 179, pl. 5, figs. 4, 5; Schafer and Cole, 1978, p. 29, pl. 4, figs. 4a, b.

Trochammina squamata Parker and Jones
Plate 4, Figures 6, 7

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

Note: *Cribrononion umbilicatulum* (Williamson) should be *C. williamsoni* (Haynes) from *Elphidium williamsoni* Haynes. J. R., 1973, Bulletin of the British Museum of Natural History, Zoology, supplement 4, p. 207–209, pl. 24, fig. 7, pl. 25, figs. 6, 9, pl. 27, figs. 1–3.

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APPENDIX TABLES 1A, B

Foraminiferal occurrences at areal marsh stations 1–6, Chezzetcook Inlet: percent living and total number of species and individuals per sample. X indicates less than 1%, L = live, T = total. *J. polystoma* is differentiated from *T. macrescens* in all of the following tables; however, the two forms are believed ecotypes of the same species (see SYSTEMATIC TAXONOMY).

STATION NUMBER		1a1	1a2	1b1	1b2	1c1	1c2	1d1	1d2	1e1	1e2	1f1	1f2	1g1	1g2	1h1	1h2
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
NO. OF SPECIES (LIVE/TOTAL)	L	0	0	2	0	0	3	2	4	5	6	3	4	6	5	3	6
	T	0	0	3	4	4	4	4	4	5	6	3	4	7	6	7	8
NO. OF INDIVIDUALS PER 10 cm³ (LIVE/TOTAL)	L	0	0	15	0	0	56	2	19	65	129	28	15	110	57	8	48
	T	0	0	585	1120	1600	1366	1824	2079	1107	1806	2544	5984	2845	846	205	201
Ammobaculites foliaceus	L																
	T																
A. dilatatus	L																
	T																
Ammonia beccarii	L											4			2		2
	T											X			X		1
Ammotium salsum	L															25	2
	T															12	3
Arenoparrella mexicana	L																
	T																
Cribrononion umbilicatulum	L										1			5	12		60
	T										X			X	1	3	21
Haplophragmoides bonplandi	L																
	T																
Jadammina polystoma	L									2	2	21	20	11	18		2
	T									3	4	9	7	4	10	2	3
Miliammina fusca	L						2	50	68	65	81		20	52	54	62	27
	T			X	X	5	6	52	39	63	70	30	43	88	76	76	65
Polysaccammina ipohalina	L																
	T																
Protelphidium orbiculare	L															12	4
	T													X	X	3	2
Quinqueloculina seminulum	L													1			
	T													X			
Reophax nana	L																
	T																
Tiphotrocha comprimata	L						4	50	16	6	4		7				
	T				1	4	7	10	21	10	8	X	X	X			
Trochammina inflata	L			6					10	5	5	75	53	21	14		
	T			2	2	X	X	21	16	11	10	62	49	6	13	1	2
T. macrescens	L			94			95		5	23	8						
	T			97	96	91	86	15	24	14	8					1	X

STATION NUMBER		2a1	2a2	2b1	2b2	2c1	2c2	2d1	2d2	2e1	2e2	3a1	3a2	3b1	3b2	3c1	3c2	3d1	3d2
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
NO. OF SPECIES (LIVE/TOTAL)	L	2	6	3	8	6	2	5	4	6	4	3	4	3	4	4	5	3	3
	T	5	7	5	7	7	8	8	5	8	7	5	5	5	4	5	8	5	5
NO. OF INDIVIDUALS PER 10 cm³ (LIVE/TOTAL)	L	28	40	12	47	46	2	65	77	405	71	17	48	98	59	31	56	290	157
	T	241	400	1711	2635	2186	5911	1560	1035	1733	1751	690	585	1154	2867	4205	2040	2108	1247
Ammobaculites foliaceus	L																		
	T																		
A. dilatatus	L																		
	T										X								
Ammonia beccarii	L									12	4								
	T									4	X								
Ammotium salsum	L									X									
	T						X			X									
Arenoparrella mexicana	L																		
	T					X	X	X											
Cribrononion umbilicatulum	L		10		2	4		8	4	60	70							83	96
	T		1		X	X	X	1	X	26	6							16	20
Haplophragmoides bonplandi	L																		
	T																		
Jadammina polystoma	L		5			2	50	9	5				2			9	4		
	T	X	2	1	1	1	1	10	6	X	X	1	X	X		1	X		
Miliammina fusca	L	91	65	31	26	28		77	71	26	24	8	7	20	22	90	33	15	2
	T	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									X	1								
	T									X	X								
Quinqueloculina seminulum	L				2														
	T				X			X											
Reophax nana	L																		
	T																		
Tiphotrocha comprimata	L	7	15	42	19	4	50	2				53	24	7	4	14	4		
	T	20	29	3	5	1	2	X	X			11	4	7	6	11	4	3	1
Trochammina inflata	L		2	25	30	46		3	19	X					2	33	18		
	T	1	X	22	31	17	24	25	27	X	X	X		X	X	30	25	2	4
T. macrescens	L		2		21	15						41	67	72	73		45	2	2
	T	9	20	9	8	22	9	X		X		87	94	89	91	12	44	10	16

STATION NUMBER		4a1	4a2	4b1	4b2	4c1	4c2	4d1	4d2	5a1	5a2	5b1	5b2	5c1	5c2
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
NO. OF SPECIES (Live/total)	L	4	3	4	3	2	3	5	1	2	4	4	5	7	3
	T	5	5	4	4	6	5	7	9	5	6	4	6	5	4
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	19	97	20	6	2	3	12	1	8	58	28	160	17	63
	T	4644	4199	1613	3323	2776	2264	2041	1207	2364	2387	6138	5964	3621	4504
Ammobaculites foliaceus	L														
	T														
A. dilatatus	L														
	T					X		X	X						
Ammonia beccarii	L														
	T								X						
Ammotium salsum	L														
	T														
Arenoparrella mexicana	L														
	T								X						
Cribrononion umbilicatulum	L							6	100						
	T							X	X						
Haplophragmoides bonplandi	L	26	14	10	17		40			75	24				
	T	2	2	1	X	X	1	1		15	26	X	X	X	
Jadammina polystoma	L														
	T		X												
Miliammina fusca	L	5		5	17	50		25				21	4	24	3
	T	X	1	2	2	4	3	8	14	X	X	4	1	1	1
Polysaccammina ipohalina	L														
	T														
Protelphidium orbiculare	L														
	T														
Quinqueloculina seminulum	L												4		
	T										X		X		
Reophax nana	L														
	T														
Tiphotrocha comprimata	L	16	17	10			20	38			7	28	15	12	10
	T	6	5	18	10	2	4	9	10	5	9	7	8	17	20
Trochammina inflata	L							1			6	28	26		
	T	X				X	X	X	1	2	1	5	6	1	1
T. macrescens	L	47	69	80	67	50	40	28		25	64	21	51	65	87
	T	91	92	79	88	93	92	82	74	78	74	84	84	50	77

STATION NUMBER		5d1	5d2	5e1	5e2	5f1	5f2	5g1	5g2	6a1	6a2	6b1	6b2	6c1	6c2
SAMPLING DATE		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)	L	3	3	1	1	1	0	2	0	1	0	0	1	0	0
	T	3	4	4	5	5	5	8	8	2	2	4	4	7	5
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	76	13	5	6	9	0	7	0	1	0	0	2	0	0
	T	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							2	1						
Ammonia beccarii	L														
	T														
Ammotium salsum	L							50							
	T					X	X	5	4					2	4
Arenoparrella mexicana	L														
	T														
Cribrononion umbilicatulum	L														
	T							1							
Haplophragmoides bonplandi	L												100		
	T											2	4	X	
Jadammina polystoma	L				1										
	T														
Miliammina fusca	L	8	15	100	100	100		50							
	T	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														
	T														
Reophax nana	L														
	T							X	X						
Tiphotrocha comprimata	L	3	8												
	T	11	30	25	9	2	4	9	10			7	11	4	4
Trochammina inflata	L														
	T		X	18	9	40	44	18	23					X	
T. macrescens	L	69	77							100					
	T	84	65	13	12	11	33	14	10	100	96	89	83	49	44

APPENDIX TABLES 2A, B

Foraminiferal occurrences at areal marsh stations 7–15, Chezzetcook Inlet: format same as Appendix Table 1.

STATION NO		7a1	7a2	7b1	7b2	7c1	7c2	7d1	7d2	7e1	7e2	8a1	8a2	8b1	8b2	8c1	8c2	8d1	8d2	9a1	9a2	9b1	9b2	9c1	9c2	9d1	9d2	9e1	9e2
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	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)	L	0	0	0	0	2	2	3	4	2	6	3	3	2	4	7	4	5	3	[illegible]	1	0	0	1	[illegible]	[illegible]	[illegible]	[illegible]	1
	T	2	2	2	2	6	5	8	8	10	6	6	7	1	5	7	6	8	0	3	3	3	1	5	5	8	4	7	5
NO. OF INDIVIDUALS PER 10 cm (Live/total)	L	0	0	0	0	14	20	50	14	1	20	34	34	112	19	74	33	42	11	0	1	0	3	14	1	[illegible]	[illegible]	[illegible]	[illegible]
	T	3	2	119	100	2140	1313	2458	3297	111	111	1518	2200	791	410	1647	1073	144	70	93	427	464	918	377	506	261	276	267	214
Ammobaculites dilatatus	L																												
	T																									X			
A. foliaceus	L																												
	T																								X			X	
Ammonia beccarii	L															5	9	10	9										
	T					X	X	X	X	1			X			1	1	14	17										
Ammotium salsum	L														2														
	T							X		1				X	3									X		2	2	X	X
Buccella frigida	L										10					1		10	18										
	T									2	2					X	X	6	8										
Centropyxis excentrica	L																												
	T																											X	
Cribrononion umbilicatulum	L					41	55	56	53	67	45	35	35	80	69	43	38	76	73										
	T					2	1	6	2	11	25	2	1	17	12	4	3	47	51										
C. excavatum clavatum	L										15																		
	T							1			5																		
Haplophragmoides bonplandi	L																												
	T																							X	X				4
Helenina andersoni	L								6	33	5		6					2											
	T							1	2	1	1		X					1	1										
Hemisphaerammina bradyi	L										5					3	6												
	T								X	33	25					X	X	6	3										
Jadammina polystoma	L																												
	T					X	X	X		1		X	1		X														
Miliammina fusca	L					59	45	40	35		20	59	59	20	26	30	27							50			100		100
	T	46	50	43	54	96	97	92	95	49	40	64	72	82	86	34	95	22	18	3	2	1	5	17	11	47	54	55	41
Protelphidium orbiculare	L														2	16		2											
	T								X	1					X	1		1											
Protoschista findens	L																												
	T																												
Quinqueloculina seminulum	L							4	6							1													
	T							X	X							X	X												
Tiphotrocha comprimata	L											6												14					
	T		50									1	2							8	4	41	31	16	14	2	6	8	7
Trochammina inflata	L																												
	T					2	X		X	1		33	24																
T. macrescens	L																				100			14	100			100	
	T	14		57	46	X						X						3		91	93	56	64	66	74	49	38	36	48
Urnulina compressa	L																												
	T																												

STATION NUMBER		10a1	10a2	10b1	10b2	10c1	10c2	10d1	10d2	11a1	11a2	11b1	11b2	11c1	11c2	12a1	12a2	12b1	12b2
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
NO. OF SPECIES (Live/total)	L	1	1	1	2	0	0	1	2	0	0	2	1	0	0	0	0	1	0
	T	6	7	6	6	5	3	3	3	5	4	4	4	3	3	2	3	4	3
NO. OF INDIVIDUALS PER 10 cm (Live/total)	L	1	1	1	2	0	0	1	12	0	0	3	3	0	0	0	0	2	0
	T	471	429	497	393	115	114	289	299	570	361	289	392	67	71	437	149	516	793
Ammobaculites dilatatus	L																		
	T		X	X	X														
A. foliaceus	L																		
	T	1	2	2	2														
Ammonia beccarii	L																		
	T																		
Ammotium salsum	L		100		50														
	T	2	2	1	1	1	1			X	X								
Buccella frigida	L																		
	T																		
Centropyxis excentrica	L																		
	T																		
Cribrononion umbilicatulum	L																		
	T																		
C. excavatum clavatum	L																		
	T																		
Haplophragmoides bonplandi	L																		
	T	X	X				X							7	18				
Helenina andersoni	L																		
	T																		
Hemisphaerammina obvia	L																		
	T																		
Jadammina polystoma	L																		
	T																	X	
Miliammina fusca	L	100		100									100						
	T	54	73	26	11	11	10	1	1	2	1	6	9			1	1	X	1
Protelphidium orbiculare	L																		
	T																		
Protoschista findens	L																		
	T					X													
Quinqueloculina seminulum	L																		
	T																		
Tiphotrocha comprimata	L								33										
	T	4	4	7	16	15	32	17	2	13	14	40	23	7			4	15	11
Trochammina inflata	L											67							
	T									1		21	23		1				
T. macrescens	L				50			100	67			33						100	
	T	37	18	61	69	71	57	82	90	84	85	33	45	85	80	99	95	85	89
Urnulina compressa	L																		
	T																		

STATION NUMBER		12c1	12c2	13a1	13a2	13b1	13b2	13c1	13c2	14a1	14a2	14b1	14b2	14c1	14c2	15a1	15a2	15b1	15b2	15c1	15c2	15d1	15d2
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	4/25/76	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)	L	0	1	1	2	2	2	1	4	1	2	2	[illegible]	2	2	4	1	[illegible]	1	1	3	3	1
	T	3	4	5	4	4	4	4	4	8	8	4	4	4	4	7	5	4	4	4	7	4	4
NO. OF INDIVIDUALS PER 10 cm (Live/total)	L	0	2	1	3	20	60	3	10	2	2	13	24	32	9	34	2	12	4	11	3	22	[illegible]
	T	252	360	57	129	1460	1538	733	411	756	1022	649	435	675	819	857	631	178	457	472	324	938	654
Ammobaculites dilatatus	L																						
	T									1	1									X	X		
A. foliaceus	L									100	50												
	T			2						8	6					X				2	2		
Ammonia beccarii	L																						
	T																						
Ammotium salsum	L															1							
	T			2	2					1	2					2	1			X	1		
Buccella frigida	L																						
	T																						
Centropyxis excentrica	L																						
	T																						
Cribrononion umbilicatulum	L																						
	T																						
C. excavatum clavatum	L																						
	T																						
Haplophragmoides bonplandi	L					20	20		10			15	4	41	78							5	
	T	1	1			13	22	4	5	X	1	8	12	30	32	X	X	1	1	X		12	11
Helenina andersoni	L																						
	T																						
Hemisphaerammina obvia	L																						
	T																						
Jadammina polystoma	L																						
	T																						
Miliammina fusca	L										30					76		8		8	12		
	T	1		21	27	1	4	3	2	25	30	4	2	X	X	56	30	6	8	9	12	X	Y
Protelphidium orbiculare	L																						
	T																						
Protoschista findens	L																						
	T																						
Quinqueloculina seminulum	L																						
	T																						
Tiphotrocha comprimata	L				33	30							4			6				23	25	4	14
	T	14	8	2	8	16	9	10	13	10	10	11	21	12	10	11	16	15	19	28	24	15	21
Trochammina inflata	L																						
	T									2	2					X				1	2		
T. macrescens	L		100	100	67	80	80	100	90			85	92	54	22	15	100	92	100	69	63	66	79
	T	85	90	74	62	70	64	84	80	53	47	80	66	69	38	31	53	76	72	85	57	38	62
Urnulina compressa	L																						
	T																						

APPENDIX TABLES 3A, B

Foraminiferal occurrences at areal marsh stations 16–20, 45–48, 56: format same as Appendix Table 1.

STATION NUMBER		16a1	16a2	16b1	16b2	16c1	16c2	16d1	16d2	17a1	17a2	17b1	17b2	17c1	17c2
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
NO. OF SPECIES (Live/total)	L	0	0	1	3	2	0	3	3	1	1	1	1	1	1
	T	5	5	4	5	5	5	3	5	4	3	5	7	7	8
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	0	0	5	4	10	0	12	14	1	15	19	2	2	2
	T	403	529	656	450	539	344	441	412	343	473	326	399	1018	1050
Ammobaculites dilatatus	L														100
	T											X	X	1	1
A. foliaceus	L														
	T												1	12	11
Ammonia beccarii	L														
	T														
Ammotium salsum	L														
	T		X		X								X	2	3
Arenoparrella mexicana	L														
	T														
Buccella frigida	L														
	T														
Centropyxis excentricus	L														
	T									X					
Cibicides lobatulus	L														
	T														
Cribrononion umbilicatulum	L														
	T														
C. excavatum clavatum	L														
	T														
C. excavatum selseyensis	L														
	T														
Difflugia capreolata	L														
	T														
D. urceolata	L														
	T														
Eggerella advena	L														
	T														
Glomospira gordialis	L														
	T														
Haplophragmoides bonplandi	L							25	7						
	T							17	12						X
Helenina andersoni	L														
	T														
Hemisphaerammina bradyi	L														
	T														
Jadammina polystoma	L														
	T	X				X	X								
Miliammina fusca	L				25	20									
	T	4	15	36	36	6	5	17	5	1	8	8	8	29	26
Pontigulasia compressa	L														
	T														
Protelphidium orbiculare	L														
	T														
Protoschista findens	L														
	T														
Quinqueloculina seminulum	L														
	T														
Reophax nana	L														
	T														
Tiphotrocha comprimata	L				25			8	14						
	T	26	26	5	4	9	11	22	20	5	8	8	17	8	10
Trochammina inflata	L														
	T	4	3	31	36	46	46	4	5			1	X	3	1
T. macrescens	L			100	50	80		67	78	100	100	100	100	100	
	T	66	55	29	22	38	37	45	58	94	64	63	73	44	44
T. ochracea	L														
	T														
Urnulina compressa	L														
	T														
Planktonics	L														
	T														

STATION NUMBER		18a1	18a2	18b1	18b2	18c1	18c2	19a1	19a2	19b1	19b2	19c1	19c2	19d1	19d2
DATE SAMPLED		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)	L	1	2	2	2	2	3	1	1	1	2	2	3	8	10
	T	4	4	4	5	8	9	6	3	5	5	6	7	14	14
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	3	4	14	2	2	5	13	24	2	15	26	252	186	183
	T	383	246	389	319	560	600	1519	2126	149	862	992	1316	522	544
Ammobaculites dilatatus	L														
	T					1	1								
A. foliaceus	L														
	T					14	4								
Ammonia beccarii	L													6	4
	T												X	8	4
Ammotium salsum	L														X
	T					8	6			1		X	X	X	X
Arenoparrella mexicana	L														
	T					X									
Buccella frigida	L													4	6
	T													2	2
Centropyxis excentricus	L														
	T														
Cibicides lobatulus	L														
	T													X	X
Cribrononion umbilicatulum	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												
	T	30	27		3										
Helenina andersoni	L													2	2
	T													1	1
Hemisphaerammina bradyi	L													1	1
	T													3	3
Jadammina polystoma	L														
	T							X	X	9	1	1	X	1	1
Miliammina fusca	L					50	60	50	100		60	38	32	20	17
	T	X	1	13	12	43	44	80	87	33	84	94	75	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			7			20								
	T	6	6	25	26	6	8	X			X	X			
Trochammina inflata	L				50			15							
	T			16	12	11	6	19	13	57	14	2	5	4	3
T. macrescens	L	100	75	93	50	50									
	T	63	66	46	46	17	30	X							
T. ochracea	L														
	T													X	
Urnulina compressa	L														
	T														
Planktonics	L														
	T														

STATION NUMBER		20a1	20a2	20b1	20b2	20c1	20c2	45a1	45a2	45b1	45b2	46a1	46a2
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
NO. OF SPECIES (Live/total)	L	1	0	3	3	2	3	2	1	2	2	4	3
	T	4	4	4	4	9	8	3	2	8	12	4	4
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	4	0	27	60	71	42	126	64	138	84	210	184
	T	555	508	530	960	1110	834	988	499	464	591	1680	1750
Ammobaculites dilatatus	L									3			
	T									1	2		
A. foliaceus	L												
	T					X	X				X		
Ammonia beccarii	L										2		
	T										X		
Ammotium salsum	L												
	T					X	X			X	1		
Arenoparrella mexicana	L												
	T												
Buccella frigida	L												
	T												
Centropyxis excentricus	L												
	T									1	1		
Cibicides lobatulus	L												
	T												
Cribrononion umbilicatulum	L					89	83						
	T		X			9	5						
C. excavatum clavatum	L												
	T												
C. excavatum selseyensis	L												
	T												
Difflugia capreolata	L												
	T									4	3		
D. urceolata	L												
	T												
Eggerella advena	L												
	T												
Glomospira gordialis	L												
	T												
Haplophragmoides bonplandi	L											8	22
	T										X	6	15
Helenina andersoni	L												
	T												
Hemisphaerammina bradyi	L												
	T												
Jadammina polystoma	L												
	T					X	X						
Miliammina fusca	L			41	63	11	14			97	98	2	
	T	1	2	56	64	90	93	1		86	78	5	4
Pontigulasia compressa	L												
	T									2	4		
Protelphidium orbiculare	L												
	T					X							
Protoschista findens	L												
	T												
Quinqueloculina seminulum	L												
	T												
Reophax nana	L												
	T												
Tiphotrocha comprimata	L			4	1		2	2				10	14
	T	4	10	3	4	X	X	2	3	X	2	7	12
Trochammina inflata	L												
	T	X		18	13	X	X						
T. macrescens	L	100		56	35			98	100			80	64
	T	93	87	22	19	X	1	98	97	5	8	82	69
T. ochracea	L												
	T												
Urnulina compressa	L												
	T										X		
Planktonics	L												
	T												

STATION NUMBER		46b1	46b2	46c1	46c2	46d1	46d2	46e1	46e2	47a1	47a2	47b1	47b2
DATE SAMPLED		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
NO. OF SPECIES (Live/total)	L	5	5	4	2	5	4	5	3	2	3	3	5
	T	6	5	8	6	8	8	11	7	7	7	10	8
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	210	670	53	38	202	81	14	27	7	9	492	903
	T	1436	2286	135	144	2230	711	227	195	27	36	1366	1748
Ammobaculites dilatatus	L												
	T												
A. foliaceus	L												
	T			2	1	1	X	3	1	7			X
Ammonia beccarii	L							7			22	45	54
	T							1		4	6	25	35
Ammotium salsum	L					1		14	4	14			
	T	X		8		2	X	16	32	26	6	1	
Arenoparrella mexicana	L												
	T												
Buccella frigida	L											X	
	T											X	
Centropyxis excentricus	L												
	T								X				
Cibicides lobatulus	L												
	T												
Cribrononion umbilicatulum	L					32	57	14	41		11	3	2
	T					8	7	1	6		3	2	1
C. excavatum clavatum	L												
	T							X	2				
C. excavatum selseyensis	L												
	T											X	
Difflugia capreolata	L												
	T												
D. urceolata	L												
	T												
Eggerella advena	L												
	T												
Glomospira gordialis	L												
	T												
Haplophragmoides bonplandi	L	2	2					7					
	T	4	5		2			1					
Helenina andersoni	L												
	T												
Hemisphaerammina bradyi	L												
	T			1									
Jadammina polystoma	L					1							
	T			1		X	X					X	
Miliammina fusca	L	13	26	5	24	50	43	57	56		67	31	31
	T	18	20	34	38	86	89	66	72	30	72	61	54
Pontigulasia compressa	L												
	T							X					
Protelphidium orbiculare	L					17	1			86		20	12
	T					3	X			26	6	10	10
Protoschista findens	L												
	T							X					
Quinqueloculina seminulum	L												X
	T												X
Reophax nana	L												
	T												
Tiphotrocha comprimata	L	3	8	2									
	T	11	12	2	6			2					
Trochammina inflata	L	3	1	4			1						
	T	1	X	4	2	X	X				1	X	
T. macrescens	L	79	68	89	76								
	T	66	62	49	51	X	2	10	4				X
T. ochracea	L												
	T									4	6	X	X
Urnulina compressa	L												
	T												
Planktonics	L												
	T									4			

STATION NUMBER		47c1	47c2	47d1	47d2	48a1	48a2	48b1	48b2	48c1	48c2	56a1	56a2
DATE SAMPLED		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)	L	9	6	3	5	4	5	4	3	3	4	3	2
	T	13	9	5	6	6	6	7	7	5	10	5	5
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)	L	1536	840	7	8	12	37	19	22	32	28	12	28
	T	3456	2216	38	62	260	148	71	143	942	731	297	370
Ammobaculites dilatatus	L												
	T												
A. foliaceus	L												
	T		1		6				1		X		
Ammonia beccarii	L	46	35		50		3	32	54	12	28		
	T	48	29	3	13	1	1	20	14	1	4		
Ammotium salsum	L	X	2		12	8	8	5			11		
	T	X	3	5	6	4	3	6		2	4		
Arenoparrella mexicana	L												
	T												
Buccella frigida	L												
	T												
Centropyxis excentricus	L												
	T												
Cibicides lobatulus	L												
	T	X											
Cribrononion umbilicatulum	L	3	2	28	12	25	24		9	6	32		
	T	3	3	5	2	1	6	1	1	X	2		
C. excavatum clavatum	L												
	T												
C. excavatum selseyensis	L	X	1										
	T	1	X					1					
Difflugia capreolata	L												
	T											X	X
D. urceolata	L												
	T											1	3
Eggerella advena	L	X											
	T	2	2										
Glomospira gordialis	L												
	T												
Haplophragmoides bonplandi	L												
	T												
Helenina andersoni	L												
	T												
Hemisphaerammina bradyi	L												
	T	X							1				
Jadammina polystoma	L												
	T									X	X		
Miliammina fusca	L	40	50	43	12	59	49	10		81	28	33	64
	T	34	46	82	69	93	84	44	48	97	88	8	13
Pontigulasia compressa	L												
	T												
Protelphidium orbiculare	L	9	10	28	12	8	36	53	36				
	T	6	14	5	3	X	4	25	32		X		
Protoschista findens	L												
	T												
Quinqueloculina seminulum	L												
	T	X											
Reophax nana	L	X											
	T	X	1								X		
Tiphotrocha comprimata	L											8	
	T											1	X
Trochammina inflata	L												
	T										X		
T. macrescens	L	X										58	36
	T	1				X			1		X	90	93
T. ochracea	L												
	T	X					1	3					
Urnulina compressa	L												
	T												
Planktonics	L												
	T												

APPENDIX TABLES 4A, B

Foraminiferal occurrences along transect I, Chezzetcook Inlet: format same as Appendix Table I, except that elevation of each sample is given.

[illegible]

[illegible]

APPENDIX TABLES 5A, B

Foraminiferal occurrences along transect III, Chezzetcook Inlet: format same as Appendix Table 4.

STATION NUMBER		1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a
ELEVATION IN cm ABOVE MSL		86	86	88	88	76	76	66	66	69	59	80	80	80	80	81
NO. OF SPECIES Living/total		3	4	[illegible]	2	5	4	5	5	4	4	4	4	4	4	[illegible]
		4	5	5	4	5	5	5	5	5	4	5	3	4	5	4
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		634	1144	313	44	692	840	524	568	397	284	1194	1334	728	434	496
		1294	2076	346	193	1766	1941	2972	2158	1197	908	2116	2546	1918	1572	1180
Ammobaculites dilatatus	L															
	T															
A. foliaceus	L															
	T															
Ammotium salsum	L															
	T															
Arenoparella mexicana	L															
	T															
Cribrononion umbilicatulum	L															
	T															
Difflugia sp.	L															
	T															
Hemisphaerammina bradyi	L															
	T															
Haplophragmoides bonplandi	L	4	10	3	2	10	8	X	1				X			
	T	8	8	4	2	11	9	X	1	X		X	X		X	
Jadammina polystoma	L															
	T															
Miliammina fusca	L					X		1	2	4	3	X		X	10	7
	T	X	X	X		2	1	6	12	7	8	1	3	5	15	19
Polysaccammina ipohalina	L															
	T															
Protelphidium orbiculare	L															
	T															
Reophax nana	L															
	T															
Tiphotrocha comprimata	L	7	6	3		16	8	15	10	6	31	12	7	10	24	8
	T	12	14	5	7	15	9	22	16	10	25	15	12	8	21	18
Trochammina inflata	L		X			4	X	16	21	8	15	1	3	1	4	
	T		1	X	1	2	X	7	9	8	9	1	3	2	4	X
T. macrescens	L	89	81	94	98	70	84	68	65	82	51	87	90	86	61	90
	T	80	76	90	90	70	81	65	63	75	58	83	81	85	60	68
T. ochracea	L															
	T															
T. squamata	L															
	T															

STATION NUMBER		8b	9a	9b	10a	10b	11a	11b	12a	12b	13a	13b	14a	14b	15a	15b
ELEVATION IN cm ABOVE MSL		81	83	81	86	80	83	83	86	84	86	86	33	33	40	60
NO. OF SPECIES Living/total		4	4	[illegible]	4	3	3	3	3	3	4	4	5	7	5	6
		4	5	6	5	3	3	4	3	3	5	5	8	9	8	7
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		728	458	380	734	590	536	510	896	1162	440	467	102	99	170	290
		1770	1730	1122	1919	1430	1430	1096	2050	1326	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		[illegible]
	T			X									X	X	X	X
Arenoparella mexicana	L												2			
	T												1			
Cribrononion umbilicatulum	L															
	T															
Difflugia sp.	L															
	T															
Hemisphaerammina bradyi	L															
	T															
Haplophragmoides bonplandi	L			X							1	X		1	X	
	T			1	X			X			X	X	X	X	X	X
Jadammina polystoma	L													1		
	T													X		
Miliammina fusca	L	6		X	1	X	8	7	1	4			13	9	13	8
	T	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	12	24	15	19	14	32	17	5	4	6	14	42	45	26	23
	T	12	18	16	23	16	26	22	8	8	11	9	25	16	9	15
Trochammina inflata	L	1	1	1	X						2	2	1		4	4
	T	1	X	X	X						1	1	2	2	3	4
T. macrescens	L	81	74	83	80	86	70	76	92	92	89	83	42	40	56	63
	T	72	78	78	70	82	59	64	86	88	84	87	51	68	63	63
T. ochracea	L															
	T															
T. squamata	L															
	T															

STATION NUMBER		16a	16b	17a	17b	18a	18b	19a	19b	20a	20b	21a	21b	22a	22b	23a
ELEVATION IN cm ABOVE MSL		89	89	89	89	88	88	87	87	85	65	83	83	87	87	91
NO. OF SPECIES (Living/total)		8	6	4	5	3	4	3	3	3	3	2	3	3	4	3
		9	8	4	7	3	4	3	3	3	3	3	4	6	6	5
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		759	1158	430	440	470	362	442	728	566	458	61	105	186	250	636
		817	2106	686	838	1580	1352	1158	2742	1466	1546	236	365	768	863	1250
Ammobaculites dilatatus	L	X	X													
	T	X	X													
A. foliaceus	L	X														
	T	X	X													
Ammotium salsum	L		X													
	T	1	X		X									X	X	
Arenoparella mexicana	L															
	T															
Cribrononion umbilicatulum	L															
	T															
Difflugia sp.	L															
	T															
Hemisphaerammina bradyi	L															
	T															
Haplophragmoides bonplandi	L	1														
	T	1	X		X											
Jadammina polystoma	L	X											4			X
	T	X											2			X
Miliammina fusca	L	4	3	51	70	4	8	4	X	X	2			1	6	
	T	11	9	43	52	4	5	4	8	2	3	1	X	13	13	4
Polysaccammina ipohalina	L				X											
	T				X									X		
Protelphidium orbiculare	L															
	T															
Reophax nana	L															
	T															
Tiphotrocha comprimata	L	10	2	1	2	19	19	18	16	8	16	12	69	19	14	8
	T	9	5	2	4	20	19	20	20	10	17	26	44	16	12	9
Trochammina inflata	L	1	X	X	X		1								X	
	T	3	2	X	X		X							X	3	X
T. macrescens	L	81	94	48	28	77	73	77	83	91	82	69	27	80	80	92
	T	75	63	53	44	76	76	76	72	88	80	73	54	70	74	87
T. ochracea	L															
	T															
T. squamata	L															
	T														X	

STATION NUMBER		23b	24a	24b	25a	25b	26a	26b	27a	27b	28a	28b	29a	29b	30a	30b
ELEVATION IN cm ABOVE MSL		91	86	86	82	82	81	81	82	82	67	67	16	16	-34	-34
NO. OF SPECIES (Living/total)		3	5	5	5	5	4	4	4	4	3	4	9	6	6	7
		5	7	7	7	6	8	5	5	9	6	7	13	12	11	10
NO. OF INDIVIDUALS PER 10 cm³ (Live/total)		264	434	822	386	346	402	682	89	281	126	352	295	116	188	435
		934	1218	1826	1164	864	1572	2010	1353	1411	3391	2796	1102	1788	1264	2297
Ammobaculites dilatatus	L												1		3	4
	T			X			X						1	X	1	1
A. foliaceus	L												3		11	16
	T											X	1	1	5	7
Ammotium salsum	L												4		8	4
	T		X		X	X	X	X		X	X		2	2	6	4
Arenoparella mexicana	L													7		
	T												X	2		
Cribrononion umbilicatulum	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															
	T									X		X	X	X	1	1
Jadammina polystoma	L			X												
	T			X	X					X					X	X
Miliammina fusca	L	1	6	5	1	1	1	1	4	X		1	83	41	76	70
	T	8	13	11	20	10	5	8	4	3	9	17	69	68	34	52
Polysaccammina ipohalina	L															
	T															
Protelphidium orbiculare	L												2	12	X	
	T												X	1	X	
Reophax nana	L															
	T						X			X			X			X
Tiphotrocha comprimata	L	7	6	11	9	11	14	9	21	10	35	16	2	19		1
	T	9	8	12	12	16	12	10	9	10	11	11	6	8	20	6
Trochammina inflata	L		5	5	14	11	20	24	38	21	27	33	X			X
	T	1	3	3	13	14	14	15	22	20	12	20	3	2	2	5
T. macrescens	L	92	62	79	76	76	64	65	38	69	38	48	4	19		X
	T	82	74	73	54	59	68	67	65	65	68	52	15	16	31	20
T. ochracea	L															
	T		X													
T. squamata	L															
	T															

APPENDIX TABLE 6

Foraminiferal occurrences along transect II, Chezzetcook Inlet: format same as Appendix Table 4.

APPENDIX TABLE 7

Foraminiferal occurrences along transect V, Chezzetcook Inlet: format same as Appendix Table 4.

APPENDIX TABLE 8

Foraminiferal occurrences along transect IV, Chezzetcook Inlet: format same as Appendix Table 4.

[illegible]	[illegible]

APPENDIX TABLES 9, 10

Foraminiferal occurrences in the Chebogue Harbour marshes: format same as Appendix Table 1.

[illegible]	[illegible]

APPENDIX TABLE 10

Continued.

STATION NUMBER	$5a_1$	$5a_2$	$5b_1$	$5b_2$	$5c_1$	$5c_2$	$5d_1$	$5d_2$	$5e_1$	$5e_2$	$6a_1$	$6a_2$	$6b_1$	$6b_2$	$6c_1$	$6c_2$	$6d_1$	$6d_2$	$7a_1$	$7a_2$	$7b_1$	$7b_2$	$7c_1$	$7c_2$	$7d_1$
NO. OF SPECIES (live/total)	4	5	6	6	5	3	6	6	3	3	5	5	0	3	3	3	5	4	0	1	3	4	3	5	3
	6	7	7	7	7	4	6	5	6	7	7	6	5	8	5	5	6	6	5	4	5	5	7	6	4
NO. OF INDIVIDUALS PER 10 cm^3 (live/total)	51	65	22	48	79	20	250	260	69	96	212	38	0	8	136	46	72	26	0	1	68	92	40	286	38
	329	356	1814	3306	2734	2394	2316	2468	202	414	3486	2898	702	1044	921	290	1246	1364	36	24	1218	1154	1472	1206	[illegible]

STATION NUMBER	$7d_2$	$7e_1$	$7e_2$	$8a_1$	$8a_2$	$8b_1$	$8b_2$	$8c_1$	$8c_2$	$8d_1$	$8d_2$	$8e_1$	$8e_2$	$8f_1$	$8f_2$	$9a_1$	$9a_2$	$9b_1$	$9b_2$	$9c_1$	$9c_2$	$10a_1$	$10a_2$	$10b_1$	$10b_2$	$10c_1$	$10c_2$
NO. OF SPECIES (live/total)	3	4	5	3	3	1	0	0	0	2	0	5	2	2	1	3	4	2	2	[illegible]	4	3	[illegible]	1	[illegible]	[illegible]	[illegible]
	4	6	6	1	3	[illegible]	4	6	5	4	3	[illegible]	7	[illegible]	7	5	5	[illegible]	[illegible]	7	[illegible]	[illegible]	6	4	[illegible]	[illegible]	[illegible]
NO. OF INDIVIDUALS PER 10 cm^3 (live/total)	20	104	140	190	36	[illegible]	0	[illegible]	[illegible]	4	[illegible]	10	10	[illegible]	5	31	28	11	[illegible]	45	14	[illegible]	10	[illegible]	3	12	[illegible]
	2376	2996	2066	1562	1064	414	381	100	97	936	1594	2106	2146	32	[illegible]	923	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	312	[illegible]	[illegible]	[illegible]

APPENDIX TABLES 11, 12

Foraminiferal occurrences in the Wallace Basin marshes: format same as Appendix Table 1.

STATION NUMBER		$1a_1$	$1a_2$	$1b_1$	$1b_2$	$1c_1$	$1c_2$	$1d_1$	$1d_2$	$2a_1$	$2a_2$	$2b_1$	$2b_2$	$2c_1$	$2c_2$	$2d_1$	$2d_2$
NO. OF SPECIES (live/total)			4	6	7	5	7	5	6	2	2	4	3	6	5	4	4
		6	3	8	3	7	9	7	7	3	2	5	4	8	7	9	8
NO. OF INDIVIDUALS PER 10 cm² (live/total)		154	58	144	382	125	520	398	130	46	51	[illegible]	32	46	38	36	48
		868	524	2130	2236	1462	[illegible]	921	861	273	212	490	233	611	359	1477	1100
[illegible]	L																
	T																
[illegible]	L																
	T																
Ammotium salsum	L								2								
	T				X		X	1	2			X			1	X	X
Arenoparrella mexicana	L			6	2											44	17
	T			1	X	X	X									4	4
[illegible]	L			3	1	6	4	4	3			3		2	2		6
	T			1	1	2	6	7	2			1		2	6	8	8
[illegible]	L																
	T																
[illegible]	L																
	T																
[illegible]	L																
	T																
[illegible]	L																
	T																
[illegible]	L	1			X		1						14	2	2		
	T	1	X	1	X		X						3	1	X		
[illegible]	L						2	2	2							11	
	T	X	X	X	X	X	1	1	1					X		8	4
Miliammina fusca	L	9	17	22	19	25	7	65	58							11	25
	T	17	42	44	40	21	22	64	76	1			X	X	X	30	36
Polysaccammina ipohalina	L													2			
	T		X											X		1	
[illegible]	L																
	T																
[illegible]	L																
	T																
[illegible]	L																
	T																
Tiphotrocha comprimata	L	17	31	12	12	17	10	8	8		4	28	23	28	37		
	T	19	14	17	12	34	26	7	5		2	8	7	34	43	7	7
Trochammina inflata	L	24	12	46	56	48	56	21	28	2		2		15	53	33	50
	T	36	9	29	32	40	42	20	14	X		X		36	37	43	40
[illegible]	L	49	40	11	8	2	1			98	96	67	64	50	3		
	T	26	34	6	5	2	3	X	X	98	98	31	90	31	12	1	2

STATION NUMBER		$2e_1$	$2e_2$	$2f_1$	$2f_2$	$3a_1$	$3a_2$	$3b_1$	$3b_2$	$3c_1$	$3c_2$	$3d_1$	$3d_2$	$3e_1$	$3e_2$	4a*	$4a_1$	$4a_2$
NO. OF SPECIES (live/total)		5	2	3	3	4	5	6	5	[illegible]	5	6	5	0	2	0	0	[illegible]
		11	9	12	16	[illegible]	8	8	3	8	7	10	11	17	11	[illegible]	[illegible]	[illegible]
NO. OF INDIVIDUALS PER 10 cm² (live/total)		60	20	22	16	344	207	62	147	176	[illegible]	84	120	249	34	[illegible]	[illegible]	[illegible]
		500	216	680	520	1846	[illegible]	1042	1426	[illegible]	1534	754	402	629	306	0	0	0
[illegible]	L											5		1	4			
	T											2	X	1	1			
[illegible]	L	1		46	25									4	5			
	T	1		1	2							X	1	4				
Ammotium salsum	L	3	10	46	25			3				10		34	74			
	T	4	5	7	4			2	X	X		10	10	26	29			
Arenoparrella mexicana	L									[illegible]				[illegible]				
	T	2		1					X	[illegible]	1	[illegible]	[illegible]	X	X			
[illegible]	L				12		1	1	5									
	T	3	5	X	1	2	2	3	6	X	X		1	[illegible]				
[illegible]	L																	
	T																	
[illegible]	L																	
	T																	
[illegible]	L																	
	T																	
[illegible]	L																	
	T																	
[illegible]	L																	
	T	1	2	3	2	X		X	X					X				
[illegible]	L									9	6		1					
	T	1	1	1	2	X		X	X	4	7	X	X	X	X			
Miliammina fusca	L	60	90		25	1	4	3	8	4	1	74	88	46	47			
	T	29	30	10	17	3	4	6	6	10	9	64	73	44	36			
Polysaccammina ipohalina	L																	
	T		1															
[illegible]	L																	
	T			X														
[illegible]	L												1	4	17			
	T											X	X	1				
[illegible]	L													1				
	T	X		2	2									X	X			
Tiphotrocha comprimata	L	7		9		27	21	64	14	11	4	2		1				
	T	13	7	18	21	26	22	20	31	7	4	2	1	1	5			
Trochammina inflata	L	27			12	44	27	23	48	18	67	5	[illegible]					
	T	36	38	35	39	45	24	66	64	72	79	16	10	7	9			
[illegible]	L					28	47	3	21									
	T	9	8	18	16	24	47	4	7	X	X	4	1	7	11			

STATION NUMBER		$5a_1$	$5a_2$	$5b_1$	$5b_2$	[illegible]	$6a_1$	$6b_1$	$6b_2$	$6c_1$	$6c_2$	$6d_1$	$6d_2$	$6e_1$	$6e_2$	$6f_1$	$6f_2$	$7a_1$	$7a_2$
NO. OF SPECIES (live/total)		3	6	0	0	2	2	3	3	4	5	4	2	7	7	4	7	0	1
		1	0	2	1	3	2	4	4	5	5	6	8	10	9	10	11	5	6
NO. OF INDIVIDUALS PER 10 cm² (live/total)		1	[illegible]	0	0	93	249	116	100	54	149	308	38	59	53	26	19	0	15
		1	0	8	1	196	440	1408	1218	1260	1055	868	1204	857	712	656	257	650	425
[illegible]	L													2			10		
	T													X	X	1	1		
[illegible]	L															8	5		
	T															X	X		
[illegible]	L													7	9	62	42		
	T													1	1	20	17		
[illegible]	L																		
	T												X		X	1	1		
[illegible]	L					3	X							17	11				
	T					1	X				3	1		2	1				
[illegible]	L	100																	
	T	100																	
[illegible]	L													3					
	T													X					
[illegible]	L																		
	T													X					X
[illegible]	L																		
	T																X		
[illegible]	L																		
	T																	4	1
[illegible]	L									2	X			3	4		5		
	T									X	1	1	3	2	4	1	X		
Miliammina fusca	L									2	2	6		48	42	23	10		
	T							1	1	12	8	10	6	45	26	20	10	7	X
Polysaccammina ipohalina	L																		
	T												X				X		
[illegible]	L																		
	T																		
[illegible]	L																		
	T															X			
[illegible]	L																		
	T																		
Tiphotrocha comprimata	L							3	10	17	8	66	90	20	19	8	21		33
	T					1		13	14	16	13	46	43	32	44	17	19	17	33
Trochammina inflata	L							36	42	15	18	26	18		15		5		20
	T			80	100			24	41	35	35	25	44	14	23	26	13	35	36
[illegible]	L					99	102	54	48	64	71	2			2				47
	T			12		99	100	62	54	39	44	3	5	X	X	14	18	27	27

STATION NUMBER		$7b_1$	$7b_2$	$7c_1$	$7c_2$	$7d_1$	$7d_2$	$7e_1$	$7e_2$	$7f_1$	$7f_2$	$8a_1$	$8a_2$	$8b_1$	$8b_2$	$8c_1$	$8c_2$	$8d_1$	$8d_2$	$8e_1$	$8e_2$	$8f_1$	$8f_2$
NO. OF SPECIES (live/total)		5	7	6	6	7	4	5	6	0	1	1	2	[illegible]	7	4	4	5	5	4	4	1	[illegible]
		[illegible]	6	7	7	9	10	10	9	8	[illegible]	9	7	8	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]
NO. OF INDIVIDUALS PER 10 cm² (live/total)		48	216	216	140	164	96	26	124	0	1	30	19	39	28	114	118	196	[illegible]	43	131	1	[illegible]
		3300	2240	816	593	1948	2624	960	1108	85	33	217	129	145	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	L											20	3										
	T											1	2	1	X								
[illegible]	L																						
	T																						
[illegible]	L											73	94	36	13								
	T					X	1	X				66	76	20	13	1							
[illegible]	L																						
	T																						
[illegible]	L	17	7	18	36	27	50	54	31		100			12	43								
	T	1	5	24	30	32	17	7	8	2	11	X	2	6	14								
[illegible]	L										3												
	T																						
[illegible]	L																						
	T																						
[illegible]	L																						
	T					X	X	X	X														
[illegible]	L																						
	T																						
[illegible]	L	33	22	39	26	2			5									7	4	2			
	T	21	18	19	11	2	2	1	1	5	3					1	X		4	2			
[illegible]	L						8								3								
	T						1	X	6					1	2								
Miliammina fusca	L					24	8	15	36					44	41								
	T	X	1	6	7	35	47	65	68	18	30	2	2	34	13	2	9	2	4				
Polysaccammina ipohalina	L			1	1	2		8															
	T	X		X	3	1	1	1	X			X											
[illegible]	L																						
	T																						
[illegible]	L											3											
	T											X											
[illegible]	L																						
	T																						
Tiphotrocha comprimata	L	25	7	9	17	34	33	15	10					5	3	4			18	9			
	T	25	17	14	22	18	13	9	12	26	37		5	4		9			12	1			
Trochammina inflata	L	17	41	8	3	2			2							72	27		46	5			
	T	32	17	7	4	2	5	7	7	15	18		3		X	43	18	41	43				
[illegible]	L	8	22	28	16	7		8	8							25	68	17	25	84	50	100	
	T	34	44	31	24	13	12	8	4	18	6	17	11	12	14	47	72	36	30	96	96	53	47

APPENDIX TABLE 13

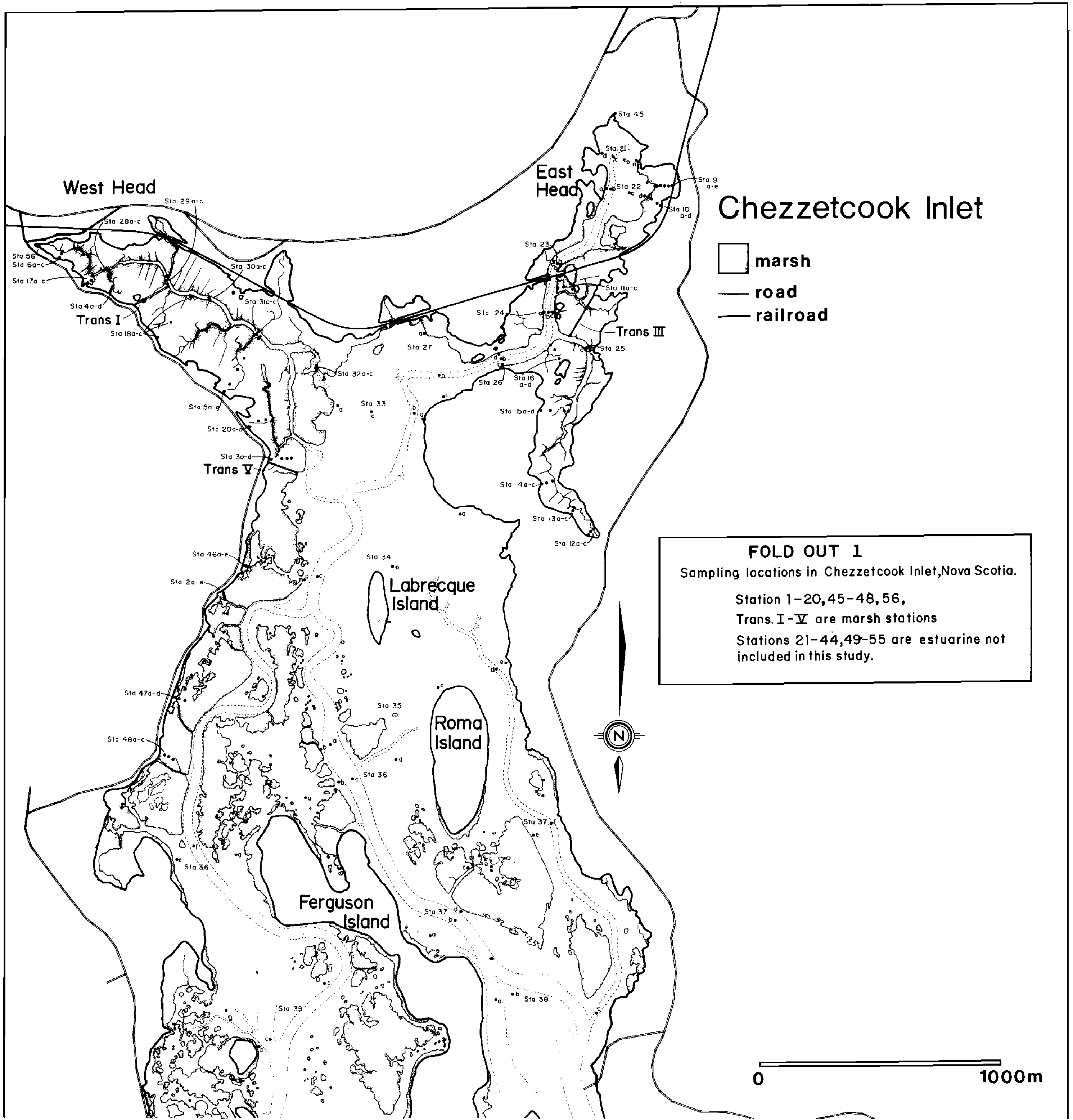
Foraminiferal occurrences in Summerville marsh: percent of living and total number of species and specimens for each sample, X indicates less than 1%, L = live, T = total. *J. polystoma* is differentiated from *T. macrescens* in all tables; however, the two forms are believed to be ecotypes of the same species (see SYSTEMATIC TAXONOMY).

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	0/460	5/822	0/568	0/1150	116/2310	0/1448	12/1036	0/1040	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																						
Cribrononion umbilicatulum	L								50	25																									
	T							2	4	1			2																						
C. excavatum clavatum	L																																		
	T	3	6			X		12	11	6	21	28	6																						
C. excavatum selseyensis	L																																		
	T							1	1	1																									
C. frigidum	L																																		
	T							2	2																										
C. incertum	L																																		
	T							1	1	4			9																						
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	8	3	94	98	10	87	17	X		4	1	7	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	35	42	58	32	56	2	2	37	8	54	48	32	40	45	46	13	9	14	14	15	19
T. 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																						

APPENDIX TABLE 14

Foraminiferal occurrences in Newport Landing transect. Format same as Appendix Table 13 except that elevation above mean sea level for each station is given.

STATION NO.		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	18a	18b
ELEVATION IN METERS a.m.s.l.		7.73	7.73	7.47	7.47	7.27	7.27	6.89	6.89	6.71	6.71	6.56	6.54	6.39	6.39	6.25	6.25	5.47	5.47	4.86	4.86	4.10	4.10	6.45	6.45	6.57	6.57	6.69	6.69	6.72	6.72	6.77	6.77	6.74	6.74	6.73	6.73
NO. OF SPECIES (Live/total)		0/1	0/1	0/6	0/5	0/4	0/2	1/4	0/6	1/7	0/5	0/2	1/5	3/6	4/4	4/4	4/4	2/3	2/3	1/2	1/1	1/1	1/2	1/4	2/3	3/6	3/5	2/3	2/3	2/3	2/4	1/4	2/4	1/4	1/3	3/4	1/3
NO. OF INDIVIDUALS per 10 cc (Live/total)		0/1	0/6	0/315	0/290	0/36	0/4	1/33	0/66	4/283	0/79	0/3	1/13	40/78	24/48	7/20	15/47	232/276	60/62	72/84	87/103	24/25	98/149	1/65	10/41	27/92	12/55	48/163	3/31	11/113	8/144	8/116	1/73	19/182	7/127	5/297	3/91
[illegible]	L																																				
	T																			1																	
[illegible]	L													2																							
	T													1																							
[illegible]	L												100	95	79	57	11	2	2							7					12						
	T												8	59	40	25	8	2	2							9	4				1		1				
Eggerella advena	L																													9							
	T			3	1			4	6	7	38		54											5						1	3	6	5				
[illegible]	L							100		100																										20	
	T			1		69	75	26	9	72	33	67	8																					X		11	19
Jadammina polystoma	L														4		4										8	2									
	T	100		14	24					2	4		8		2		6						1	2	2	2	15	1	2			1			X	X	
Miliammina fusca	L																																				
	T				X	6																												X			
[illegible]	L													2	8	14	14	98	98	100	100	100	100	100	10	37	25		67								
	T													1	4	5	15	97	97	99	100	100	99	5	2	11	7		4								
Tiphotrocha comprimata	L																																67			60	
	T			16	17	12		9	18	1				1												1	2	1		1	1	4	8	2	3	37	31
Trochammina inflata	L														8	14	66								90	56	67	98	33	91	88	100	33	100	100	20	100
	T		100	46	55	12	25	60	64	10	24	33	23	37	54	65	70	X						88	93	74	71	98	94	98	96	83	85	97	97	42	50
T. macrescens	L															14																					
	T								2	X						5																1					
Trochammina ochracea	L																																				
	T			1					2	1	1								2							1						2					



FOLD OUT 1

Sampling locations in Chezzetcook Inlet, Nova Scotia.

Station 1-20, 45-48, 56,
Trans. I-V are marsh stations
Stations 21-44, 49-55 are estuarine not included in this study.


Trans II
Sta 1a-h
Sta 40
Sta 41
Gaetz Island
Sta 49
Conrad Island
Sta 8a-d
Sta 50
Red Island
Sta 19a-d
Sta 7a-e
Trans IV
Sta 52
Sta 51
Sta 53
Sta 42
Black Point
Sta 44
Sta 54
Cape Entry
Sta 55
Sta 43
Story Head